3-6-97

DATA EVALUATION RECORD
§ 70-1 -- ACUTE SEDIMENT TOXICITY TEST WITH A FRESHWATER INVERTEBRATE

1. **CHEMICAL**: (RS)-a-cyano-3-phenoxybenzyl(1RS,3RS;1RS,3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate

2. **TEST MATERIAL**: Cypermethrin
   Purity: 92.3 %

3. **CITATION**:

Farrelly, E., Gentle, W., Goggin, U., Rapley, J.H., and Hamer, M.J. 1996. Cyperpethrin: Toxicity to *Hyalella aztec* in Sediment-water Systems. Zeneca Agrochemicals Report No. RC0006. Performed by Zeneca Agrochemicals Laboratory for the Pyrethroid Working Group (PWG). EPA MRID #440744-06.

4. **REVIEWED BY**:

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Signature: Miachel Rexrode
Date: 2-26-97

5. **APPROVED BY**:

Dan Reider
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Ecological Effects Branch
Environmental Fate and
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Signature: Ann Stavola
Date: 3/6/97

6. **STUDY PARAMETERS**

Scientific Name of Test Organism:	(*Hyalella azteca*)
Age of Test Organism:	7 to 10 days old
Definitive Test Duration:	10 days
Study Method:	Static
Type of Concentrations:	Mean measured/Nominal

7. CONCLUSIONS:

This study appears to be scientifically sound but will not support the proposed ASTM Guidelines for an acute sediment study.The researchers ran the toxicity test with a sediment:water ratio of 1:25. Since amphipods can avoid toxic sediments by swimming up into the large volumn of overlying water, EEB has concern for this sediment:water mix. However, the results from these studies show that sediment-bound cypermethrin is potentially biologically available to epibenthic organisms like *Hyalella*. The LC_{50} values were found in the range of very high toxicity (3.1 - 21.1 ug kg^{-1}) while, NOEC were <1.24 - 1.68 ug kg^{-1}.

9. Guideline Deviations

1. Total hardness is recommended at 40-48 mg l^{-1}, the researchers used a higher level (164-168 mg l^{-1}).

2. The researchers ran the toxicity test with a sediment:water ratio of 1:25. Since amphipods can avoid toxic sediments by swimming up into the large volumn of overlying water, EEB has concern for this sediment:water mix. Consultation with Gary Ankley at the US EPA Laboratory at Duluth suggests that a ratio of 1:1 or 1:2 would be more appropriate.

10. SUBMISSION PURPOSE: Investigate the toxicity of sediment-sorbed ^{14}C-cypermethrin to the freshwater benthic amphipod *Hyalella azteca* by exposure in sediment-water system.

11. MATERIALS AND METHODS

A. Test Organisms: *Hyalella azeteca* were obtained from laboratory cultures at Jealott's Hill Research Station. Mixed age cultures were maintained in hard water at 23°C on a 16 hour: 8 hour light:dark photoperiod. Pre-conditioned (soaked in hard water) Horsechestnut (*Aesculus hippocastanum)* leaves, were used as substrate and food.

The test was run with 7 to 14 day old *H. azteca*. Organisms <7 days old were sorted from the culture and transferred to a fresh culture vessel for a further 7 days.

B. Test Sediments: The following three natural uncontaminated sediments were used:

B. Test Sediments: The following three natural uncontaminated sediments were used:

1) **"Florrisant"**: supplied by N. Kimble, Midwest Science Centre, 4200 New Haven Rd, Columbia, USA.

2) **"Mississippi 3"**: supplied by J. Rogers at the University of Mississippi, Biological Field Station, USA.

3) **" Duluth"**: supplied by K. Lieber, Lake Superior Research Institute, University of Wisconsin-Superior, USA.

Prior to physico-chemical analysis, the air-dried samples were passed through 2 mm sieve. Moisture contents of these air-dried samples were determined by oven-drying at 75°C overnight. Sediment physico-chemical parameters that include amount of sand, silt, clay and organic matter were characterized (Table 1).

C. Test Water: Dilution water was prepared by mixing dechlorinated mains water with the same amount of deionized (reverse osmosis system) water. The final hardness was 164-168 mg l^{-1} $CaCO_3$.

Table 1. Sediment Physico-chemical Characteristics

Properties	Florrisant	Mississippi 3	Duluth
pH	6.0	5.1	7.2
% Sand (2000-50 mm)	6	10	30
% Silt (50-2 mm)	70	65	45
% Clay (<2 mm)	24	25	25
% Organic Matter (%Organic Carbon)	1.7 (.99)	5.4 (3.1)	22.9 (13.3)
CEC (meq/100g)	14.5	13.2	43.6
Classification	Silt Loam	Silt Loam	Loam
Zeneca Soil Reference	53/12	53/10	53/14

D. **Test System:**

Test systems consisted of 500 ml glass jars containing 10 g dry weight sediment and 250 ml water (sediment:water ratio of 1:25). Each sediment had a control and a solvent control (spiked with 25 ul acetone) prepared for each treatment. Six replicates (A to F) at each concentration were prepared. Replicate A to D were used for the biological assessments and radiochemical analysis of sediment and overlying water at the end of the test. Replicates E and F were used for radiochemical analysis of sediment, pore water and overlying water at the start and end of the study.

A series of application solutions in acetone were prepared for each sediment and used to spike in 25 ul aliquots at the following nominal sediment concentrations:

Florrisant:	40, 20, 10, 5, and 2.5 ug kg^{-1} dry weight.
Mississippi 3:	60, 20, 6.7, 2.2 and 0.74 ug kg^{-1} dry weight.
Duluth:	150, 50, 17, 5.6, and 1.9 ug kg^{-1} dry weight.

In order to insure even mixing of spiked sediments, test chambers were sealed, shaken and transferred to a rolling mill for two hours at ambient temperature. Test chamber were then placed in a water bath at 23 $\pm$ 2°C and allowed to stand undisturbed for two days while sediment settled. After this period of time, juvenile *Hyalella* were introduced into the Florrisant and Duluth sediment systems. However, for the Mississippi 3 sediment, the overlying water was replaced and the system allowed to stand for an additional 2 days prior to test organism introduction. Replicates A to E received 10 organisms each, selected at random from the cultures. These were introduced below the water surface with a 5 mm pipette, while a subset of organisms were used to determine length at the time of introduction.

Test vessels were covered throughout the test to reduce evaporation, maintained at 23 $\pm$ 2°C in the water bath and illuminated at approximately 800 lux on a 16 hour:8 hour light:dark cycle.

E. Biological Assessment: At day 10 the overlying water from replicates A to D was removed and the sediments transferred to shallow trays. Survival of test organisms was defined as visible movement to the naked eye. Surviving individuals were removed and preserved for length and weight determination. Length was measured using Jandel Scientific Sigma Scan Image Analysis Program. After length measurements, the organisms from each replicate were pooled and oven dried to a constant weight to calculate mean dry weight.

F. Radiochemical Analysis:

Analysis of Test Systems E and F

1) **Overlying Water Phase Analysis (Replicates E and F):** A 100 ml aliquot of overlying water was sampled and extracted with 5 ml n-hexane to remove parent cypermethrin. The hexane was subsample and analyzed by Liquid Scintillation Counting (LSC) to determine ^{14}C-cypermethrin concentrations.

2) **Pore Water Analysis:** Remaining overlying water was removed and the sediment transferred to centrifuge tube. Pore water was separated by centrifugation of sample at 2111 g-force for 15 minutes. The resulting pore water was removed with a pipette and further extracted with hexane in a 1:1 ratio. Sample of the hexane was then analyzed by LSC to determine the concentration of ^{14}C-cypermethrin in pore water.

3) **Sediment Analysis:** Sediment was sequentially extracted with approximately 2 x acetonitrile (35 ml) by shaking for 1 hour. Extracts were combined and brought up to 100 ml with additional acetonitrile. Aliquots of 1 ml samples were analyzed by LSC to determine ^{14}C-cypermethrin concentrations. Unextractable radioactivity was determined by drying the sediment extracts and combusting the samples with a Harvey OX300 Biological Oxidizer. The efficiency of the combustion process, was $\geq$ 87% and values for the combusted samples were not corrected.

Representative sediment extracts were analyzed by Thin Layer Chromatography (TLC) in order to determine the purity of the ^{14}C-cypermethrin application solutions and to characterize radioactivity. Samples were chromatographed in parallel with the unlabeled analytical standards of cypermethrin. Quantification was carried out relative to the level of radioactivity applied to the TLC plate. Analysis was conducted with a Rita 68000 Automatic TLC Analyzer or a Fuji BAS Phosphorimager.

Analysis of Test Systems A to D

1) The overlying water was analyzed at the end of the study as noted for systems E and F (hexane extraction and LSC). After biological assessment, sediment was transferred to centrifuge tubes for extraction with acetonitrile and combustion (as noted previously).

G. Physicochemical Analysis:

1) Dissolved oxygen was measured daily using a YSI Model 57 meter (one replicate per concentration).

2) Specific conductivity and pH were measured using YSI Model 33 and Radiometer pHM62 meters (one replicate per concentration).

3) Ammonium nitrogen analysis was carried out by NRM Ltd. by reaction with hypochlorite and phenol, catalyzed by sodium prusside and colormetric determination of the indophenol formed using an Alpkem RFA analyzer.

4) Temperature within test vessels was maintained with a water bath, with readings every 30 minutes.

H. Statistical Analysis:

Survival data from replicates A to D were analyzed by the technique of iteratively reweighed linear regression of logit response on $\log_{10}$ (concentration) using LOGITPC, version 1.2 to obtain estimates of slope, LC_{50} and 95% confidence intervals. Adjustments were made for any mortality in the solvent control. Length and weight were analyzed by analysis of variance, comparing the treated group with the solvent controls using Statistical Analysis System (SAS).

I. Results:

The LC_{50} values, were based upon the measured sediment concentrations at day 0 (Table 2). The reported LC_{50}s were 3.6, 19, 23 ug kg^{-1} for Florrisant, Mississippi 3 and Duluth sediments, respectively. No Effect Concentration Levels for changes in growth were found to be as follows: Florrisant, <1.8 ug kg^{-1}; Mississippi 3, 2.3 - 6.2 ug kg^{-1}; Duluth, 1.8 ug kg^{-1}.

Table 2. Statistical Results Based on Measured Concentrations at Day 0.

Sediment	10 Day LC_{50} Values	NOEC Weight	NOEC Length
Florrisant	3.6 (3.1-4.2)	<1.8	<1.8
Mississippi 3	19 (15-23)	6.2	2.3
Duluth	23 (19-28)	1.8	1.8

Table 3. ^{14}C-cypermethrin Concentrations

Sediment Nominal Levels (ug kg^{-1})	Sediment Measured Levels (ug kg^{-1}) Day 0	Sediment Measured Levels (ug kg^{-1}) Day 10	Average Measured Levels (ug kg^{-1})
Florrisant			
40	31	17.6	24.3
20	14	8.7	11.3
10	7.1	4.7	5.9
5	3.8	2.4	3.1
2.5	1.8	1.2	1.5
Sol. Control	<0.5	<0.5	<0.5
Control	-	<0.5	<0.5
Mississippi 3			
60	54	44.8	49.4
20	19	15.4	17.2
6.7	6.2	5.0	5.6
2.2	2.3	1.7	4
0.74	1.0	<0.5	<0.5
Sol. Control	<0.5	<0.5	<0.5
Control	-		
Duluth			
150	122	93.2	107.6
50	44	33.8	38.7
17	16	12.4	14.2
5.6	5.4	3.9	4.6
0.74	1.8	1.7	1.7
Sol. Control	<0.5	<0.5	<0.5
Control	-	<0.5	<0.5

12. REVIEWER'S COMMENTS:

The researchers ran the toxicity test with a sediment:water ratio of 1:25. Since amphipods can avoid toxic sediments by swimming up into the large volumn of overlying water, EEB has concern for this sediment:water mix. Consultation with Gary Ankley at the US EPA Laboratory at Duluth suggests that a ratio of 1:1 or 1:2 would be more appropriate.

Total hardness is recommended at 40-48 mg l^{-1}, the researchers used a higher level (164-168 mg l^{-1}).

Instead of using the measured concentrations from Day 0, EEB calculated a mean measured average concentration from Day 0 and Day 10 data. The LC_{50}s were as follows: 3.1, 19.6, 21.1 ug kg^{-1} for Florrisant, Mississippi 3 and Duluth, respectively. These values coincide with the findings and 95% confidence limits noted by the researchers.

An evaluation of growth was conducted with measurements of length and weight by running ANOVA with Dunnetts and Williams multirange test. Using the measured average concentrations, EEB concluded that growth was significantly affected at the following levels: Florrisant, <1.24 ug kg^{-1}; Mississippi 3, 1.68; Duluth, 1.68 ug kg^{-1}.

Adequacy of the Study:

1) Classification: Supplemental

2) Rationale: The water:sediment ratio of 1:25 may bias the studies. A preferred ratio is 1:1 or 1:2.

3) Repairability: No

NOEC
1.68
Length

TITLE: Sediment 10 Day; Hyalella Mississippi 3
FILE: C:\wp51\sediment\hyalell.miss
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 5

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	3.1000	3.1000
1	Solvent Control	2	3.1000	3.1000
1	Solvent Control	3	3.4500	3.4500
1	Solvent Control	4	3.1000	3.1000
2	.54	1	3.2000	3.2000
2	.54	2	3.3400	3.3400
2	.54	3	3.3000	3.3000
2	.54	4	3.3000	3.3000
3	1.68	1	3.5600	3.5600
3	1.68	2	3.3400	3.3400
3	1.68	3	3.9400	3.9400
3	1.68	4	3.0900	3.0900
4	5	1	2.9200	2.9200
4	5	2	2.9200	2.9200
4	5	3	2.8000	2.8000
4	5	4	2.7700	2.7700
5	15.4	1	2.7500	2.7500
5	15.4	2	2.3300	2.3300
5	15.4	3	2.5600	2.5600
5	15.4	4	2.3600	2.3600

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	3.100	3.450	3.188
2	.54	4	3.200	3.340	3.285
3	1.68	4	3.090	3.940	3.482
4	5	4	2.770	2.920	2.853
5	15.4	4	2.330	2.750	2.500

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.031	0.175	0.088
2	.54	0.004	0.060	0.030

3	1.68	0.130	0.360	0.180
4	5	0.006	0.079	0.039
5	15.4	0.038	0.195	0.098

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	4	2.408	0.602	14.333
Within (Error)	15	0.626	0.042	
Total	19	3.034		

Critical F value = 3.06 (0.05,4,15)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	3.188	3.188		
2	.54	3.285	3.285	-0.673	
3	1.68	3.482	3.482	-2.036	
4	5	2.853	2.853	2.312	
5	15.4	2.500	2.500	4.744	*

Dunnett table value = 2.36 (1 Tailed Value, P=0.05, df=15,4)

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	Solvent Control	4			
2	.54	4	0.342	10.7	-0.097
3	1.68	4	0.342	10.7	-0.295
4	5	4	0.342	10.7	0.335
5	15.4	4	0.342	10.7	0.687

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	4	2.408	0.602	14.333
Within (Error)	15	0.626	0.042	
Total	19	3.034		

Critical F value = 3.06 (0.05,4,15)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 5	0 4	0 1	0 2	0 3
5		15.4	2.500	\				
4		5	2.853	.	\			
1	Solvent Control	3.188	3.188	*	.	\		
2		.54	3.285	*	.	.	\	
3		1.68	3.482	*	*	.	.	\

* = significant difference (p=0.05) . = no significant difference
Tukey value (5,15) = 4.37 s = 0.042

Sediment 10 Day; Hyalella Mississippi 3
File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	3.188	3.188	3.318
2	.54	4	3.285	3.285	3.318
3	1.68	4	3.482	3.482	3.318
4	5	4	2.853	2.853	2.853
5	15.4	4	2.500	2.500	2.500

Sediment 10 Day; Hyalella Mississippi 3

File: C:\wp51\sediment\hyalell.miss Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	3.318				
.54	3.318	0.906		1.75	k= 1, v=15
1.68	3.318	0.906		1.84	k= 2, v=15
5	2.853	2.320	*	1.87	k= 3, v=15
15.4	2.500	4.761	*	1.88	k= 4, v=15

s = 0.204

Note: df used for table values are approximate when v > 20.

TITLE: Sediment 10 Day; Hylella dry wt. Miss. 3
FILE: C:\wp51\sediment\Hyaldrywt.mis
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 5

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	0.0490	0.0490
1	Solvent Control	2	0.0340	0.0340
1	Solvent Control	3	0.0760	0.0760
1	Solvent Control	4	0.0570	0.0570
2	0.54	1	0.0460	0.0460
2	0.54	2	0.0620	0.0620
2	0.54	3	0.0480	0.0480
2	0.54	4	0.0630	0.0630
3	1.68	1	0.0810	0.0810
3	1.68	2	0.0660	0.0660
3	1.68	3	0.0830	0.0830
3	1.68	4	0.0520	0.0520
4	5	1	0.0540	0.0540
4	5	2	0.0480	0.0480
4	5	3	0.0470	0.0470
4	5	4	0.0480	0.0480
5	15.4	1	0.0270	0.0270
5	15.4	2	0.0800	0.0800
5	15.4	3	0.0320	0.0320
5	15.4	4	0.0370	0.0370

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	0.034	0.076	0.054
2	0.54	4	0.046	0.063	0.055
3	1.68	4	0.052	0.083	0.071
4	5	4	0.047	0.054	0.049
5	15.4	4	0.027	0.080	0.044

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.000	0.017	0.009
2	0.54	0.000	0.009	0.004

3	1.68	0.000	0.014	0.007
4	5	0.000	0.003	0.002
5	15.4	0.001	0.024	0.012

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	4	0.0016	0.0004	2.000
Within (Error)	15	0.0036	0.0002	
Total	19	0.0052		

Critical F value = 3.06 (0.05,4,15)
Since F < Critical F FAIL TO REJECT Ho:All groups equal

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	0.054	0.054		
2	0.54	0.055	0.055	-0.075	
3	1.68	0.071	0.071	-1.650	
4	5	0.049	0.049	0.475	
5	15.4	0.044	0.044	1.000	

Dunnett table value = 2.36 (1 Tailed Value, P=0.05, df=15,4)

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	Solvent Control	4			
2	0.54	4	0.024	43.7	-0.001
3	1.68	4	0.024	43.7	-0.017
4	5	4	0.024	43.7	0.005
5	15.4	4	0.024	43.7	0.010

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	4	0.0016	0.0004	2.000
Within (Error)	15	0.0036	0.0002	
Total	19	0.0052		

Critical F value = 3.06 (0.05,4,15)
Since F < Critical F FAIL TO REJECT Ho:All groups equal

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 0 5 4 1 2 3
5	15.4	0.044	0.044	\
4	5	0.049	0.049	. \
1	Solvent Control	0.054	0.054	. . \
2	0.54	0.055	0.055	. . . \
3	1.68	0.071	0.071	. . . . \

* = significant difference (p=0.05) . = no significant difference
Tukey value (5,15) = 4.37 s = 0.000

Sediment 10 Day; Hylella dry wt. Miss. 3
File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	0.054	0.054	0.060
2	0.54	4	0.055	0.055	0.060
3	1.68	4	0.071	0.071	0.060
4	5	4	0.049	0.049	0.049
5	15.4	4	0.044	0.044	0.044

Sediment 10 Day; Hylella dry wt. Miss. 3

File: C:\wp51\sediment\Hyaldrywt.mis Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	0.060				
0.54	0.060	0.525		1.75	k= 1, v=15
1.68	0.060	0.525		1.84	k= 2, v=15
5	0.049	0.434		1.87	k= 3, v=15
15.4	0.044	0.913		1.88	k= 4, v=15

s = 0.015

Note: df used for table values are approximate when v > 20.

WDEC

Length 1.24

TITLE: Sediment 10 Day; Hyalella in Florrisant
FILE: C:\wp51\sediment\hyalell.flo
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 4

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	3.5500	3.5500
1	Solvent Control	2	3.5700	3.5700
1	Solvent Control	3	3.8500	3.8500
1	Solvent Control	4	3.4800	3.4800
2	1.24	1	2.6000	2.6000
2	1.24	2	2.8900	2.8900
2	1.24	3	2.6000	2.6000
2	1.24	4	2.3600	2.3600
3	4.68	1	2.3500	2.3500
3	4.68	2	2.3000	2.3000
3	4.68	3	2.5500	2.5500
3	4.68	4	2.5000	2.5000
4	8.76	1	2.3200	2.3200
4	8.76	2	2.8500	2.8500
4	8.76	3	2.2700	2.2700

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	3.480	3.850	3.612
2	1.24	4	2.360	2.890	2.612
3	4.68	4	2.300	2.550	2.425
4	8.76	3	2.270	2.850	2.480

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.027	0.163	0.081
2	1.24	0.047	0.217	0.108
3	4.68	0.014	0.119	0.060
4	8.76	0.103	0.321	0.186

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalel1.flo Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	3.651	1.217	28.302
Within (Error)	11	0.470	0.043	
Total	14	4.121		

Critical F value = 3.59 (0.05,3,11)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalel1.flo Transform: NO TRANSFORM

DUNNETTS TEST

****** WARNING ******

This data set has unequal replicates. The Bonferroni T-test should be used instead of the Dunnetts test.

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalel1.flo Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	3.612	3.612		
2	1.24	2.612	2.612	6.820	*
3	4.68	2.425	2.425	8.099	*
4	8.76	2.480	2.480	7.151	*

Dunnett table value = 2.31 (1 Tailed Value, P=0.05, df=11,3)

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalel1.flo Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

	NUM OF	Minimum Sig Diff	% of	DIFFERENCE

GROUP	IDENTIFICATION	REPS	(IN ORIG. UNITS)	CONTROL	FROM CONTROL
1	Solvent Control	4			
2	1.24	4	0.339	9.4	1.000
3	4.68	4	0.339	9.4	1.187
4	8.76	3	0.366	10.1	1.132

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	3.651	1.217	28.302
Within (Error)	11	0.470	0.043	
Total	14	4.121		

Critical F value = 3.59 (0.05,3,11)
Since F ≥ Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 3 4 2 1
3	4.68	2.425	2.425	\
4	8.76	2.480	2.480	. \
2	1.24	2.612	2.612	. . \
1	Solvent Control	3.612	3.612	* * * \

* = significant difference (p=0.05) . = no significant difference
Tukey value (4,11) = 4.26 s = 0.043

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	3.612	3.612	3.612
2	1.24	4	2.612	2.612	2.612
3	4.68	4	2.425	2.425	2.449

4	8.76	3	2.480	2.480	2.449

Sediment 10 Day; Hyalella in Florrisant
File: C:\wp51\sediment\hyalell.flo Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	3.612				
1.24	2.612	6.843	*	1.80	k= 1, v=11
4.68	2.449	7.965	*	1.89	k= 2, v=11
8.76	2.449	7.374	*	1.92	k= 3, v=11

s = 0.207
Note: df used for table values are approximate when v > 20.

Florrisant

TITLE: Sediment 10 Day: Hyalella Dry Wt.
FILE: C:\wp51\sediment\Hyadrywt.flo
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 4

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	0.0750	0.0750
1	Solvent Control	2	0.0840	0.0840
1	Solvent Control	3	0.0980	0.0980
1	Solvent Control	4	0.0840	0.0840
2	1.24	1	0.0330	0.0330
2	1.24	2	0.0530	0.0530
2	1.24	3	0.0430	0.0430
2	1.24	4	0.0300	0.0300
3	4.68	1	0.0350	0.0350
3	4.68	2	0.0280	0.0280
3	4.68	3	0.0350	0.0350
3	4.68	4	0.0400	0.0400
4	8.76	1	0.0400	0.0400
4	8.76	2	0.0400	0.0400

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	0.075	0.098	0.085
2	1.24	4	0.030	0.053	0.040
3	4.68	4	0.028	0.040	0.035
4	8.76	2	0.040	0.040	0.040

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.000	0.009	0.005
2	1.24	0.000	0.010	0.005
3	4.68	0.000	0.005	0.002
4	8.76	0.000	0.000	0.000

File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	0.0065	0.0022	22.000
Within (Error)	10	0.0007	0.0001	
Total	13	0.0072		

Critical F value = 3.71 (0.05,3,10)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

DUNNETTS TEST

****** WARNING ******

This data set has unequal replicates. The Bonferroni T-test should be used instead of the Dunnetts test.

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	0.085	0.085		
2	1.24	0.040	0.040	6.435	*
3	4.68	0.035	0.035	7.177	*
4	8.76	0.040	0.040	5.225	*

Dunnett table value = 2.34 (1 Tailed Value, P=0.05, df=10,3)

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL

1	Solvent Control	4			
2	1.24	4	0.017	19.4	0.045
3	4.68	4	0.017	19.4	0.051
4	8.76	2	0.020	23.8	0.045

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	0.0065	0.0022	22.000
Within (Error)	10	0.0007	0.0001	
Total	13	0.0072		

Critical F value = 3.71 (0.05,3,10)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 3 2 4 1
3	4.68	0.035	0.035	\
2	1.24	0.040	0.040	. \
4	8.76	0.040	0.040	. . \
1	Solvent Control	0.085	0.085	* * * \

* = significant difference (p=0.05) . = no significant difference
Tukey value (4,10) = 4.33 s = 0.000

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	0.085	0.085	0.085
2	1.24	4	0.040	0.040	0.040
3	4.68	4	0.035	0.035	0.036
4	8.76	2	0.040	0.040	0.036

Sediment 10 Day: Hyalella Dry Wt.
File: C:\wp51\sediment\Hyadrywt.flo Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	0.085				
1.24	0.040	7.691	*	1.81	k= 1, v=10
4.68	0.036	8.268	*	1.91	k= 2, v=10
8.76	0.036	6.751	*	1.94	k= 3, v=10

s = 0.008
Note: df used for table values are approximate when v > 20.

NOEC
1.68

TITLE: Sediment 10 Day on Hyalella in Duluth Sed. (length)
FILE: C:\wp51\sediment\Hyalella.dul
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 4

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	3.7000	3.7000
1	Solvent Control	2	3.5300	3.5300
1	Solvent Control	3	3.7800	3.7800
1	Solvent Control	4	3.6500	3.6500
2	1.68	1	3.9200	3.9200
2	1.68	2	3.5300	3.5300
2	1.68	3	3.5300	3.5300
2	1.68	4	3.5500	3.5500
3	3.92	1	2.7000	2.7000
3	3.92	2	2.9400	2.9400
3	3.92	3	3.1000	3.1000
3	3.92	4	3.1000	3.1000
4	12.4	1	2.4000	2.4000
4	12.4	2	2.1000	2.1000
4	12.4	3	2.6000	2.6000
4	12.4	4	2.4000	2.4000

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	3.530	3.780	3.665
2	1.68	4	3.530	3.920	3.632
3	3.92	4	2.700	3.100	2.960
4	12.4	4	2.100	2.600	2.375

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.011	0.105	0.052
2	1.68	0.037	0.192	0.096
3	3.92	0.036	0.189	0.095
4	12.4	0.043	0.206	0.103

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	4.538	1.513	47.281
Within (Error)	12	0.378	0.032	
Total	15	4.916		

Critical F value = 3.49 (0.05,3,12)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	3.665	3.665		
2	1.68	3.632	3.632	0.257	
3	3.92	2.960	2.960	5.574	*
4	12.4	2.375	2.375	10.198	*

Dunnett table value = 2.29 (1 Tailed Value, P=0.05, df=12,3)

1.68 NOEC

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	Solvent Control	4			
2	1.68	4	0.290	7.9	0.033
3	3.92	4	0.290	7.9	0.705
4	12.4	4	0.290	7.9	1.290

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	4.538	1.513	47.281
Within (Error)	12	0.378	0.032	
Total	15	4.916		

Critical F value = 3.49 (0.05,3,12)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 4 3 2 1
4		12.4	2.375	2.375 \
3		3.92	2.960	2.960 * \
2		1.68	3.632	3.632 * * \
1	Solvent Control		3.665	3.665 * * . \

* = significant difference (p=0.05) . = no significant difference
Tukey value (4,12) = 4.20 s = 0.032

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	3.665	3.665	3.665
2	1.68	4	3.632	3.632	3.632
3	3.92	4	2.960	2.960	2.960
4	12.4	4	2.375	2.375	2.375

Sediment 10 Day on Hyalella in Duluth Sed. (length)
File: C:\wp51\sediment\Hyalella.dul Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	3.665				
1.68	3.632	0.259		1.78	k= 1, v=12

3.92	2.960	5.617	*	1.87	k= 2, v=12
12.4	2.375	10.277	*	1.90	k= 3, v=12

s = 0.178

Note: df used for table values are approximate when v > 20.

NOEC
1.68

TITLE: Sediment 10 Day; Hyalella dry wt.
FILE: C:\wp51\sediment\hyaldrywt.dul Duluth
TRANSFORM: NO TRANSFORM NUMBER OF GROUPS: 4

GRP	IDENTIFICATION	REP	VALUE	TRANS VALUE
1	Solvent Control	1	0.0910	0.0910
1	Solvent Control	2	0.0810	0.0810
1	Solvent Control	3	0.0970	0.0970
1	Solvent Control	4	0.0890	0.0890
2	1.68	1	0.0860	0.0860
2	1.68	2	0.0660	0.0660
2	1.68	3	0.0900	0.0900
2	1.68	4	0.0880	0.0880
3	3.92	1	0.0390	0.0390
3	3.92	2	0.0390	0.0390
3	3.92	3	0.0490	0.0490
3	3.92	4	0.0790	0.0790
4	12.4	1	0.0380	0.0380
4	12.4	2	0.0210	0.0210
4	12.4	3	0.0310	0.0310
4	12.4	4	0.0320	0.0320

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	Solvent Control	4	0.081	0.097	0.090
2	1.68	4	0.066	0.090	0.083
3	3.92	4	0.039	0.079	0.051
4	12.4	4	0.021	0.038	0.031

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	Solvent Control	0.000	0.007	0.003
2	1.68	0.000	0.011	0.006
3	3.92	0.000	0.019	0.009
4	12.4	0.000	0.007	0.004

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	0.0091	0.0030	30.000
Within (Error)	12	0.0017	0.0001	
Total	15	0.0108		

Critical F value = 3.49 (0.05,3,12)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	Solvent Control	0.090	0.090		
2	1.68	0.083	0.083	0.990	
3	3.92	0.051	0.051	5.374	*
4	12.4	0.031	0.031	8.344	*

Dunnett table value = 2.29 (1 Tailed Value, P=0.05, df=12,3)

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	Solvent Control	4			
2	1.68	4	0.016	18.1	0.007
3	3.92	4	0.016	18.1	0.038
4	12.4	4	0.016	18.1	0.059

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	3	0.0091	0.0030	30.000
Within (Error)	12	0.0017	0.0001	
Total	15	0.0108		

Critical F value = 3.49 (0.05,3,12)
Since F > Critical F REJECT Ho:All groups equal

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

TUKEY method of multiple comparisons

GROUP	IDENTIFICATION	TRANSFORMED MEAN	ORIGINAL MEAN	GROUP 0 0 0 0 4 3 2 1
4	12.4	0.031	0.031	\
3	3.92	0.051	0.051	. \
2	1.68	0.083	0.083	* * \
1	Solvent Control	0.090	0.090	* * . \

* = significant difference (p=0.05) . = no significant difference
Tukey value (4,12) = 4.20 s = 0.000

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 1 OF 2

GROUP	IDENTIFICATION	N	ORIGINAL MEAN	TRANSFORMED MEAN	ISOTONIZED MEAN
1	Solvent Control	4	0.090	0.090	0.090
2	1.68	4	0.083	0.083	0.083
3	3.92	4	0.051	0.051	0.051
4	12.4	4	0.031	0.031	0.031

Sediment 10 Day; Hyalella dry wt.
File: C:\wp51\sediment\hyaldrywt.dul Transform: NO TRANSFORM

WILLIAMS TEST (Isotonic regression model) TABLE 2 OF 2

IDENTIFICATION	ISOTONIZED MEAN	CALC. WILLIAMS	SIG P=.05	TABLE WILLIAMS	DEGREES OF FREEDOM
Solvent Control	0.090				
1.68	0.083	0.837		1.78	k= 1, v=12
3.92	0.051	4.542	*	1.87	k= 2, v=12

12.4	0.031	7.052	*	1.90	k= 3, v=12

s = 0.012

Note: df used for table values are approximate when v > 20.