**Final Report**

# *Ceriodaphnia dubia*
# Whole Sediment Survival and Reproduction Toxicity Test Results

# TVA, Kingston Monitoring and Analysis Project
# Emory River Sediment Sample ERM5.5

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# EXECUTIVE SUMMARY

A whole sediment toxicity test was conducted by Environmental Enterprises USA, Inc. (EE USA) to determine potential toxicity of an Emory River site sediment sample to *Ceriodaphnia dubia* neonates. Three samples were used in this test: Emory River site sediment identified as BULKSED-ERM5.5-EEUSA-052411 (ERM5.5); Emory River reference sediment identified as BULKSED-EMORYREFERENCE-EEUSA-052511 (ERS); and Emory River water identified as BULKSW-ERM9.0-EEUSA-060611 (ERW). Several dilutions of ERM5.5 prepared with ERS were tested with four concurrent controls. A moderately hard synthetic freshwater (MHSW) only control was included to assess test organism health. Separate laboratory control sediment (LCS) exposures with either MHSW or ERW were included to assess test acceptability requirements.

*C. dubia* survival and reproduction in the ERM5.5 treatments were compared to survival and reproduction in an ERS control with ERW. Survival and reproduction of *C. dubia* neonates in the ERM5.5 treatments were not reduced when compared to survival and reproduction in the ERS control. Test results are shown in Table 1.

**Table 1. *Ceriodaphnia dubia* Chronic Survival and Reproduction Test Results for ERM5.5.**

| SURVIVAL | REPRODUCTION |
|---|---|
| NOEC / LOEC = 100.0 / > 100.0% | NOEC / LOEC = 100.0 / > 100.0% |
| $IC_{25}$ > 100.0% | $IC_{25}$ > 100.0% |

# INTRODUCTION

EE USA was contracted by Tennessee Valley Authority (TVA) to complete whole sediment toxicity tests with Emory River sediment and water samples using *C. dubia* neonates. The project is described in TVA's Sediment Toxicity Study Design [1]. Site sediment samples were collected from eight representative locations on the Emory River. Emory River reference sediment samples and river water samples were collected upstream of the site sediment locations. The two reference sediment samples were mixed together 50:50 and homogenized in the field. TVA's contractors, Jacobs Engineering and Restoration Services, Inc., coordinated sample collection in the field and delivery of the samples to EE USA. The samples were delivered to EE USA on June 7, 2011, on ice and with custody seals intact (Appendix D).

This test, which was performed on one (ERM5.5) of the eight sediment samples obtained from the Emory River, was conducted in accordance with American Society for Testing and Materials (ASTM) [2] and U. S. EPA [3] toxicity testing methods. Test organisms were cultured at EE USA and were 9.5 to 17.5 hours old when this test was initiated. Ten replicates of each control treatment and six ERM5.5 concentrations were prepared the day before the test was initiated. ERM5.5 dilutions were prepared with ERS. ERM5.5 concentrations tested were 10.0, 20.0, 40.0, 60.0, 80.0, and 100.0%. A portion of the overlying water in each replicate was replaced daily. This test was initiated June 10, 2011, at 1530 and completed June 17 at 1715.

# MATERIALS AND METHODS

*C. dubia* was cultured and maintained in MHSW at 25 ± 1°C. Test organisms were selected from adults producing at least ten in their third or subsequent brood. Only ten neonates from any one adult were used so that one replicate in each treatment was populated with a neonate from the same adult. Test organisms were fed *Selenastrum capricornutum* (SCAP) and Yeast-Cerophyl-digested Tetramin (YCT) daily at the rate of 0.1 mL each per 15 mL of water.

On June 7, 2011, the ERM5.5, ERS, and ERW samples were delivered to EE USA and stored at 0.1 to 6°C (Appendix D & Table 2). Two 1-liter containers each of ERM5.5 and ERS were put into separate mixing bowls. Each 2-liter sediment sample was mixed for approximately five minutes with a KitchenAid Model KHM7TGCS hand-held mixer set at position "3", 580 ± 5 rpm. On June 9th (Day -1), the density of each sediment, LCS, ERS, and ERM5.5, was measured and the test treatments were prepared (Appendix A, page 1). Eight-dram shell vials were used as test chambers. The vials were washed with soap and water and rinsed with acetone, 10% HCl, deionized water, and MHSW prior to being used as test chambers. Test chambers were labeled with test concentration, replicate, and EE USA's project number. Dilutions of ERM5.5 were made with ERS according to the calculations on page 1 of Appendix A. For each treatment, 400 mL of sediment was prepared, homogenized, and then 5 mL were transferred to 11 test replicates. The 11th replicate of each treatment was used for water quality only.

**Table 2. Emory River Site Sediment, Reference Sediment, and Water Samples.**

| TVA Sample ID | EE USA Sample ID | Date Collected | Date Received |
|---|---|---|---|
| BULKSED-ERM5.5-EEUSA-052411<br>Composite Sample, Site Sediment (ERM5.5) | E-384-11 | May 24, 2011 @ 0955 | June 7, 2011 @ 0740 |
| BULKSED-EMORYREFERENCE-EEUSA-052511<br>Composite Sample, Emory Reference Sediment (ERS) | E-382-11 | May 25, 2011 @ 0855 | |
| BULKSW-ERM9.0-EEUSA-060611<br>Grab Sample, Emory River Water (ERW) | E-381-11 | June 6, 2011 @ 1349 | June 7, 2011 @ 0740 |

SCAP and YCT were added to aliquots of the overlying waters, MHSW and ERW; 6.0 mL each of SCAP and YCT was added to 900 mL of MHSW and 12 mL each of SCAP and YCT was added to 1800 mL ERW. The MHSW and ERW aliquots were warmed up to 25 ± 1°C. Twenty mL of MHSW were transferred to 11 test replicates of the MHSW only control. LCS, No. 5 sand supplied by EE USA and wetted to saturation with MHSW, was homogenized with a stainless steel spoon and five mL were transferred to 22 test replicates. Eleven LCS + MHSW replicates received 20 mL MHSW and 11 LCS + ERW replicates received 20 mL ERW. Twenty mL of ERW were added to each replicate of the ERS and ERM5.5 treatments.

After dispensing the sediments and water, the test chambers were placed in an environmental chamber at 25 ± 1°C with a photoperiod of 16 hours light and 8 hours dark. The test was not aerated. Initial water quality parameters (dissolved oxygen (DO) and temperature) were measured daily in the 11th replicate of each treatment. At the end of each 24-hour exposure period, prior to renewal, the ending DO and temperature in each treatment were recorded (Appendix A, pages 9 – 12 & Table 3). Alkalinity, hardness, conductivity, pH, DO, total residual chlorine, and ammonia were measured in ERW and each batch of MHSW (Appendix A, page 2 & Table 4).

**Table 3. Initial and Final Temperature and Dissolved Oxygen Data for Each Treatment: Mean, Minimum, and Maximum.**

| Water Quality Summary for Test Exposures June 10 – 17, 2011 | | | | | Mean Min Max |
|---|---|---|---|---|---|
| % Sample | Temperature, °C | | Dissolved Oxygen, mg/L | | |
| | Initial | Final | Initial | Final | |
| MHSW | 24.6<br>24.2 24.9 | 24.6<br>24.1 25.2 | 7.9<br>7.7 8.3 | 7.7<br>7.4 8.0 | |
| LCS + MHSW | 24.7<br>24.3 25.1 | 24.6<br>24.2 25.2 | 7.6<br>7.2 7.9 | 7.3<br>6.0 7.7 | |
| LCS + ERW | 24.7<br>24.3 25.3 | 24.7<br>24.3 25.2 | 7.3<br>6.5 7.9 | 6.8<br>5.5 7.7 | |
| ERS + ERW | 24.7<br>24.2 25.1 | 24.8<br>24.4 25.2 | 5.9<br>4.8 6.3 | 5.4<br>4.4 5.8 | |
| 10.0 | 24.7<br>24.2 25.4 | 24.7<br>24.4 25.0 | 5.5<br>4.8 5.8 | 5.1<br>4.6 5.5 | |
| 20.0 | 24.7<br>24.2 25.3 | 24.7<br>24.3 25.1 | 5.7<br>5.2 6.4 | 5.1<br>4.2 5.7 | |
| 40.0 | 24.6<br>24.0 25.1 | 24.8<br>24.3 25.2 | 6.0<br>5.6 6.5 | 5.3<br>4.4 5.8 | |
| 60.0 | 24.6<br>24.2 25.2 | 24.7<br>24.2 25.2 | 6.2<br>5.7 6.7 | 5.5<br>4.9 5.9 | |
| 80.0 | 24.6<br>24.0 25.5 | 24.6<br>24.2 25.3 | 6.4<br>6.1 6.8 | 5.8<br>5.2 6.2 | |
| 100.0 | 24.5<br>24.0 25.3 | 24.7<br>24.2 25.2 | 6.2<br>5.2 7.0 | 5.8<br>5.0 6.3 | |

**Table 4. Water Quality Data for ERW and Each Batch of MHSW.**

| | ERW | MHSW | MHSW | MHSW | MHSW |
|---|---|---|---|---|---|
| Collected | 6/06/2011 | ///// | ///// | ///// | ///// |
| Batch Number | BULKSW-ERM9.0-EEUSA-060611 | FW-057-11[1] | | | |
| Alkalinity, mg/l | 40 | 64 | | | |
| Hardness, mg/l | 36 | 108 | | | |
| Conductivity, µmhos/cm | 114.5 | 327 | | | |
| pH, su | 7.2 | 8.1 | | | |
| Dissolved Oxygen, mg/l | 6.7 | 7.9 | | | |
| TRC, mg/l | 0.03 | 0.00 | | | |
| Total Ammonia, mg/l | 0.2 | < 0.02 | | | |
| | | [1] used 06/09-16/2011 | | | |

The test was initiated June 10th (Day 0) after 15 mL of water were removed from each replicate of each treatment and replaced with water into which proper aliquots of food had been added. One *C. dubia* neonate was transferred to each replicate, and then the test chambers were placed in an environmental chamber. On Days 1-6, the test exposures were renewed as follows:

1. The *C. dubia* in each replicate and approximately 5 mL of the water in the replicate were transferred to a 30-mL disposable plastic cup.
2. Additional water equivalent to a total of 15 mL was removed from the replicate.
3. 15 mL of fresh MHSW or ERW as appropriate was transferred to the replicate.
4. The *C. dubia* was transferred back to the replicate.

Water was removed from and added to each replicate with a 25-mL pipette. *C. dubia* were transferred with disposable 3.5-mL transfer pipettes. Survival was recorded daily (Appendix A, pages 3 - 8). Reproduction was also recorded and newly produced neonates discarded before renewal. The test was terminated after seven days, after $\geq$ 60% of each set of control organisms released their third brood.

The endpoints for the chronic test were survival and neonate production. The test acceptability criteria were 80% or greater survival in the LCS + MHSW control and an average of 15 or more young per surviving female in the control solutions (60% of surviving control females must produce three broods).

The response used in the statistical analysis of the survival data was the proportion of test organisms surviving in each treatment chamber after seven days. Fisher's Exact test was used to test for a significant difference between survival in the ERS + ERW control and each ERM5.5 concentration. The response used in the reproduction data analysis was the total number of neonates produced per replicate. Reproduction data were tested for normal distribution and homogeneity of variance using the Kolmogorov D and Bartlett's tests, respectively. Reproduction data were normally distributed, equal in variance, and evaluated by Dunnett's Test. The statistical tests were performed using ToxCalc Version 5.0.32 at a probability level of 0.05 [4].

Sensitivity of test organisms to a known toxicant was determined by performing a chronic Standard Reference Toxicant (SRT) test, CD1106, with potassium chloride (Sigma Chemical, Lot 060M0116V). The most recent SRT test was initiated on May 26, 2011, with less than 24-hour-old *C. dubia* neonates.

## RESULTS AND DISCUSSION

The control *C. dubia* met the test acceptability criteria of 80% or greater survival and an average of 15 or more young per surviving female in the LCS + MHSW control solution. One hundred percent survival occurred in the LCS + MHSW control. Ten out of ten (100%) of the control females produced three broods; the mean brood size was 26.5.

The No Observed Effect Concentration (NOEC) for survival was 100% ERM5.5. The Lowest Observed Effect Concentration (LOEC) was > 100.0% ERM5.5. The $IC_{25}$, a point estimate of the concentration that causes a 25% reduction in survival was > 100.0% ERM5.5 (Appendix B, page 1 & Table 5).

The NOEC for reproduction was 100.0% ERM5.5. The LOEC was > 100.0% ERM5.5. The Minimum Significant Difference percent for this reproduction data set was 10.3% (Appendix B, page 2). The $IC_{25}$, a point estimate of the concentration that causes a 25% reduction in reproduction was > 100.0% ERM5.5 (Appendix B, page 2 & Table 5).

**Table 5. Summary of Percent Survival, Mean Reproduction, and Survival and Reproduction NOECs, LOECs, and $IC_{25}$s for ERM5.5.**

| | LCS + ERW | ERS + ERW | 10% ERM5.5 | 20% ERM5.5 | 40% ERM5.5 | 60% ERM5.5 | 80% ERM5.5 | 100% ERM5.5 |
|---|---|---|---|---|---|---|---|---|
| **% Survival** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Mean Reproduction** | 26.7 | 26.2 | 27.6 | 28.6 | 28.6 | 29.1 | 30.7 | 28.3 |

| | NOEC | LOEC | $IC_{25}$ |
|---|---|---|---|
| **Survival** | 100% ERM5.5 | > 100% ERM5.5 | > 100% ERM5.5 |
| **Reproduction** | 100% ERM5.5 | > 100% ERM5.5 | > 100% ERM5.5 |

In summary, *C. dubia* survival and reproduction were not significantly reduced in any control or ERM5.5 treatment. Survival and reproduction statistical data for the MHSW only, LCS + MHSW, and LCS + ERW controls are presented on pages 3 and 4 of Appendix B.

The neonates used in the potassium chloride SRT met all of the quality control test parameters. The following SRT control charts are given in Appendix C:

- Survival IC25 with ± 2 SD Control Limits
- Survival IC25 %CV with 75th and 90th Percentile Warning Limits
- Survival PMSD
- Reproduction IC25 with ± SD Control Limits
- Reproduction IC25 %CV with 75th and 90th Percentile Warning Limits
- Control Reproduction with Lower Limit
- Control Reproduction %CV with TVA Limit
- Reproduction PMSD

## REFERENCES


1. Tennessee Valley Authority. 2011. Kingston Monitoring and Analysis Project Non-Time-Critical Removal Action Sampling and Analysis Plan Sediment Toxicity Study Design. Chattanooga, TN.

2. American Society for Testing and Materials. 2005. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. Annex A2. Guidance for Conducting Sediment Toxicity Tests with *D. magna* and C. *dubia*. E 1706-05. West Conshohocken, PA.

3. U.S. Environmental Protection Agency. 2002. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms, 4th ed. EPA-821-R-02-013. Office of Water, Washington, DC.

4. Tidepool Scientific Software. 2007. ToxCalc™ Toxicity Data Analysis Software. Version 5.0.32. McKinleyville, CA.

# REPORT TEST REVIEW

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# APPENDIX A

# Cladoceran, *Ceriodaphnia dubia*

## Whole Sediment Survival and Reproduction Test

ASTM E 1706 – 05, Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates:
A2. GUIDANCE FOR CONDUCTING SEDIMENT TOXICITY TESTS WITH
*DAPHNIA MAGNA* (*D. magna*) AND *CERIODAPHNIA DUBIA* (*C. dubia*)

# TVA, Kingston Monitoring and Analysis Project

### ERM5.5 Sediment & ERS Reference Sediment

| | Density | | |
|---|---|---|---|
| | LCS | ERS | ERM5.5 |
| 1 | 68.55 g/40 ml | 52.23 g/40 ml | 52.92 g/40 ml |
| 2 | 64.88 g/40 ml | 52.33 g/40 ml | 52.95 g/40 ml |
| 3 | 68.80 g/40 ml | 52.81 g/40 ml | 53.04 g/40 ml |
| MEAN | 66.74 g/40 ml | 52.46 g/40 ml | 52.97 g/40 ml |
| g/ml | 1.72 | 1.31 | 1.32 |
| g/5 ml | 8.59 | 6.56 | 6.62 |
| Scale ID | N7 | N7 | N7 |
| Date & Time | 6/9/11 0930 | 6/9/11 1345 | 6/9/11 1400 |
| Initial | DP JG | DP JG | DP JG |

| Test Concentrations, % ERM5.5 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ceriodaphnia dubia* | Total Sediment Vol./ Conc., ml | ERM5.5 ml / gram | ERS ml / gram | LCS ml / gram | grams sediment/ replicate | ERW/rep | | MHSW/rep | | Tech, Date, & Time | |
| | | | | | | Day 0 | Days 1 - 6 | Day 0 | Days 1 - 6 | Sed | H2O |
| 100.0% | 400 | 400 / 529.7 | 0 | 0 | 6.62 | 20 | 15 | 0 | 0 | JG 6-9-11 1445 | DP 6/9/11 1570 |
| 80.0% | 400 | 320 / 423.8 | 80 / 104.9 | 0 | 6.61 | 20 | 15 | 0 | 0 | | |
| 60.0% | 400 | 240 / 317.8 | 160 / 209.9 | 0 | 6.60 | 20 | 15 | 0 | 0 | | |
| 40.0% | 400 | 160 / 211.9 | 240 / 314.7 | 0 | 6.58 | 20 | 15 | 0 | 0 | | |
| 20.0% | 400 | 80 / 105.9 | 320 / 419.7 | 0 | 6.57 | 20 | 15 | 0 | 0 | | |
| 10.0% | 400 | 40 / 53.0 | 360 / 472.1 | 0 | 6.56 | 20 | 15 | 0 | 0 | | |
| ERS w ERW | 400 | 0 | 400 / 524.6 | 0 | 6.56 | 20 | 15 | 0 | 0 | | |
| LCS w ERW | 400 | 0 | 0 | 400 / 681.4 | 8.59 | 20 | 15 | 0 | 0 | | |
| LCS w MHSW | 400 | 0 | 0 | 400 / 687.4 | 8.59 | 0 | 0 | 20 | 15 | | |
| MHSW | n/a | 0 | 0 | 0 | n/a | 0 | 0 | 20 | 15 | | |

Data pages & Calculations by: [signature] QA/QC Check by: Veronica McNew

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

## MHSW = Moderately Hard Synthetic Freshwater

| | MHSW | MHSW | MHSW | | Meter # |
|---|---|---|---|---|---|
| Date | 06/09/2011 | ___/___/2011 | ___/___/2011 | | /// |
| Batch # | FW-057-11 | FW- -11 | FW- -11 | | |
| Alkalinity | 64 | | | | |
| Hardness | 108 | | | | |
| Conductivity | 327 | | | | A46 |
| pH | 8.1 | | | | Q8 |
| DO | 7.9 | | | | S7 |
| TRC | 0.0 | | | | A27 |
| Ammonia | <0.02 | | | | |
| Initial | DW | | | | |

## ERW = Emory River Reference Water

| | ERW | ERW | | | Meter # |
|---|---|---|---|---|---|
| Date | 06/07/2011 | ___/___/2011 | | | /// |
| Batch # | Delivered 06/07/2011 | Delivered 03/ /2011 | | | |
| Alkalinity | 40 | DW 6/9/11 | | | |
| Hardness | 36 | | | | |
| Conductivity | 114.5 | | | | A46 |
| pH | 7.2 | | | | Q8 |
| DO | 6.7 | | | | S7 |
| TRC | 0.03 | | | | A27 |
| Ammonia | 0.2 | | | | |
| Initial | VR | | | | |

Alkalinity: mg/l as $CaCO_3$ Hardness: mg/l as $CaCO_3$ Conductivity: µS/cm pH: su
TRC: mg/l Dissolved Oxygen (DO): mg/l Total Residual Chlorine (TRC): mg/l Ammonia, Total: mg/l

Comments: ERS very clean.

ERM5.5 has a lot of low-density black rocks of various sizes up to 1"x1"x0.5"

DW 6/9/11

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

## Cladoceran, *Ceriodaphnia dubia*

Whole Sediment Survival and Reproduction Test

ASTM E 1706 – 05, Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates: A2. GUIDANCE FOR CONDUCTING SEDIMENT TOXICITY TESTS WITH *DAPHNIA MAGNA* (*D. magna*) AND *CERIODAPHNIA DUBIA* (*C. dubia*)

# TVA, Kingston Monitoring and Analysis Project

**ERM5.5 Sediment & ERS Reference Sediment**

Test Organisms Age: 9.5 - 17.5 Hours Old

Test Organisms Source: EEUSA Test Initiation At: 1530 on 6 / 10 /2011

Counted by: David L. Daniel QC/QA by: Veronica [illegible]

Loaded by: David L. Daniel Organism Lot # C061011-02

**Exposure Chamber**: 8 dram vials. **Feeding**: 0.1 ml *S. capricornutum* (Lot # 54-11) & 0.1 ml YCT (Lot # Y6-11 + Y7-11 *) / 15 ml.

## *C. dubia* Daily Survival & Reproduction Data

**Treatment: MHSW only.**

| DAY | REP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DLD | DLD |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLD | DLD |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLD | DLD |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLD | DLD |
| | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 3 | 100 | 45 | DLD | JG |
| | 5 | 11 | 10 | 10 | 9 | 9 | 8 | (A) 11 | 10 | 13 | 11 | 100 | 102 | DLD | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 100 | 2 | DLD | JG |
| | 7 | 14 | 9 | 13 | 14 | 11 | 14 | 10 | 11 | 12 | 10 | 100 | 118 | DLD | MA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | /////// | |
| | | 30 | 24 | 27 | 27 | 24 | 29 | 26 | 26 | 30 | 24 | 26.7 | 8.84 | | |

Comments: (A) split brood DLD 6/16/11

* Y6-11 used 6/9-14/11. Y7-11 used 6/15+16/11 DLD.

# *C. dubia* Daily Survival & Reproduction Data Cont.

## Treatment: LCS w MHSW.

| DAY | REP | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DLO | DLO |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 4 | 5 | 5 | 6 | 4 | 5 | 5 | 6 | 5 | 5 | 4 | 100 | 50 | DLO | JG |
| | 5 | 11 | 11 | 10 | 9 | 10 | 10 | 12 | 10 | 11 | 10 | 100 | 104 | DLO | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | JG |
| | 7 | 10 | 10 | 11 | 13 | 12 | 13 | 12 | 10 | 9 | 11 | 100 | 111 | DLO | MH |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | /////// | |
| | | 26 | 26 | 27 | 26 | 27 | 28 | 30 | 25 | 25 | 25 | 26.5 | 5.97 | | |

## Treatment: LCS w ERW.

| DAY | REP | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DLO | DLO |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | DLO |
| | 4 | 4 | 5 | 5 | 6 | 5 | 6 | 4 | 4 | 5 | 4 | 100 | 48 | DLO | JG |
| | 5 | 9 | 13 | 10 | 12 | 10 | 10 | 12 | 10 | 12 | 9 | 100 | 107 | DLO | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DLO | JG |
| | 7 | 11 | 14 | 12 | 11 | 10 | 11 | 12 | 12 | 9 | 10 | 100 | 112 | DLO | MH |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | /////// | |
| | | 24 | 32 | 27 | 29 | 25 | 27 | 28 | 26 | 26 | 23 | 26.7 | 9.68 | | |

Comments:

# *C. dubia* Daily Survival & Reproduction Data Cont.

## Treatment: ERS w ERW.

| DAY | REP | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DAD | DAD |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 5 | 4 | 4 | 100 | 51 | DAD | JG |
| | 5 | 9 | 10 | 9 | 11 | 11 | 9 | 12 | 11 | 9 | 9 | 100 | 100 | DAD | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | JG |
| | 7 | 10 | 14 | 11 | 12 | 10 | 10 | 13 | 10 | 10 | 11 | 100 | 111 | DAD | MA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | ////// | |
| | | 24 | 29 | 25 | 28 | 27 | 25 | 31 | 26 | 23 | 24 | 26.2 | 9.606 | | |

## Treatment: 10% ERM5.5 w ERW.

| DAY | REP | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DAD | DAD |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | DAD |
| | 4 | 5 | 4 | 5 | 6 | 5 | 6 | 5 | 5 | 6 | 6 | 100 | 53 | DAD | JG |
| | 5 | 11 | 9 | 11 | 8 | 11 | 9 | 12 | 10 | 12 | 12 | 100 | 105 | DAD | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DAD | JG |
| | 7 | 12 | 12 | 12 | 10 | 13 | 10 | 13 | 12 | 11 | 13 | 100 | 118 | DAD | MA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | ////// | |
| | | 28 | 25 | 28 | 24 | 29 | 25 | 30 | 27 | 29 | 31 | 27.6 | 8.40 | | |

Comments:

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# *C. dubia* Daily Survival & Reproduction Data Cont.

## Treatment: 20% ERM5.5 w ERW.

| DAY | REP | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DW | DW |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 5 | 6 | 100 | 53 | DW | JG |
| | 5 | 10 | 9 | 10 | 8 | (A) 10 | 10 | 12 | 11 | 11 | 10 | 100 | 101 | DW | JG |
| | 6 | 0 | 3 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 9 | DW | JG |
| | 7 | 14 | 12 | 9 | 14 | 12 | 11 | 13 | 12 | 14 | 12 | 100 | 123 | DW | NA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | ////// | |
| | | 28 | 28 | 26 | 31 | 28 | 27 | 31 | 29 | 30 | 28 | 28.6 | 5.76 | | |

## Treatment: 40% ERM5.5 w ERW.

| DAY | REP | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DW | DW |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 4 | 5 | 5 | 4 | 5 | 5 | 6 | 5 | 5 | 7 | 4 | 100 | 51 | DW | JG |
| | 5 | 13 | 11 | 9 | 9 | 11 | 9 | 12 | 10 | 12 | 13 | 100 | 109 | DW | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | JG |
| | 7 | 15 | 12 | 12 | 12 | 13 | 12 | 11 | 12 | 15 | 12 | 100 | 126 | DW | NA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | ////// | |
| | | 33 | 28 | 25 | 26 | 29 | 27 | 28 | 27 | 34 | ~~34~~ 29 (B) | 28.6 | 10.1 | | |

Comments: (A) split broods DW 6/6/11
(B) wrong data JG 06-20-11

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# *C. dubia* Daily Survival & Reproduction Data Cont.

## Treatment: 60% ERM5.5 w ERW.

| DAY | REP | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DW | DW |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 4 | 6 | 4 | 6 | 7 | 6 | 4 | 5 | 5 | 5 | 6 | 100 | 54 | DW | JG |
| | 5 | 10 | 12 | 9 | 11 | 14 | 12 | 10 | 11 | 13 | 10 | 100 | 112 | DW | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | JG |
| | 7 | 13 | 15 | 12 | 15 | 12 | 14 | 12 | 13 | 10 | 9 | 100 | 125 | DW | MA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | /////// | |
| | | 29 | 31 | 27 | 33 | 32 | 30 | 27 | 29 | 28 | 25 | 29.1 | 8.49 | | |

## Treatment: 80% ERM5.5 w ERW.

| DAY | REP | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DW | DW |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW |
| | 4 | 6 | 6 | 4 | 5 | 4 | 6 | 7 | 7 | 6 | 5 | 100 | 56 | DW | JG |
| | 5 | 10 | 12 | 11 | 9 | 15 | 13 | 11 | 12 | 12 | 11 | (A) 100 | 116 | DW | JG |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 100 | 1 | DW | JG |
| | 7 | 12 | 14 | 12 | 13 | 16 | 10 | 15 | 15 | 14 | 13 | 100 | 134 | DW | MA |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | /////// | |
| | | 28 | 32 | 27 | 27 | 35 | 29 | 33 | 34 | 32 | 30 | 30.7 | 9.47 | | |

Comments: (A) split brood DW 6/16/11

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

## *C. dubia* Daily Survival & Reproduction Data Cont.

### Treatment: 100% ERM5.5 w ERW.

| DAY | REP | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | % Sur. | No. of Neonates Per Day | Tech CD | Tech H2O | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | /// | /// | DW | DW | 1530 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW | 1215 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW | 1100 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | DW | 0920 |
| | 4 | 4 | 5 | 5 | 6 | 6 | 4 | 4 | 5 | 5 | 6 | 100 | 50 | DW | JG | 1245 |
| | 5 | 12 | 10 | 10 | 9 | 10 | 11 | 13 | 12 | 12 | 12 | 100 | 111 | DW | JG | 1700 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | DW | JG | 1530 |
| | 7 | 8 | 12 | 9 | 11 | 13 | 15 | 11 | 14 | 16 | 13 | 100 | 122 | DW | NA | 1715 |
| | 3rd Brood Reproduction Per Replicate | | | | | | | | | | | Mean | CV % | ////// | | |
| | | 24 | 27 | 24 | 26 | 29 | 30 | 28 | 31 | 33 | 31 | 28.3 | 10.8 | | | |

Calculations by: [signature] QA/QC by: Jennifer Griffith

Data Entry by: [signature]

QA/QC Officer: Mac A. O'Neill (verify data entry!)

Comments:

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# *C. dubia* Water Quality Data

All Treatments: Initial Temp.: 23.5 to 26.4°C; Initial DO: 4.0 to 8.3 mg/l

| Day 0 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/10/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO I | 7.7 | 7.6 | 7.7 | 4.8 | 5.1 | 5.2 | 5.6 | 5.7 | 6.4 | 5.2 | 57 |
| Temp I | 24.2 | 24.4 | 24.4 | 24.2 | 24.2 | 24.2 | 24.0 | 24.2 | 24.0 | 24.0 | A46 |
| Tech. Initials | Finals: N/A | | | | | Initials: ME | | | | | |
| Times | Final Time: | | | | | Initial Time: 1350 | | | | | |

| Day 1 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/11/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.9 | 7.6 | 7.7 | 4.4 | 4.8 | 4.2 | 4.4 | 5.2 | 6.0 | 5.3 | 57 |
| I | 8.0 | 7.9 | 7.9 | 5.8 | 4.8 | 6.3 | 6.4 | 6.5 | 6.8 | 6.7 | 57 |
| Temp F | 24.1 | 24.2 | 24.3 | 24.4 | 24.4 | 24.3 | 24.3 | 24.2 | 24.2 | 24.2 | A46 |
| I | 24.3 | 24.3 | 24.6 | 24.8 | 24.7 | 24.7 | 24.7 | 24.7 | 24.7 | 24.7 | A46 |
| Tech. Initials | Finals: ME | | | | | Initials: ME | | | | | |
| Times | Final Time: 0932 | | | | | Initial Time: 1155 | | | | | |

| Day 2 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/12/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.6 | 7.6 | 7.3 | 5.5 | 4.6 | 5.0 | 5.6 | 5.8 | 6.1 | 6.3 | 57 |
| I | 7.7 | 7.7 | 7.5 | 6.2 | 5.8 | 6.4 | 6.5 | 6.7 | 6.8 | 7.0 | 57 |
| Temp F | 25.2 | 25.2 | 25.2 | 25.2 | 25.0 | 25.0 | 25.0 | 24.8 | 24.8 | 24.9 | A46 |
| I | 24.8 | 24.8 | 24.8 | 24.9 | 24.8 | 24.7 | 24.6 | 24.5 | 24.5 | 24.4 | A46 |
| Tech. Initials | Finals: ME | | | | | Initials: DW | | | | | |
| Times | Final Time: 0840 | | | | | Initial Time: 1200 | | | | | |

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# *C. dubia* Water Quality Data Cont.

All Treatments: Initial Temp.: 23.5 to 26.4°C; Initial DO: 4.0 to 8.3 mg/l

| Day 3 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/13/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.7 | 7.7 | 7.7 | 5.7 | 5.1 | 5.3 | 5.3 | 5.7 | 5.5 | 6.0 | 57 |
| I | 7.8 | 7.5 | 7.6 | 6.1 | 5.8 | 5.6 | 6.2 | 5.9 | 6.1 | 6.3 | 57 |
| Temp F | 24.7 | 24.6 | 24.7 | 24.8 | 24.6 | 24.7 | 24.7 | 24.6 | 24.6 | 24.6 | A46 |
| I | 24.9 | 24.8 | 25.0 | 24.9 | 24.7 | 24.7 | 24.6 | 24.6 | 24.6 | 24.5 | A46 |
| Tech. Initials | Finals: DW | | | | | | Initials: DW | | | | |
| Times | Final Time: 0810 | | | | | | Initial Time: 1220 | | | | |

| Day 4 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/14/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.6 | 7.4 | 7.0 | 5.8 | 5.5 | 5.7 | 5.6 | 5.9 | 6.0 | 6.3 | 57 |
| I | 7.9 | 7.7 | 7.4 | 6.3 | 5.7 | 5.5 | 5.9 | 6.2 | 6.3 | 6.4 | 57 |
| Temp F | 24.9 | 24.9 | 24.7 | 24.8 | 24.9 | 24.8 | 24.9 | 24.9 | 24.8 | 24.8 | A46 |
| I | 24.8 | 25.1 | 25.3 | 25.1 | 25.4 | 25.3 | 25.1 | 25.2 | 25.5 | 25.3 | A46 |
| Tech. Initials | Finals: DW | | | | | | Initials: DW | | | | |
| Times | Final Time: 0930 | | | | | | Initial Time: 1318 | | | | |

Comments:

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# *C. dubia* Water Quality Data Cont.

All Treatments: Initial Temp.: 23.5 to 26.4°C; Initial DO: 4.0 to 8.3 mg/l

| Day 5 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/15/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 8.0 | 7.4 | 6.1 | 5.6 | 5.3 | 5.4 | 5.8 | 5.8 | 6.2 | 6.0 | 57 |
| I | 8.0 | 7.7 | 6.7 | 6.0 | 5.7 | 5.5 | 5.7 | 6.1 | 6.2 | 6.2 | 57 57 |
| Temp F | 24.5 | 24.6 | 24.8 | 24.7 | 25.0 | 25.1 | 25.2 | 25.2 | 25.3 | 25.2 | A46 |
| I | 24.4 | 24.4 | 24.3 | 24.3 | 24.3 | 24.3 | 24.4 | 24.3 | 24.2 | 24.2 | A46 |
| Tech. Initials | Finals: ME | | | | | Initials: ME | | | | | |
| Times | Final Time: 1030 | | | | | Initial Time: 1720 | | | | | |

| Day 6 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | Emory River Water | | | | | | | | |
| 06/16/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.8 | 7.1 | 6.4 | 5.4 | 5.1 | 5.1 | 5.2 | 5.2 | 5.5 | 5.5 | 57 |
| I | 8.3 | 7.2 | 6.5 | 5.9 | 5.8 | 5.6 | 5.6 | 6.0 | 6.1 | 5.9 | 57 |
| Temp F | 24.6 | 24.6 | 24.6 | 24.6 | 24.5 | 24.5 | 24.4 | 24.4 | 24.3 | 24.3 | A46 |
| I | 24.7 | 24.8 | 24.8 | 24.8 | 24.8 | 24.8 | 24.8 | 24.7 | 24.7 | 24.6 | A46 |
| Tech. Initials | Finals: ME | | | | | Initials: ME | | | | | |
| Times | Final Time: 0924 | | | | | Initial Time: 1641 | | | | | |

Comments:

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

## *C. dubia* Water Quality Data Cont.

All Treatments: Initial Temp.: 23.5 to 26.4°C; Initial DO: 4.0 to 8.3 mg/l

| Day 7 | Controls | | | | Treatment % ERM5.5 | | | | | | Meter # |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MHSW | | TVA Supplied Emory River Water | | | | | | | | |
| 06/17/11 | MHSW | LCS + MHSW | LCS + ERW | ERS | 10.0% | 20.0% | 40.0% | 60.0% | 80.0% | 100.0% | |
| DO F | 7.4 | 6.0 | 5.5 | 5.2 | 5.0 | 5.0 | 4.9 | 4.9 | 5.2 | 5.0 | 57 |
| Temp F | 24.3 | 24.4 | 24.6 | 24.8 | 24.7 | 24.8 | 24.8 | 24.6 | 24.5 | 24.6 | 446 |
| Tech. Initials | Finals: ME | | | | Initials: | | | | | | |
| Times | Final Time: 0910 | | | | Initial Time: N/A | | | | | | |

Comments:

RAW DATA QA/QC: Mark A. O'Neil

TVA, ERM5.5, Site Sediment E-384-11
TVA, ERS, Reference Sediment E-382-11
TVA, ERW, River Water E-381-11

# APPENDIX B

## Ceriodaphnia Survival and Reproduction Test-7 Day Survival

| | | | | | |
|---|---|---|---|---|---|
| Start Date: | 6/10/2011 | Test ID: | cd38411 | Sample ID: | ERM5.5 |
| End Date: | 6/17/2011 | Lab ID: | EE USA | Sample Type: | WHOLE SEDIMENT |
| Sample Date: | 5/24/2011 | Protocol: | ASTM E1706-05 Annex A2 | Test Species: | CD-Ceriodaphnia dubia |

Comments: LCS=Lab control Sediment; ERW=Emory River Water; ERS=Emory Reference Sediment.

| Conc-% | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| LCS+ERW | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| ERS+ERW | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 10 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 20 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 40 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 60 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 80 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 100 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| Conc-% | Mean | N-Mean | Resp | Not Resp | Total | N | Fisher's Exact P | 1-Tailed Critical | Isotonic Mean | Isotonic N-Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| LCS+ERW | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 0.6238 | | | |
| ERS+ERW | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | * | | 1.0000 | 1.0000 |
| 10 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |
| 20 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |
| 40 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |
| 60 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |
| 80 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |
| 100 | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 | 1.0000 | 1.0000 |

| Hypothesis Test (1-tail, 0.05) | NOEC | LOEC | ChV | TU |
|---|---|---|---|---|
| Fisher's Exact Test | 100 | >100 | | 1 |
| Treatments vs ERS+ERW | | | | |

Linear Interpolation (200 Resamples)

| Point | % | SD | 95% CL | Skew |
|---|---|---|---|---|
| IC05 | >100 | | | |
| IC10 | >100 | | | |
| IC15 | >100 | | | |
| IC20 | >100 | | | |
| IC25 | >100 | | | |
| IC40 | >100 | | | |
| IC50 | >100 | | | |

## Ceriodaphnia Survival and Reproduction Test-Reproduction

| | | | | | |
|---|---|---|---|---|---|
| Start Date: | 6/10/2011 | Test ID: | cd38411 | Sample ID: | ERM5.5 |
| End Date: | 6/17/2011 | Lab ID: | EE USA | Sample Type: | WHOLE SEDIMENT |
| Sample Date: | 5/24/2011 | Protocol: | ASTM E1706-05 Annex A2 | Test Species: | CD-Ceriodaphnia dubia |

Comments: LCS=Lab control Sediment; ERW=Emory River Water; ERS=Emory Reference Sediment

| Conc-% | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| LCS+ERW | 24.000 | 32.000 | 27.000 | 29.000 | 25.000 | 27.000 | 28.000 | 26.000 | 26.000 | 23.000 |
| ERS+ERW | 24.000 | 29.000 | 25.000 | 28.000 | 27.000 | 25.000 | 31.000 | 26.000 | 23.000 | 24.000 |
| 10 | 28.000 | 25.000 | 28.000 | 24.000 | 29.000 | 25.000 | 30.000 | 27.000 | 29.000 | 31.000 |
| 20 | 28.000 | 28.000 | 26.000 | 31.000 | 28.000 | 27.000 | 31.000 | 29.000 | 30.000 | 28.000 |
| 40 | 33.000 | 28.000 | 25.000 | 26.000 | 29.000 | 27.000 | 28.000 | 27.000 | 34.000 | 29.000 |
| 60 | 29.000 | 31.000 | 27.000 | 33.000 | 32.000 | 30.000 | 27.000 | 29.000 | 28.000 | 25.000 |
| 80 | 28.000 | 32.000 | 27.000 | 27.000 | 35.000 | 29.000 | 33.000 | 34.000 | 32.000 | 30.000 |
| 100 | 24.000 | 27.000 | 24.000 | 26.000 | 29.000 | 30.000 | 28.000 | 31.000 | 33.000 | 31.000 |

| | | | Transform: Untransformed | | | | | | 1-Tailed | | Isotonic | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc-% | Mean | N-Mean | Mean | Min | Max | CV% | N | t-Stat | Critical | MSD | Mean | N-Mean |
| LCS+ERW | 26.700 | 1.0191 | 26.700 | 23.000 | 32.000 | 9.678 | 10 | | | | | |
| ERS+ERW | 26.200 | 1.0000 | 26.200 | 23.000 | 31.000 | 9.656 | 10 | * | | | 28.467 | 1.0000 |
| 10 | 27.600 | 1.0534 | 27.600 | 24.000 | 31.000 | 8.402 | 10 | -1.213 | 2.347 | 2.710 | 28.467 | 1.0000 |
| 20 | 28.600 | 1.0916 | 28.600 | 26.000 | 31.000 | 5.757 | 10 | -2.079 | 2.347 | 2.710 | 28.467 | 1.0000 |
| 40 | 28.600 | 1.0916 | 28.600 | 25.000 | 34.000 | 10.053 | 10 | -2.079 | 2.347 | 2.710 | 28.467 | 1.0000 |
| 60 | 29.100 | 1.1107 | 29.100 | 25.000 | 33.000 | 8.487 | 10 | -2.512 | 2.347 | 2.710 | 28.467 | 1.0000 |
| 80 | 30.700 | 1.1718 | 30.700 | 27.000 | 35.000 | 9.472 | 10 | -3.898 | 2.347 | 2.710 | 28.467 | 1.0000 |
| 100 | 28.300 | 1.0802 | 28.300 | 24.000 | 33.000 | 10.802 | 10 | -1.819 | 2.347 | 2.710 | 28.300 | 0.9941 |

| Auxiliary Tests | Statistic | Critical | Skew | Kurt |
|---|---|---|---|---|
| Kolmogorov D Test indicates normal distribution (p > 0.05) | 0.691859 | 0.895 | 0.217879 | -0.72077 |
| Bartlett's Test indicates equal variances (p = 0.69) | 3.903799 | 16.81189 | | |
| The control means are not significantly different (p = 0.67) | 0.437223 | 2.100922 | | |

| Hypothesis Test (1-tail, 0.05) | NOEC | LOEC | ChV | TU | MSDu | MSDp | MSB | MSE | F-Prob | df |
|---|---|---|---|---|---|---|---|---|---|---|
| Dunnett's Test | 100 | >100 | | 1 | 2.709925 | 0.103432 | 18.89524 | 6.665079 | 0.016566 | 6, 63 |
| Treatments vs ERS+ERW | | | | | | | | | | |

### Linear Interpolation (200 Resamples)

| Point | % | SD | 95% CL | Skew |
|---|---|---|---|---|
| IC05 | >100 | | | |
| IC10 | >100 | | | |
| IC15 | >100 | | | |
| IC20 | >100 | | | |
| IC25 | >100 | | | |
| IC40 | >100 | | | |
| IC50 | >100 | | | |

## Ceriodaphnia Survival and Reproduction Test-7 Day Survival

| | | | | | |
|---|---|---|---|---|---|
| Start Date: | 6/10/2011 | Test ID: | cd38411c | Sample ID: | ERM5.5 |
| End Date: | 6/17/2011 | Lab ID: | EE USA | Sample Type: | WHOLE SEDIMENT |
| Sample Date: | 5/24/2011 | Protocol: | ASTM E1706-05 Annex A2 | Test Species: | CD-Ceriodaphnia dubia |

Comments: MHSW=Mod Hard Synthetic Water; LCS=Lab Control Sediment; ERW=EMORY River Water

| Conc-% | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| MHSW | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| LCS+MHSW | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| LCS+ERW | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

| Conc-% | Mean | N-Mean | Resp | Not Resp | Total | N | Fisher's Exact P | 1-Tailed Critical |
|---|---|---|---|---|---|---|---|---|
| MHSW | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 0.6238 | |
| LCS+MHSW | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | * | |
| LCS+ERW | 1.0000 | 1.0000 | 0 | 10 | 10 | 10 | 1.0000 | 0.0500 |

**Hypothesis Test (1-tail, 0.05)**

Fisher's Exact Test indicates no significant differences

Treatments vs LCS+MHSW

## Ceriodaphnia Survival and Reproduction Test-Reproduction

| | | | | | |
|---|---|---|---|---|---|
| Start Date: | 6/10/2011 | Test ID: | cd38411c | Sample ID: | ERM5.5 |
| End Date: | 6/17/2011 | Lab ID: | EE USA | Sample Type: | WHOLE SEDIMENT |
| Sample Date: | 5/24/2011 | Protocol: | ASTM E1706-05 Annex A2 | Test Species: | CD-Ceriodaphnia dubia |

Comments: MHSW=Mod Hard Synthetic Water; LCS=Lab Control Sediment; ERW=EMORY River Water

| Conc-% | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| MHSW | 30.000 | 24.000 | 27.000 | 27.000 | 24.000 | 29.000 | 26.000 | 26.000 | 30.000 | 24.000 |
| LCS+MHSW | 26.000 | 26.000 | 27.000 | 26.000 | 27.000 | 28.000 | 30.000 | 25.000 | 25.000 | 25.000 |
| LCS+ERW | 24.000 | 32.000 | 27.000 | 29.000 | 25.000 | 27.000 | 28.000 | 26.000 | 26.000 | 23.000 |

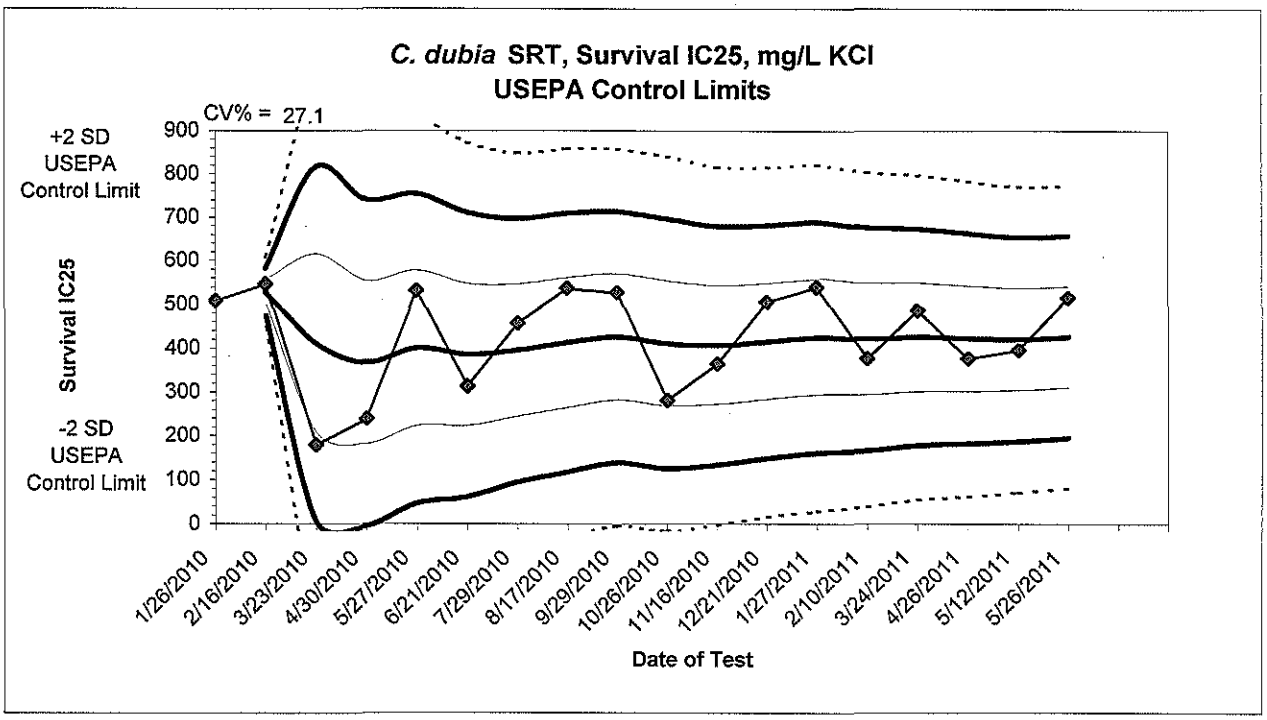
| | | | Transform: Untransformed | | | | | | 1-Tailed | |
|---|---|---|---|---|---|---|---|---|---|---|
| Conc-% | Mean | N-Mean | Mean | Min | Max | CV% | N | t-Stat | Critical | MSD |
| MHSW | 26.700 | 1.0075 | 26.700 | 24.000 | 30.000 | 8.837 | 10 | | | |
| LCS+MHSW | 26.500 | 1.0000 | 26.500 | 25.000 | 30.000 | 5.967 | 10 | * | | |
| LCS+ERW | 26.700 | 1.0075 | 26.700 | 23.000 | 32.000 | 9.678 | 10 | -0.209 | 1.734 | 1.661 |

| Auxiliary Tests | Statistic | Critical | Skew | Kurt |
|---|---|---|---|---|
| Shapiro-Wilk's Test indicates normal distribution (p > 0.05) | 0.952123 | 0.905 | 0.795863 | 1.200101 |
| F-Test indicates equal variances (p = 0.16) | 2.671111 | 6.54109 | | |
| The control means are not significantly different (p = 0.83) | 0.222681 | 2.100922 | | |

| Hypothesis Test (1-tail, 0.05) | MSDu | MSDp | MSB | MSE | F-Prob | df |
|---|---|---|---|---|---|---|
| Homoscedastic t Test indicates no significant differences Treatments vs LCS+MHSW | 1.661245 | 0.062689 | 0.2 | 4.588889 | 0.836975 | 1, 18 |

Environmental Enterprises USA, Inc.

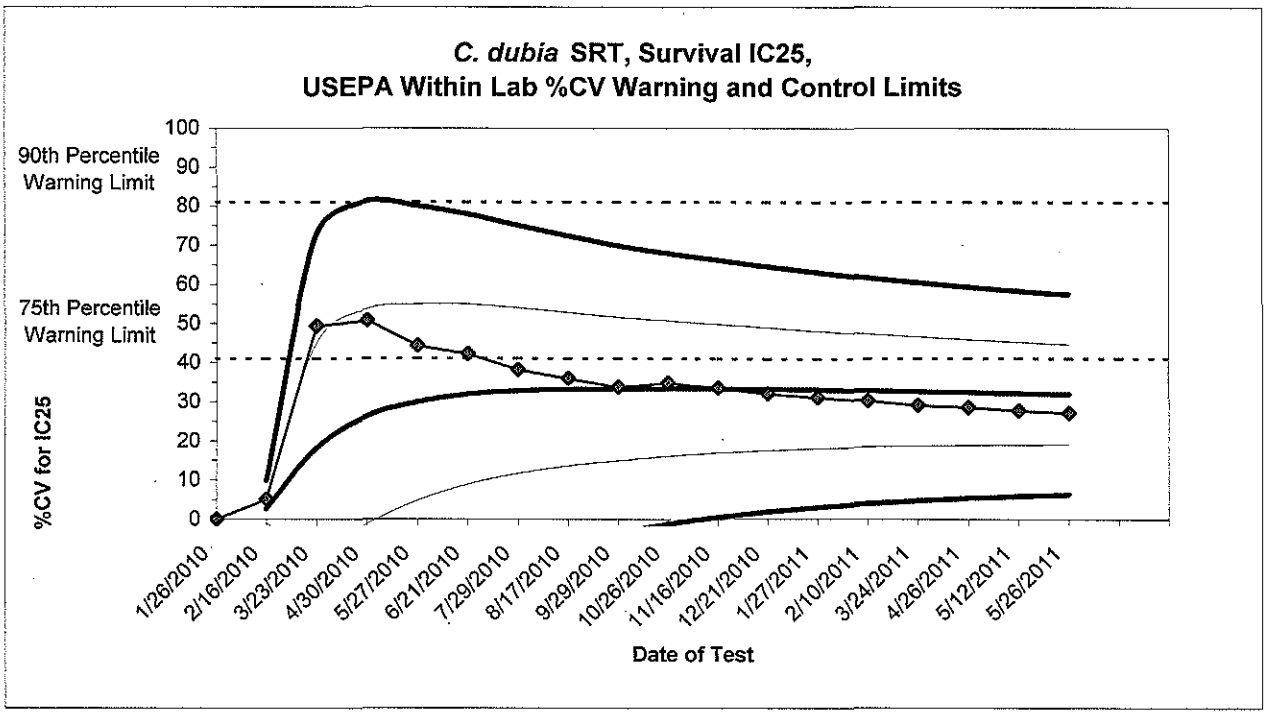
# APPENDIX C




| Test # | Test Date | Survival IC25 | Mean IC25 | -1 SD | -2 SD | +1 SD | +2 SD | -3 SD | +3 SD | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 508 | | | | | | | | 079K0011 |
| CD1003 | 2/16/2010 | 546 | 527 | 500 | 473 | 554 | 581 | 446 | 608 | 079K0011 |
| CD1004 | 3/23/2010 | 178 | 411 | 208 | 6 | 613 | 815 | -197 | 1018 | 049K0305 |
| CD1006 | 4/30/2010 | 238 | 368 | 181 | -5 | 554 | 740 | -192 | 927 | 049K0305 |
| CD1007 | 5/27/2010 | 531 | 400 | 223 | 46 | 577 | 755 | -132 | 932 | 049K0305 |
| CD1009 | 6/21/2010 | 312 | 386 | 223 | 60 | 548 | 711 | -102 | 873 | 049K0305 |
| CD1010 | 7/29/2010 | 456 | 396 | 245 | 94 | 546 | 697 | -57 | 848 | 079K0011 |
| CD1011 | 8/17/2010 | 536 | 413 | 265 | 117 | 561 | 709 | -31 | 858 | 079K0011 |
| CD1012 | 9/29/2010 | 527 | 426 | 282 | 138 | 569 | 713 | -5 | 857 | 079K0011 |
| CD1013 | 10/26/2010 | 281 | 411 | 268 | 125 | 554 | 697 | -18 | 840 | 099K0202 |
| CD1014 | 11/16/2010 | 364 | 407 | 271 | 134 | 543 | 680 | -2 | 816 | 099K0202 |
| CD1015 | 12/21/2010 | 506 | 415 | 282 | 149 | 548 | 682 | 16 | 815 | 099K0202 |
| CD1101 | 1/27/2011 | 539 | 425 | 293 | 161 | 557 | 689 | 29 | 821 | 099K0202 |
| CD1102 | 2/10/2011 | 376 | 421 | 294 | 166 | 549 | 676 | 39 | 804 | 099K0202 |
| CD1103 | 3/24/2011 | 485 | 426 | 302 | 178 | 550 | 674 | 54 | 797 | 099K0202 |
| CD1104 | 4/26/2011 | 376 | 422 | 302 | 182 | 543 | 663 | 61 | 784 | 099K0202 |
| CD1105 | 5/12/2011 | 396 | 421 | 304 | 187 | 538 | 654 | 71 | 771 | 099K0202 |
| CD1106 | 5/26/2011 | 515 | 426 | 311 | 195 | 542 | 657 | 80 | 772 | 060M0116V |

CD1005 - IC25 less than lowest concentration tested and could not be graphed

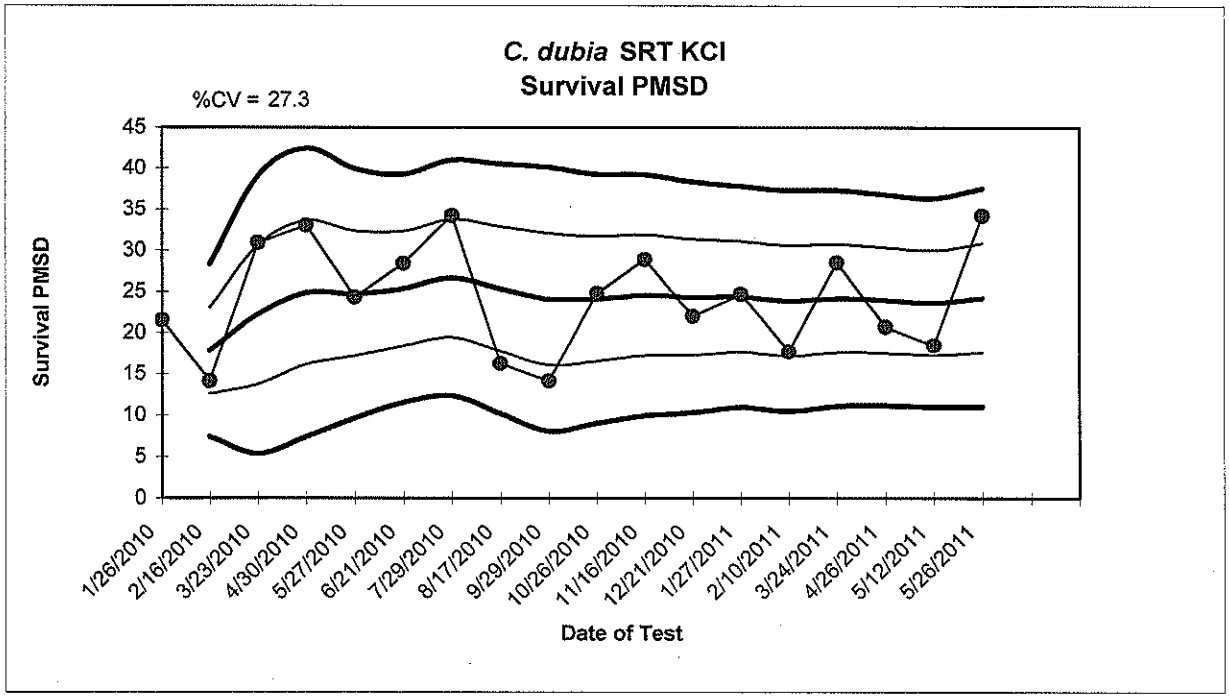
CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl



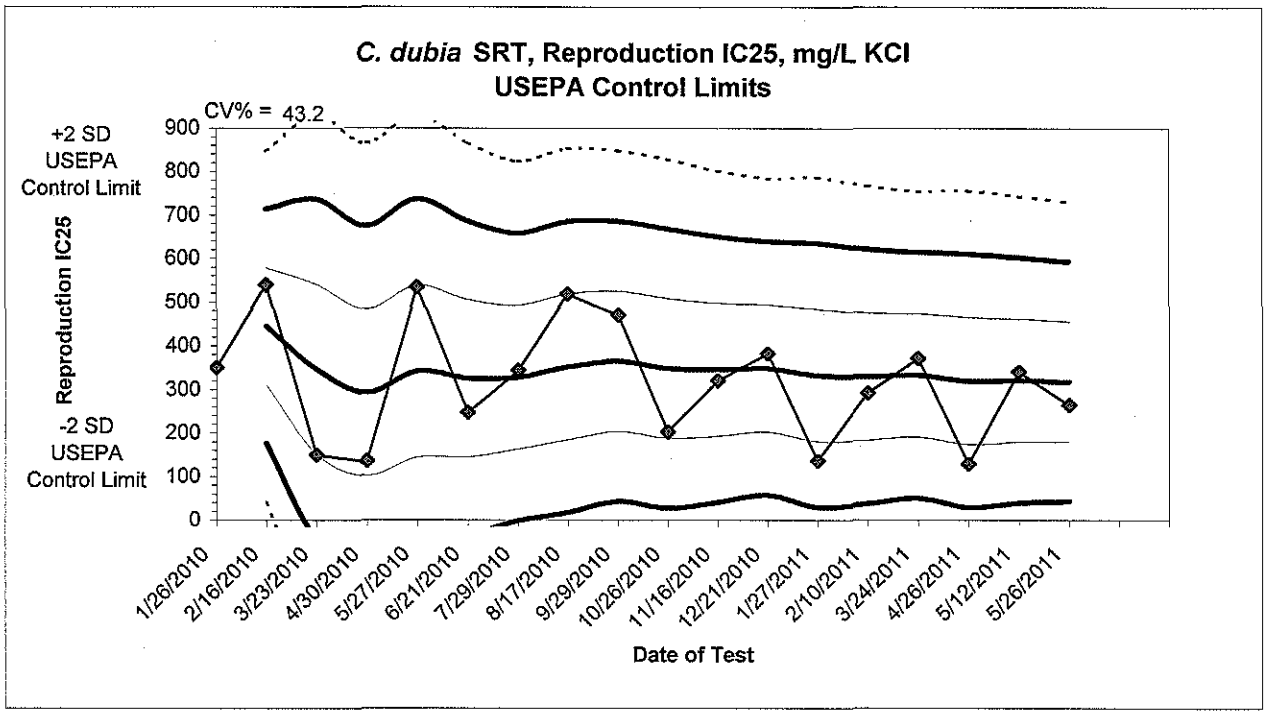

| Test # | Test Date | %CV for IC25 | Mean %CV | -1 SD | -2 SD | +1 SD | +2 SD | 75th Warning Limit | 90th Warning Limit | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 0.0 | | | | | | 41.0 | 81.0 | 079K0011 |
| CD1003 | 2/16/2010 | 5.1 | 2.5 | -1.1 | -4.7 | 6.2 | 9.8 | 41.0 | 81.0 | 079K0011 |
| CD1004 | 3/23/2010 | 49.3 | 18.1 | -9.0 | -36.1 | 45.2 | 72.3 | 41.0 | 81.0 | 049K0305 |
| CD1006 | 4/30/2010 | 50.7 | 26.3 | -1.2 | -28.7 | 53.8 | 81.2 | 41.0 | 81.0 | 049K0305 |
| CD1007 | 5/27/2010 | 44.3 | 29.9 | 4.8 | -20.4 | 55.0 | 80.1 | 41.0 | 81.0 | 049K0305 |
| CD1009 | 6/21/2010 | 42.2 | 31.9 | 8.9 | -14.1 | 55.0 | 78.0 | 41.0 | 81.0 | 049K0305 |
| CD1010 | 7/29/2010 | 38.1 | 32.8 | 11.7 | -9.5 | 54.0 | 75.1 | 41.0 | 81.0 | 079K0011 |
| CD1011 | 8/17/2010 | 35.9 | 33.2 | 13.6 | -6.0 | 52.8 | 72.4 | 41.0 | 81.0 | 079K0011 |
| CD1012 | 9/29/2010 | 33.7 | 33.3 | 14.9 | -3.4 | 51.6 | 70.0 | 41.0 | 81.0 | 079K0011 |
| CD1013 | 10/26/2010 | 34.8 | 33.4 | 16.1 | -1.2 | 50.7 | 68.0 | 41.0 | 81.0 | 099K0202 |
| CD1014 | 11/16/2010 | 33.5 | 33.4 | 17.0 | 0.6 | 49.8 | 66.3 | 41.0 | 81.0 | 099K0202 |
| CD1015 | 12/21/2010 | 32.1 | 33.3 | 17.6 | 2.0 | 49.0 | 64.6 | 41.0 | 81.0 | 099K0202 |
| CD1101 | 1/27/2011 | 31.1 | 33.1 | 18.1 | 3.1 | 48.1 | 63.1 | 41.0 | 81.0 | 099K0202 |
| CD1102 | 2/10/2011 | 30.3 | 32.9 | 18.5 | 4.1 | 47.4 | 61.8 | 41.0 | 81.0 | 099K0202 |
| CD1103 | 3/24/2011 | 29.1 | 32.7 | 18.7 | 4.8 | 46.6 | 60.6 | 41.0 | 81.0 | 099K0202 |
| CD1104 | 4/26/2011 | 28.5 | 32.4 | 18.9 | 5.4 | 45.9 | 59.4 | 41.0 | 81.0 | 099K0202 |
| CD1105 | 5/12/2011 | 27.7 | 32.1 | 19.0 | 5.9 | 45.3 | 58.4 | 41.0 | 81.0 | 099K0202 |
| CD1106 | 5/26/2011 | 27.1 | 31.9 | 19.1 | 6.3 | 44.7 | 57.5 | 41.0 | 81.0 | 060M0116V |
| | | | | | | | | 41.0 | 81.0 | |
| | | | | | | | | 41.0 | 81.0 | |

CD1005 - IC25 less than lowest concentration tested and could not be graphed

CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl



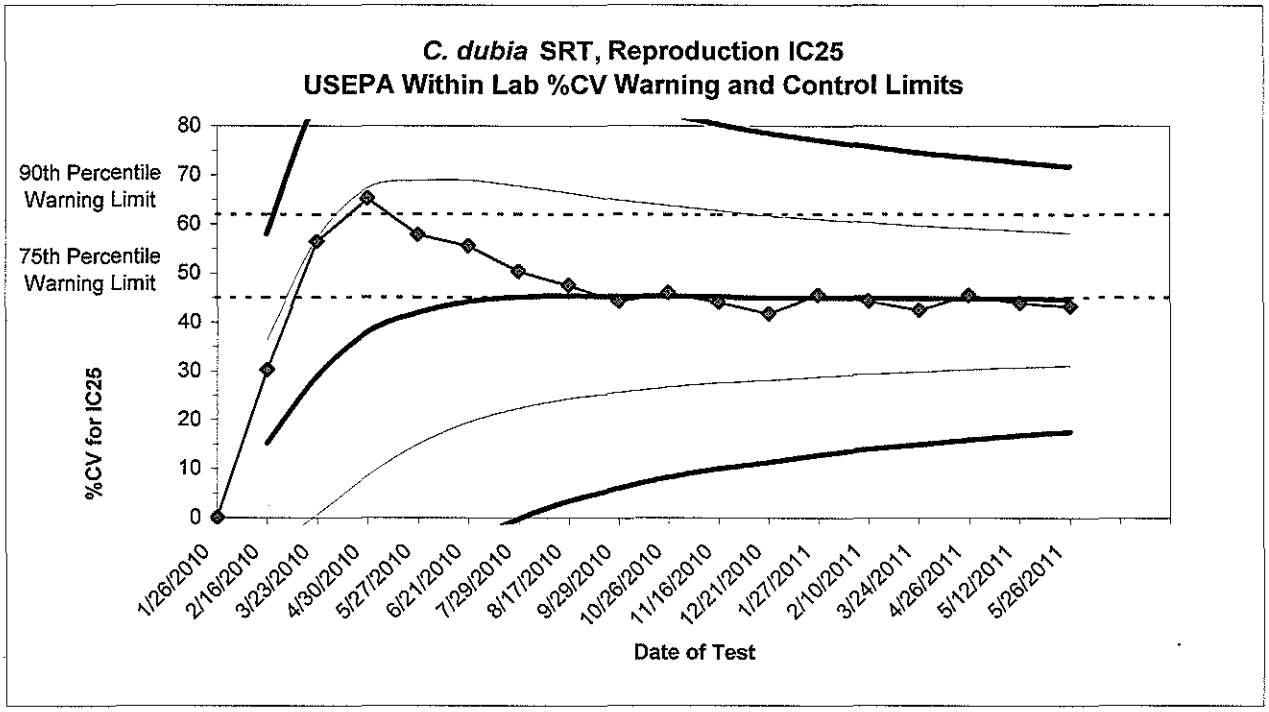

| Test # | Test Date | Survival PMSD | Mean | -1 SD | -2 SD | +1 SD | +2 SD | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 21.5 | | | | | | 079K0011 |
| CD1003 | 2/16/2010 | 14.1 | 17.8000 | 12.5674 | 7.3348 | 23.0326 | 28.2652 | 079K0011 |
| CD1004 | 3/23/2010 | 30.9 | 22.1667 | 13.7468 | 5.3270 | 30.5865 | 39.0063 | 049K0305 |
| CD1006 | 4/30/2010 | 33.0 | 24.8750 | 16.1227 | 7.3704 | 33.6273 | 42.3796 | 049K0305 |
| CD1007 | 5/27/2010 | 24.3 | 24.7600 | 17.1759 | 9.5919 | 32.3441 | 39.9281 | 049K0305 |
| CD1009 | 6/21/2010 | 28.4 | 25.3667 | 18.4224 | 11.4782 | 32.3109 | 39.2552 | 049K0305 |
| CD1010 | 7/29/2010 | 34.2 | 26.6286 | 19.4639 | 12.2992 | 33.7932 | 40.9579 | 079K0011 |
| CD1011 | 8/17/2010 | 16.2 | 25.3250 | 17.7360 | 10.1469 | 32.9140 | 40.5031 | 079K0011 |
| CD1012 | 9/29/2010 | 14.1 | 24.0778 | 16.0532 | 8.0285 | 32.1024 | 40.1270 | 079K0011 |
| CD1013 | 10/26/2010 | 24.8 | 24.1500 | 16.5809 | 9.0117 | 31.7191 | 39.2883 | 099K0202 |
| CD1014 | 11/16/2010 | 28.9 | 24.5818 | 17.2597 | 9.9376 | 31.9040 | 39.2261 | 099K0202 |
| CD1015 | 12/21/2010 | 22.0 | 24.3667 | 17.3456 | 10.3246 | 31.3877 | 38.4088 | 099K0202 |
| CD1101 | 1/27/2011 | 24.7 | 24.3923 | 17.6695 | 10.9467 | 31.1151 | 37.8379 | 099K0202 |
| CD1102 | 2/10/2011 | 17.7 | 23.9143 | 17.2122 | 10.5101 | 30.6164 | 37.3185 | 099K0202 |
| CD1103 | 3/24/2011 | 28.5 | 24.2200 | 17.6540 | 11.0881 | 30.7860 | 37.3519 | 099K0202 |
| CD1104 | 4/26/2011 | 20.7 | 24.0000 | 17.5959 | 11.1919 | 30.4041 | 36.8081 | 099K0202 |
| CD1105 | 5/12/2011 | 18.5 | 23.6765 | 17.3339 | 10.9913 | 30.0190 | 36.3616 | 099K0202 |
| CD1106 | 5/26/2011 | 34.2 | 24.2611 | 17.6268 | 10.9925 | 30.8954 | 37.5298 | 060M0116V |




| Test # | Test Date | Repro. IC25 | Mean IC25 | -1 SD | -2 SD | +1 SD | +2 SD | -3 SD | +3 SD | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 349 | | | | | | | | 079K0011 |
| CD1003 | 2/16/2010 | 539 | 444 | 310 | 175 | 578 | 713 | 41 | 847 | 079K0011 |
| CD1004 | 3/23/2010 | 149 | 346 | 151 | -44 | 541 | 736 | -239 | 931 | 049K0305 |
| CD1006 | 4/30/2010 | 135 | 293 | 102 | -89 | 484 | 675 | -280 | 866 | 049K0305 |
| CD1007 | 5/27/2010 | 533 | 341 | 144 | -53 | 538 | 735 | -250 | 932 | 049K0305 |
| CD1009 | 6/21/2010 | 246 | 325 | 145 | -36 | 506 | 686 | -216 | 867 | 049K0305 |
| CD1010 | 7/29/2010 | 343 | 328 | 163 | -2 | 493 | 658 | -167 | 823 | 079K0011 |
| CD1011 | 8/17/2010 | 518 | 352 | 185 | 18 | 518 | 685 | -149 | 852 | 079K0011 |
| CD1012 | 9/29/2010 | 469 | 365 | 204 | 43 | 525 | 686 | -118 | 847 | 079K0011 |
| CD1013 | 10/26/2010 | 202 | 348 | 188 | 28 | 508 | 669 | -132 | 829 | 099K0202 |
| CD1014 | 11/16/2010 | 320 | 346 | 194 | 41 | 498 | 650 | -111 | 802 | 099K0202 |
| CD1015 | 12/21/2010 | 382 | 349 | 203 | 58 | 494 | 640 | -88 | 785 | 099K0202 |
| CD1101 | 1/27/2011 | 136 | 332 | 181 | 30 | 484 | 635 | -121 | 786 | 099K0202 |
| CD1102 | 2/10/2011 | 292 | 330 | 184 | 38 | 475 | 621 | -108 | 767 | 099K0202 |
| CD1103 | 3/24/2011 | 370 | 332 | 191 | 51 | 473 | 614 | -90 | 755 | 099K0202 |
| CD1104 | 4/26/2011 | 128 | 319 | 174 | 29 | 465 | 610 | -117 | 755 | 099K0202 |
| CD1105 | 5/12/2011 | 340 | 321 | 180 | 39 | 461 | 602 | -102 | 743 | 099K0202 |
| CD1106 | 5/26/2011 | 264 | 318 | 180 | 43 | 455 | 592 | -94 | 729 | 060M0116V |

CD1005 - IC25 less than lowest concentration tested and could not be graphed

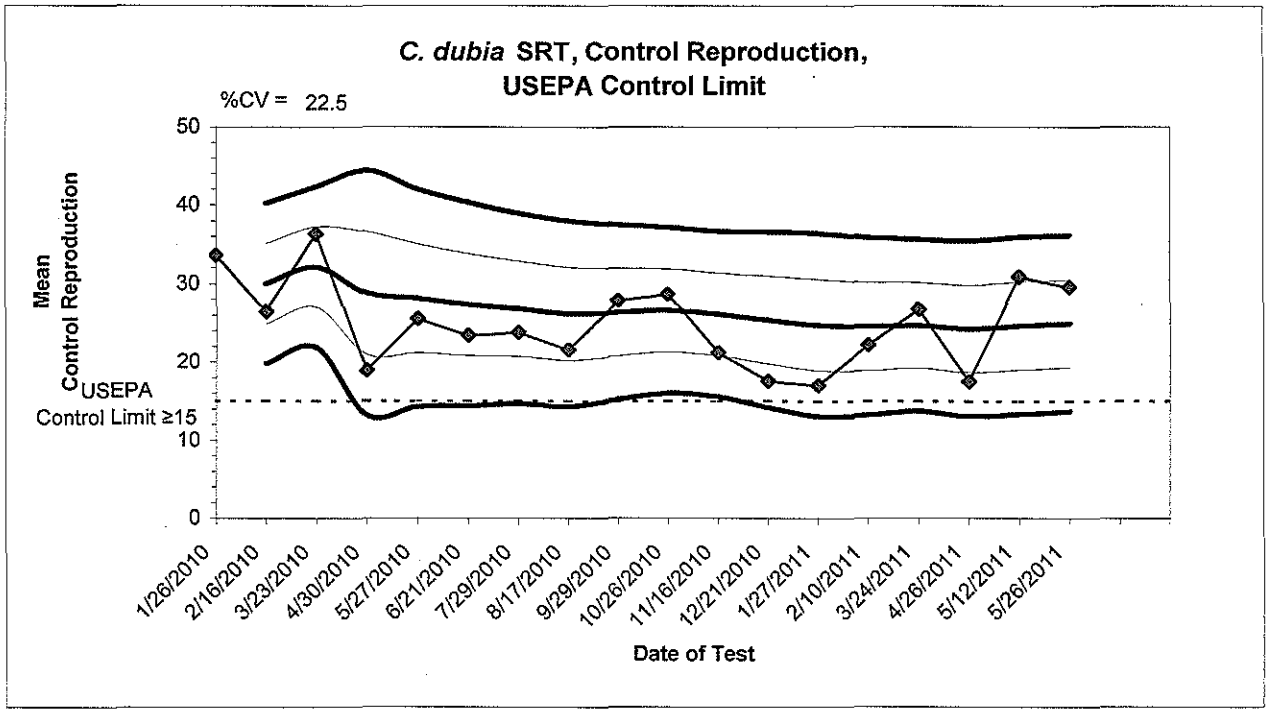
CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl




| Test # | Test Date | %CV for IC25 | Mean %CV | -1 SD | -2 SD | +1 SD | +2 SD | 75th Warning Limit | 90th Warning Limit | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 0.0 | | | | | | 45.0 | 62.0 | 079K0011 |
| CD1003 | 2/16/2010 | 30.3 | 15.1 | -6.3 | -27.7 | 36.5 | 57.9 | 45.0 | 62.0 | 079K0011 |
| CD1004 | 3/23/2010 | 56.4 | 28.9 | 0.7 | -27.6 | 57.1 | 85.4 | 45.0 | 62.0 | 049K0305 |
| CD1006 | 4/30/2010 | 65.2 | 38.0 | 8.6 | -20.7 | 67.3 | 96.6 | 45.0 | 62.0 | 049K0305 |
| CD1007 | 5/27/2010 | 57.8 | 41.9 | 15.0 | -11.9 | 68.8 | 95.7 | 45.0 | 62.0 | 049K0305 |
| CD1009 | 6/21/2010 | 55.5 | 44.2 | 19.5 | -5.2 | 68.9 | 93.6 | 45.0 | 62.0 | 049K0305 |
| CD1010 | 7/29/2010 | 50.3 | 45.1 | 22.4 | -0.3 | 67.7 | 90.4 | 45.0 | 62.0 | 079K0011 |
| CD1011 | 8/17/2010 | 47.5 | 45.4 | 24.4 | 3.4 | 66.4 | 87.4 | 45.0 | 62.0 | 079K0011 |
| CD1012 | 9/29/2010 | 44.1 | 45.2 | 25.6 | 5.9 | 64.9 | 84.5 | 45.0 | 62.0 | 079K0011 |
| CD1013 | 10/26/2010 | 46.0 | 45.3 | 26.8 | 8.3 | 63.8 | 82.4 | 45.0 | 62.0 | 099K0202 |
| CD1014 | 11/16/2010 | 44.0 | 45.2 | 27.6 | 10.0 | 62.8 | 80.4 | 45.0 | 62.0 | 099K0202 |
| CD1015 | 12/21/2010 | 41.7 | 44.9 | 28.1 | 11.3 | 61.7 | 78.5 | 45.0 | 62.0 | 099K0202 |
| CD1101 | 1/27/2011 | 45.5 | 45.0 | 28.9 | 12.8 | 61.0 | 77.1 | 45.0 | 62.0 | 099K0202 |
| CD1102 | 2/10/2011 | 44.2 | 44.9 | 29.5 | 14.0 | 60.3 | 75.8 | 45.0 | 62.0 | 099K0202 |
| CD1103 | 3/24/2011 | 42.4 | 44.7 | 29.8 | 14.9 | 59.6 | 74.5 | 45.0 | 62.0 | 099K0202 |
| CD1104 | 4/26/2011 | 45.5 | 44.8 | 30.4 | 16.0 | 59.2 | 73.6 | 45.0 | 62.0 | 099K0202 |
| CD1105 | 5/12/2011 | 43.9 | 44.7 | 30.8 | 16.8 | 58.7 | 72.6 | 45.0 | 62.0 | 099K0202 |
| CD1106 | 5/26/2011 | 43.2 | 44.6 | 31.1 | 17.6 | 58.2 | 71.7 | 45.0 | 62.0 | 060M0116V |
| | | | | | | | | 45.0 | 62.0 | |
| | | | | | | | | 45.0 | 62.0 | |

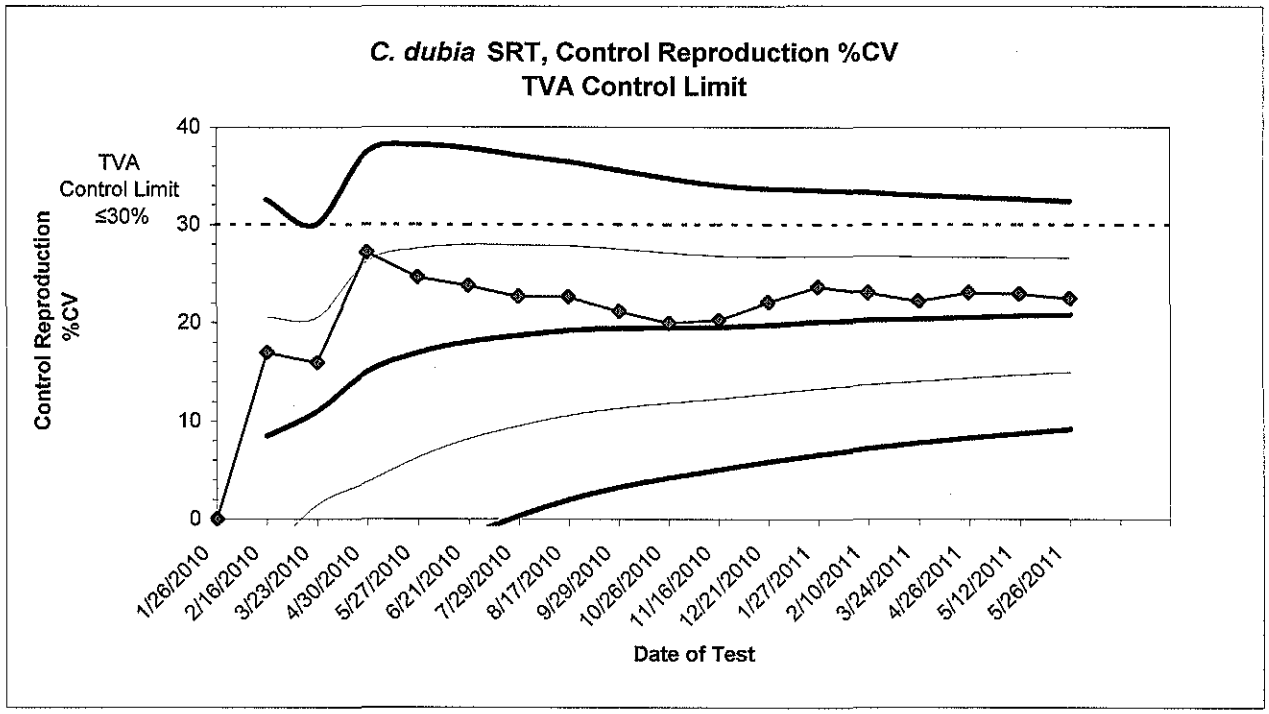
CD1005 - IC25 less than lowest concentration tested and could not be graphed

CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl



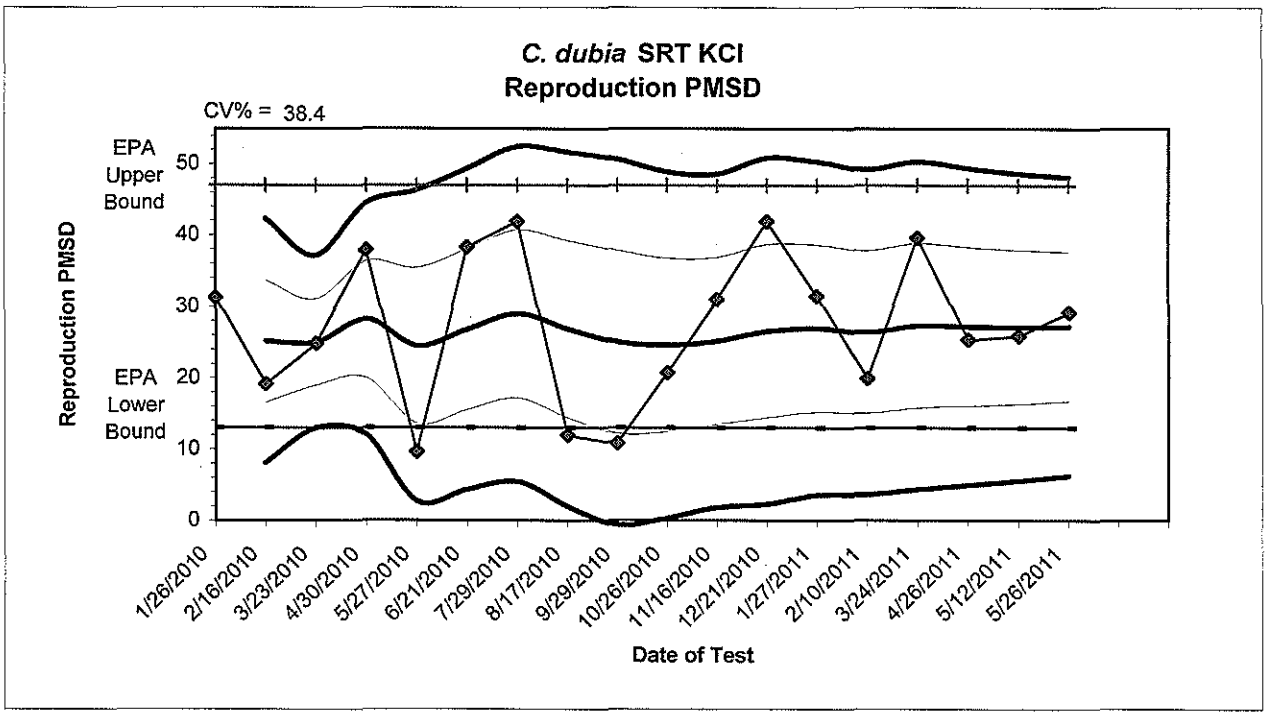

| Test # | Test Date | Mean Control Repro. | Mean | -1 SD | -2 SD | +1 SD | +2 SD | | Control Limit | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 33.6 | | | | | | | 15.0 | 079K0011 |
| CD1003 | 2/16/2010 | 26.4 | 30.0 | 24.9 | 19.8 | 35.1 | 40.2 | | 15.0 | 079K0011 |
| CD1004 | 3/23/2010 | 36.3 | 32.1 | 27.0 | 21.9 | 37.2 | 42.3 | | 15.0 | 049K0305 |
| CD1006 | 4/30/2010 | 18.9 | 28.8 | 21.0 | 13.2 | 36.6 | 44.4 | | 15.0 | 049K0305 |
| CD1007 | 5/27/2010 | 25.5 | 28.1 | 21.2 | 14.3 | 35.1 | 42.0 | | 15.0 | 049K0305 |
| CD1009 | 6/21/2010 | 23.4 | 27.4 | 20.9 | 14.4 | 33.8 | 40.3 | | 15.0 | 049K0305 |
| CD1010 | 7/29/2010 | 23.8 | 26.8 | 20.8 | 14.7 | 32.9 | 39.0 | | 15.0 | 079K0011 |
| CD1011 | 8/17/2010 | 21.6 | 26.2 | 20.3 | 14.3 | 32.1 | 38.0 | | 15.0 | 079K0011 |
| CD1012 | 9/29/2010 | 27.8 | 26.4 | 20.8 | 15.2 | 31.9 | 37.5 | | 15.0 | 079K0011 |
| CD1013 | 10/26/2010 | 28.6 | 26.6 | 21.3 | 16.0 | 31.9 | 37.2 | | 15.0 | 099K0202 |
| CD1014 | 11/16/2010 | 21.2 | 26.1 | 20.8 | 15.5 | 31.4 | 36.7 | | 15.0 | 099K0202 |
| CD1015 | 12/21/2010 | 17.6 | 25.4 | 19.8 | 14.2 | 31.0 | 36.6 | | 15.0 | 099K0202 |
| CD1101 | 1/27/2011 | 17.0 | 24.7 | 18.9 | 13.1 | 30.6 | 36.4 | | 15.0 | 099K0202 |
| CD1102 | 2/10/2011 | 22.2 | 24.6 | 18.9 | 13.3 | 30.2 | 35.9 | | 15.0 | 099K0202 |
| CD1103 | 3/24/2011 | 26.7 | 24.7 | 19.2 | 13.8 | 30.2 | 35.7 | | 15.0 | 099K0202 |
| CD1104 | 4/26/2011 | 17.5 | 24.3 | 18.7 | 13.1 | 29.8 | 35.4 | | 15.0 | 099K0202 |
| CD1105 | 5/12/2011 | 30.9 | 24.6 | 19.0 | 13.4 | 30.3 | 35.9 | | 15.0 | 099K0202 |
| CD1106 | 5/26/2011 | 29.6 | 24.9 | 19.3 | 13.7 | 30.5 | 36.1 | | 15.0 | 060M0116V |
| | | | | | | | | | 15.0 | |
| | | | | | | | | | 15.0 | |

CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl




| Test # | Test Date | Control Repro. %CV | Mean %CV | -1 SD | -2 SD | +1 SD | +2 SD | | Control Limit | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 0.0 | | | | | | | 30.0 | 079K0011 |
| CD1003 | 2/16/2010 | 17.0 | 8.5 | -3.5 | -15.5 | 20.5 | 32.5 | | 30.0 | 079K0011 |
| CD1004 | 3/23/2010 | 15.9 | 11.0 | 1.5 | -8.1 | 20.5 | 30.0 | | 30.0 | 049K0305 |
| CD1006 | 4/30/2010 | 27.1 | 15.0 | 3.8 | -7.4 | 26.2 | 37.4 | | 30.0 | 049K0305 |
| CD1007 | 5/27/2010 | 24.6 | 16.9 | 6.3 | -4.3 | 27.5 | 38.2 | | 30.0 | 049K0305 |
| CD1009 | 6/21/2010 | 23.7 | 18.1 | 8.2 | -1.7 | 27.9 | 37.8 | | 30.0 | 049K0305 |
| CD1010 | 7/29/2010 | 22.6 | 18.7 | 9.5 | 0.3 | 27.9 | 37.1 | | 30.0 | 079K0011 |
| CD1011 | 8/17/2010 | 22.6 | 19.2 | 10.6 | 2.0 | 27.8 | 36.4 | | 30.0 | 079K0011 |
| CD1012 | 9/29/2010 | 21.1 | 19.4 | 11.3 | 3.2 | 27.5 | 35.6 | | 30.0 | 079K0011 |
| CD1013 | 10/26/2010 | 19.9 | 19.5 | 11.8 | 4.2 | 27.1 | 34.7 | | 30.0 | 099K0202 |
| CD1014 | 11/16/2010 | 20.2 | 19.5 | 12.3 | 5.1 | 26.8 | 34.0 | | 30.0 | 099K0202 |
| CD1015 | 12/21/2010 | 22.0 | 19.7 | 12.8 | 5.9 | 26.7 | 33.6 | | 30.0 | 099K0202 |
| CD1101 | 1/27/2011 | 23.6 | 20.0 | 13.3 | 6.6 | 26.8 | 33.5 | | 30.0 | 099K0202 |
| CD1102 | 2/10/2011 | 23.0 | 20.3 | 13.7 | 7.2 | 26.8 | 33.3 | | 30.0 | 099K0202 |
| CD1103 | 3/24/2011 | 22.2 | 20.4 | 14.1 | 7.8 | 26.7 | 33.0 | | 30.0 | 099K0202 |
| CD1104 | 4/26/2011 | 23.0 | 20.5 | 14.4 | 8.3 | 26.7 | 32.8 | | 30.0 | 099K0202 |
| CD1105 | 5/12/2011 | 22.9 | 20.7 | 14.7 | 8.8 | 26.6 | 32.6 | | 30.0 | 099K0202 |
| CD1106 | 5/26/2011 | 22.5 | 20.8 | 15.0 | 9.2 | 26.6 | 32.4 | | 30.0 | 060M0116V |
| | | | | | | | | | 30.0 | |
| | | | | | | | | | 30.0 | |

CD1002 - Widened dilution series to 140, 212, 316, 476, & 716 mg/L KCl




| Test # | Test Date | Reprod. PMSD | Mean PMSD | -1 SD | -2 SD | +1 SD | +2 SD | Upper PMSD Bound | Lower PMSD Bound | Toxicant Lot # |
|---|---|---|---|---|---|---|---|---|---|---|
| CD1002 | 1/26/2010 | 31.2 | | | | | | 47 | 13 | 079K0011 |
| CD1003 | 2/16/2010 | 19.1 | 25.1500 | 16.5940 | 8.0380 | 33.7060 | 42.2620 | 47 | 13 | 079K0011 |
| CD1004 | 3/23/2010 | 24.8 | 25.0333 | 18.9800 | 12.9266 | 31.0867 | 37.1401 | 47 | 13 | 049K0305 |
| CD1006 | 4/30/2010 | 37.9 | 28.2500 | 20.1373 | 12.0245 | 36.3627 | 44.4755 | 47 | 13 | 049K0305 |
| CD1007 | 5/27/2010 | 9.6 | 24.5200 | 13.6146 | 2.7093 | 35.4254 | 46.3307 | 47 | 13 | 049K0305 |
| CD1009 | 6/21/2010 | 38.3 | 26.8167 | 15.5566 | 4.2965 | 38.0768 | 49.3369 | 47 | 13 | 049K0305 |
| CD1010 | 7/29/2010 | 41.9 | 28.9714 | 17.2173 | 5.4632 | 40.7255 | 52.4796 | 47 | 13 | 079K0011 |
| CD1011 | 8/17/2010 | 11.9 | 26.8375 | 14.3936 | 1.9497 | 39.2814 | 51.7253 | 47 | 13 | 079K0011 |
| CD1012 | 9/29/2010 | 10.8 | 25.0556 | 12.2465 | -0.5626 | 37.8646 | 50.6737 | 47 | 13 | 079K0011 |
| CD1013 | 10/26/2010 | 20.7 | 24.6200 | 12.4652 | 0.3104 | 36.7748 | 48.9296 | 47 | 13 | 099K0202 |
| CD1014 | 11/16/2010 | 31.0 | 25.2000 | 13.5096 | 1.8192 | 36.8904 | 48.5808 | 47 | 13 | 099K0202 |
| CD1015 | 12/21/2010 | 41.9 | 26.5917 | 14.4474 | 2.3032 | 38.7359 | 50.8802 | 47 | 13 | 099K0202 |
| CD1101 | 1/27/2011 | 31.5 | 26.9692 | 15.2626 | 3.5559 | 38.6759 | 50.3825 | 47 | 13 | 099K0202 |
| CD1102 | 2/10/2011 | 19.9 | 26.4643 | 15.0593 | 3.6544 | 37.8693 | 49.2742 | 47 | 13 | 099K0202 |
| CD1103 | 3/24/2011 | 39.6 | 27.3400 | 15.8385 | 4.3369 | 38.8415 | 50.3431 | 47 | 13 | 099K0202 |
| CD1104 | 4/26/2011 | 25.4 | 27.2188 | 16.0966 | 4.9745 | 38.3409 | 49.4630 | 47 | 13 | 099K0202 |
| CD1105 | 5/12/2011 | 25.9 | 27.1412 | 16.3675 | 5.5938 | 37.9149 | 48.6886 | 47 | 13 | 099K0202 |
| CD1106 | 5/26/2011 | 29.2 | 27.2556 | 16.7923 | 6.3290 | 37.7188 | 48.1821 | 47 | 13 | 060M0116V |

# APPENDIX D

RECORD COPY

# BIOMONITORING CHAIN OF CUSTODY RECORD



COC No. BULKSED-052711-EEUSA

Client: TVA

Project Name: KIF Ash Toxicity Study

Dates of Sample Collection: 052311, 052411, 052511

Location: Emory River (ERM0.5, ERM0.8, ERM1.0, ERM2.5, ERM3.0, ERM3.5, ERM4.0, ERM5.5, ERM8.0, ERM10.0)

Collected By: R. Josefczyk/RSI, L. Burton/RSI, D. Mathis/RSI, A. Johnson/RSI, T. Walls/RSI: G. Frye/RSI

Environmental Enterprises USA, Inc.
58485 Pearl Acres Road, Suite D
Slidell, LA 70461
Attn: David L. Daniel
Office 800.966.2788
Cell 985.707.5442

Delivered By (Circle One): FedEx UPS Bus Client Courier

Other (specify): Access America

**General Comments:**
Homogenized sediment from the Emory River.

"EMORYREFERENCE" is a composite sample of ERM8.0 and ERM10.0.

Logbook:TVA-KIF-NTC-TOX-001,002,004

| Field Identification / Sample Description | Grab/ Comp | Collection Date/Time | | Number of Containers & | Depth (ft) | Rain Event? (Mark as Appropriate) | | | | Laboratory Use (as applicable) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Example: BULKSED-ERM0.0-EEUSA-052311 | | Date | Time | | | Yes | If Yes, Inches | No | Trace | Log # | Arrival Temp. (°C) | By | Time | Appearance |
| BULKSED-ERM0.5-EEUSA- 052311 | C | 05/23/2011 | 0950 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-389-11 | 0.5 | VR | 0819 | * |
| BULKSED-ERM0.8-EEUSA-052311 | C | 05/23/2011 | ~~1042~~ 1145 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-387-11 | 0.7 | VR | 0810 | * |
| BULKSED-ERM1.0-EEUSA-052311 | C | 05/23/2011 | 0850 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-390-11 | 0.5 | VR | 0819 | * |
| BULKSED-ERM2.5-EEUSA-052311 | C | 05/23/2011 | ~~1145~~ 1042 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-386-11 | 0.7 | VR | 0810 | * |
| BULKSED-ERM3.0-EEUSA-052411 | C | 05/24/2011 | 0813 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-388-11 | 0.5 | VR | 0819 | * |
| BULKSED-ERM3.5-EEUSA-052411 | C | 05/24/2011 | 1111 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-385-11 | 0.7 | VR | 0810 | * |
| BULKSED-ERM4.0-EEUSA-052311 | C | 05/23/2011 | 1440 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-383-11 | 1.6 | VR | 0802 | * |
| BULKSED-ERM5.5-EEUSA-052411 | C | 05/24/2011 | 0955 | (4) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-384-11 | 1.6 | VR | 0802 | * |
| BULKSED-EMORYREFERENCE-EEUSA-052511 | C | 05/25/2011 | 0855 | (32) 1000 mL | 0.0-0.5 | NA | NA | X | NA | E-382-11 | 1.6 | VR | 0802 | * |

Sample Custody – Fill In From Top Down

| Relinquished By (Signature)/Affiliation: | Date/Time | Received By (Signature)/ Affiliation: | Date/Time |
|---|---|---|---|
| Ramona Josefczyk /RSI | 053111/0810 | Jesse Morris/RSI | 053111/0810 |
| Jesse Morris/RSI | 060611/1333 | Veronica McNew/EEUSA | 06/07/11 / 0240 |

Associated UPS Tracking #s (if applicable): NA

*Sample received with custody seals intact, on ice; and in fine condition. 06/07/11 VR

Logbook # TVA-KIF-NTC-TOX-004

# CHAIN OF CUSTODY RECORD

Page 1 of 1

COC No. BULKSW-060611-EEUSA

Client: TVA

Project Name: KIF Ash Toxicity Study

Date of Sample Collection: 06/06/2011

Location: ERM9.0

Collected By: R. Josefczyk (RSI), E. Burton (RSI), G. Schwartz (RSI), A. Stojak (Arcadis), E. Arnold (RSI), R. Vance (RSI), T. Walls (RSI), E. Hickey (RSI), J. Ross (Jacobs), A. Johnson (RSI)

Environmental Enterprises USA, Inc.
58485 Pearl Acres Road, Suite D
Slidell, LA 70461
Attn: David L. Daniel
Office 800.966.2788
Cell 985.707.5442

Delivered By (Circle One):
FedEx UPS Bus Client Courier Access America
Other (specify):

**General Comments:**

Bulk Emory River reference water for sediment toxicity study collected in 2.5 gallon (10L) cubitainers.

Batch A

| Field Identification / Sample Description | Grab/ Comp. | Collection Date/Time | | Number of Containers & Volume Collected | Depth (m) | Rain Event? (Mark as Appropriate) | | | | Laboratory Use (as applicable) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Date | Time | | | Yes | If Yes, Inches | No | Trace | Log# | Arrival Temp. (°C) | By | Time | Appearance |
| BULKSW-ERM9.0-EEUSA-060611 | G | 06/06/2011 | 1349 | (3) 10L cubitainers | 9.50 | — | — | X | — | E-381-11 | 0.2 | VR | 0800 | * |
| | | | | | | | | | | | 0.2 | VR | 0800 | * |
| | | | | | | | | | | | 0.2 | VR | 0801 | * |

VR 06/06/11

Sample Custody – Fill In From Top Down

| Relinquished By (Signature)/Affiliation: | Date/Time | Received By (Signature)/Affiliation: | Date/Time |
|---|---|---|---|
| [signature] / RSI | 060611 / 1522 | Jesse Morris / RSI | 060611 / 1522 |
| Jesse Morris / RSI | 060611 / 1530 | Veronica McNew / EE USA | wrong date 06/07/11 ~~06/06~~ 06/07/11 / 0740 |

Associated UPS Tracking #s (if applicable): *Samples received with custody seals intact, on ice, and in fine condition. 06/07/11 VR

COURIER TRANSPORT DOCUMENTATION

DATE: 06/06/2011

COURIER COMPANY:

Access America Transport

| From: | To: |
|---|---|
| TVA<br>c/o Jesse Morris<br>189 Lakeshore Drive<br>Harriman, TN 37748<br>865-685-8364 | Environmental Enterprises USA, Inc.<br>58485 Pearl Acres Road, Suite D<br>Slidell, LA 70461<br>Attn: David L. Daniel<br>1-800-966-2788<br>985-707-5442 |

| No. of Items: | Description: |
|---|---|
| 12 | Cooler(s) taped and custody sealed (Batched 6 of 6, 1 of 1, and 5 empty EEUSA coolers). |

Shippers Name/Company: Jesse Morris / RSI

Date / Time: 060611/1539

Courier Signature/Company: F. Sdu[illegible] / Express-1

Date / Time: 060611 / 1539

Receipt Signature/Company: Veronica [illegible] / EE USA

Date / Time: 06/07/11 0740

Corresponding Chains of Custody:

| | |
|---|---|
| BULKSED-052711-EEUSA page 1 of 1 | |
| BULKSW-060611-EEUSA page 1 of 1 | |
| | |
| | |
| | |
| | |