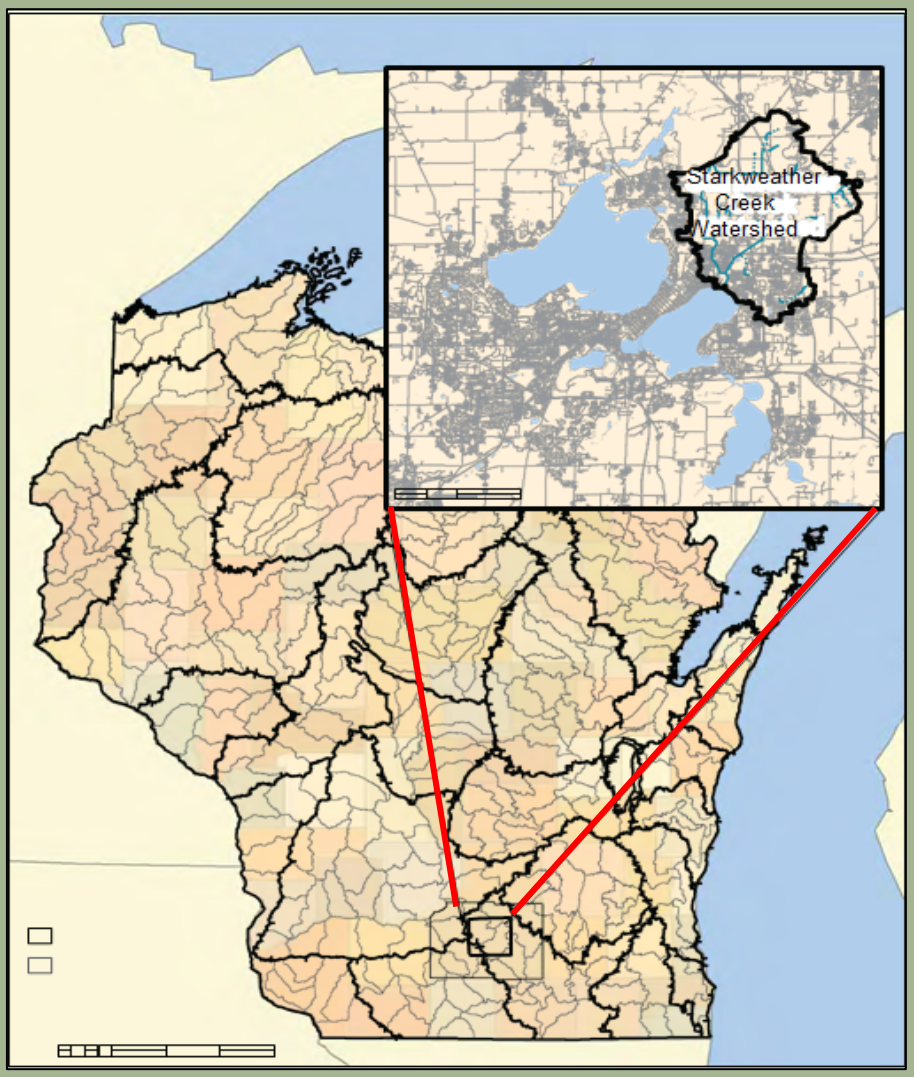
# STARKWEATHER CREEK SEDIMENT TOXICITY STUDY 2017




**Water Quality Bureau,**
**Wisconsin DNR**

EGAD #3200-2017-26

## Starkweather Creek Sediment Toxicity Study Report Overview

This report summarizes findings of toxicity tests conducted on stream sediment samples collected at seven sites throughout the Starkweather Creek Watershed in Madison, Wisconsin in May 2017. Study results indicate that stream sediment collected from 5 of the 7 sample sites in the Starkweather Creek watershed were toxic to invertebrate test organism species that live in streambed sediment and at the sediment – water column interface.

### Study Cooperators

- Wisconsin State Laboratory of Hygiene
- Friends of Starkweather Creek, Madison, WI
- City of Madison, Engineering Department

### Report Acknowledgements

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# Contents



Photo by Ashley Beranek, Mouth of Starkweather Creek and Monona Drive Bridge (2012).

## Project Summary

The Friends of Starkweather Creek (FSC) is a citizen - led advocacy group dedicated to the enhancement of the Starkweather Creek Watershed's environmental quality. Their primary goals are to raise public awareness and appreciation of the creek through education of and outreach to watershed residents. FSC members contacted Department of Natural Resources (DNR) staff in December 2016 seeking support to better understand the current environmental quality of the stream and potential sources of degradation, beyond the routine monitoring of water quality and macroinvertebrates, regularly currently done by FSC.

The State Laboratory of Hygiene (SLH) had capacity in spring 2017 to test the toxicity of sediment samples through contract services with the DNR. City of Madison engineering staff mapped seven pore points in the Starkweather Creek Watershed that reflect relatively discrete areas of stormwater drainage to the stream in this highly urbanized watershed (Figure 1). In May 2017, sediment grab samples were collected by DNR staff and FSC members immediately downstream of these seven pour points.

The goals of this study were to assess whether the sediment in Starkweather Creek was toxic to aquatic life, and whether there were geographic differences in sediment toxicity in the watershed. This study was not designed identify the pollutants that may be impacting the stream or their sources, or provide guidance on management actions. Various studies and reports cited in this report provide information on pollutant types, sources, and management goals and recommendations.

## Study Findings

Survival of laboratory test organisms (amphipoda: Hyalella azteca adults, and dipteran: Chironomus dilutus larvae) did not appear to be affected by exposure to Starkweather Creek sediment during standard 10 - day toxicology tests. The sediment samples did appear to reduce the growth rates of the test organisms at five of the seven sample sites, indicating sediment pollutants are toxic to aquatic life in the stream. Sites where sediment decreased test organism growth included:

- Site 1: a headwater location on the West Branch of Starkweather Creek that receives stormwater runoff from the City of Sun Prairie northeast of Interstates 90 - 94 and northwest of State Highway 151
- Site 4: a mid-reach location on the East Branch of Starkweather Creek that receives stormwater from East Towne Shopping Mall,
- Site 5: on the lower reaches of the West Branch subwatershed,
- Site 6: on the lower reaches of the East Branch subwatershed,
- Site 7: the lowest point sampled in the watershed located on the East Branch of Starkweather Creek near the confluence with the West Branch.

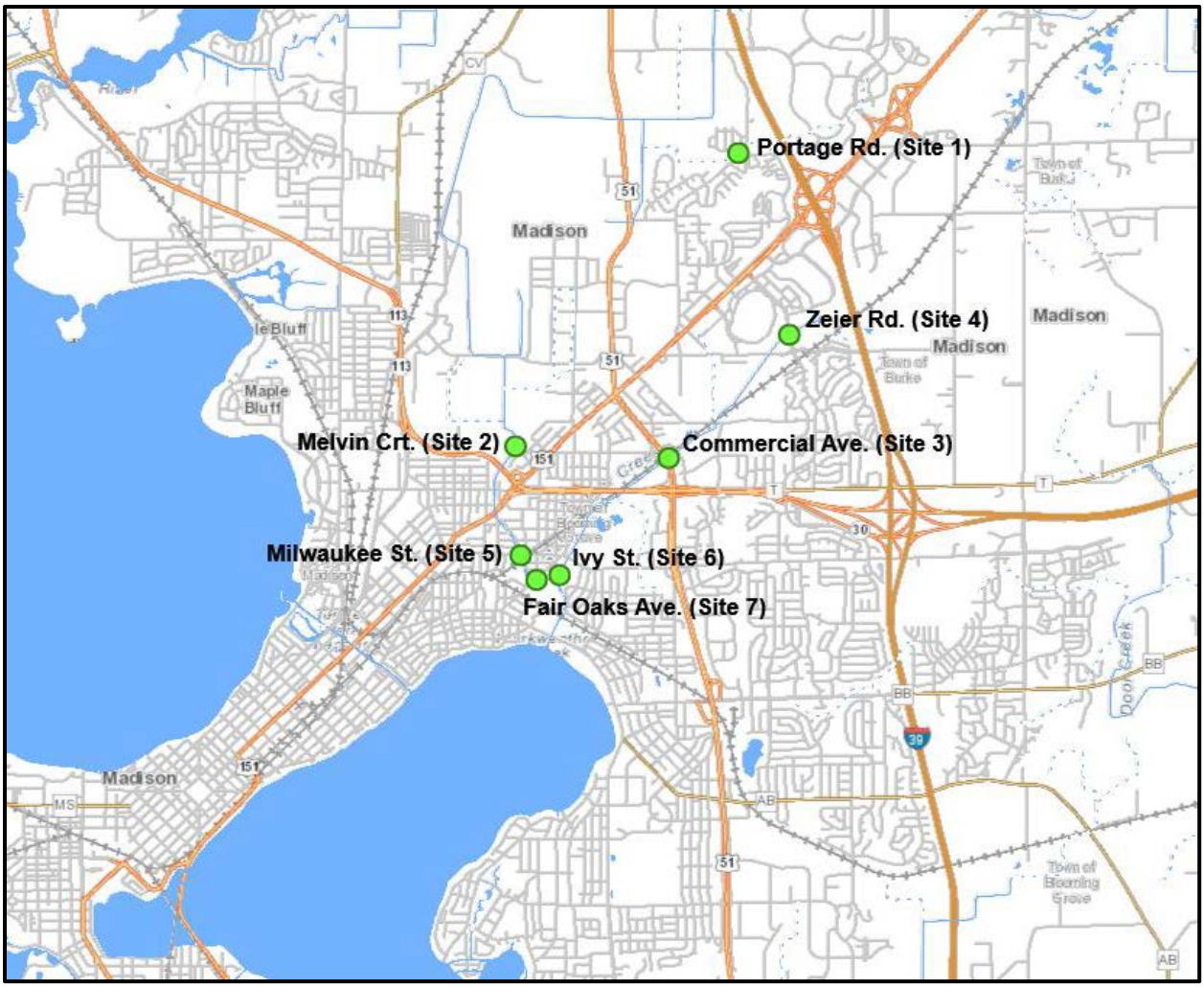


Figure 1. Locations of Starkweather Creek Watershed sediment sample sites.

## Overview of the Starkweather Creek Watershed

An extensive study of the Starkweather Creek Watershed was conducted by students in the University of Wisconsin's Nelson Institute's Water Resources Management (WRM) Program beginning in 2005. Detailed information on the watershed, its streams, land uses, sources of environmental degradation, and management needs and goals are in the WRM report: (https://nelson.wisc.edu/docs/report.pdf).

The following overview of the watershed was excerpted from the 2005 WRM report:

> *The Starkweather Creek watershed is a 24-square-mile basin in east-central Dane County, encompassing parts of the City of Madison and the Towns of Burke and Blooming Grove. Starkweather Creek consists of two branches that total nearly 20 miles in length. The headwaters of the West Branch of the creek originate northeast of Interstates 90–94 near Token Creek County Park; the East Branch originates east of Interstates 90–94 approximately four miles southwest of the City of Sun Prairie. The two branches of Starkweather Creek eventually converge near Olbrich Botanical Gardens in Madison, and empties into the eastern end of Lake Monona. The basin is part of the Yahara River–Lake Monona Watershed, which* is part of the *larger Rock River Watershed that drains parts of eleven southeastern Wisconsin counties, including much of Dane County.*

The City of Madison's *Starkweather Creek Master Plan 2004 Update* addresses environmental concerns and recreational opportunities in the watershed:

https://www.cityofmadison.com/engineering/stormwater/starkweathercreek

In 2016 FSC received a $10,000 grant from the City of Madison to assess water pollution in Starkweather Creek. FSC hired the consulting firm Freshwater Engineering (FE) to conduct the study. Semi-permeable membrane devices (SPMDs) were anchored at various locations in the stream (most sites replicated the 2005 sampling sites done by the UW Madison, WRM Program project). The SPMDs absorb chemicals from the water column that bind to lipids (fats). These fat-soluble chemical compounds tend to accumulate in animals and become more concentrated in animals higher in the foodchain (bioaccumulate). The FE report can be found on the FSC website:

https://starkweatherfriends.org/wp-content/uploads/2017/05/SPMD-Water-Quality-Sampling-of-Starkweather-Creek.pdf

Table 1. Starkweather Creek sediment sampling site locations

| Sample Site Number | SWIMS Station ID | Sample Site Location | Latitude and Longitude |
|---|---|---|---|
| 1 | 10049075 | West Branch at Portage Road, south of Hayes Rd | 43.14262 -89.30683 |
| 2 | 10039474 | West Branch at end of Melvin Court | 43.11142 -89.33887 |
| 3 | 133072 | East Branch at Commercial Avenue near Walmart store | 43.1100 -89.31712 |
| 4 | 10049076 | East Branch at Zeier Road below East Towne Mall detention pond | 43.12313 -89.29982 |
| 5 | 133071 | West Branch below Milwaukee Street | 43.09975 -89.33825 |
| 6 | 133409 | East Branch, Ivy Street Bike Bridge | 43.09759 -89.33276 |
| 7 | 133079 | West Branch - Fair Oaks | 43.09710 -89.33603 |

## Starkweather Creek 2017 Sediment Toxicity Assessment Field Methods

Approximately 3 gallons of sediment were collected at each of the seven sampling sites. A one-gallon plastic bucket was used to skim surficial sediment (approximately 2 – 5 inches deep) along the stream channel banks, (and mid-channel if water depth was shallow enough to allow the person collecting the samples to reach the stream bottom). Care was taken to collect sediment that appeared depositional and not collect streambank soil. Broken concrete occurring mid-channel and concrete and rock used to stabilize stream banks at a majority of the sample sites prevented the use of standard sampling procedures that typically involve using sampling gear such as dredges or coring devices. Multiple sub-samples (typically 5 – 10) were composited at each site until sufficient sediment volume was collected. One sample collection bucket was used at all of the sites and was washed with Alconox™ soap and rinsed with stream water between sampling sites. Overlying water in each sample was poured-off prior to sealing the lab-provided containers. All samples were delivered to the lab within 3 hours of collection.

## Laboratory Toxicity Test Methods

Sediment toxicity tests were conducted using two species of organisms: Hyalella azteca and Chironomus dilutus, which are standard laboratory toxicity test organisms and are also common in Wisconsin streams, lakes and wetlands. Chironomid species are insects in the Order Diptera, and their larvae used in toxicology tests burrow several inches into benthic sediment. Hyalella species are crustaceans in the taxonomic Order Amphipoda and tend to live at the interface of the sediment and water column.

H. azteca and C. dilutus were exposed to the Starkweather Creek and laboratory control sediment samples for ten days. For each test species, ten organisms were added to each of eight replicate test chambers for each of the seven stream sediment samples and the lab control sediment samples (a total of 168 test chambers). Dissolved oxygen, pH, and temperature of the overlying test chambers' water were recorded daily. Hardness, alkalinity, ammonia and conductivity of overlying water were measured at the beginning and at the end of the test (day 0 and day 10, respectively). These water chemistry measures were assessed to determine whether any of these environmental conditions were potentially stressful to the test animals, which could influence animal survivorship or growth and confound the interpretation of the test results.

On day 10, the living organisms were recovered from the sediment in each test chamber to determine animal survivorship. Dry weights of gammarus and ash-free dry weights of chironomids were used to determine the growth rates of these two species. Surviving chironomids and gammarus were dried overnight at 100° C and then weighed to determine dry weights. The dried chironomid test organisms were then ashed (burned) at 550° C for a minimum of 2 hours and weighed to determine ash-free dry weights. Dry weights were used to estimate gammarus growth rates. Ash-free dry weights were used to determine chironomid growth rates.

## Statistical Analyses

Statistical analyses of the laboratory test results data included one-way analysis of variance (ANOVA) followed by a multiple comparison tests (Student-Newman-Keuls) to identify differences in survival and weight of survivors of C. dilutus and H. azteca among test samples. Differences among test samples with $p \leq 0.05$ were considered statistically significant.

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## Laboratory Organism Survival Tests Results

The following tables report the results of the acute and chronic toxicity tests.

Table 2. Starkweather Creek sediment Chironomus dilutus survival tests results

| Lab Number | Site Name | Description | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 315495008 | Lab Control | Synthetic Sediment | 100 | 90 | 90 | 100 | 70 | 90 | 100 | 60 | 87.5 | 5.3 |
| 315495001 | Starkweather 1 10049075 | Portage Road, just South of Hayes Rd | 20 | 80 | 90 | 10 | 90 | 60 | 60 | 50 | 57.5 | 10.7 |
| 315495002 | Starkweather 2 10039474 | End of Melvin Court | 100 | 90 | 100 | 70 | 90 | 100 | 80 | 100 | 91.3 | 4.0 |
| 315495003 | Starkweather 3 10039474 | Commercial Avenue by Walmart | 100 | 90 | 90 | 60 | 90 | 100 | 10 | 70 | 76.3 | 10.7 |
| 315495004 | Starkweather 4 10049076 | Zeier Road below East detention pond | 90 | 100 | 90 | 90 | 60 | 100 | 90 | 100 | 90 | 4.6 |
| 315495005 | Starkweather 5 133071 | West Branch below Milwaukee Street | 90 | 10 | 100 | 100 | 90 | 90 | 90 | 90 | 82.5 | 10.5 |
| 315495006 | Starkweather 6 133409 | East Branch, Ivy Street Bike Bridge | 90 | 80 | 90 | 30 | 100 | 60 | 80 | 80 | 76.3 | 7.8 |
| 315495007 | Starkweather 7 133079 | West Branch - Fair Oaks | 70 | 70 | 70 | 70 | 80 | 90 | 90 | 60 | 75 | 3.8 |

Table 3. Starkweather Creek sediment Hyallela azteca survival test results

| Lab Number | Site Name | Description | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 315495008 | Lab Control | Synthetic Sediment | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0.0 |
| 315495001 | Starkweather 1 10049075 | Portage Road, just South of Hayes Rd | 100 | 100 | 90 | 90 | 100 | 90 | 100 | 90 | 95 | 1.9 |
| 315495002 | Starkweather 2 10039474 | End of Melvin Court | 100 | 100 | 100 | 90 | 100 | 100 | 100 | 100 | 98.8 | 1.3 |
| 315495003 | Starkweather 3 10039474 | Commercial Avenue by Walmart | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0.0 |
| 315495004 | Starkweather 4 10049076 | Zeier Road below East detention pond | 100 | 90 | 100 | 90 | 100 | 100 | 100 | 100 | 100 | 1.7 |
| 315495005 | Starkweather 5 133071 | West Branch below Milwaukee Street | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 0.0 |
| 315495006 | Starkweather 6 133409 | East Branch, Ivy Street Bike Bridge | 100 | 90 | 100 | 100 | 100 | 100 | 80 | 100 | 96.3 | 2.8 |
| 315495007 | Starkweather 7 133079 | West Branch - Fair Oaks | 100 | 100 | 100 | 40 | 100 | 100 | 100 | 100 | 92.5 | 8.0 |

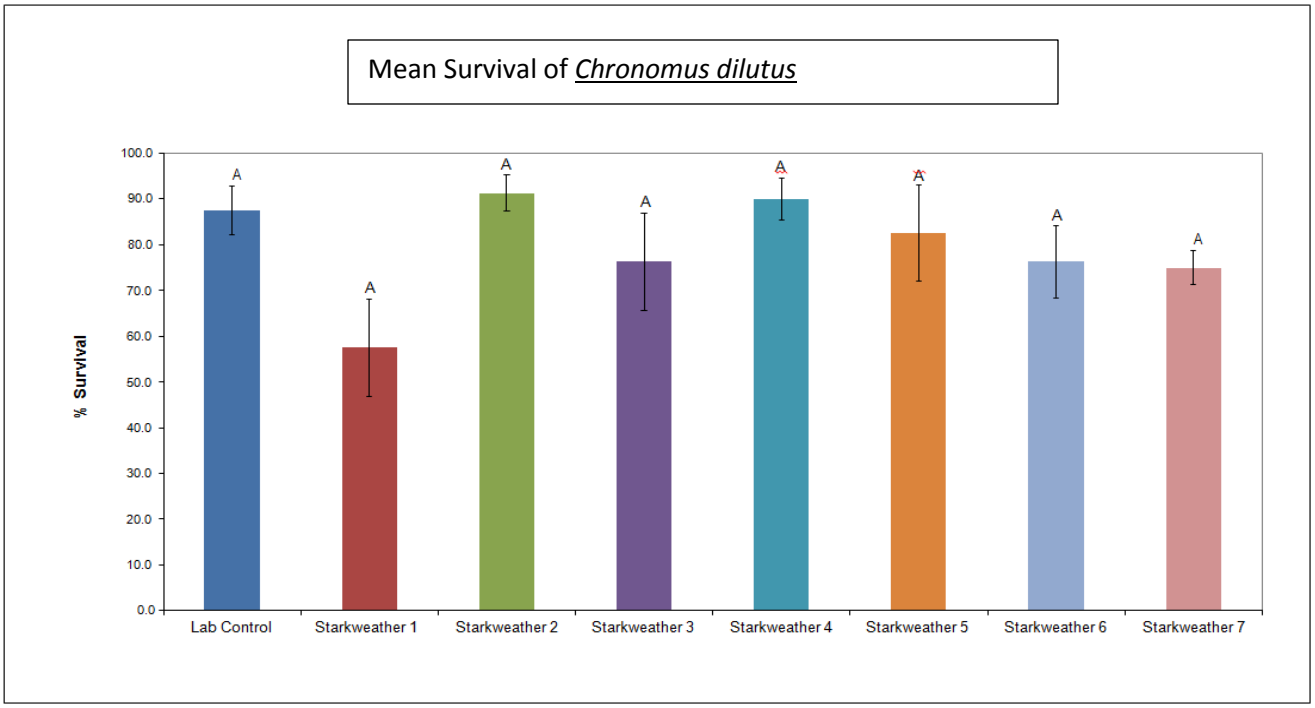


Figure 2. Mean percent survival of Chironomus dilutus in laboratory control and Starkweather Creek sediment test samples. Histogram bars show standard errors. Histogram bars with same letters above them do not have statistically-significant differences in organism survivorship.

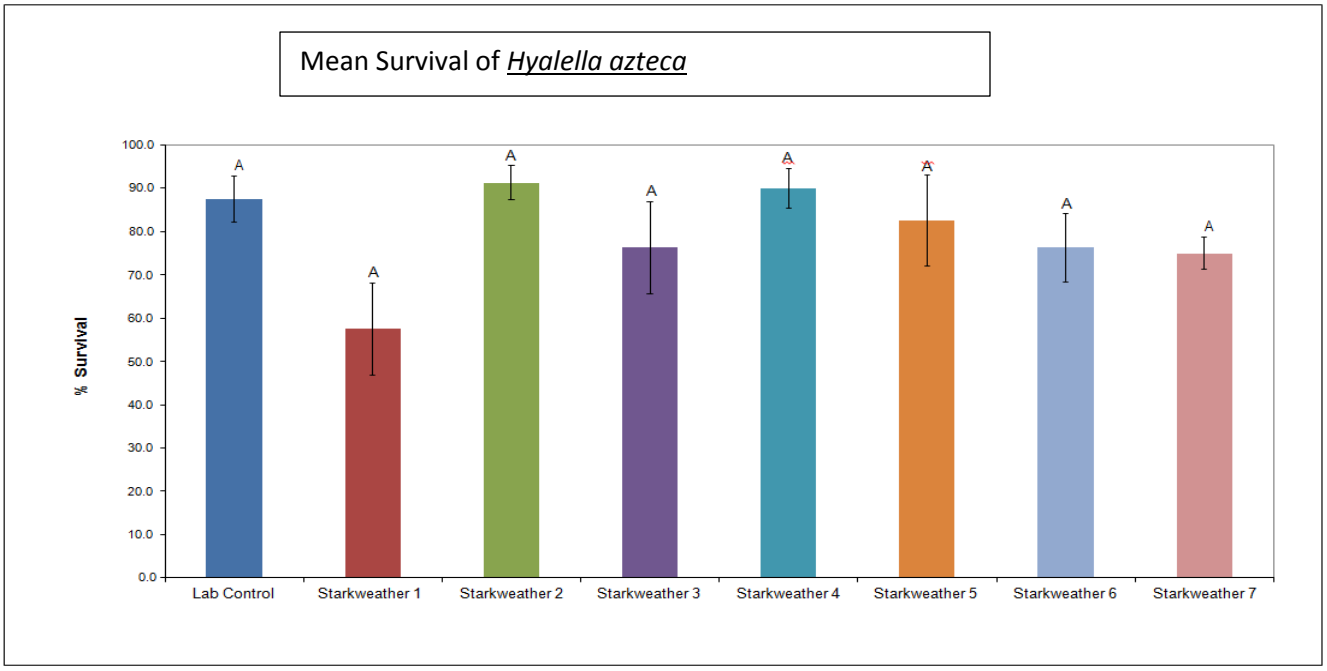


Figure 3. Mean percent survival of Hyalella azteca in laboratory control and Starkweather Creek sediment test samples. Histogram bars show standard errors. Histogram bars with the same letters above them do not have statistically-significant differences in organism survivorship.

Table 4. Starkweather Creek sediment samples Chironomus dilutus ash-free dry weights (mg).

| Lab Number | Site Name | Description | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 315495008 | Lab Control | Synthetic Sediment | 1.823 | 1.715 | 1.785 | 1.743 | 1.645 | 1.914 | 1.446 | 1.894 | 1.7 | 0.05 |
| 315495001 | Starkweather 1 10049075 | Portage Road, just South of Hayes Rd | 0.427 | 1.037 | 0.692 | 1.204 | 0.958 | 0.864 | 0.847 | 1.003 | 0.9 | 0.08 |
| 315495002 | Starkweather 2 10039474 | End of Melvin Court | 1.854 | 1.983 | 1.811 | 2.202 | 2.07 | 2.208 | 1.892 | 1.846 | 2 | 0.05 |
| 315495003 | Starkweather 3 10039474 | Commercial Avenue by Walmart | 1.902 | 1.732 | 1.829 | 2.533 | 2.026 | 1.841 | 2.22 | 2.321 | 2.1 | 0.1 |
| 315495004 | Starkweather 4 10049076 | Zeier Road below East detention pond | 1.259 | 1.059 | 0.763 | 0.963 | 1.242 | 0.967 | 0.555 | 0.699 | 0.9 | 0.09 |
| 315495005 | Starkweather 5 133071 | West Branch below Milwaukee Street | 1.305 | 3.864 | 0.447 | 1.253 | 1.1019 | 1.18 | 1.194 | 0.889 | 1.4 | 0.36 |
| 315495006 | Starkweather 6 133409 | East Branch, Ivy Street Bike Bridge | 0.586 | 1.082 | 1.319 | 1.298 | 1.066 | 1.079 | 1.18 | 0.962 | 1.1 | 0.08 |
| 315495007 | Starkweather 7 133079 | West Branch - Fair Oaks | 1.066 | 0.742 | 1.529 | 1.053 | 1.26 | 1.029 | 0.933 | 1.1272 | 1.1 | 0.08 |

Table 5. Starkweather Creek sediment samples Hyalella azteca dry weights (mg).

| Lab Number | Site Name | Description | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 315495008 | Lab Control | Synthetic Sediment | 0.28 | 0.4 | 0.37 | 0.32 | 0.31 | 0.39 | 0.28 | 0.36 | 0.34 | 0.02 |
| 315495001 | Starkweather 1 10049075 | Portage Road, just South of Hayes Rd | 0.23 | 0.25 | 0.27 | 0.23 | 0.23 | 0.29 | 0.25 | 0.25 | 0.25 | 0.01 |
| 315495002 | Starkweather 2 10039474 | End of Melvin Court | 0.44 | 0.44 | 0.44 | 0.36 | 0.51 | 0.36 | 0.41 | 0.41 | 0.42 | 0.02 |
| 315495003 | Starkweather 3 10039474 | Commercial Avenue by Walmart | 0.3 | 0.36 | 0.44 | 0.43 | 0.45 | 0.41 | 0.43 | 0.42 | 0.41 | 0.02 |
| 315495004 | Starkweather 4 10049076 | Zeier Road below East detention pond | 0.24 | 0.23 | 0.26 | 0.25 | 0.3 | 0.25 | 0.27 | 0.27 | 0.26 | 0.01 |
| 315495005 | Starkweather 5 133071 | West Branch below Milwaukee Street | 0.3 | 0.26 | 0.31 | 0.29 | 0.32 | 0.37 | 0.2 | 0.28 | 0.29 | 0.02 |
| 315495006 | Starkweather 6 133409 | East Branch, Ivy Street Bike Bridge | 0.32 | 0.45 | 0.29 | 0.36 | 0.36 | 0.38 | 0.38 | 0.31 | 0.36 | 0.02 |
| 315495007 | Starkweather 7 133079 | West Branch - Fair Oaks | 0.24 | 0.28 | 0.29 | 0.13 | 0.31 | 0.27 | 0.27 | 0.38 | 0.27 | 0.02 |

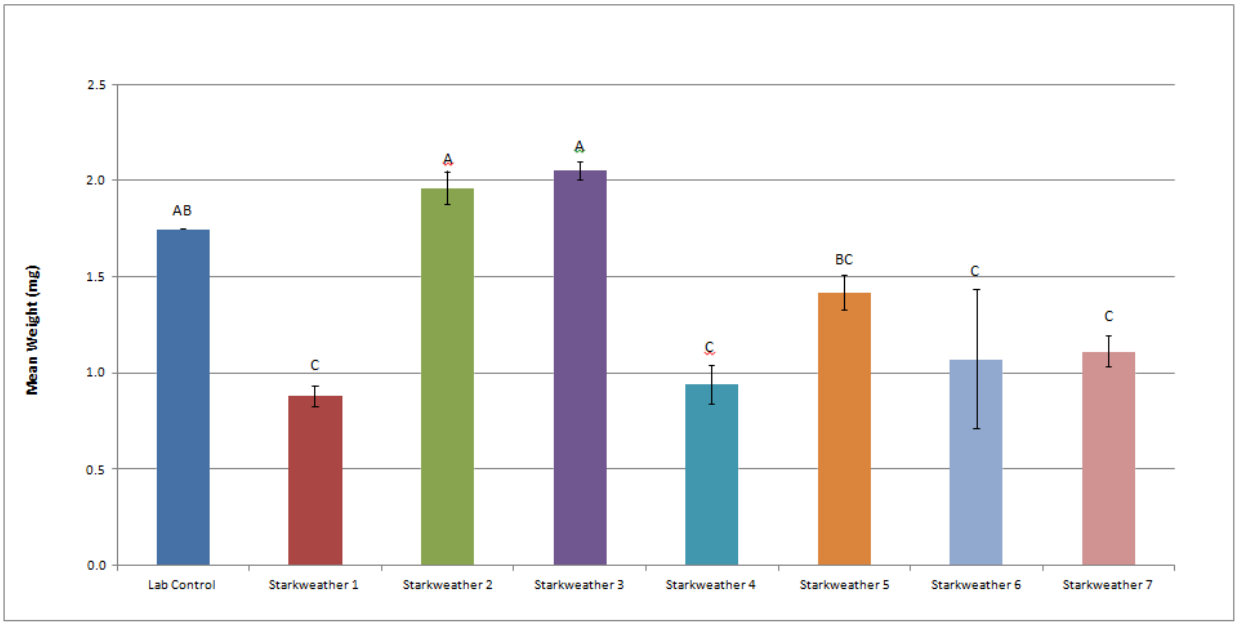


Figure 4. Ash-free dry weights (mg) of Chironomus dilutus exposed to laboratory control and Starkweather Creek sediment test samples. Histogram bars show standard errors. Histogram bars with the same letters above them do not have statistically-significant differences in organism survivorship.

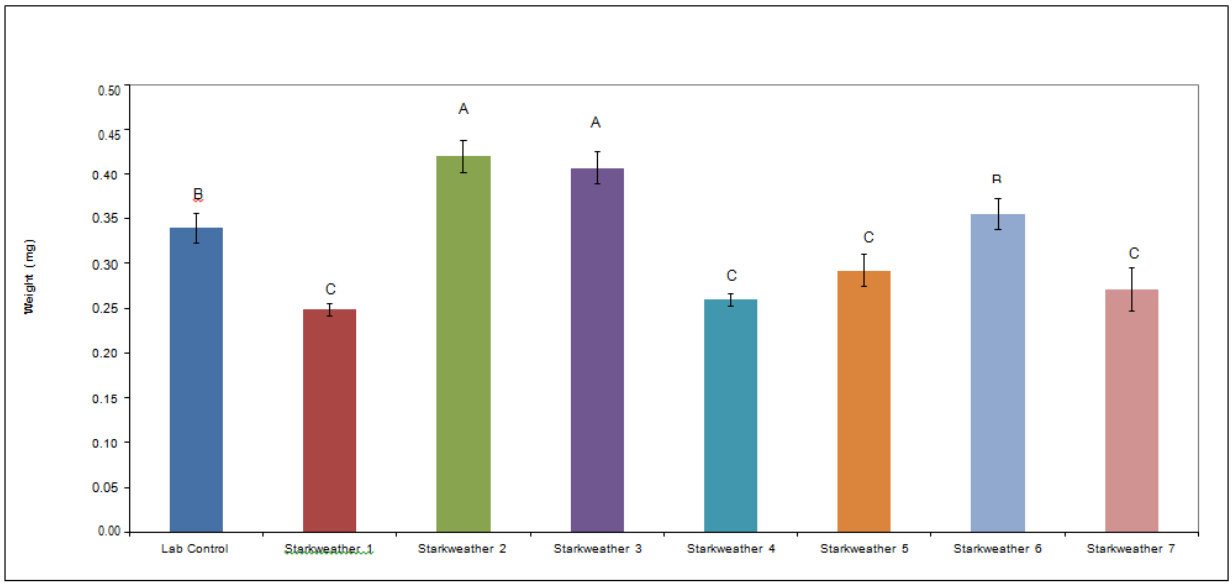


Figure 5. Dry weights (mg) of Hyallela azteca exposed to laboratory control and Starkweather Creek sediment test samples. Histogram bars show standard errors. Histogram bars with the same letters above them do not have statistically-significant differences in organism survivorship.

## Summary of Laboratory Tests Findings

Wisconsin State Laboratory of Hygiene toxicity test protocols define DO concentrations above 2.5 mg/L in the test chambers as acceptable. DO concentrations above 1.5 mg/L are thought to be adequate for the Chironomus and Hyallela test organisms. U.S. Environmental Protection Agency laboratory toxicological testing protocol guidelines report that periodic depressions of DO below 2.5 mg/L that are still above 1.5 mg/L are not likely to adversely affect test results for these test organisms. DO concentrations were below 2.5 mg/L for Day 1 of the Site 1 H. azteca test chambers, all other test samples for H. azteca had acceptable conditions for DO, pH, conductivity, hardness, alkalinity, and ammonia. For C. dilutus, Site 1 had DO below 2.5 mg/L on Day 1 (1.97 mg/L), Day 2 (2.22 mg/L), Day 4 (2.29 mg/L), Day 6 (2.43 mg/L), and Day 7 (2.30 mg/L). C. dilutus Site 4 DO was below 2.5 mg/L on Days 3, 4, 6, and 7, but all were above 2.1 mg/L. C. dilutus Site 6 replicates also had some DO concentrations below 2.5 on Days 3, 6, 7, and 8, but all were above 2.2 mg/L.

Test organism survival results are reported (Tables 2 and 3, Figures 2 and 3). Growth results (dry weights of gammarus and ash-free dry weights of chironomids) are reported in Tables 4 and 5, and plotted in Figures 4 and 5.

There were no statistically significant differences in survival between laboratory control and test samples or among any of the sites for either C. dilutus or H. azteca ($p \leq 0.05$). However, study results did indicate statistically significant reductions in test organism growth compared to the laboratory control samples and significant differences in growth rates of C. dilutus and H. Azteca among sample sites.

C. dilutus Survival

Survival data for C. dilutus is presented in Table 2 and Figure 2. Mean survival ranged from 58 to 91 %. Survival of C. dilutus was not significantly different from the laboratory control samples or among any of the sample sites.

Although C. dilutus survival was only 58% at Site 1, it was not statistically different from the laboratory control samples (88 % survival) or any of the other sample sites (Figure 2).The lack of statistical difference despite the lower survival is due in part to the large variation in replicate sample survivorship at several sites where some replicates had survival as low as 10% while others had 90-100% survival for the same sample site. The State Laboratory of Hygiene toxicologist conducting the study reported this inherent variability may in part have been caused in by the physical makeup of the samples from some of the sites, having coarse debris that created less desirable physical habitat in the test containers for C. dilutus which prefers fine silts and sands.

H. azteca Survival

Survival data for H. azteca is presented in Table 3 and Figure 3. Mean survival ranged from 92 to 100%. Even though samples had similar physical properties (i.e. rocks, excess vegetation etc.) as C. dilutus samples, there was not a similar pattern of variability seen in the survival of H. azteca. This is likely due in part to the fact that H. azteca live at the sediment-water interface and so were not as greatly affected by physical constraints of the debris in each sample. Survival of H. azteca was not significantly different among any of the sites and the lab control samples.

C. dilutus and H. azteca Growth Rates

Starkweather Creek sediment did appear to reduce the growth rate of the test organisms at five of seven sample sites.

C. dilutus Growth

C. dilutus growth results data based on ash-free dry weight is reported in Table 2 shown in Figure 2. The larval weights ranged from 0.9 mg to 2.1 mg per larval C. dilutus for all of the sediment sites. The lab control averaged 1.7 mg per larvae. Sites 1 and 4 both had the lowest average weight of 0.9 mg.

H. azteca Growth

H. azteca growth data based on dry weight is given in Figure 5. Mean dry weight ranged from 0.25 to 0.41 mg. The lab control had mean dry weight of 0.34 mg.

Sites 1, 4, 5 and 7 had the lowest mean dry weights which were significantly lower than the lab control, Site 2, Site 3, and Site 6. Mean dry weight of H. azteca was not significantly different between the lab controls and Site 6. Mean dry weight of H. azteca was the highest at Sites 2 and 3 which were significantly higher than the control and all the other sites.

Test organism growth rates were reduced when exposed to sediment collected at:

- Portage Road (Site 1) headwater of the west branch of Starkweather Creek that receives runoff from north Madison suburban housing developments near the I-90-94 and STH – 151 interchange,
- Zeier Road (Site 4) headwater of the east branch of Starkweather Creek downstream of an East Towne Mall stormwater detention basin outfall that receives parking lot runoff from East Towne Mall,
- Milwaukee Street (Site 5,) lower west branch that receives stormwater from mixed urban residential and light industrial land use in an area 1 – 2 miles north of Lake Monona,
- Ivy Street bike path bridge (Site 6), lower east branch near confluence with west branch approximately 0.5 miles north of Lake Monona,
- Fair Oaks Avenue (Site 7), lower west branch near confluence with east branch approximately 0.5 miles north of Lake Monona.

Sediment samples from west branch of Starkweather Creek near Melvin Court (Site 2) which is approximately 5 miles downstream of the headwater and 2 miles upstream of the confluence with the east branch, and Commercial Avenue (Site 3) on the east branch approximately 2 miles downstream of its headwater near the STH - 51 and STH – 30 interchange, did not appear to reduce the growth rate of test organisms.

Both test species had similar growth responses to the sediment samples at most of the sites. The growth rates of both H. azteca and C. dilutus was significantly reduced at Sites 1, 4, and 7. The best growth for both species was seen at Sites 2 and 3. Growth results from Sites 5 and 6 differed between the two species. Site 5 had significantly lower growth for H. azteca as compared to the lab control but C. dilutus growth at Site 5 was not significantly different from the lab control. Site 6 had significantly lower growth than the lab control for C. dilutus but not for H. azteca.

## Appendix A References

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