UPPER COLUMBIA RIVER

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

Amendment No. 2

Prepared for

Teck American Incorporated

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Prepared by

ENTRIX

Down to Earth. Down to Business.™

Saskatoon, SK S7N 3B5, Canada

and

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Saskatoon, SK S7N 3B5, Canada

in consultation with

Exponent **Parametrix** **HydroQual**

July 2010

SECTION A: PROJECT MANAGEMENT

A1 TITLE AND APPROVAL SHEET

QUALITY ASSURANCE PROJECT PLAN FOR THE "ASSESSMENT OF SEDIMENT TOXICITY TO WHITE STURGEON (*Acipenser transmontanus*) AMENDMENT NO. 2"

Quality Assurance Project Plan Approvals

EPA Project Coordinator:	Helen Bottcher	Helen H Bottcher	Date: 7/16/2010
EPA Quality Assurance (QA) Manager:	for Gina Grepo-Grove		Date: 7/19/10
Teck Project Coordinator:	Marko Adzic		Date: 07-16-10
Principal Investigator:	Dr. Markus Hecker		Date: 07-16-10

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A3 DISTRIBUTION LIST

EPA Project Coordinator:	Helen Bottcher
EPA QA Manager:	Gina Grepo-Grove
Teck Project Coordinator:	Marko Adzic
Principal Investigator:	Dr. Markus Hecker
Study Team Leader:	David Vardy

A4 INTRODUCTION

A4.1 Introduction

As detailed within the May 2010 Quality Assurance Project Plan (QAPP) for the *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* (Teck 2010c), information regarding final study design and optimization of flow-through fluvial exposure chambers were being evaluated per the *Methods Development for the White Sturgeon Sediment Toxicity Study* QAPP and its Amendments (Teck 2010a, b, d). Results from methods development work and associated final study design are presented herein.

All other aspects associated with field sampling and handling procedures, laboratory analysis, Quality Assurance/Quality Control (QA/QC) measures, and data validation activities remain unchanged from the approved QAPP (May 2010) and its amendment (June 2010).

A4.2 Modifications

A summary of observations and associated recommendations optimizing the design and performance of flow-through fluvial exposure chambers and test conditions for sediment toxicity tests using white sturgeon are presented within Table A-1. Details associated with this summary are presented within technical memoranda; see Appendices A through E. Similarly, and based on field sampling efforts detailed within Amendment No. 1 to the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP, the number of treatments and exposures; laboratory analyses, and associated sample containers have been optimized, see Table A-2, A-3, and A-4 respectively.

SECTION B: REFERENCES

Teck. 2010a. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study, Upper Columbia River RI/FS. Submitted and approved by EPA, April 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010b. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study - Amendment No. 1, Upper Columbia River RI/FS. Submitted and approved by EPA, April 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010c. Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*), Upper Columbia River RI/FS. Submitted and approved by EPA, May 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Parametrix, and HydroQual

2010d. Quality Assurance Project Plan for Methods Development for the White Sturgeon Sediment Study - Amendment No. 2, Upper Columbia River RI/FS. Submitted and approved by EPA, June 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Inc., Parametrix, Inc., HydroQual Inc., and Cardwell Consulting, LLC

2010e. Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) - Amendment No. 1, Upper Columbia River RI/FS. Submitted and approved by EPA, June 2010. Prepared for Teck American Incorporated, Prepared by ENTRIX, Inc., in Consultation with Exponent, Parametrix, and HydroQual

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TABLES

Table A-1. Parameters, Methods, Measurements and Recommendations to Optimize the Design of the Exposure Systems and Test Conditions for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus)*.

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm^2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table continues

Table A-1 continued - Parameters, Methods, Measurements and Recommendations to Optimize the Design of the Exposure Systems and Test Conditions for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*).

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	Flow-rates between 17 and 25L are appropriate as they do not affect gradients. Porewater sampling depth between 1 and 1.5 inches recommended due to observed gradients. Short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time of 4 to 7 days prior to introduction of fish is sufficient.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648), all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle and Lower Arrow Lake, gravelly sand, all analytes below SEVs. Acceptable for use.

Table A-2. Exposure System Treatments Based on Results from Methods Development Work and Available Substrates.

Treatment Group	No. of Biology Replicates	No. of Chemistry Only Replicates
LMF - 02	3	1
UMF - 01	4	2
NP - 03	2	0
LD - 01	4	2
DME [a]	2	1
GE	3	1
LALL	4	2
Laboratory Control Substrate [b]	4	2
Water Only (No Sediment)	4	0

Notes:
LMF – Lower Marcus Flats
UMF – Upper Marcus Flats
NP – Northport
LD – Little Dalles
DME – Deadman's Eddy
GE – Genelle (reference sediment)
LALL – Lower Arrow Lake (reference sediment)
[a] Test chambers for materials collected as part of methods development work from the gravel bar at DME will be established but may not be employed as required by the U.S. Environmental Protection Agency
[b] As determined during methods development work laboratory control sediments will consist of Hagen Geosystems Substrate.

Table A-3. Parameters Measured and Frequency in Sturgeon Exposure Chambers.

Analyte/Parameter	Sediment [a]		Pore/SWI/Overlying Water	
	CAS	U of S	CAS	U of S
Conventional Parameters				
Alkalinity			W	start[b], W
Hardness			W	start[b], W
TDS			W	
TOC / DOC	start, end		W	
pH	start, end			start[b] D
DO				D
Temperature				D
Conductivity				D
Cations/Anions				
Calcium			W	
Chloride			W	
Fluoride			W	
Magnesium			W	
Potassium			W	
Sodium			W	
Sulfate			W	
Nutrients				
Ammonia				W
Nitrate+Nitrite				W
Common Metals and Metalloids				
Aluminum	start, end		W	
Antimony	start, end		W	
Arsenic	start, end		W	
Barium	start, end		W	
Beryllium	start, end		W	
Cadmium	start, end		W	
Chromium	start, end		W	
Cobalt	start, end		W	
Copper	start, end		W	
Iron	start, end		W	
Lead	start, end		W	
Manganese	start, end		W	
Mercury	start, end		W	
Molybdenum	start, end		W	
Nickel	start, end		W	
Selenium	start, end		W	
Silver	start, end		W	
Thallium	start, end		W	
Vanadium	start, end		W	
Zinc	start, end		W	

	Sediment [a]		Pore/SWI/Overlying Water	
Analyte/Parameter	CAS	U of S	CAS	U of S
Other				
AVS	start, end			
SEM	start, end			
Grain Size	start			
Total PCBs[c, d]	start			
Total DDT[c, d]	start			
Biological Measurements				
Length				Measure Day 0, end of test, and all dead fish; photo document periodically
Weight				Measure Day 0 and end of test; all dead fish
Survival				D

Notes:

D Daily measurements conducted by the U of S to control for appropriate water quality required for successful sturgeon culture

W Weekly measurements will be conducted by the U of S to assess changes in exposure conditions that require immediate corrective action. During the beginning of the exposure these parameters will be measured more frequently (e.g. every 2 to 5 days).

AVS = acid volatile sulfides (only measured in sediments)

DO = dissolved oxygen (only measured in water samples)

SEM = simultaneously extracted metals (only measured in sediments)

TDS = total dissolved solids (only measured in water samples)

TOC = total organic carbon (only measured in sediments)

DOC = dissolved organic carbon (only measured in water samples)

[a] samples will also be archived per Table B-4 of the May 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*)

[b] parameters to be analyzed / adjusted in artificial river water

[c] Total PCBs and DDT will be analyzed using EPA Methods 8082 and 8081A, respectively. Detection limits and accuracy for total PCB analyses will be ~(0.05 – 0.2) µg/kg and (53-143) % recovery, respectively. Detection limits and accuracy for total DDT analyses will be ~(0.07 – 0.3) µg/kg and (53-143) % recovery, respectively.

[d] Samples will be collected in 8 oz. wide mouth glass jars with no headspace and maintained at 4±2°C prior to analysis by the laboratory. Extraction will be performed within 14 days of sample collection.

Table A-4. Required Sample Containers, Preservation, and Holding Times for Overlying Water, Sediment-Water Interface Water, and Porewater Samples.

	Container [a]		Preservation	Holding Time	Proposed Minimum Laboratory Sample Size [b]
	Type	Size			
Conventional Parameters					
Alkalinity as $CaCO_3$	HDPE	1000 mL	4±2ºC	14 days	25 mL
Dissolved organic carbon	HDPE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	25 mL
Hardness as $CaCO_3$	HDPE	with metals	1 mL of 1:1 HNO_3; 4±2ºC	6 months	with metals[e]
Total dissolved solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Total suspended solids	HDPE	with alkalinity	4±2ºC	7 days	200 mL
Major Ions					
Calcium, magnesium, potassium, sodium	HDPE	with metals	1 mL of 1:1 HNO_3; 4±2ºC	6 months	with metals[e]
Chloride, fluoride, sulfate	HDPE	250 mL	4±2ºC	28 days	5 mL
Nutrients					
Ammonia	HPDE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	5 mL
Nitrate + nitrite	HDPE	250 mL	H_2SO_4 to pH <2; 4±2ºC	28 days	5 mL
Common metals and metalloids [c]	HDPE	250 mL	1 mL of 1:1 HNO_3; 4±2ºC	6 months	15 to 20 mL
Mercury [d]	FP or G with FP-lined lids	500 mL	BrCl in lab within 28 days of collection; 4±2ºC	90 days	100 mL

Notes:
BrCl = bromine chloride
FP = fluoropolymer
G = glass
HDPE = high density polyethylene bottle
H_2SO_4 = sulfuric acid
HNO_3 = nitric acid
[a] Sample container sizes may be modified to meet laboratory requirements
[b] Extra sample volume will be collected at a frequency of 5 percent of samples to accommodate requirements for laboratory quality control samples.
[c] Surface water samples will be collected and analyzed for dissolved metals and metalloids. A total of 1 L of water will be collected for the common metals/metalloids analyses (dissolved), and 500 mL will be collected for analysis of mercury.
[d] Due to volume limitations mercury analyses will not be performed on porewater samples.
[e] These analyses will be conducted from the same sample collected for metals analysis; therefore, no additional volume is required.

APPENDIX A

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 1 – MIXING AND HOMOGENIZATION OF SEDIMENTS (JULY 9, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 12, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Mixing and Homogenization of Sediments

Dear Mr. Adzic,

This letter is in response to a Technical Memorandum, *Sturgeon sediment toxicity testing – mixing and homogenization of sediments*. The Technical Memorandum was submitted to the United States Environmental Agency via email on July 9, 2010. It summarizes the results of testing performed to confirm the effectiveness of sediment homogenization procedures. The procedures that were tested are described in detail in Standard Operating Procedure Number 8 of the approved May 2010 *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*. Test results showed that three hours of tumbling in a modified cement mixer is sufficient to ensure the sediments are well mixed.

With this letter, EPA is approving the Technical Memorandum and the recommendation of a three hour mixing time. Teck American Incorporated is authorized to begin mixing sediments per the approved Technical Memorandum upon receipt of this letter.

Sincerely,

Helen H. Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

E X T E R N A L   M E M O R A N D U M

TO:	Helen Bottcher, US EPA Region 10
FROM:	Markus Hecker, Ph.D., ENTRIX, Inc.
DATE:	July 9, 2010
PROJECT:	UCR Sturgeon Sediment Toxicity Testing
SUBJECT:	Sturgeon sediment toxicity testing - mixing and homogenization of sediments

This summary memo provides recommendations regarding mixing and homogenizing sediments to be used in the study described in the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. All sediments (including reference sediments, sediments from the Site, and control sediments) need to be mixed sufficiently to ensure homogeneity of the material, prior to layering it into the fluvial exposure chambers. The following sections summarize the work done during methods development to arrive at the proposed mixing method and duration; details and all data are provided in Appendix A of this memo.

Sediment Mixing

Objective: Confirm the effectiveness and reliability of sediment homogenization procedures outlined within Standard Operating Procedure Number 8 (SOP-8) of the May 2010 QAPP *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* (see Appendix B of this memo). Sediments collected from the sandbar at Deadman's Eddy (see Appendix C of this memo) were used in this mixing study.

Results and Recommendations: Sediments for the definitive sturgeon study should be mixed for three hours, as results for Cu, Cd and Zn indicate that sediment achieves homogeneity after this amount of mixing time. The cement mixer will be used in the test as it has been shown to be an effective method of mixing sediment. Methods will follow those in SOP #8, with samples being tumbled for 3 hours, stopping every half an hour to rotate the drum and scrap any sediment from the side before repeating the process.

Pb results are more variable (still >20% variation after three hours of mixing), like due to the fact that Pb is present in part as larger solid particles as opposed to associated with fines as surface oxides and bound to organic ligands, and to the size of the sub-subsample collected for quantification. If a larger sub-subsample had been collected and digested, and the digestate diluted prior to analysis, it is likely that the variation among sub samples would be less. The volume of bulk sediment added to the experimental systems will be such that the variation observed in very small sub-subsamples will not be observed among exposure systems (see Appendix A, data summary report for further discussion of this issue). It can be concluded, based on the results for Cu, Cd and Zn, that the sediments are sufficiently homogenized to be used in further experimentation. As a corrective action, larger sub-sub samples can be collected and submitted for reanalysis to verify that the above-explanation is the cause of the observed variation in concentrations of Pb.

Following mixing, sediments will be placed into 5 gallon HDPE buckets, overlaid with water, and stored at 4°C under a nitrogen atmosphere until placement into the fluvial system chambers.

Appendices

Sediment Mixing Test

Appendix A	Data Summary Report
Appendix B	SOP #8: Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and disposal.
Appendix C	Field report for sediment collection at Deadman's Eddy

Appendix A: Summary Data Report

Experiment #: 9 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Sediment Mixing

Goal:

Confirm the effectiveness and reliability of sediment homogenization procedures outlined within Standard Operating Procedure Number 8 (SOP-8) of the May 2010 QAPP *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*.

Experimental Design:

Samples collected from the gravel bar at Deadman's Eddy (see Appendix C) were mixed and homogenized in a specially designed 'concrete mixer.' The large rotating drum of the mixer contains a plastic liner that has been tested to confirm lack of leaching of metals into a water rinsate. Composited sediment was tumbled for a period long enough (e.g., hours) to create a visual appearance of complete mixing. Two sediment samples each were taken from the top, middle, and bottom layers of the drum and analyzed for Cu, Cd, Pd and Zn to verify the visual determination of a homogenized sediment. If analyses had greater than ±20 percent maximum calculated difference in concentration, then the sample was tumbled for another period and the analysis repeated. Methods for sample collection and storage were as stated in the April 2010 QAPP; analysis of metal concentrations was conducted by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) at the U of S.

Decision Criteria:

Sediments were determined to be completely homogenized when all six samples collected were within ±20 percent the maximum calculated difference. Photographs of homogenized sediment were taken to document the visual appearance of samples at homogeneity.

Results:

Rinsate:

The cement mixer was scrubbed with 5% HCl, followed by Liqui-Nox, and thoroughly rinsed with reverse osmosis (RO) water. 50 L of nanopure water was then tumbled in the mixer for a period of 3 hours. The average of two rinsate samples (ppb), ± standard deviation, for Cu, Zn, Cd and Pb were 0.68 ± 0.33, 0.92 ± 0.2, 0.1 ± 0.02 and 0.03 ± 0.01, respectively (Table 1).

Homogenization:

Two sets of six samples were analyzed for homogeneity, for a total of 12 data points for each metal of concern. The decision criteria for sediment homogenization states that the 6 samples (2 from the top, middle and bottom of the mixer) will be analyzed for Cu, Zn, Cd, and Pb and that concentrations ≤ 20% of the mean of the six samples will be considered acceptable. Cu, Zn and Cd results all were well below the 20% criterion, whereas not all Pb results were below the criterion. When comparing all 12 samples, Pb exceeds 20% 6 times (50%, 48%, 26%, 33%, 33% and 21%); (Recovery analysis, Table 2).

Conclusions:

Results for Cu, Cd and Zn indicate that the sediment achieved homogeneity after three hours mixing time. The cement mixer appears to be an effective method of mixing sediment and we propose to use the cement mixer method for mixing sediments for the definitive study. Methods will follow those in SOP #8, with samples being tumbled for 3 hours, stopping every half an hour to rotate the drum and scrap any sediment from the side before repeating the process.

The probable cause for the greater variation in concentrations of Pb among subsamples than was observed for Cu, Zn or Cd is that Pb likely is present in part as larger solid particles as opposed to associated with fines as surface oxides and bound to organic ligands. Since concentrations of Cu, Zn and Cd all indicated that the bulk sediment was homogenized, the greater variation in concentrations of Pb is likely due to the size of the sub-subsample collected for quantification. A sub-subsample of 0.1 g dw was taken for digestion. If a larger sub-subsample had been collected and digested, and the digestate diluted prior to analysis, it is likely that the variation among sub samples would be less. Since the Pb generally is occluded in the solid matrix of particles it is less likely to contribute directly to toxicity in porewater. This conclusion is supported by the results reported by Besser et al. (2008)[1] for location L7, which is in the vicinity of Deadman's Eddy. In that study of the toxic potential of metals in sediments from the UCR, the concentration of Pb in bulk sediment from L7 was 590 μg Pb/g, dw while the concentration in the porewater was 7.1 μg Pb/l. At other locations such as L6, which is downstream from L7, the concentration in the bulk sediment was 200 μg Pb/g, dw but the concentration in the pore water was 250 μg Pb/l. A fractionation of the sediment at L7 showed that more than 50% of the Pb was in the residual unextractable fraction and an additional 40% was present as a sulfide (or organic) but most likely an insoluble sulfide material. These results taken together indicate that Pb in the vicinity of Deadman's Eddy is more likely to be bound in the matrix of the sediments and less likely to contribute to lead concentrations in pore water. The volume of bulk sediment added to the experimental systems will be such that the variation observed in very small sub-subsamples will not be observed among exposure systems.

It can be concluded based on the results for Cu, Cd and Zn that the sediments are sufficiently homogenized to be used in further experimentation. As a corrective action, larger sub-sub samples can be collected and submitted for reanalysis to verify that the above-explanation is the cause of the observed variation in concentrations of Pb.

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[1] Besser, J.M., Brumbaugh, W.G., Ivey, C.D., Ingersoll, C.G., Moran, P.W. 2008. Biological and Chemical Characterization of Metal Bioavailability in Sediments from Lake Roosevelt, Washington, USA. *Arch. Environ. Contam. Toxicol.* .54: 557-570.

Table 1. *Cu, Cd, Zn and Pb analysis for rinsate of cement mixer. Nanopure results indicate concentration levels of metals of concern in nanopure water before being introduced into the cement mixer. The average for two cement mixer samples are presented along with standard deviation (SD).*

	Cu (ppb)	**Zn (ppb)**	**Cd (ppb)**	**Pb (ppb)**
Detection Limit (DL)	0.07	0.19	0.02	0.003
Blank	< DL	< DL	0.064	< DL
Nanopure 1	< DL	0.01	0.099	< DL
Nanopure 2	< DL	0.027	0.092	0.001
Cement mix 1	0.45	1.062	0.109	0.033
Cement mix 2	0.91	0.783	0.083	0.018
Avg. Cement	0.68	0.92	0.1	0.03
SD Cement	0.33	0.2	0.02	0.01

Sediment Homogenization -- Test Data

	Instrument analysis (these are numbers as they come out of the ICP)				Acceptable instrument limits: ± 10% recove This is the lab QA/QC data)			
	Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Level of Detection (LOD)	0.051	0.146	0.003	0.005				
BLANK 13	-0.865	-3.769	-0.026	0.003	-2.561	-10.535	-0.013	0.011
BLANK 14	-0.868	-3.818	-0.004	0.002				
BLANK 15	-0.874	-3.81	-0.014	0				
BLANK 16	-0.869	-3.796	-0.008	0				
BLANK 18	-0.871	-3.8	0.019	0.001				
BLANK 19	-0.828	-2.948	0.017	0.006				
average	-0.8625	-3.65683	-0.00267	0.002				
1643 e	22.09	77.4	6.587	11.56	0.570143	-1.91362	-0.01518	-0.34722
1643 e	21.62	74.98	6.591	11.45	2.685671	1.272823	-0.07592	0.607639
1643 e	22.94	75.46	6.58	11.55	-3.25581	0.640801	0.091102	-0.26042
Control A (MB)	-0.36	-0.585	0.196	0.079				
Control B (MB)	-0.387	1.901	0.064	0.062				
Control C (MB)	-0.448	0.489	0.063	0.087				
Top 1A	329.6	2873	2.431	115	-2.2174	-0.36681	-2.98666	5.193735
Top 1B	315.3	2852	2.29	127.6				
Middle 1A	336.4	2887	2.508	121.7	5.941563	0.017316	0.555115	25.8379
Middle 1B	378.9	2888	2.536	206.5				
Bottom 1A	339.5	2862	2.523	117.4	-1.69238	-0.01747	-2.20782	27.12601
Bottom 1B	328.2	2861	2.414	204.8				

	Instrument analysis (these are numbers as they come out of the ICP)				Acceptable instrument limits: ± 10% recove This is the lab QA/QC data)			
	Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	413.3	2768	2.334	145.1	-9.16535	3.905572	1.185436	9.369144
Top 2B	343.9	2993	2.39	175.1				
Middle 2A	363.1	2783	2.502	93	-2.5996	0.784314	-1.45985	21.25318
Middle 2B	344.7	2827	2.43	143.2				
Bottom 2A	342.6	2608	2.493	92.25	-3.69249	0.286752	-4.79193	9.757887
Bottom 2B	318.2	2623	2.265	112.2				
PACS A	98.55	135.6	4.544	96.11	1.050905	3.188958	4.930609	1.761499
PACS B	98.74	140.4	4.969	98.18	0.860136	-0.23798	-3.96122	-0.35434
PACS C	101.5	144.2	4.826	99.21	-1.91104	-2.95098	-0.96938	-1.40716

ent Homogen

ery		Method analysis				Acceptable methods limits: ± 30% recovery			
		(this is the data after correction for blanks, tare weight, etc.)							
		USE THESE DATA							
		Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
f Detection (LOD)									
BLANK 13									
BLANK 14									
BLANK 15									
BLANK 16									
BLANK 18									
BLANK 19									
1643 e									
1643 e									
1643 e									
Control A (MB)	Control A	-0.06	-0.09	0.03	0.01				
Control B (MB)	Control B	-0.06	0.28	0.01	0.01				
Control C (MB)	Control C	-0.06	0.07	0.01	0.01				
Top 1A	Top 1A	51.17	446.01	0.38	17.85	-2.28	-0.43	-3.05	5.13
Top 1B	Top 1B	48.89	442.21	0.36	19.78				
Middle 1A	Middle 1A	52.44	450.03	0.39	18.97	5.19	-0.74	-0.20	25.13
Middle 1B	Middle 1B	58.18	443.45	0.39	31.71				
Bottom 1A	Bottom 1A	52.40	441.75	0.39	18.12	-2.44	-0.76	-2.95	26.43
Bottom 1B	Bottom 1B	49.91	435.04	0.37	31.14				

ry		Method analysis				Acceptable methods limits: ± 30% recovery			
	(this is the data after correction for blanks, tare weight, etc.)								
		USE THESE DATA							
		Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	Top 2A	61.88	414.40	0.35	21.72	-8.36	4.72	2.00	10.17
Top 2B	Top 2B	52.33	455.43	0.36	26.64				
Middle 2A	Middle 2A	55.36	424.32	0.38	14.18	-1.83	1.55	-0.69	21.99
Middle 2B	Middle 2B	53.37	437.71	0.38	22.17				
Bottom 2A	Bottom 2A	52.35	398.54	0.38	14.10	-4.90	-0.92	-6.00	8.56
Bottom 2B	Bottom 2B	47.46	391.25	0.34	16.74				
PACS A	PACS A	15.46	21.27	0.71	15.07	-2.12	0.06	1.69	-1.43
PACS B	PACS B	13.70	19.48	0.69	13.62	9.47	8.43	4.87	8.31
PACS C	PACS C	16.25	23.08	0.77	15.88	-7.35	-8.48	-6.57	-6.87

ent Homogen

QAPP acceptable limits for homogenization: ± 20% of mean

	USE THESE DATA				USE THESE DATA			
	All data points				6 samples			
	Cu	Zn	Cd	Pb	Cu	Zn	Cd	Pb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
f Detection (LOD)								
BLANK 13								
BLANK 14								
BLANK 15								
BLANK 16								
BLANK 18								
BLANK 19								
1643 e								
1643 e								
1643 e								
Control A (MB)								
Control B (MB)								
Control C (MB)								
Top 1A	3.42	-3.32	-1.57	15.37	1.91	-0.66	0.22	22.14
Top 1B	7.72	-2.44	4.44	6.21	6.28	0.20	6.12	13.72
Middle 1A	1.02	-4.25	-5.21	10.07	-0.53	-1.57	-3.37	17.27
Middle 1B	-9.82	-2.73	-4.80	-50.32	-11.53	-0.08	-2.96	-38.28
Bottom 1A	1.09	-2.33	-4.80	14.10	-0.46	0.30	-2.96	20.97
Bottom 1B	5.80	-0.78	1.21	-47.63	4.33	1.81	2.95	-35.81

QAPP acceptable limits for homogenization: ± 20% of mean

	USE THESE DATA				USE THESE DATA			
	All data points				6 samples			
	Cu ppb	Zn ppb	Cd ppb	Pb ppb	Cu ppb	Zn ppb	Cd ppb	Pb ppb
Top 2A	-16.80	4.00	5.96	-2.98	-15.03	1.40	4.25	-12.80
Top 2B	1.22	-5.50	2.13	-26.31	2.72	-8.36	0.35	-38.35
Middle 2A	-4.50	1.71	-2.66	32.78	-2.92	-0.96	-4.53	26.37
Middle 2B	-0.74	-1.40	-1.25	-5.11	0.78	-4.15	-3.10	-15.13
Bottom 2A	1.18	7.68	-2.53	33.17	2.67	5.17	-4.39	26.80
Bottom 2B	10.41	9.37	9.08	20.66	11.77	6.91	7.42	13.10
PACS A								
PACS B								
PACS C								

Appendix B SOP #8 Sample Management: Receiving, Preservation, Storage, Documentation, Decontamination, and disposal.

STANDARD OPERATING PROCEDURE SOP-8

SAMPLE MANAGEMENT: RECEIVING, PRESERVATION, STORAGE, DOCUMENTATION, DECONTAMINATION, AND DISPOSAL

Purpose

This standard operating procedure (SOP) specifies the requirements for sample receipt, control, record keeping, decontamination, and disposal at the Environmental Toxicology Laboratory (ETL) at the University of Saskatchewan (U of S).

Scope and Applicability

This SOP applies to the ETL for samples supplied from the Upper Columbia River white sturgeon studies.

Safety Considerations

Safety training and medical monitoring requirements are described in the Health and Safety Plan for the Upper Columbia River Remedial Investigation and Feasibility Study (TCAI 2007).

In addition, there are various safety concerns regarding the receipt, storage, and disposal of sample containers at the ETL. Upon receipt, the sample containers will be monitored for breakage. If sample containers are broken, the appropriate personnel will be immediately notified and the Department of Health, Safety and Environment (DHSE) will be called in order to assess the hazard. DHSE will also be contacted in the case of chemical spills and will be responsible for the disposal of hazardous wastes.

Personal Protective Equipment

Personnel protective equipment (PPE), consisting of lab coats, safety glasses, and latex gloves will be worn at all times when handling samples.

Waste Management

All waste will be managed and disposed of in accordance with U of S DHSE regulations. Waste management practices will include the control of all standards and solutions. This means that if required expired or used standards, associated solvents and other chemicals used for preservation and biological or element analysis will be disposed of in labeled waste containers and DHSE will be notified for waste pick up.

Spill Decontamination

If a spill occurs in the laboratory, DHSE will be notified immediately. The area where the spill occurred will be evacuated and marked.

Equipment, Materials, and Reagents

The sample storage area is equipped with a locked freezer, refrigerator and a liquid nitrogen Dewar flask in which samples are stored as appropriate. Access to these storage areas is limited to laboratory personnel with appropriate authorization that work at the Toxicology Centre (lockable walk-in cold room and freezer, and liquid nitrogen storage room), or only to the white sturgeon UofS study team (separate lockable fridge and freezer units). A list of personnel with access to refrigerators, freezers and dewars and other storage areas will be established once the hiring and training portion of the studies is completed. Sediments and archived samples will be sealed with a breakable seal that is dated and initialed. The freezer and Dewar flask are connected to phone and audible alarm systems that monitor temperature and notify laboratory personnel in cases of temperature and/or power related issues. A calibrated balance is also kept in the sample storage area and is used to weigh sub-samples. Sample storage at 4°C will occur in a lockable walk-in refrigerator that is connected to a phone alarm system. Temperature in the walk-in refrigerator is monitored continuously by an automated temperature logging system, and checked manually every morning during weekdays. In case of a building power outage, an auxiliary generator automatically provides power to freezers and the walk-in refrigerator and an alarm is sent to U of S Public Safety office.

No materials or reagents are used in sample receipt.

METHOD, PROCEDURES, AND REQUIREMENTS

Sample Receipt

The physical condition of coolers or other containers used for transportation, and each individual sample container will be inspected upon arrival at the ETL. The following objectives have been established for sample receiving:

A. Inspect sample coolers and samples for signs of damage upon receipt at the laboratory.

B. Attach air bill or shipping receipt to the chain-of-custody (COC) form.

C. Examine individual samples and record their status (frozen/ not frozen; immersed in preservation liquid, etc.) on a sample receipt form.

D. Verify that a COC form is submitted with samples, and that the COC contains all information required for analysis and reporting. Maintain custody of samples by ensuring that all dates, times, and signatures are provided on the COC forms.

E. Identify and reconcile any discrepancies between the COC and sample labels.

F. Verify that sample containers, labeling, or other requirements are correct. Assign a unique lab identification number to each sample and log samples into the sample tracking sheet (STS) (see attached STS.) Identify any hazards or special precautions associated with the incoming samples.

G. Notify appropriate laboratory and field study personnel when samples have arrived. These individuals are to be identified in either a Work Plan or Sampling and Analysis Plan (SAP).

H. Track and document the handling of samples from receipt through data reporting to final disposal. This will be accomplished by keeping all of the log forms in a binder kept in the laboratory.

Sample Documentation

Upon arrival, the shipping receipts will be collected from the cooler and be stapled to the COC form. Samples submitted to the ETL will be accounted for by documenting their arrival and condition on COC and sample tracking sheets. Within the ETL, the STS will be used to monitor the samples whereabouts at all times. Aliquots removed will be recorded on the STS. While handling samples, any anomalies or problems will be noted in bound laboratory notebooks.

Sample Storage and Preservation

Samples will be stored in liquid nitrogen, freezer, refrigerator or locked storage room at room temperature (formalin preserved sturgeon samples) in the laboratory. This room is accessible only to lab personnel. The freezer and (walk-in) refrigerators will be set at -20°C and +4°C, respectively, and the temperature will be monitored daily. If for any reason there is a power outage or an increase in temperature, the facility manager on call and/or other lab personnel will be immediately notified by the automated phone alarm system that will automatically call the cell phone of the person on duty. Also, the walk-in refrigerator for the storage of sediments is connected to a backup generator that insures continuous operation in case of a power outage. The necessary action will then be taken to ensure that sample integrity is not compromised. If samples are removed from any of the storage compartments/units for any reason, this activity will be documented on the STS form. Copies of the forms will be placed in the records archive. When samples are removed for preparation and analysis, a sample extraction form will be completed.

Storage Container and Compositing Equipment Decontamination

All equipment used for storage (e.g. HPDE buckets, instruments to move samples) as well as all other equipment that could come into contact with chemically affected materials will be thoroughly cleaned, before and after each use, by washing with Liquinox® (a laboratory-grade detergent) and rinsing with deionized water followed by dilute nitric acid and another wash of deionized water. Decontamination procedures may be modified and/or revised based upon the data obtained or the equipment used (e.g. no acid will be used if the equipment or parts of the equipment consist of non-coated metal). Sub-samples of final deionized water rinses after acid washing will be collected for metal analysis to insure successful decontamination of equipment.

Decontamination waste is expected to consist of dilute nitric acid. Decontamination solutions will be properly disposed through the Department of Health, Safety and Environment (DHSE) of the U of S.

Sediment Sample Transport and Storage [1]

Freshly collected sediment will be placed in 5 gallon HDPE buckets from Columbia Analytical Services (CAS). Buckets will be cleaned and shipped to the field site in a protective covering to ensure they are contamination free. Buckets will be completely filled with sediment except for a small layer of river water above the sediment. The container will be filled to the brim to reduce oxygen exposure. The container will be purged with an inert gas (for example, nitrogen) before filling and then again before capping tightly. Sediment samples will never be frozen. All sediment containers will be properly labeled with a waterproof marker before sampling. Each label will include: the study title, station location or sample identification, date and time of collection, sample type, and name of collector. Labeled containers will be stabilized in an upright position in the transport/storage container. Following collection from each location the sediment samples will be immediately transferred to a refrigerated truck and stored upright at 4°C until placed in refrigerated room (walk-in refrigerator) at the ETL.

Sediment Sample Compositing [2]

Compositing will be accomplished in the laboratory in the following manner:

1. Overlying water will be siphoned off, not decanted, prior to compositing.

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[1] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

[2] These procedures follow ASTM guidelines 1391-03 (2008) Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates.

2. All utensils that are used to process samples will be made of inert materials such as high quality stainless steel, or high density polyethylene (HDPE).
3. Unrepresentative materials (for example, twigs, shells, leaves, large stones, wood chips etc.) will be removed and documented before homogenization.
4. A high-grade stainless steel concrete mixer (or similar industrial mixing device made out of stainless steel or HDPE) will be used to thoroughly homogenize samples (homogenization will occur at medium to low mixing speed for a minimum of 30 minutes).
5. Reference sediments will be mixed first.
6. The sediment mixer will be cleaned thoroughly between uses (low percent nitric acid bath followed by thorough rinsing with ultraclean water, as appropriate).

Partitioning sediments for biological testing will be accomplished by removing small portions from random locations in the sediment mixer and distributing them randomly in all corresponding exposure chambers until the appropriate volume of sediment is contained in each. During distribution, the sediment will be periodically mixed to minimize stratification effects due to differential settling. Remaining sediments will be placed into 5 gallon HDPE buckets, overlaid with water, and stored at 4°C under a nitrogen atmosphere.

Scheduled Monitoring

All Dewar flasks, refrigerators, and freezers used in the ETL will be examined frequently due to constant use and will be monitored at a minimum daily. Freezer temperatures are maintained at a nominal -20°C. If the freezer temperature rises to equal or greater than -15°C, if the liquid nitrogen levels decrease such that it triggers the alarm, or if the refrigerator temperature rises over +7°C, corrective action must be taken. Actions include adjusting the thermostats, refilling liquid nitrogen, having the unit serviced, or moving the samples to another unit.

Sample Accountability

To ensure that all samples will be accounted for, the following guidelines will be followed:

A. The person obtaining the sample or submitting the sample to the laboratory for analysis must establish sample identity.

B. Integrity of sample must be maintained from collection to delivery.

C. Composition of sample must remain the same during handling and storage before analysis.

D. Evidence must exist of sample's receipt and COC record filled out, and appropriate personnel notified of the sample arrival.

E. Person preparing sample must not allow composition of sample to change or integrity to be questioned.

F. Analyst must ensure correct sample is analyzed.

G. Analyst must record all data contributing to the analysis.

H. Records must be kept to trace sample from retrieval through data reporting.

I. Special storage conditions must be documented.

Label and COC Discrepancies

Discrepancies between the sample labels and COC will be noted on the COC or Sample Receipt Form. The sample manager will resolve any documentation discrepancies by contacting the personnel that submitted the samples. For discrepancies impacting sample viability (i.e., improper sample temperature) where a Corrective Action Report (CAR) is required to be completed, the sample manager will coordinate with the sample submitter, quality assurance (QA), and Project Study Group representatives to determine the appropriate corrective action.

RECORDS, DOCUMENTATION, AND QUALITY CONTROL (QC) REQUIREMENTS

The primary analyst shall document any anomalies and/or deviation from the specified method in a bound, serially numbered, laboratory notebook with tear-out carbon copies. All electronic files and hardcopies will be kept at the participating laboratory.

The carbon copies from data notebooks will be removed and archived in a separate building. Copies of the COC forms, the STS, and laboratory notes will be kept in three-ring binders in separate places at all times in case of fire or other disaster.

RESPONSIBILITIES

Project Manager. Dr. Markus Hecker will oversee and approve all project activities, authorize necessary actions and adjustments, and act as liaison between the principle investigator and other U of S personnel, Teck American personnel, and the sponsor Project Manager.

Principle Investigator. Prof. John P. Giesy will advise the Project Manager in overseeing and approving all project activities, authorize necessary actions and adjustments related to U of S activities to accomplish program QA objectives; and act as liaison between agencies, staff, and the sponsor Project Manager.

Study Team Leaders (STLs). David Vardy and Jonathon Doering, under the supervision of Markus Hecker, will oversee all research activities and supervise all personnel involved with the assemblage of the experimental exposure systems. The STLs will ensure that proper sample collection, preservation, storage, transport, and COC QC procedures are followed and will inform the Project QA Manager when problems occur, and will communicate and document corrective actions taken. The STLs will discuss study activities with the Project Manager.

Quality Assurance (QA) Manager. Dr. Shaun Roark will initiate audits on work completed by project personnel. The manager will review program QA activities, quality problems, and quality-related requests. In response to experimental findings, the QA manager will approve corrective actions. The QA manager will report quality non-conformances to the Project Manager.

QUESTIONS OR COMMENTS

Please feel free to contact the following persons with any questions, comments, etc., you may regarding the procedures outlined in this SOP.

Markus Hecker	Paul D. Jones, Ph.D.	John P. Giesy, Ph.D.
mhecker@entrix.com	paul.jones@usask.ca	john.giesy@usask.ca
(306) 966-5233	(306) 966-5062	(306) 966-2096

REFERENCES

Comprehensive Analytical Laboratory Services Quality Assurance Management Plan, April 1997.

Environmental Analytical Laboratory, Laboratory Quality Control Plan, April 1997.

TCAI (Teck Cominco American, Inc.). 2007. Upper Columbia River: Draft general health and safety plan for the remedial investigation and feasibility study. Prepared for Teck Cominco American Incorporated. December 27, 2007. Integral Consulting Inc., Mercer Island, Washington, and Parametrix, Bellevue, Washington.

Appendix C Field report for sediment collection at Deadman's Eddy

The four UTM corner coordinates were located using a consumer-grade, hand-held Global Positioning System (GPS) unit (Magellan Triton) and marked using wooden stakes. See Figures 1 through 4. The following methods were used to locate and provide documentation for each on-shore surface grab sample.

- Based on field observations of the sediment composition a transect line was laid between the northeast and northwest corners using a string marker.

- The distance between the two corners was measured by tape as 458 feet (139.5 meters). Based on this measured distance, the transect was divided into 50 foot (15.2 meter) increments or ten references points, with a total transect distance of 450 feet (137.2 meters). The 10 reference points were labeled A (northeast corner) to J (northwest corner).

- The 10 grab sample points were located at various distances in the sand sediments south of the 50 foot transect reference points and marked with flags. Two grab samples were collected south of transect reference point E, as the reference point A (northeast corner) sediment material was comprised of cobbles and boulders. UTM coordinates and elevations were recorded using the hand-held GPS unit for each flagged grab sample point. Attachment A provides the individual grab sample location data.

- Each of the 10 grab samples were collected using a decontaminated shovel and placed into decontaminated polyethylene (PE) 5-gallon bucket. The upper 4 inches (10 centimeters) of sediment was removed to access the underlying sample area. Grab samples were generally collected between 4 and 12 inches (30 centimeters) below the ground surface; 12 inches being the maximum depth prescribed by the QAPP. Unique sample numbers and container numbers were assigned based on QAPP SOP-4. See Figures 5 and 6

- Sample data and observations were recorded on field sample logs (Attachment B). The field sample logs include information on the sample time, UTM coordinates, sample texture and colors, general characteristics, photographic record, and other relevant notes. A bound environmental field book (Attachment C) was used to record general information regarding project personnel, activities, and operations.

- Photographic documentation was collected (Attachment D). Photographs of the locations, samples, and procedures are sequentially identified using a white board marker to record pertinent information (e.g., time, date, and location). The photograph directory is labeled TAI-DME 5_27_2010. The photographs are labeled IMG_0001 to IMG_0091. The individual grab sample photographs (numbers) are recorded on the field sample logs for reference.

- Archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist who meets the U.S. Secretary of Interior’s Professional Qualification Standards (as outlined in 36 CFR Part 61). The DME sediment sampling program was monitored by a URS Registered Professional Archeologist (RPA) Sarah McDaniel, RPA in accordance with protocols outlined in Appendix C of the QAPP (April 2010). Ms. McDaniel's archaeological monitoring results are provided in Attachment E.

Field Observations

The field sampling event was attended by the following persons:

Sampling and Support

- Eric Weatherman, Captain, Columbia Navigation, Inc.
- Alan Burkhart, Columbia Navigations, Inc.
- Sarah McDaniel, RPA, URS Corporation
- Jeffrey E. Leppo LG, URS Corporation

Observers

- Joseph Wichmann, PhD, Technical Advisor, representing Citizens for a Clean Columbia
- Steve Demus, CH2M Hill, providing EPA technical oversight

Figure 5 shows sampling, support, and observer personnel present on May 27, 2010 (Jeffery Leppo is not present in the photograph). The DME location is situated on the west side of the Columbia River and is a depositional sediment bar comprised primarily of sands, gravels, cobbles and boulders. Figures 6 and 7 present surface conditions at DME. Ten sediment grab samples (five gallons each) were obtained from within the DME sampling area delineated by the four corner markers. The primary sample matrix consisted of dark gray and yellowish brown well-graded sands. The presence of buried cobbles and boulders was encountered at several locations at depths ranging from 5 to 8 inches (13 to 20 cm) below ground surface; in these instances the sand sediments were collected above these materials. Figures 8 and 9 present typical grab sample collection activities.

The ten sediment grab samples were labeled TAI-US-DME-HS-1 through TAI-US-DME-HS-10 and are illustrated within Map 1. The corresponding container tag numbers were DME-1 through DME-10. Grab samples were transported by vehicle to Spokane, Washington under chain-of-custody protocol and delivered to representatives of Teck on May 28, 2010. The grab samples were then transported by Teck to the Teck Metals, Ltd facility in Trail, British Columbia, Canada, with subsequent shipping to the University of Saskatchewan, Aquatic Exposure Laboratory. Please refer to Appendix F for the chain-of-custody and shipping documents.

The archaeological monitoring reported no cultural resources were identified or disturbed as a result of this on-shore sediment sampling program.

A benchmark at the Northport (WA) boat launch was established as a reference point for both UTM coordinates and elevation data. The data is entered into the Environmental Field Book, page 1. Photographs IMG_001 and IMG_002 provide a view of the location.

Deviations and Corrective Actions

No reportable deviations, contingencies, or corrective actions were required for this project phase as defined by the QAPP or SOPs.

Attachments:

Figures 1-9:	May 27, 2010 Site Photographs
Map 1:	Sediment Sample Locations
Attachment A:	Sample Locations and Coordinates Table
Attachment B:	Field Data/Sampling Diaries
Attachment C:	Environmental Field Book
Attachment D:	Photographic Record
Attachment E:	Archaeological Monitoring Results
Attachment F:	Chain-of-Custody

Figure 1
Photograph of the northeast corner coordinate, view to west

Figure 2
Southeast corner coordinate, view to southeast.

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Figure 3
Southwest corner coordinate, view to northeast.

Figure 4
Northwest corner coordinate, view to northwest.

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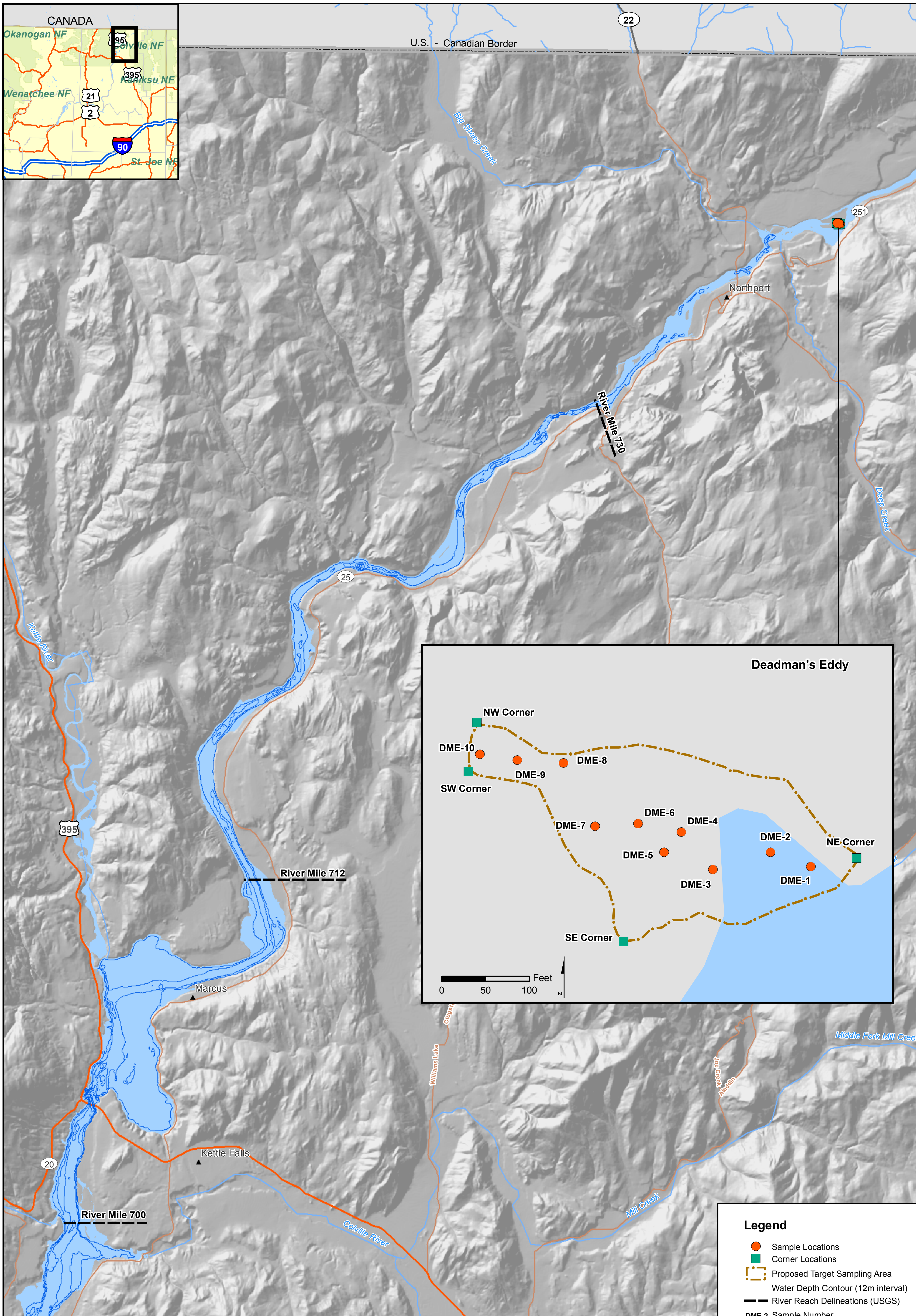
Figure 5
Sampling and support, and observer personnel, view to east.

Figure 6
Deadman's Eddy surface conditions, view to northwest.

Figure 7
Deadman's Eddy surface conditions, view to south

Figure 8
Grab sample collection, sample number TAI-US-DME-HS-1, view to northeast.

Figure 9
Grab sample test pit, sample number TAI-US-DME-HS-1.



Sediment Sample Locations

Km: 0 — 2.5 — 5
Miles: 0 — 1.5 — 3
N

URS Corporation

Source:
GIS base layer Information
provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)**

Upper Columbia River, WA

ATTACHMENT A
Sample Locations and Coordinates Table

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Sample Locations and Coordinates
Methods Development - White Sturgeon Sediment Toxicity Study
Upper Columbia River - Deadman's Eddy (U.S.)

Attachment A

Sample Container Tag No.	Reference Point	Reference Point Distance from NE to NW Corner (m) (1) (2)	Northing (UTM) (3)	Easting (UTM)	Elevation (m)	Distance from Transect Line (m)
DME-1	B	15.2	5421094	447142	392	1.5
DME-2	C	30.5	5421099	447128	392	4.6
DME-3	D	45.7	5421093	447108	397	16.8
DME-4	E	61.0	5421106	447097	399	7.6
DME-5	E	61.0	5921099	447091	398	21.3
DME-6	F	76.2	5421109	447082	399	10.7
DME-7	G	91.4	5421108	447067	398	18.3
DME-8	H	106.7	5421130	447056	397	3.0
DME-9	I	121.9	5421131	447040	399	7.0
DME-10	J	137.2	5421133	447027	398	9.1

Notes:
(1) Total transect line distance from northeast corner to northwest corner was hand measured at approximately 139.5 meters
(2) Northeast Corner - N5421068, E447077, Elevation 401,Northwest Corner - N5421144, E447026, Elevation 398
(3) Coordinates based on Universal Transverse Mercator (UTM) using North American Datum of 1983 (NAD83), Zone 11
Grab sample points (container tag no.) located approximately perpendicular to and south of transect line

ATTACHMENT B
Field Data/Sampling Diaries

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FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 /27 /2010

Time: 12:17

Sample No. : TAI-US-DME-HS- 1 **Container Tag : DME** 1

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
392	5421094	447142

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines.	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines.	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) Moist	Very dark gray	10 YR 3 / 1 YR /		☐ **GC**	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions:	
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 8 inches Sample Depth: 10 to 20 cm	

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Cobbles and boulders @ 6 to 8 inches below surface

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_033 to 038

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 12:30

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 12:35

Sample No. : TAI-US-DME-HS- 2 **Container Tag : DME** 2

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
392	5421099	447128

PHYSICAL CHARACTERISTICS

☐ SW	Well graded sand, gravelly sand, little to no fines	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☑ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) moist	Brown 10 YR 4 / 3 Brownish yellow 10 YR 6 / 6			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions:	Mixed matrix colors
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 6 inches Sample Depth: 10 to 15 cm	

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Primarily fine sands, increasing uniformity w/ depth. Cobbles and boulders @ 5 to 6 inches below surface. Mixed color matrix for sands.

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-10
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0039 to 0042

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 12:50

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 :05

Sample No. : TAI-US-DME-HS- 3 **Container Tag : DME** 3

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
397	5421093	447108

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures

Color (Munsell) Moist / Dry: Dark gray 10 YR 4 / 1; Yellowish brown 10 YR 5 / 6

☐ GC Clayey gravels, gravel-sand-clay mixtures

Other Matrix Descriptions: mixed matrix colors

Visible Organic Matter Yes ☐ No ☑ Description:

Odors Yes ☐ No ☑ Description:

Sample Depth: 4 to 12 inches
Sample Depth: 10 to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

Cultural Resources: Archaeologist Sarah McDaniel Resources Found or Identified? Yes ☐ No ☑ (Please refer to archaeologist's observation record)

Other Notes:

Layered sand horizons - dark gray & yellow brown

~~[illegible]~~

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI - DME 5_27_10

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0043 to 0048

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 13:08

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 : 15

Sample No. : TAI-US-DME-HS- 4 **Container Tag : DME** 4

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421106	447097

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines.	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines.	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures

Color (Munsell) Moist/Dry: DarkGray 10 YR 3 / 1; Dark yellowish brown 10 YR 4 / 6

☐ **GC** Clayey gravels, gravel-sand-clay mixtures

Other Matrix Descriptions: Mixed color matrix

Visible Organic Matter Yes ☐ No ☑ **Description:**

Odors Yes ☐ No ☑ **Description:**

Sample Depth: 4 to 12 inches
Sample Depth: 10 to 30 cm

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Layered sand horizons / striations of dark gray and dark yellowish brown sands

vertical deposition

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0049 to 0053

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 13:18

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 :25

Sample No. : TAI-US-DME-HS- 5 **Container Tag : DME** 5

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421099	447091

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures
Color (Munsell) moist	Dark gray 10 YR 3 / 1 Dark yellowish brown 10 YR 4 / 6			☐ **GC**	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions: Mixed color matrix	
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 12 inches Sample Depth: 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Layered sand horizons, dark gray and dark yellowish brown.

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-10

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0054 to 0059

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 13:30

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 : 35

Sample No. : TAI-US-DME-HS- 6 **Container Tag : DME** 6

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421109	447082

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines.	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines.	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 ~~Dark yellowish brown 10 YR 4 / 6~~			☐ **GC**	Clayey gravels, gravel-sand-clay mixtures

Visible Organic Matter Yes ☐ No ☑ **Description:**

Other Matrix Descriptions: Mixed color matrix

Odors Yes ☐ No ☑ **Description:**

Sample Depth: ________ to ________ inches
Sample Depth: ________ to ________ cm

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed sand layers / horizons of dark gray and dark yellowish brown, vertical deposition

Evidence of beach washing

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman

Photo Directory: TAI-DME 5-27-2010

Sampler Type: HS (hand sample)

Photo File No(s): IMG_0060 to 0065

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 13:40

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 13 :50

Sample No. : TAI-US-DME-HS- 7 **Container Tag : DME** 7

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421108	447067

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines.	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines.	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 ~~Brownish yellow 10 YR 6 / 6~~			☐ **GC**	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	**Description:**		**Other Matrix Descriptions:**	Mixed color matrix
Odors	Yes ☐ No ☑	**Description:**		**Sample Depth:** 4 to 12 inches **Sample Depth:** 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed color matrix, relatively even distribution, no layering/striations

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG0066 to 0071

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 13:52

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14 :00

Sample No. : TAI-US-DME-HS- 8 **Container Tag : DME** 8

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
397	5421130	447056

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 Dark yellowish brown 10 YR 4 / 6			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions:	Mixed color matrix
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 6 inches Sample Depth: 10 to 15 cm	

Obvious Abnormalities (wood, shells, organisms, etc): Yes ☐ No ☑

See notes below

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed layered sand horizons of dark gray and dark yellowish brown over gravels and cobbles - coarse materials w/ yellowish brown (10YR 5/8) fine sand (SP). Roots present (near shrubs), some limited organic litter (wood particles)

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27_2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0072 to 0079

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 14:05

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14:15

Sample No. : TAI-US-DME-HS- 9 **Container Tag : DME** 9

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
399	5421131	447040

PHYSICAL CHARACTERISTICS

☑ **SW**	Well graded sand, gravelly sand, little to no fines.	☐ **SM**	Silty sands, sand-silt mixtures	☐ **GW**	Well graded gravels, gravel-sand mixtures, little to no fines
☐ **SP**	Poorly graded sand, gravelly sand, little to no fines.	☐ **SC**	Clayey sands, sand-clay mixtures	☐ **GP**	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ **ML**	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ **CL**	Clayey sands, sand-clay mixtures	☐ **GM**	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray / Brownish yellow	10 YR 3 / 1 ; 10 YR 6 / 6		☐ **GC**	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions: mixed color matrix	
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 12 inches Sample Depth: 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Evenly mixed sands, no visible layers/striations. Few gravels w/ depth. Carser sands appear to be browinsh yellow

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5_27_2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0080 to 0084

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 14:17

URS

FIELD SAMPLE LOG - SEDIMENTS

Upper Columbia River - Methods Development White Sturgeon Sediment Toxicity Study

U.S. Location - Deadman's Eddy

Date: 5 / 27 /2010

Time: 14 : 21

Sample No. : TAI-US-DME-HS- 10 **Container Tag : DME** 10

ELEVATION (M)	UTM Northing (NAD83)	UTM Easting (NAD83)
398	5421133	447027

PHYSICAL CHARACTERISTICS

☑ SW	Well graded sand, gravelly sand, little to no fines.	☐ SM	Silty sands, sand-silt mixtures	☐ GW	Well graded gravels, gravel-sand mixtures, little to no fines
☐ SP	Poorly graded sand, gravelly sand, little to no fines.	☐ SC	Clayey sands, sand-clay mixtures	☐ GP	Poorly graded gravels, gravel-sand mixtures, little to no fines
☐ ML	Inorganic silts, very fine sands, rock flour, silt or clay silts with low plasticity	☐ CL	Clayey sands, sand-clay mixtures	☐ GM	Silty gravels, gravel-sand-silt mixtures
Color (Munsell)	Dark gray 10 YR 3 / 1 Yellowish brown 10 YR 5 / 6			☐ GC	Clayey gravels, gravel-sand-clay mixtures
Visible Organic Matter	Yes ☐ No ☑	Description:		Other Matrix Descriptions:	
Odors	Yes ☐ No ☑	Description:		Sample Depth: 4 to 12 inches Sample Depth: 10 to 30 cm	

Obvious Abnormalities (wood, shells, organisms, etc): **Yes** ☐ **No** ☑

Cultural Resources: Archaeologist Sarah McDaniel **Resources Found or Identified? Yes** ☐ **No** ☑ **(Please refer to archaeologist's observation record)**

Other Notes:

Mixed matrix, evenly distributed colors + grain size

Boat Contractor: Columbia Navigation, Inc, Capt. Eric Weatherman	**Photo Directory:** TAI-DME 5-27-2010
Sampler Type: HS (hand sample)	**Photo File No(s):** IMG_0085 to 0089

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 27 /2010

Time: 14:25

ATTACHMENT C
Environmental Field Book

URS

Location URS Office Spokane Date 5/26/10

Project / Client UCR Methods Sediment Study

Deadman's Eddy (1 of 1)

Field Prep + Mobilization - Surface Sediments

General QAPP References

* Sample Coordinates:

Deadman's Eddy Gravel Bar

	Northing	Easting
NE Corner	5421097	447158
NW Corner	5421144	447026
SW Corner	5421127	447023
SE Corner	5421068	447077

Polygon - 20 meters (66 ft) Radius

- establish grid from 4 Corners

* Collect Benchmark UTM + Elev @ Northport Boat Launch

* Grain Size Sands (0.5 to 2mm)

* Steel Shovel, see QAPP Decon

* Remove Top 4 in (10.16 cm)

Collect 4 to 12 in (10-31 cm)

No samples below (12 in) or (31 cm)

Location: TAI Teck American Inc Date 5/27/10 (1)

Project / Client: UCR Deadman's Eddy
White Sturgeon - Methods - Sediments

084 Arrive @ site
D

Attendees
Sarah McDaniel, URS
Steve Demus, CH2MHill
Joe Wickman
Alan Burkhart, Columbia Nav.
Eric Weatherman, Columbia Nav.

Establish BM for UTM / Elev.
Zone 11, NAD83
Elev. ~~402~~ meters 411 M
5419055 N, 443452 E
Photos Take 1st 2 Photos.
TAI-DME 5_27_2010 IMG_0001 to 0002
Safety Meeting
Boat Safety
Slips Trip / Falls
PF Devices
GPS Unit - Magellan Triton (hand-held)

Location: UCR Deadman's Eddy Date 5/27/10 (2)

Project / Client: TAI
White Sturgeon / Methods - Sediment

0910 - leave dock for DME
0940 - Arrive @ DME Sandbar. Landing on cut / curve north of sampling area. Beachcraft on sand @ water's edge. 397
Appr. Water Elev. GPS 401 m
0955 Stake out NE Corner
@ N 5421097, 447058 E

1010 Stake out SE Corner
@ 5421068, 447077 E
395 m elev.

1020 Stake @ SW Corner
N 5421127, 447023, 395 m

1030 Stake @ NW Corner
5421144, 447026, 398 Elev m

Photos DME 5_27_2010 IMG_0003 - IMG_0020

Location UCR Date 5/27/10

Project / Client Deadman's Eddy TAI

White Sturgeon Methods - Sediment (3)

General Photos - Views
From Approx middle area

- Sarah McD @ center of sampling area (where photos shot from)

1 Picture to NE Δ from center

2 Photo to SE Δ from center

3 Photo to SW + NW

Photos
TAI-DME 5_27_2010 IMG_0003 to IMG_0020

GPS Unit - Magellan, hand held.

- Variable elevation readings observed, not consistent with topography

Location UCR Date 5/27/10

Project / Client Deadman's Eddy TAI

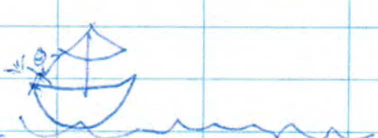
White Sturgeon methods - sediments 4

Location UCR Deadman's Eddy Date 5/27/10

Project / Client TAI

White Sturgeon Methods - Sediment (5)

String line set up between NE △ and NW △ as reference line - logical place between sand bar & rock bar to set line, then systematic interval of 50 ft intervals measured out. Total length of line: 453 ft.



NE △ 0 - cobbles A

50 - Test (B) - offset 5' DME (1) 447142E/5421094N 392m

100 C - offset 15' (no slag) DME (2) 447128E/5421099N 392m

150 D - off 55' (3) 447108E/5421093N 397m

200 E - E1: off 25' (4) 447097E/5421106N 399m
E2: off 70' (5) 447091E/5421099N 398m

250 F - off 35' (6) 447082E/5421109N 399'

300 G - off 60' (7) 447067E/5421108N 398m

350 H - off 10' (8) 447056E/5421130N 397'

400 I - off 23' (9) 447040/5421131N 399 ft

450 (J) - off 30' DME (10) 447027E/5421133N 398'

+3 ft

NW △

Location UCR Deadman's Eddy Date 5/27/10

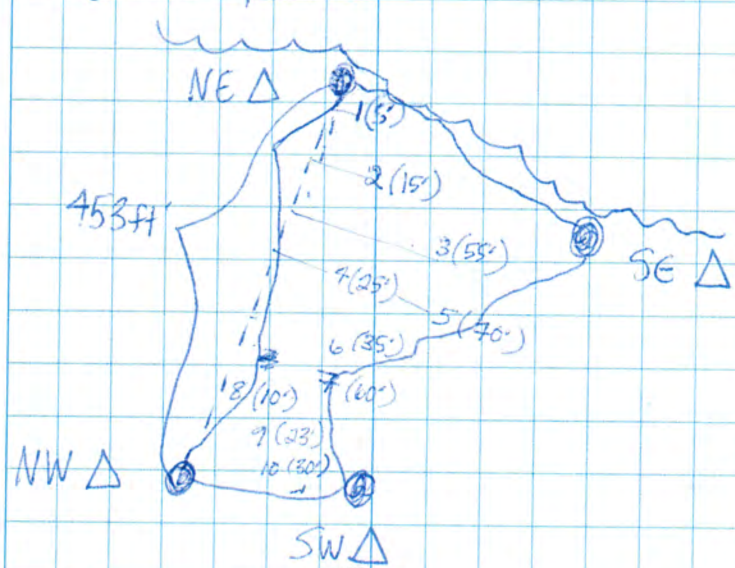
Project / Client TAI

White Sturgeon Methods - Sediment (6)

Complete Transect layout & station markings. Photos TAI-DME 5_27_2010 IMG_0021-0024

1115 Decon buckets w/ alconox, DI, Alcohol Photos TAI-DME 5.27.2010 IMG_0025 to 0027

1120 Search to start layout of 10 grab sample points based on station points



Other Photos

Site TAI-DME 5_27_2010 IMG_0028-0032

Samples TAI-DME 5-27-2010 IMG_0033-0091

- see field logs for specific photos

Location UCR Deadman's Eddy Date 5/27/10

Project / Client TAI

White Sturgeon Methods - Sediments (7)

Weather conditions - change throughout session from 55°F and cloudy to increasing rain. Steady rain continues thru to end of sampling

1435 - leave site, head for Northport Boat Launch. Unload buckets & gear into truck.

1515 - Leave for Spokane

Note: Fieldsheets/logs prepared for each 10 grab samples, included descriptions, sample numbers, UTM coordinates etc.

Location UCR Deadman's Eddy Date 5/27/10

Project / Client TAI (8)

White Sturgeon Methods - Sediments

1815 - Return to Spokane, complete sample QA/QC and C of C for delivery to TAI

Container No.	Sample Time
DME-1	1217
DME-2	1235
DME-3	1305
DME-4	1315
DME-5	1325
DME-6	1335
DME-7	1350
DME-8	1400
DME-9	1415
DME-10	1421

* C of C No. DME-COC-001

1850 Finish demob for day

[signature]
Jeffrey E. Leppo

ATTACHMENT D
Photographic Record
Provided on Compact Disc (CD)

URS

ATTACHMENT E
Archaeological Monitoring Results

URS

MEMORANDUM

TO: Marko Adzic, Teck American Incorporated

FROM: Sarah McDaniel, RPA

DATE: June 23, 2010

FILE: 36310054.00002

SUBJECT: Archaeological Monitoring Results,
On-Shore Sediment Sampling - Deadman's Eddy, Upper Columbia River, Stevens County, Washington
Methods Development for the White Sturgeon Sediment Toxicity Study

Introduction

URS Corporation (URS) conducted field services for Teck American Incorporated (Teck) along the Upper Columbia River (UCR) at Deadman's Eddy (DME). Specifically, on-shore sediment samples were collected from the gravel bar at Deadman's Eddy located in Stevens County, Washington, on May 27, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOPs) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010 and as approved by the U.S. Environmental Protection Agency (EPA). This cultural resource monitoring report has been prepared in support of the above-mentioned work and is consistent with the protocols outlined in Appendix C Cultural Resources Coordination Plan of the aforementioned approved QAPP.

As per the QAPP, archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist meeting the Secretary of Interior's Professional Qualification Standards (as outlined in 36 CFR Part 61). This memorandum documents results of the monitoring that occurred on May 27, 2010, by URS archaeologist Sarah McDaniel, Registered Professional Archeologist (RPA) in conjunction with the on-shore sediment sampling. No cultural resources were identified or disturbed as a result of this investigation.

Location

The DME project site is located along the Columbia River (River Mile 738.5), about two miles northeast of the town of Northport, Washington, in Stevens County. The sampling area is found in Section 26, Township 39 ½ North, Range 40 East, on the USGS 7.5' Series Boundary, Washington quadrangle (Figure 1). The DME location is identified within the QAPP (April 2010) and delineated within four coordinates under the Universal Transverse Mercator (UTM) system using North American Datum for 1983 (NAD83, Zone 11). The four UTM corner coordinates are identified as:

- Northeast Corner –Easting (447158), Northing (5421097)
- Southeast Corner –Easting (447077), Northing (5421068)
- Southwest Corner –Easting (447023), Northing (5421127)
- Northwest Corner –Easting (447026), Northing (5421144)

URS Corporation
920 North Argonne Road, Suite 300
Spokane, WA 99212-2722
Tel: 509.928.4413
Fax: 509.928.4415

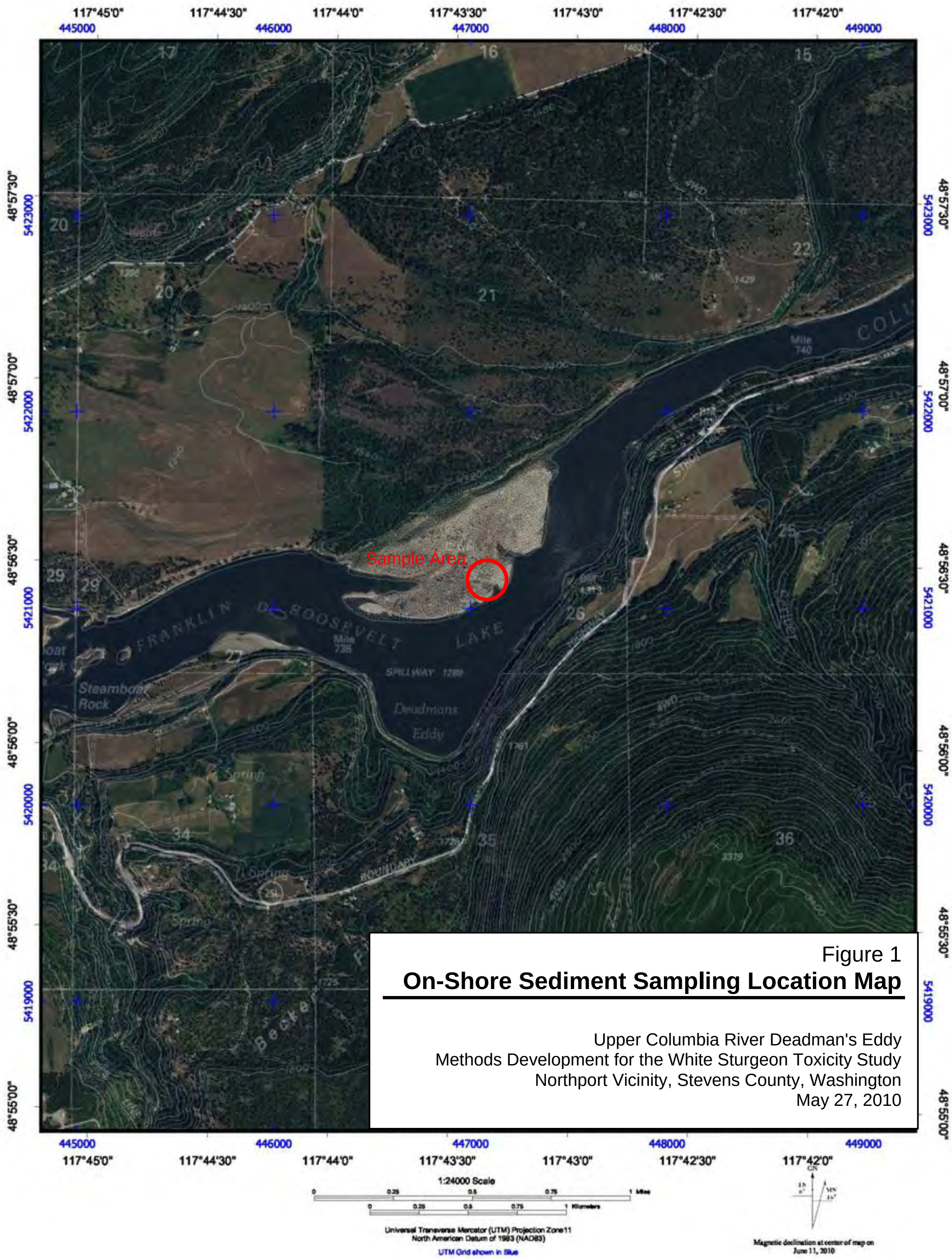


Figure 1
On-Shore Sediment Sampling Location Map

Upper Columbia River Deadman's Eddy
Methods Development for the White Sturgeon Toxicity Study
Northport Vicinity, Stevens County, Washington
May 27, 2010

Background Research

Prior to the fieldwork, a records search was conducted by URS to identify any previously recorded archaeological sites, historic resources, or cultural surveys within one mile radius of the project Area. The May 2010 search was conducted via the online Washington State Department of Archaeology and Historic Preservation (DAHP) Washington Information System for Architectural and Archaeological Records Data (WISAARD) database. This restricted-access, searchable GIS database depicts locations of the following: 1) previously-recorded archaeological sites, 2) cultural resource surveys conducted after 1995, 3) historic register properties, and 4) cemeteries. Regional ethnographic, historic, and archaeological references were also consulted as part of this pre-field review.

General sensitivity of the sampling area is high based on the quantity of archaeological sites that can be found along this stretch of the UCR. Results of the records search indicate that there are two archaeological sites (45ST89 and 45ST90) located over 0.25 mile to the east and to the west, respectively, of the DME sampling area; but none are known to be present within the sampling area. Previously-recorded site types include pre-contact period resources, such as shell, bone, caches, sweatlodges, hearths, and stone tool materials, as well as historic period resources related to mining and homesteading. These sites appear to be found at slightly higher elevations than the project site, which is seasonally inundated by the Columbia River, but are often found eroding into the Columbia River.

Ethnographic literature (e.g., Bouchard and Kennedy 1979, 1984; Kennedy and Bouchard 1998; Pearkes 2002) does not indicate specific place-names for the project site, but describes a number of ethnogeographic locales in this general area. For example, a small Lakes village was reportedly located about three miles upriver from Northport, which would put it in the vicinity of the project site. The project site may also be at or near the locale of an "aboriginal campsite," described as being located "northeast from the gravel bar immediately upriver from Nigger Creek and across the river from Deadmans Eddy", which was occupied until around 1910 (Bouchard and Kennedy 1979:320; Chance 1967:77). Clair Hunt's Homesteaders Map of the North Half of the Colville Indian Reservation (http://content.wsulibs.wsu.edu/u?/maps,720), dated 1900, depicts the locations of several Indian allotments along the west side of the Columbia River in the area of Nigger Creek and the project site. In sum, ethnographic and historic references indicate the project site, which falls within ceded North Half of the Colville Indian Reservation, has been used by ancestral to contemporary Lakes and Colville peoples and could contain evidence of this prior use, especially as related to fishing or habitation activities. Historic use of the area could also be found as related to mining and homesteading activities.

Field Methods

One the day of the site visit, project observers, including boat operators and environmental representatives, were advised of the potential for archaeological resources and to avoid contact with any such resources should they be encountered. As some of the individuals are local residents and familiar with the history of this area, URS asked if any were aware of the presence of potential cultural resources or the origin of the name "Deadman's Eddy." Eric Weatherman, of Columbia Navigation Inc., believed the name has something to do with an historic train derailment, but was uncertain as to the accuracy of this information (personal communication, May 27, 2010). Technical Advisor for Citizens for a Clean Columbia Joe Wichmann, Ph.D., stated that the gravel bar on which the project sampling occurred had been altered by historic mining activities (personal communication, May 27, 2010). None of the individuals questioned knew of any specific cultural resource concerns within the project site.

The DME location is on the west side of the Columbia River and is a depositional sediment bar composed primarily of sands, gravels, cobbles and boulders. Within this area, 10 grab sample points were collected at 50-foot intervals. At each sample point, a 5-gallon bucket was filled by a URS geologist using a shovel, within an area previously-approved for sampling in the QAPP. Coordinates of the samples were plotted under the UTM system using North American Datum for 1983 (NAD83) (Table 1), as shown in Map 1, Sediment Sample Locations.

Individual grab sample points were visually inspected for any evidence of cultural resources prior to any sampling. Sediment removed for sampling was also visually inspected by the archaeologist during ground disturbance. As outlined within the approved QAPP, the hand excavation removed the upper 4 inches (10 centimeters) of sediment to access the underlying sample area, and grab samples were generally collected between 4 and 12 inches (30 centimeters) below the ground surface. The presence of buried cobbles and boulders was observed at several locations, with the sand sediments collected above these materials. Depth of the shovel sampling did not exceed 12 inches.

Table 1. Grab Sample Locations Coordinates.

Northing (UTM-NAD83)	Easting (UTM-NAD83)	Elevation (m)
5421094	447142	392
5421099	447128	392
5421093	447108	397
5421106	447097	399
5921099	447091	398
5421109	447082	399
5421108	447067	398
5421130	447056	397
5421131	447040	399
5421133	447027	398

Field Observations

The project site is used as a local “party spot” by adolescents, with campfire rings, rubber tires and other modern debris observed across the gravel bar. Two metal artifacts, including a tin cup and unidentifiable metal fragment, were observed near the project site but were not impacted by the sediment removal. The gravel bar that comprises the project site is largely characterized by rounded river cobbles that appear to have been re-deposited as a result of natural riverine forces, and possibly the reported historic mining activities.

The project site is subject to frequent inundation, as evidenced by the overall absence of vegetation and soil development (Photo 1). Sediment consists of black and tan sand deposits (Photo 2) along with river cobbles. No significant cultural resources were observed during the pre-investigation surface examination, and none were encountered during the limited subsurface sediment sampling activities. Additional sediment sampling at this same QAPP locale, using the same techniques of shovel excavation and extending to the same limited depths of about 12 inches, is unlikely to affect any significant, buried resources given the frequent inundation of this landform and the absence of surficial artifacts.

Photo 1. Overview of the Deadman's Eddy sample area, facing south. Lathe at bottom left of photo demarks the northeast corner of the DME sediment sampling area.

Photo 2. Deadman's Eddy sediment sampling methods, facing east.

References

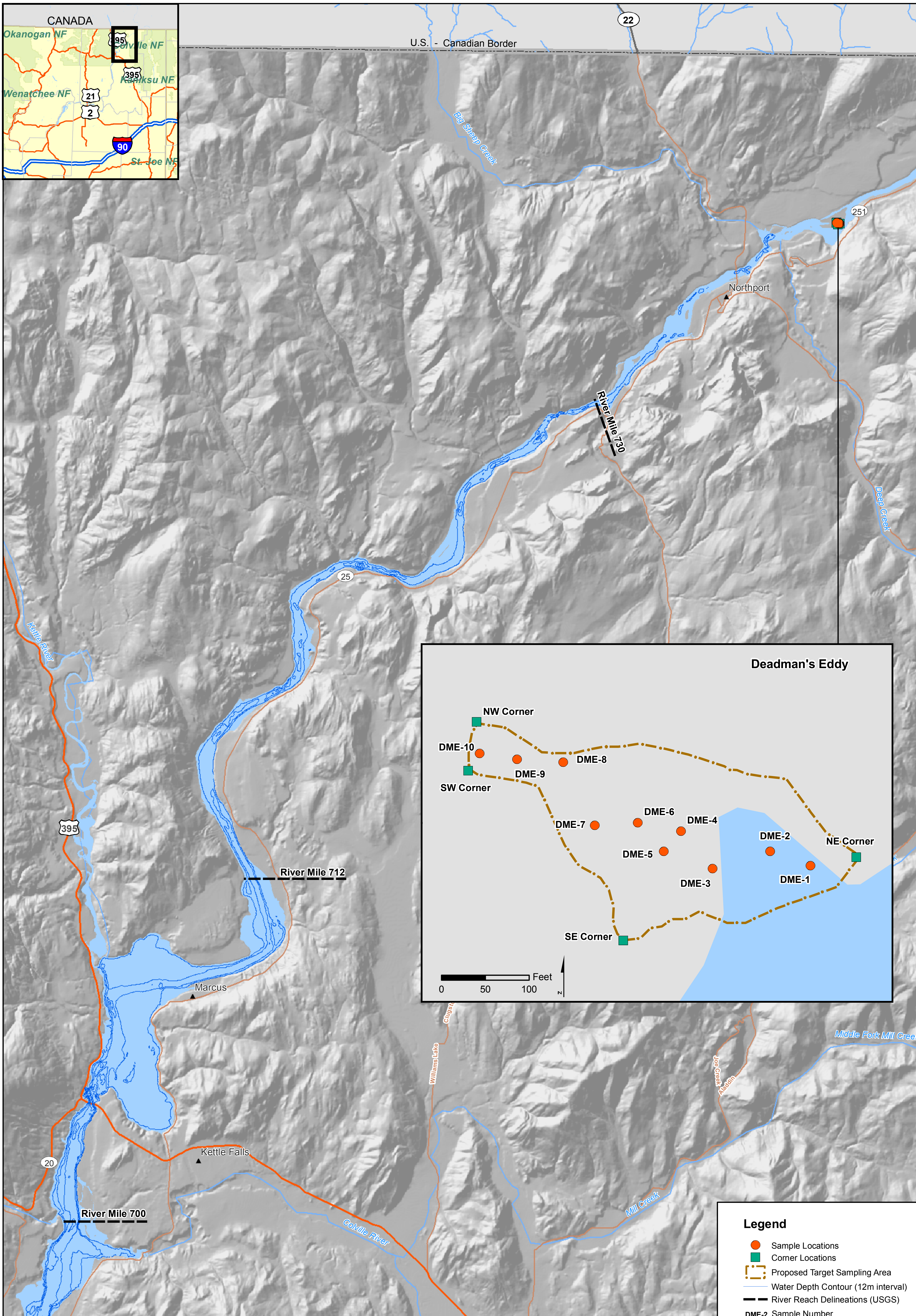
Bouchard, Randy and Dorothy I.D. Kennedy
1979 Ethnogeography of the Franklin D. Roosevelt Lake Area. British Columbia Indian Language Project. Prepared for the Bureau of Reclamation, U.S. Department of the Interior.

1984 Indian Land Use and Occupancy in the Franklin D. Roosevelt Lake Area of Washington State. British Columbia Language Project. Prepared for the Colville Confederated Tribes and the United States Bureau of Reclamation.

Chance, David H.
1967 *Archaeological Survey of Coulee Dam National Recreation Area, Part 2: Spring Draw Down of 1967*. Report of Investigations No. 42. Laboratory of Anthropology, Washington State University, Pullman.

Kennedy, Dorothy I.D., and Randall T. Bouchard
1998 Northern Okanagan, Lakes, and Colville. In *Handbook of North American Indians,* Vol. 12, Plateau, pp. 238-252. William C. Sturtevant, series editor. Smithsonian Institution, Washington, D.C.

Pearkes, Eileen Delehanty
2002 *The Geography of Memory: Recovering Stories of a Landscape's First People*. Kutenai House Press, Wilaw, British Columbia, Canada.



Sediment Sample Locations	Km 0 2.5 5; Miles 0 1.5 3; N	**URS Corporation** **Source:** GIS base layer Information provided by Parametrix Inc.	Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)** **Upper Columbia River, WA**

ATTACHMENT F
Chain-of-Custody

Revenue Canada
Customs and Excise

CANADA CUSTOMS INVOICE

Page 1 of 1

1. Vendor (Name and Address)
TECK AMERICAN INC.
501 N RIVERPOINT BLVD
SUITE 300
SPOKANE, WA 99202

2. Date of Direct Shipment to Canada
MAY 27 , 2010

3. Other References (Include Purchaser's Order No.)
SAMPLES FOR TESTING PURPOSES

4. Consignee (Name and Address)
TECK METALS LTD.
25 ALDRIDGE AVE.
TRAIL, B.C. V1R 4L8

5. Purchaser's Name and Address (if other than Consignee)

6. Country of Transhipment

7. Country of Origin of Goods
USA

IF SHIPMENT INCLUDES GOODS OF DIFFERENT ORIGINS ENTER ORIGINS AGAINST ITEMS IN 12

8. Transportation: Give Mode and Place of Direct Shipment Canada
PRIVATE VEHICLE EX SPOKANE, WA
TECK REPRESENTATIVE: MARKO ADZIC

9. Conditions of Sale and Terms of Payment (i.e. Sale, Consignment Shipment, Leased Goods, etc.)
NOT SOLD. SAMPLES FOR TESTING PURPOSES

10. Currency of Settlement
US DOLLARS

11. No. of Pkgs	12. Specification of Commodities (Kind of Packages, Marks and Numbers, General Description and Characters (i.e. Grade, Quality)	13. Quantity (State Unit)	Selling Price: 14. Unit Price	Selling Price: 15. Total
10	5 GALLON BUCKETS CONTAINING GRANULATED SLAG/SILICA SEDIMENT SAMPLES 79YT PARS 007471 / TECKCOMINCO METALS **H.S. 2621.90.00.00**	120 KGS.		$10.00 NO COMMERCIAL VALUE. NOT SOLD. VALUE FOR CUSTOMS PURPOSES ONLY.

Canada Border Services Agency / Agence des services frontaliers du Canada RELEASED / Dédouané JUN 01 2010 Okanagan District Osoyoos

18. If any of fields 1 to 17 are included on the attached commercial invoice, check this box [ ]
Commercial Invoice No. ______

16. Total Weight — Net: — Gross: 120 KGS.

17. Invoice Total — $10.00

19. Exporter's Name and Address (if other than Vendor)

20. Originator (Name and Address)
TECK METALS LTD.
TRAIL, B.C. V1R 4L8

21. Departmental Ruling (if applicable)

22. If fields 23 to 25 are not applicable, check this box [x]

23. If included in field 17 indicate amount:
(i) Transportation charges, expenses and insurance from the place of direct shipment to Canada
(ii) Costs for construction, erection and assembly incurred after importation into Canada
(iii) Export packing

24. If not included in field 17 indicate amount:
(i) Transportation charges, expenses and insurance to the place of direct shipment to Canada
(ii) Amounts for commissions other than buying commissions
(iii) Export packing

25. Check (if applicable):
(i) Royalty payments or subsequent proceeds are paid or payable by the purchaser [ ]
(ii) The purchaser has supplied goods or services for use in the production of these goods [ ]

TECK COMINCO METALS LTD. TRAIL, B.C. CANADA V1R 4L8

teckcominco

WAREHOUSE SHIPPING INSTRUCTIONS FOR OUTBOUND SHIPMENTS

(THIS FORM MUST ACCOMPANY ALL OUTGOING SHIPMENTS WHEN THE SHIPMENT IS SENT TO THE WAREHOUSE)

SHIP TO:

Company Name: U of Saskatchewan Toxicology centre Date: June 1, 2010

Street : 44 CAMPUS DRIVE

City : SASKatoon Province: SASK. Attn Markus Hecker

Postal Code: S7N 5B3 Phone No. (306) 966-5233

CONTACT TRAFFIC DEPT. FOR DOCUMENTATION FOR EXPORT SHIPMENTS.

Description of Goods Being Shipped: (Show total weight or volume or dangerous goods in each package)

10 Barrels of sediments on Pallet

CHAIN OF CUSTODY Required

Reason Material Being Shipped:

(Note: Purchasing must be advised of any goods being sent to a supplier. Contact Purchasing if you have any questions.)

Credit Return ☐ Exchange ☐ Repair & Return ☐ Sample ☐ Testing ☒ Warranty ☐

Reason: River Sediment For Testing

P.O. Number ____________ Supplier Return Authorization No. (or Invoice No.) ____________

Buyer Contacted ____________ Supplier Contact (Who Authorized Return): ____________

Shipping Instructions:

Air ☐ Courier ☐ Mail ☐ Truck ☐ Prepaid ☒ Collect ☐

Approximate Value of Shipment: No Commercial Value

Charge Code for Prepaid Shipments: 1154

IMPORTANT: DANGEROUS GOOD DECLARATION

Is this material classified under the T.D.G.R. YES ☐ NO ☒	Proper Shipping Name:				
Certain materials are classified as Dangerous goods under the Transportation of Dangerous goods Regulations (T.D.G.R.) and require special packaging, labeling and documentation. Complete the information requested here if the regulations apply to this material.	Major Component - If * N. O. S. **				
	Identification No. (UN, NA of PIN)				
If in doubt, contact Warehouse Shipper, Phone 4975	Primary Class		Sub. Class		Packing Group

Environmental Remediation — PLANT ORIGINATOR (PRINT)

Bill Duncan — ACTIVITY (PRINT)

[signature] — SIGNATURE OF PLANT ORIGINATOR

4236 — PHONE NO.

ALL OF ABOVE PORTION OF FORM MUST BE COMPLETED BY ORIGINATOR

Warehouse Remarks (To be completed by Warehouse Personnel)		
Date Shipped:	**Carrier:**	**Way Bill No.**
No. of Cartons:	**Total Weight:** 750 lbs	**Warehouse Shipper:**

WHITE - TRAFFIC COPY **GREEN -** SUPPLIER COPY (INCLUDE WITH OUTBOUND SHIPMENT) **CANARY -** WAREHOUSE COPY

PINK - THIS COPY TO BE RETURNED TO INITIATOR BY WAREHOUSE ONCE SHIPMENT SENT **GOLD** - ACCOUNTS PAYABLE (IF REQUIRED)

URS

Client: Teck American Incorporated 501 North Riverpoint Blvd, Ste 300 Spokane, WA 99202	**CHAIN of CUSTODY** Project: Upper Columbia River White Sturgeon Sediment Toxicity Study		Page 1 of 1 Lab Turn-around Time: Please refer to project QAPP (April 2010)
Project Manager Kris McCaig, kris.mccaig@teck.com	Telephone No. 509-459-4451	Fax No. 509-459-4400 P.O. #	DEADMAN'S EDDY - U.S.

Sample I.D.	Container Tag No	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical / Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Sample Notes and Comments	Lab ID No.
TAI-US-DME-1-HS -1	DME1	1	Sed	5/27/10	1217	✓			
TAI-US-DME-1-HS -2	DME2	1	Sed	5/27/10	1235	✓			
TAI-US-DME-1-HS -3	DME3	1	Sed	5/27/10	1305	✓			
TAI-US-DME-1-HS -4	DME4	1	Sed	5/27/10	1315	✓			
TAI-US-DME-1-HS -5	DME5	1	Sed	5/27/10	1325	✓			
TAI-US-DME-1-HS -6	DME6	1	Sed	5/27/10	1335	✓			
TAI-US-DME-1-HS -7	DME7	1	Sed	5/27/10	1350	✓			
TAI-US-DME-1-HS -8	DME8	1	Sed	5/27/10	1400	✓			
TAI-US-DME-1-HS -9	DME9	1	Sed	5/27/10	1415	✓			
TAI-US-DME-1-HS -10	DME10	1	Sed	5/27/10	1421	✓			

Custodial Record	Date	Time	Sample Receiving Notes	
Relinq. by Sampler (Sign & Print Name): Jeffrey E. Leppo	5/28/10	0900		Unique Chain of Custody No. DME-COC-001
Received by: Alexandra Vermeulen	5/28/10	0900		Laboratory Work Order No.
Relinquished by: Alexandra Vermeulen	6/01/10	10.45 am		
Received by: K.S. Paez	06/01/10	10:45		
Relinquished by:				
Received by Laboratory:				

URS

MEMORANDUM

TO: Marko Adzic, Teck American Incorporated

FROM: Sarah McDaniel, RPA

DATE: June 23, 2010

FILE: 36310054.00002

SUBJECT: Archaeological Monitoring Results,
On-Shore Sediment Sampling - Deadman's Eddy, Upper Columbia River, Stevens County, Washington
Methods Development for the White Sturgeon Sediment Toxicity Study

Introduction

URS Corporation (URS) conducted field services for Teck American Incorporated (Teck) along the Upper Columbia River (UCR) at Deadman's Eddy (DME). Specifically, on-shore sediment samples were collected from the gravel bar at Deadman's Eddy located in Stevens County, Washington, on May 27, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOPs) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010 and as approved by the U.S. Environmental Protection Agency (EPA). This cultural resource monitoring report has been prepared in support of the above-mentioned work and is consistent with the protocols outlined in Appendix C Cultural Resources Coordination Plan of the aforementioned approved QAPP.

As per the QAPP, archaeological monitoring of ground-disturbing activities was conducted by a qualified archaeologist meeting the Secretary of Interior's Professional Qualification Standards (as outlined in 36 CFR Part 61). This memorandum documents results of the monitoring that occurred on May 27, 2010, by URS archaeologist Sarah McDaniel, Registered Professional Archeologist (RPA) in conjunction with the on-shore sediment sampling. No cultural resources were identified or disturbed as a result of this investigation.

Location

The DME project site is located along the Columbia River (River Mile 738.5), about two miles northeast of the town of Northport, Washington, in Stevens County. The sampling area is found in Section 26, Township 39 ½ North, Range 40 East, on the USGS 7.5' Series Boundary, Washington quadrangle (Figure 1). The DME location is identified within the QAPP (April 2010) and delineated within four coordinates under the Universal Transverse Mercator (UTM) system using North American Datum for 1983 (NAD83, Zone 11). The four UTM corner coordinates are identified as:

- Northeast Corner –Easting (447158), Northing (5421097)
- Southeast Corner –Easting (447077), Northing (5421068)
- Southwest Corner –Easting (447023), Northing (5421127)
- Northwest Corner –Easting (447026), Northing (5421144)

URS Corporation
920 North Argonne Road, Suite 300
Spokane, WA 99212-2722
Tel: 509.928.4413
Fax: 509.928.4415

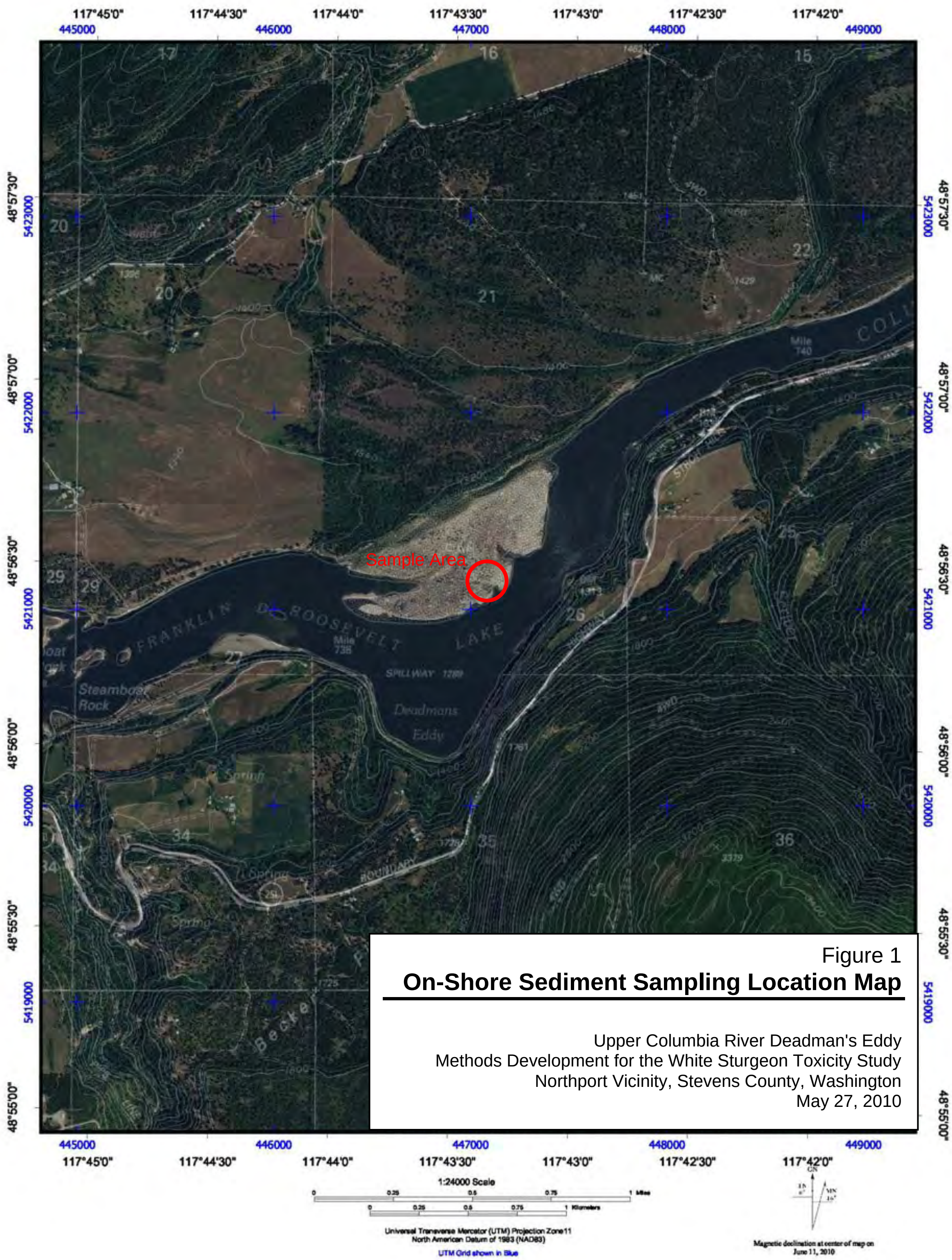


Figure 1
On-Shore Sediment Sampling Location Map

Upper Columbia River Deadman's Eddy
Methods Development for the White Sturgeon Toxicity Study
Northport Vicinity, Stevens County, Washington
May 27, 2010

Background Research

Prior to the fieldwork, a records search was conducted by URS to identify any previously recorded archaeological sites, historic resources, or cultural surveys within one mile radius of the project Area. The May 2010 search was conducted via the online Washington State Department of Archaeology and Historic Preservation (DAHP) Washington Information System for Architectural and Archaeological Records Data (WISAARD) database. This restricted-access, searchable GIS database depicts locations of the following: 1) previously-recorded archaeological sites, 2) cultural resource surveys conducted after 1995, 3) historic register properties, and 4) cemeteries. Regional ethnographic, historic, and archaeological references were also consulted as part of this pre-field review.

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Photo 1. Overview of the Deadman's Eddy sample area, facing south. Lathe at bottom left of photo demarks the northeast corner of the DME sediment sampling area.

Photo 2. Deadman's Eddy sediment sampling methods, facing east.

References

Bouchard, Randy and Dorothy I.D. Kennedy
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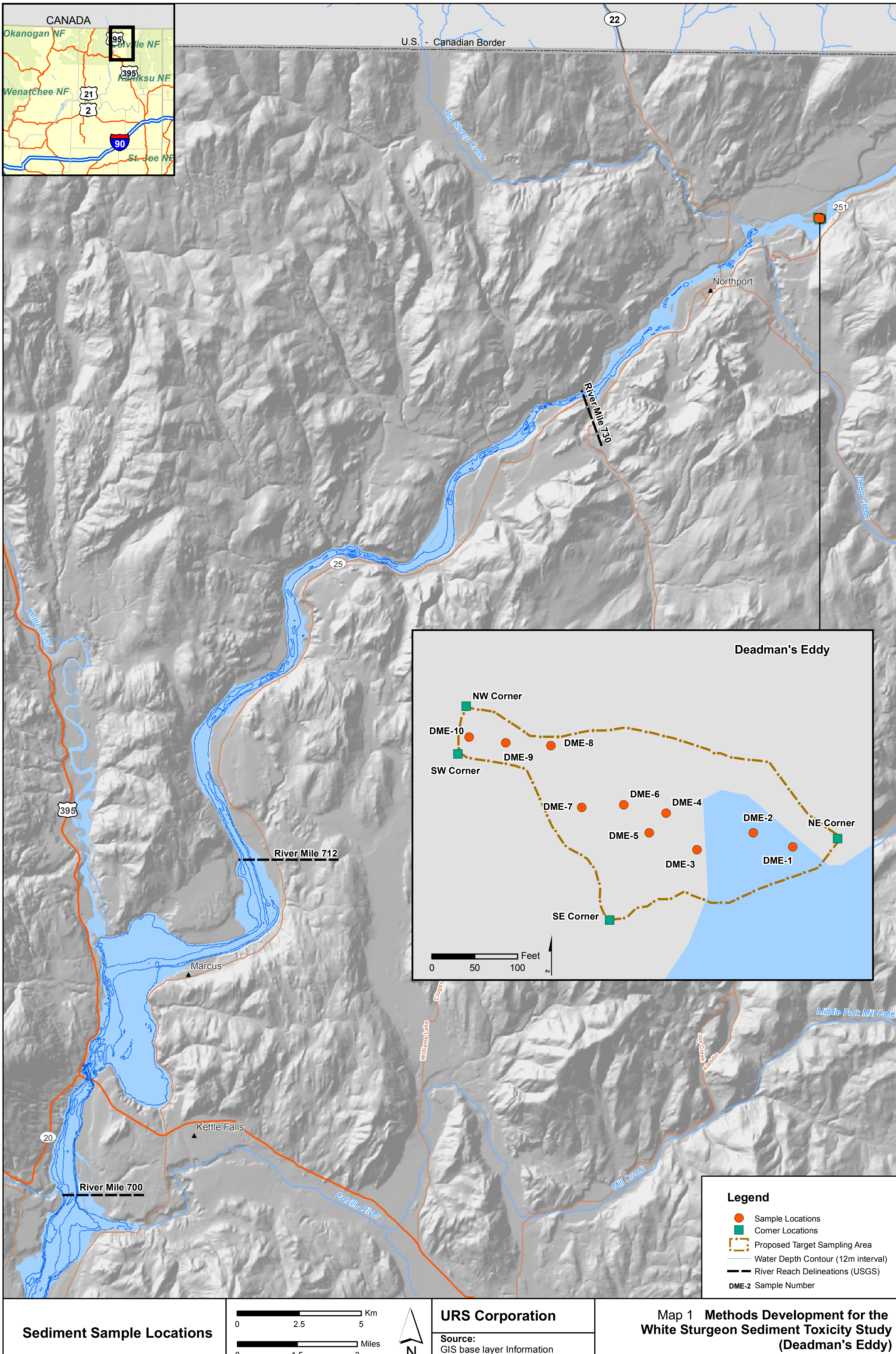


Sediment Sample Locations

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Deadman's Eddy)**

Upper Columbia River, WA

APPENDIX B

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 2 – METHOD RESULTS AND RECOMMENDATIONS (JULY 9, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 13, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Methods Results and Recommendations

Dear Mr. Adzic,

This letter is in response to a Technical Memorandum, *Sturgeon sediment toxicity testing –methods results and recommendations*, submitted to the United States Environmental Agency (EPA) via email on July 9, 2010. The Technical Memorandum summarizes the results of testing performed to evaluate and establish methodologies for the white sturgeon sediment toxicity program. It also provides information supporting the use of reference sediments collected upstream of the site. The parameters tested and reported upon in the Technical Memorandum are described in detail in the approved April 2010 *Quality Assurance Project Plan, Methods Development for the White Sturgeon Sediment Toxicity Study.*

With this letter, EPA is approving the Technical Memorandum and all of the recommendations for the design of the fluvial chambers that are described within the memorandum. Specifically, EPA approves the recommendations for the following paramaters:

1. Flow condition
2. Gravel volume and distributions
3. Porewater sampling
4. Sediment depth
6. Time to steady-state
7. Cleaning methods
8. Laboratory control sediment

Results for parameter number 5, Gradients between Pore water and Overlying Water, were not presented in the Technical Memorandum. These results should be provided to EPA, as soon as they are available, in a separate submittal.

EPA is also approving the use of reference sediments collected upstream of the site at the Genelle and Lower Arrow Lake sediment sampling stations.

A few outstanding items must be approved by EPA before the toxicity tests can begin. Results for Parameter 5 (see above) must be submitted, along with any resulting recommendations for adjustments in flow. A technical memorandum needs to be submitted for approval that describes the final study design and any adjustments resulting from the collection of fewer samples than planned. Finally, day 8 results from ongoing studies using DGT probes, peepers, and modified pipettes must be used to support a final decision on which devices will be used to collect samples during the full study.

EPA looks forward to resolving these outstanding issues quickly so that the laboratory is ready to begin the tests when the fish start to hatch.

Sincerely,

Helen H Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

E X T E R N A L   M E M O R A N D U M

TO:	Helen Bottcher, US EPA Region 10
FROM:	Markus Hecker, Ph.D., ENTRIX, Inc.
DATE:	July 9, 2010
PROJECT:	UCR Sturgeon Sediment Toxicity Testing
SUBJECT:	Sturgeon sediment toxicity testing - methods results and recommendations

The overall goal of the herein described and discussed studies was to inform and establish appropriate and relevant methodologies for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. Specifically, the objectives of this work were to optimize the performance of flow-through fluvial simulation systems and associated exposure chambers, and confirm reference area sediments (including laboratory control sediments). It has to be noted that the information and observations recorded during this work are not be used to inform risk-based management decisions, and they solely are aimed to inform and refine technical elements of future sediment toxicity tests using white sturgeon early life-stages. Tasks associated with this work were divided into two general categories: 1) Fluvial exposure system evaluation, and 2) Reference sediment confirmation.

This summary memo provides recommendations for the design of the fluvial chambers for the definitive sturgeon sediment toxicity study. The following sections summarize the work done during methods development to arrive at this optimized chamber design and verify that reference and control sediments are acceptable for use in the study; details and all data are provided in Appendix A.

Optimized design for exposure chambers

While test systems comparable to those to be utilized as part of this study have been previously employed at the U of S Aquatic Exposure Laboratory to evaluate surface water chronic exposures to fish including white sturgeon, they have not been used or specifically tested for the purpose of conducting flow-through sediment toxicity tests. To ensure that future sediment toxicity tests using the test species (white sturgeon) are completed successfully, it is important that anticipated system design elements for the fluvial flow through system be tested and evaluated prior to the start of future sediment toxicity testing. Specifically, parameters associated with the design (e.g., depth of sediment, fluvial chamber dimensions and layout, location of sampling devices, artificial control substrate) and operational conditions (e.g., flow rates, porewater sampling depth and volumes, gravel distribution, time to steady-state, cleaning techniques) were to be tested and established to inform the definite study design of the summer 2010 white sturgeon sediment toxicity studies (Table 1). Detailed method descriptions are provided in each of the individual reports provided in Appendix A. A brief summary of the experiments conducted and their objectives is provided here.

Order 1: Flow conditions

Objective: Evaluate and establish homogenous water flow conditions to ensure uniform distribution of influx and within the posterior chamber, and to minimize "dead spaces" at inflow and outflow.

Results and Recommendations: Stable and homogenous flows were achieved at flow rates greater than 17 L/min. It is therefore recommended to initiate work to be performed under the May 2010 *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon* (*Acipenser transmontanus*) with a flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding, and are large enough to easily withstand these flows. The here proposed flow-rates will result in ground velocities that are less than those occurring in the UCR, and do not impact sediments layered into the chambers (e.g. causing re-suspension).

Order 2: Gravel (stones) volume and distributions

Objective: Indentify the effect of different volumes and distribution of gravel on hydrological conditions in fluvial chambers.

Results and Recommendations: Addition of stones to the fluvial exposure chambers had no impact on flow conditions and little to no impact on water quality. In our experience early life-stages of white sturgeon appear less stressed when provided a refuge under experimental conditions. A density of 4 stones per 100 cm^2 is recommended as the optimal loading density.

Order 3: Porewater sampling (suction device)

Objective: Establish methods for porewater sampling by means of suction (airstones).

Results & Recommendations: To insure that during a sampling event there will be equal drawing of porewater throughout the sediment layer, a minimum of 12 ports should be sampled. A volume of 8-10 mL will be drawn from each port, resulting in a total sample volume of approximately 100 mL, which will be sufficient for the water quality and COPC analyses proposed in the white sturgeon sediment toxicity studies QAPP. Also, given the variation observed at the ports located closest to the in- and outflow of the test chambers, it is proposed to not sample at ports within the first and last 4 inches of the fluvial test systems. This study did not permit the assessment of the influence of the removed sediment volumes on re-equilibration of porewater; however, it is assumed that the proposed withdrawal volume of 100 mL per chamber will not significantly deplete the porewater. This volume is significantly less than the maximum amount that could be removed without detection of dye from overlying water, namely 110 and 80 mL per port using a design of 8 or 16 ports, respectively and two inches of sediment.

Order 4: Sediment Depth

Objective: Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection.

Results and Recommendations: It is recommended to utilize a sampling depth of 1.5 inches with a total sediment depth of 2 inches, due to the enhanced sampling properties as defined by the large retrievable volumes without ingestion of overlying water when sampling porewater from this depth. Because total depth of sediments did not significantly affect porewater sampling, and considering volume restrictions for certain sediments, it is proposed to use a depth of 2 inches in the definite exposure studies. It also is important to note that volumes of porewater that could be sampled without incorporation of overlying water increased significantly with sediment depths greater than 1 inch, but this was dependent on the depth of airstone installment rather than overall sediment depth

Order 5: Gradients between pore- and overlying water

Objective: Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity) using dyed sediments – monitor basic water quality parameters at different sediment depths, and at the sediment-water interface.

Results and Recommendations: To be completed and submitted in a separate memo.

Order 6: Time to steady-state

Objective: The objective is to identify the minimum period of time necessary for the exposure chamber to attain a steady-state based on basic water quality parameters. The objective of this work is not to attain steady-state conditions for chemicals of potential concern (COPCs); but rather, to ensure that non-COPCs do not adversely affect test results (i.e., introduce uncertainty) when organisms are introduced.

Results and Recommendations: A minimum of 48 hours is proposed for allowing sediments to reach steady-state within the fluvial chambers. Temperature, conductivity, dissolved oxygen, pH, colour, and total dissolved solids all reached steady state (<10 percent variation between measurements) within 48 hours. Ammonia and nitrate did not reach steady-state, but this is likely due to the natural variability of these measurements and therefore does not influence the recommended period for equilibration. DOC did not reach steady-state during the 96 hr test period, but the experiment is ongoing to determine if DOC measurements with variability below ±10 percent between measurement events can be achieved.

Order 7: Optimum cleaning techniques

Objective: Identify optimum cleaning techniques avoiding utilization of suction devices, and installment of large particle filters – with and without addition of diet (bloodworms, oligochaetes; semi-moist diet, other).

Results and Recommendations: A modified pipette is proposed as the primary cleaning method for sediment within the exposure chamber. Cleaning by the use of a modified pipette allowed the technician to select and remove unwanted debris from the exposure chamber with minimal disturbance to the sediment. In addition, the risk of injury to fish will be minimized. Siphoning may prove effective when cleaning reservoirs or screens, but only when direct contact with fish and sediment is not involved. The aid of the spatula may prove useful in instances were biofilm is strongly adhere to surfaces, but it is proposed that the spatula be used only as a backup after cleaning with the modified pipette.

Order 8: Artificial laboratory control sediment

Objective: Selection of a laboratory control sediment that has physical characteristics appropriate for ELS of sturgeon and is comparable to sediments used historically in fish early life stage tests. The purpose of such a sediment is to benchmark this study with other fish early life stage studies reported in the literature to ensure comparability of results.

Results and Recommendations: The Hagen Geosystem Black Fine Gravel (ART #12648) is a suitable laboratory reference control sediment. This sediment is within the required 0.5 to 2 mm grain size with an average grain size of 1.11 mm and a lowest and highest grain size of 0.85 mm and 1.68 mm, respectively. This sediment is predominantly dark in coloration and very similar in appearance to some of the riverine sediments that have been collected. This sediment did not change water quality parameters more than 10% compared to the average water quality parameters measured in test chambers with reference sediments. Analysis by CAS shows this sediment to be free of contamination by all chemicals/metals analyzed.

Deviations to Methods QAPP

During the course of the methods development work, the following deviations from the approach specified in the QAPP or in the subsequent Change Orders occurred (Table 2). None of these deviations, however, were such that they affected addressing the study objectives as set forth in Section A3.1 of the Sturgeon Method Development QAPP. A more detailed description of the different deviations that occurred for some of the experiments are described in the individual reports attached to this memo (Appendix A).

Reference sediment confirmation

Off site sampling locations were selected at putative reference sites (Map 1 and Appendix B). These included re-sampling areas previously used as reference locations. The objective of this task was to evaluate and confirm off site reference area sediments upstream of the Trail facility with sediment characteristics (grain size) similar to that of areas where white sturgeon spawn.

Ten competent grab samples (five gallons each) were obtained from both the Genelle and Lower Arrow Lake locations; for a total of 20 grab samples. The river bottom composition of the Birchbank Eddy was primarily composed of cobble and boulder-sized material. Three attempts were made to collect sediments at this location, but the presence of a course substrate precluded the recovery of a suitable fine to coarse sand matrix so no sample was collected.

Both reference sediments that were retrieved resembled a gravelly sand substrate, which is in accordance with both substrate requirements for successful sturgeon culture and expected sediment composition in the upper reach of the UCR to be tested in the definite sediment toxicity studies with white sturgeon early life-stages. Analysis of the two off-site reference sediments showed all measured metals and organic chemicals are significantly below the screening ecological values (SEVs; from the Screening Level Ecological Risk Assessment) (see Appendix A, Summary Data Report #8 for data). Therefore, based on both the physical (grain size) and chemical analyses, these sediments are considered valid for use as reference sediments in the definitive sturgeon test.

Table 1. Parameters, Methods, Measurements and Recommendations for the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity.

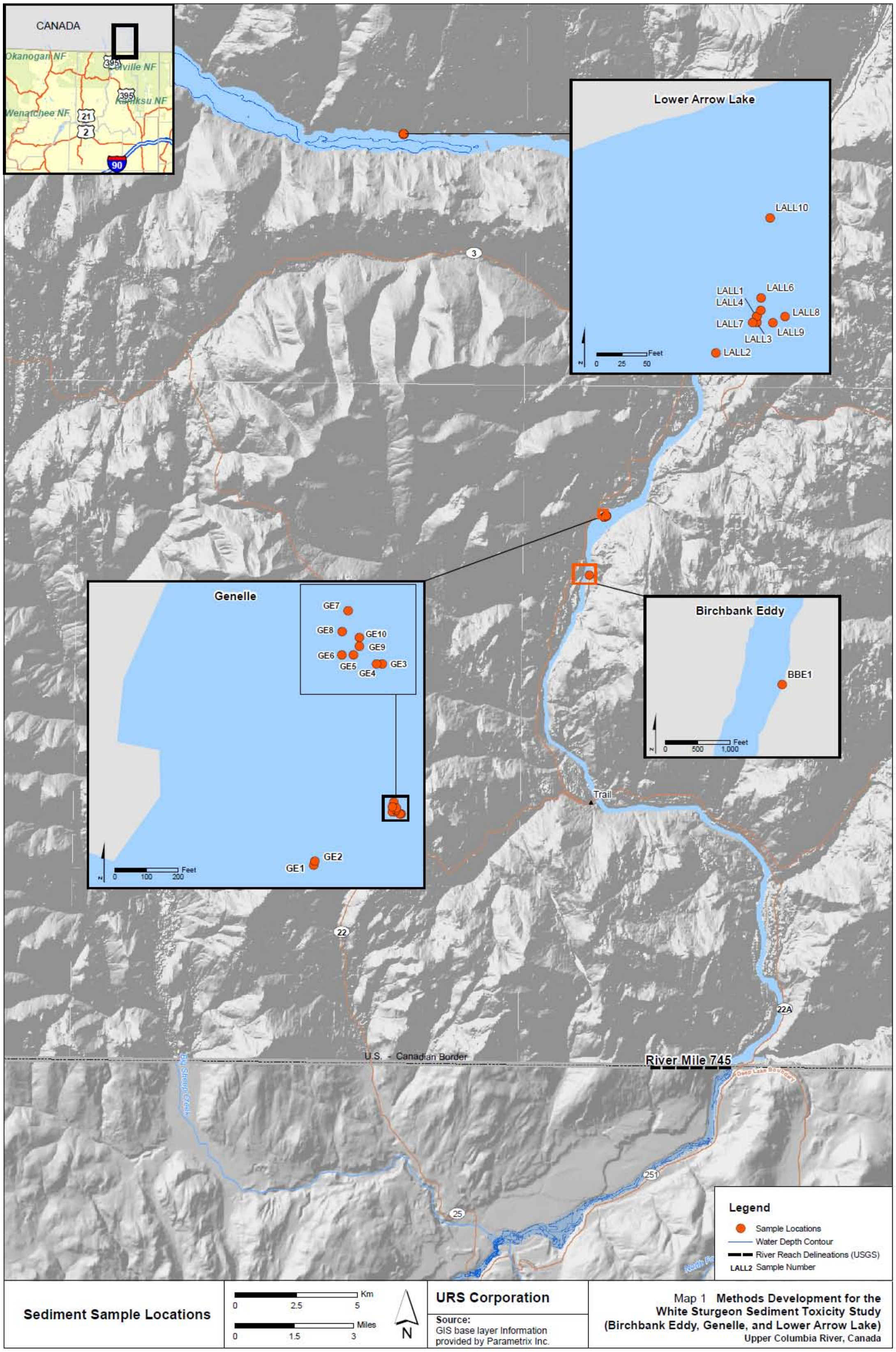
Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm^2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table 1. (cont.)

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	To be done.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648) is sandy, with all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle Eddy and Lower Arrow Lake are gravelly sand, with all analytes below screening ecological values (SEVs). Acceptable for use.

Table 2. Deviations from the procedures described in the 2010 Methods Development for White Sturgeon Sediment Toxicity Study QAPP.

Order	Parameter	Test conditions	Deviation
1	Flow condition	- Water samples taken every 4 inches throughout the chamber for dye quantification; 9 x 9 = 81 samples	- 9 positions throughout water column and three locations (inflow, middle, outflow) were analyzed; 9x3 = 27 samples.
2	Gravel volume and distribution	- Sediments layered 2, 3 and 4” - Stone densities of 0, 3, 7, 10 and 17 per 100cm2 tested	- 4” deemed unnecessary to meet the study objectives ; only 2 and 3” tested; - >7 stones per $100cm^2$ not tested; too crowded.
3	Porewater sampling	- Porewater sampling ports will be placed at depths of 0.5 and 1” below the sediment surface for sampling	- 0.5” not tested; too little sediment on top, airstone would be exposed; tested 1, 2, 3, 4 “ in static tests, and 1, 1.5” in flow through
4	Sediment depth	- Sediment depth at 2” with trials of 3 and 4” - Porewater sampling at 0.5 and 1”	-4” deemed unnecessary to meet the study objectives ,only 2 and 3” tested; - 0.5” not tested; too little sediment on top, airstone would be exposed; tested 1, 1.5 and 2”.
5	Gradients	- Use of dyed sediment - Performed with and without gravel on top - Parameters to be evaluated included dye concentrations, Dissolve Oxygen Concentration, conductivity and pH - High and low velocities to be tested according to flows found in the UCR at DE and MF, respectively.	- Dye not used because dye would not readily seep into sediment; - Only performed with gravel as it was determined that ~4 stones per $100cm^2$ will be definite study design; - Dye not used for reasons mentioned above; Dissolve Organic Carbon measure instead of oxygen; - UCR velocities in river too great for WS larvae, tested 17L/min and 25L/min.
6	Time to steady-state	- Table 1 in Amendment #2 indicates that peeper samples will be analyzed for DOC and pH	- Impossible to measure pH and DOC in small volumes recovered from peepers. Included 20 additional min peepers into both water only exposures to obtain sufficient volumes for DOC analyses at two time points (4 and 8 days post initiation of experiment).
7	Cleaning methods	- Avoid use of suction devices and use only spatula to scrap surfaces.	- Spatula did not work; - Siphon method sucked up too much sediment; -Turkey baster worked best; Therefore, proceeded with 5 day measurements - 1 day measurements were done with spatula and siphon methods; video recorded to show problems.
8	Laboratory control sediment	- Vendors will provide certificate of analysis for contaminants.	- Change order form issued to send to CAS for analysis.


CANADA
Okanogan NF
Wenatchee NF
Lower Arrow Lake
LALL10
LALL1
LALL4
LALL6
LALL7
LALL8
LALL3
LALL9
LALL2
Feet
0 25 50
Genelle
GE7
GE8
GE10
GE9
GE6
GE5
GE4
GE3
GE2
GE1
Feet
0 100 200
Birchbank Eddy
BBE1
Feet
0 500 1,000
Trail
U.S. - Canadian Border
River Mile 745
Legend
Sample Locations
Water Depth Contour
River Reach Delineations (USGS)
LALL2 Sample Number
Sediment Sample Locations
Km
0 2.5 5
Miles
0 1.5 3
N
URS Corporation
Source:
GIS base layer information
provided by Parametrix Inc.
Map 1 Methods Development for the
White Sturgeon Sediment Toxicity Study
(Birchbank Eddy, Genelle, and Lower Arrow Lake)
Upper Columbia River, Canada

APPENDIX

Sturgeon Test Methods

Appendix A   Data summary reports for:

- Flow condition
- Gravel volume and distribution
- Sediment depth and porewater sampling (airstones)
- Time to steady-state
- Cleaning methods
- Control and reference sediments

Appendix B   Field reports for collection of reference sediments

Appendix A Data summary reports for:

- Flow condition
- Gravel volume and distribution
- Sediment depth and porewater sampling (airstones)
- Gradients between porewater and overlying water
- Time to steady-state
- Cleaning methods
- Control and reference sediments

Summary Data Report

Experiment #: 1 **Date:** 5/20/ - 6/27/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Optimum Flow Rate in Fluvial Test Chamber.

Goal:
Evaluate and establish homogenous water flow conditions to ensure uniform distribution of inflow and flow within the posterior chamber, and to minimize "dead spaces" at inflow and outflow of test chamber.

Experimental Design:
A fluorescent dye (Fluorescein) was used to measure water flow; such dyes are cost-effective and easily and accurately measured with a fluorometer and observed with an ultraviolet (UV) lamp. Flow-rates ranging from 5 to 25 L/min were tested in duplicate. After the dye was introduced into the test chamber ($t = 0$), it was made visible by UV lighting, and dispersal of dye and associated water flows were recorded by means of a digital video camera across the entire chamber. Additionally, at flow rates that appeared acceptable as gauged against the goal of this experiment (i.e., ≥17 L/min), water samples were taken at $t =$ 10 sec (intake), $t = 20$ sec (middle) and $t = 30$ sec (outflow) at 3 locations equally distributed over the cross-section of the chamber. This was repeated for cross-sections close to the inflow, centre and outflow of the test chamber, resulting in a total of $3 \times 9 = 27$ water samples. The first and last sampled cross-sections were located at the inflow and outflow screens of the sediment exposure chamber, respectively, to identify potential dead spaces (see Figure 1). Samples obtained during the second experiment (flow-rates ≥17 L/min) were analyzed for dye concentrations using a microtiter plate fluorescent reader (Polastar Optima, BMG Labtech, Offenburg, Germany), as described in UCR-SOP#13, and dye concentrations were mapped throughout the chamber. Sampling was conducted using 10 mL pipettes modified such that samples could be taken at different depths throughout the chambers. Dye concentration experiments during which water samples for fluorometer quantification were collected were run either in two (17 and 25 L/min) ot three (20 L/min) replicates.

Data Presentation:
Descriptive statistics (mean ± SD) of relative dye intensities. Fluorescence measurements are expressed relative to the maximum fluorescence intensity (FLU) measured during each experiment (FLU/maximum FLU). Assessment and evaluation of water flow conditions within the exposure chamber was also based on visual observations and records (e.g., video).

Results:
The dye experiment revealed a significant impact of flow rate on the uniformity of flow throughout the test chamber (Table 1). Flow rates less than 17 L/min caused uneven flows that were biased towards one side of the test chamber (Figure 2 A&B). Flow rates equal to or greater than 17 L/min resulted in even flows across the chamber both horizontally and vertically (Figure 2 C&D). When measuring dye concentrations using the fluorometer,

there was still some remaining variation at a flow rate of 17 L/min (Figure 3A). At flow rates greater 17 L/min there were only minor differences in fluorescent dye concentrations across sampled cross-sections regardless of the position in the chamber (Figure 3 B&C).

Table 1: *Assessment of flow properties based on video-dye experiment.*

Flow Rate	Comment
5 L/min	Uneven flow, too much variability
8 L/min	Uneven flow, too much variability
13 L/min	Difficulties in obtaining acceptable flow conditions
17 L/min	Acceptable flow conditions
20 L/min	Acceptable flow conditions
25 L/min	Acceptable flow conditions

Conclusions:

Stable and homogenous flows were achieved at flow rates greater than 17 L/min. It is therefore recommended to initiate work to be performed under the May 2010 Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (*Acipenser transmontanus*) with a flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding, and are large enough to easily withstand these flows. The here proposed flow-rates will result in ground velocities that are less than those occurring in the UCR, and do not impact sediments layered into the chambers (e.g. causing re-suspension).

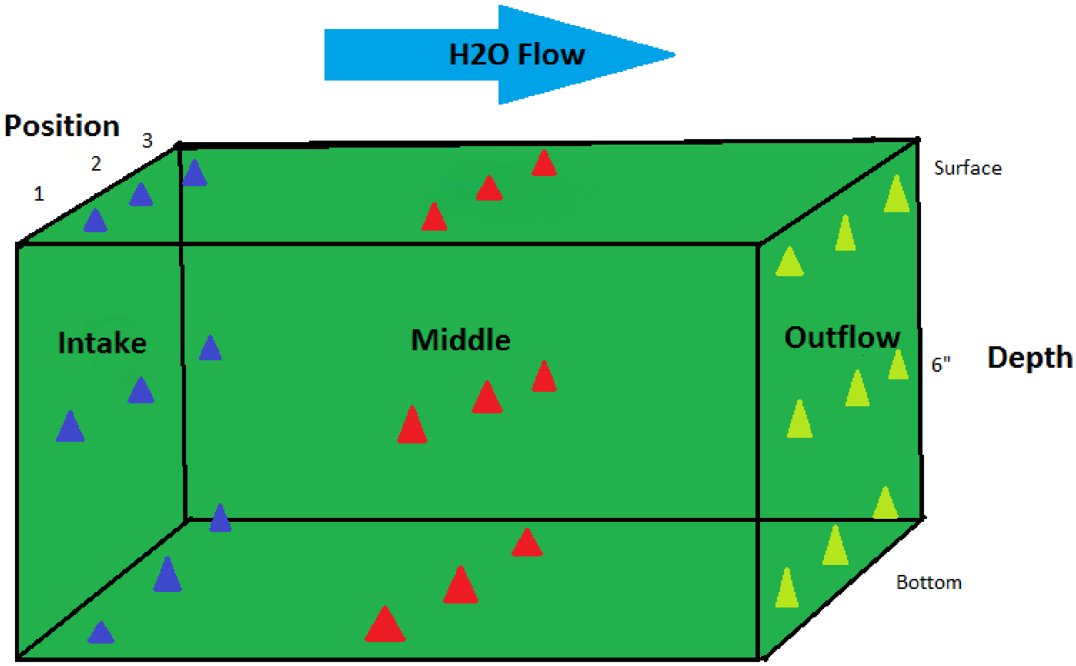


Figure 1: *Illustration of Sampling Point Distribution for Collecting Water Samples Throughout an Exposure Chamber During the Flow Condition Experiment.*

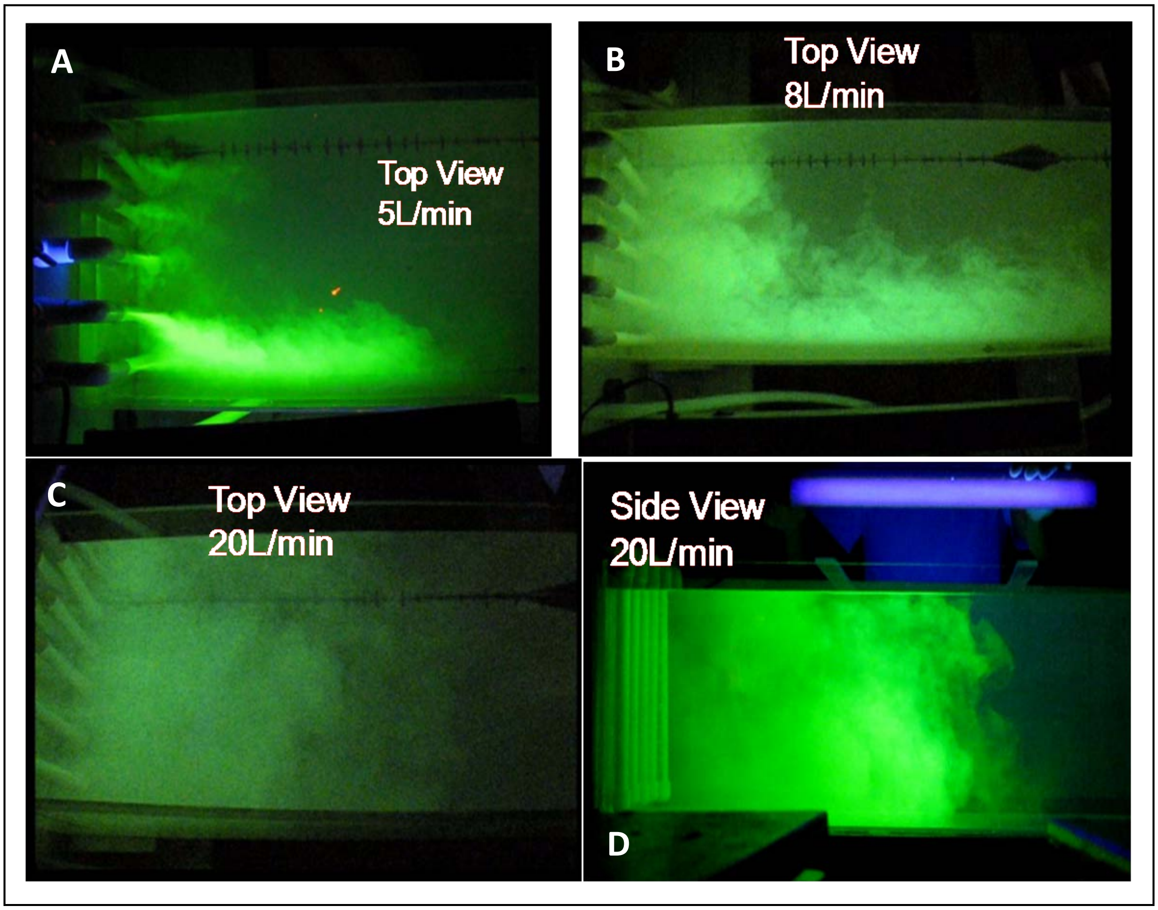


Figure 2: *Photographs of dye distribution in test chamber at low (<17 L/min;* ***A&B****) and high (≥ 17 L/min;* ***C&D****) flow rates.*

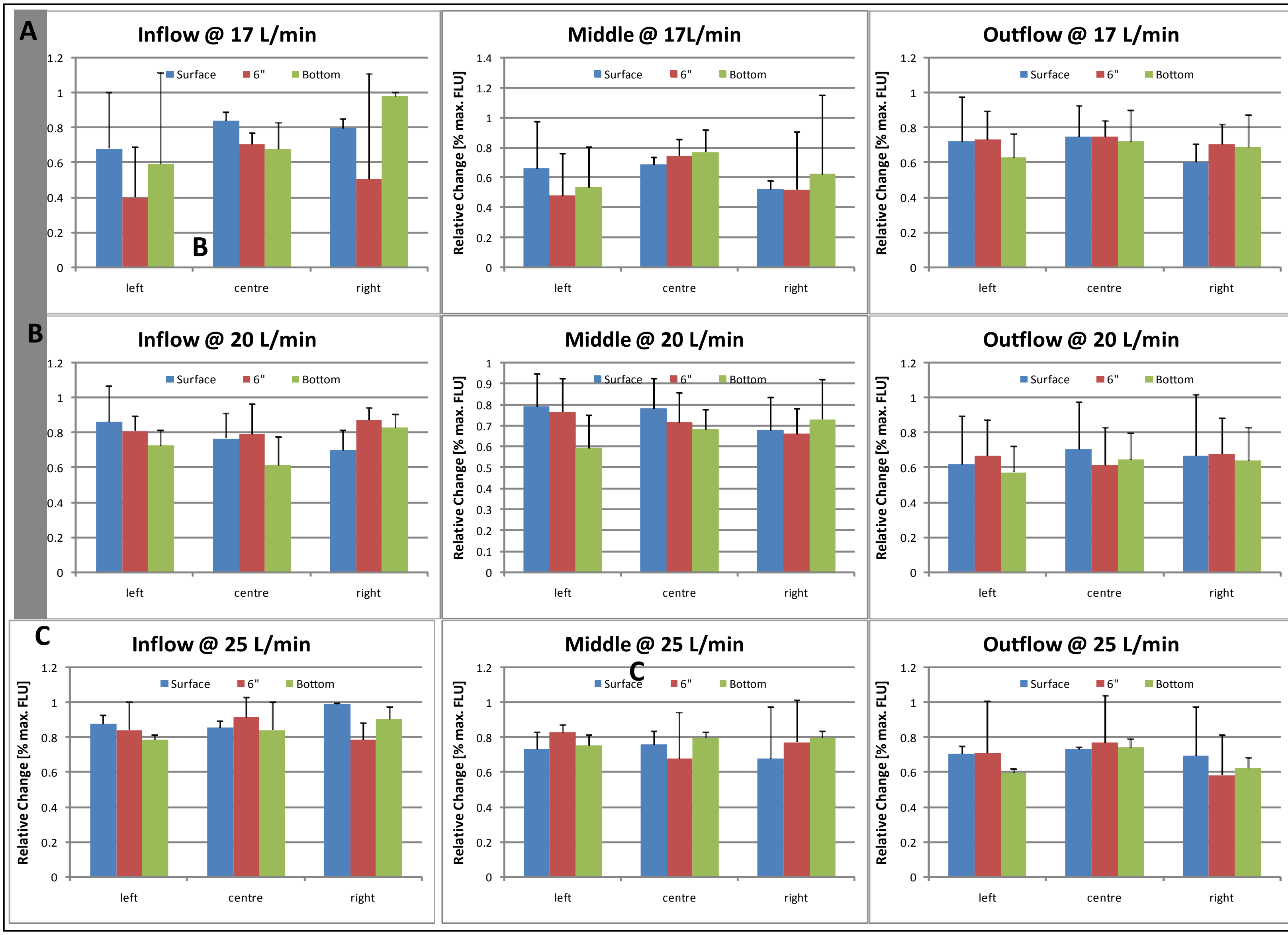


Figure 3: *Mean ± 1SD relative dye concentrations at sampling points in cross sections sampled at the inflow, middle, and outflow of the test chamber at flow rates of 17 (A), 20 (B) and 25 (C) L/min. Cross sectional position in exposure system (viewed from inflow end of test chamber): 1=left; 2=centre; 3=right. Values are expressed relative to the maximum dye concentration measured in the same experiment (maximum dye concentration = 1).*

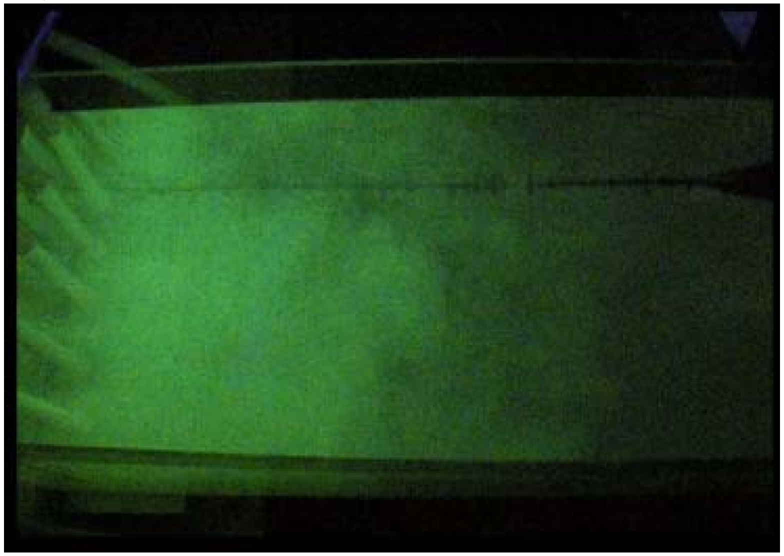
Video Log

Flow Rate	Comments	Side View Video	Top View Video
5L/min	Severe rightward tendency. Vertically even.	Uploaded	Uploaded
5L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
8L/min	Strong topward tendency due to backdraft.	Uploaded	Lost (hardware failure)
8L/min	Extreme left and topward tendency.	Uploaded	Uploaded
8L/min	Faster flow tendency for top and left.	Uploaded	Uploaded
8L/min	Severe rightward tendency. Vertically even.	Uploaded	Uploaded
8L/min	Extreme left and topward tendency.	Uploaded	Uploaded
8L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
13L/min	Slight left and topward tendency.	Uploaded	Uploaded
13L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
17L/min	Slight rightward tendency. Vertically even.	Uploaded	Uploaded
17L/min	Fairly even overall.	Uploaded	Uploaded
17L/min	Slight topward tendency due to backdraft.	Uploaded	Uploaded
17L/min	Vertically even with slight backdraft.	Uploaded	Uploaded
17L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
17:/min		Uploaded	Uploaded
19L/min	Fairly even.	Uploaded	Lost (hardware failure)
19L/min	Fairly even.	Uploaded	Uploaded
19L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
20L/min	Equipment malfunction	Lost (hardware failure)	Lost (hardware failure)
20L/min	Fairly even.	Uploaded	Lost (hardware failure)
20L/min	Fairly even. Slight topward tendency.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	Uploaded	Lost (hardware failure)
20L/min	Fairly even.	Uploaded	Lost (hardware failure)
20L/min	Vertically even.	none taken	Uploaded
20L/min		Uploaded	Uploaded
20L/min		Uploaded	Uploaded
23L/min	Fairly even.	Uploaded	Uploaded
25L/min		Uploaded	Uploaded
25L/min		Uploaded	Uploaded

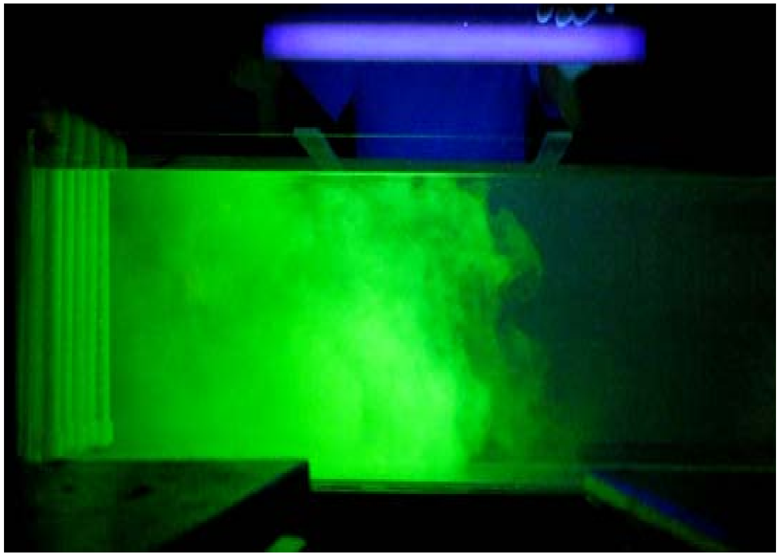
Still Images

20L/min

Top View

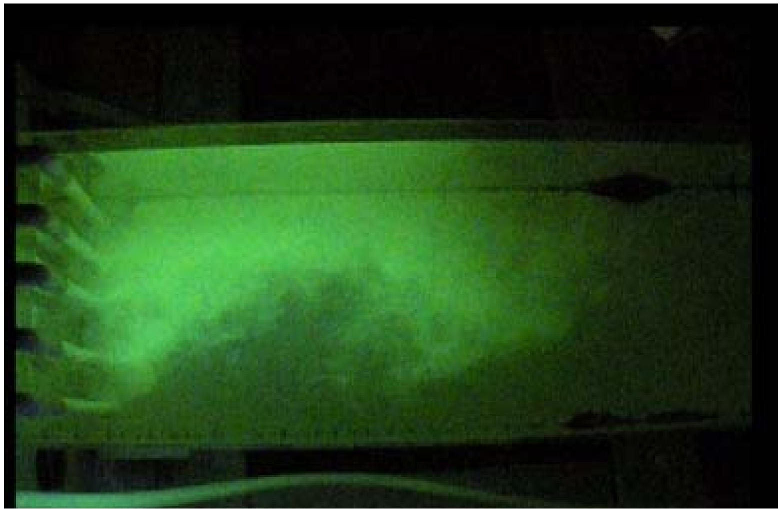


Side View

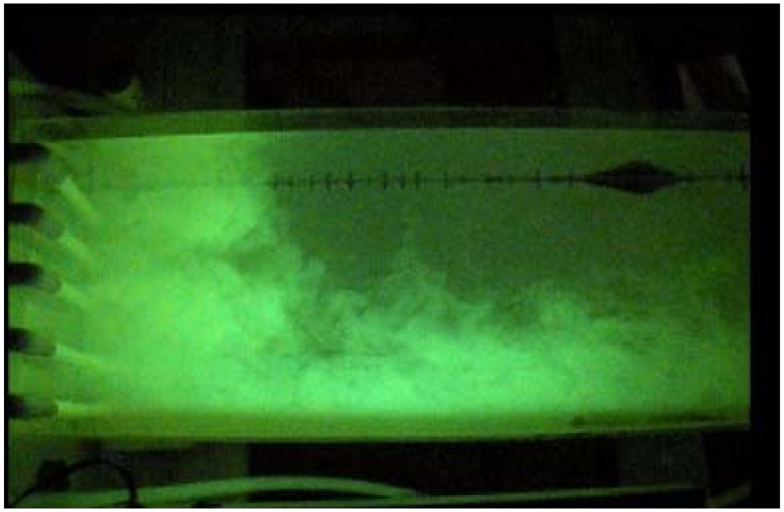


8L/min

Top View

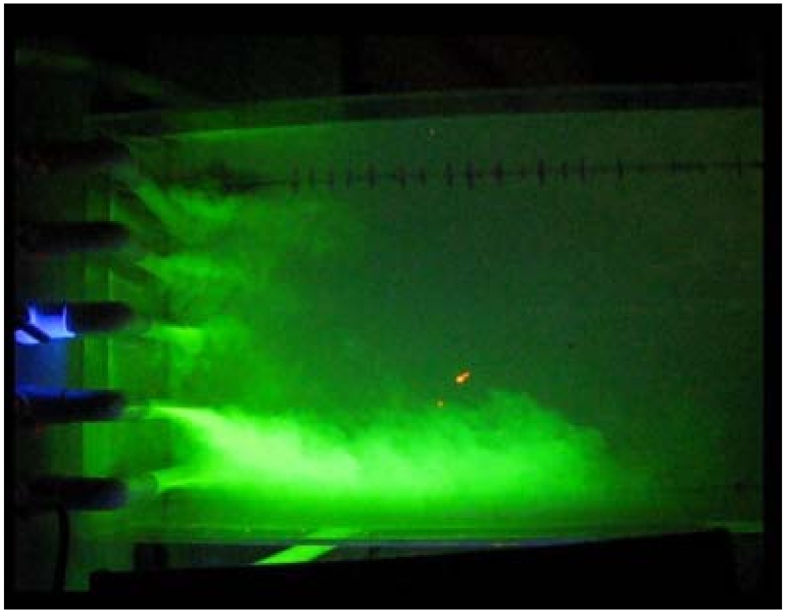


Side View



5L/min

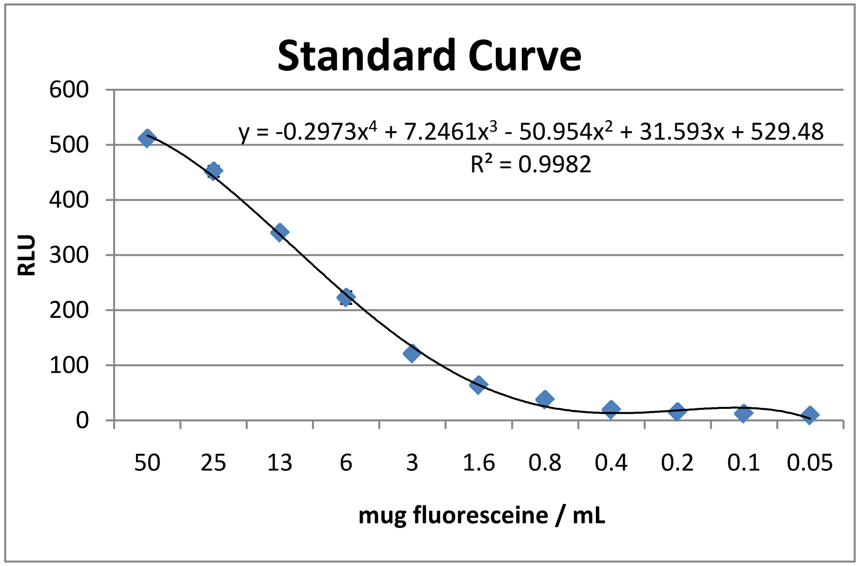
Top View

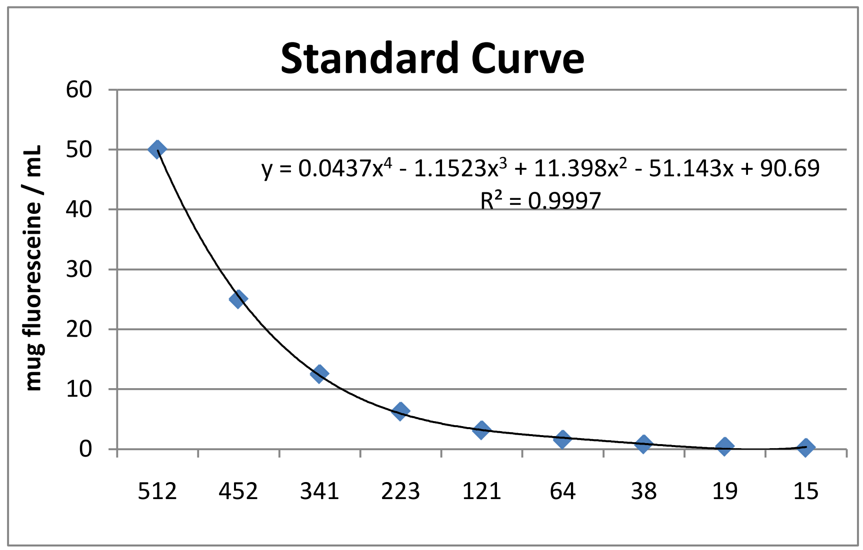


Fluoresceine Standard Curve

Standard curve

	50	25	13	6	3	1.6	0.8	0.4	0.2	0.1	0.05	Blank
A	513	441	340	218	121	63	35	20	15	9	10	9
B	510	455	338	215	121	59	36	17	16	14	9	10
C	512	460	344	236	122	70	42	21	15	14	8	6
AV	512	452	341	223	121	64	38	19	15	12	9	8
SD	2	10	3	11	1	6	4	2	1	3	1	2





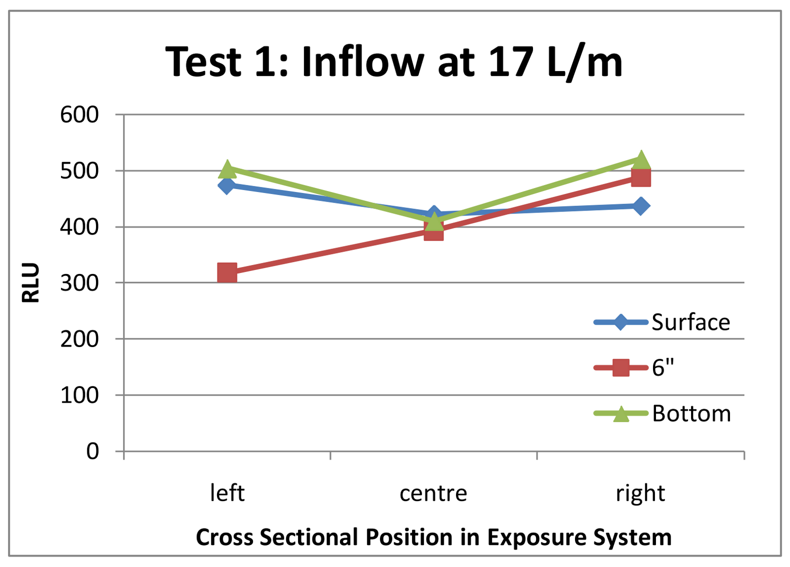
INFLOW

Test one; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	474	422	437
6"	318	393	488
Bottom	504	410	521

Rel Change: (Vertical Position)	left	centre	right
Surface	0.90978887	0.80998081	0.838772
6"	0.61036468	0.75431862	0.93666
Bottom	0.96737044	0.78694818	1

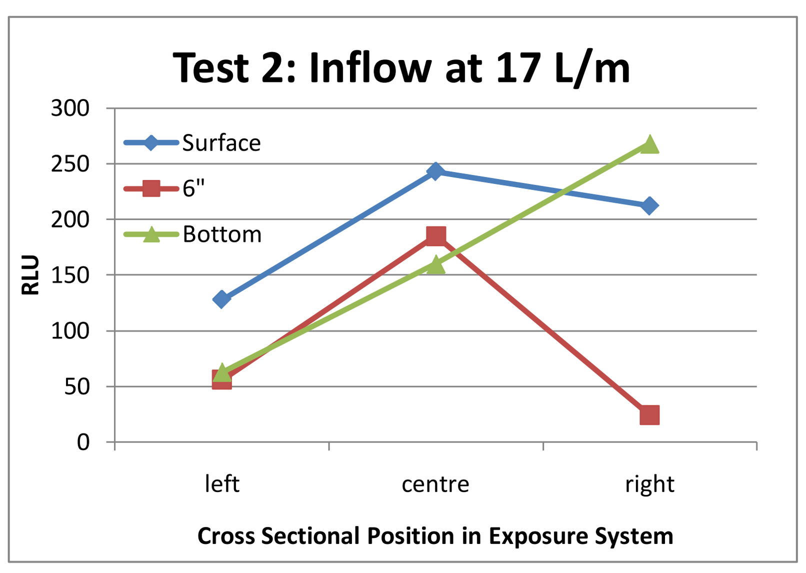


Test two; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	128	243	212
6"	56	185	24
Bottom	63	160	268

Rel Change: (Vertical Position)	left	centre	right
Surface	0.46209386	0.87725632	0.765343
6"	0.20216606	0.66787004	0.086643
Bottom	0.22743682	0.57761733	0.967509

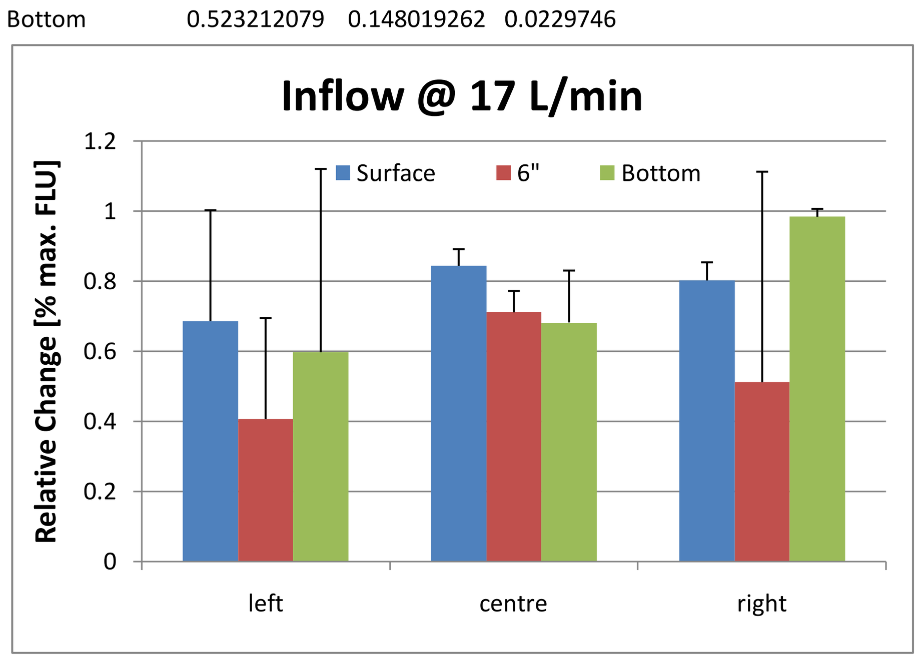


Summary (Relative Change: % max. FLUs); 17 L/m

Horizontal Position

Average (Vertical Position)	left	centre	right
Surface	0.685941365	0.843618562	0.8020573
6"	0.406265374	0.711094327	0.5116514
Bottom	0.597403632	0.682282753	0.9837545

SD (Vertical Position)	left	centre	right
Surface	0.316568174	0.04757097	0.0519219
6"	0.288640011	0.061128379	0.6010533
Bottom	0.523212079	0.148019262	0.0229746



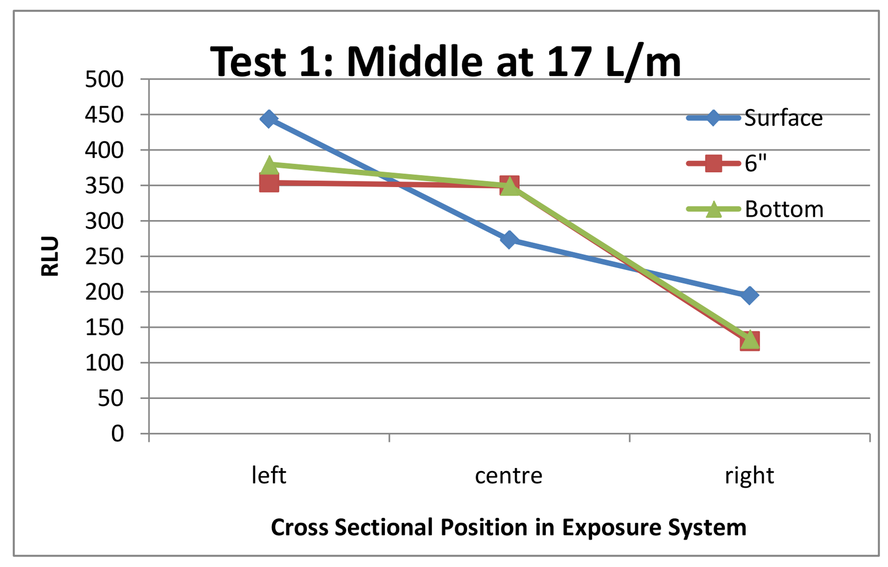
MIDDLE

Test one; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	444	273	194
6"	354	350	130
Bottom	380	350	134

Rel Change: (Vertical Position)	left	centre	right
Surface	0.852207	0.523992	0.372361
6"	0.679463	0.671785	0.24952
Bottom	0.729367	0.671785	0.257198

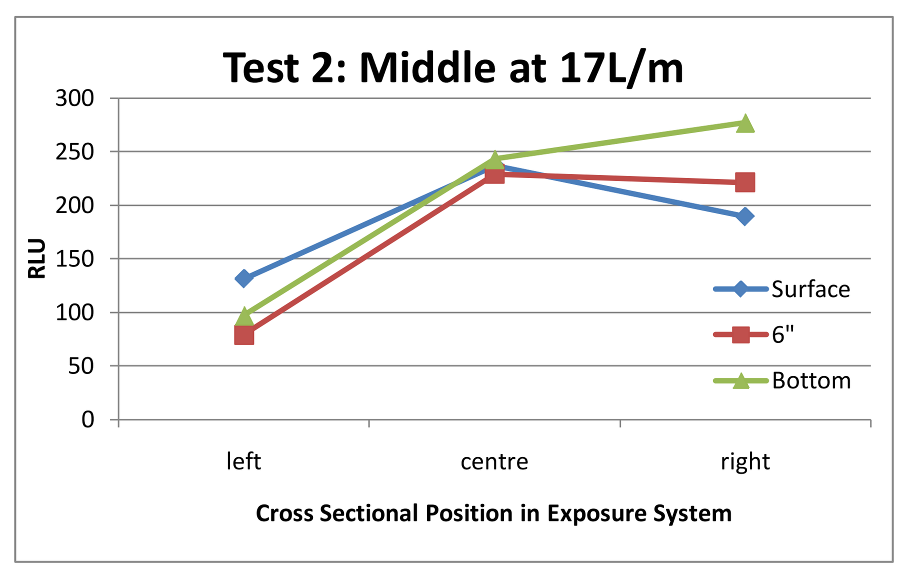


Test two; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	131	237	189
6"	79	229	221
Bottom	97	243	277

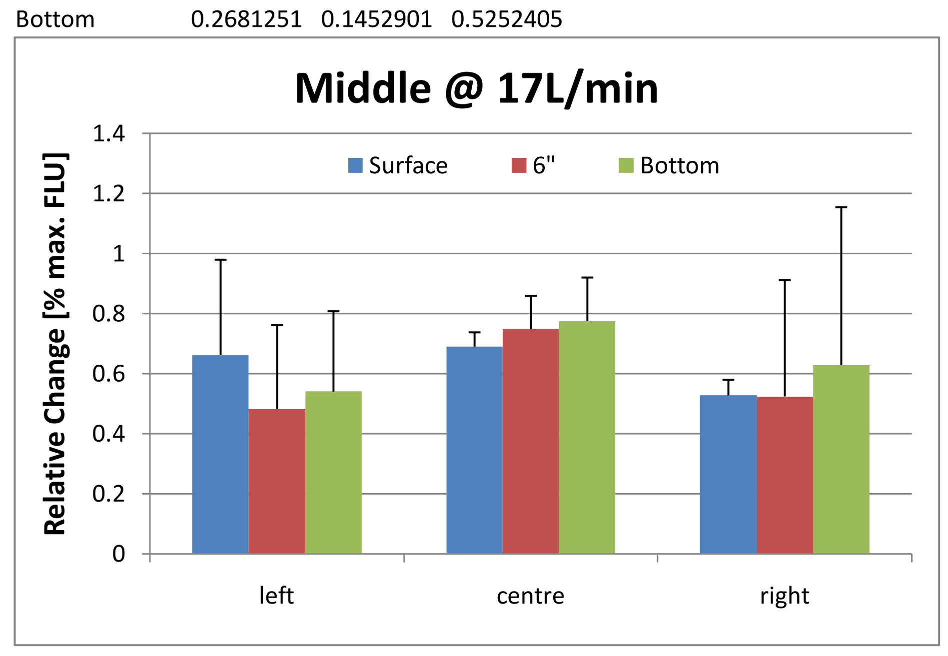
Rel Change: (Vertical Position)	left	centre	right
Surface	0.472924	0.855596	0.68231
6"	0.285199	0.826715	0.797834
Bottom	0.350181	0.877256	1



Horizontal Position

Average (Vertical Position)	left	centre	right
Surface	0.6625657	0.689794	0.5273357
6"	0.4823306	0.7492499	0.523677
Bottom	0.5397736	0.7745207	0.6285988

SD (Vertical Position)	left	centre	right
Surface	0.2681937	0.234479	0.2191675
6"	0.2787868	0.1095519	0.3877164
Bottom	0.2681251	0.1452901	0.5252405



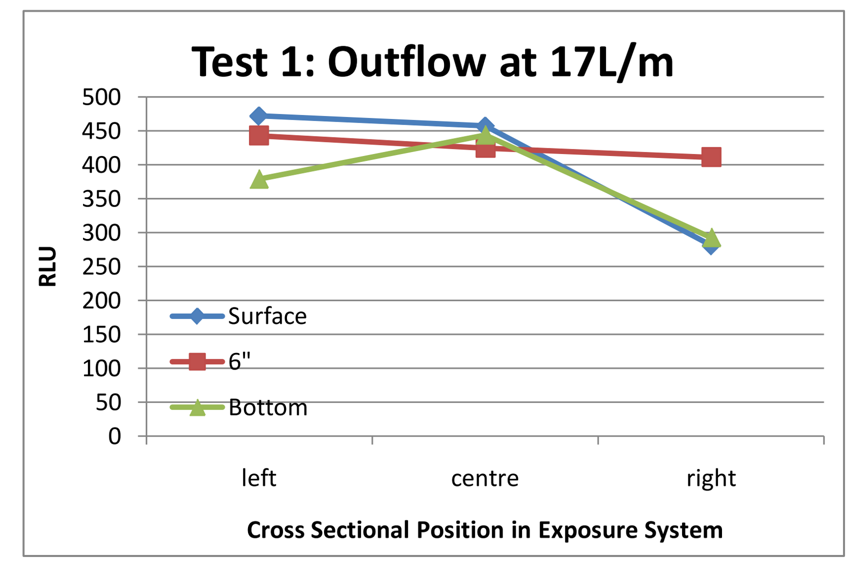
OUTFLOW

Test one; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	472	457	281
6"	443	425	411
Bottom	379	444	293

Rel Change: (Vertical Position)	left	centre	right
Surface	0.90595	0.877159	0.539347
6"	0.850288	0.815739	0.788868
Bottom	0.727447	0.852207	0.56238

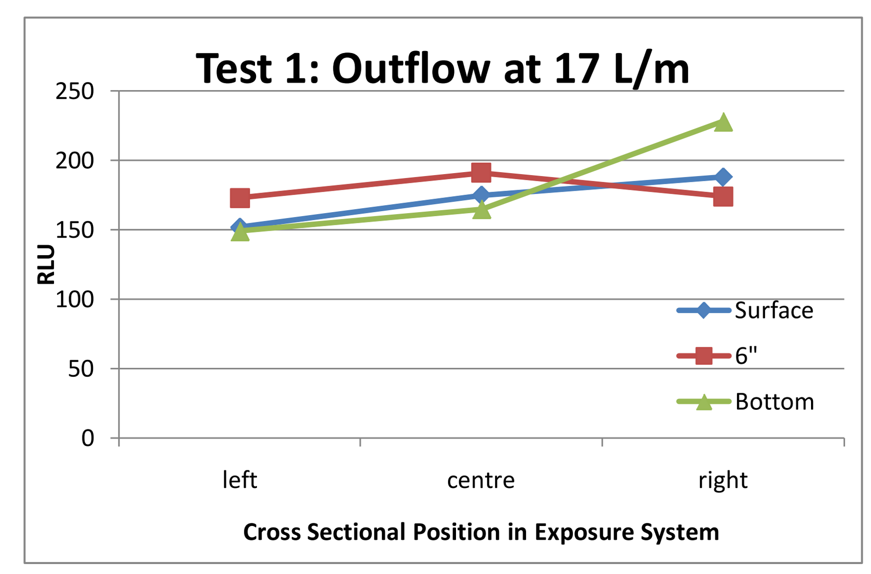


Test two; 17 L/m

Horizontal Position

RLUs: (Vertical Position)	left	centre	right
Surface	152	175	188
6"	173	191	174
Bottom	149	165	228

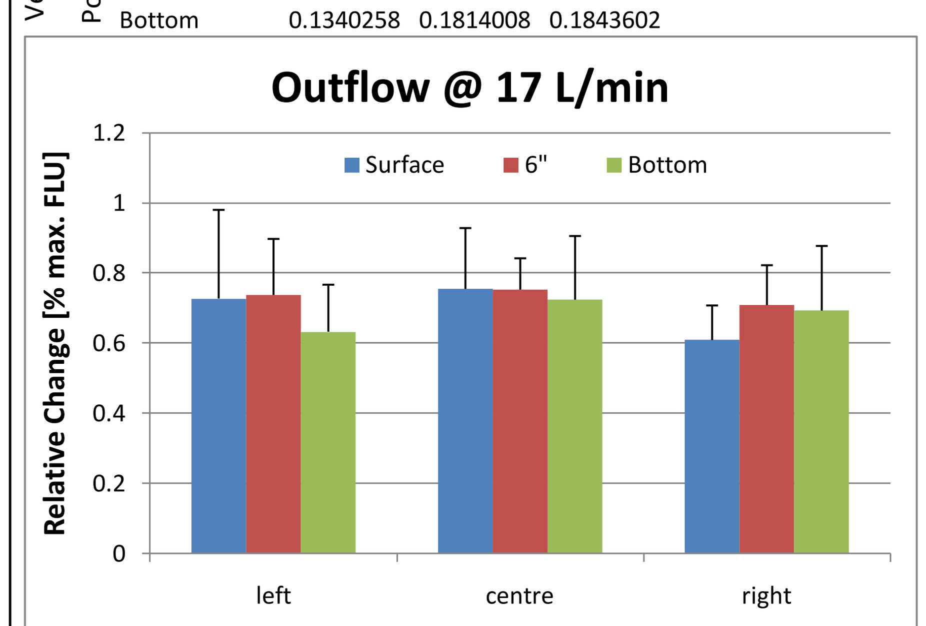
Rel Change: (Vertical Position)	left	centre	right
Surface	0.548736	0.631769	0.6787
6"	0.624549	0.689531	0.628159
Bottom	0.537906	0.595668	0.823105



Horizontal Position

Average (Vertical Position)	left	centre	right
Surface	0.7273433	0.7544641	0.6090239
6"	0.7374183	0.7526348	0.7085132
Bottom	0.6326767	0.7239376	0.6927424

SD (Vertical Position)	left	centre	right
Surface	0.2525882	0.1735172	0.0985374
6"	0.1596217	0.0892427	0.1136382
Bottom	0.1340258	0.1814008	0.1843602



INFLOW

Test one; 17 L/m

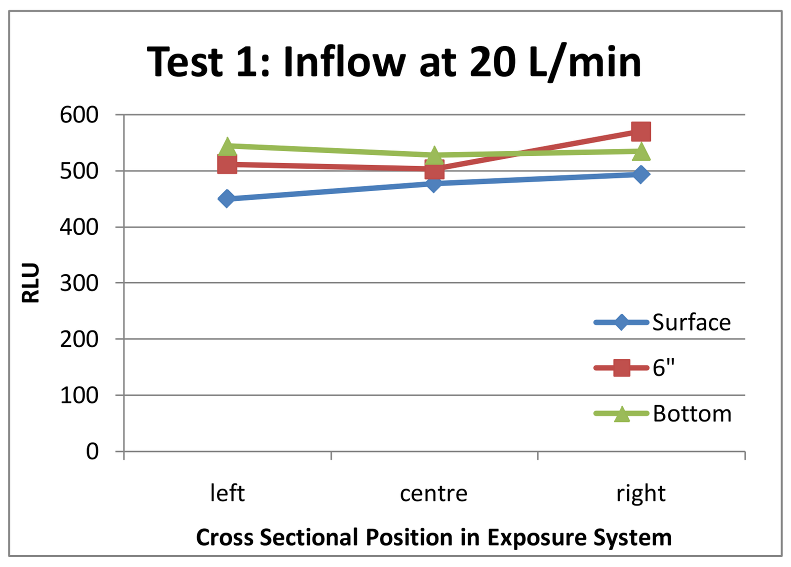
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	450	477	493
6"	512	503	570
Bottom	544	528	535

Vertical Position

Rel Change:	left	centre	right
Surface	0.63291139	0.67088608	0.69339
6"	0.72011252	0.70745429	0.801688
Bottom	0.76511955	0.74261603	0.752461



Test two; 17 L/m

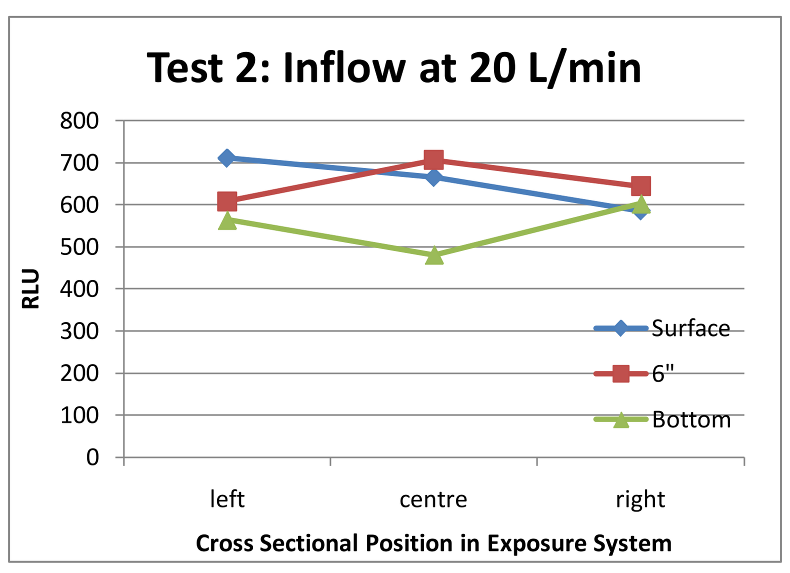
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	711	665	585
6"	608	706	644
Bottom	564	481	603

Vertical Position

Rel Change:	left	centre	right
Surface	1	0.93530239	0.822785
6"	0.85513361	0.99296765	0.905767
Bottom	0.79324895	0.67651195	0.848101



Test three; 17 L/m

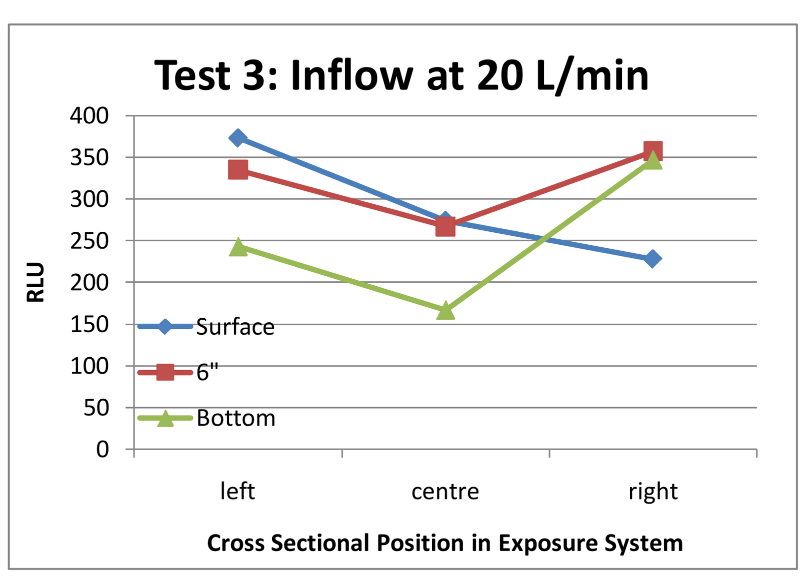
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	373	274	228
6"	335	267	357
Bottom	243	167	347

Vertical Position

Rel Change:	left	centre	right
Surface	0.96632124	0.70984456	0.590674
6"	0.86787565	0.69170984	0.92487
Bottom	0.62953368	0.43264249	0.898964



Summary (Relative Change: % max. FLUs); 17 L/m

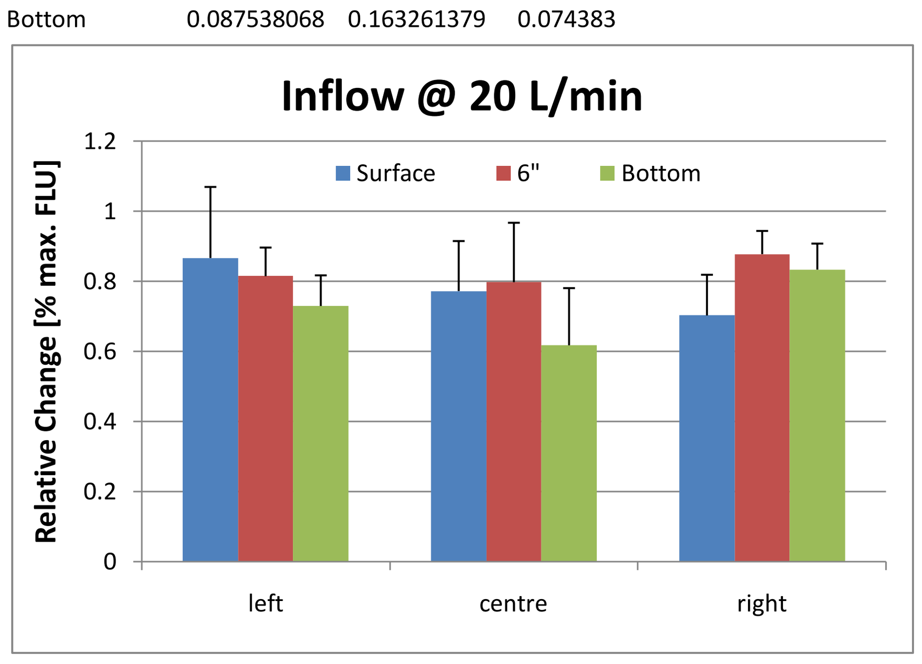
Horizontal Position

Vertical Position

Average	left	centre	right
Surface	0.866410879	0.772011009	0.7022827
6"	0.814373927	0.797377262	0.8774416
Bottom	0.729300725	0.617256825	0.8331754

Vertical Position

SD	left	centre	right
Surface	0.202916417	0.142749772	0.1163109
6"	0.08188101	0.169569078	0.0662965
Bottom	0.087538068	0.163261379	0.074383



MIDDLE

Test one; 17 L/m

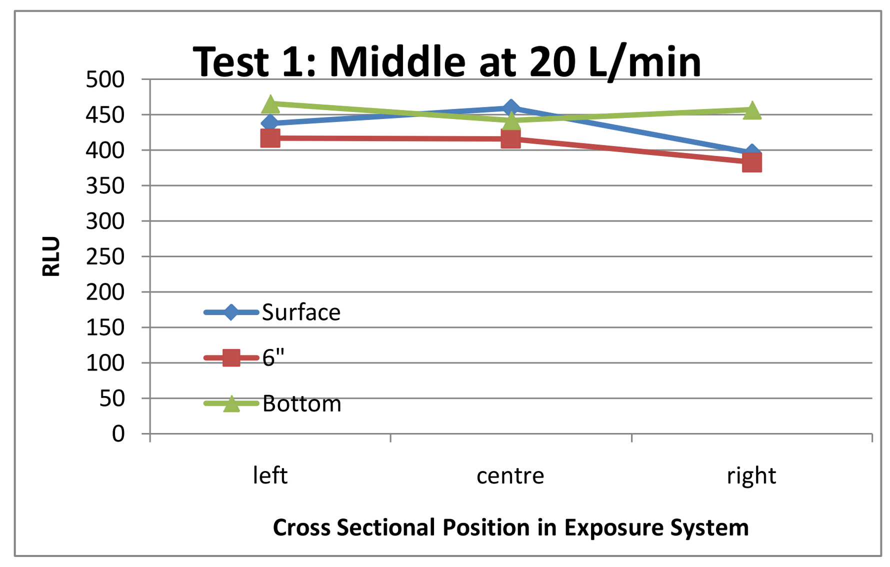
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	438	459	396
6"	417	416	383
Bottom	466	442	457

Vertical Position

Rel Change:	left	centre	right
Surface	0.616034	0.64557	0.556962
6"	0.586498	0.585091	0.538678
Bottom	0.655415	0.62166	0.642757



Test two; 17 L/m

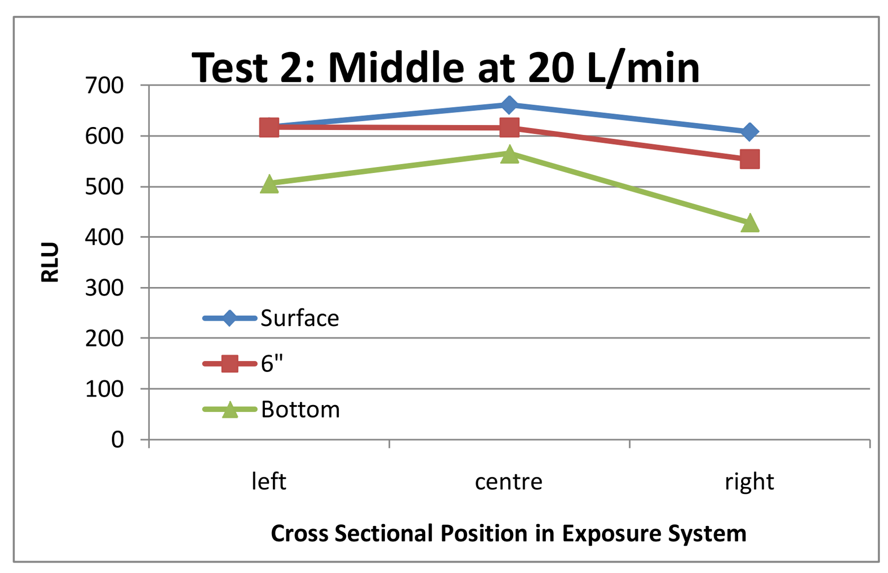
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	618	661	608
6"	617	616	554
Bottom	506	565	429

Vertical Position

Rel Change:	left	centre	right
Surface	0.869198	0.929677	0.855134
6"	0.867792	0.866385	0.779184
Bottom	0.711674	0.794655	0.603376



Test three; 17 L/m

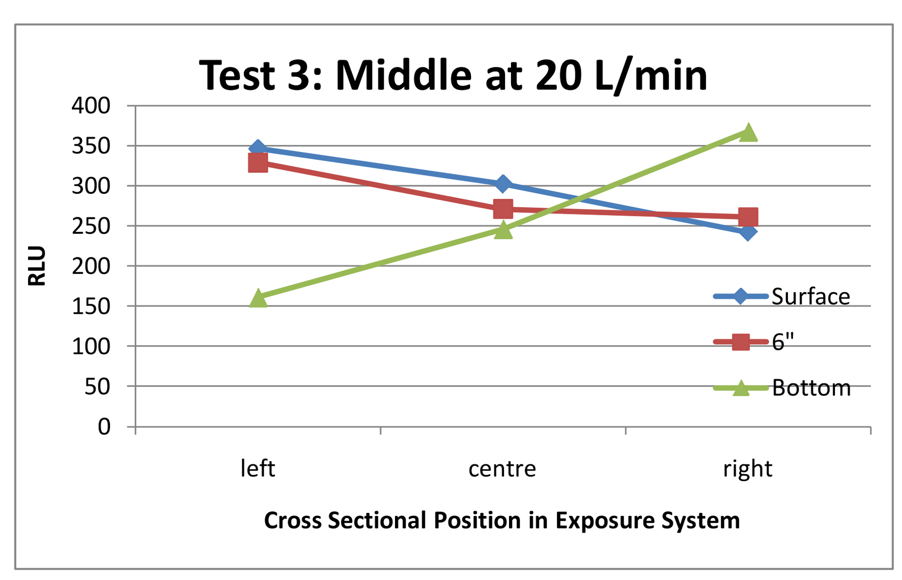
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	346	302	242
6"	329	271	261
Bottom	161	246	367

Vertical Position

Rel Change:	left	centre	right
Surface	0.896373	0.782383	0.626943
6"	0.852332	0.702073	0.676166
Bottom	0.417098	0.637306	0.950777



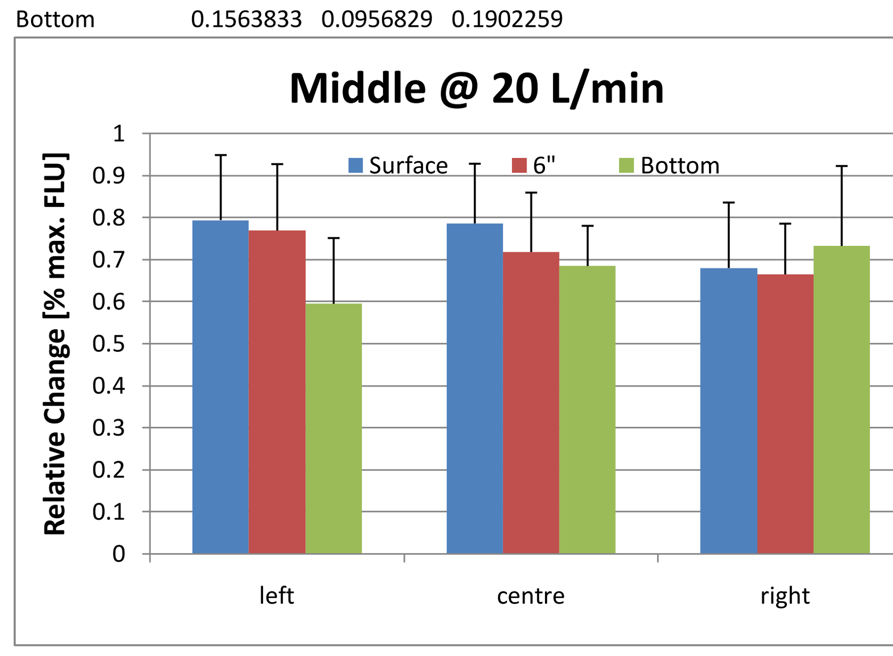
Horizontal Position

Vertical Position

Average	left	centre	right
Surface	0.7938684	0.7858765	0.6796795
6"	0.7688738	0.7178498	0.664676
Bottom	0.594729	0.6845402	0.7323031

Vertical Position

SD	left	centre	right
Surface	0.1546075	0.1420857	0.1559244
6"	0.1581312	0.1413091	0.1206641
Bottom	0.1563833	0.0956829	0.1902259



OUTFLOW

Test one; 17 L/m

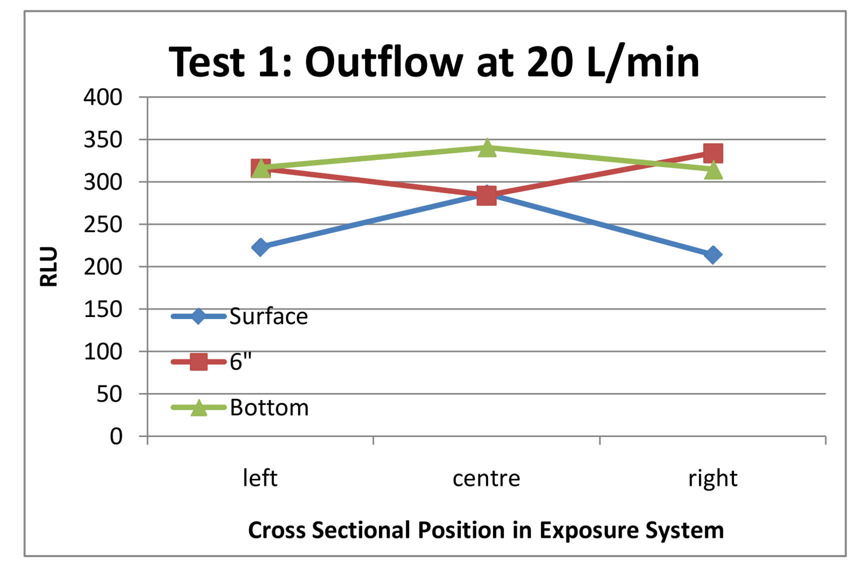
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	223	286	214
6"	316	284	334
Bottom	317	341	315

Vertical Position

Rel Change:	left	centre	right
Surface	0.313643	0.40225	0.300985
6"	0.444444	0.399437	0.469761
Bottom	0.445851	0.479606	0.443038



Test two; 17 L/m

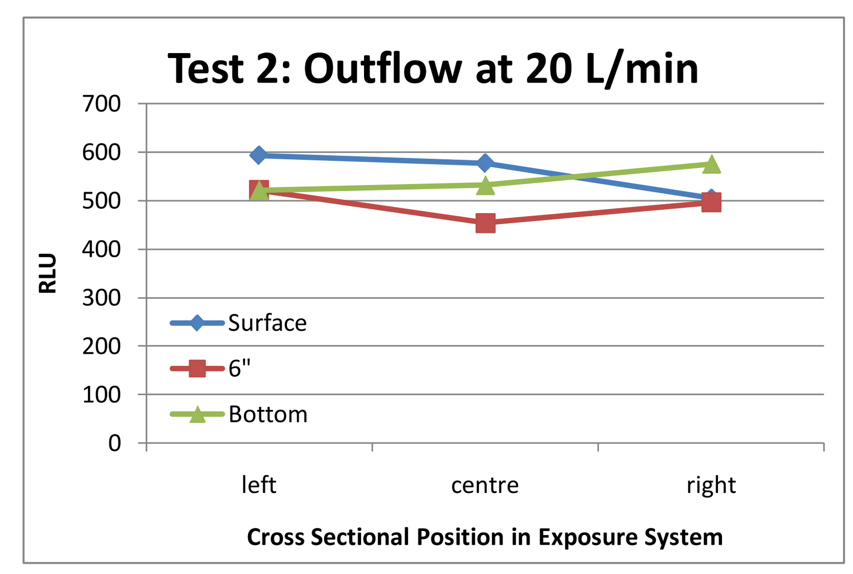
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	593	577	505
6"	522	454	496
Bottom	522	532	576

Vertical Position

Rel Change:	left	centre	right
Surface	0.834037	0.811533	0.710267
6"	0.734177	0.638537	0.697609
Bottom	0.734177	0.748242	0.810127



Test three; 17 L/m

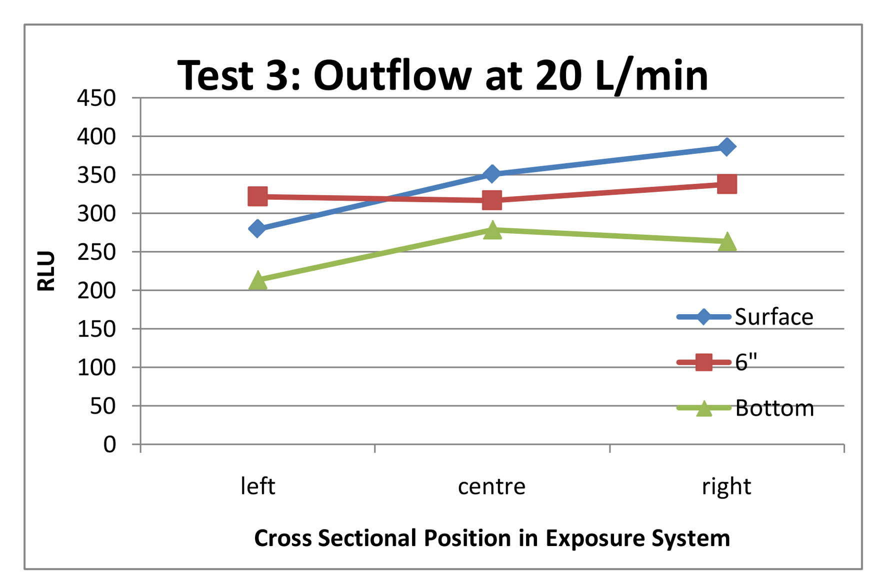
Horizontal Position

Vertical Position

RLUs:	left	centre	right
Surface	280	351	386
6"	322	317	338
Bottom	214	279	264

Vertical Position

Rel Change:	left	centre	right
Surface	0.725389	0.909326	1
6"	0.834197	0.821244	0.875648
Bottom	0.554404	0.722798	0.683938



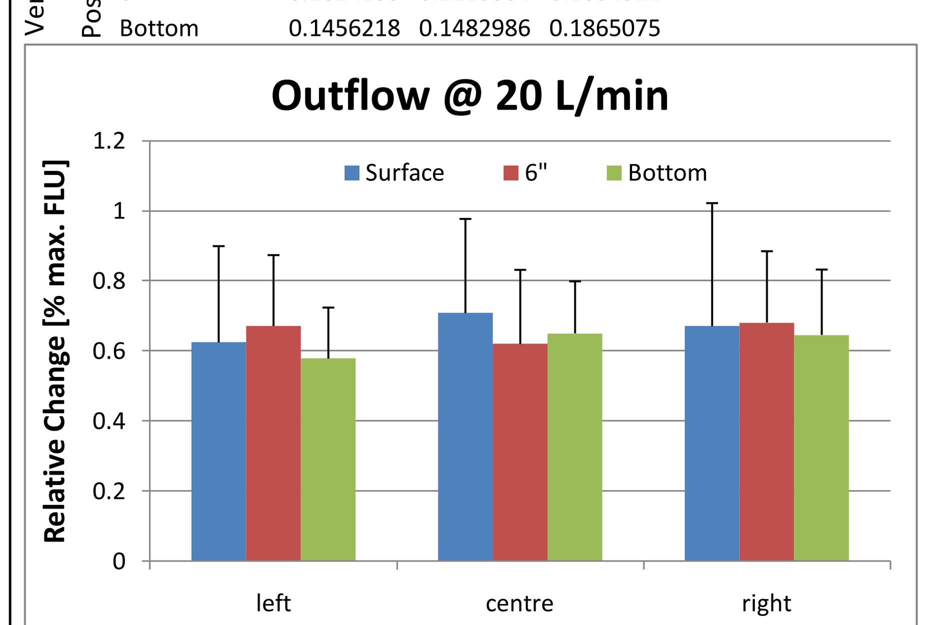
Horizontal Position

Vertical Position

Average	left	centre	right
Surface	0.624356	0.7077033	0.6704173
6"	0.6709395	0.6197394	0.6810059
Bottom	0.5781441	0.6502153	0.6457008

Vertical Position

SD	left	centre	right
Surface	0.2745143	0.2690112	0.3512074
6"	0.2024253	0.2115304	0.2034521
Bottom	0.1456218	0.1482986	0.1865075



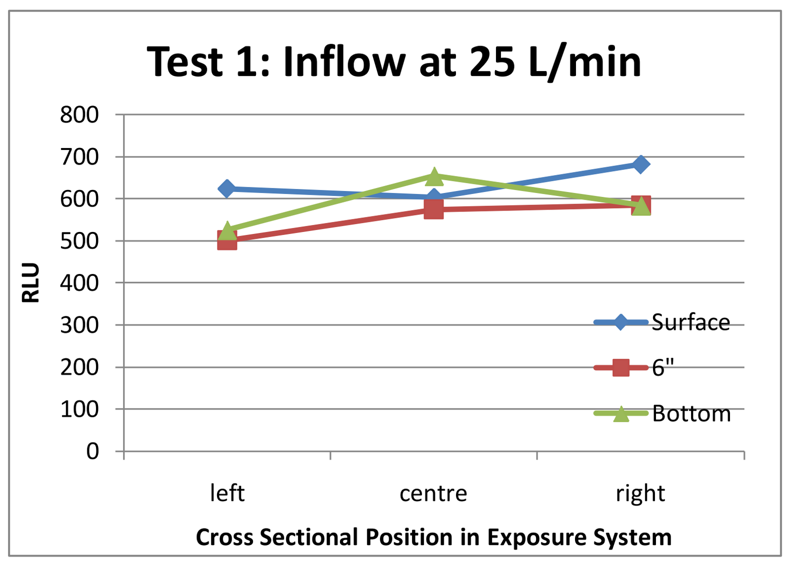
INFLOW

Test one; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	624	603	681
6"	501	574	584
Bottom	526	654	584

Vertical Position	***Rel Change:*** left	centre	right
Surface	0.91629956	0.88546256	1
6"	0.73568282	0.84287812	0.857562
Bottom	0.77239354	0.96035242	0.857562

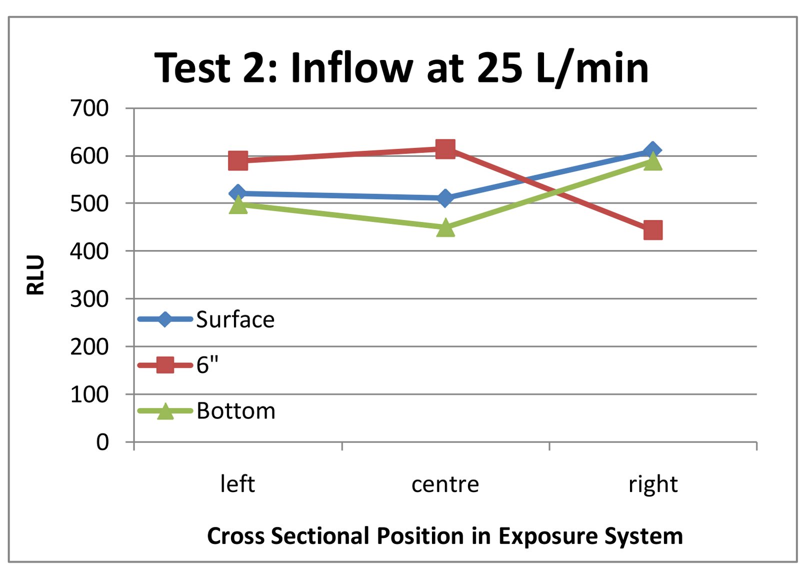


Test two; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	521	511	610
6"	589	614	444
Bottom	498	450	589

Vertical Position	***Rel Change:*** left	centre	right
Surface	0.8485342	0.83224756	0.993485
6"	0.95928339	1	0.723127
Bottom	0.81107492	0.73289902	0.959283

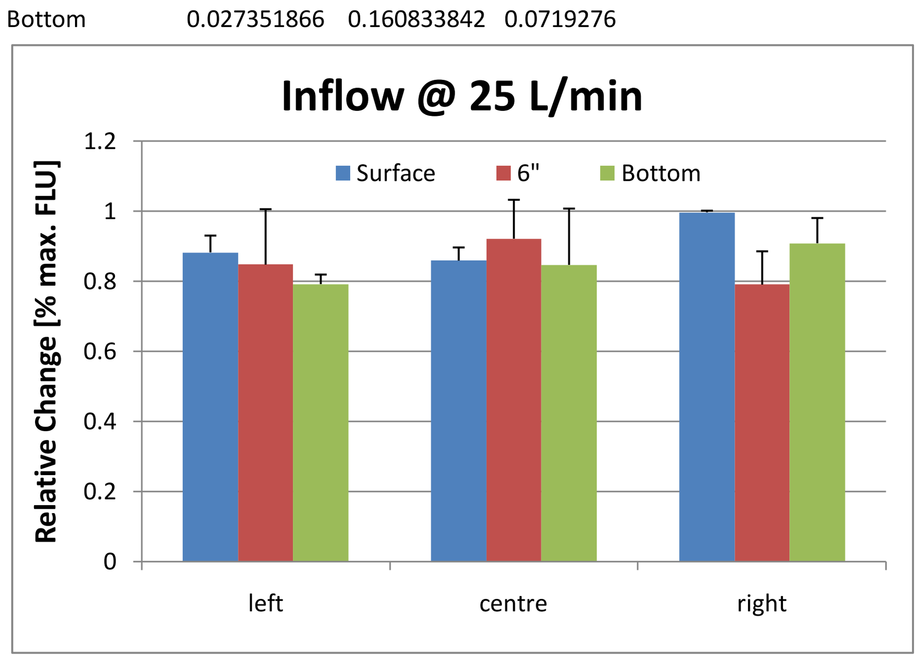


Summary (Relative Change: % max. FLUs); 17 L/m

Horizontal Position

Vertical Position	***Average*** left	centre	right
Surface	0.882416881	0.858855056	0.9967427
6"	0.847483104	0.92143906	0.7903447
Bottom	0.791734229	0.846625723	0.9084229

Vertical Position	***SD*** left	centre	right
Surface	0.047917344	0.037628686	0.0046066
6"	0.158109478	0.111101947	0.0950602
Bottom	0.027351866	0.160833842	0.0719276



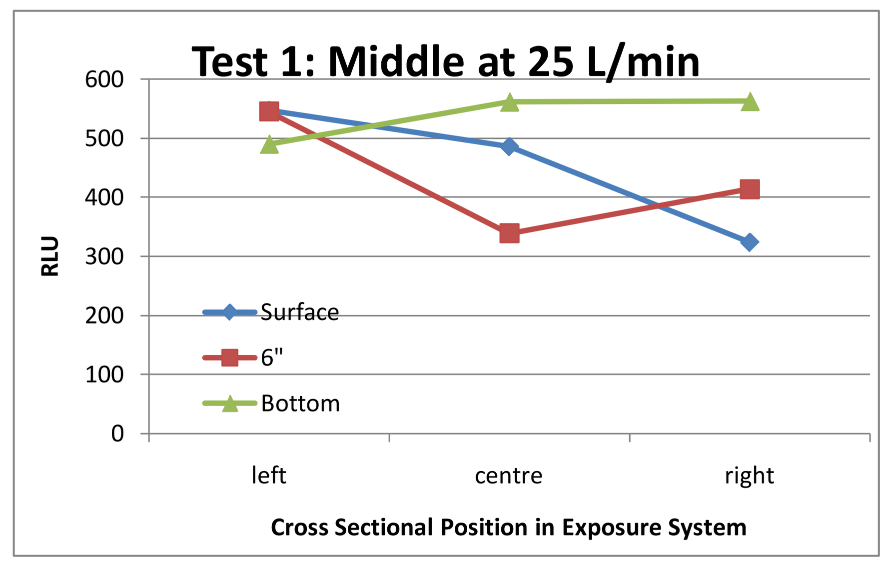
MIDDLE

Test one; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	547	486	324
6"	545	339	414
Bottom	490	562	563

Vertical Position	***Rel Change:*** left	centre	right
Surface	0.803231	0.713656	0.475771
6"	0.800294	0.497797	0.60793
Bottom	0.71953	0.825257	0.826725

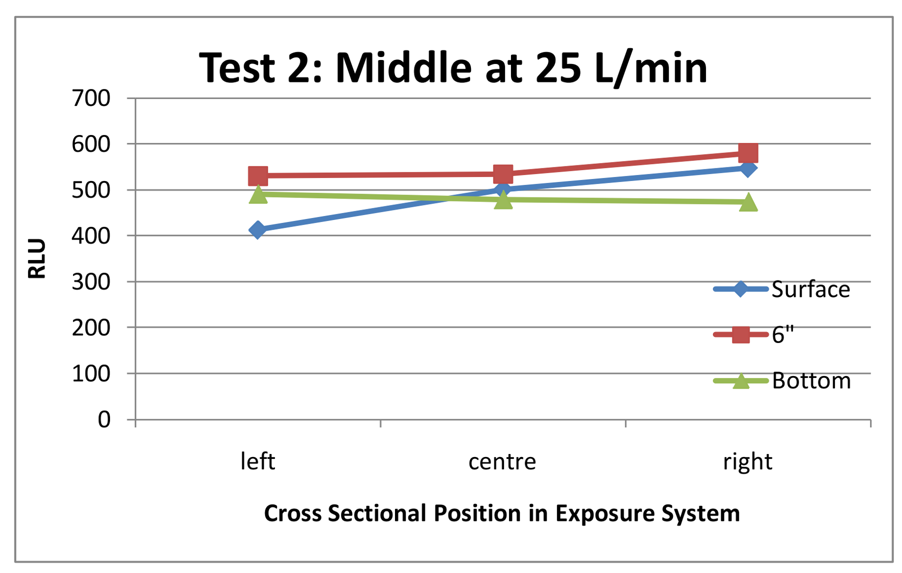


Test two; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	413	501	547
6"	530	534	580
Bottom	491	479	474

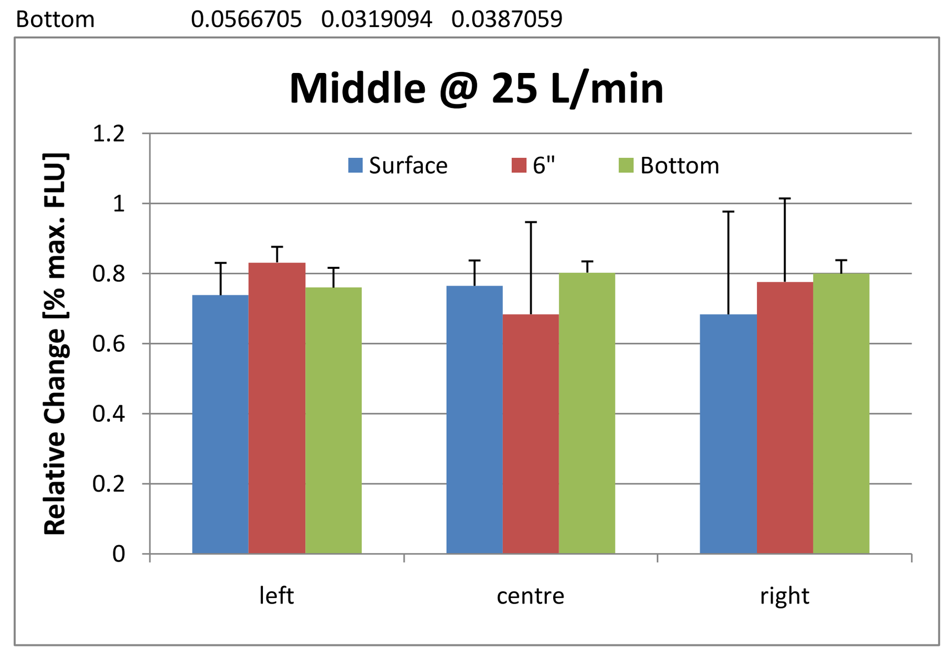
Vertical Position	***Rel Change:*** left	centre	right
Surface	0.672638	0.815961	0.890879
6"	0.863192	0.869707	0.944625
Bottom	0.799674	0.78013	0.771987



Horizontal Position

Vertical Position	***Average*** left	centre	right
Surface	0.7379345	0.7648086	0.6833252
6"	0.8317429	0.6837521	0.7762775
Bottom	0.7596022	0.8026936	0.7993562

Vertical Position	***SD*** left	centre	right
Surface	0.0923426	0.0723402	0.2935261
6"	0.044476	0.2629797	0.2380799
Bottom	0.0566705	0.0319094	0.0387059



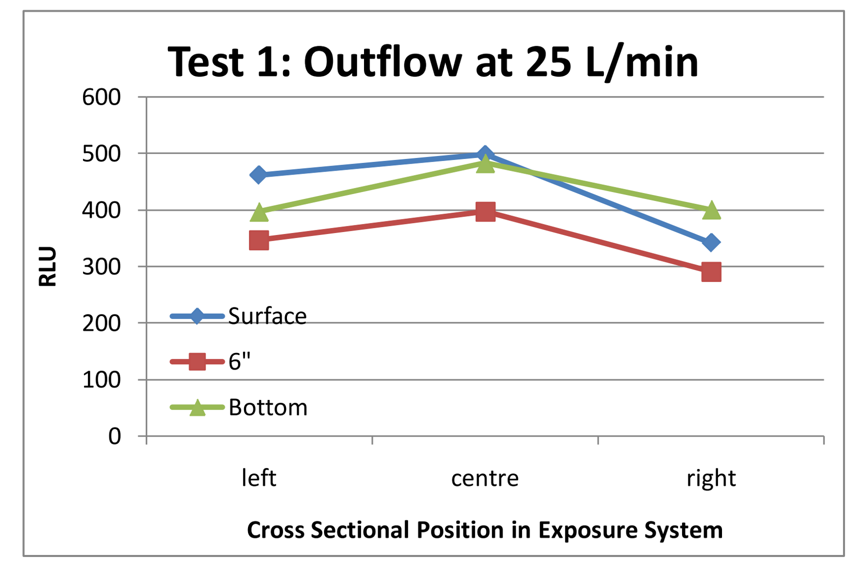
OUTFLOW

Test one; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	462	498	342
6"	347	397	291
Bottom	397	483	401

Vertical Position	***Rel Change:*** left	centre	right
Surface	0.678414	0.731278	0.502203
6"	0.509545	0.582966	0.427313
Bottom	0.582966	0.709251	0.58884

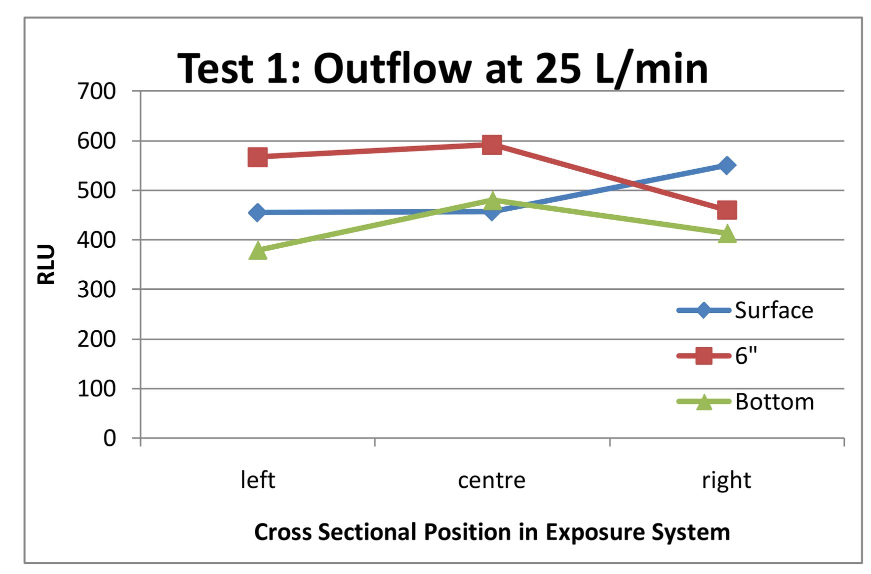


Test two; 17 L/m

Horizontal Position

Vertical Position	***RLUs:*** left	centre	right
Surface	455	457	550
6"	567	592	460
Bottom	379	480	413

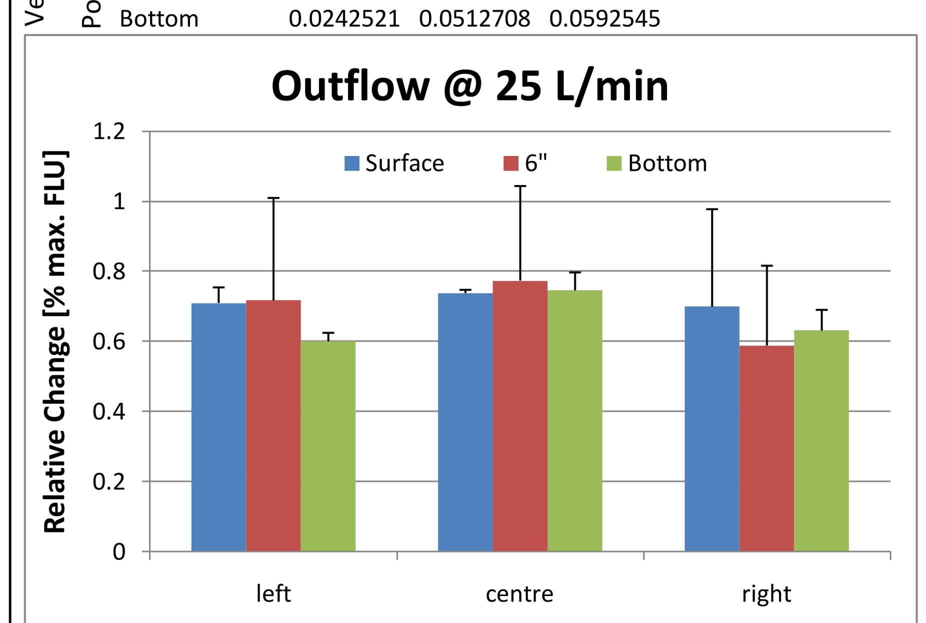
Vertical Position	***Rel Change:*** left	centre	right
Surface	0.741042	0.7443	0.895765
6"	0.923453	0.964169	0.749186
Bottom	0.617264	0.781759	0.672638



Horizontal Position

Vertical Position	***Average*** left	centre	right
Surface	0.7097282	0.7377886	0.6989841
6"	0.7164988	0.7735678	0.5882492
Bottom	0.600115	0.745505	0.6307392

Vertical Position	***SD*** left	centre	right
Surface	0.0442849	0.009208	0.2782909
6"	0.2926771	0.2695513	0.2275985
Bottom	0.0242521	0.0512708	0.0592545



Summary Data Report

Experiment #: __2___ **Date:** 5/20/-6/27/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Optimum Stone Volume and Distribution in Fluvial Test Chambers.

Goal:

Indentify the effect of different volumes and distribution of stones on hydrological conditions in fluvial chambers.

Experimental Design:

1. Stone volume selection

Stones (Geosubstrate # 12422, Hagen) (10 to 20 mm diameter) were placed in exposure chambers without sediment to visually assess optimal spatial densities. Spatial densities of stones tested included: 0, 3, 5 and 7 stones per 100 cm^2. Tests with densities greater than 7 stones per 100 cm^2 were not included because of crowding issues.

2. Water quality evaluation

Conductivity measurements (Symphony Probe, VWR; UCR-SOP #16) were taken at 0, 24 and 48 hrs in the 1 cm water layer overlying the stones to assess variation in water quality. Stone densities of 0, 3, 5 and 7 stones per 100 cm^2 were tested in exposure chambers without sediment while stone densities of 0, 4 and 7 stones per 100 cm^2 were tested in exposure chambers with sediment. Sediments were layered at a thickness of 2 and 3 inches into the exposure portion of the test chambers and stones were placed on top. Sediment depths greater than 3 inches were not included based on the evaluation of optimum sediment depths; refer to summary data report for Experiment Nos. 3 and 4.

3. Flow condition evaluation

Flow condition was evaluated visually by use of fluorescent dye to determine if the stones altered the flow of water.

Decision Criteria:

Conductivity measurements to evaluate variation in water quality: target value of <30% variation among samples taken. Visual assessment of flow conditions using fluorescent dye.

Results:

1. Stone volume selection

Visual assessment of stone densities of 3 and 7 stones per 100 cm^2 appeared too sparse and too crowded, respectively, whereas stone densities of 4 and 5 per 100 cm^2 appeared appropriate leaving sufficient room to enable observations of sediments while providing appropriate shelter for white sturgeon early life-stages (Figure 1).

2. Water quality evaluation

Conductivity analysis revealed less than 15% variation among samples taken from all stone densities at 0, 24 and 48 hrs in exposure systems with and without sediment (Figure 2). Variation in conductivity was less than 10% in exposure systems with sediment and stone densities of 4 and 7 stones per 100 cm^2 (Figure 3).

3. Flow condition evaluation

Visual assessments of flow condition revealed no impact on water flow with the incorporation of stones into the exposure chamber or with increased stone densities in chambers with or without sediment (see enclosed video records).

Conclusions:

Addition of stones to the fluvial exposure chambers had no impact on flow conditions and little to no impact on water quality. In our experience early life-stages of white sturgeon appear less stressed when provided a refuge under experimental conditions. A density of 4 stones per 100 cm^2 is recommended as the optimal loading density.

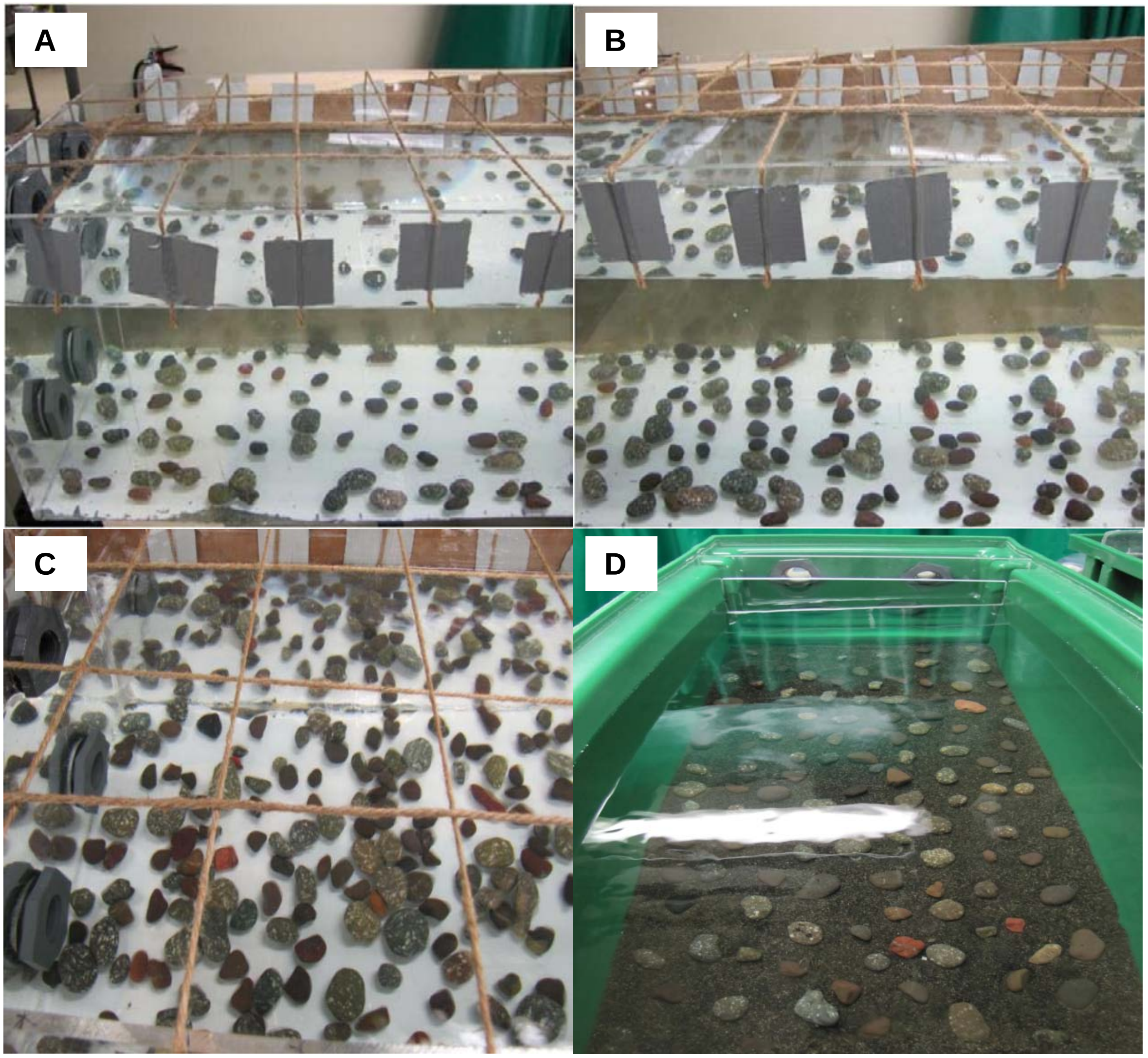


Figure 1: *Photographs of exposure systems with stone densities of 3 per 100 cm^2 without sediment (A), 5 per 100 cm^2 without sediment (B), 7 per 100 cm^2 without sediment (C), and 4 per 100cm^2 with sediment.*

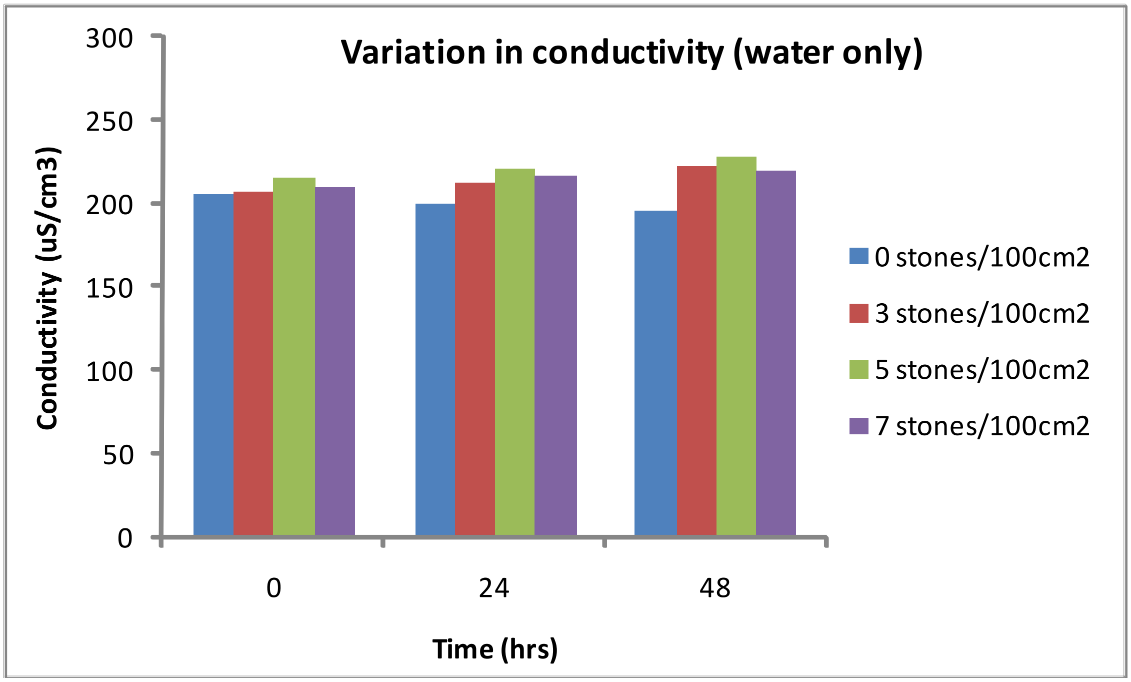


Figure 2: *Variation in conductivity in water-only exposure systems over 48 hrs at stone densities of 0, 3, 5 and 7 stones per 100 cm^2.*

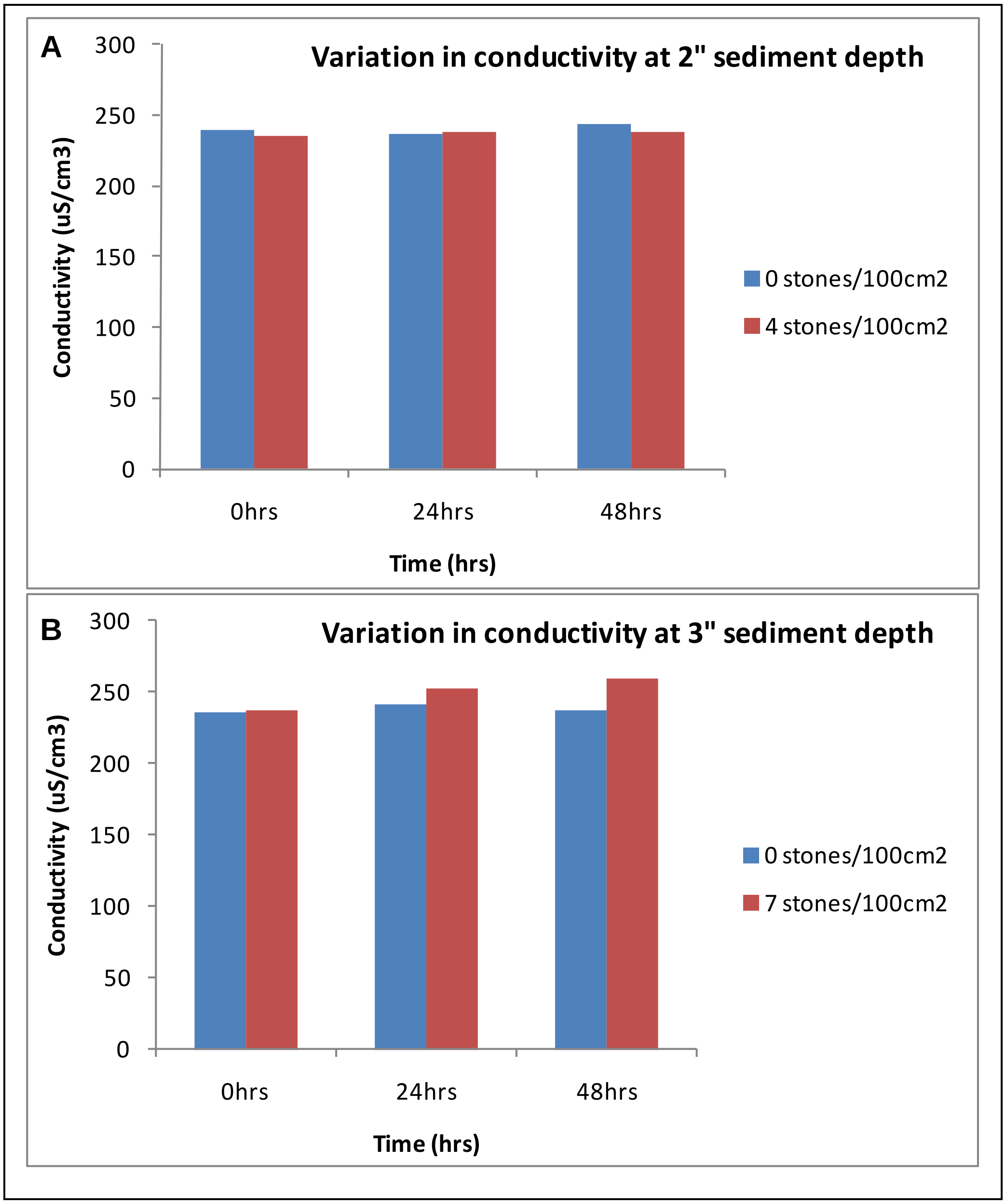


Figure 3: *Variation in conductivity at 2" sediment depth over 48 hrs with 0 and 4 stones per 100 cm^2 (A) and variation in conductivity at 3" sediment depth over 48 hrs with 0 and 7 stones per 100 cm^2 (B).*

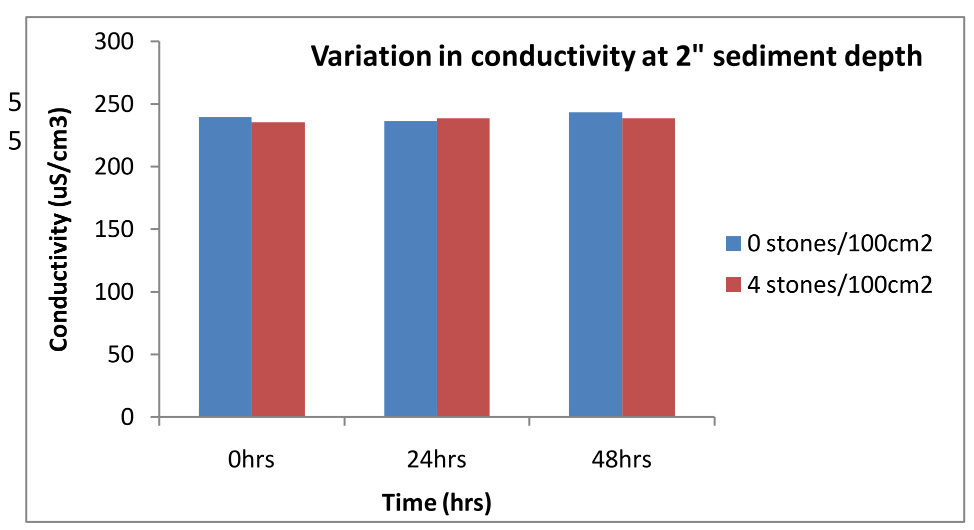
Gravel Volume and Distribution

Number of Stones pe	Matrix	Time (hours post stone addition)	Conductivity (uS/cm3)	Average conductivity (uS/cm3) of 0 stone density	% variation from 0 stone density	% variation from time 0
0	2" sediment	0hrs	240	240.0	0	0
0	2" sediment	24hrs	236.6		1.4	1.4
0	2" sediment	48hrs	243.5		1.4	1.5
4	2" sediment	0hrs	235.7		1.8	0
4	2" sediment	24hrs	239		0.4	1.4
4	2" sediment	48hrs	238.8		0.5	1.3
0	3" sediment	0hrs	236.5	238.2	0.7	0
0	3" sediment	24hrs	241.2		1.3	2.0
0	3" sediment	48hrs	236.9		0.5	0.2
7	3" sediment	0hrs	237.5		0.3	0
7	3" sediment	24hrs	252.7		6.1	6.4
7	3" sediment	48hrs	259.3		8.9	9
		Standard deviation	7.273629205			
0	water only	0	206.4	201.4		0
0	water only	24	201.3			2.5
0	water only	48	196.4			4.8
3	water only	0	207.7		3.1	0
3	water only	24	213.3		5.9	################################
3	water only	48	222.9		10.7	################################
5	water only	0	216.5		7.5	0
5	water only	24	221.7		10.1	2.4
5	water only	48	228.9		13.7	5.7
7	water only	0	210		4.3	0
7	water only	24	217.4		7.9	3.5
7	water only	48	220		9.2	4.8
		Standard deviation	9.519306538			

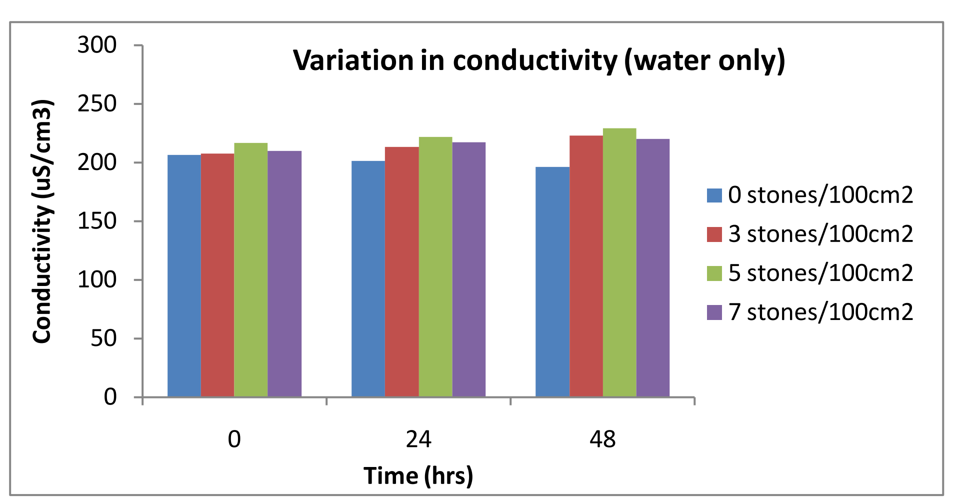
0 stones/100cm^2
3 stones/100cm^2
5 stones/100cm^2
7 stones/100cm^2

Gravel Volume and Distribution

5
5

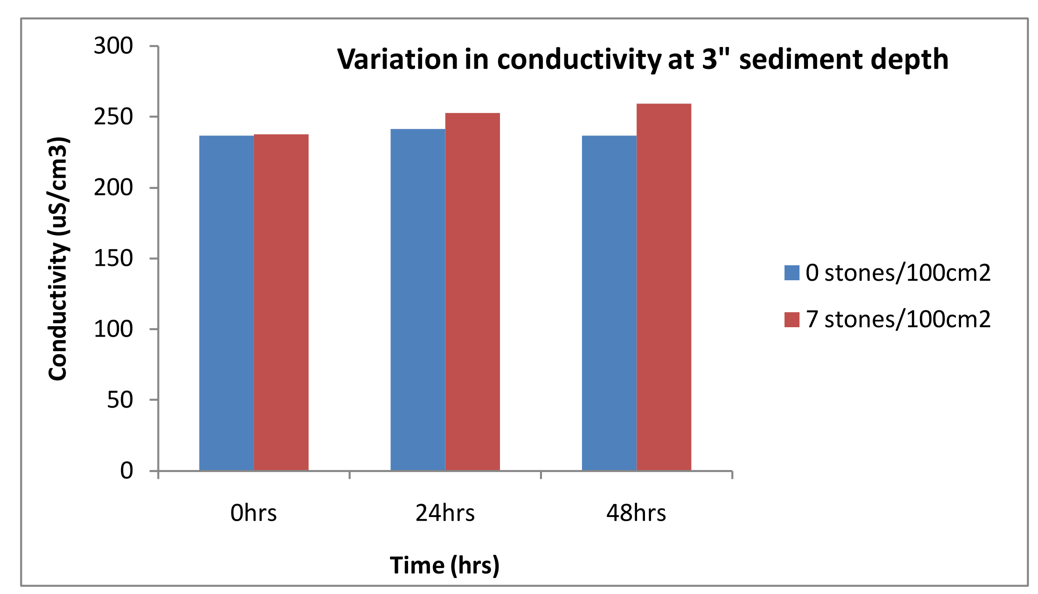


Variation in conductivity at 2" sediment depth over 48hrs with 0 and 4 stones per 100cm2



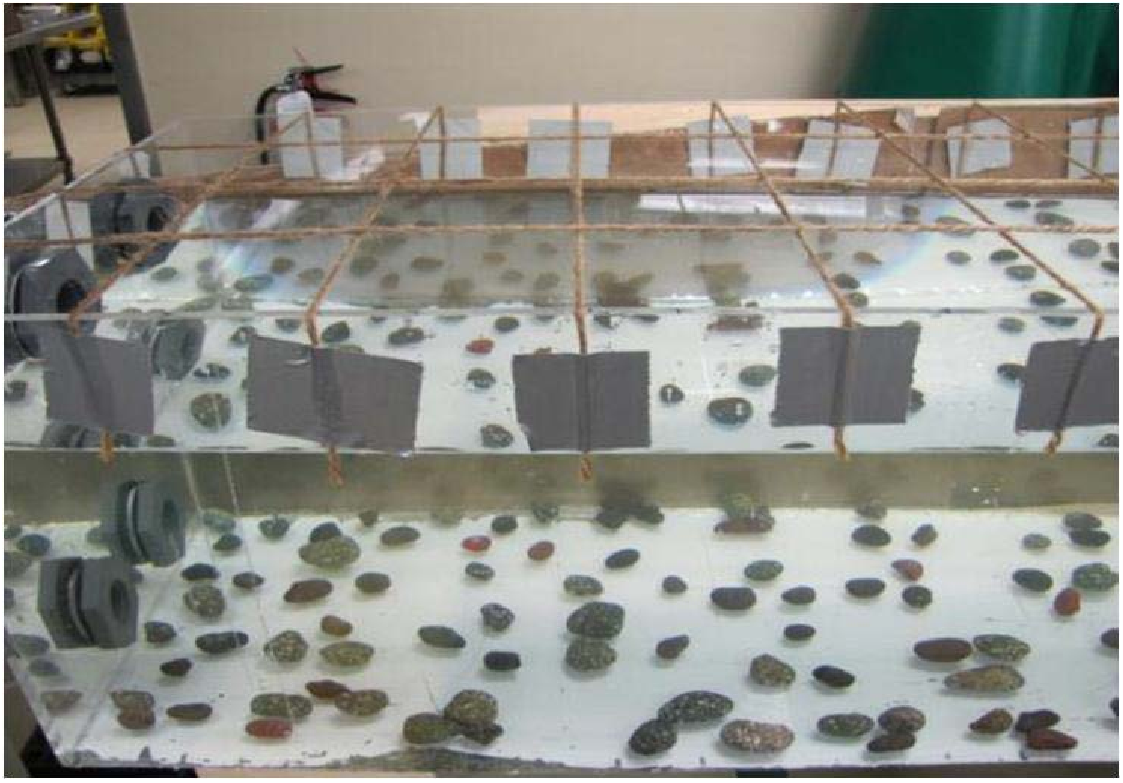
Variation in conductivity at 0, 3, 5 and 7 stones per 100cm2.

Gravel Volume and Distribution

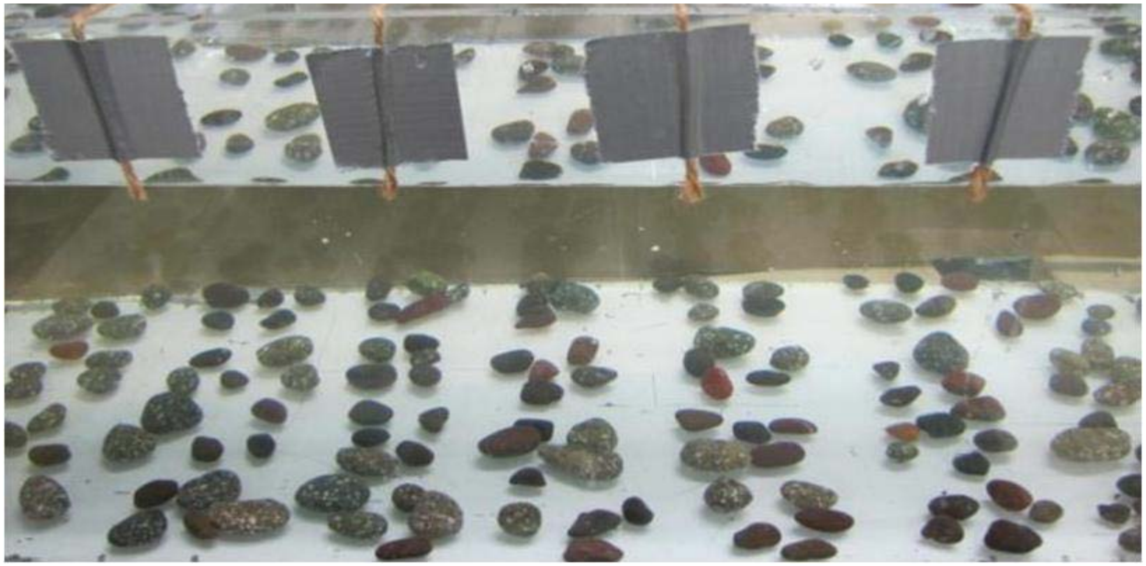


Variation in conductivity at 3" sediment depth over 48hrs with 0 and 7 stones per 100cm2

3 Rocks per 100cm2



5 Rocks per 100cm 2



7 Rocks per 100cm2

4 Rocks per 100cm2

Summary Data Report

Experiment #: 6 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Time to 'Steady-state' After Introduction of Test Sediments into the Test Chambers

Goal:

The objective is to identify the minimum period of time necessary for the exposure chamber to attain a steady-state based on basic water quality parameters. The objective of this work is not to attain steady-state conditions for chemicals of potential concern (COPCs); but rather, to ensure that non-COPCs do not adversely affect test results (i.e., introduce uncertainty) when organisms are introduced.

Experimental Design:

Basic water quality parameters were monitored in test chambers containing river sediment at 0, 12, 24, and 48 h, and every 48 h thereafter until steady state. Measurements included conductivity, dissolved oxygen (DO), ammonia, nitrate, colour, total dissolved solids (TDS), and pH at the inflow and outflow of the exposure chamber.

Decision Criteria:

'Steady-state' is attained when measured water quality parameters do not vary more than 10 percent from one measurement event to the next.

Results:

Over the course of the experiment values for temperature, dissolved oxygen, pH, and colour had no significant variability (greater than ±10 percent between measurement events) at either the inflow or outflow of the test chamber. Values for ammonia and nitrate had significant variability at both the inflow and outflow of the test chamber between measurement events. The measurements for conductivity, total dissolved solids (TDS), and dissolved organic carbon (DOC) are considered the most likely parameters to determine steady-state. Conductivity and TDS had no significant variability during the experiment. DOC did have variability during the experiment with measurements as high as 41.67% between the readings at 48 and 96 hours at the inflow and 21.43% at the outflow.

Conclusions:

Steady-state is achieved for temperature, conductivity, dissolved oxygen, pH, colour, and total dissolved solids within 48 hours. Ammonia and nitrate did not reach steady-state, but this is likely due to the natural variability of these measurements. DOC did not reach steady-state but the experiment is ongoing to determine if DOC measurements with variability below ±10 percent between measurement events can be achieved.

A Measured parameters at inflow over 96 hours

Inflow						
Hour	**Conductivity**		**TDS**		**DOC**	
		% Difference		% Difference		% Difference
0	176.6		118		1.9	
12	177.3	0.40				
24	178.8	0.85	119	0.85	1.3	46.15
48	177.6	0.68	121	1.68	1.2	8.33
96	181.5	2.20	129	6.61	1.7	41.67

B Measured parameters at outflow over 96 hours

Outflow						
Hour	**Conductivity**		**TDS**		**DOC**	
		% Difference		% Difference		% Difference
0	179.3		119		1.8	
12	176.9	1.36				
24	175.5	0.80	120	0.84	1.5	20.00
48	177.5	1.14	122	1.67	1.4	7.14
96	178.2	0.39	117	4.27	1.7	21.43

	Inflow				
Time (hrs)	Temp (°C)	% Difference	DO (mg/L)	DO (%)	% Difference
0	15.4		8.42	86.7	
12	15.9	3.246753247		90.5	4.382929642
24	16	0.628930818	8.39	85.5	5.847953216
48	15.7	1.910828025	8.8	88.5	3.50877193
96	16.1	2.547770701	8.9	90.6	2.372881356

Time (hrs)	Conductivity	% Difference	pH	% Differe	Colour
0	176.6		7.82		clear
12	177.3	0.396375991	7.98	2.04604	clear
24	178.8	0.846023689	7.82	2.04604	clear
48	177.6	0.675675676	7.98	2.04604	clear
96	181.5	2.195945946	7.98	0	clear

Time (hrs)	Ammonia (p	% Difference	Ammonia (p	% Differe	Nitrate (ppm NC	% Difference
0	0.04		0.048		0.25	
12	0.04	0	0.048	0	0.02	1150
24	0.04	0	0.048	0	0.5	2400
48	< 0.02	300	< 0.024	3900	0.25	100
96	0.02	100	0.04	1900	0.02	1150

Time (hrs)	Nitrate (ppm	% Difference	TDS (mg/L) DL =5	% Differe	DOC (mg/L) DL =0.2	% Difference
0	1.1		118		1.9	
12	1.1	0				
24	2.2	100	119	0.84746	1.3	46.15384615
48	1.1	100	121	1.68067	1.2	8.333333333
96	1.1	0	129	6.61157	1.7	41.66666667

Time (hrs)	Outflow Temp (°C)	% Difference	DO (mg/L)	DO (%)	% Difference
0	15.5		8.55	87	
12	15.7	1.290322581		90.7	4.252873563
24	15.3	2.614379085	8.56	87.1	4.133180253
48	15.7	2.614379085	8.89	88.9	2.066590126
96	15.9	1.27388535	8.79	90.8	2.137232846

Time (hrs)	Conductivity	% Difference	pH	% Differe	Colour
0	179.3		7.82		clear
12	176.9	1.3566987	7.95	1.6624	clear
24	175.5	0.797720798	7.8	1.92308	clear
48	177.5	1.13960114	7.94	1.79487	clear
96	178.2	0.394366197	7.99	0.62972	clear

Time (hrs)	Ammonia (p	% Difference	Ammonia (pp	% Difference
0	0.04		0.048	
12	0.04	0	0.048	0
24	0.04	0	0.048	0
48	< 0.02	300	< 0.024	300
96	0.02	100	0.24	1900

Time (hrs)	Nitrate (ppm	% Difference	Nitrate (ppm	% Difference
0	0.25		1.1	
12	0.25	0	1.1	0
24	0.25	0	1.1	0
48	0.25	0	1.1	0
96	0.02	1150	1.1	0

Time (hrs)	TDS (mg/L)	% Difference	DOC (mg/L)	% Difference
	5		0.2	
0	119		1.8	
12				
24	120	0.840336134	1.5	20
48	122	1.666666667	1.4	7.14286
96	117	4.273504274	1.7	21.4286

	Temp (°C)	DO (%)	DO (mg/L)	Conductivity (uS/cm)	pH
Day 2: 02/07/2010					
CONTROL					
Rep 1	15	87.1	8.69	176.4	7.71
Rep 2	15	87.9	8.87	175.1	7.91
Rep 3	14.9	87.4	8.85	175	7.96
DE	15.4	89	8.86	171.7	7.81
Rep 1	15.2	88.6	8.88	170.4	7.88
Rep 2	15	88	8.85	169.7	7.8
Rep 3					
H2O @ 5					
Rep 1	15	87.6	8.82	322	7.71
Rep 2	14.9	87.6	8.83	319	8.08
Rep 3	14.9	87.6	8.78	320	8.14
H2O @ 2					
Rep 1	15.5	87.4	8.7	174.8	7.86
Rep 2	15.5	87.7	8.74	173.9	7.87
Rep 3	15.6	87.2	8.68	173.9	7.84
Day 4: 04/07/2010					
CONTROL					
Rep 1	15.1	90.9	9.05	173.1	8.06
Rep 2	15.2	91.7	9.19	175.5	7.49
Rep 3	15.2	91.5	9.12	175.2	7.06
DE					
Rep 1	15.2	91.2	9.16	171	7.04
Rep 2	15.1	91.6	9.2	170	7.18
Rep 3	15.2	90.5	9.15	169.8	7.3
H2O @ 5					
Rep 1	15.1	90.5	9.05	322.6	7.59
Rep 2	15.2	89.9	9.02	321.9	8
Rep 3	15.2	89.2	8.02	320.8	8.1
H2O @ 2					
Rep 1	15.7	91	9.02	175.9	7.66
Rep 2	15.7	91.2	9.05	174.4	7.78
Rep 3	15.6	91.3	9.08	173.7	7.75
Day 8: 08/07/2010					
CONTROL					
Rep 1	15.3	92.4	9.28	174.2	7.43

Rep 2	15.2	92	9.24	176.3	7.88
Rep 3	15.4	93.1	9.31	176.4	7.76
DE					
Rep 1	15.2	92.4	9.28	174.2	7.43
Rep 2	15.2	92.2	9.26	172.3	7.67
Rep 3	15.2	92.1	9.25	172	7.8
H2O @ 5					
Rep 1	15	90	8.99	321.1	7.91
Rep 2	15.1	90.9	9.13	320.1	8.05
Rep 3	15.1	91.2	9.1	319.7	8.05
H2O @ 2					
Rep 1	15.5	92.8	9.18	173.6	7.72
Rep 2	15.6	92.4	9.19	173.1	7.48
Rep 3	15.5	92.2	9.2	172.8	7.48

	Temp (°C)	DO (%)	DO (mg/L)	Conductivity (uS/cm)	pH
Day 2: 02/07/2010					
CONTROL					
Rep 1	15	87.1	8.69	176.4	7.71
Rep 2	15	87.9	8.87	175.1	7.91
Rep 3	14.9	87.4	8.85	175	7.96
DE	15.4	89	8.86	171.7	7.81
Rep 1	15.2	88.6	8.88	170.4	7.88
Rep 2	15	88	8.85	169.7	7.8
Rep 3					
H2O @ 5					
Rep 1	15	87.6	8.82	322	7.71
Rep 2	14.9	87.6	8.83	319	8.08
Rep 3	14.9	87.6	8.78	320	8.14
H2O @ 2					
Rep 1	15.5	87.4	8.7	174.8	7.86
Rep 2	15.5	87.7	8.74	173.9	7.87
Rep 3	15.6	87.2	8.68	173.9	7.84
Day 4: 04/07/2010					
CONTROL					
Rep 1	15.1	90.9	9.05	173.1	8.06
Rep 2	15.2	91.7	9.19	175.5	7.49
Rep 3	15.2	91.5	9.12	175.2	7.06
DE					
Rep 1	15.2	91.2	9.16	171	7.04
Rep 2	15.1	91.6	9.2	170	7.18
Rep 3	15.2	90.5	9.15	169.8	7.3
H2O @ 5					
Rep 1	15.1	90.5	9.05	322.6	7.59
Rep 2	15.2	89.9	9.02	321.9	8
Rep 3	15.2	89.2	8.02	320.8	8.1
H2O @ 2					
Rep 1	15.7	91	9.02	175.9	7.66
Rep 2	15.7	91.2	9.05	174.4	7.78
Rep 3	15.6	91.3	9.08	173.7	7.75
Day 8: 08/07/2010					
CONTROL					
Rep 1	15.3	92.4	9.28	174.2	7.43

Rep 2	15.2	92	9.24	176.3	7.88
Rep 3	15.4	93.1	9.31	176.4	7.76
DE					
Rep 1	15.2	92.4	9.28	174.2	7.43
Rep 2	15.2	92.2	9.26	172.3	7.67
Rep 3	15.2	92.1	9.25	172	7.8
H2O @ 5					
Rep 1	15	90	8.99	321.1	7.91
Rep 2	15.1	90.9	9.13	320.1	8.05
Rep 3	15.1	91.2	9.1	319.7	8.05
H2O @ 2					
Rep 1	15.5	92.8	9.18	173.6	7.72
Rep 2	15.6	92.4	9.19	173.1	7.48
Rep 3	15.5	92.2	9.2	172.8	7.48

Summary Data Report

Experiment #: __7 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Determination of Most Efficient Cleaning Method Minimizing Re-Suspension of Sediments.

Goal:

Identify optimum cleaning techniques without utilization of invasive suction devices while employing large particle filters-with and without addition of diet (bloodworms, oligochaetes, semi-moist diet, and *Artemia*).

Experimental Design:

Food was introduced simulating three feeding event per day using *Artemia*, worms and semi-moist diet. At days 2, 3, 4, and 5 chambers were manually cleaned (daily) to remove as much biofilm as possible without significant re-suspension of sediments. At 5, 10, 20, and 30 minutes after each cleaning event, bottom near water samples (approximately 1 cm above the sediment surface) were taken as described in section 7.7.2.1 of the methods development QAPP (April 2010). Turbidity of samples as a measure of re-suspended matter was determined using light scattering methods as described in EPA Method 180.1 or Standard Method 2130B (Standard Method 1995).

Three different cleaning techniques were initially investigated at the beginning of the experiment:

1.) Siphoning the sediment surface with the use of a 3/8" ID hose.
2.) Scraping the sediment surface with the use of a plastic spatula.
3.) Pipetting debris with the use of a modified pipette.

After initial attempts it was decided that siphoning and scraping with a spatula were not appropriate methods of cleaning sediment surfaces as they were too invasive and ineffective, respectively.

Decision Criteria:

Optimum cleaning techniques were determined as a function of minimizing re-suspension of sediment and efficiency of cleaning as determined by measurements of turbidity. It is acknowledged that any type of physical removal of bio-growth will cause re-suspension to a certain degree, and the final method to be established will be a compromise between efficiency of cleaning and amount of sediment resuspended during the cleaning event.

Results:

1. Siphoning

Siphoning debris from the sediment surface was effective but was deemed too invasive as it removed and disturbed sediment in the process (siphoning video, cleaning techniques). Grains of sediment were removed from the chamber in the cleaning process. Past experience demonstrated an increased risk of fish injury as some organisms would be sucked into the cleaning tube. Turbidity analyses did not reveal any significant differences between pre-cleaning conditions or at any time period of up to 30 minutes post cleaning (Figure 1A). Investigation of siphoning as a cleaning method was discontinued after day 2.

2. Scrapping with a spatula

Scrapping with a spatula was ineffective. It was time consuming and once the debris was dislodged from the sediment surface it was difficult to remove from exposure chamber (spatula video, cleaning techniques). Turbidity analyses revealed an increase in turbidity 5 and 10 minutes post cleaning and decreasing there after (Figure 1B). Investigation of scrapping with a spatula as a cleaning method was discontinued after day 2.

3. Modified pipette

Pipetting the sediment surface to remove debris proved to be the most efficient and less invasive method. Biofilm and food could be easily dislodged from the sediment surface with minimal disturbance to sediment and effectively removed from the exposure chamber (modified pipette video, cleaning techniques). Turbidity analysis revealed no significant differences between pre-cleaning conditions or at any time period of up to 30 minutes post cleaning for the entirety of the experiment (day 2 -5), with the one exception at day 3, 10 minutes post cleaning (Figure 1C). Turbidity analyses at this time point revealed 0.6 NTU. This is considered to be a condition of other factors than cleaning techniques as all other turbidity results were within normal ranges throughout the 30 minute test. The possible introduction of foreign material during sampling could explain elevated turbidity levels at this time point.

Conclusions:

Cleaning by the use of a modified pipette allowed the technician to select unwanted debris and remove it from the exposure chamber with minimal disturbance to the sediment. In addition, the risk of injury to fish is minimized. Siphoning may prove effective when cleaning reservoirs or screens, but only when direct contact with fish and sediment is not involved. The aid of the spatula may prove useful in instances were biofilm is strongly adhere to surfaces, but it is our recommendation that the modified pipette be used as the primary cleaning method for sediment within the exposure chamber.

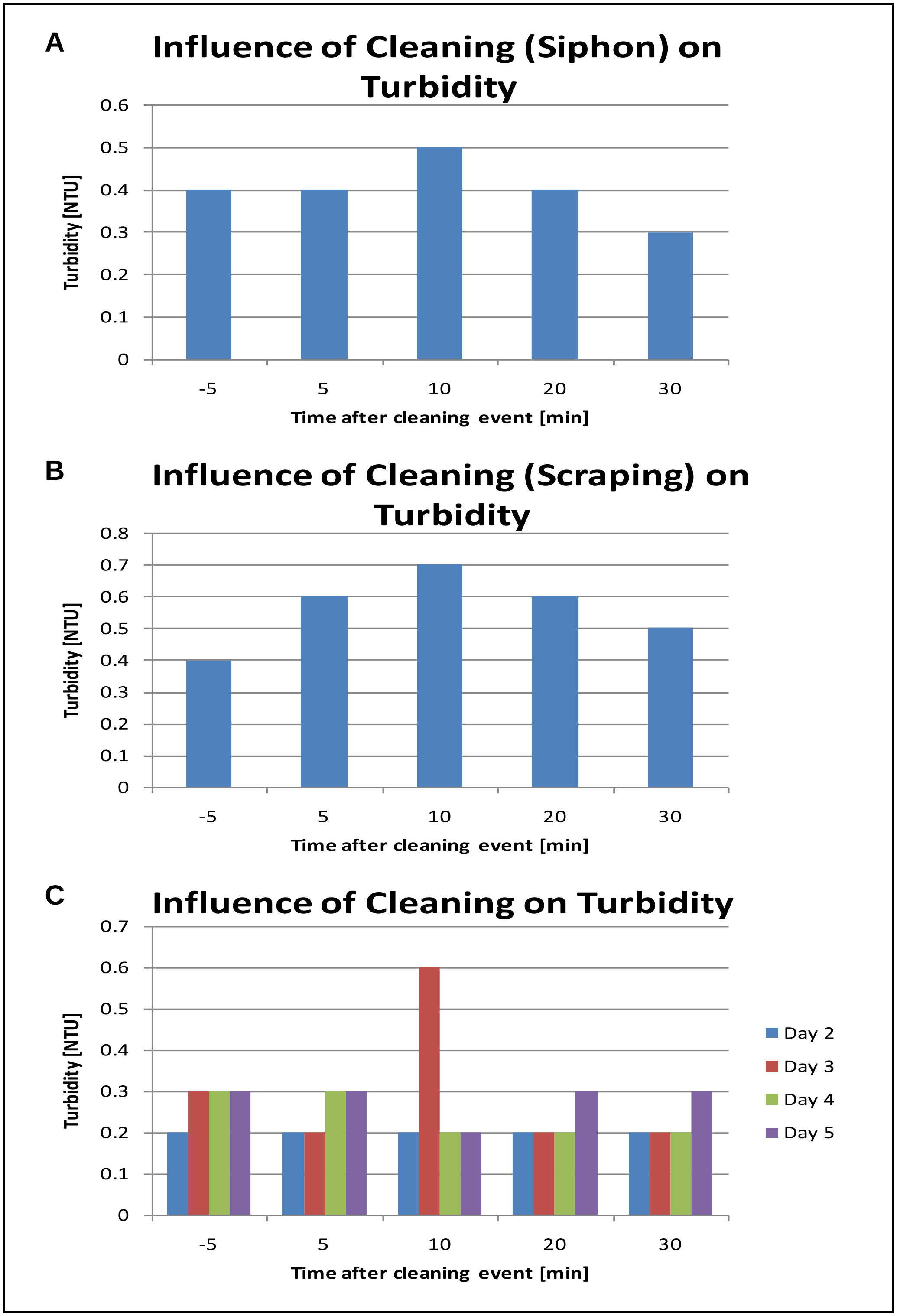


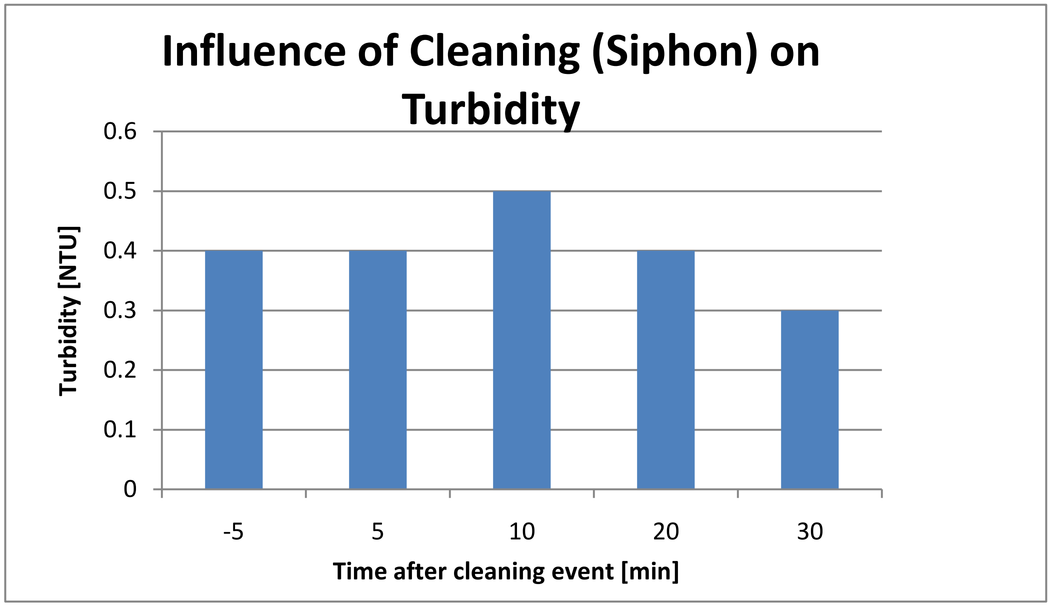
Figure 1: *Turbidity in surface water prior (-5 [minutes]) and after (5, 10, 20 and 30 [minutes]) addition of food to fluvial test chamber at days 2 (A, B, C), 3 (C), 4(C) and 5(C) after initiation of feeding routine as determined by nephelomety using different cleaning techniques (A: Siphoning; B: Scraping; C: Modified Pipette). NTU = Nephelometric Turbidity Units (NTU).*

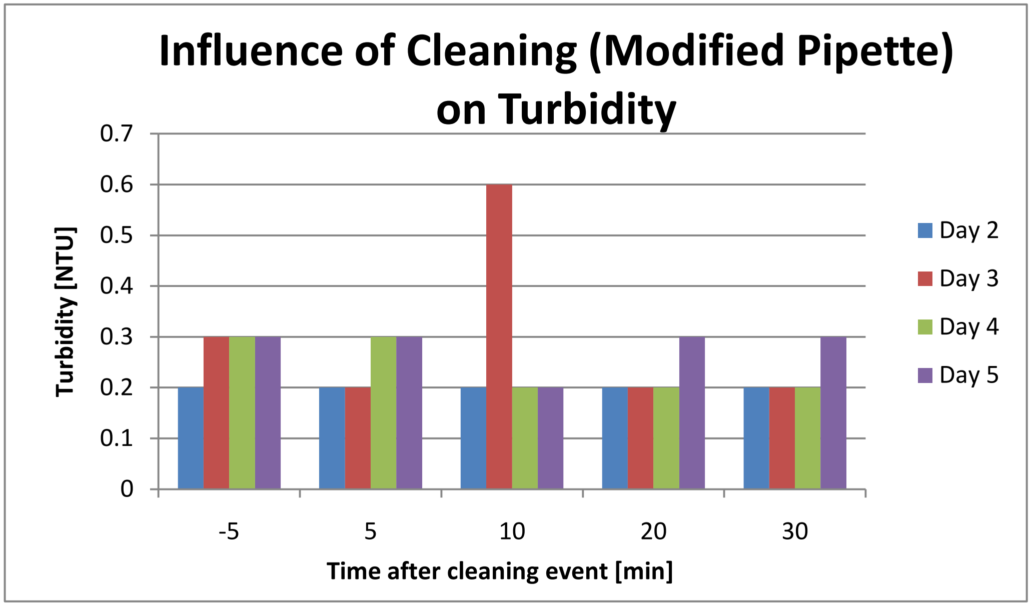
Cleaning Experiment DL: 0.1 NTU

Day	Time after cleaning (min)	Control (turbidity; NTU)	Feeding exposure: pipette method (turbidity; NTU)
2	-5		0.2
	5	0.3	0.2
	10		0.2
	20		0.2
	30	0.3	0.2
3	-5		0.3
	5	0.1	0.2
	10		0.6
	20		0.2
	30	0.1	0.2
4	-5		0.3
	5	0.2	0.3
	10		0.2
	20		0.2
	30	0.2	0.2
5	-5	0.1	0.3
	5	0.3	0.3
	10		0.2
	20		0.3
	30	0.2	0.3

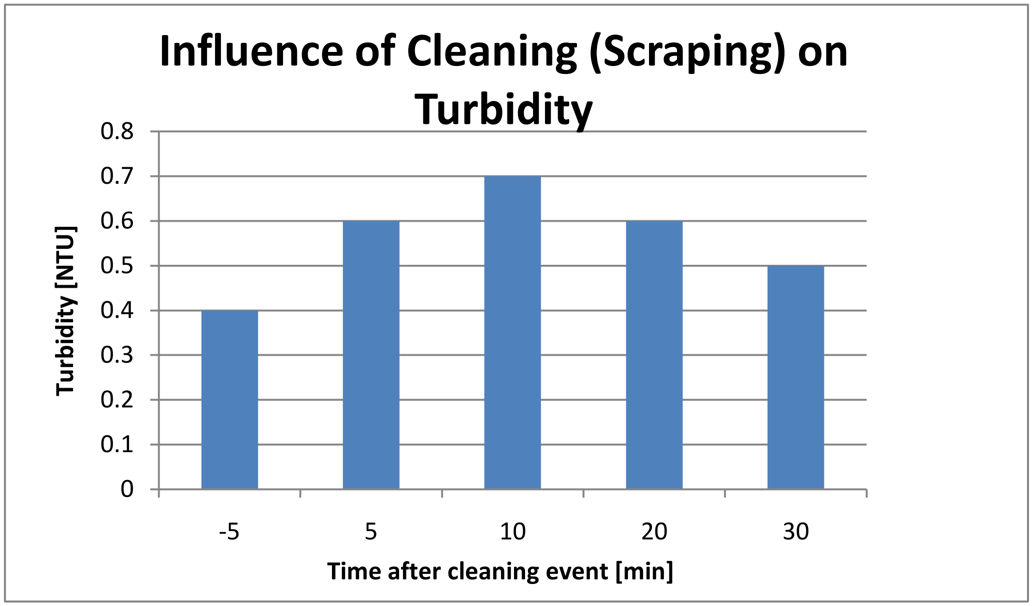
Day 2
Day 3
Day 4
Day 5

Feeding exposure: siphon method (turbidity; NTU)	Feeding exposure: spatula method (turbidity; NTU)
0.4	0.4
0.4	0.6
0.5	0.7
0.4	0.6
0.3	0.5





Influence of Cleaning (Modified Pipette) on Turbidity
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Turbidity [NTU]
-5
5
10
20
30
Time after cleaning event [min]
Day 2
Day 3
Day 4
Day 5



Influence of Cleaning (Scraping) on Turbidity
Turbidity [NTU]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
5
10
20
30
Time after cleaning event [min]

Summary Data Report

Experiment #: 8 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Artificial Laboratory Control Sediment

Goal:

The objective is to select a laboratory control sediment that has physical characteristics suitable for ELS of sturgeon and is comparable to sediments used historically in fish early life stage tests.

Experimental Design:

Several different silica sand and crushed/ground granites available from commercial vendors were considered. Sediments were layered into the test chamber and water quality parameters were assessed in comparison to average reference riverine sediment water quality parameters.

Decision Criteria:

Criteria used to select a suitable laboratory reference sediment were:

- Grain sizes between 0.5 and 2 mm in diameter
- Color similar to UCR sediments (preference for dark coloration)
- pH, dissolved oxygen, hardness, and alkalinity do not differ by more than 50 percent from average values determined for riverine sediments
- Certificate of analysis for contamination

Results:

Several different candidate sediments were selected including: Hagen Geosystem Black Fine Gravel (ART# 12648), Hagen Geosystem Extra Fine White River Gravel (ART# 12647), Hagen Geosystem Pacific Gravel (ART# 12404), Hagen Geosystem Black Beach Gravel (ART# 12418), Aquaterra Black Sand (#80035), Aquaterra Natural Tan Sand (#80075), and Pure Water Pebbles Cumberland River Gems (#30095). The Hagen Geosystem Black Fine Gravel (ART# 12648) was the only sediment that met both the grain size and color criteria and so was selected for further trials.

No certificate of analysis for contamination was available from the manufacturer so samples of the Black Fine Gravel were analyzed at Columbia Analytical Services (CAS). The Hagen Geosystem Black Fine Gravel did not exceed any of the screening ecological values (SEV; from the SLERA) for chemicals/metals analyzed. The Black Fine Gravel did not change water quality parameters in any significant (±50%) way compared to average water quality parameters found in test chambers with reference riverine sediments.

Upon analysis for percent gravel and percent sand, it was found that the two reference sediments (Ginelle and Lower Arrow Lake) were a gravelly sand with approximately 25% gravel content. Analysis by CAS shows that none of the chemicals/metals analyzed exceeded SEVs in any of the three reference sediments.

Conclusions:

The Hagen Geosystem Black Fine Gravel (ART #12648) is a suitable laboratory reference control sediment. This sediment is within the 0.5 to 2 mm grain size with an average grain size of 1.11 mm and a lowest and highest grain size of 0.85 mm and 1.68 mm, respectively. This sediment is predominantly dark in coloration and very similar in appearance to some riverine sediments of interest. This sediment did not change water quality parameters more than 10% compared to the average water quality parameters measured in test chambers with riverine sediments. Analysis by CAS shows this sediment to be free of contamination by all chemicals/metals analyzed.

All three of the reference sediments are suitable, as they are within the desired grain size, have an appropriate color, and are free of contamination.

Figure 1.0 Candidate Sediments: 1) Aquaterra Black Sand (#80035), 2) Pure Water Pebbles Cumberland River Gems (#30095), 3) Hagen Geosystem Pacific Gravel (ART# 12404), 4) Hagen Geosystem Black Fine Gravel (ART# 12648), 5) Aquaterra Natural Tan Sand (#80075), 6) Hagen Geosystem Extra Fine White River Gravel (ART# 12647)

Figure 2.0 Hagen Geosystem Black Fine Gravel (ART# 12648) selected for further trials. Grain size of 0.85 to 1.68 mm with an average grain size of 1.11 mm. Dark coloration similar to UCR sediments.

Table 1.0 Grain Size of Hagen Geosystem Black Fine Gravel (ART# 12648)

	Grain Size (mm)
	1.54
	0.89
	0.81
	1.58
	0.91
	0.98
	1.68
	0.85
	0.89
	0.97
Average =	1.11

Figure 3.0 Candidate reference sediment and river reference sediments. 1) Hagen Geosystem Black Fine Gravel (ART# 12648), 2) Deadman's Eddy, 3) Lower Arrow Lake, 4) Ginelle Eddy.

Figure 4.0 Hagen Geosystem Black Fine Gravel (ART# 12648) packaging (front).

Figure 4.1 Hagen Geosystem Black Fine Gravel (ART# 12648) packaging (back)

Table 2.0 Hagen Geosystem Black Fine Gravel (ART # 12648) Water Quality Parameters Compared to Reference Riverine Sediments

	Hour	pH		DO		Hardness		Alkalinity	
			% Dif.		% Dif.		% Dif.		% Dif.
	0	7.7	2.60	89	1.14	84	7.69	54	5.88
	24	7.5	5.33	85	3.53	74	5.41	48	6.25
Riverine Sediment (Average) WQ		7.9		88		78		51	

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001							LALL Composite 05/13/10 K1005430-002		Lab Reference Sediment Received at CAS 06/22/10 K1006419-001					
Parameter	Units	Basis	Primary		Duplicate		Triplicate			Primary		Primary		Duplicate		Triplicate	
Total Carbon	percent	Unfilt	0.106							0.089		3.95					
pH	SU	WW	6.29		6.41					6.27		9.28		9.35			
Sulfide	µmol/g	DW	0.06						ave	0.004	*U*	0.03					
Total Solids	percent	WW	85.7		88.6					86.2		100		100			
Cobbles	percent	DW	0		0		0			0		0		0		0	
Very Coarse Gravel	percent	DW	0	*12*	0	*37*	0	*25*	25	0	*29*	0	*0*	0	*0.1*	0	*0*
Coarse Gravel	percent	DW	0		0		0			0		0		0		0	
Medium Gravel	percent	DW	0		19.6		6.4			13.7		0		0		0	
Fine Gravel	percent	DW	7.4		11.6		10.3			6.57		0		0		0	
Very Fine Gravel	percent	DW	4.48		6.14		8.17			9.11		0		0.12		0	
Very Coarse Sand	percent	DW	11.5	*81*	8.88	*61*	13	*72*	71	12.7	*67*	6.98	*99*	10.7	*101*	9.21	*99*
Coarse sand	percent	DW	38.1		27.7		34.4			18.5		78.6		80.4		80	
Med. Sand	percent	DW	24.3		19.2		20.1			22.4		13.4		8.03		10	
Fine Sand	percent	DW	5.35		4.29		3.8			12		0.39		1.28		0.08	
Very fine sand	percent	DW	1.54		1.08		0.84			1.53		0.11		0.11		0.08	
Silt	percent	DW	0.55	0.6	0.24		0.21	0.2		0.67	0.7	0.32	0.3	0.17	0.2	0.24	0.2
Clay	percent	DW	0.45	0.5	0.35		0.26	0.3		0.39	0.4	0.31	0.3	0.27	0.3	0.18	0.2
Aluminum	mg/kg	Unfilt	2100		2860					2070		198		244			
Antimony	mg/kg	Unfilt	0.043		0.013					0.069		0.009	*U*	0.012			
Arsenic	mg/kg	Unfilt	2.47		1					0.52		1.01		1.17			
Barium	mg/kg	Unfilt	19.3		27					29.2		13.7		15.4			
Beryllium	mg/kg	Unfilt	0.11		0.12					0.1		0.07		0.07			
Cadmium	mg/kg	Unfilt	0.123		0.131					0.097		0.068		0.071			
Calcium	mg/kg	Unfilt	1170		1420					910		354000		355000			
Chromium	mg/kg	Unfilt	4.86		3.9					3.52		0.98		1.03			
Cobalt	mg/kg	Unfilt	1.6		2.3					1.3		0.4		0.5			
Copper	mg/kg	Unfilt	4.6		8.1					2.4		1.2		1.3			
Iron	mg/kg	Unfilt	5790		7140					5120		1160		2440			
Lead	mg/kg	Unfilt	5.62		5.95					6.1		7.27		7.5			
Magnesium	mg/kg	Unfilt	1560		2140					1160		10400		11900			
Manganese	mg/kg	Unfilt	77.4		90.7					56.3		96.3		98.8			
Mercury	mg/kg	Unfilt	0.002	*U*	0.002	*U*				0.002	*U*	0.005					
Molybdenum	mg/kg	DW										0.73		0.88			
Nickel	mg/kg	Unfilt	6.09		7.89					4.11		1.03		1.42			
Potassium	mg/kg	Unfilt	496		584					364		164		191			
Selenium	mg/kg	Unfilt	0.2	*U*	0.2	*U*				0.2	*U*	0.2	*U*	0.2	*U*		
Silver	mg/kg	Unfilt	0.03		0.036					0.021		0.025		0.025			
Sodium	mg/kg	Unfilt	47		54					32		29		30			
Thallium	mg/kg	Unfilt	0.037		0.027					0.044		0.063		0.07			
Vanadium	mg/kg	Unfilt	8.5		12.4					8.4		2.6		3.1			
Zinc	mg/kg	Unfilt	33.9		34					22.6		15.5		20.5			

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001			LALL Composite 05/13/10 K1005430-002	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001		
Parameter	Units	Basis	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate
Antimony	µmol/g	Unfilt	0.0048 *U*			0.0047 *U*	0.0041 *U*		
Arsenic	µmol/g	Unfilt	0.02 *U*			0.02 *U*	0.0036		
Cadmium	µmol/g	Unfilt	0.0005 *U*			0.0007	0.0003		
Chromium	µmol/g	Unfilt	0.0037			0.0055	0.003		
Copper	µmol/g	Unfilt	0.01			0.007	0.0045		
Lead	µmol/g	Unfilt	0.012			0.022	0.009		
Mercury	µmol/g	Unfilt	0.00005 *U*			0.00005 *U*	0.00004 *U*		
Nickel	µmol/g	Unfilt	0.007			0.004 *U*	0.002		
Zinc	µmol/g	Unfilt	0.089			0.051	0.0308		
2,4'-DDD	µg/kg	DW	0.13 *U*			0.13 *U*			
4,4'-DDD	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4'-DDE	µg/kg	DW	0.16 *U*			0.16 *U*			
4,4'-DDE	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4'-DDT	µg/kg	DW	0.058 *U*			0.058 *U*			
4,4'-DDT	µg/kg	DW	0.17 *U*			0.17 *U*			
2-Chlorobiphenyl	µg/kg	DW	1.2 *U*			1.2 *U*			
2,3-Dichlorobiphenyl	µg/kg	DW	0.13 *U*			0.13 *U*			
2,4'-Dichlorobiphenyl	µg/kg	DW	0.21 *U*			0.21 *U*			
2,2',5-Trichlorobiphenyl	µg/kg	DW	0.096 *U*			0.096 *U*			
2,3',4'-Trichlorobiphenyl	µg/kg	DW	0.11 *U*			0.11 *U*			
2,4,4'-Trichlorobiphenyl	µg/kg	DW	0.064 *U*			0.064 *U*			
2,4',5-Trichlorobiphenyl	µg/kg	DW	0.056 *U*			0.056 *U*			
3,4,4'-Trichlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,5'-Tetrachlorobiphenyl	µg/kg	DW	0.065 *U*			0.065 *U*			
2,2',4,5'-Tetrachlorobiphenyl	µg/kg	DW	0.058 *U*			0.058 *U*			
2,2',5,5'-Tetrachlorobiphenyl	µg/kg	DW	0.059 *U*			0.059 *U*			
2,3,3',4'-Tetrachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
2,3,4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.039 *U*			0.039 *U*			
2,3',4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,3',4',5-Tetrachlorobiphenyl	µg/kg	DW	0.051 *U*			0.051 *U*			
2,4,4',5-Tetrachlorobiphenyl	µg/kg	DW	0.044 *U*			0.044 *U*			
3,3',4,4'-Tetrachlorobiphenyl	µg/kg	DW	0.047 *U*			0.047 *U*			
3,4,4',5-Tetrachlorobiphenyl	µg/kg	DW	0.05 *U*			0.05 *U*			
2,2',3,4,5'-Pentachlorobiphenyl	µg/kg	DW	0.038 *U*			0.038 *U*			
2,2',3,4',5'-Pentachlorobiphenyl	µg/kg	DW	0.053 *U*			0.053 *U*			
2,2',3,4',5-Pentachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,2',3,5',6-Pentachlorobiphenyl	µg/kg	DW	0.049 *U*			0.049 *U*			
2,2',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.045 *U*			0.045 *U*			
2,2',4,5,5'-Pentachlorobiphenyl	µg/kg	DW	0.049 *U*			0.049 *U*			
2,3,3',4,4'-Pentachlorobiphenyl	µg/kg	DW	0.033 *U*			0.033 *U*			
2,3,3',4',6-Pentachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,3,4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.023 *U*			0.023 *U*			
2,3',4,4',5'-Pentachlorobiphenyl	µg/kg	DW	0.067 *U*			0.067 *U*			
2,3',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,3',4,4',6-Pentachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
3,3',4,4',5-Pentachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',3,3',4,4'-Hexachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,2',3,3',4,6'-Hexachlorobiphenyl	µg/kg	DW	0.075 *U*			0.075 *U*			
2,2',3,4,4',5'-Hexachlorobiphenyl	µg/kg	DW	0.064 *U*			0.064 *U*			
2,2',3,4,5,5'-Hexachlorobiphenyl	µg/kg	DW	0.035 *U*			0.035 *U*			
2,2',3,4',5',6-Hexachlorobiphenyl	µg/kg	DW	0.067 *U*			0.067 *U*			
2,2',3,5,5',6-Hexachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.038 *U*			0.038 *U*			
2,3,3',4,4',5'-Hexachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,3,3',4,4',5-Hexachlorobiphenyl	µg/kg	DW	0.042 *U*			0.042 *U*			
2,3,3',4,4',6-Hexachlorobiphenyl	µg/kg	DW	0.028 *U*			0.028 *U*			
2,3',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.046 *U*			0.046 *U*			
2,3,4,4',5,6-Hexachlorobiphenyl	µg/kg	DW	0.03 *U*			0.03 *U*			
2,3',4,4',5',6-Hexachlorobiphenyl	µg/kg	DW	0.027 *U*			0.027 *U*			
3,3',4,4',5,5'-Hexachlorobiphenyl	µg/kg	DW	0.041 *U*			0.041 *U*			
2,2',3,3',4,4',5-Heptachlorobiphenyl	µg/kg	DW	0.026 *U*			0.026 *U*			
2,2',3,3',4,5,6'-Heptachlorobiphenyl	µg/kg	DW	0.03 *U*			0.03 *U*			

Preliminary laboratory results from CAS, as received on July 7, 2010

			GE Composite 05/12/10 K1005430-001			LALL Composite 05/13/10 K1005430-002	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001		
Parameter	Units	Basis	Primary	Duplicate	Triplicate	Primary	Primary	Duplicate	Triplicate
2,2',3,3',4,5',6'-Heptachlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,4,4',5,5'-Heptachlorobiphenyl	µg/kg	DW	0.095 *U*			0.095 *U*			
2,2',3,4,4',5',6-Heptachlorobiphenyl	µg/kg	DW	0.081 *U*			0.081 *U*			
2,2',3,4,4',6,6'-Heptachlorobiphenyl	µg/kg	DW	0.052 *U*			0.052 *U*			
2,2',3,4',5,5',6-Heptachlorobiphenyl	µg/kg	DW	0.047 *U*			0.047 *U*			
2,3,3',4,4',5,5'-Heptachlorobiphenyl	µg/kg	DW	0.029 *U*			0.029 *U*			
2,2',3,3',4,4',5,5'-Octachlorobiphenyl	µg/kg	DW	0.043 *U*			0.043 *U*			
2,2',3,3',4,4',5,6-Octachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
2,2',3,3',4,5',6,6'-Octachlorobiphenyl	µg/kg	DW	0.041 *U*			0.041 *U*			
2,2',3,4,4',5,5',6-Octachlorobiphenyl	µg/kg	DW	0.039 *U*			0.039 *U*			
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	µg/kg	DW	0.031 *U*			0.031 *U*			
Decachlorobiphenyl (PCB 209)	µg/kg	DW	0.041 *U*			0.041 *U*			

Preliminary laboratory results from CAS compared to sediment screening criteria[a]

Parameter	Units	Basis	Sediment Screening SEV	Exceedance	GE Composite 05/12/10 K1005430-001 Primary	GE Composite Duplicate	GE Composite Triplicate	LALL Composite 05/13/10 K1005430-002 Primary	Lab Reference Sediment Received at CAS 06/22/10 K1006419-001 Primary	Lab Reference Duplicate	Lab Reference Triplicate
Antimony	mg/kg	Unfilt	0.40	No	0.043	0.013		0.069	0.009 *U*	0.012	
Arsenic	mg/kg	Unfilt	9.79	No	2.47	1		0.52	1.01	1.17	
Beryllium	mg/kg	Unfilt	0.46	No	0.11	0.12		0.1	0.07	0.07	
Cadmium	mg/kg	Unfilt	0.99	No	0.123	0.131		0.097	0.068	0.071	
Chromium	mg/kg	Unfilt	43.4	No	4.86	3.9		3.52	0.98	1.03	
Copper	mg/kg	Unfilt	31.6	No	4.6	8.1		2.4	1.2	1.3	
Lead	mg/kg	Unfilt	35.8	No	5.62	5.95		6.1	7.27	7.5	
Mercury	mg/kg	Unfilt	0.18	No	0.002 *U*	0.002 *U*		0.002 *U*	0.005		
Nickel	mg/kg	Unfilt	22.7	No	6.09	7.89		4.11	1.03	1.42	
Silver	mg/kg	Unfilt	0.545	No	0.03	0.036		0.021	0.025	0.025	
Zinc	mg/kg	Unfilt	121	No	33.9	34		22.6	15.5	20.5	
4,4'-DDD	µg/kg	DW	96	No	0.11 *U*			0.11 *U*			
Total DDD (all ND, max DL shown)	µg/kg	DW	4.88	No	0.13 *U*			0.13 *U*			
4,4'-DDE	µg/kg	DW	21	No	0.11 *U*			0.11 *U*			
Total DDE (all ND, max DL shown)	µg/kg	DW	3.16	No	0.16 *U*			0.16 *U*			
4,4'-DDT	µg/kg	DW	19	No	0.17 *U*			0.17 *U*			
Total DDT (all ND, max DL shown)	µg/kg	DW	4.16	No	0.17 *U*			0.17 *U*			
Total DDx (all ND, max DL shown)	µg/kg	DW	5.28	No	0.17 *U*			0.17 *U*			
Total PCBs (all ND, max DL shown)	µg/kg	DW	59.8	No	1.2 *U*			1.2 *U*			

[a] - Results received from CAS as of July 7, 2010.

Appendix B Field reports for collection of reference sediments

MEMORANDUM

TO:	Marko Adzic, Teck American Incorporated
FROM:	Jeffrey E. Leppo, LG
DATE:	June 30, 2010
FILE:	36310054.00001
SUBJECT:	Field Report and Records – Methods Development for the White Sturgeon Sediment Toxicity Study Sediment Sampling, British Columbia, Canada

Introduction

URS Incorporated (URS) conducted field services for Teck American Incorporated (Teck) on the Columbia River (CR) at Birchbank Eddy (BBE), Genelle (GE), and Lower Arrow Lake (LALL) sediment sampling locations in British Columbia, Canada on May 12 and 13, 2010. The field services scope of work was based on the requirements and standard operating procedures (SOP) outlined within the *Quality Assurance Project Plan – Methods Development for the White Sturgeon Sediment Toxicity Study* (QAPP) prepared for Teck in April 2010.

Field records attached to this memorandum include:

- Photographs of the locations, general sampling procedures, and grab samples
- Field Data/Sampling Diary sheets for each sample location and station
- Photocopy of the hard-bound Environmental Field Book daily record
- Chain-of-custody for May 12 and 13, 2010 grab samples

Scope of Work

Three below-water sediment sampling locations and coordinates are identified in the QAPP, including BBE, GE, and LALL located above Trail, British Columbia. Each of the three general sample locations was accessed by boat and positioned for sediment grab sampling by Gravity Environmental, Inc. (Gravity) based on the QAPP coordinates. The longitude and latitude coordinates for each grab sample station were marked using the sample boat's global positioning system (GPS) and recorded on the individual field data/sampling diaries. Table 1 presents coordinates of each grab sample location. Sediment sample locations are shown in Map 1.

All sediment samples were collected using a decontaminated compressed air operated Power Grab sampler. Sediment was collected as ten grab samples at each general location and transferred to five-gallon decontaminated polyethylene buckets; dependent on the river bottom composition and sample recovery. Unique sample numbers and tags were assigned based on QAPP SOP-4 instructions.

Photographs of each location, sample procedures, and grab samples were taken and are sequentially identified using a white board to record pertinent information (e.g., time, date, and location) within Attachment A. Typical sampling activities and sediments collected during this event are presented in Figures 1 through 15.

Individual photo files are labeled with the name of the station and a sequential number within the photographic directory for each of the three locations, as follows:

Birchbank Eddy – BBE_001 to BBE_021
Genelle – GE_001 to GE_045
Lower Arrow Lake – LALL_001 to LALL_035

Field data and sampling diary sheets were prepared for each grab sample (Attachment B). Field sampling diaries include observations on the weather, time, latitude and longitude, water depth, sediment texture and characteristics, photograph record, abnormalities, and other relevant notes. A bound environmental field book (Attachment C) was used to record general information regarding project personnel, activities, and operations.

Field Observations

Ten competent grab samples (five gallons each) were obtained from both the Genelle and Lower Arrow Lake locations; for a total of 20 grab samples. The river bottom composition of the Birchbank Eddy was primarily composed of cobble and boulder-sized material. Three attempts were made to collect sediments at this location; unfortunately, the presence of a course substrate precluded the recovery of a suitable fine to coarse sand matrix. Please refer to the Birchbank Eddy photos and field diary for reference.

Grab samples were transported to shore and relinquished under chain-of-custody protocol to Dr. Markus Hecker (Principal Investigator) and representatives of the University of Saskatchewan, Aquatic Exposure Laboratory. Samples were placed in a refrigerated truck maintained to approximately 4° C and transported to the University of Saskatchewan. Please refer to Attachment D for the chain-of custodies.

Deviations and Corrective Actions

The presence of a cobble and boulder river bottom cover precluded the ability to collect a competent sample from the Birchbank Eddy location.

No other reportable deviations, contingencies, or corrective actions required for this project phase as defined by the QAPP or SOPs.

Attachments:

Table 1:	Sample Coordinates
Map 1:	Sediment Sample Locations
Figures 1-15:	Site Photographs
Attachment A:	Photographic Record
Attachment B:	Field Data/Sampling Diaries
Attachment C:	Environmental Field Book
Attachment D:	Chain-of-Custodies

Table 1
Sample Numbers and Coordinates
Methods Development - White Sturgeon Sediment Toxicity Study
Upper Columbia River - Birchbank Eddy, Genelle, and Lower Arrow Lake (Canada)

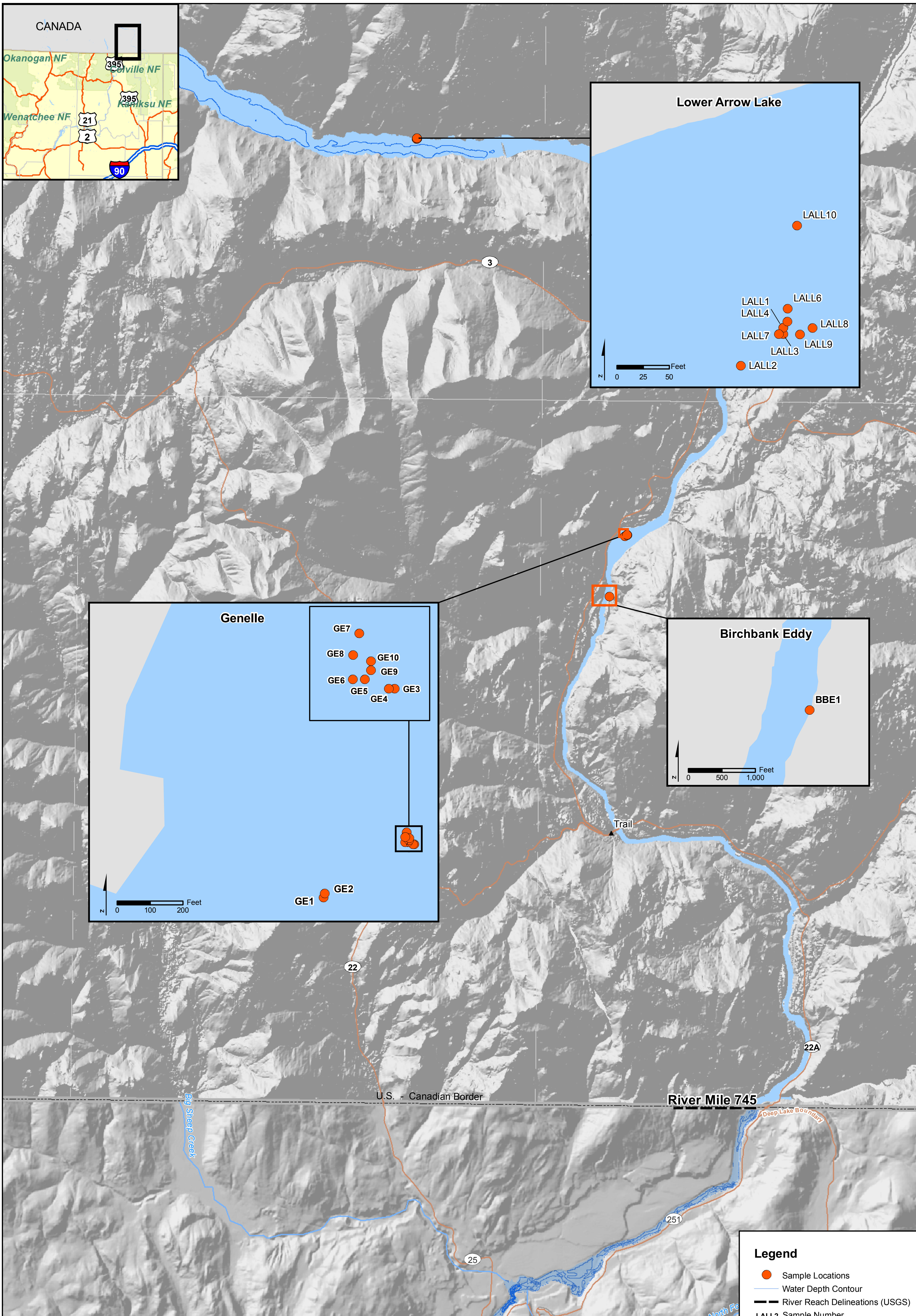
Site Name	Sample No.	Container Tag No.	Northing (UTM) [(2)]	Easting (UTM)
Birchbank Eddy	TAI-CAN-BBE-1-PG-1	N/A[1]	5447789.379	448050.484
Genelle	TAI-CAN-GE-1-PG-1	GE1	5450155.375	448668.936
Genelle	TAI-CAN-GE-1-PG-2[3]	GE2	5450159.069	448670.185
Genelle	TAI-CAN-GE-1-PG-3	GE3	5450204.621	448753.173
Genelle	TAI-CAN-GE-1-PG-4	GE4	5450204.632	448751.959
Genelle	TAI-CAN-GE-1-PG-5	GE5	5450206.530	448747.120
Genelle	TAI-CAN-GE-1-PG-6	GE6	5450206.553	448744.692
Genelle	TAI-CAN-GE-1-PG-7	GE7	5450215.805	448745.992
Genelle	TAI-CAN-GE-1-PG-8[3]	GE8	5450211.445	448744.760
Genelle	TAI-CAN-GE-1-PG-9	GE9	5450208.371	448748.352
Genelle	TAI-CAN-GE-1-PG-10	GE10	5450210.224	448748.369
Lower Arrow Lake	TAI-CAN-LALL-1-PG-1	LALL1	5465801.313	440479.821
Lower Arrow Lake	TAI-CAN-LALL-1-PG-2	LALL2	5465790.327	440467.594
Lower Arrow Lake	TAI-CAN-LALL-1-PG-3	LALL3	5465799.460	440479.801
Lower Arrow Lake	TAI-CAN-LALL-1-PG-4	LALL4	5465801.313	440479.821
Lower Arrow Lake	TAI-CAN-LALL-1-PG-5	LALL5	5465803.152	440481.052
Lower Arrow Lake	TAI-CAN-LALL-1-PG-6	LALL6	5465806.858	440481.092
Lower Arrow Lake	TAI-CAN-LALL-1-PG-7	LALL7	5465799.473	440478.590
Lower Arrow Lake	TAI-CAN-LALL-1-PG-8	LALL8	5465801.221	440488.296
Lower Arrow Lake	TAI-CAN-LALL-1-PG-9	LALL9	5465799.407	440484.644
Lower Arrow Lake	TAI-CAN-LALL-1-PG-10	LALL10	5465830.918	440483.775

Notes:

(1) Sample could not be collected because river bottom comprised of cobbles and boulders

(2) Coordinates based on Universal Transverse Mercator (UTM) using North American Datum of 1983 (NAD83), Zone 11

(3) Sample coordinates miss-recorded in field. Presented UTM coordinates have been corrected.



Sediment Sample Locations

Km: 0 2.5 5
Miles: 0 1.5 3
N

URS Corporation

Source:
GIS base layer Information provided by Parametrix Inc.

Map 1 **Methods Development for the White Sturgeon Sediment Toxicity Study (Birchbank Eddy, Genelle, and Lower Arrow Lake)**
Upper Columbia River, Canada

FIGURES 1 through 15
Site Photographs

Figure 1
Photograph of Birchbank Eddy Station, view to north. Note cobbley river bottom.

Figure 2
Deployment of the Power Grab sediment sampling device, Birchbank Eddy Station, view to the north.

Figure 3
Retrieval of Power Grab sediment sample at Birchbank Eddy Station, view to the north.

Figure 4
Poor recovery at Birchbank Eddy Station. Note cobbles and absence of finer sediment material.

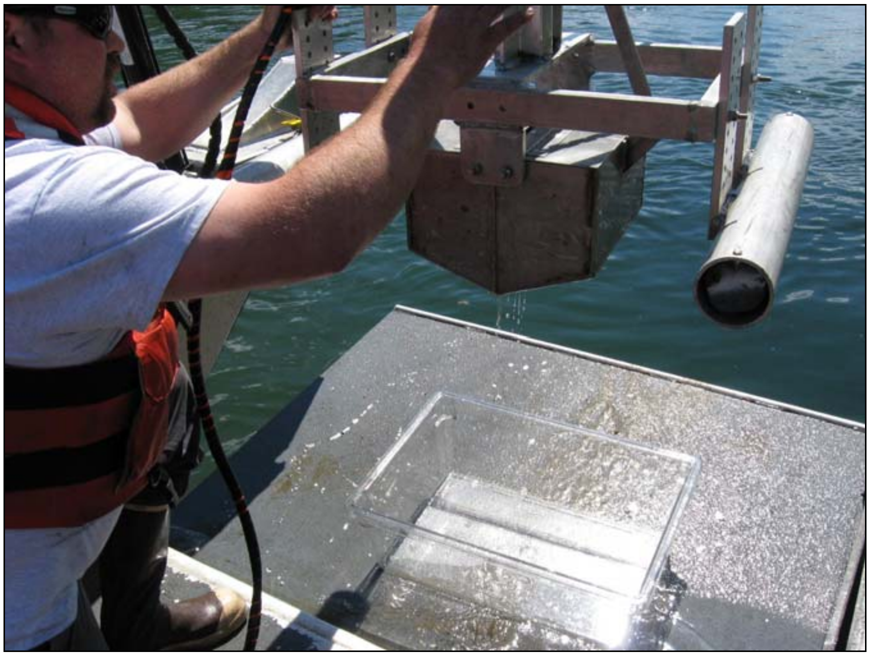


Figure 5
Preparing to deposit Power Grab sediment grab sample into sample tray at the Genelle Station.

Figure 6
Sediment grab sample following placement in sample tray at the Genelle Station.

Figure 7
Close-up view of Genelle Station sediment grab sample.

Figure 8
Transfering Genelle Station sediment grab sample from sample tray.

Figure 9
Sediment grab sample number GE4 following placement in sample container, Genelle Station.

Figure 10
Shoreline at Genelle Station, view toward east.

Figure 11
Shoreline at Genelle Station, view to southeast.

Figure 12
Sediment grab sample number LALL2 in sample tray, Lower Arrow Lake Station

Figure 13
Sediment grab sample number LALL4 in sample tray, Lower Arrow Lake Station

Figure 14
Close-up of grab sample number LALL4 in sample tray, Lower Arrow Lake Station

URS

Figure 15
Shoreline at Lower Arrow Lake Station, view to northeast

ATTACHMENT A
Photographic Record
Provided on Compact Disc (CD)

URS

ATTACHMENT B
Field Data/Sampling Diaries

URS

Birchbank Eddy

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE ✓	GE	LALL
DATE:	5/12/2010		
WEATHER CONDITIONS:	Sunny, clear, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:	No sample. No fine to coarse grain sands.		

Station Reference UTM Coordinates

Lat ~~Easting:~~	46 10.843
Long ~~Northing:~~	117 42.771

Sample No.	TAI-CAN-BBE-1-PG-1
Container Tag No.	NA
Time	12:39
UTM Easting	See Above
UTM Northing	"
Field Photo No.	UCR Birchbank Eddy
Camera Image No.	BBE_001 to BBE_021, Photo sequence < Sample Area
Water Depth (cm)	229 (7.5 ft)
Sampler Depth Penetration (cm)	2 to 5 cm
Sediment Texture (ASTM/Unified)	GW, well graded gravels w/ cobbles & boulders, little to no fines or sand
Sediment Color (~~Munsell~~)	Variable matrix parent material & colors
Odors	No odors
Leakage Disturbance	Very poor recovery - unable to close sampler
Abnormalities	(1) Freshwater clam
Other Notes	Cobble to boulder sized material as river bottom. Sand limited to matrix intercies.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5/19/2010

Time: 16:00

Genelle

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE	
STATION CODE:	BBE	GE ✓	LALL	
DATE:	5 / 12 /2010			
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F			
SEDIMENT SAMPLER TYPE:	Power Grab			
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo			
Other Notes:				

Station Reference UTM Coordinates

Lat ~~Easting~~:	49 12.123
Long ~~Northing~~:	117 42.280

Sample No.	TAI-CAN-GE-1-PG-1
Container Tag No.	GE1
Time	1330
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE001 to GE_006, Photo sequence - sampling, sample
Water Depth (cm)	179 (5.8 ft)
Sampler Depth Penetration (cm)	15 (5 to 6 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Minimal visible organic material - small wood particles on surface - removed as feasible

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:02

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 2	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 10.125
Long ~~Northing:~~	117 42.279

Sample No.	TAI-CAN-GE-1-PG - 2
Container Tag No.	GE2
Time	1400
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_007 to GE_011
Water Depth (cm)	162 (5.3 ft)
Sampler Depth Penetration (cm)	15 (5 to 6 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels to large
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery - cobbles present
Abnormalities	Small roots
Other Notes	Increase in visible organic matter - roots removed, as feasible. Move to center of eddy for next sample based on field observations. Few cobbles.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:06

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 3	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE: 5 / 12 /2010			
WEATHER CONDITIONS: Clear, sunny, 65 to 70 °F			
SEDIMENT SAMPLER TYPE: Power Grab			
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo			
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 12.150
Long ~~Northing:~~	117 42.211

Sample No.	TAI-CAN-GE-1-PG-3
Container Tag No.	GE3
Time	1450
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_012 to GE_016
Water Depth (cm)	180 (5.9ft)
Sampler Depth Penetration (cm)	23 (8 to 10in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Good sample located close to middle of eddy. Little to no visible organic matter. Good place for remaing grab samples

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:07

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 4	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 12.150
Long	~~Northing:~~	117 42.212

Sample No.	TAI-CAN-GE-1-PG-4
Container Tag No.	GE4
Time	1508
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_017 to GE_021
Water Depth (cm)	192 (6.3 ft)
Sampler Depth Penetration (cm)	27 (10 to 11 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 1908

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 5	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE	
STATION CODE:	BBE	GE ✓	LALL	
DATE: 5/12/2010				
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F			
SEDIMENT SAMPLER TYPE:	Power Grab			
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo			
Other Notes:				

Station Reference UTM Coordinates

Lat ~~Easting~~:	49 12.151
Long ~~Northing~~:	117 42.216

Sample No.	TAI-CAN-GE-1-PG-5
Container Tag No.	GE5
Time	1514
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR GENELLE
Camera Image No.	GE_022 to GE_024
Water Depth (cm)	228 (7.5 ft)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5/19/2010

Time: 19:10

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 6	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, Sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 12.151
Long ~~Northing:~~	117 42.218

Sample No.	TAI-CAN-GE-1-PG-6
Container Tag No.	GE6
Time	1522
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_025 to GE_027
Water Depth (cm)	177 (5.8ft)
Sampler Depth Penetration (cm)	28 (11in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:12

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 7	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat, ~~Easting:~~	49 12.156
Long ~~Northing:~~	117 42.217

Sample No.	TAI-CAN-GE-1-PG - 7
Container Tag No.	GE7
Time	1535
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_031
Water Depth (cm)	182 (6.0 ft.)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Dark gray stringers w/in grayish brown color matrix. Possible evidence of different depositions or disturbance (natural)

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:4

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 8	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE	
STATION CODE:	BBE	GE ✓	LALL	
DATE: 5 / 12 /2010				
WEATHER CONDITIONS: Clear, sunny, 70°F				
SEDIMENT SAMPLER TYPE: Power Grab				
URS FIELD PERSONNEL: Gary Panther, Jeff Leppo				
Other Notes:				

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 12.066
Long ~~Northing:~~	117 42.128

Sample No.	TAI-CAN-GE-1-PG-8
Container Tag No.	GE8
Time	1541
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_032
Water Depth (cm)	204 (6.7 ft.)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:17

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 9	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE ✓	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 70 to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

~~Easting:~~ Lat	49 12.152
~~Northing:~~ Long	117 42.215

Sample No.	TAI-CAN-GE-1-PG-9
Container Tag No.	GE9
Time	1548
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR-Genelle
Camera Image No.	GE_033
Water Depth (cm)	179 (5.9 ft)
Sampler Depth Penetration (cm)	20 (8 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:19

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 10	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL
DATE:	5 / 12 /2010		
WEATHER CONDITIONS:	Clear, sunny, 70-75°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 12.153
Long	~~Northing:~~	117 42.215

Sample No.	TAI-CAN-GE-1-PG-10
Container Tag No.	GE10
Time	1555
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Genelle
Camera Image No.	GE_028 to GE_030, also GE_034 to GE_045, Area + core
Water Depth (cm)	192 (6.3 ft)
Sampler Depth Penetration (cm)	25 (10 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Grayish brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	No visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:13

Lower Arrow Lake

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 1	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE ✓	
STATION CODE:	BBE	GE	LALL	
DATE:	5 / 13 /2010			
WEATHER CONDITIONS:	Clear, sunny, 60 to 65 °F			
SEDIMENT SAMPLER TYPE:	Power Grab			
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo			
Other Notes:				

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.522
Long ~~Northing:~~	117 49.164

Sample No.	TAI-CAN-LALL-1-PG-1
Container Tag No.	LALL1
Time	0940
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_01 to LALL_012, Photo Sequence of sampling & sample
Water Depth (cm)	207 (6.8 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	No odors
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Some organic matter/litter on surface, overlying sand sediment

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 17:20

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 2	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting~~:	49 20.516
Long	~~Northing~~:	117 49.174

Sample No.	TAI-CAN-LALL-1-PG - 2
Container Tag No.	LALL2
Time	0950
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_013 & LALL_014
Water Depth (cm)	210 (6.9 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Limited organic matter / litter on sediment surface. Good sand samples.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:21

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 3	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5/13/2010		
WEATHER CONDITIONS:	Clear, Sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.521
Long ~~Northing:~~	117 49.164

Sample No.	TAI-CAN-LALL-1-PG-3
Container Tag No.	LALL3
Time	1005
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_015
Water Depth (cm)	213 (7.0 ft.)
Sampler Depth Penetration (cm)	28 (11 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5/19/2010

Time: 19:22

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 4	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Cleer, sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting~~:	49 20.522
Long ~~Northing~~:	117 49.164

Sample No.	TAI-CAN-LALL-1-PG - 4
Container Tag No.	LALL4
Time	1013
UTM Easting	See above
UTM Northing	See above
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-016 to LALL-018
Water Depth (cm)	201 (6.6 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in.)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:23

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 5	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 60 to 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting~~:	49 20.523
Long ~~Northing~~:	117 49.163

Sample No.	TAI-CAN-LALL-1-PG-5
Container Tag No.	LALL 5
Time	1020
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR - Lower Arrow Lake
Camera Image No.	LALL_019
Water Depth (cm)	219 (7.2 ft)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:23

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 6	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Clear, sunny, 65° to 70°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.525
Long ~~Northing:~~	117 49.163

Sample No.	TAI-CAN-LALL-1-PG-6
Container Tag No.	LALL6
Time	1030
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	~~222 (7.3 ft)~~ [initials] LALL_020 & LALL_021
Water Depth (cm)	~~23 (8 to 10 in)~~ 222 (7.3 ft)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:24

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 7	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5/13/2010		
WEATHER CONDITIONS:	Partly cloudy, 65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.521
Long ~~Northing:~~	117 49.165

Sample No.	TAI-CAN-LALL-1-PG-7
Container Tag No.	LALL7
Time	1043
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL_022
Water Depth (cm)	229 (7.5 ft.)
Sampler Depth Penetration (cm)	23 (8 to 10 in)
Sediment Texture (ASTM/Unified)	SW-well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter.

Sampler Name: ______________________

Sample Signature: ______________________

Date: ______/______/2010

Time:

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 8	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, 60-65°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.522
Long ~~Northing:~~	117 49.157

Sample No.	TAI-CAN-LALL-PG - 8
Container Tag No.	LALL8
Time	1055
UTM Easting	See above.
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-023 to LALL-029 Photo sequence of sample and area
Water Depth (cm)	232 (7.6 ft)
Sampler Depth Penetration (cm)	23 (9 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small to med. gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Two grab efforts, poor recovery on first grab
Abnormalities	None observed
Other Notes	Little to no visible organic matter. Matrix more variable with increase in gravel size. Need to move to concentrate on more uniform sand matrix.

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:27

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 9	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, cool, 55 to 60°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat	~~Easting:~~	49 20.521
Long	~~Northing:~~	117 49.160

Sample No.	TAI-CAN-LALL-1-PG-9
Container Tag No.	LALL 9
Time	1105
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-030
Water Depth (cm)	222 (7.3 ft)
Sampler Depth Penetration (cm)	23 (9 in.)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (~~Munsell~~)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: ____________________

Sample Signature: ____________________

Date: ______ / ______ /2010

Time:

URS

FIELD DATA / SAMPLING DIARY
Upper Columbia River - White Sturgeon Sediment Toxicity Study

STATION: 10	BIRCHBANK EDDY	GENELLE	LOWER ARROW LAKE
STATION CODE:	BBE	GE	LALL ✓
DATE:	5 / 13 /2010		
WEATHER CONDITIONS:	Partly cloudy, 55 to 60°F		
SEDIMENT SAMPLER TYPE:	Power Grab		
URS FIELD PERSONNEL:	Gary Panther, Jeff Leppo		
Other Notes:			

Station Reference UTM Coordinates

Lat ~~Easting:~~	49 20.538
Long ~~Northing:~~	117 49.161

Sample No.	TAI-CAN-LALL-1-PG-10
Container Tag No.	LALL10
Time	1110
UTM Easting	See above
UTM Northing	" "
Field Photo No.	UCR Lower Arrow Lake
Camera Image No.	LALL-031 to LALL-035. Photo sequence of sample and CofC
Water Depth (cm)	216 (7.1 ft.)
Sampler Depth Penetration (cm)	25 (10 in)
Sediment Texture (ASTM/Unified)	SW - well graded sands, little to no fines, few small gravels
Sediment Color (Munsell)	Light brown
Odors	None observed
Leakage Disturbance	Good recovery
Abnormalities	None observed
Other Notes	Little to no visible organic matter

Sampler Name: Jeff Leppo

Sample Signature: [signature]

Date: 5 / 19 /2010

Time: 19:28

ATTACHMENT C
Environmental Field Book

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

ALL-WEATHER
ENVIRONMENTAL FIELD BOOK

Name Jeff Leppo] URS Corp.
Gary Panther] Spokane, WA
Address 920 N. Argonne Rd
Suite 300 Spokane 99212
Phone (509) 928 4413

Project UCR
White Sturgeon Sediment
Toxicity Study

36310054.00001

Specifications for this book:

Page Pattern		Cover Options	
Left Page	Right Page	Polydura Cover	Fabrikoid Cover
Columnar	1/4" Grid	N/A	Item No. 550-4F

CONTENTS

Reference Page Index

CONTENTS

PAGE	REFERENCE	DATE

Location ____ Date ____

Project / Client ____

Teck Contact: David Espenhain
250. 231.0104

Start
Page 4: →

Location TRAIL Boat Launch. Date 5.12.10

Project / Client UCR - Sediment

Jeff Leppo, Gary Panther

8:00 Boat Launch in Trail - Meet w/ Marcus + crew. Discuss field protocol. Marcus is worried that we do not have HDPE Bags for Buckets - calls Marko - will Decon Buckets.

Discuss COCs - will use COCs w/ carbon for 1st Location

Launch Both Boats - Load Gear -

0855

(P) Photo No. 1 - Boat @ Launch Clearwater (Gravity Environmental)

Boats: Monarch, Eric Weatherman
& Columbia Navigation

Captains
Clearwater, Shawn Hinz
Gravity Environmental

Location Trail Boat Launch Date 5/12/10

Project / Client UCR - Sediment

Other Persons @ Dock

* Markus Hecker - ENTRIX and Univ. of Saskatchewan

* Jonathan Doering - U of S

* Jeff ~~Dhohsam~~ Thomson - U of Sask

* Renee Trudeau - Gravity Environmental

* Allen Burkhart - Columbia

0915 Weather: Clear skies, 55°F
Dry conditions.

10:10 Gravity Work continues w/ hydraulics for power grab. Sampler.

* Prep Decon setup for buckets. Markus/Marko Adzic Bucket decon procedure agreed on under QAPP SOP

Location Trail Boat Launch Date 5/12/10
Project / Client UCR Sediment Sampling

10:30 Shawn & Eric go to pick up parts for pulley / pump on powergrab.

11:24 H&S Tailgate Mtg
Fire Ext, Trips & Falls, Hyd Systems, helmets around
A Frame, man-overboard

11:35 Leave Gyro Park Boat Launch, head up river

11:50 Arrive @ Birchbank Eddy
1st Locat
Rock bottom - cobble and boulder sized materials on riverbottom.
Extends over area into deeper water, and up the bank

Lat N 49 10.619 1st Site
Long W 117.42.915 Exam

Location Birch Bank Eddy Date 5/12/10
Project / Client UCR Sediment

12:00 Discuss cobble / boulder. Sand filled intercies, between rocks
Difficult to gather significant sand sample
2nd Location @ Birchbank - review
N 49 10.637
W 117 42.877
- same bottom, cobbles & boulders w/ limited sand intercises
Not able to sample w/ powergrab
(Collect / Take Photos)

River Sounding - out to 14 ft depth appears cobble & boulders
12:10 or limit of visibility
3rd Location 7.5 ft Depth

N 46 10.843
W 117 42.771

Setup to collect sample

Location Birchbank Eddy to Genelle Date 5/12/10
Project / Client UCR Sediment

Birchbank Eddy - 3rd Location
Setup for power-grab sampler
See grab sample no. TAI-CAN-BBE-1-PG-1
- cobbles, gravels with sand

12:50 Markus + crews agree to move and forego BBE sampling due to bottom matrix
12:55 Move to Genelle

13:15 Arrive @ Genelle. Identify sand bottom sediments, mixed with other areas of gravel/sand mixtures. Within eddy between river courses.

Start Sampling - See Field Diary

Location Genelle to Trail Boat Launch Date 5/12/10
Project / Client UCR Sediment

16:05 Complete sediment sampling @ Genelle. Good recoveries w/ well graded sands. Collect all 10 grab samples from
TAI-CAN-GE-1-PG-1 (QL)
TAI-CAN-GE-1-PG-10
Containers GE1 to GE10

Agreed Upon - Marko + Markus
* Liquinox, Then river water rinse was field approved following discussion of the use of liners / no liners

1655 Finish w/ sampling + decon. Prep for move back down to Trail Boat Launch

Location: Trail Boat Launch Date: 5/12/10
Project / Client: UCR Sediment

1720 - Arrive back @ Trail Boat Launch

Work w/ Markus on QA/QC of sample labels, date/time numbers etc.
Prep. COCs

1740 - Sign + relinquish Chain of Custody with Jonathon Doering, Univ of Saskatchewan.
- take photo for copy
Gravity Env. Crew doing boat cleanup + maintenance

1800 leave site, head to motel
1815 - Arrive @ hotel

Location: Lower Arrow Lake Date: 5/13/10
Project / Client: UCR Sediment

0845 - Arrive @ Arrow Lake
Personnel - see notes from 5/12/10] same
Boats - see notes from 5/12/10]
mobilization + Safety Meeting
0910 - Startup boats, prep for departure
Head out to sediment sample point
0930 Decon power grab, lexan tray + all bucket interiors w/ water rinse, liquinox scrub + water rinse.
1110 - Collect last grab sample LALL10
1120 - Finish up w/ sample platform work - cleanup/decon
Head to dock
1135 Return to dock

1150 - Complete C of C
relinquish to Jon Doering

Location Lower Arrow Lake Date 5/13/10

Project / Client UCR Sediment

Camera/Photo copies to:

Jonathon Doering
jad929@mail.usask.ca
306-270-3372 (cell)
306-966-~~4223~~ 4557 (office)

1220 - Call Marko w/update/status
1230 - Crews finish up demob, head home.

✗ See field diaries for reference sediment sample site observations, sample info/descriptions, and locations

Location Date

Project / Client

ATTACHMENT D
Chain-of-Custody

URS

Client:	Teck American Incorporated 501 North Riverpoint Blvd, Ste 300 Spokane, WA 99202
Project Manager:	Kris McCaig, kris.mccaig@teck.com

CHAIN of CUSTODY

Project: Upper Columbia River - White Sturgeon Sediment Toxicity Study

Telephone No. 509-459-4451 | Fax No. 509-459-4400 | P.O. #

Page 1 of 1

Method of Shipment

TAT: Standard

Per QAPP, April 2010

Sample I.D.	Container Tag No.	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical/Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Notes and Comments
TAI-CAN-GE-1-PG -1	GE1	1	Sed	5/12/10	1330	✓		Samplers: Jeff Leppo / Gary
TAI-CAN-GE-1-PG -2	GE2	1	Sed	5/12/10	1400	✓		Panther - URS Corp (Spokane)
TAI-CAN-GE-1-PG -3	GE3	1	Sed	5/12/10	1450	✓		
TAI-CAN-GE-1-PG-4	GE4	1	Sed	5/12/10	1508	✓		
TAI-CAN-GE-1-PG-5	GE5	1	Sed	5/12/10	1514	✓		
TAI-CAN-GE-1-PG-6	GE6	1	Sed	5/12/10	1522	✓		
TAI-CAN-GE-1-PG -7	GE7	1	Sed	5/12/10	1535	✓		
TAI-CAN-GE-1-PG -8	GE8	1	Sed	5/12/10	1541	✓		
TAI-CAN-GE-1-PG -9	GE9	1	Sed	5/12/10	1548	✓		
TAI-CAN-GE-1-PG -10	GE10	1	Sed	5/12/10	1555	✓		

Reference Location

GENELLE

REFERENCE UTM COORDINATES

EASTING

448723.51

NORTHING

5450261.18

Coordinates for QAPP Reference only. Please refer to Field Diaries for Lat/Long data for each grab sample.

Sample Received Intact: Yes No

Sample Receiving Notes: (Jonathon Doering)

Relinq. by sampler (Sign & Print Name)	Date	Time	
Jeffrey E. Leppo [signature]	5/12/10	1735	5/12/10 1735 recieved by JD
Relinquished by	Date	Time	
Relinquished by	Date	Time	
Relinquished by	Date	Time	Date Time

URS

Client: Teck American Incorporated
501 North Riverpoint Blvd, Ste 300
Spokane, WA 99202
Project Manager: Kris McCaig, kris.mccaig@teck.com

CHAIN of CUSTODY

Project: Upper Columbia River - White Sturgeon Sediment Toxicity Study
Telephone No. 509-459-4451 | Fax No. 509-459-4400
P.O. #

Page 1 of 1
Method of Shipment
TAT: Standard
Per QAPP, April 2010

Sample I.D.	Container Tag No.	No. of Containers	Matrix	Sampling Date	Sampling Time	Analytical/Physical Parameters: Upper Columbia River - Quality Assurance Project Plan Methods Development for the White Sturgeon Sediment Toxicity Study, April 2010		Notes and Comments
TAI-CAN-LALL-1-PG -1	LALL1	1	Sed	5/13/10	0940	✓		Fieldsamplers - Jeff Leppo
TAI-CAN-LALL-1-PG -2	LALL2	1	Sed	5/13/10	0950	✓		and Gary Panther
TAI-CAN-LALL-1-PG -3	LALL3	1	Sed	5/13/10	1005	✓		
TAI-CAN-LALL-1-PG-4	LALL4	1	Sed	5/13/10	1013	✓		
TAI-CAN-LALL-1-PG-5	LALL5	1	Sed	5/13/10	1020	✓		
TAI-CAN-LALL-1-PG-6	LALL6	1	Sed	5/13/10	1030	✓		
TAI-CAN-LALL-1-PG -7	LALL7	1	Sed	5/13/10	1043	✓		
TAI-CAN-LALL-1-PG -8	LALL8	1	Sed	5/13/10	1055	✓		
TAI-CAN-LALL-1-PG -9	LALL9	1	Sed	5/13/10	1105	✓		
TAI-CAN-LALL-1-PG -10	LALL10	1	Sed	5/13/10	1110	✓		

Reference Location
LOWER ARROW LAKE

REFERENCE UTM COORDINATES
EASTING 435940
NORTHING 5466319

UTM coordinates for reference only. From UCR QAPP White Sturgeon Sediment Toxicity Tests

Sample Received Intact: Yes No

Relinq. by Sampler (Sign & Print Name) [signature] Jeffrey E. Leppo	Date 5/13/10	Time 1205	Sample Receiving Notes: Received By Jonathon Downing 5/13/10 1205
Relinquished by	Date	Time	
Relinquished by	Date	Time	
Relinquished by	Date	Time	Date Time

APPENDIX C

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 3 – STUDY DESIGN (JULY 13, 2010); INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

July 14, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Testing – Study Design

Dear Mr. Adzic:

With this letter, the United States Environmental Protection Agency (EPA) is providing partial approval of the technical memorandum *Sturgeon Sediment Toxicity Testing – Study Design* (study design memo). The study design memo is dated July 13, 2010 and it was submitted by Dr. Markus Hecker of ENTRIX on behalf of Teck American Incorporated (Teck). The study design memo meets the final requirement for approval by EPA stated in Section B3.3 of the Methods Development QAPP that "Teck will consult with EPA on final design parameters for the sturgeon exposure system prior to setting up the chambers for the sediment toxicity study. Following the consultation, Teck will provide EPA with a written addendum to the Draft Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon that describes the parameterization of the chambers along with the acceptable performance criteria (e.g., allowable excursions from preferred measures)."

EPA is approving the portions of the study design memo that relate to the set-up of the exposure chambers, summarized in Table 2. EPA is also requiring the changes described below.

MANIPULATION OF SAMPLES – EPA does not agree that fines should be separated from sandy portions of the samples prior to homogenization, as recommended in the study design memo for sample LMF-02. This sample must be handled and prepared using the same procedures as those for all of the other samples. EPA agrees that large woody debris and large gravel (>5mm) that are readily removable by hand should be removed. However Teck must not alter the samples in any other way prior to homogenization.

STUDY DESIGN – EPA is requiring modifications to the test matrix proposed in the text and summarized in Table 2. Please see the attached Table, which is a revision of Table 2. The modifications required are:

1. Teck will include a "chemistry" replicate for samples LMF-02, UMF-01, LD-01, GE, and LALL. In the chemistry replicates, airstones, DGT probes and peepers are to be used to collect samples at the sediment / porewater interface, as proposed by Teck and depicted in Figure 4 of the study design memo. EPA believes that one chemistry replicate per sample is sufficient and is not requiring two chemistry replicates for samples LMF-02, UMF-01, LD-01 and LALL, as proposed by Teck. If sufficient lab space is available after Teck addresses EPA's second required design modification, Teck may choose to run two chemistry replicates. However, only one is required.

2. Replicate chamber(s) must be set up using the remaining material collected from Deadman's Eddy for the methods development work. EPA recognizes that there are uncertainties with this material, but we believe that the benefit of gaining additional information outweighs the risks. EPA will make a final determination as to whether the Deadman's Eddy chambers must be included in the study after reviewing the technical memoranda submitted by Teck earlier today. To ensure that the Deadman's Eddy material can be included in the study, if that is EPA's final decision, Teck must set up the Deadman's Eddy chambers at the same time as the rest of the chambers.

With this partial approval, Teck is authorized to place sediment in the test chambers per the revised Table 2 (attached). EPA has carefully reviewed the study design memo. Our team needs some additional time to discuss aspects of the memo not addressed in this letter. We also plan to review the Technical Memorandum on Parameter 5 of the Methods Development Work and the day-8 data from the ongoing methods development work, both of which were received late this afternoon, before rendering a decision on other aspects of the study design memo. Please be assured that we are well aware of the time constraints under which you are operating, and will get a final approval letter with any additional required changes to you this Friday.

If you have any questions about this approval, please don't hesitate to contact me.

Sincerely,

Helen H. Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

Attachment

Revised Table 2 – study design memo

Treatment Group	# of Possible Replicates	# of Replicates[1]	Comments	Differential Exposure Experiment
UCR				
LMF-02	4-5	3 biology, 1 chemistry	Remove wood debris, include surface layer of fines in sample	Insufficient Volume
LMF-03	1	1	Remove large stones; assume sufficient sample volume	Insufficient Volume
UMF-01	9-10	4 biology, 1 chemistry	Use as is	Yes
NP-03	2-3	2-3	Use as is	Insufficient Volume
LD-01	9-10	4 biology, 1 chemistry	Use as is	Yes
Deadman's Eddy	2 (?)	as many as possible with available volume, ideally 3 biology, 1 chemistry	Use as is	Insufficient Volume (?)
References				
GE	4	3 biology, 1 chemistry	Use as is	Insufficient Volume
LALL	9-10	4 biology, 1 chemistry	Use as is	Yes
Controls				
Control Substrate	>10	4 biology, 1 chemistry	Use as is	Yes
Water Only	>10	4 biology, 0 chemistry[2]	Use as is	Yes

Notes:
1. Teck may run additional chemistry replicates where there is sufficient sediment and lab space
2. EPA does not believe that a chemistry replicate is needed for the water only exposure, but Teck may run chemistry replicate(s) if there is sufficient lab space

E X T E R N A L   M E M O R A N D U M

TO: Helen Bottcher, US EPA Region 10

FROM: Markus Hecker, Ph.D., ENTRIX, Inc.

DATE: July 13, 2010

PROJECT: UCR Sturgeon Sediment Toxicity Testing

SUBJECT: Sturgeon sediment toxicity testing - Study design

This memo describes the study design for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* Quality Assurance Project Plan (QAPP). It lays out the approach and rationale for the within-Site, reference, and control sediments that will be used, the number of replicates per sediment, and how additional chemistry measurements (if required) can be accommodated.

AVAILABLE MATRICES

Based on the successfully sampled sites and retrievable volumes of sediments collected (Table 1) as part of the here described sampling efforts a total of eight and two samples from the UCR and upstream reference areas, respectively, are available for use in the sediment toxicity studies with white sturgeon (Figures 1 & 2). Of the eight UCR sediments, three have a fine silty nature (Figure 2: LMF-01, UMF-02&03), which is sub-optimal for the conduct of exposure studies with the test species for reasons of potential health impacts (e.g. clogging of gills). This results in a total of five UCR and two reference sediments available for inclusion into the exposure studies.

Overall, the successfully sampled sites are representative of the originally proposed regional sampling pattern with one sampling site having been sampled in each of the original or alternative locations as listed in the May 2010 sediment toxicity QAPP. Furthermore, sites are assumed to represent a range of metal concentrations as reported by previous studies conducted by the USGS and US EPA (Bortleson et al. 2001; Cox et al. 2005; Era and Serdar 2001; Johnson et al. 1988; Majewski et al. 2003; Paulson et al. 2006; USEPA 2003, 2006) at approximately the same locations (Figure 3). In fact, locations represent areas in which some of the greatest exposure concentrations were reported in whole sediments (Figure 3).

MANIPULATION OF SAMPLES

Due to the nature of sediments collected at sites LMF-02 and LMF-03, samples need to be manipulated prior to use in the exposure studies with white sturgeon. Specifically, this requires removal of debris (wood, larger gravel [>0.5mm], and other organic materials if feasible) by hand. Furthermore, sample LMF-02 is characterized by a significant proportion of fine silty material (Figure 2: LMF-02). While it is not recommended to "sieve" samples prior to using them in the toxicity tests, it is recommended to remove the fine silty portion of the sample prior to mixing to the extent possible to prevent potential risks associated with these fines as described above. The preferable method to separate fines from sandy portions is by hand using a plastic spatula, shovel or similar device where possible (samples appear layered, and thus, physical removal seems possible). Alternatively, the sample can be sieved to exclude fine particles. However, this is not recommended as the first choice as this would result in the loss of the majority of the organic fraction.

SEDIMENT ANALYSIS

Samples LMF-02 and LMF-03 were characterized by significant amount of wood debris, which, for site LMF-02, may be the result of a historic wood mill that was present at this location. Because such activities and/or the general presences of wood materials represent a potential source for organic chemicals it is therefore recommended to extend the currently proposed analytical set of COPCs to include organics as described for the analysis of reference sediments in the April 2010 methods development QAPP. This analysis would be conducted on the samples collected from the exposure chambers at the time of test initiation. Furthermore, sample LMF-02 appears to be characterized by a significant proportion of fines which can be representative of the presence of elevated concentrations of organic matter that can serve as a potential sink for organic chemicals.

STUDY DESIGN

Only limited sediment volumes were obtained from three UCR sampling sites (Table 1). This limits the number of replicates that can be tested for these substrates. This is especially true for sediments LMF-03 and LMF-02, which contain debris and larger rocks that need to be removed prior to sediment mixing, further reducing the total available volumes (Figure 2: LMF-02&03). Sufficient sample volumes and qualities were obtained from all other successfully sampled locations. As a consequence of the reduced number of samples available for toxicity testing, additional laboratory capacities have been made available. To increase statistical power of the experiments and to reduce uncertainty, therefore, it is proposed to increase replicate numbers from three to four parallel test chambers per sample where permitted by sample volume. In addition, the test protocol requires one control substrate and a clean water only control group to be tested in parallel (four replicates each) to the above described sediments. The study design also includes two reference sediments (LLAL and GE) in four replicates each. Due to reduced sample volume, NP-03 and LMF-03 will be tested in two and one replicate chambers, respectively. However, final decisions on exact replicate numbers per sample will depend on available volumes after sediment mixing has been completed.

In addition to the above-described study design for testing of white sturgeon early life-stages, a sub-set (two replicate chambers each) of parallel experiments will be conducted with those sediments for which sufficient (50 gal) volumes were retrieved (UMF-01, LD-01, LLAL), and the controls. These experiments aim at the differential assessment of exposure with COPCs through porewater and the sediment-water interface water (SWI). These systems will be operated under the same conditions as the test systems receiving white sturgeon, with the difference that additional passive sampling devices will be installed for differential assessment of porewater and SWI and no biological measurements will be made. Specifically, these experiments will utilize suction and diffusive sampling techniques in measuring aquatic exposure point concentrations of metals (i.e., porewater and SWI). Specific sampling techniques/devices to be assessed include:

A. Suction – ceramic airstone; and

B. Diffusive Samplers:
    - Peeper[1]
    - DGT (Diffusive Gradients in Thin-film)

All sampling devices will be installed as described in the report to Order #6 of the 2010 "*Methods Development for the White Sturgeon Sediment Toxicity Study*" (Figure 4). Peepers and DGTs will be installed at days 0, 20 and 50 after initiation of the experiments, and retrieval of devices will occur after 7 days (i.e. 7, 27 and 57 days). Three peepers and one DGT will be removed per sampling event, and analyzed as describe in the report to Order #6 of the methods development work. In addition, at each of the sampling times (days 7, 27 and 57) triplicate porewater and SWI samples will be obtained by means of suction and modified pipette, respectively. A summary of the proposed sampling schedule and analyses to be conducted is provided in Table 1.

---

[1] Details associated with the use of peepers are outlined and presented within the QAPP for Methods Development for the White Sturgeon Sediment Toxicity Study - Amendment No 1 (April 2010).

The reason for exclusion of the passive sampling devices from the experiments where data will be collected on test organisms is the relatively large impact of DGT probe and peeper extraction on sediment integrity and associated re-suspension processes that can confound biological observations and have an impact on the test species. However, the same number of fish will be added to these test systems to insure comparable test conditions in the DGT/peeper analytical exposure characterization experiment.

In addition to the above described study design, EPA suggested including dilutions of natural sediment to supplement the 2010 sediment toxicity studies with white sturgeon to be conducted by the UofS. However, there are a number of logistical issues and study design concerns associated with this proposed approach:

1. It is anticipated that installment of passive samplers would also be required for dilutions. The proposed design would reduce the replicates for the passive sampling portion of the studies to one for all samples to be tested. We are concerned that this sacrifice of statistical power by reducing the passive sampling design to one replicate per treatment group is jeopardizing the interpretability of the data as it will not be possible to distinguish between random and true effects. While one of the sediment samples during the fish portion of the sediments will also be tested in only one replicate (LMF-03), all remaining treatment groups will be tested at 2 to 4 replicates, and thus, it will possible to relate this individual measurement to the overall response pattern observed during the *in vivo* portion of the study.

2. If dilution of sediments is to be conducted, appropriate controls will have to be included (at a minimum one reference sediment and the artificial control substrate each in triplicate + passive sampling portion of study). Without these it will be impossible to distinguish effects due to dilution (change in matrix) from potential COPCs induced toxicities.

3. It is assumed that the LLAL sediment will be used for dilution of the sediments. Even when using a total of only four replicates (3 for *in vivo* portion and one for the DGT portion of the studies) **there will be insufficient volume to conduct experiments** (Table 3B; red cell). Furthermore, as discussed under bullet 1 above, it is not recommended to only include one replicate for the DGT portion of the studies.

4. There is significant concern about using different dilutions for different sediments as proposed by EPA. In controlled toxicity testing it is desirable (and common practice) to keep variables as constant as possible. We would discourage using different dilutions due to potential matrix effects as this makes comparisons among treatments more difficult and

requires inclusion of additional controls. If a 10% and 50% dilution is to be tested this would require doubling controls as well (one for 10% and one for 50% dilution).

Overall, it is ENTRIX' opinion that there is a significant risk in sacrificing the solid (in terms of replicates) study design to accommodate as many parameters as possible. The sampled sediments are assumed to provide a range of exposures to COPCs that is representative of that assumed in the original QAPP based on the larger amount of sampling sites (Figure 3). It is ENTRIX' opinion that we should continue with the plan to increase replications (where possible) and to include passive sampling device experiments (at least 2 replicates per treatment group) as this increases the power of the study. ENTRIX acknowledges the risk of the occurrence of an "unbound" LOAEC as the result of the overall study. If such a scenario should occur, it is recommended to follow up with a second series of studies enabling the characterization of exact thresholds (e.g. by means of dilution series to be tested in 2011). The data obtained during the 2010 studies would then form the basis for these studies by enabling selection of relevant samples, and the optimization of the further approach.

Finally, it was recommended by EPA to include the substrate collected from the gravel/sand bar at Deadman's Eddy for use in the 2010 methods development studies. However, we recommend not including this matrix as an additional treatment group for the following reasons:

1. This substrate was not collected using the same methodologies than those in the river.

2. While some portions of the sandbar are submerged during periods of the year, a portion of the samples was collected from higher grounds that have not been under water for multiple years. As a consequence, the composition of this substrate as well at its physical and chemical properties are likely to be very different than the remaining samples that were taken under water, and thus, not directly comparable to each other.

3. There is only a limited volume (20 gal) remaining of this substrate, limiting the number of possible replicates.

4. To accommodate this additional sample we would have to reduce replications for the other samples, reducing the overall power associated with each experiment.

SUMMARY RECOMMENDATION

The proposed design (four replicates per *in vivo* test; two replicates per DGT chemical analysis test; no dilution) will result in a total of 41 test chambers to be tested during the sediment toxicity studies. A summary of the sediment samples available for testing, and proposed replications is provided in Table 2.

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Cox, S.E., P.R. Bell, J.S. Lowther, and P.C. Van Metre. 2005. Vertical distribution of trace element concentrations and occurrence of metallurgical slag particles in accumulated bed sediments of Lake Roosevelt, Washington, September 2002. Scientific Investigations Report 2004 5090. U.S. Geological Survey, Reston, VA. 70 pp.

Era, B. and D. Serdar. 2001. Reassessment of toxicity of Lake Roosevelt sediments. Publication No. 01-03-043. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. 54 pp.

Johnson, A., B. Yake, and D. Norton. 1988. An assessment of metals contamination in Lake Roosevelt. Publication No. 89-e26. Washington State Department of Ecology, Olympia, Washington.

Majewski, M.S., S.C. Kahle, J.C. Ebbert, and E.G. Josberger. 2003. Concentrations and distribution of slag-related trace elements and mercury in fine-grained beach and bed sediments of Lake Roosevelt, Washington, April–May, 2001: U.S. Geological Survey Water-Resources Investigations Report 03-4170, 29 pp.

Paulson, A.J., R.J. Wagner, R.F. Sanzolone, and S.E. Cox. 2006. Concentrations of elements in sediments and selective fractions of sediments, and in natural waters in contact with sediments from Lake Roosevelt, Washington, September 2004. Open-file report 2006-1350. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

USEPA. 2003. Upper Columbia River expanded site inspection report; Northeast Washington. TDD:01-02-0028. Contract: 68-S0-01-01. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

USEPA. 2006. Settlement agreement for implementation of remedial investigation and feasibility study at the Upper Columbia River Site. June 2, 2006. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

Table 1. Proposed sampling schedule, analyses and sample numbers for the differential exposure experiment using passive and active water sampling devices.

Sampling Day [a]	COPCs (Cd, Cu, Pb and Zn)	pH	DOC	Conductivity	Alkalinity	Anions/ Cations
Suction						
Day 7	3	3	3	3	3	3
Day 27	3	3	3	3	3	3
Day 57	3	3	3	3	3	3
Modified Pipette						
Day 7	3	3	3	3	3	3
Day 27	3	3	3	3	3	3
Day 57	3	3	3	3	3	3
Peeper						
Day 7	3					
Day 27	3					
Day 57	3					
DGT						
Day 7	3					
Day 27	3					
Day 57	3					
Σ	***36***	***12***	***12***	***12***	***12***	***12***

[a] Sampling Day refers to the sampling for parameter after initiation of experiment.

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Table 2. Proposed sediment samples as per the June 2010 sediment sampling effort in the UCR, and replication for definite sediment toxicity studies with white sturgeon, at the University of Saskatchewan.

Treatment Group	# of Possible Replicates	# of Replicates [a]	Comments	Differential Exposure Experiment
UCR				
LMF-02	4-5	4	Remove wood debris; consider organic contaminants	Insufficient Volume
LMF-03	1	1	Remove large stones; assume sufficient volume	Insufficient Volume
UMF-01	9-10	4 + 2	Use as is	Yes
NP-03	2-3	2-3	Use as is	Insufficient Volume
LD-01	9-10	4 + 2	Use as is	Yes
References				
GE	4	4	Use as is	Insufficient Volume[b]
LALL	9-10	4 + 2	Use as is	Yes
Controls				
Control Substrate	>10	4 + 2	Use as is	Yes
Water Only	>10	4 + 2	Use as is	Yes

[a] The numbers refer to the number of replicates to be tested with fish plus two separate treatment system for the differential exposure experiment (without test organisms.

[b] 20 gallons of GE sediment were used in methods development studies.

Table 3A. Example matrix for white sturgeon sediment toxicity study design assuming three and two replicates for in vivo fish exposure and DGT exposure chambers, respectively.

Proposed Exposure Chambers	**Study Design Corrections (2 DGT replicates)**			
Sample/Treatment Group	# Fish Replicates	# DGT Replicates	Volume of Dilution Sediment (gal)	Volume Available (gal)
NP-03	2	0	0	15
LD-01	3	2	0	25
LD-01 diluted 50% ?	3	2	12.5	25
UMF-01	3	2	0	25
UMF-01 diluted 50%	3	2	12.5	25
LMF-02	3	2	0	18
LMF-02 diluted 50%	2	0	5	7
LMF-03	1	0	0	1
LALL (reference)	3	2	25	50
GE (reference)	2	1		30[a]
GE diluted 50%	1	1	7.5	
Control	3	2		n/a
Control diluted 50%	3	2	12.5	
total number of replicates	33	18	75	

Total # of replicates:	50
Reference Sediment Volume:	-25

Assuming LLAL sediment will be used for dilution (same rules would apply if GE sediment would be used)

[a] 20 gallons of GE sediment were used in methods development studies.

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Table 3B. Example matrix for white sturgeon sediment toxicity study design assuming three and one replicates for in vivo fish exposure and DGT exposure chambers, respectively.

Proposed Exposure Chambers	**Study Design Corrections (1 DGT replicate)**			
Sample/Treatment Group	Fish Replicates	DGT Replicates	Volume of Dilution Sediment (gal)	Volume Available
NP-03	2	0	0	15
LD-01	3	1	0	25
LD-01 diluted 50% ?	3	1	7.5	25
UMF-01	3	1	0	25
UMF-01 diluted 50%	3	1	7.5	25
LMF-02	3	1	0	18
LMF-02 diluted 50%	2	0	5	7
LMF-03	1	0	0	1
DME (Dead Man's Eddy)	0	0	0	0
LALL (reference)	3	1	25	50
GE (reference)	2	1		30[a]
GE diluted 50%	1	1	7.5	
Control	3	1		n/a
Control diluted 50%	3	1	7.5	
total number of replicates	34	10	60	

Total # of replicates:	44
Reference Sediment Volume:	-10

Assuming LLAL sediment will be used for dilution (same rules would apply if GE sediment would be used)

[a] 20 gallons of GE sediment were used in methods development studies.

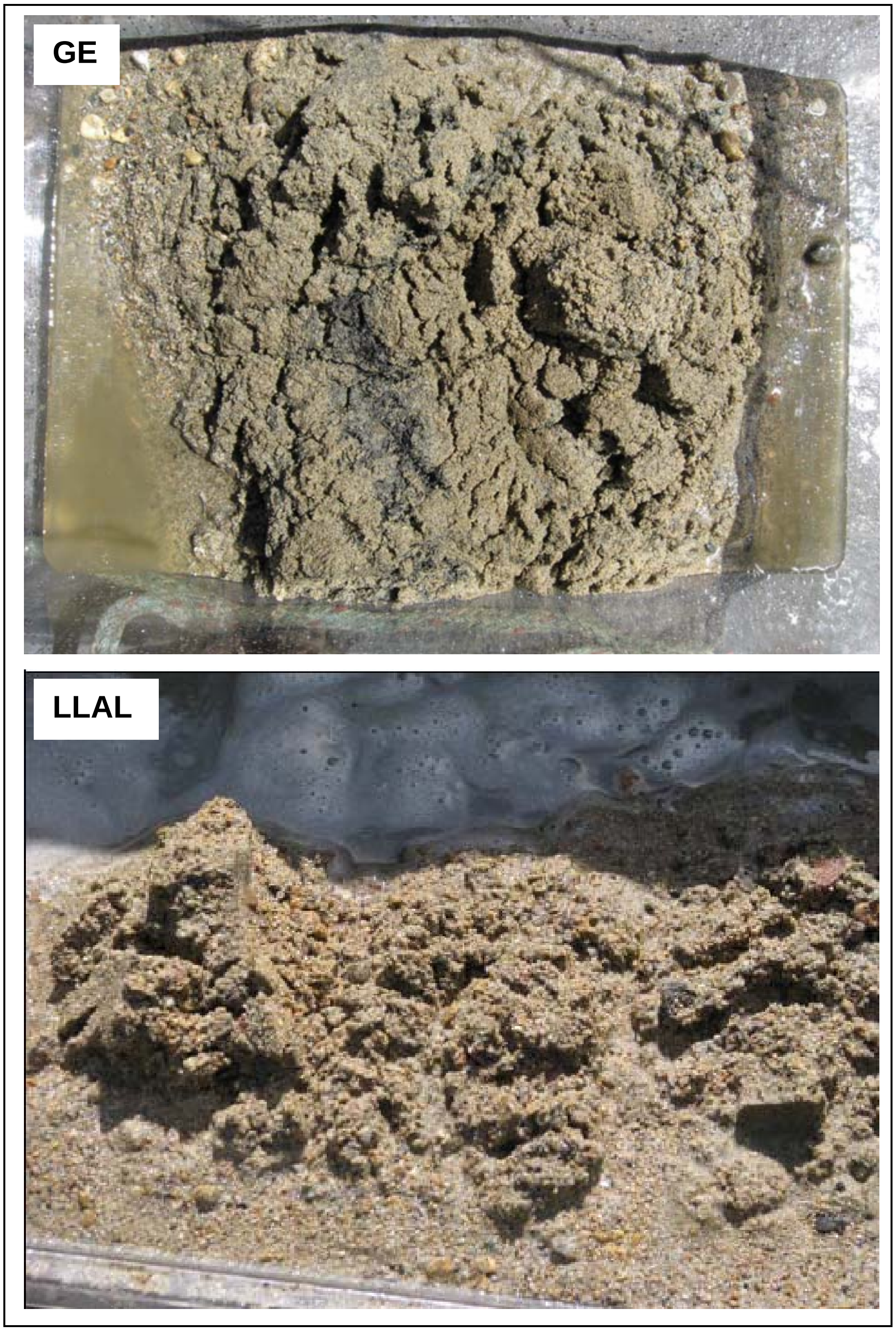

Figure 1: Photographs of sediments collected at the two reference locations upstream of the U.S.-Canada border at Genelle (GE) and Lower Arrow Lakes (LLAL).

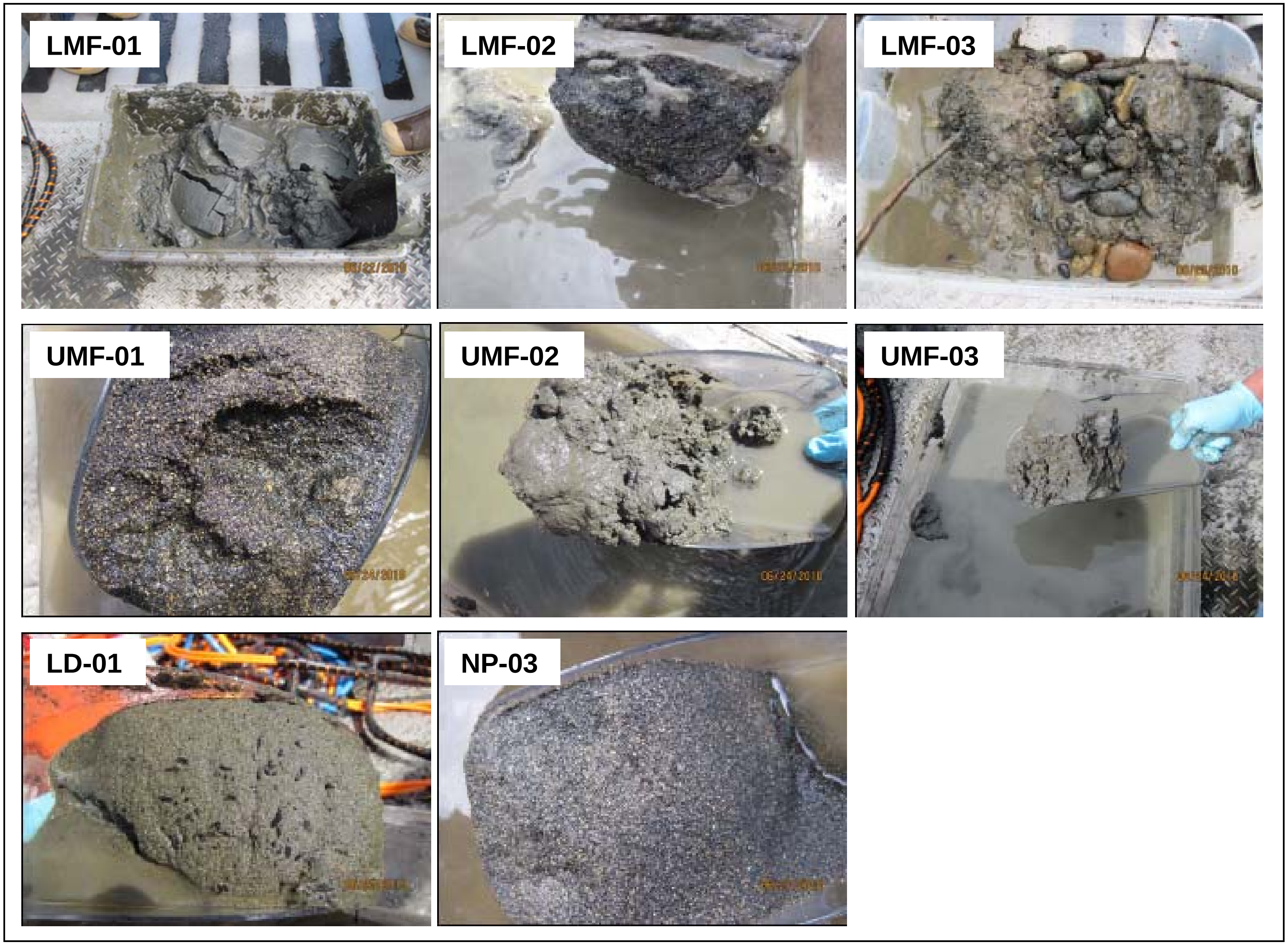

Figure 2: Photographs of sediments successfully collected at the originally proposed UCR sampling sites in the area of Lower (LMF-01-03) and Upper (UMF-01-03) Marcus Flats, Little Dalles (LD-01) and Northport (NP-03).

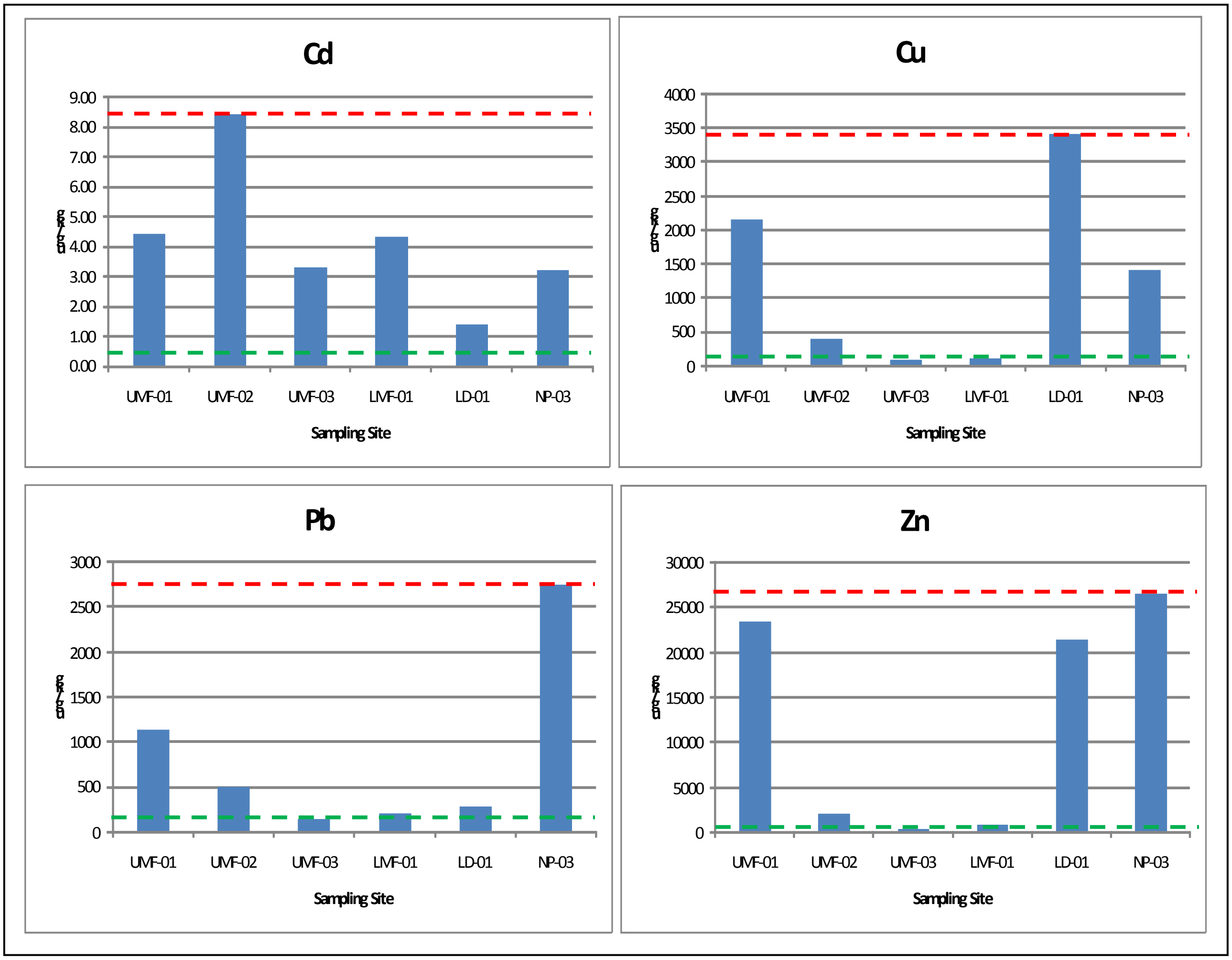

Figure 3: Concentrations (μg/kg) of Cd, Cu, Pb and Zn previously reported by the USGS or US-EPA at the same sampling locations that were successfully sampled as part of the June 2010 sediment sampling effort by Teck. Dotted red line: Maximum concentration of metal reported for all proposed sampling sites in the 2010 sediment toxicity QAPP; Dotted green line: Minimum concentration of metal reported for all proposed sampling sites in the 2010 sediment toxicity QAPP.

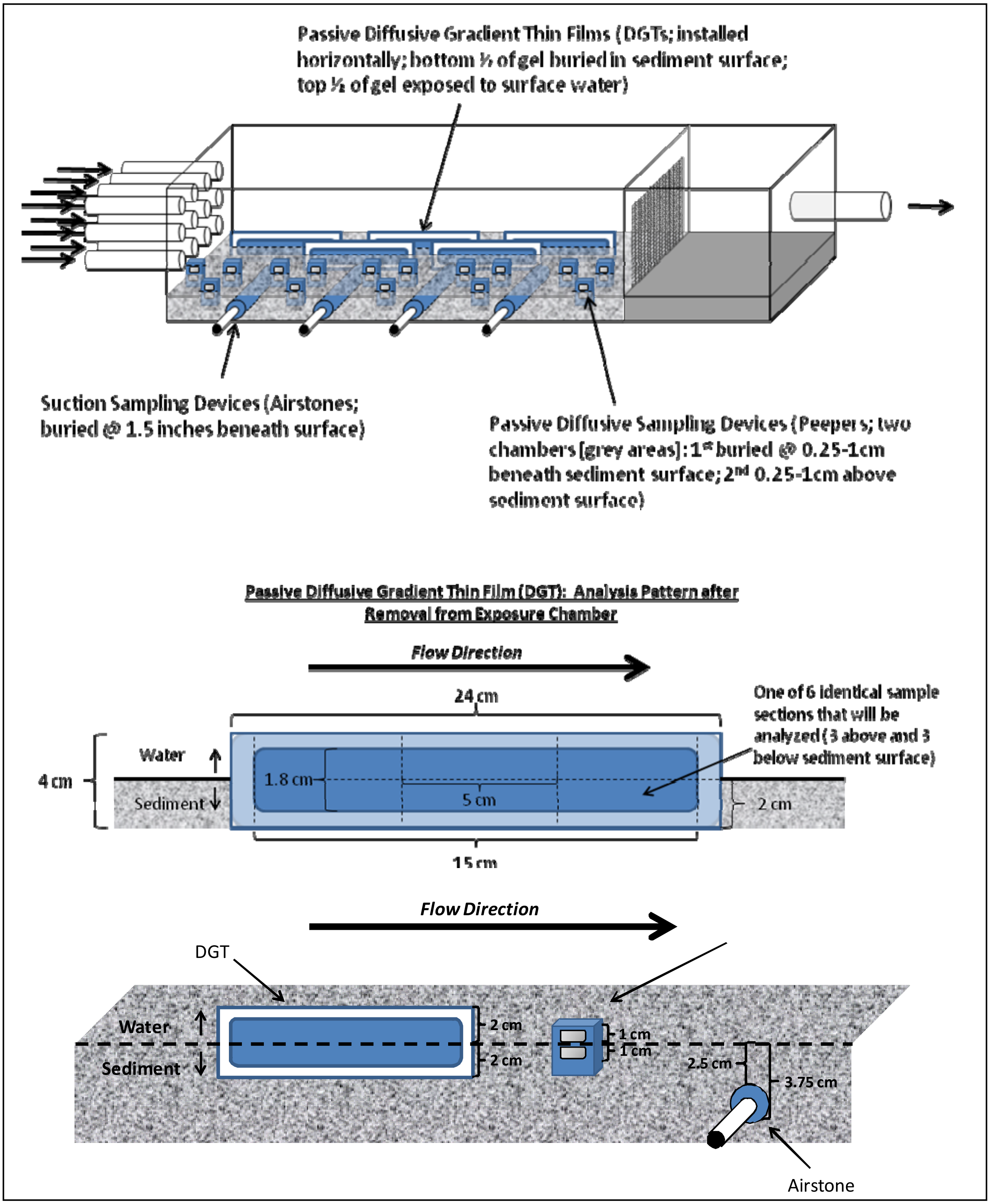

Figure 4: Schematic of sampling device installation in the test systems used for the differential exposure experiment. Note: The here presented dimensions are not to scale, and definite designs may deviate. Also, no sampling devices will be installed within 4 inches from the inflow and outflow of the test chambers.

APPENDIX D

WHITE STURGEON METHODS DEVELOPMENT WORK TECHNICAL MEMORANDUM NO. 4 – TIME TO STEADY STATE (JULY 14, 2010) –UPDATED; INCLUDES APPROVAL LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL CLEANUP

July 16, 2010

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Reply To: ECL-111

Marko Adzic
Teck American Incorporated
501 North Riverpoint Boulevard, Suite 300
Spokane, Washington 99202

RE: UCR Sturgeon Sediment Toxicity Program – EPA Direction on Final Study Design

Dear Mr. Adzic:

The purpose of this letter is three-fold:

1) To provide approval, conditioned upon incorporation of EPA's comments in the section below entitled "Technical Memo on Order #5, of the technical memorandum *Sturgeon sediment toxicity testing – results and recommendations: Order #5* dated July 13, 2010
2) To provide approval, conditioned upon incorporation of EPA's comments in the section below entitled "Study Design Memo" of the technical memorandum *Sturgeon sediment toxicity testing – Study Design* dated July 13, 2010
3) To communicate to Teck all final changes and clarifications the study design that are required

Technical Memo on Order #5. EPA received a technical memorandum on July 13, 2010, entitled *Sturgeon sediment toxicity testing – results and recommendations: Order #5*. This technical memo describes the results of the last outstanding item of the methods development studies. EPA agrees with the results and recommendations provided in this technical memorandum, and approves a sampling depth of 3.4 centimeters for the full study.

EPA disagrees with language in Appendix A of the technical memorandum. The text states that there was a "clear" decrease in DOC concentrations in the DME sediments after 96h, "indicating that steady-state for this sediment and parameter was not reached after this time." While there was apparent decrease (see Figure 3 of Appendix A), the decrease was not statistically significant and may be within the range of analytical variability. EPA does not agree that the data provided in this technical memorandum supports a determination that the DME sample had not reached steady state after 96 hours. Therefore, Teck must resubmit the Technical Memo deleting the text quoted above from the last paragraph of the main body text and from the second paragraph on page 2 of Appendix A. Consistent with the authorization set forth in the second to last paragraph of this letter, Teck may proceed with toxicity tests. The revised Technical Memo must be submitted to EPA no later than July 23, 2010.

Study Design Memo. EPA provided comments on and partial approval of the technical memorandum *Sturgeon sediment toxicity testing – Study Design* on July 14, 2010. Our additional comments and required changes to the recommendations in the study design technical memo are below. Teck must prepare and submit, for EPA approval, a final QAPP amendment that incorporates the following comments. Teck must also incorporate in the final QAPP amendment the changes required in EPA's July 14, 2010 letter. The final QAPP amendment must be submitted to EPA prior to introducing fish into the exposure chambers.

SEDIMENT ANALYSIS – EPA agrees with the recommendation by Teck American Incorporated (Teck) in the study design memo to analyze sediment samples for organic COPCs after placing sediments into test chambers. In addition, Teck must archive samples at the end of exposures (appropriately collected and preserved) for analyses. If toxicity is observed that cannot be explained by the contaminants being measured or other factors, Teck will be required to analyze the preserved samples for organics that are detected in samples at test initiation. These analyses will include all organics that were not eliminated in the Screening Level Ecological Risk Assessment.

CHEMISTRY REPLICATES -- EPA is not convinced that the presence of DGT and peeper samplers in chemistry replicates will adversely affect the fish. It is EPA's opinion that the approved tank cleaning technique is likely to be as disruptive, if not more so, than occasionally removing DGT or peeper sampling devices from the test chambers. Teck must collect the same biological information (i.e., fish survival growth and behavior) in the chemistry replicates that is collected in the biology replicates. If the biological results in the chemistry chambers are within the range of responses observed in the biology chambers, then data from the chemistry replicate chamber may be used as another replicate in the statistical analysis of the data. If the biological responses observed in the chemistry replicate chambers are outside the range observed in the biology chambers, then the biological data will not be used, and only the chemistry data from the chemistry replicates will be used in the data analysis.

DEADMAN'S EDDY SAMPLES – Teck must include in the study the Deadman's Eddy sediments that were collected for methods development. EPA recognizes that there are uncertainties associated with this material, including the fact that the sediments were collected in the dry and were composited from subsamples collected over a broad area. However, we believe that these sediments still have value because they may have different chemistry and grain size characteristics than the other samples, and would provide an additional data point along the gradient of conditions observed in UCR sediments. EPA will view the resulting data cautiously, and will agree to exclude the resulting data from the study analysis if the sample produces results that are inconsistent with the other site sediment samples. To determine whether data from the Deadman's Eddy samples could be used, EPA would consider a number of factors, including but not limited to:

- How quickly the sediments reach equilibrium, relative to other site samples

- Whether grain size, DOC, pH or other basic parameters differ significantly from the other site samples
- Whether any observed toxicity seems to be related to the chemistry – i.e., how well the sample fits the dose response curve established with the other samples.

There may not be enough material left from this sample to make up four test chambers (i.e., the ideal of three biology chambers and one chemistry chamber). Therefore, the existing chamber set up for the methods development tests should be used as a biology chamber. The remaining material not used for methods development work should be used to set up the chemistry chamber and as many biology chambers as possible. Any other needed changes (e.g., the addition of gravel / stones) to the existing chamber should be made at the same time the new chambers are being prepared. EPA recognizes that using the existing chamber may introduce additional uncertainty because these chambers have had longer to equilibrate than the other chambers.

DECONTAMINATION OF PEEPERS – Due to high variability in the peeper results during methods development testing, additional steps should be taken to ensure and demonstrate that peepers are effectively decontaminated prior to deployment. Teck must submit, by July 23, 2010, an SOP describing in detail the peeper decontamination procedures used for the full study. In addition, Teck must include blank peeper samples (i.e. beakers with metal-free water and peepers only) in the study, at the start, at the completion of the change to exogenous feeding, and near the end of the test (approximately days 0, 27, and 50).

EPA's understanding is that water samples from the biology replicate chambers will be collected using airstones and pipettes, while water sample collection from the chemistry replicate chambers will also include the use of peepers and DGTs (per the amended methods development QAPP). Further, it is our understanding that toxicity testing deployments of these sampling devices will be as described in Figure 4 of the study design memo dated July 13, 2010. If EPA is incorrect in its understanding of these issues, please contact me prior to introducing fish into the exposure chambers.

Finally, EPA will evaluate the adequacy of this test in meeting the data quality objective based on the data that are produced. However, the number of samples collected for this study falls short of the objective of the RI/FS to investigate the nature and extent of contamination and risk to sturgeon at the Site and more work will be required to meet the DQOs. More work may include repeating this study in the future with more samples, collecting other types of samples such as additional surface sediment chemistry and porewater chemistry samples, using other data generated for this or other investigations, or using information from the literature to inform the risk assessment for sturgeon.

Teck is authorized to begin toxicity tests per the approved study design memo, including the changes described in this letter, and according to the amended QAPP, *Quality Assurance Project Plan for the Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)*, May 2010. Please prepare and submit a final QAPP amendment documenting these changes for EPA approval.

EPA is pleased to see the studies get underway, and we look forward to receiving regular updates as the study progresses.

Sincerely,

Helen H Bottcher

Helen Bottcher
Project Manager

cc: Dan Audet, U.S. Department of the Interior
Patti Bailey, Confederated Tribes of the Colville Reservation
Randy Connolly, Spokane Tribe of Indians
John Roland, Washington State Department of Ecology

EXTERNAL MEMORANDUM

TO: Helen Bottcher, US EPA Region 10

FROM: Markus Hecker, Ph.D., ENTRIX, Inc.

DATE: July 14, 2010

PROJECT: UCR Sturgeon Sediment Toxicity Testing

SUBJECT: Sturgeon sediment toxicity testing - results and recommendations: Order #5

The overall goal of the herein described and discussed studies was to inform and establish appropriate and relevant methodologies for the sturgeon sediment toxicity test described within the May 2010 *Assessment of Sediment Toxicity to White Sturgeon (Acipenser transmontanus)* QAPP. Specifically, the objectives of this work were to optimize the performance of flow-through fluvial simulation systems and associated exposure chambers, and confirm reference area sediments (including laboratory control sediments). It has to be noted that the information and observations recorded during this work are not be used to inform risk-based management decisions, and they solely are aimed to inform and refine technical elements of future sediment toxicity tests using white sturgeon early life-stages.

This memo reports results and recommendations for the final task: evaluation of gradients in the fluvial exposure chambers. The following sections summarize the work done under this task, and provides recommendations for test chamber functions.

Optimized design for exposure chambers

Detailed method descriptions are provided in the individual report included in Appendix A. A brief summary of the objectives and experiments conducted and is provided here. Table 1 now includes recommendations for Order #5 and therefore is complete.

Order 5: Gradients between pore- and overlying water

Objective: Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity)– monitor basic water quality parameters at different sediment depths, and at the sediment-water interface.

Results and Recommendations: Based on the results from this study and the findings from Orders #3 and #4, sampling ports at shallower sampling depths of 3.4 cm is recommended. Also, the short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time prior to introduction of test organisms will not be problematic for the definite exposure studies.

Gradients in conductivity, pH and dissolved organic carbon (DOC) between porewater and overlying water were measured by means of suction devices that were installed at 10.2 cm intervals along the entire length of the centre of the sediment exposure chamber. Flows rates ranged from greater (25 L/min) to lesser flow rates (17 L/min); these flow-rates were deemed appropriate for maintaining conditions appropriate for white sturgeon ELS culture. There were gradients among measurement parameters between overlying water and porewater. These appeared, however, to not be influenced by flow-rate or duration with the exception of a small difference in the reference sediment at the greatest porewater sampling depth and dissolved organic carbon at early time periods. This indicates that gradients are relatively stable and do not change over time under constant flow-conditions. Time-dependent increases in conductivity observed at greater sampling depth could be indicative of shallower sediment horizons reaching steady-state more quickly, particularly for sediments with greater amounts of fines. Furthermore, sediment-sampling depth had no effect on pH or DOC.

In general, DOC concentrations were highly variable in porewater when measured 24h after initiation of the experiment. It is assumed that these differences between the early (24h) and later measurements are due to the fact that the DME substrate tested was of a dry nature prior to submersion in the test systems, and therefore, at 24h there were still significant dissolution processes ongoing. Similarly, the reference sediment used was mixed and introduced into the test system, likely resulting in a very different initial porewater composition after storage for an extended time. It is assumed that after 48h this dissolution or exchange between overlying and porewater was mostly completed or had stabilized. While the artificial substrate group showed no further change in porewater DOC concentrations after 48h, there was still an apparent decrease in DOC concentrations in the DME sediments after 96h. It is difficult, however, to extrapolate from this observation to riverine sediments because the DME substrate was dry, and thus, it can be assumed that water saturated sediments will behave very differently due to the lack of initial dissolution processes. This also may explain the differences observed between the DME and reference substrate. Depth of porewater sampling did not have a marked effect on DOC patterns.

Table 1. Parameters, Methods, Measurements and Recommendations for the Design of the Exposure Systems and Test Conditions for the 2010 Studies with White Sturgeon ELS to Investigate Sediment Related Toxicity.

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
1	Flow condition	Establish parameters and operational conditions that enable the maintenance of homogenous flow conditions in the test system.	Initial flow rate of 19 L/min, with incremental changes of +/- 2 L/min to achieve desired end state	Video record of fluorescein dye movement	Initial flow rate of 20 L/min to accommodate low flow requirement for yolksac larvae, and then increase flow rates to 25 L/min around the time when larvae initiate exogenous feeding
2	Gravel volume and distributions	Establish optimum density of gravel to create pseudo-hyporheic zone	Gravel: 0, 3, 7, 10 and 13 stones per 100 cm^2	Conductivity measurements	4 stones per 100 cm^2
3	Porewater sampling	Establish porewater sampling method	Airstone suction device in different depths of sediment using variable strength and duration of suction (via manual use of syringe). Initial volume to be collected 30 mL, with incremental changes of +/- 5 mL to obtain sufficient sample volume.	Only porewater is collected with no overlying water in the sample • Dye concentration measurements.	12 ports, with a volume of 8-10 mL each; no ports within the first and last 4 inches of the fluvial chamber.
4	Sediment depth	Establish optimum depth of sediment for ELS sturgeon and to maximize porewater collection	Initial depth at 2 inches, with trials of 3 and 4 inches	Porewater sampling at 0.5 and 1 inch and overlying water sampling within the 1 cm of water overlying the sediment • Dye concentration measurements.	Two (2) inches of sediment, with airstones positioned on top of 0.5 inches and below 1.5 inches of sediment

Table 1. (cont.)

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
5	Gradients between pore- and overlying water	Establish operational conditions that minimize gradients in water quality parameters between pore- and overlying water.	Each flow/sediment depth combination that is tested.	Time-resolved measurements of: • Dye concentration • Conductivity • DOC • pH	Flow-rates between 17 and 25L are appropriate as they do not affect gradients. Porewater sampling depth between 1 and 1.5 inches recommended due to observed gradients. Short time-dependency of gradients between overlying water and porewater indicates that a reduced equilibration time of 4 to 7 days prior to introduction of fish is sufficient.
6	Time to steady-state	Establish operational conditions that minimize time to steady-state.	Characterize time to steady-state between pore- and overlying water after establishing optimal flow and gravel conditions.	Time-resolved measurements of: • Alkalinity • Ammonia • Conductivity • DO • DOC • Hardness • pH	48 hours is sufficient for all parameters, with the exception of DOC which may not reach steady state
7	Cleaning methods	Establish most efficient method for cleaning	Introduce food 3X daily and scrape tanks at days 2, 3, 4 and 5.	Measure turbidity of samples using light scattering methods	Modified pipette, with spatula used to remove biofilm, if necessary

Order	Parameter	Goal	Test Conditions	Measurement	Recommendation
8	Laboratory control sediment	Define clean sediment with characteristics similar to UCR sediments	Research lab controls used in other bioassays Create sediment from clean silica sand and/or granite with grain size 0.5 to 2 mm and preference to dark color	Measure grain size and color	Control sediment: Hagen Geosystem Black Fine Gravel (ART #12648) is sandy, with all analytes below screening ecological values (SEVs). Acceptable for use. Reference sediments from Genelle Eddy and Lower Arrow Lake are gravelly sand, with all analytes below screening ecological values (SEVs). Acceptable for use.

APPENDIX

Sturgeon Test Methods

Appendix A Data summary reports for:

Order #5: Gradient Study

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Summary Data Report

Experiment #: 5 **Date:** 5/20/-7/04/10 **Expt. Leader:** DV/JD/MH

Title: Gradients

Goal:

Evaluate potential gradients between porewater and overlying water under different hydrological conditions (e.g., flow velocity).

Experimental Design:

Gradients in conductivity, pH and dissolved organic carbon (DOC) between porewater and overlying water were measured by means of suction devices that were installed at 10.2 cm intervals along the entire length of the centre of the sediment exposure chamber. Suction devices were buried at different depths to enable sampling of porewater in the top 2.5 cm of sediment and in the sediment-surface water transitional zone (pseudo hyporheic area with 4 rocks per 100 cm^2 for habitat enrichment as described in Order 2). Experiments without rocks for habitat enrichment were excluded as it was decided based on the findings from Order 2 that rocks were to be used in subsequent sturgeon experiments. Parameters that were used to assess potential gradients between porewater and overlying water were conductivity, DOC and pH. Measurements were made 24, 48, and 96 hr after initiation of the experiment. Dye was not used in these experiments since it was discovered during studies for Orders 3 and 4 that dye would not readily seep into the sediment without being physically pulled through. Flows that were tested ranged from greater (25 L/min) to lesser flow rates (17 L/min). These flow-rates were deemed appropriate for maintaining conditions appropriate for white sturgeon ELS culture.

Decision Criteria:

The goal of this experiment was to establish conditions under which the gradient between porewater and overlying water in the pseudo-hyporheic area is minimal while maintaining conditions appropriate for sturgeon ELS culture.

Results:

There were significant differences between overlying water and porewater for a number of parameters. These differences were most prominent for conductivity where significant greater values were recorded in porewater samples regardless of depth and time of sampling (Figure 1). There were differences in conductivity between porewater at different greater depths in the sediment. However, the differences were less than those between overlying water and porewater. Also in the reference sediment treatment group (Genelle sediment) statistically significant increases in conductivity in porewater were observed between the 24 and 96 hr at the greatest sampling depth. No such differences occurred in the experiment with Deadman's Eddy

(DE) sediment. Flow rate did not have an effect on conductivity in any of the matrices analyzed.

In the reference sediment experiment there was a statistically significant decrease in pH of porewater from both depths relative to that in overlying water. No such difference was observed in the DE sediment test group. In fact, pH was not different among sampling times or depths in this group.

In general, DOC concentrations were highly variable in porewater when measured 24h after initiation of the experiment. It is assumed that these differences between the early (24h) and later measurements are due to the fact that the DME substrate tested was of a dry nature prior to submersion in the test systems, and therefore, at 24h there were still significant dissolution processes ongoing. Similarly, the reference sediment (saturated with water during storage) used was mixed and introduced into the test system just prior to t=0, likely resulting in a very different initial porewater composition that slowly mixed with overlying water until a certain degree of steady-state was reached. It is assumed that after 48h this dissolution or exchange between overlying and porewater was mostly completed or had stabilized. While the artificial substrate group showed no further change in porewater DOC concentrations after 48h, there was still an apparent decrease in DOC concentrations in the DME sediments after 96h. It is not possible, however, to extrapolate from this observation to riverine sediments because the DME substrate was dry (collected above the water line from a beach/gravel bar). It can be assumed that water saturated sediments will behave very differently due to the lack of initial dissolution processes. This also may explain the differences observed between the DME and reference substrate. Depth of porewater sampling did not have a marked effect on DOC patterns.

Conclusions:

There were gradients among measurement parameters between overlying water and porewater. These appeared, however, to not be influenced by flow-rate or duration with the exception of a small difference in the reference sediment at the greatest porewater sampling depth. This also indicates - with the exception of some sediments at greater sampling depth - that gradients were relatively stable and do not change over time under constant flow-conditions. Also, the time-depended increase in conductivity at greater sampling depth as observed for the reference sediment could be indicative of shallower sediment horizons reaching steady-state more quickly. The reason why this only occurred for the reference substratum could be due to the fact that the DE sediment was collected from the gravel bar above the water line, and thus, may contain lesser amounts of fines. This could result in a lesser porous structure of the reference sediment causing more resistance in the flow of porewater between sediment horizons. Furthermore, sediment-sampling depth had a significant influence on conductivity but not pH or DOC. Based on this result and the findings from Orders 3 and 4, to enable sampling of sufficient volumes while reducing differences between overlying water and porewater sampling ports at shallower sampling depths between 2.5 and 3.4 cm is recommended. Also, considering the lack of time-dependency of gradients between overlying water and porewater indicating rapid establishment of steady-state after initiation of the experiments is in favor of reducing the equilibration time prior to introduction of test organisms in the definite exposure studies.

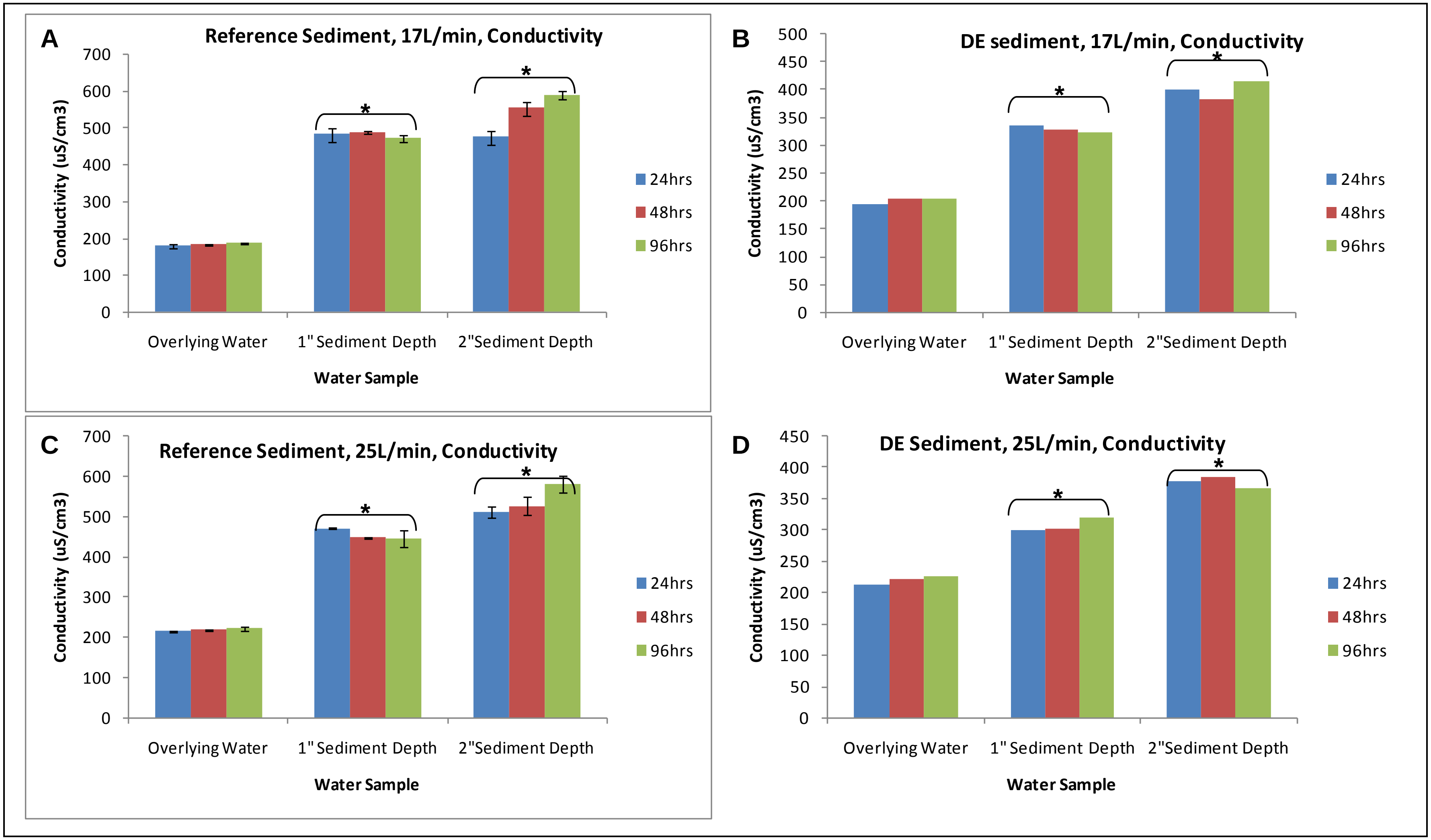


Figure 1: *Mean conductivity in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1") and 2 (2") inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman's Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time (p<0.05; Student's t-test).*

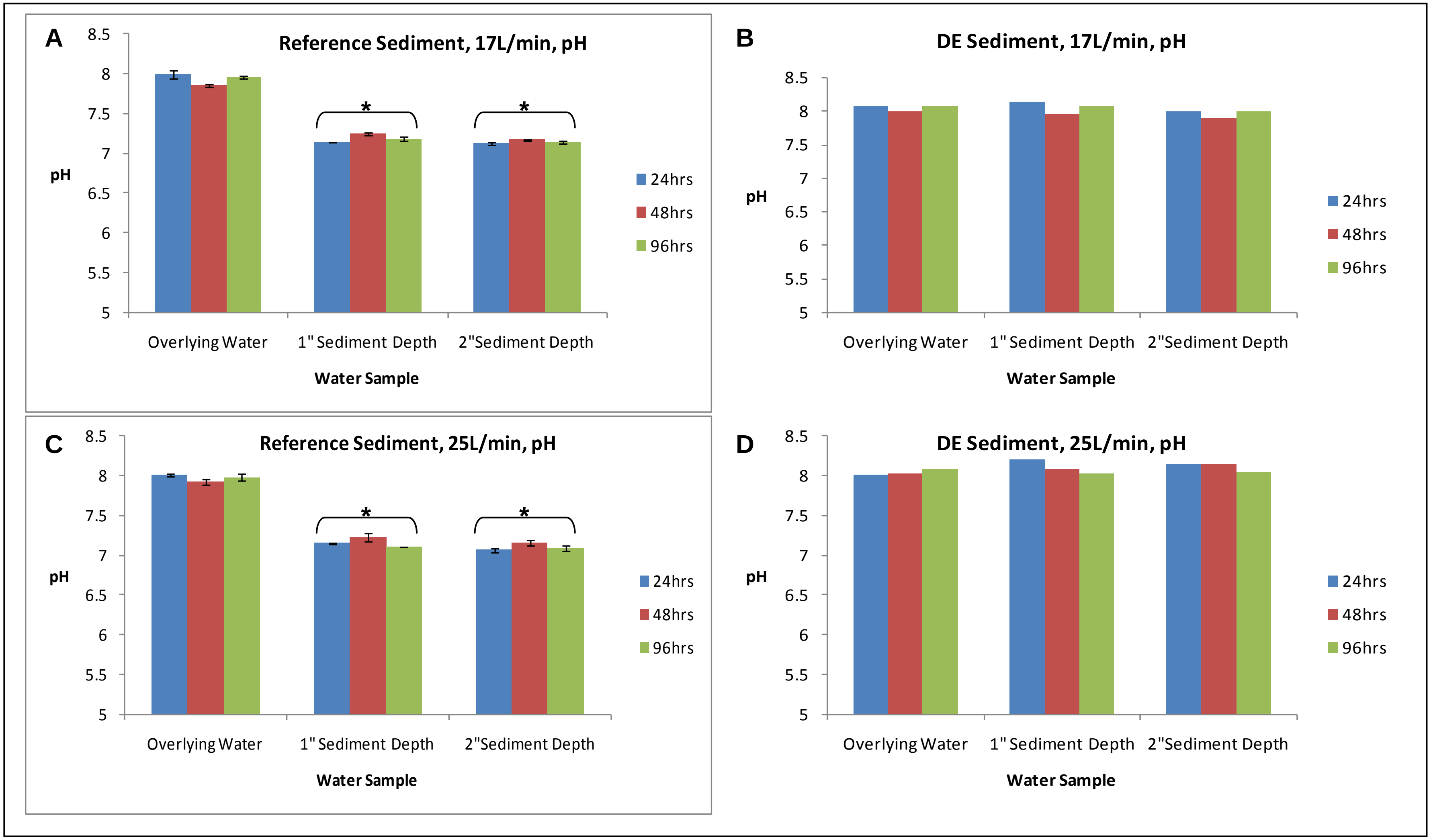


Figure 2: *Mean pH in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1") and 2 (2") inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman's Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time ($p<0.05$; Student's t-test).*

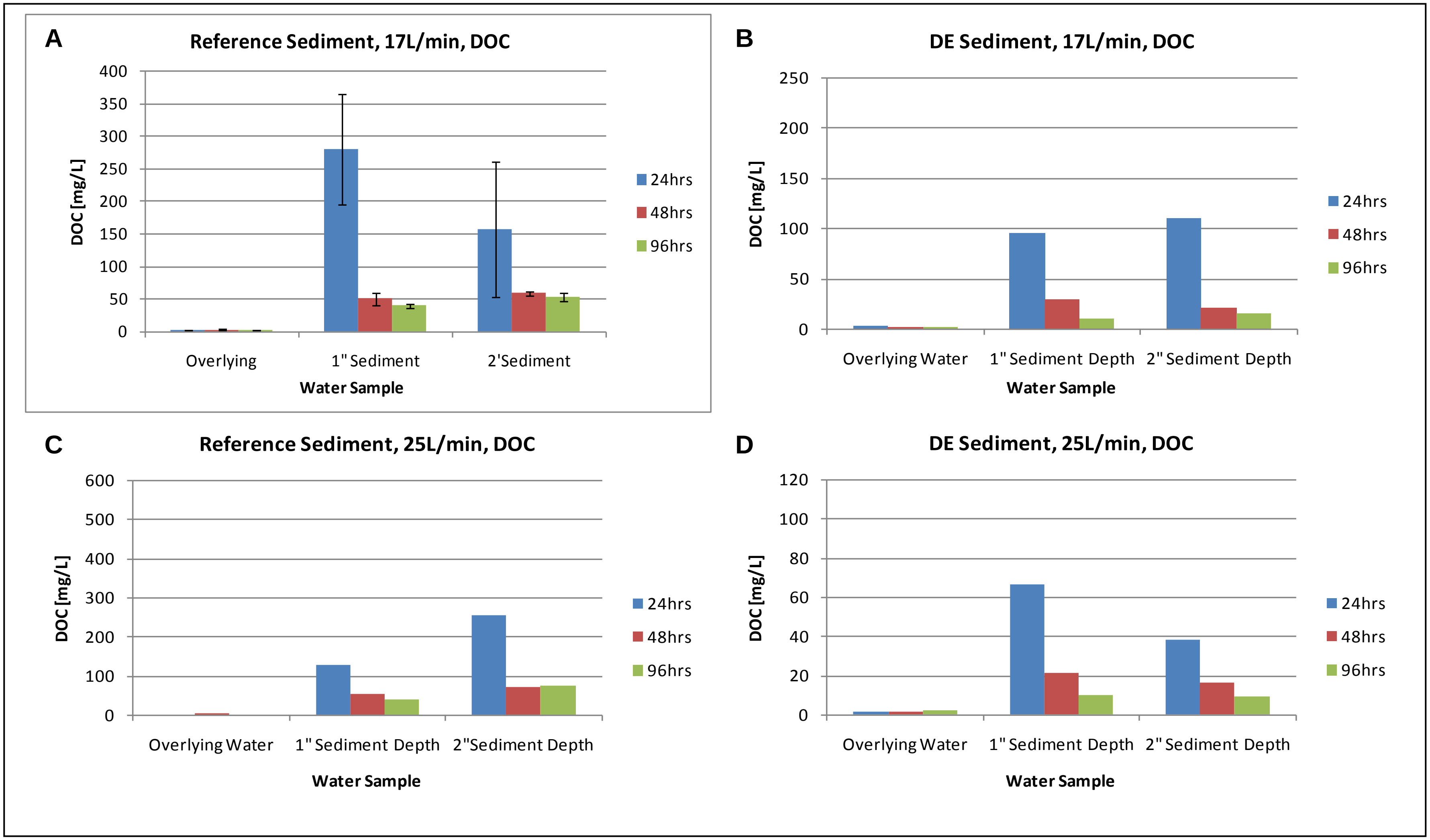


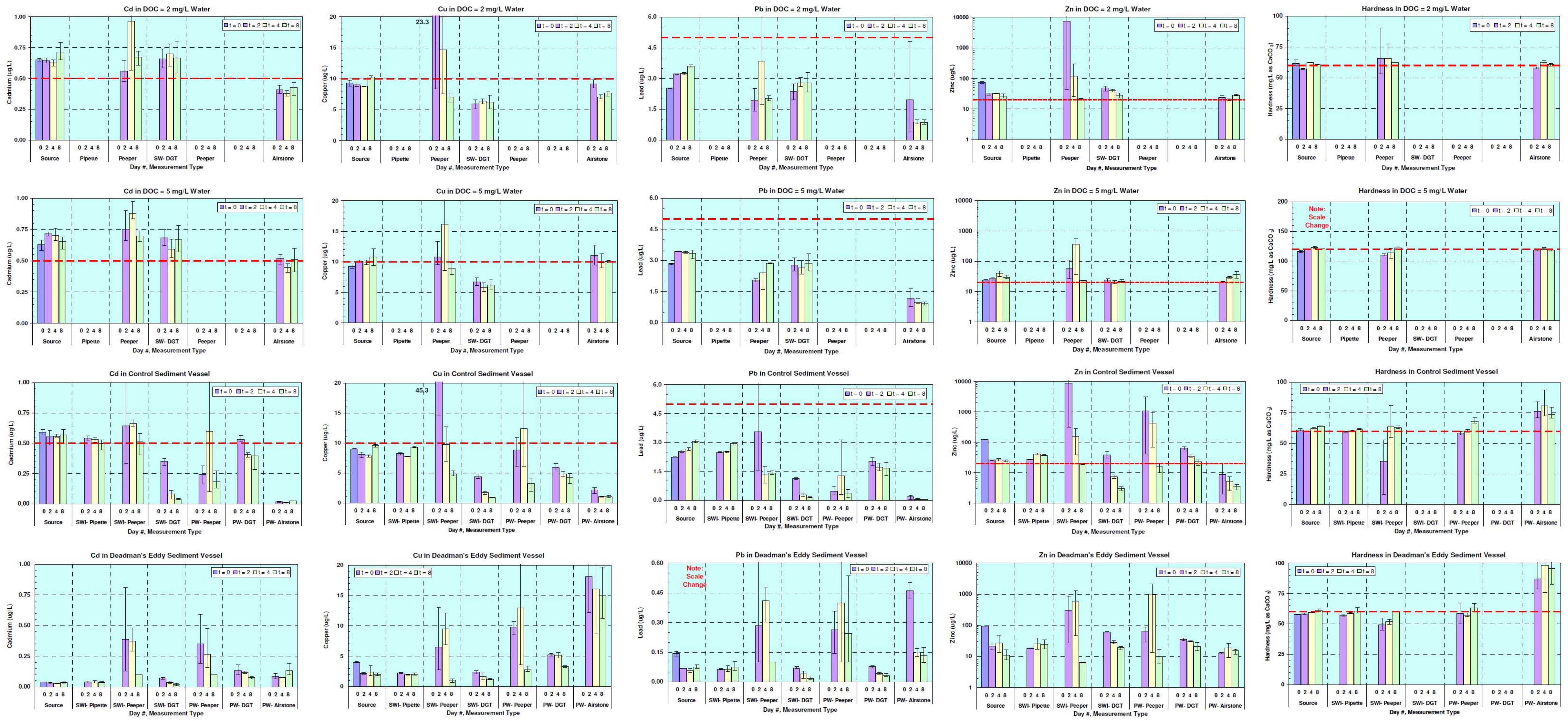
Figure 3: *Mean DOC [mg/L] in overlying water, and porewater at flow-rates of 17 (A&B) and 25 (C&D) L/min. Overlying and porewaters were sampled at depths of 1 (1”) and 2 (2”) inches at 24, 48 and 96 h after initiation of experiment. Sediment types tested were reference sediment and sand bar substrate collected at Genelle (A&C) and Deadman’s Eddy (B&C). Asterisks indicate significant difference from mean response in overlying water measured at the same time (p<0.05; Student’s t-test).*

APPENDIX E

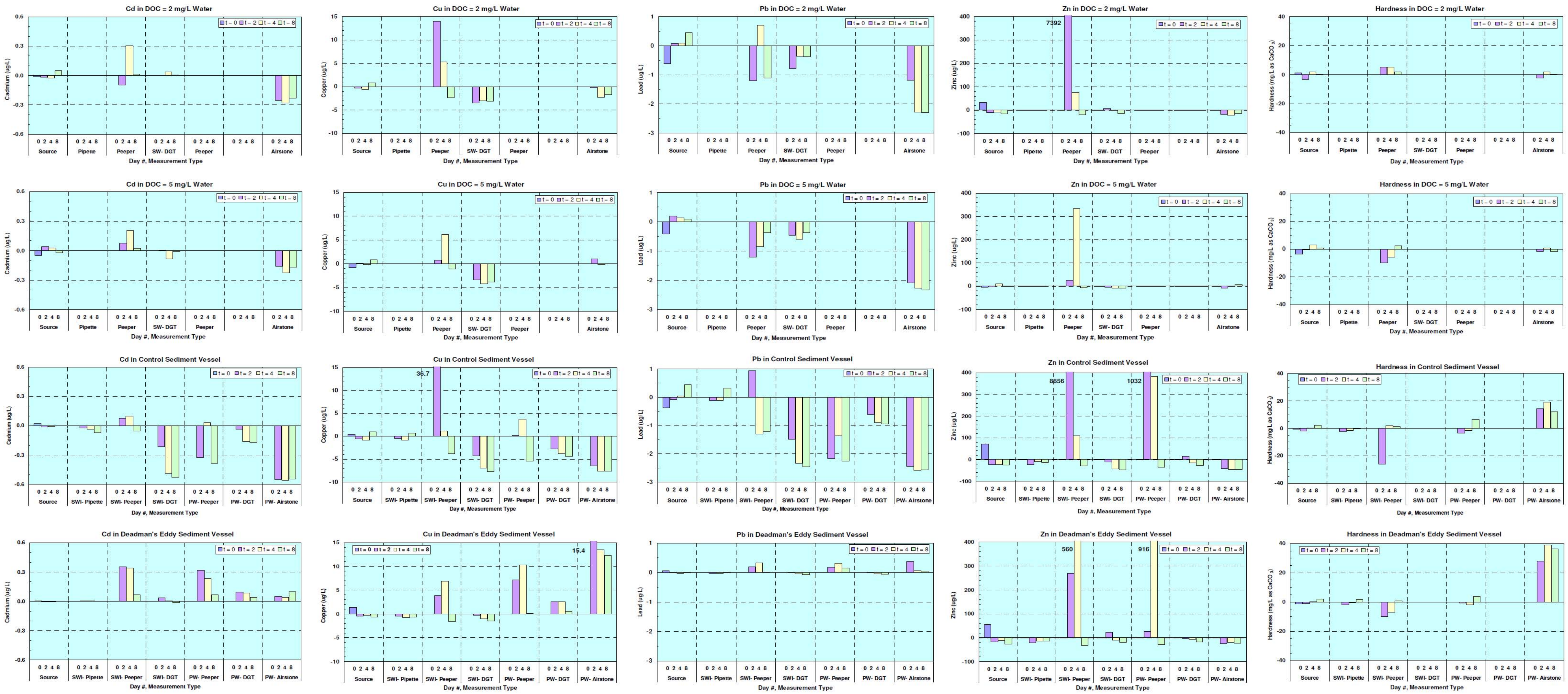
WHITE STURGEON METHODS DEVELOPMENT WORK EVALUATION AND COMPARISON OF POREWATER, SEDIMENT-INTERFACE WATER SAMPLING DEVICES - PRELIMINARY DATA FOR DAYS 0, 2, 4, AND 8

			Cadmium			Copper			Lead			Zinc		
Sample	Type	Day	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Ctrl														
	Source	0	0.59	0.022	0.038	9.0	0.055	0.006	2.2	0.010	0.004	122	1.0	0.008
		2	0.55	0.061	0.110	8.1	0.48	0.059	2.5	0.075	0.030	26.3	0.67	0.025
		4	0.56	0.014	0.026	7.9	0.19	0.024	2.7	0.078	0.029	26.1	2.1	0.080
		8	0.57	0.06	0.10	9.58	0.24	0.03	3.06	0.06	0.02	24.87	1.86	0.07
	Grab	2	0.54	0.022	0.040	8.2	0.22	0.027	2.5	0.026	0.011	27.1	0.90	0.033
		4	0.53	0.021	0.039	7.8	0.055	0.007	2.5	0.040	0.016	41.0	2.9	0.071
		8	0.50	0.04	0.09	9.3	0.125	0.013	2.9	0.066	0.022	37.5	1.9	0.050
	Airstone	2	0.02	0.0055	0.312	2.2	0.57	0.258	0.18	0.12	0.689	8.8	9.1	1.037
		4	0.01	0.0050	0.521	1.0	0.078	0.076	0.047	0.029	0.609	5.3	2.5	0.476
		8	0.03	0.0000	0.000	1.1	0.210	0.200	0.052	0.015	0.287	3.6	0.8	0.222
	Peeper, Above	2	0.65	0.34	0.520	45	53	1.160	3.6	3.5	0.989	8905	14546	1.633
		4	0.66	0.042	0.064	9.8	4.1	0.420	1.3	0.62	0.466	159	170	1.068
		8	0.37	0.16	0.43	7.0	2.3	0.327	0.7	0.70	0.969	55	43	0.795
	Peeper, Below	2	0.24	0.076	0.313	8.8	2.5	0.287	0.46	0.24	0.523	1081	1749	1.617
		4	0.60	0.87	1.443	12	9.8	0.790	1.3	1.6	1.293	434	469	1.081
		8	0.18	0.08	0.431	3.19	1.14	0.358	0.373	0.207	0.554	15.67	4.88	0.312
	DGT, Sediment	2	3.15	0.17	0.055	35.9	3.4	0.095	15.8	1.6	0.098	378	43.0	0.114
		4	4.83	0.22	0.046	58.5	5.6	0.095	26.9	3.1	0.115	417.3	38.6	0.092
		8	9.44	2.54	0.269	102.7	21.6	0.210	52.37	10.9	0.208	539.3	110.4	0.205
	DGT, Water	2	2.09	0.18	0.087	26.7	2.5	0.095	8.8	0.363	0.041	228	65	0.285
		4	0.97	0.43	0.440	21.2	3.3	0.156	4.5	1.4	0.308	86	12	0.134
		8	0.98	0.05	0.055	22.5	0.7	0.031	5.1	0.8	0.160	72	10	0.144
DE														
	Source	0	0.04	0.016	0.375	4.0	0.090	0.023	0.14	0.011	0.079	94	0.70	0.007
		2	0.03	0.0070	0.224	2.2	0.13	0.061	0.068	0.0012	0.017	22	5.6	0.260
		4	0.03	0.0042	0.142	2.4	0.94	0.397	0.056	0.010	0.186	27	19.1	0.714
		8	0.04	0.012	0.320	2.0	0.2	0.1	0.1	0.0	0.1	11.0	4.9	0.4
	Grab	2	0.04	0.0076	0.194	2.2	0.061	0.028	0.064	0.0040	0.063	18	0.46	0.025
		4	0.04	0.0097	0.247	1.9	0.098	0.051	0.064	0.016	0.241	26	12.2	0.478
		8	0.04	0.007	0.192	2.0	0.229	0.116	0.075	0.024	0.324	25	8.5	0.338
	Airstone	2	0.09	0.023	0.270	18	5.1	0.283	0.46	0.042	0.090	13	0.81	0.062
		4	0.08	0.0040	0.053	16	8.9	0.555	0.15	0.021	0.144	19	8.8	0.464
		8	0.13	0.0484	0.360	15	4.3	0.291	0.13	0.038	0.283	15	3.0	0.196
	Peeper, Above	2	0.39	0.37	0.953	6.5	5.7	0.872	0.28	0.32	1.121	307	479	1.559
		4	0.37	0.098	0.262	9.5	2.6	0.274	0.41	0.096	0.233	598	633	1.059
		8	0.10	0.00	0.00	1.03	0.31	0.30	0.10	0.00	0.00	6.33	0.32	0.05
	Peeper, Below	2	0.35	0.21	0.604	9.8	1.1	0.116	0.26	0.11	0.414	66	31.9	0.484
		4	0.27	0.18	0.686	13	12	0.888	0.40	0.29	0.713	954	1091	1.143
		8	0.10	0.000	0.000	3	1	0.190	0.25	0.25	1.026	10	6	0.586
	DGT,Sediment	2	0.78	0.26	0.340	31.6	1.4	0.044	0.60	0.05	0.078	209	18	0.088
		4	1.40	0.14	0.097	62.8	5.9	0.094	0.67	0.08	0.112	370	21	0.057
		8	1.82	0.25	0.137	78.8	3.5	0.045	0.99	0.29	0.296	497	162	0.326
	DGT,Water	2	0.43	0.05	0.125	14.3	1.6	0.112	0.56	0.03	0.057	365	1	0.003

Sample	Type	Day	Cadmium			Copper			Lead			Zinc		
			Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
		4	0.44	0.12	0.263	19.7	6.9	0.348	0.64	0.30	0.473	340	39	0.115
		8	0.51	0.21	0.423	28.2	3.0	0.106	0.59	0.16	0.278	457	60	0.132
H2O@2														
	Source	0	0.65	0.012	0.018	9.4	0.51	0.055	2.5	0.015	0.006	73	4.3	0.059
		2	0.64	0.022	0.034	9.1	0.26	0.029	3.2	0.042	0.013	31	2.6	0.082
		4	0.63	0.030	0.047	8.8	0.055	0.006	3.2	0.050	0.016	33	1.0	0.031
		8	0.71	0.071	0.100	10.2	0.231	0.023	3.6	0.061	0.017	26	4.4	0.168
	Airstone	2	0.41	0.034	0.085	9.2	0.67	0.073	2.0	2.4	1.245	24	3.8	0.160
		4	0.38	0.023	0.060	7.1	0.34	0.047	0.88	0.10	0.119	20	1.1	0.053
		8	0.43	0.058	0.136	7.7	0.42	0.054	0.85	0.12	0.146	28	1.7	0.061
	Peeper	2	0.56	0.086	0.153	23	24	1.035	2.0	0.56	0.285	7432	12789	1.721
		4	0.96	0.50	0.514	15	11	0.756	3.9	3.4	0.885	118	152	1.283
		8	0.67	0.1	0.090	7.0	0.731	0.104	2.0	0.1	0.061	22	0	0.012
	DGT,Water	2	3.91	0.36	0.093	36	3.65	0.102	18.5	2.0	0.110	285	35	0.123
		4	8.28	0.79	0.095	77	4.05	0.052	43.7	2.8	0.065	469	37	0.079
		8	15.77	2.505	0.159	150.50	22.59	0.150	86.8	12.0	0.138	656	96	0.146
H2O@5														
	Source	0	0.63	0.042	0.068	9.2	0.30	0.032	2.8	0.038	0.013	24	0.35	0.014
		2	0.72	0.018	0.025	10	0.20	0.020	3.4	0.010	0.003	26	2.8	0.104
		4	0.70	0.050	0.072	9.9	0.38	0.039	3.4	0.046	0.014	40	8.4	0.210
		8	0.66	0.1	0.085	10.8	1.37	0.127	3.3	0.221	0.066	30	4.4	0.149
	Airstone	2	0.52	0.040	0.077	11	1.6	0.148	1.2	0.46	0.394	21	0.99	0.048
		4	0.45	0.036	0.081	9.9	1.2	0.126	0.98	0.14	0.138	29	1.8	0.063
		8	0.51	0.094	0.186	10.1	0.2	0.015	0.93	0.08	0.085	36	9.1	0.254
	Peeper	2	0.75	0.13	0.172	11	2.2	0.201	2.0	0.075	0.037	56	45.2	0.808
		4	0.88	0.08	0.091	16	6.6	0.409	2.4	0.723	0.302	363	283.2	0.780
		8	0.70	0.04	0.059	9.0	0.955	0.107	6.90	6.49	0.941	23	0.2	0.010
	DGT,Water	2	4.04	0.32	0.080	40	2.9	0.071	21.7	1.706	0.079	143	10.6	0.074
		4	7.01	0.66	0.093	71	6.0	0.085	41.4	3.840	0.093	243	22.9	0.094
		8	15.83	2.13	0.134	151	17.7	0.117	89.8	10.938	0.122	510	59.1	0.116



Cd in DOC = 2 mg/L Water
Cu in DOC = 2 mg/L Water
Pb in DOC = 2 mg/L Water
Zn in DOC = 2 mg/L Water
Hardness in DOC = 2 mg/L Water
Cd in DOC = 5 mg/L Water
Cu in DOC = 5 mg/L Water
Pb in DOC = 5 mg/L Water
Zn in DOC = 5 mg/L Water
Hardness in DOC = 5 mg/L Water
Note: Scale Change
Cd in Control Sediment Vessel
Cu in Control Sediment Vessel
Pb in Control Sediment Vessel
Zn in Control Sediment Vessel
Hardness in Control Sediment Vessel
Cd in Deadman's Eddy Sediment Vessel
Cu in Deadman's Eddy Sediment Vessel
Pb in Deadman's Eddy Sediment Vessel
Note: Scale Change
Zn in Deadman's Eddy Sediment Vessel
Hardness in Deadman's Eddy Sediment Vessel
23.3
45.3
Cadmium (ug/L)
Copper (ug/L)
Lead (ug/L)
Zinc (ug/L)
Hardness (mg/L as CaCO3)
t = 0
t = 2
t = 4
t = 8
Source
Pipette
Peeper
SW- DGT
Airstone
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone
0 2 4 8
Day #, Measurement Type



Cd in DOC = 2 mg/L Water
Cu in DOC = 2 mg/L Water
Pb in DOC = 2 mg/L Water
Zn in DOC = 2 mg/L Water
7392
Hardness in DOC = 2 mg/L Water
Cd in DOC = 5 mg/L Water
Cu in DOC = 5 mg/L Water
Pb in DOC = 5 mg/L Water
Zn in DOC = 5 mg/L Water
Hardness in DOC = 5 mg/L Water
Cd in Control Sediment Vessel
Cu in Control Sediment Vessel
36.7
Pb in Control Sediment Vessel
Zn in Control Sediment Vessel
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1032
Hardness in Control Sediment Vessel
Cd in Deadman's Eddy Sediment Vessel
Cu in Deadman's Eddy Sediment Vessel
15.4
Pb in Deadman's Eddy Sediment Vessel
Zn in Deadman's Eddy Sediment Vessel
560
916
Hardness in Deadman's Eddy Sediment Vessel
t = 0 t = 2 t = 4 t = 8
Cadmium (ug/L)
Copper (ug/L)
Lead (ug/L)
Zinc (ug/L)
Hardness (mg/L as CaCO3)
Day #, Measurement Type
Source
Pipette
Peeper
SW- DGT
Airstone
SWI- Pipette
SWI- Peeper
SWI- DGT
PW- Peeper
PW- DGT
PW- Airstone