SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM

ASSESSMENT/PLANNING PROJECT FINAL REPORT

Emigration Implementation Project

By

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Sponsored by Salt Lake County Watershed Planning & Restoration Program

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State (DEQ) Contract #14-0983
Salt Lake County Contract #PV13147C

EXECUTIVE SUMMARY

PROJECT TITLE: **Emigration Creek Implementation Project**

PROJECT START DATE July 15, 2013 PROJECT COMPLETION DATE October 31, 2014

FUNDING: TOTAL BUDGET 77,984.86 $

TOTAL EPA GRANT $46,633

TOTAL EXPENDITURES OF EPA FUNDS $38,028.66

TOTAL SECTION 319 MATCH ACCRUED $42,108.63

BUDGET REVISIONS None

TOTAL EXPENDITURES $80,137.29

MAJOR PARTNERS:

- Salt Lake City Parks and Recreation
- Salt Lake County Flood Control
- Emigration Improvement District (EID)
- Emigration Canyon Community Council (ECCC)
- Hogle Zoo
- Emigration Residents

SUMMARY ACCOMPLISHMENTS: Emigration Creek Implementation Accomplished all objectives and tasks of the project, including some extra achievements. These include:

- Regarding of slope at Rotary Park Detention Basin Pond to assist with public safety and vegetation establishment.
- Installation of a fence around the detention basin to minimize dog and human traffic to Emigration Creek.
- Riparian and Upland seeding in both the spring and fall of 2014.
- Mechanical weed removal and trash removal.
- Optical Brightener study and 2 Caffeine Studies to determine anthropogenic source of *E. Coli* in May and September 2014.
- Bioenegineering along Emigration Creek at the Rotary Park Detention Basin and west of Hogle Zoo.
- Stakeholder and Public Meetings.
- Water Quality Monitoring as well as photo monitoring.

2.0 BACKGROUND

Emigration Creek Watershed

The Emigration Creek Watershed, located in the northeast corner of Salt Lake County in in Northern Utah, drains a total of 24.1 square miles. It is divided into two subwatersheds based on differences in land cover, land use, elevation and topography (Figure 1).

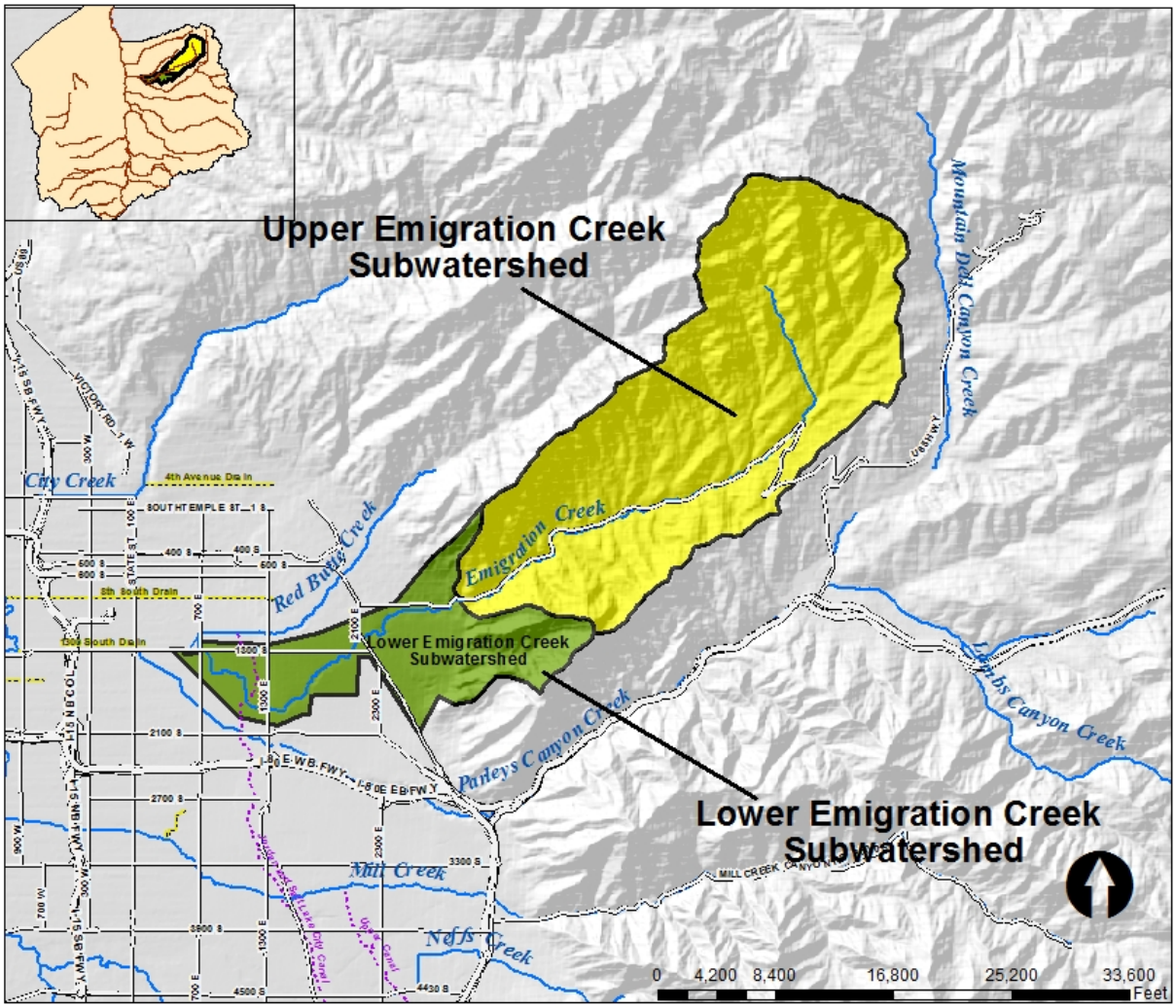


Figure 1. Emigration Creek Watershed

The Upper Emigration Creek Sub-watershed has a drainage area of 18.2 square miles comprised of moderately steep mountain slopes with an elevation range from 5,000 to 8,900 feet. The land use is primarily comprised of residential with limited commercial. The Emigration Creek sub-watershed is in close proximity to shopping centers, a golf course, and a zoo. Emigration Creek is a perennial stream with tributary flow from Killyon and Burr Fork canyons along with several mountain springs. Stream headwaters commence in a small open valley near the top of Emigration Canyon at an elevation of approximately 6,000 feet. This sub-watershed has high

residential development that is primarily serviced by private wells and septic systems. Upper Emigration sub-watershed contains a groundwater recharge zone.

The Lower Emigration Creek Sub-watershed has a drainage area of 5.9 square miles comprised of the bench area below the canyon outlet. The land use is comprised primarily of Westminster College, Heritage Park, Hogle Zoo, commercial development and single-family residential neighborhoods. The Creek flows through in an open channel through the watershed to a piped system. The piped system (1300 South storm drain) carries stream flow to the Jordan River.

Watershed Concerns

In July 2012, US Environmental Protection Agency, Region 8 (EPA) approved the "Total Maximum Daily Load TMDL for *Escherichia coli (E. coli*) in the Upper Emigration Creek Watershed." Upper Emigration Creek, from the Salt Lake County flow gage at Rotary Park to its headwaters, was listed on Utah's 2002 Section 303(d) list of impaired waters for pathogens (Fecal Coliform). In 2006, Utah switched to *Escherichia coli (E. coli)* as the indicator species for pathogens as it provides a better indicator of human health threat. The approved TMDL document addresses water quality impairments within the Upper Emigration Creek Sub-Basin and established allowable loading of *E. coli*. The TMDL assesses watershed conditions, establishes water quality endpoints, and proposes effective strategies to restore the Creek's designated beneficial uses.

The TMDL defined the critical season as the months of July, August and September and required a load reduction of 41% collectively. The observed loading is higher during the summer months due to a combination of several factors including warmer water temperatures and increased activity of humans, domestic animals and wildlife. There are no UDWQ permitted point sources of pollution in the Upper Emigration Creek watershed, thus all necessary load reductions are allocated to nonpoint sources of pollution.

Previous studies suggest that the origin of nonpoint pollution in Emigration Creek may include residential waste disposal, fecal contamination from dogs and wildlife, stormwater runoff, hydrologic modifications, and groundwater seepage from old holding vaults and septic tank leach fields. Although many improvements have been implemented in the Upper Sub-Basin, exceedances of water quality standards still occur on a regular basis.

3.0 GOALS

The goals to address the problems of Emigration Creek are as follows:

- Help document the source of the pollutant load is from failing septic systems in Upper Emigration Creek with an Optical Brightener study and caffeine study.
  - The State DWQ performed the Optical Brightener Study on July 1, 2013 and did identify sites that were positive for Optical Brighteners (Appendix A).
  - Salt Lake County performed two caffeine studies: The first was done in May 2014 and the other September 2014. Caffeine was identified in the September 2014 study however in May 2014 the water was unusually high and therefore did not detect caffeine (Appendix A).
- Educate residents about watershed stewardship:
  - Distribute the upcoming *Salt Lake County Stream Care Guide for Streamside Landowners* to all residents within the Emigration Creek Watershed. This includes a section on pet waste and maintaining septic systems http://slco.org/watershed/pdf/StreamCareGuide_SLCo.pdf.
  - Meetings with the Emigration Canyon Community Council and Emigration Improvement District to keep stakeholders and residents informed.
- Revegetate and restore streambanks and detention basin pond to help stabilize the banks as well as help with filtration of pollutants in overland flow.
  - Revegetation as well as in stream work occurred between February 2014 through October 2014. Additional Details in Section 4.0.
  - Includes: Seeding in spring and fall (Upland and Riparian), Bank work, instream structures such as J-Hooks and Cross Veins, Fascines, willow and dogwood staking, installation of potted plants, riparian sod, and upland vegetation.
- Weed Mitigation.
  - Mechanical weed pull in the spring and fall 2014.
- Continue monitoring efforts of Emigration Creek.
  - This includes photo monitoring as *E. Coli* water quality monitoring (Appendix C).
- Fencing of Rotary Park Detention Pond.
  - This was not included in the original scope, however was added after Salt Lake City Parks and Recreation said that they had wanted to do this for years and this project gave them the impetus to proceed.

4.0 ACTIVITIES

Objective 1: Optical Brightener and Caffeine Studies

Task 1.1: Identify Sampling locations on map

- DWQ identified sites for the Optical Brightener Study in June 2013 (See Map Appendix A).

Task 1.2: Perform Optical Brightener Study including sampling and analysis

- DWQ performed Optical Brightener Study on July 1, 2013 using Standard Operating Procedure (SOP) 3.4.1.4. Optical Brighteners were identified below Sun and Moon Café and Maryfield Lane (Results in Appendix A). This demonstrates anthropogenic source of *E. Coli.*

Task 1.3: Perform Caffeine Study including sampling and analysis

- The first caffeine study was performed on May 13th 2014. May was selected since the prior year Emigration Creek went dry shortly after May therefore the goal was to sample before this occurred. However in 2014 there were late precipitation events thus resulting in a higher discharge rate. Therefore a second study was performed on September 8th 2014 during very low flow. This corresponded with the seasonal TMDL.
- First there was an extensive literature review of peer reviewed studies using caffeine as an indicator of anthropogenic source of *E. Coli*. This literature was used to establish the Minimal Detection Limit (MDL) of 0.01 ppb (Appendix A).
- The analytical methodology used was *Method 1694: Pharmaceuticals and Personal Care Products in Water, Soil, Sediment, and Biosolids by HPLC/MS/MS* (Appendix A).
- It was decided to use ChemTec Ford as the analytical lab for caffeine since they are one of the few labs that could analyze for caffeine at a Minimal Detection Limit (MDL) of 0.01 ppb.
- Sites were selected using the existing *E. Coli* data and the results from the Optical Brightener Study (Appendix A).
- Flow was taken at each site to help identify loading.
- Two (2) 1 liter amber bottles were collected at each site per hour for three hours. In addition, three (3) 100 ml *E. Coli* and fecal coliform samples were collected at each site per hour for three hours. *E. Coli* and total coliform total quantification used the IDEXX Quanti-Tray/2000 analysis system, which is the EPA approved protocol. Samples were stored on ice and analysis started within 3 hours of collection.

Product: Confirm Source is From Failing Septic Systems

- Caffeine was detected in the September study, which makes sense due to the lower flows compared to the May study. This reflects the seasonal TMDL of July through September. Also caffeine concentrations increase downstream as well at the 9:00 sampling hour.
- Both the Optical Brightener and caffeine studies confirm an anthropogenic source of *E. Coli* due to failing septic systems.

Cost: Projected $8,180.19, actual $16,651.73 ($6,823.72 Grant and $9,828.01 Match)

Objective 2: Education and Outreach

Task 2.1: Distribute *Stream Care Guide* to Emigration Canyon Residents

- The *Salt Lake County Country Stream Care Guide for Homeowners* has been completed and already being distributed to residents at events.

Task 2.2: Meet with Emigration Improvement District

- SLCo Watershed Planning & Restoration Program has met with the Emigration Improvement District via the Emigration Stakeholder meetings (Dates Below) and relayed information about the restoration work, monitoring, caffeine studies, and optical brightener study.
    - October 21, 2013
    - June 25, 2014

    - September 24, 2014
- SLCo Watershed Planning & Restoration Program established a Dropbox to disseminate and share information for all stakeholders https://www.dropbox.com/home/Emigration%20Library?shareoptions=1.
- SLCo Watershed Planning & Restoration Program has routinely communicated with stakeholders including the EID, via e-mail, phone conversations, and in person throughout the project as well as before and after the project has ended.

Task 2.3: Meet with Emigration Canyon Community Council

- Salt Lake County (SLCo) Watershed Planning & Restoration Program and Planning met with Rick Raile of the Emigration Canyon Community Council (ECCC) on April 16, 2014 to discuss Emigration Canyon as a whole as well as the project.
- SLCo Watershed Planning & Restoration Program has met with the Emigration Canyon Community Council (ECCC) via the Emigration Stakeholder meetings (Dates Below) and relayed information about the restoration work, monitoring, caffeine studies, and optical brightener study.
    - October 21, 2013
    - June 25, 2014
    - September 24, 2014
- SLCo Watershed Planning & Restoration Program established a Dropbox to disseminate and share information for all stakeholders https://www.dropbox.com/home/Emigration%20Library?shareoptions=1.
- SLCo Watershed Planning & Restoration Program has routinely communicated with stakeholders including the ECCC, via e-mail, phone conversations, and in person throughout the project as well as before and after the project has ended.

Task 2.4: Distribute Information to Stakeholders and Residents

- SLCo Watershed Planning & Restoration Program routinely meets with and talks to residents and stakeholders along Emigration Creek to receive input and distribute information.
- There have been multiple stakeholder meetings (see Task 2.3) with the EID and ECCC, who have conveyed information to the residents.

Product: Keep Residents and Stakeholders informed

Cost: Projected $7,786.07, actual $649.57 ($420.31 Grant and $229.26 Match)

Objective 3: Revegetation and Restoration

Task 3.1: Revegetate Stream Banks

- This was completed as a phased approach. This approach was ideal to accommodate seasonality, plant dormancy, flows, potential permitting, and weather.
- Met with Riparian Ecologist Chris Hoag on October 24th 2013 to discuss optimal vegetation selection, timing, and location of plantings for Rotary Glen Park Detention Basin and Wasatch Hollow Open Space.
    - It was decided later in the project not to perform work on Wasatch Hollow since Salt Lake City plans to do a project in the area that will destroy what the SLCo Watershed Planning & Restoration Program would put in.

Therefore restoration was moved to Emigration Creek just below (west) of Hogle Zoo.

- The Rotary Park Detention Basin was dredged and the steep bank contoured February 2014. Salt Lake County Flood Control did this early to accommodate the timing of the projects.
- Seeding of both upland and riparian seed occurred in early March 2014 to try to establish seed and also try to out-compete the invasive weeds (See Appendix B for seed mix and plan).
- SLCo Watershed Planning & Restoration Program contacted the State of Utah to determine if a Stream Alteration Permit and Salt Lake City Riparian Public Works to determine if a Riparian Ordinance Permit in April 2014. Although according to the rules and ordinance a permit would not be required, however SLCo Watershed Planning & Restoration Program thought it was best to contact the necessary entities to ensure they knew about the project and to ensure they did not want a permit. Salt Lake City Public Works never responded back , however we were working with Salt Lake City Parks and Recreation since October 2013 who were already fully aware of the project. Chuck Williamson of the State responded and said a permit was not needed.
- Since Rotary Park Detention Basin is technically a dam structure, SLCo Watershed Planning & Restoration Program and Salt Lake City Parks and Recreation worked with Salt Lake County Flood Control and the State Sam Safety Program Manager to ensure the work would not potentially compromise the structure. This was the reason why beyond a certain point only grasses were planted and the trees, shrubs, and willows were set back.
- Salt Lake City Parks and Recreation completed the fence in June 2014. This was pivotal in keeping dogs and potential waste out of the Creek and pond.
- SLCo Watershed Planning & Restoration Program with the help of Utah Conservation Corps (UCC) installed the live riparian plants and inert treatments the weeks of June 16th and June 23rd 2014. This was considered the ideal time since the riparian plants require hydrology and therefore to ensure this hydrology needed to be at low flow.
    - Wetland plants including riparian sod mats and Nebraska Sedge plugs
    - Installed inert treatments along Emigration Creek west of Hogle Zoo and Rotary Park week of June 23rd.
    - Implemented instream structures such as cross-veins and J-hooks to redirect flow to center of the creek to prevent scouring of banks thus minimizing sediment deposition in the creek, and also provide fish habitat.
- SLCo Watershed Planning & Restoration Program with the help of Utah Conservation Corps (UCC) performed manual weed mitigation and trash removal at Rotary Glen Park and west of Hogle Zoo the weeks of June 16th and June 23rd 2014.
- It was discovered during Phase I that the new fence installed by Salt Lake City Parks & Recreation had been vandalized and damaged. SLCo Watershed Planning & Restoration Program with the help of Utah Conservation Corps (UCC) and Salt Lake City repaired the fence June 22-23 2014.

- Phase II of the revegetation occurred the week of October 20th 2014. This was considered a good time to install dormant and potted Coyote Willow and Red Osier Dogwoods as well as the upland vegetation (Appendix B).
- SLCo Watershed Planning & Restoration Program with the help of Utah Conservation Corps (UCC) performed manual weed mitigation and trash removal at Rotary Glen Park and west of Hogle Zoo the week of October 20th 2014.
- Once the planting was completed, the upland area was reseeded the following week.

Product: Help reduce erosion and NPS Pollutant load from banks
Cost: Projected $38,213.20, actual $58,257.85 ($30,784.63 Grant and $27,473.22 Match)

Objective 4: Monitoring

Task 4.1: Water Quality Monitoring (Appendix C)

- SLCo Watershed Planning & Restoration Program has performed extensive water quality monitoring including macroinvetebrate, P-Hab, *E. Coli*, and chemistry before the start of the project.
- Water quality monitoring of *E. Coli* and phot monitoring occurred during the project.
- There will be continued water quality monitoring of *E. Coli* and photo monitoring following the project, projecting the next two years. In addition, SLCo Watershed Planning & Restoration Program anticipates resuming monitoring of macroinvetebrates, P-Hab, *E. Coli*, and Chemistry of the County starting early 2015.

Task 4.2: Macroinvetebrate

- SLCo Watershed Planning & Restoration Program has performed extension macroinvertebrate monitoring before the project started. In addition, SLCo Watershed Planning & Restoration Program anticipates resuming monitoring of macroinvetebrates, P-Hab, *E. Coli*, and Chemistry of the County starting early 2015.

Task 4.3: Physical Habitat (P-Hab)

- SLCo Watershed Planning & Restoration Program has performed extension physical habitat monitoring before the project started.
- Photo monitoring-Salt Lake County performed photo monitoring before, during, and after the completion of the project.
- It is anticipated to continue photo monitoring post project, similar to the *E. Coli* monitoring.

Product: Ongoing Water Quality Monitoring to Help Measure Success
Cost: Projected $23,805.40, actual $4,578.14 (Match)

5.0 PARTNERS

5.1 State Agencies

- The Utah Division of Water Quality (DWQ) provided the EPA 319 Funding, performed the Optical Brightener study, and participated in the two caffeine studies.

5.2 Local Governments, Other Groups, Public at Large

- Salt Lake County Flood Control-regarded the steep bank at Rotary Pond Detention Basin, dredged the Rotary Glen Pond of sediment before the work started, and delivered rocks for Phase II.
- Salt Lake City Parks and Recreation-Built fence around the Rotary Glen Pond to prevent *E. Coli* input from dogs, repaired the fence once SLCo Watershed Planning & Restoration identified it had been vandalized, helped communicate with the communities on the project.
- Emigration Improvement District (EID)-Keep the Emigration Canyon Community informed of the project.
- Emigration Canyon Community Council (ECCC)- Keep the Emigration Canyon Community informed of the project.
- Hogle Zoo-Provided access as well as restroom facilities for the bioengineering work along the reach west the Zoo.
- Emigration Residents-Allowed SLCo Watershed Planning & Restoration to perform work on the banks of Emigration Creek that runs along their property.

6.0 COMPLICATIONS

As with any restoration and vegetation project there were some unforeseen complications, however all were something that could be worked through and make accommodations for.

- Wasatch Hollow-Initially it was planned to perform bioengineering and revegetate the Wasatch Hollow Park and stabilize the banks. The purpose was to help with bank scouring and pet waste from the dogs. However later on in the project Salt Lake City made plans to do a large restoration project, which would destroy any work SLCo Watershed Planning & Restoration would have performed. Therefore it was decided to move the second site to below Hogle Zoo. This had some great unforeseen benefits including partnering with Hogle Zoo and education and outreach with the residents of the reach.
- Weather-As mentioned with the caffeine study, flow was an issue. The caffeine study was planned for May 2014 since the previous year at that time that was low flow and the Creek went dry shortly thereafter. However this year in 2014 there were late precipitation events which caused the Creek to be higher than anticipated. Therefore a second study was recommended for September 2014. This worked out well because the second study confirmed anthropogenic sources of caffeine and also verified the seasonality of the TMDL.
- Weather-The first day of the Phase I plant install there was a large precipitation event. This caused the detention basin pond to quickly fill with water before plants were even delivered to be installed. Since it is necessary to ensure hydrology was at low flow, it was

decided to perform manual weed removal until the water subsided. Also, even after the riparian sod was installed it was moved slightly when the flow decreased.

- Rotary Glen Detention Basin Dam Structure-Since Rotary Park is a detention basin, technically that is a dam. Therefore we had to be very careful not to install anything that could compromise the structure. As a result there were no shrubs or trees planted beyond a certain point. Also, only grasses were included in the upland seed mix.
- Irrigation-Since it is unsure if the irrigation would reach the upland plants, it was decided to plant the trees closest to the irrigation and use upland species that were drought tolerant. Also SLCo Watershed Planning & Restoration performed hand watering of the plants and anticipate doing so in the future if needed.
- Fence-As part of the project Salt Lake City installed a fence around Rotary Glen Pond to keep dogs and people out of the water. Even with outreach and public meetings before the fence was installed, many park users were very upset. We used this as an opportunity to educate park users as to the reason why a fence was installed. Also, the fence was vandalized and damaged shortly after it was installed. SLCo Watershed Planning & Restoration, UCC, and Salt Lake City quickly repaired the fence and as of November 2014 there have not been issues with vandalism.
- Optical Brightener Study-This study was performed in the middle of the week in the middle of the day, thus there were most likely limited households doing laundry. This could account for the low results of optical brightener detected. Therefore it is recommended to redo the study during a more optimal time such as the weekend.

7.0 FUTURE ACTIVITY RECOMMENDATIONS

There are multiple future activity and recommendations with this project.

- Continued monitoring-This project would benefit with continued monitoring. This is planned for the next two years pending staffing. Monitoring includes *E. Coli* and photo monitoring. . In addition, SLCo Watershed Planning & Restoration Program anticipates resuming monitoring of macroinvetebrates, P-Hab, *E. Coli,* and Chemistry of the County starting early 2015.
- Continued seeding and weed mitigation-This is recommended since this has a vegetation component. Weeding would be good to do for both the upland and riparian vegetation. As of November 2014 the riparian vegetation does not need continued weed mitigation. The upland area will be determined and if so it is planned for some mechanical removal in the spring pending staffing levels. Also, it is planned for seeding post weed removal.
- Hogle Zoo-Partnering with Hogle Zoo for access and facilities was very beneficial and would recommend doing so again. The Zoo gave SLCo Watershed Planning & Restoration Program a tour of the Creek within the Zoo boundaries to get our input. It appears as though there are ample opportunities to do bioengineering along Emigration Creek within the Zoo and something would like to pursue in the future.
- Optical Brightener Study- Due to the issues with the study it is recommended to perform another Optical Brightener Study time of week that there is heavy laundry use.
- Stakeholder Involvement-Working with stakeholders including Salt Lake City Parks & Recreation, Emigration Canyon Community Council (ECC) and the Emigration Improvement District (EID) was vital to the project and made the project a success. Also, keeping all stakeholders involved on a regular basis was vital and addressed potential

issues in a timely manner so they could be resolved whereas not to delay the project. Therefore SLCo Watershed Planning & Restoration Program will continue to inform and involve all the stakeholders including the interested public.

- Team Work- SLCo Watershed Planning & Restoration Program works in a team atmosphere. This has proven to be very effective and results in a much more robust project with better results. Therefore it is recommended to continue this team involvement for future projects.

8.0 ENVIRONMENTAL RESULTS

There was extensive monitoring of Emigration Creek before the project. This included Macroinvertebrates, P-Habitat, *E. Coli,* and Chemistry. All data has been shared with the Utah Division of Water Quality.

As part of the project, there was *E. Coli* monitoring as well as photo monitoring (Appendix C). Although it is still too early to determine if the project has been successful with *E. Coli* monitoring, photo monitoring has already determined success of bioengineering and vegetation. In addition, with the bioengineering there has already been increased fish and various animal siting's. This is due to the fish habitat that has been established from the fascines, J-Hooks, and Cross Veins as well as the desirable Vegetation.

Since it takes multiple years to establish vegetation, Salt Lake County will continue *E. Coli* and photo monitoring to measure the success of the project. However, according to STEPL there is a projected load reduction of approximately 1902 lb/year of TSS and there is an estimated load reduction of 3100 lb/year of *E. Coli.*

The caffeine studies identified there is a source of anthropogenic *E. Coli*, which is contributed to failing septic systems. There were two different caffeine studies done: May 13th 2014 and September 4th 2014. The first study was done at a time that was supposed to be immediately after spring runoff yet before the creek went dry, such as the year 2013. However in 2014 there was an unusually late spring runoff, which resulted in higher flows than expected. Due to the high flows caffeine was not detected with the MDL of 10 ng/L.

A second study was performed in September. Although there was still flow in Emigration Creek in September it was very low and the creek was dry at lower Sunnydale. Therefore the lower Sunnydale site had to be adjusted upstream to middle Sunnydale. Also, due to a cost savings in the restoration portion of the project, there were additional funds for an even more robust study that included a 10:00 sampling time.

The September study showed there is a connection between *E. Coli*, caffeine, and flow in Emigration Creek. Figure 2 and Figure 3 illustrate as samples are collected further downstream there is an increase in caffeine and *E. Coli* concentrations. This could be due to the concentration of the caffeine and *E. Coli* as well as the reduction in flow (Figure 4). A regression analysis demonstrates there is a linear relationship between caffeine and flow (r^2 =0.419)[1]. Summary of

[1] Statistical analysis was done with IBM SPSS.

the sampling results and statistical analysis are listed in Appendix A. In addition, the results of the May 13th 2014 and September 4th 2014 correlate the seasonality of the *E. Coli* impairment.

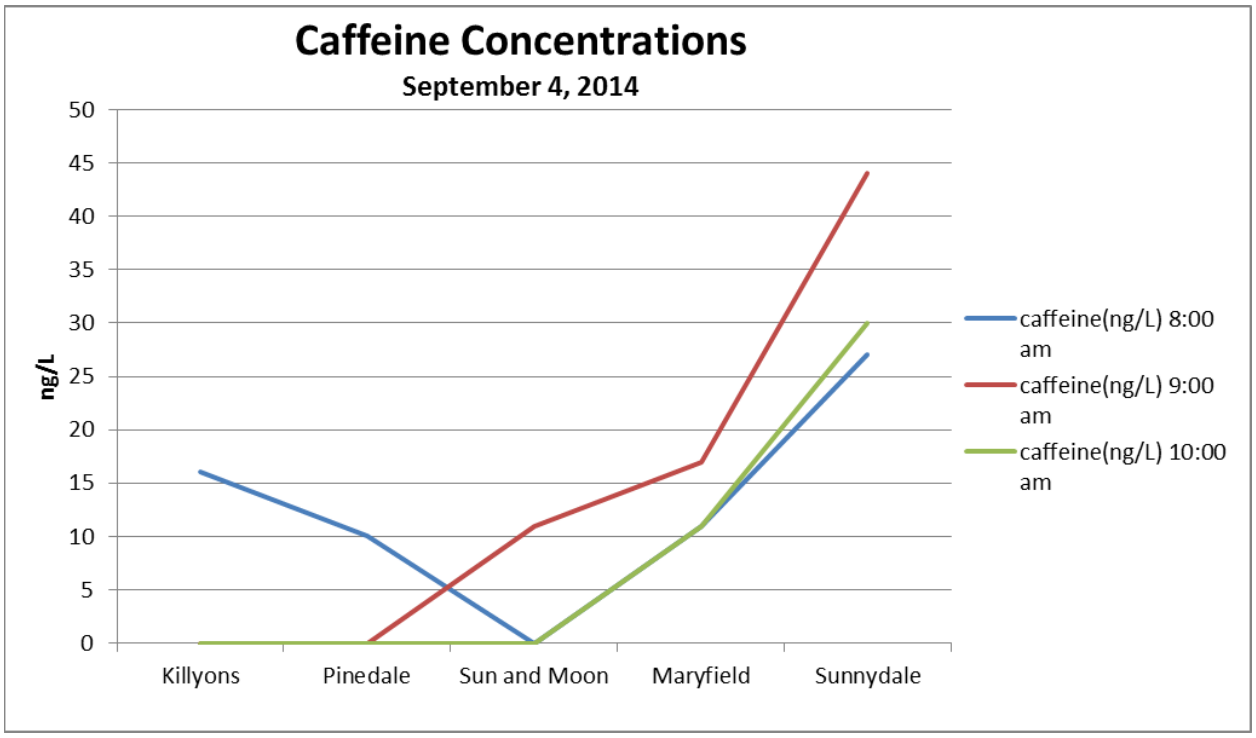


Figure 2. Caffeine Concentrations

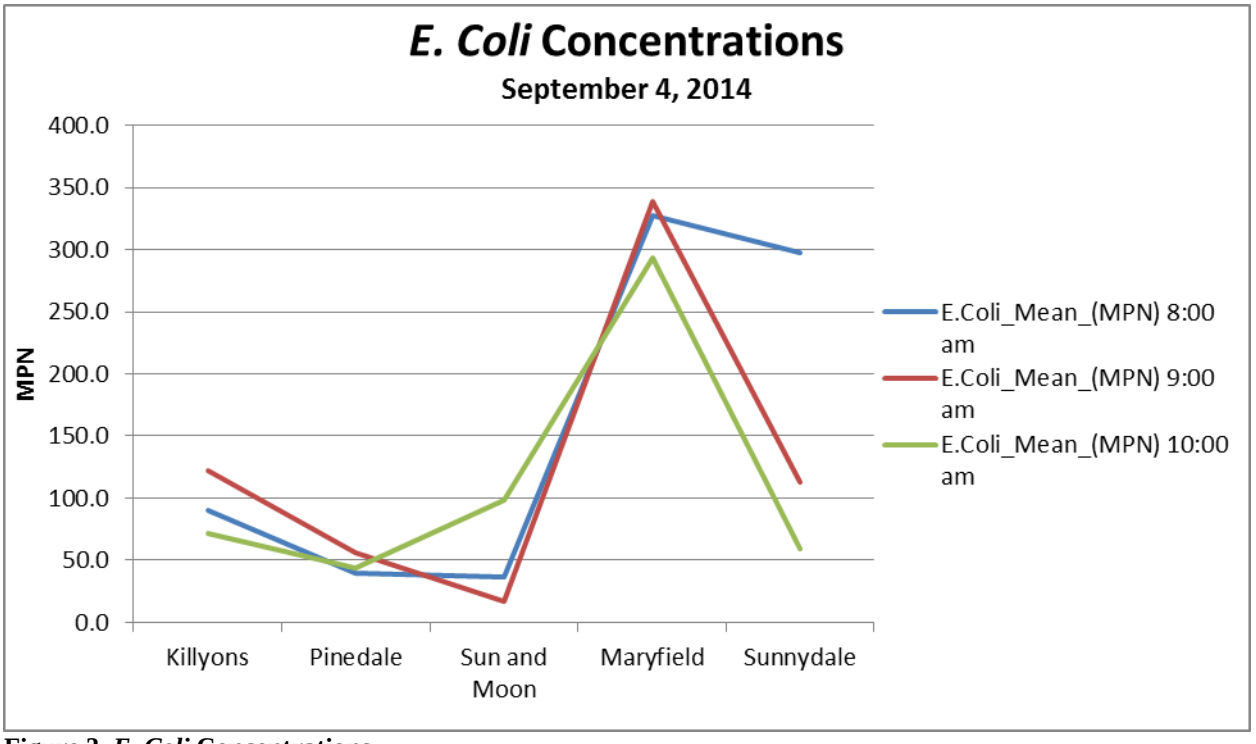


Figure 3. *E. Coli* Concentrations

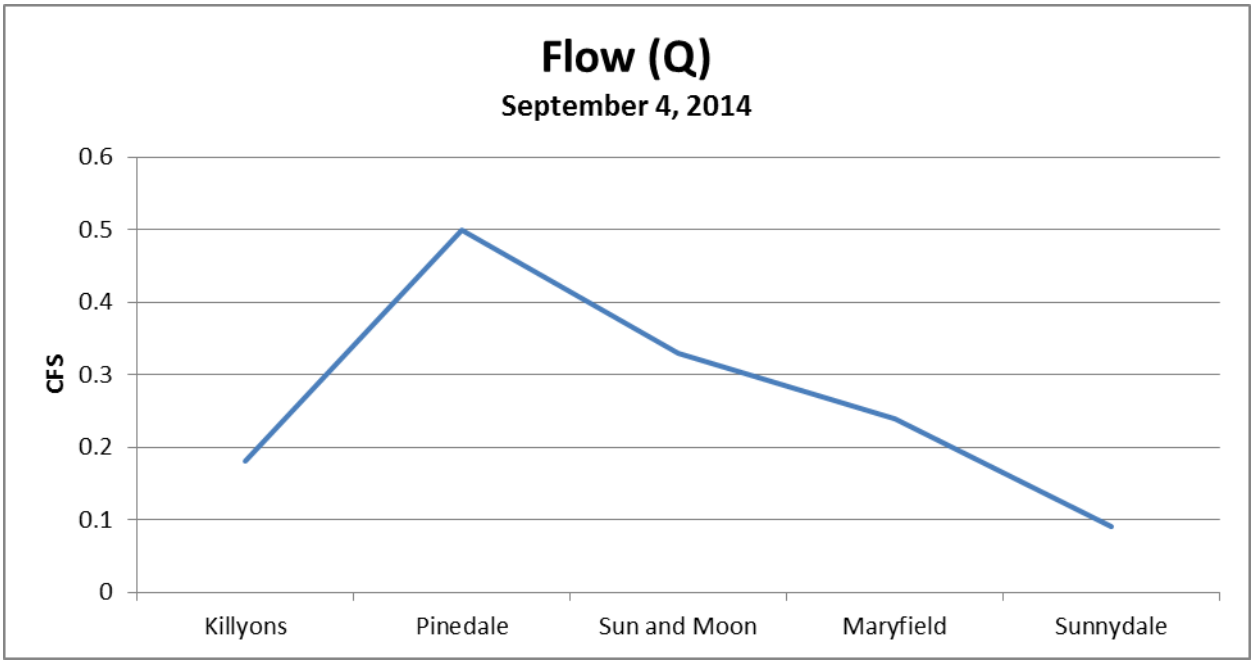


Figure 4. Flow

9.0 DELIVERABLES AND FINANCES

SLCo Watershed Planning & Restoration was able to accomplish all objectives of the 319 Grant PIP and additional tasks that were beneficial to the project and water quality of Emigration Creek. In addition, Watershed Planning will continue monitoring and maintenance (pending staff) for multiple years post expiration of the 319 Grant.

Table 1. Table of Project Deliverables

Objective	Figure 5 Deliverables	319/NPS Funding	Additional Funding	Total
Objective 1: Optical Brightener and Caffeine Studies	Optical Brightener Study and 2 Caffeine Studies	$6,823.72	SLCo WPRP Match: $8861.01 DWQ Match:$967.00	$16,651.73
Objective 2: Education and Outreach	3 stakeholder meetings, a variety of onsite planning meetings with Salt Lake City and Flood Control, meeting with ECCC, various phone calls and conversations with stakeholders and residents, distribution of Stream Care Guide for Homeowners	$420.31	SLCo WPRP Match: 229.26	$649.57
Objective 3: Revegetation	Approximately 1600 linear feet of stream bank restoration, 0.44 acres of riparian wetland restoration, 0.37 acres of upland restoration, 430 feet of fence installed	$30,784.63	SLCo WPRP Match: $27,473.22	$58,257.85
Objective 4: Monitoring	Extensive pre-monitoring of Macroinvetebrates, P-Hab, *E. Coli*, and Chemistry (see SAP Appendix X), monitoring of *E. Coli* and photo monitoring during the project, post monitoring of Macroinvetebrates, *E. Coli*, chemistry and Photo monitoring (See SAP)	$0.00	SLCo Match: $4,578.14	4578.14

9.1 IMAGES OF RESTORATION AND REVEGETATION

Figures 5-26: Restoration

Rotary Glen Park and Creek


Before February 24 2014

June 2014 Install


June 2014 Install


Post Install July 15 2014


Phase II-October 2014


Phase II-October 2014

Hogle Zoo Reach


Install June 2014


Install June 2014

Roatary Park Creek Reach


Install June 2014

Phase II-October Install

Phase II-October Install

10.0 CONCLUSIONS AND NEXT STEPS

The Emigration Implementation Project has been and continues to be a success. By doing the Optical Brightener Study and Caffeine Studies, it has confirmed anthropogenic sources of *E. Coli* contamination in Emigration Creek. Although this has been identified in the past with the Microbial Source Tracking Study (MST) many residents are skeptical the contamination is from septic systems. Therefore these studies confirmed that a major source of *E. Coli* contamination is anthropogenic.

The education and outreach via constant communication with the various stakeholders including the EID and ECCC has been important to keep the residents and stakeholders informed of the

project status and benefits. In addition, by distributing the *Stream Care Guide for Homeowners*, it helps inform and educate the residents about failing septic systems, pet waste, and bank stabilization. These efforts have been and will continue even after the project.

The restoration has been more successful than anticipated. By planting live Nebraska Sedge plugs and Riparian Sod mats there was an immediate noticeable benefit to the Rotary Glen Park Detention Basin pond and creek. The instream structures and inert bank treatments installed along the Creek in the Park and then reach west of Hogle Zoo also added an immediate benefit to prevent additional scouring. The fence installed by Salt Lake City Parks & Recreation had an immediate noticeable benefit to the Creek with less trampling of desirable vegetation and a drastic reduction of pet waste. By installing dormant Coyote Willow and Red Osier Dogwoods to both sites there is an anticipated benefit of bank stabilization and nutrient filtration. The upland vegetation will also contribute bank stabilization thus reducing sediment runoff and benefit the Creek with nutrient filtration. Finally, by performing weed mitigation in the Spring and Fall of 2014 as well the upland and riparian seeding there has been noticeable plant establishment beyond the potted, pole, sod, and plug plantings.

Monitoring is vital to demonstrate the success of the project. SLCo WPRP has been monitoring for Macroinvetebrtes, P-Hab, *E.coli*, and Chemistry throughout the entire County for the past five years. There was monitoring for *E. Coli* and photo monitoring during the timeframe of the project as well. Additionally WPRP will start county monitoring of Macroinvetebrtes, P-Hab, *E. Coli*, and Chemistry beginning of 2015 and photo monitoring will continue for the site.

The next steps are to continue to work with the Emigration Canyon community to maintain and repair failing septic systems. In addition, the EID has identified a location for a pilot program to install a community on-site treatment facility for approximately six homes (Figure 27). This site was selected due to the property access and the potential for failing septic systems along the reach. Monitoring has already started above and below the site. The EID will go to the Water Quality Board to ask for funds to design the pilot project and then subsequently build the pilot project. The goal is for this pilot project to be a success and to thus champion similar subsequent projects in the community.

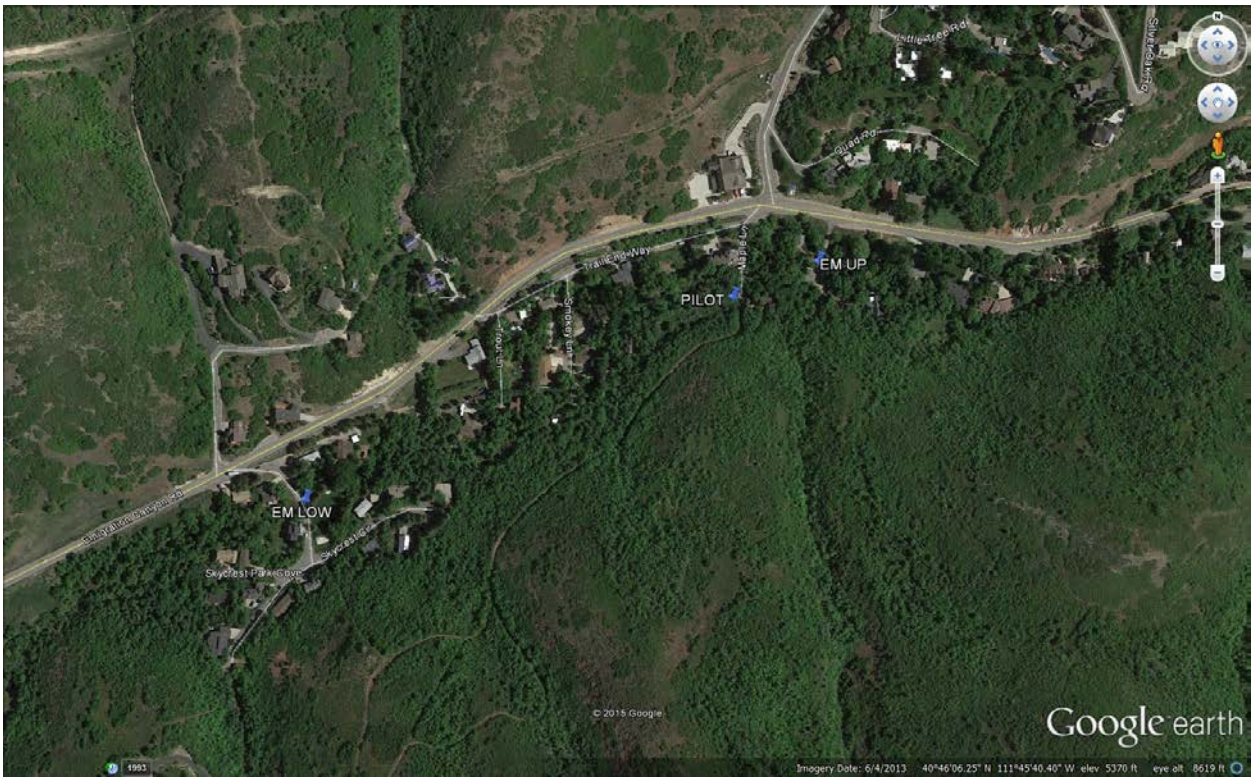


Figure 27. Map of Pilot Project

It should be stressed the reasons behind the success of the project is stakeholder and community involvement as well as a team effort by Watershed Planning & Restoration Program. Furthermore, the success of the selected vegetation has established a "template" for future projects. Watershed Planning & Restoration Program is grateful to EPA and Utah DWQ for the opportunity to do this project.

11.0 ATTACHMENTS

Appendix A

Optical Brightener and Caffeine Studies

Optical Brightener Study Spreedsheet

Sample ID	Analysis Date	Replicate	Fluorescence at 0 min.	Step 1	Fluorescence at 5 min.	% Reduction in fluorescence at 5 min.	Step 2	Fluorescence at 10 min.	% Reduction in fluorescence at 10 min.	Ratio of % reductionat 10 min. to that at 5 min.	Step 3	OB Result	Notes	Average initial fluoresence	Presence or Absence of OB
Killyons	7/1/2013	1	7.282									-			
Killyons	7/1/2013	2	8.275									-			
Killyons	7/1/2013	3	6.723									-			
Pinecrest	7/1/2013	1	6.783									-			
Pinecrest	7/1/2013	2	6.527									-			
Pinecrest	7/1/2013	3	6.943									-			
Burr Fork	7/1/2013	1	12.100		10.510	13%		9.589	9%	0.69		-			
Burr Fork	7/1/2013	2	10.380		8.870	15%		8.160	8%			-			
Burr Fork	7/1/2013	3	7.474		6.516	13%		6.063	7%			-			
Sun & Moon	7/1/2013	1	10.270									+			
Sun & Moon	7/1/2013	2	9.505									-			
Sun & Moon	7/1/2013	3	8.544									-			
Maple Lane	7/1/2013	1	10.100		9.470	6%						-			
Maple Lane	7/1/2013	2	13.050		9.336	28%						+			
Maple Lane	7/1/2013	3	10.020		9.421	6%						-			
Fire House	7/1/2013	1	11.940		10.700	10%		10.100	6%	0.60		-			
Fire House	7/1/2013	2	10.470		9.309	11%		8.753	6%	0.55		-			
Fire House	7/1/2013	3	10.230		9.190	10%		8.688	5%	0.50		-			
Maryfield	7/1/2013	1	10.430		9.205	12%		8.381	9%	0.75		-			
Maryfield	7/1/2013	2	10.840		9.581	12%		8.815	8%	0.67		-			
Maryfield	7/1/2013	3	11.150		9.306	17%		8.591	8%	0.47		-			
Sunnydale	7/1/2013	1	10.810		9.403	13%		8.841	6%	0.46		-			
Sunnydale	7/1/2013	2	10.040		8.944	11%		7.914	12%	1.09		-			
Sunnydale	7/1/2013	3	10.300		9.031	12%		8.745	3%	0.25		-			
Below Rotary Park	7/1/2013	1	5.140									-			
Below Rotary Park	7/1/2013	2	5.141									-			
Below Rotary Park	7/1/2013	3	4.438									-			
Anderson Library	7/1/2013	1	6.443									-			
Anderson Library	7/1/2013	2	6.703									-			
Anderson Library	7/1/2013	3	8.003									-			
1900 E.	7/1/2013	1	7.345									-			
1900 E.	7/1/2013	2	8.139									-			
1900 E.	7/1/2013	3	7.250									-			
Blane Ave.	7/1/2013	1	8.158									-			
Blane Ave.	7/1/2013	2	7.948									-			
Blane Ave.	7/1/2013	3	7.503									-			
Westminster	7/1/2013	1	8.180									-			
Westminster	7/1/2013	2	8.440									-			
Westminster	7/1/2013	3	8.100									-			

Legend
- Cells that will be filled during measurement
- Cell that give results (Positive, Negative) orinstruction (UV) for next step
- Results on OB detection (Positive, Negative)
- Final results reported

Bibliography

"Caffeine Tracks Contamination." Nature Retrieved 3/18/2014, 2014.

(2006). California GAMA Program: Fate and Transport of Wastewater Indicators: Results from Ambient Groundwater and from Groundwater Directly Influenced by Wastewater. Lawrence Livermore National Laboratory, CALIFORNIA STATE WATER RESOURCES CONTROL BOARD**:** 60.

Buerge, I. J., T. Poiger, et al. (2003). "Caffeine, an Anthropogenic Marker for Wastewater Contamination of Surface Waters." Environmental Science & Technology **37**(4): 691-700.

Comeau, F. and C. Surette (2008). "The occurrence of acidic drugs and caffeine in sewage effluents and receiving waters from three coastal watersheds in Atlantic Canada." Science of The Total Environment **396**(2-3): 132-146.

Ferreira, A. P. (2005). "Caffeine as an Environmental Indicator for Assessing Urban Aquatic Ecosystems." Cadernos de Saúde Pública **21**(6): 1884-1892.

Goel, R., T. Datta, et al. (2008). Emigration Canyon Microbial Source Tracking. Civil & Environmental Engineering University of Utah, Utah Division of Water Quality,**:** 9.

Hillebrand, O., K. Nödler, et al. (2011). "Application of Caffeine as Indicator for the Quantification of Recharging Wastewater in Karst Systems – A case study." Water Research **46**(2): 395-402.

Hillebrand, O., K. Nodler, et al. (2011). "Caffeine as an Indicator for the Quantification of Untreated Wastewater in Karst Systems." Water Research **46**(2): 395-402.

James McConaghie Evaluation of the behavior of caffeine in fresh watersheds and as a tracer of sewage contamination. School of Forestry and Environmental Studies,. New Haven, Yale University. **M.E.Sc:** 12.

Peeler, K. A. (2004). CAFFEINE AS AN ANTHROPOGENIC SOURCE INDICATOR IN FRESHWATER AND MARINE SYSTEMS. Oceanography, THE FLORIDA STATE UNIVERSITY. **Masters of Science:** 130.

Seiler, R. L., S. D. Zaugg, et al. (2005). "Caffeine and Pharmaceuticals as Indicators of Waste Water Contamination in Wells." Ground Water **37**(3): 405-410.

Emigration Creek Caffeine Study

September 4, 2014

Caffeine Sample Sites (Table 1)

There are a total of 4 sample sites and 1 control site (Figure 1) as well as one person collecting flow along all sites.

- If you have a flow meter available please bring it as well as measuring tape.

Table 1-Sample Sites

Site Number	Description	Person Sampling
CS-CON1	Control-Killyons Canyon	Marian Hubbard-Rice
CS1	Pinecrest Gage	Steve Burgon
CS2	Sun & Moon Café-Culvert	Lynn Berni
CS3	Above Maryfield Lane	Bob Thomspon
CS4B	Sunnydale (mid)	Hilary Arens
FLOW	Flow at all sample sites	Alex Hamilton

Sampling Supplies Needed (Table 2)

Table 2-Sampling Supplies

Item	Quantity	Purpose
Galvanized Buckets	5	Collect Caffeine Sample
dH_2O	5 1-gallon containers	Triple rinse bucket before pulling caffeine sample
Galvanized Funnels	5	To help pour
Amber Bottles	30	Caffeine Sample-supplied by Chem Tec Ford
E. Coli Vessels	45	E. Coli Samples
Cooler	5	Hold and Transport Samples
Ice	2 10-gallon Bag	Hold Samples
Sharpies	5	Write on sample Bottles
Pencil	5	Notes, Chain of Custody Forms
Wading Boots	5	Wading in water to collect samples
Water	5 bottles	To stay hydrated

Sampling Timeline (Table 3)

Table 3-Timeline

Time	Task
6:15 am	Marian arrive at County Bldg. to fill coolers with ice and for final preparations
7:00 am	Bob, Lynn, Hilary, and Steve, and Alex arrive at County or designated site
7:10 am	Leave County for Emigration Creek sites
8:00 am	Pull 2 Caffeine sample then 3 *E. Coli* Samples
9:00 am	Pull 2 Caffeine sample then 3 *E. Coli* Samples
10:00 am	Pull 2 Caffeine sample then 3 *E. Coli* Samples
10:20 am	Regroup in Emigration Canyon-Ruth's Diner

Sampling methodology

Because of the need to analyze samples in the sub part per billion (ppb) range and a desired MDL of 0.01 ppb, the caffeine analysis will be performed using the Liquid chromatography-electrospray tandem mass spectrometry (HPLC/MS/MS) EPA Method 1694. Two (2) 1 liter amber bottles will be collected at each site per hour for three hours. In addition, three (3) 100 ml *E. Coli* and fecal coliform samples will be collected at each site per hour for three hours. *E. Coli* and total coliform total quantification will use the IDEXX Quanti-Tray/2000 analysis system, which is the EPA approved protocol.

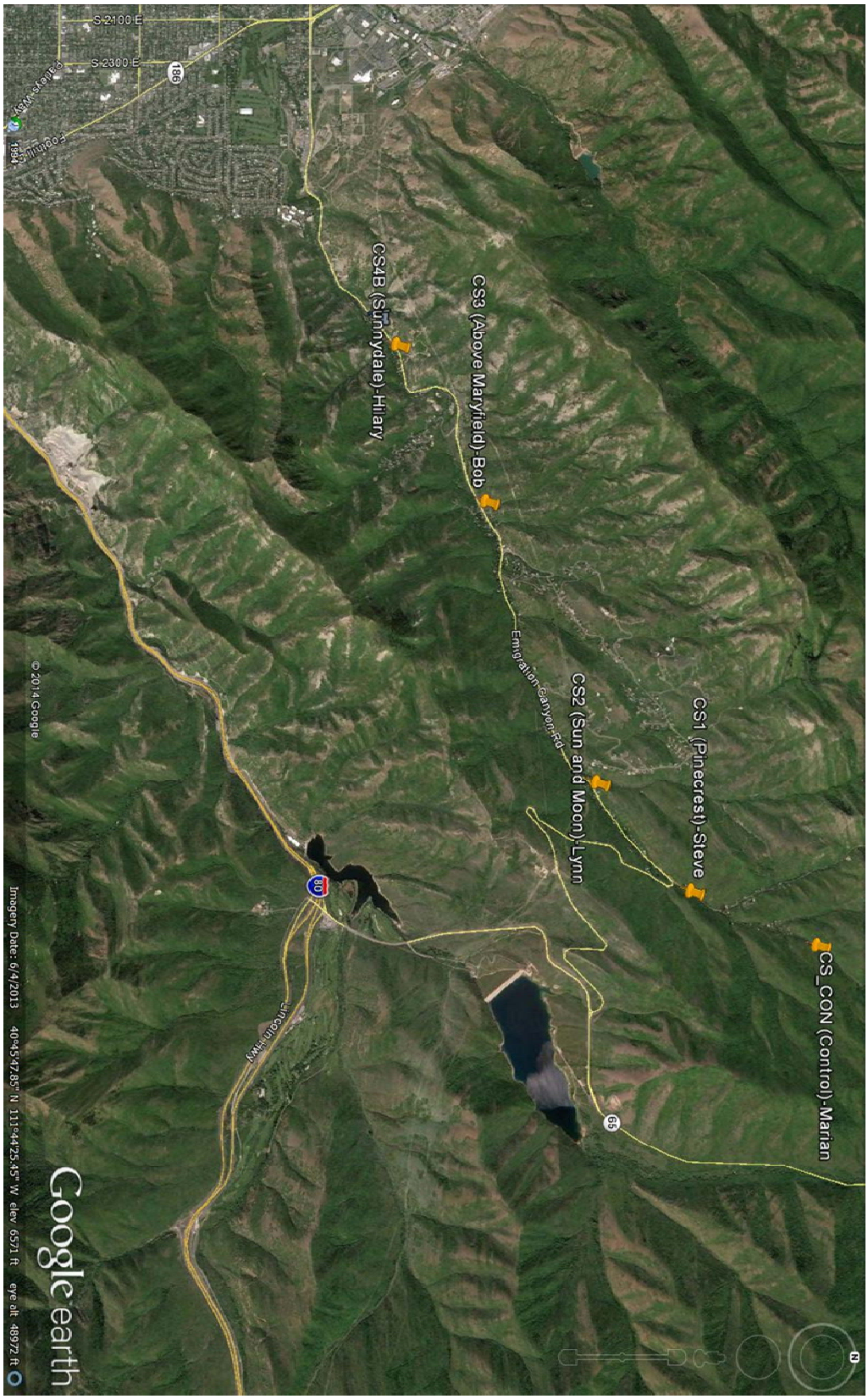


Figure 1. Caffeine Sample Sites

Emigration Creek Caffeine Study

Study Date: May 13, 2014

Site	Site Code	time	Caffeine (ng/L)	E. coli (MPN)	Fecal Coliform (MPN)	Flow	Sampler
Sunnydale	CS4	8:00	ND	131.7	> 2419.6	6.18	HA
Sunnydale	CS4	9:00	ND	160.7	> 2419.6	6.18	HA
Maryfield	CS3	8:00	ND	39.5	> 2419.6	5.73	RB
Maryfield	CS3	9:00	ND	20.1	> 2419.6	5.73	RB
Sun & Moon	CS2	7:58	ND	5.2	1413.6	3.92	LB
Sun & Moon	CS2	8:59	11	96	1203.3	3.92	LB
Pinecrest	CS1	8:00	ND	5.1	1203.3	3.73	SB
Pinecrest	CS1	9:00	ND	5.2	1986.3	3.73	SB
Killyons	CON	8:00	ND	4.1	1299.7	1.64	MR
Killyons	CON	9:00	ND	<1.0	1203.3	1.64	MR

Emigration Creek Caffeine Study

Study Date: September 4, 2014

Site	Site Code	time	Caffeine (ng/L)	*E. Coli* (MPN)	*E. Coli* Mean (MPN)	Fecal Coliform (MPN)	Fecal Coliform Mean (MPN)	Flow	Sampler
Sunnydale	CS4	8:00	27	325.5	297	> 2419.6	> 2419.6	0.09	HA
Sunnydale	CS4	8:00		240		> 2419.6			HA
Sunnydale	CS4	8:00		325.5		> 2419.6			HA
Sunnydale	CS4	9:00	44	75.9	113.2	> 2419.6	> 2419.6	0.09	HA
Sunnydale	CS4	9:00		140.1		> 2419.6			HA
Sunnydale	CS4	9:00		123.6		> 2419.6			HA
Sunnydale	CS4	10:00	30	73.3	58.8	> 2419.6	> 2419.6	0.09	HA
Sunnydale	CS4	10:00		52		> 2419.6			HA
Sunnydale	CS4	10:00		51.2		> 2419.6			HA
Maryfield	CS3	8:00	11	228.2	327	> 2419.6	> 2419.6	0.24	RB
Maryfield	CS3	8:00		387.3		> 2419.6			RB
Maryfield	CS3	8:00		365.4		> 2419.6			RB
Maryfield	CS3	9:00	17	365.4	338.7	> 2419.6	> 2419.6	0.24	RB
Maryfield	CS3	9:00		410.6		> 2419.6			RB
Maryfield	CS3	9:00		240		> 2419.6			RB
Maryfield	CS3	10:00	11	387.3	292.8	> 2419.6	> 2419.6	0.24	RB
Maryfield	CS3	10:00		272.3		> 2419.6			RB
Maryfield	CS3	10:00		218.7		> 2419.6			RB
Sun & Moon	CS2	8:00	ND	30.5	36.4	> 2419.6	> 2419.6	0.33	LB
Sun & Moon	CS2	8:00		42		> 2419.6			LB
Sun & Moon	CS2	8:00		36.8		> 2419.6			LB
Sun & Moon	CS2	9:00	11	13.4	17.3	> 2419.6	> 2419.6	0.33	LB
Sun & Moon	CS2	9:00		19.9		> 2419.6			LB
Sun & Moon	CS2	9:00		18.5		> 2419.6			LB
Sun & Moon	CS2	10:00	ND	78.9	98.2	> 2419.6	> 2419.6	0.33	LB
Sun & Moon	CS2	10:00		101.2		> 2419.6			LB
Sun & Moon	CS2	10:00		114.5		> 2419.6			LB
Pinedale	CS1	8:00	10	35	39.7	> 2419.6	> 2419.6	0.5	SB
Pinedale	CS1	8:00		40.8		> 2419.6			SB
Pinedale	CS1	8:00		43.2		> 2419.6			SB
Pinedale	CS1	9:00	ND	55.6	56.5	> 2419.6	> 2419.6	0.5	SB

Pinedale	CS1	9:00		68.3		> 2419.6			SB
Pinedale	CS1	9:00		45.5		> 2419.6			SB
Pinedale	CS1	10:00	ND	42	43.8	> 2419.6	> 2419.6	0.5	SB
Pinedale	CS1	10:00		37.3		> 2419.6			SB
Pinedale	CS1	10:00		52.1		> 2419.6			SB
Killyons	CON	8:00	16	90.8	90.1	2419.6	2190.7	0.18	MR
Killyons	CON	8:00		86		1732.9			MR
Killyons	CON	8:00		93.4		2419.6			MR
Killyons	CON	9:00	ND	95.9	122.3	> 2419.6	> 2419.6	0.18	MR
Killyons	CON	9:00		98.7		> 2419.6			MR
Killyons	CON	9:00		172.2		> 2419.6			MR
Killyons	CON	10:00	ND	101.4	72.1	1986.3	2203	0.18	MR
Killyons	CON	10:00		57.6		> 2419.6			MR
Killyons	CON	10:00		57.3		2419.6			MR

Emigration Creek Caffeine Study

Statistical Analysis

Study Date: September 4, 2014

Descriptive Statistics Caffeine Study, September 4th 2014

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Caffeine (ng/L)	15	0	44.00	11.80	13.32
E. Coli (MPN)	15	17.30	338.70	133.59	116.61
Fecal Coliform (MPN)	15	2190.70	2419.60	2389.90	78.41
Flow (CFS)	15	0.09	0.50	0.27	0.14

Model 1: Logistic Regression Model: Effect *E. Coli*, Fecal Coliform, and Flow on Caffeine

Variable	Slope (B)	Std. Error	Beta	t-ratio	Sig.
E. Coli (MPN)	-0.011	0.028	-0.095	-0.391	0.01
Fecal Coliform (MPN)	0.053	0.039	0.314	1.360	0.20
Flow(CFS)	-70.110	22.76	-0.762	-3.080	0.70

Constant = -75.694
Adjusted R^2 = 0.343
F- Ratio = 2.83
SEE = 10.80
N = 15

Model 2: Logistic Regression Model: Effect *E. Coli* on Caffeine

Variable	Slope (B)	Std. Error	Beta	t-ratio	Sig.
E. Coli (MPN)	0.03	0.031	0.263	0.983	0.343

Constant = 7.784
R^2 = 0.069
F- Ratio = 0.967
SEE = 13.34
N = 15

Model 3: Logistic Regression Model: Effect Fecal Coliform on Caffeine

Variable	Slope (B)	Std. Error	Beta	t-ratio	Sig.
Fecal Coliform (MPN)	0.19	0.047	0.109	0.395	0.699

Constant = -32.47
R^2 = 0012
F- Ratio = 0.156
SEE = 13.74
N = 15

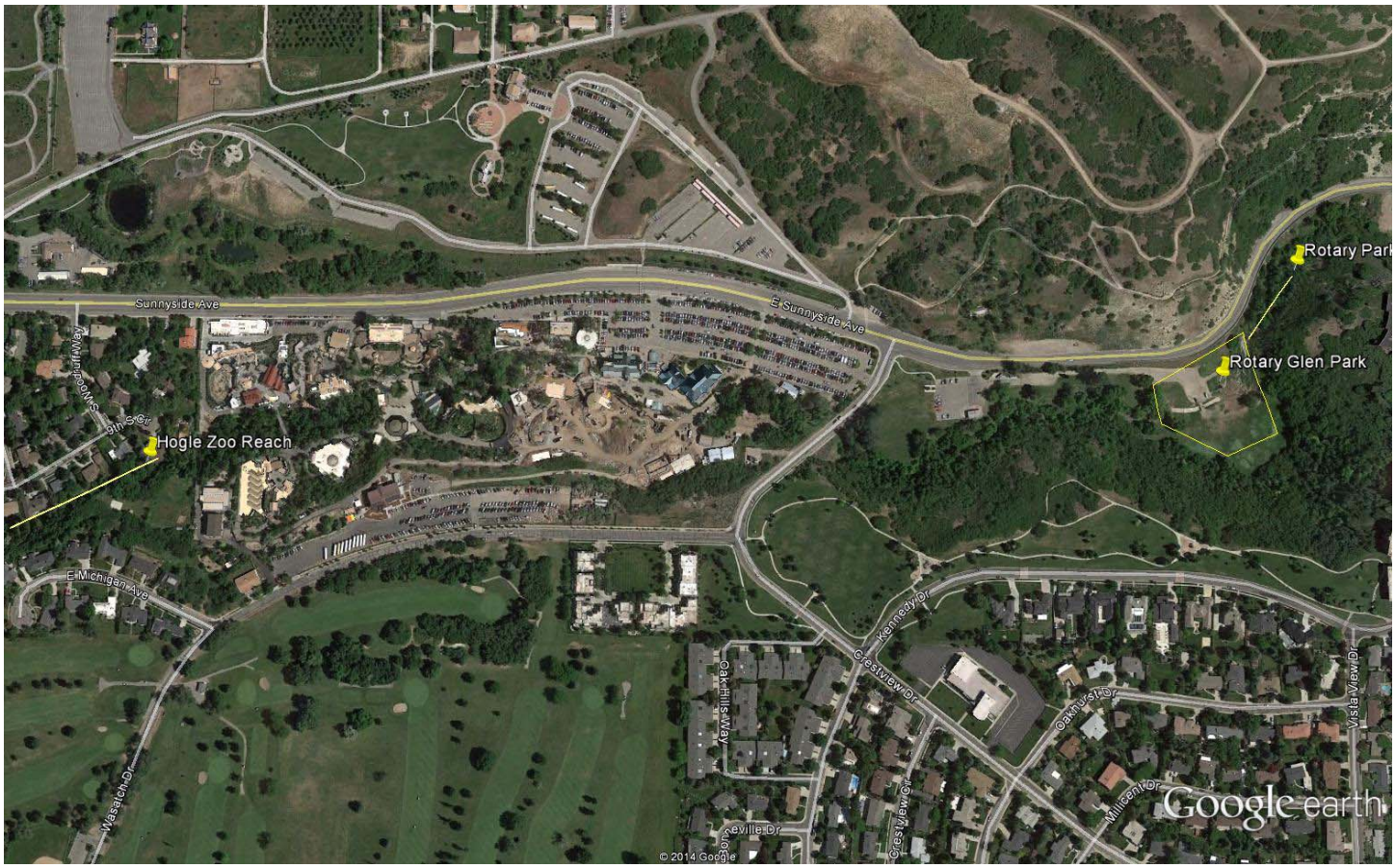
Model 4: Logistic Regression Model: Effect Flow on Caffeine

Variable	Slope (B)	Std. Error	Beta	t-ratio	Sig.
Flow (CFS)	-59.515	19.451	-0.647	-3.060	0.009

Constant = 27.75
R^2 = 0.419
F- Ratio = 9.362
SEE = 10.54
N = 15

Appendix B

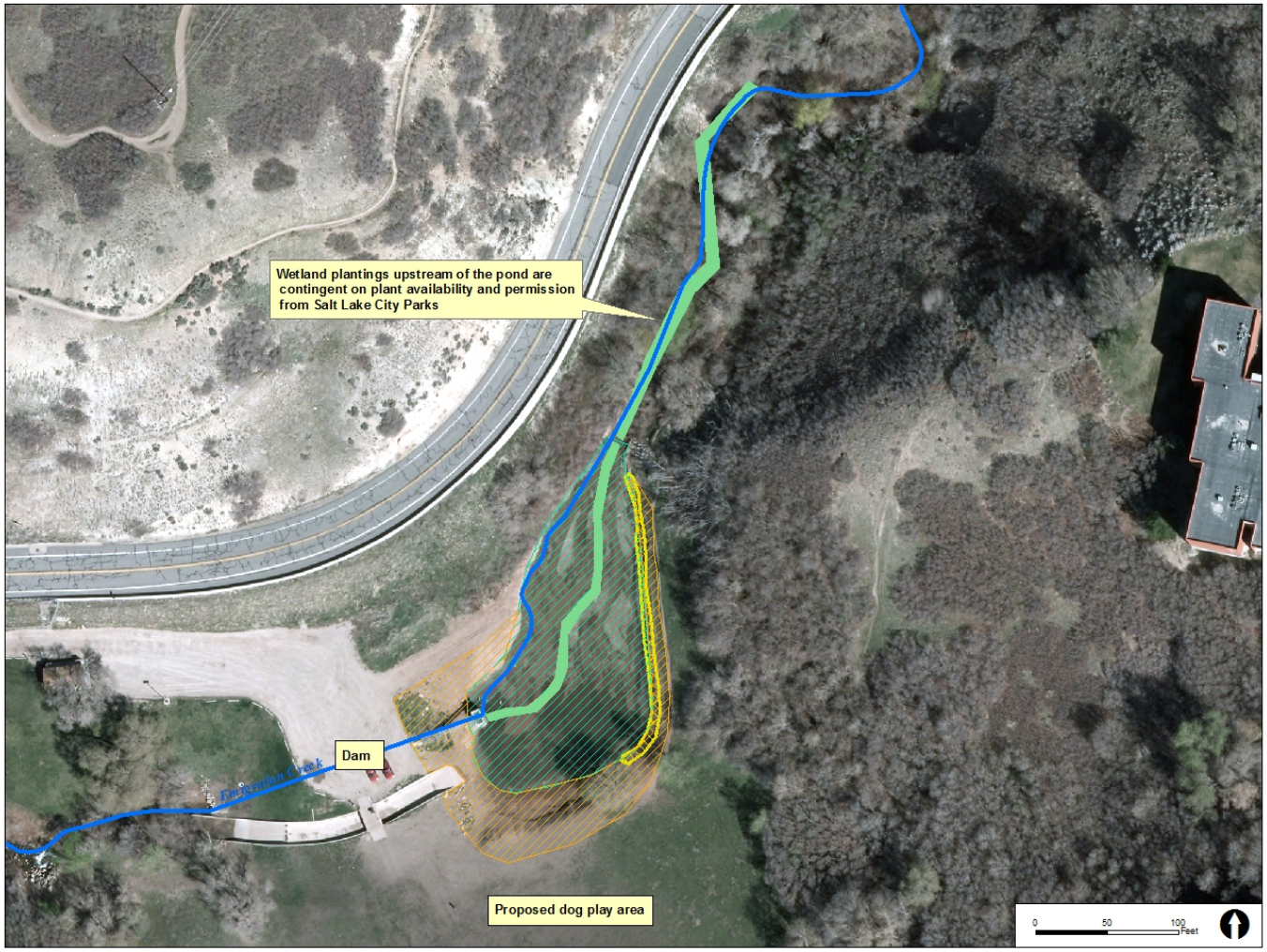
Revegetation and Restoration



Google earth

feet 2000

meters 700



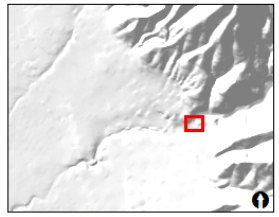
Rotary Glen Park Detention Basin Planting Plan

Emigration Creek Restoration and Streambank Stabilization Project

Legend

Plantings

- Riparian seed mix
- Upland seed mix
- Wetland plants
- Willow stakes
- Park Boundary



Locator Map

April 24, 2014

Prepared by: Lynn Berni, Salt Lake County Watershed Planning & Restoration Program

Data Sources: Salt Lake County, Utah's State Geographic Information Database

SALT LAKE COUNTY

1=20

WASHINGTON STANDARD DRAWING

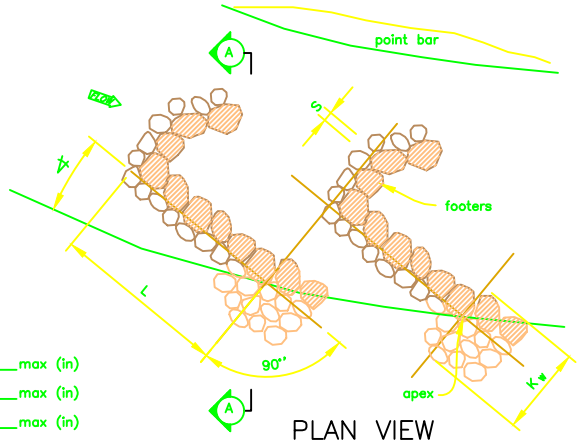
BIOENGINEERING BANK PROTECTION

J–HOOK ROCK VANE

STANDARD DRAWING NO.
BIO–0059
APPROVED BY: LAJ
DRAWN BY: KLY
ISSUE DATE: 5/01

DIMENSIONS

$\measuredangle$ = _____ (deg)
L = _____ (ft)
W = _____ (ft)
D = _____ (ft)
K_L = _____ (ft)
K_W = _____ (ft)
K_D = _____ (ft)
S = _____ (ft)



PLAN VIEW

ROCK KEY GRADATION

D_{100} = _____ min (in) _____ max (in)
D_{75} = _____ min (in) _____ max (in)
D_{50} = _____ min (in) _____ max (in)
D_{min} = _____ min (in) _____ max (in)

ROCK VANE DIAMETER

HEADER ROCK:

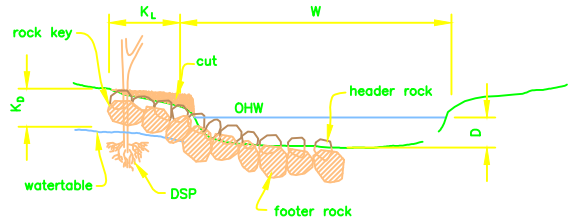
Dia = _____ min (in) _____ max (in)

FOOTER ROCK:

Dia = _____ min (in) _____ max (in)

GENERAL NOTES

1. Vane will extend into the channel a total of 1/3 of the bank full width flow and will be angled from the streambank between 20° to 30°.
2. The top of the vane shall have a slope between 4° to 7°.
3. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.



SECTION (A)

Drawing not to scale.

JOB CLASS
CAD FILE NO.
BIO–0059.DWG
SHEET OF

Date
Designed
Drawn
Checked
Approved

U.S.D.A. NATURAL RESOURCES CONSERVATION SERVICE

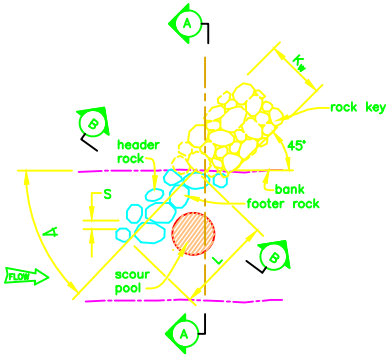
1=20

WASHINGTON STANDARD DRAWING

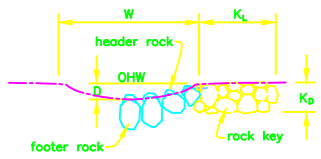
BIOENGINEERING BANK PROTECTION

ROCK VANE

STANDARD DRAWING NO. BIO-0060
APPROVED BY: LAJ
DRAWN BY: KLY
ISSUE DATE: 5/99

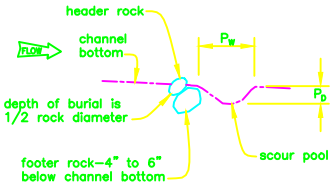


PLAN VIEW



Note: Scour pool is not shown in this view.

SECTION (A)



SECTION (B)

GENERAL NOTES

1. Vane will extend into the channel a total of 1/3 of the bank full width flow and will be angled from the streambank between 20° to 30°.
2. The top of the vane shall have a slope between 4° to 7°.
3. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

DIMENSIONS

4 = _____(deg)
L = _____(ft)
W = _____(ft)
D = _____(ft)
K_L = _____(ft)
K_W = _____(ft)
K_D = _____(ft)
S = _____(ft)
P_W = _____(ft)
P_D = _____(ft)

ROCK KEY GRADATION

D_{100} = _____min (in)_____max (in)
D_{75} = _____min (in)_____max (in)
D_{50} = _____min (in)_____max (in)
D_{min} = _____min (in)_____max (in)

ROCK VANE DIAMETER

HEADER ROCK:
Dia = _____min (in)_____max (in)
FOOTER ROCK:
Dia = _____min (in)_____max (in)

Drawing not to scale.

JOB CLASS		Date
CAD FILE NO. BIO-0060.DWG	Designed	
SHEET OF	Drawn	
	Checked	
U.S.D.A. NATURAL RESOURCES CONSERVATION SERVICE	Approved	

REVISIONS

NO.	DATE	APPROVED	DESCRIPTION
1	5/99		Changed vortex rock weir to rock vane in dimension area

Emigration Implementation Seed Mix

UPLAND SEED SCHEDULE		
BOTANICAL NAME	**COMMON NAME**	**POUNDS PER Acre LBS/ACRE**
Linum lewisii	Lewis Blue Flax	2.5
Asclepia Tuberosa	Butterfly Milkweed	1
Gaillardia aristata	Blanket Flower	2.5
Bromus marginatus	Mountain brome	7.5
Elymus trachycaulus ssp. trachycaulus	Slender wheatgrass	6.25
Poa secunda ssp. Sandbergii	Sandberg bluegrass	1.25
Poa secunda ssp. ampla	Big bluegrass	1.25
Festuca ovina	Sheep fescue	1.25
Pseudoroegneria spicata ssp. spicata	Bluebunch wheatgrass	2.5
Western wheatgrass	Pascopyrum smithii	5

RIPARIAN SEED SCHEDULE		
BOTANICAL NAME	**COMMON NAME**	**POUNDS PER Acre LBS/ACRE**
Carex Nebraskensis	Nebraska Sedge	1
Schoenoplectus Acutus Var. Acutus	Hardstem Bullrush	0.5
Juncus Balticus	Baltic Rush	0.5

SALT LAKE COUNTY
PUBLIC WORKS PROJECT
ENGINEERING DIVISION

SALT LAKE COUNTY

PROJECT DRAWINGS

EMIGRATION CREEK IMPLEMENTATION PROJECT

PROJECT #FV_130007

FOR MORE INFORMATION REGARDING THIS PROJECT CONTACT:
MARIAN HUBBARD-RICE
SALT LAKE COUNTY PUBLIC WORKS DEPARTMENT,
ENGINEERING DIVISION
2001 SOUTH STATE STREET, PO BOX 144575
SALT LAKE CITY, UTAH 84114-4575
PHONE # (385) 468-6600
FAX # (385) 468-6603

SPECIFICATIONS REFERENCE

When reference is made to specifications, they refer to the Manual of Standard Specifications 2007 Edition, Utah APWA, and Utah AGC. This reference shall control except for modifications and supplements contained in the project manual.

SALT LAKE COUNTY
PUBLIC WORKS PROJECT
ENGINEERING DIVISION

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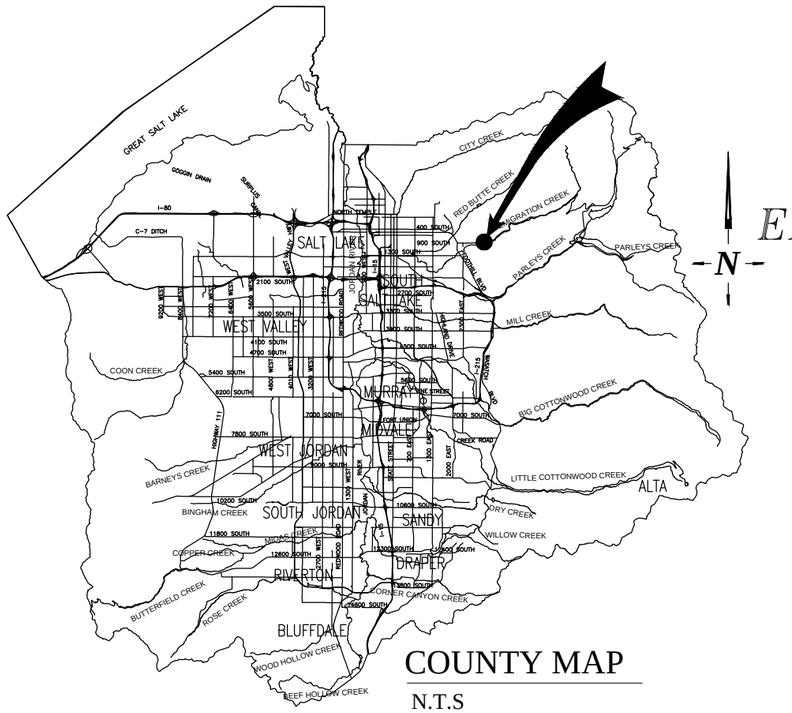
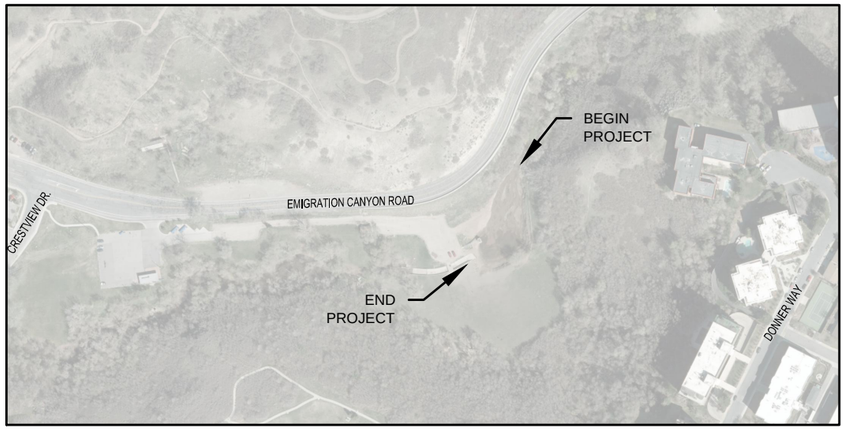
SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION
PHONE (385) 468-6600



COUNTY MAP

N.T.S

EMIGRATION CREEK IMPLEMENTATION
ROTARY GLEN PARK



VICINITY MAP

N.T.S

GENERAL PROJECT NOTES:
1.PLANTING OF VEGETATION SHOULD OCCUR IN THE FALL.
2. WILLOWS SHOULD BE IN DORMANCY AND SOAKED FOR WEEK PRIORT TO INSTALLATION.
3.IRRIGATION RECOMMENDED.

DRAWING INDEX	
SHEET NO.	DESCRIPTION
	COVER SHEET
1	TITLE SHEET
2	SITE LAYOUT
3	CONTROL PLAN
4	UPLAND SEED PLAN
5	DETAILS

SALT LAKE COUNTY MAYOR
RECOMMENDED FOR APPROVAL
MAYOR OR DESIGNEE — DATE

SALT LAKE COUNTY PUBLIC WORKS
RECOMMENDED FOR APPROVAL
PUBLIC WORKS DIRECTOR — DATE

SALT LAKE COUNTY ENGINEERING DIVISION
APPROVED
DIRECTOR — DATE

UTILITIES - CONTACT BLUE STAKES BEFORE DIGGING (1-800-662-4111)

UTILITIES MAY OR MAY NOT BE LOCATED AS SHOWN ON THE PLANS. CONTRACTOR SHALL POTHOLE ALL UTILITIES AND NOTIFY RESPECTIVE UTILITY COMPANIES 14 DAYS PRIOR TO WORK IN THE AREA OF EACH UTILITY.
POWER - Rocky Mountain Power, ALENE BENTLEY 801-220-4437, alene.bently@pacificcorp.com
GAS - Questar, BURKE PETERSON 801-324-3643, burke.peterson@questar.com
TELEPHONE - Century Link, CHERYL BOLINDER 801-974-8152, cheryl.bolinder@qwest.com
WATER - Salt Lake City Public Utilities CLAUDIA WHEELER 801-509-9997, cwheeler@mwdsls.org
SANITARY SEWER - Salt Lake City Public Utilities CLAUDIA WHEELER 801-509-9997, cwheeler@mwdsls.org
CABLE TV - Comcast, GARY GOLDSTEIN 801-401-3041, gary_goldstein@cable.comcast.com

SALT LAKE COUNTY

RECOMMENDED FOR APPROVAL

PROJECT ENGINEER

SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION
2001 SOUTH STATE STREET, SUITE N3100
SALT LAKE CITY, PO BOX 144575, UTAH 84114-4575

EMIGRATION CREEK IMPLEMENTATION

TITLE SHEET

REVIEWED AND APPROVAL RECOMMENDED:

PROJECT MANAGER — DATE

ENGINEERING MANAGER — DATE

DESIGNED BY: MLHR
DRAWN BY: MLHR
CHECKED BY:
DATE CHECKED:

PROJECT NUMBER: FV_130007
FILE NUMBER: 0605
SHEET NUMBER: 1 OF 5

ROTARY PARK DETENTION BASIN
CONTROL PLAN

EMIGRATION CANYON ROAD

ROTARY GLEN PARK

PARKING LOT

SURVEY MONUMENT
16111002
EL. 4943.24
N: 7442208.3327
E: 1554794.7346

S 74° E 474.24'

START
OF PROJECT
STA: 00+00
N:7442308.4220
E:1555408.1100

END
OF PROJECT
STA: 02+54
N:7442088.3278
E:1555307.3893

CURRENT
EMIGRATION
CREEK FLOW

1+00.0

2+00.0

2+53.7

FENCE
LINE

CONTROL POINT
EL. 4943.24
N: 7442067.00
E: 1555246.00

UNAUTHORIZED
SOCIAL TRAIL

FENCE
LINE

DETENTION
BASIN DAM

CONTROL POINT

FIGURE 1

FIGURE 2

NOTES: CONTROL POINT

1. CONTROL POINT IS ON THE BRIDGE CROSSING SPILLWAY (FIGURE 1).
2. TAKE POINT ON THE NORTH EAST SIDE OF BRIDGE.
3. TAKE POINT ON THE NORTH EAST CORNER OF CONCRETE WERE IT MEETS SOIL (FIGURE 2).
4. BEFORE TAKING POINT ENSURE SOIL AND DEBRIS REMOVED FROM CONCRETE.

NO.	REVISION	MADE BY	DATE

N — 0 — 80 — 160 — SCALE: 1" = 80'

DESIGNED BY:	MLHR
DRAWN BY:	MLHR
CHECKED BY:	
DATE CHECKED:	

SALT LAKE COUNTY

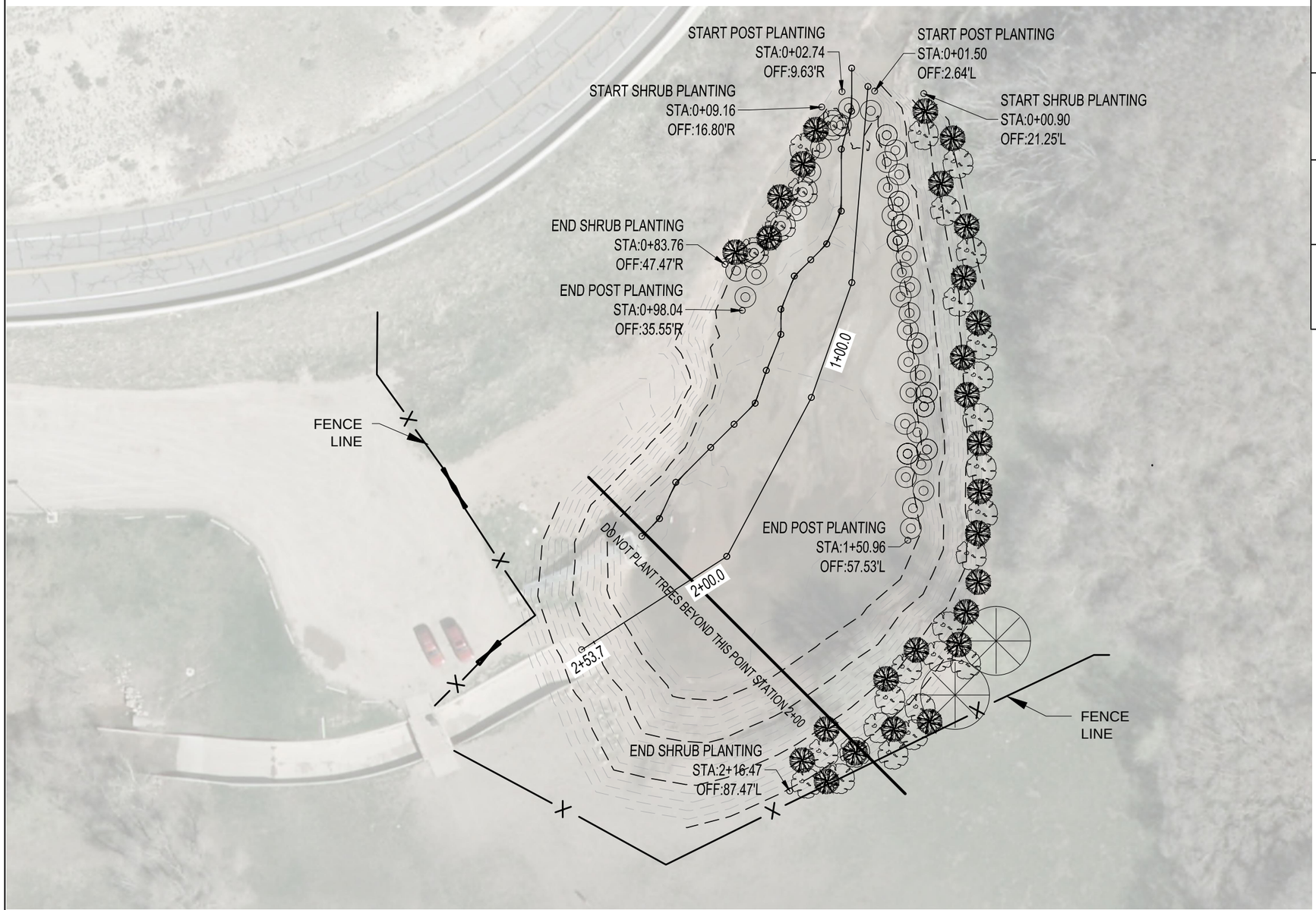
SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

2001 SOUTH STATE STREET
PO BOX 144575, SALT LAKE CITY, UTAH, 84114-4575

CONTROL PLAN

EMIGRATION CREEK IMPLEMENTATION

PROJECT NUMBER:	FV_130007
FILE NUMBER:	0605
SHEET NUMBER:	2 OF 5



VEGETATION SCHEDULE

BOTANICAL NAME	COMMON NAME	CONT SIZE	SYMBOL	QUAI
Acer negundo 'Sensation'	SENSATION BOX ELDER MAPLE	5 gal		2
Artemisia tridentata tridentata	BIG SAGEBRUSH	1 gal		25
Chrysothamnus nauseosus	RUBBER RABBIT BRUSH	1 gal		25
Salix exigua	COYOTE WILLOW	Dormant Post		150

NOTES: TYPICAL TREE PLANTING ON SLOPE

1. ALL PLANT MATERIALS SHALL BE IN ACCORDANCE WITH THE AMERICAN STANDARDS FOR NURSERY STOCK (ANSI Z60.1-20
PLANT ACCORDING TO ANSI A300 PART 6.
2. DIG THE PLANTING HOLE A MINIMUM OF 2x WIDTH OF ROOTBALL FOR AT LEAST THE FIRST 12 INCHES OF DEPTH. BELOW 1
INCHES, DIG HOLE WIDE ENOUGH TO PERMIT ADJUSTING. DO NOT DIG THE HOLE DEEPER THAN ROOT BALL DEPTH.
3. SCARIFY THE SUBGRADE AND SIDES OF THE PLANTING HOLE WHEN PLANTING IN CLAY SOILS (MORE THAN 15% CLAY).
4. LIFT AND SET THE TREE BY ROOT BALL ONLY. DO NOT LIFT USING THE TREE TRUNK AND DO NOT USE TREE TRUNK AS A L
5. SET THE TOP OF THE ROOT BALL LEVEL WITH THE SOIL SURFACE OR SLIGHTLY HIGHER IF THE SOIL IS PRONE TO SETTLIN
6. AFTER THE TREE IS SET IN PLACE, REMOVE BURLAP, WIRE AND STRAPS FROM AT LEAST THE UPPER 1/3 OF THE ROOTBAI
7. BACKFILL WITH EXISTING SOIL THAT HAS BEEN WELL-TILLED OR BROKEN UP. DO NOT ADD AMENDMENTS TO THE BACKFIL
SOIL. AMEND THE SURFACE WITH MULCH.
8. USE THREE 2" X 2" WOOD STAKES DRIVEN INTO UNDISTURBED SOIL A MINIMUM OF 16 INCHES. SPACE STAKES EQUALLY
AROUND THE TREE.
9. ATTACH 3/4" NYLON WEBBING TO CONNECT THE TREE TO STAKES. ATTACH WEBBING AT 1/3 THE TREE HEIGHT.
10. APPLY A 2-3" (SETTLED) DEPTH OF PINE STRAW OR BARK MULCH TO THE PLANTING SURFACE. LEAVE A 2" SPACE AROUNI
TRUNK FOR AIR CIRCULATION.
11. SPACE TREES MINIMUM 15 FEET APART.
12. PRUNING SHALL BE LIMITED TO DEAD, DISEASED, OR BROKEN LIMBS ONLY AND SHALL BE IN ACCORDANCE WITH ANSI A3
SPECIFICATIONS.
13. SEE DETAIL ON SHEET 5 OF 5.

NOTES: TYPICAL SHURB PLANTING, INDIVIDUAL PLANTING HOLE

1. DIG PLANTING HOLE AT LEAST 3X THE WIDTH OF THE ROOT BALL OR CONTAINER.
2. SCARIFY SUBGRADE AND SIDES OF PLANTING HOLE WHEN PLANTING IN CLAY SOIL.
3. SET THE TOP OF THE ROOT BALL LEVEL WITH THE SOIL SURFACE.
4. IF CONTAINER GROWN PLANT, GENTLY SLIDE PLANT OUT OF CONTAINER. DISTURB THE ROOTS.
5. IF B&B PLANT, REMOVE BURLAP FROM AT LEAST THE TOP 12 INCHES OF THE ROOTBALL, WITHOUT DISTURBING THE ROOT
REMOVE ALL CORD FROM THE TRUNK. REMOVE BURLAP AND WIRE BASKET (IF PRESENT) FROM THE ROOT BALL.
6. BACK FILL THE PLANTING HOLE WITH EXCAVATED NATIVE SOIL, BROKEN UP OR TILLED. WATER TO REMOVE AIR POCKETS
7. PLACE PINE STRAW OR BARK MULCH ON THE SURFACE TO A (SETTLED) DEPTH OF 1 TO 3 INCHES.
8. SPACE PLANTS 4-5 FEET APART.
9. SEE DETAIL ON SHEET 5 OF 5.

NOTES: TYPICAL DORMANT POST PLANTING

1.IT IS ESSENTIAL TO HAVE GOOD CONTACT BETWEEN CUTTING AND SOIL FOR ROOTS TO SPROUT. AIR POCKETS AROUND T
CUTTING WILL KILL THE ROOTS.
2.ADDITIONAL SOIL MAY BE NEEDED TO ENSURE GOOD SOIL TO STEM CONTACT. PREFERENCE SHOULD BE GIVEN TO NATIV
NEARBY TO ENCOURAGE MYCORRHIZAL FORMATION AND/OR NODULE FORMATION BY NITROGENFIXING ORGANISMS.
3.MUD THE CUTTINGS IN AFTER THEY ARE PLACED IN THE HOLE. USE A BUCKET AND MIX SOIL AND WATER TOGETHER TO G
THE CONSISTENCY OF SYRUP. POUR THE MIX INTO THE HOLE AROUND THE CUTTING UNTIL IT REACHES THE SURFACE. AS
WATER LEACHES INTO THE SURROUNDING SOIL, THE SOIL WILL SETTLE OUT AROUND THE CUTTING AND WILL ENSURE GOC
SOIL TO STEM CONTACT.
4.THE PLANTING DEPTH WILL DETERMINE THE PLANTING METHOD. DEEPER HOLES WILL BE EASIER IF YOU USE A POWER AU
THE STINGER, THE WATERJET STINGER, OR A SOIL AUGER.
5. PLANT IN BUNDLES OF 2 TO 3, SPACE 2 TO 3 FEET APART IN A DIAMOND PATTERN.
6. SEE DETAIL ON SHEET 5 OF 5.

NO.	REVISION	MADE BY	DATE

N

0 40 80

SCALE: 1" = 40'

DESIGNED BY:	MLHR
DRAWN BY:	MLHR
CHECKED BY:	
DATE CHECKED:	

SALT LAKE COUNTY

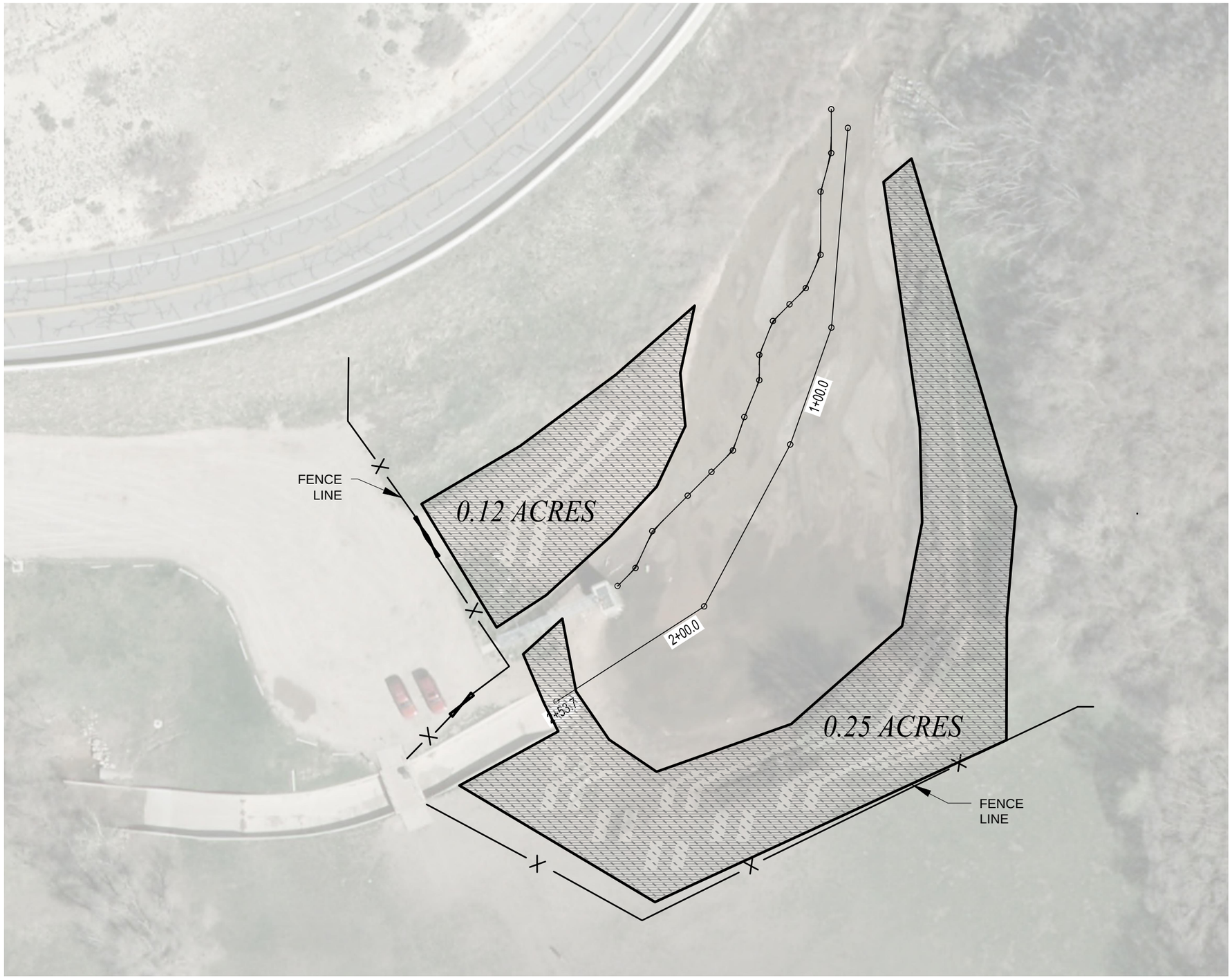
SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

2001 SOUTH STATE STREET
PO BOX 144575, SALT LAKE CITY, UTAH, 84114-4575

LANDSCAPE PLAN

EMIGRATION CREEK IMPLEMENTATION

PROJECT NUMBER: FV_130007
FILE NUMBER:
SHEET NUMBER: 3 OF 5



UPLAND SEED SCHEDULE		
BOTANICAL NAME	**COMMON NAME**	**LBS/ACR**
Linum lewisii	Lewis Blue Flax	2.5
Asclepia Tuberosa	Butterfly Milkweed	1
Gaillardia aristata	Blanket Flower	2.5
Bromus marginatus	Mountain brome	7.5
Elymus trachycaulus ssp. trachycaulus	Slender wheatgrass	6.25
Poa secunda ssp. Sandbergii	Sandberg bluegrass	1.25
Poa secunda ssp. ampla	Big bluegrass	1.25
Festuca ovina	Sheep fescue	1.25
Pseudoroegneria spicata ssp. spicata	Bluebunch wheatgrass	2.5
Western wheatgrass	Pascopyrum smithii	5

LEGEND:

AREA TO BE BROADCAST SEEDED

TOTAL ACRES: 0.37 ACRES

NOTES: UPLAND SEED

1. TO BE BROADCAST SEEDED
2. RECOMMENDED APPLICATION RATE OF 30 LBS/ACRE.
3. SEEDING TO BE DONE AS FINAL TASK OF THE PROJEC
4. AFTER BROADCAST SEEDING, RAKE SEED INTO SOIL
5. TO BE SEEDED IN FALL BEFORE FIRST FREEZE.

NO.	REVISION	MADE BY	DATE

N

0 40 80

SCALE: 1" = 40'

DESIGNED BY:	MLHR
DRAWN BY:	MLHR
CHECKED BY:	
DATE CHECKED:	

SALT LAKE COUNTY

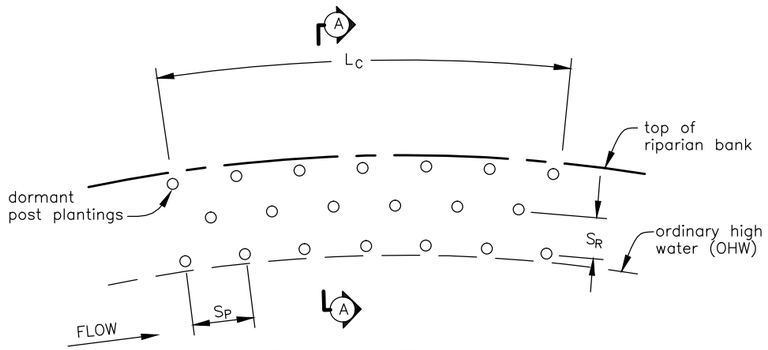
SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

2001 SOUTH STATE STREET
PO BOX 144575, SALT LAKE CITY, UTAH, 84114-4575

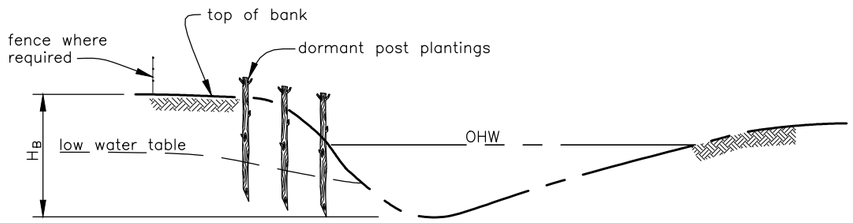
UPLAND SEED PLAN

EMIGRATION CREEK IMPLEMENTATION

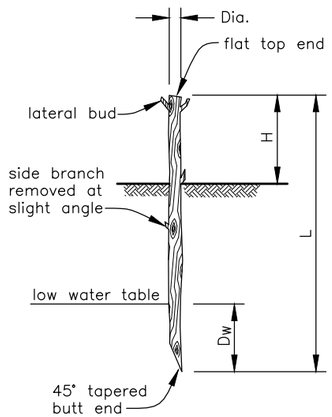
PROJECT NUMBER:	FV_130007
FILE NUMBER:	0605
SHEET NUMBER:	4 OF 5



PLAN VIEW



SECTION Ⓐ



All lateral branches shall be trimmed to avoid damage.

A minimum of two lateral buds shall be above the planting depth.

PLANT DETAIL

PLANT DIMENSIONS

Species Salix exigua (Coyote Willow)

Dia. = 0.5 min (in) 2.0 max (in)

D_W = 2 min (in) 6 max (in)

H = 1/5L min (in) 1/4L max (in)

L = 2 min (ft) 3+ max (ft)

S_R (row spacing) = 2–3 (ft)

S_P (plant spacing) = 2–3 (ft)

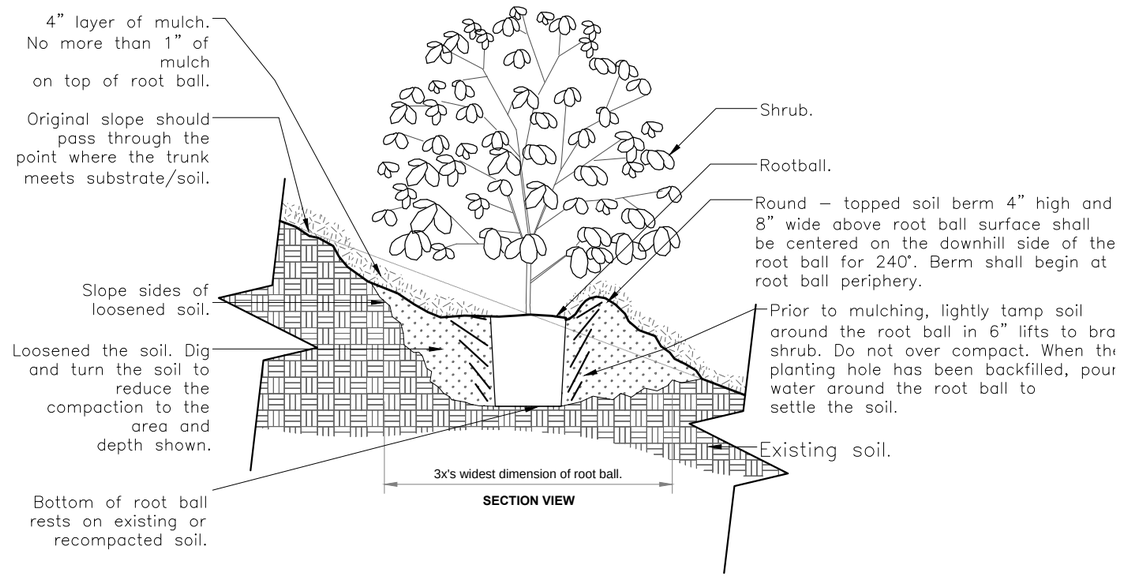
Number of rows = Varies

Stake Planting Depth= 18–24 (in)

Drawing not to scale. Standardized drawing must be adapted to the specific site.

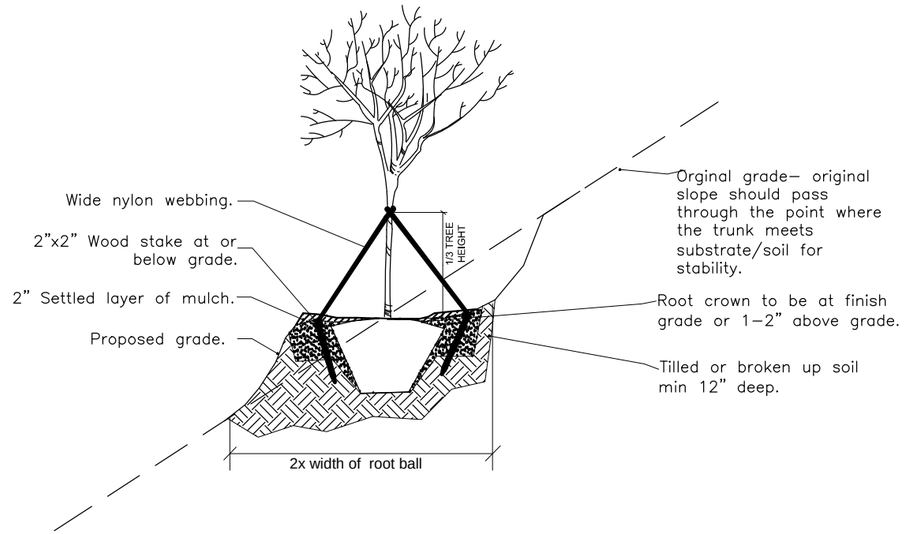
TYP. DORMANT POST PLANTING

N.T.S.



TYP.SHRUB PLANTING ON SLOPE

N.T.S.



TYP.TREE PLANTING ON SLOPE

N.T.S.

NOTE: SEE LANDSCAPE PLAN ON SHEET 3 OF 5

NO.	REVISION	MADE BY	DATE

DESIGNED BY:	MLHR
DRAWN BY:	MLHR
CHECKED BY:	
DATE CHECKED:	

SALT LAKE COUNTY

SALT LAKE COUNTY DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

2001 SOUTH STATE STREET
PO BOX 144575, SALT LAKE CITY, UTAH, 84114-4575

DETAILS AND VEGETATION SCHEDULE

EMIGRATION CREEK IMPLEMENTATION

PROJECT NUMBER:	FV_130007
FILE NUMBER:	0605
SHEET NUMBER:	5 OF 5

Appendix C

Monitoring SAP

Sampling and Analysis Plan (SAP)

For

Salt Lake County, Utah

Prepared by:

Salt Lake County

Watershed Planning & Restoration Program

2001 S. State St. Suite N3100

PO Box 144575

Salt Lake City, UT 84112-4575

Watershed.slco.org

May 2013

1.0 Introduction & Background

In 2009 Salt Lake County finalized the Salt Lake Countywide Water Quality Stewardship Plan (WaQSP), which identified the need for a greater body of water quality data in order to more completely and accurately assesses the condition of County waterways.

As a result, an expanded water quality data collection program was undertaken in 2009, and includes the following:

- Macroinvertebrate & Physical Habitat sampling program was initiated using the Utah Division of Water Quality and U.S. Environmental Protection Agency protocols
- *E.coli* sampling study was initiated in cooperation with the Utah Division of Water Quality
- Water chemistry data collected at all sampling sites (pH, DO %, DO mg/L, E, TDS, Salinity, Temperature and Turbidity)

This data provides valuable information for ongoing and future watershed planning, such as updates to the Water Quality Stewardship Plan (WaQSP), and is used by regulatory agencies at the federal, state and local levels.

1.1 Study Area

The Jordan River Watershed in Salt Lake County is part of the larger Jordan River Watershed, which is a closed basin in North Central Utah that drains a total area of 805 square miles (515,200 acres). The Watershed in Salt Lake County is bounded on the east by the Wasatch Mountains, on the west by the Oquirrh Mountains, and on the south by the Traverse Range (Figure 1). Although the majority of water flowing to the Jordan River in Salt Lake County comes from the eastern tributaries, there are sixteen (16) identified sub-basins throughout the County. The majority (72.3%; 372,800 acres) of lands in the Watershed are privately owned. The U.S. Federal Government (21.1%; 108,800 acres) and the State Government (6.5%; 33,600 acres) manage the remaining sections. With the exceptions of limited areas of Emigration, Big Cottonwood and Little Cottonwood canyons, the mountainous areas of the Jordan River Watershed are almost entirely uninhabited.

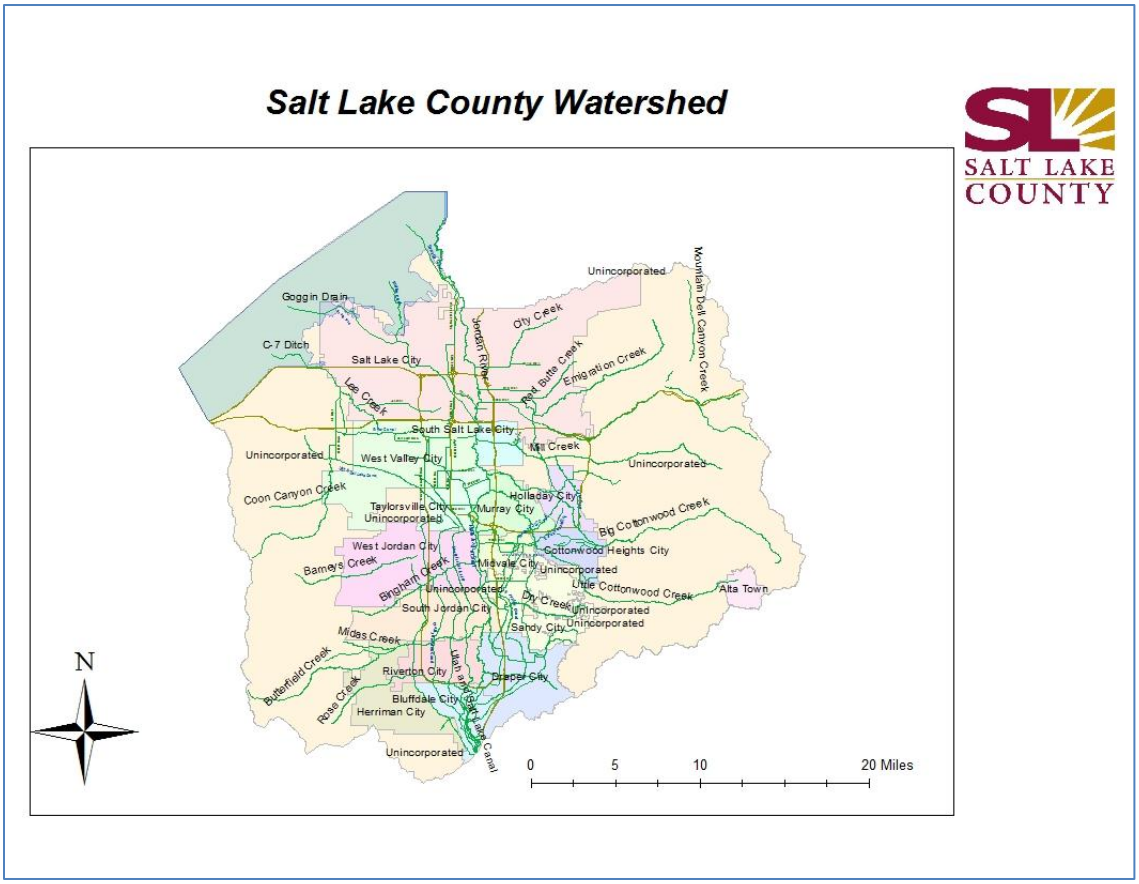


Figure 1. Salt Lake County Watershed

Over 898,387 people (40% of Utah's population) live in the Jordan River Watershed (US Census website). In this confined watershed, population is continuing to rise with densities increasing from 900 people per square mile in 1990 to 1,218 people per square mile in 2000 (SLCO, 2005). Notably, the population density of valley bottoms is much higher—2,000 people per square mile. Projected population for the year 2020 is 1.3 million, or an average of 1,614 people/square mile. The Jordan River Watershed is not only the population center for the State, but is also an economic center for the Intermountain West. As with many western states, Salt Lake County has been undergoing an economic shift away from agriculture to manufacturing and retail sales. With increasing development/land conversions, substantial stream alteration/channelization, and sections of the Jordan River and Emigration Creek on the State's 303(d) list, the Jordan River Watershed is a complex area in great need of stakeholder involvement that will result in innovative solutions to watershed concerns. The issues in this watershed range from abandoned mine concerns in the Wasatch Canyons to stormwater shock loads and land development in the urban areas. With nearly 900,000 people who live, work, and play in this county, it is a challenging and essential task to facilitate communication and restoration efforts between various constituents.

1.2 Regulatory

Area-Wide Water Quality Planning

Section 208 of the Clean Water Act requires states to designate areas which, 'as a result of urban-industrial concentrations and other factors, have substantial water quality control problems," and to designate a regional planning organization for such areas to develop area-wide management plans for the control of pollution. With respect to the point sources such as wastewater treatment plants, these plans are required to identify waste treatment facilities, specify construction priorities and develop a regulatory program.

On February 6, 1978, with the completion of the Area-Wide Water Quality Management Plan, Salt Lake County Government was designated the regional water quality planning authority by then Governor Scott M. Matheson. The primary goals outlined in the 1978 Plan were to provide a "continuous planning process directed toward achieving the policy of restoring and maintaining the chemical, physical and biological integrity of the waters of Salt Lake County."

At this time, the Council of Governments (COG), in conjunction with the Salt Lake County Planning Commission, hired staff to conduct water quality planning and subsequently created the Water Quality and Water Pollution Department. The Water Quality and Water Pollution Department functioned as the primary water quality planning authority until 1985.

In 1985, the Salt Lake County Health Department took over this responsibility. Liability was again shifted in 1992 when water quality planning was placed directly under the Salt Lake County Commission. This situation continued until 1997 when the Public Works Department of Salt Lake County again took on the charge of area-wide water quality planning.

303(d) List

The Utah 303(d) list of impaired waters is used to characterize water quality from a regulatory perspective. The initial assessment of water quality monitoring is compiled into a report (more commonly called the 303(d) list), that is updated every 2 years and submitted to the Environmental Protection Agency (EPA) for review and approval. Once a water body is included on the 303(d) list, action must be taken to identify pollutant sources that contribute to water quality impairment. Load recommendations are then made for each source that will result in achievement of water quality standards. This process results in a Total Maximum Daily Load (TMDL) for a water body. When a TMDL has been approved by the EPA, the water body is recommended for delisting and removal from the 303(d) list.

Waters of Utah are organized by the Utah Division of Water Quality (DWQ). Streams and rivers are typically divided into individual Assessment Units (AU) that may have different beneficial uses and water quality standards. Individual AUs for a stream can be included on the 303(d) list. The target for the 303(d) List is 100 percent of all AUs, including those found on mountain and valley tributaries as well as the Jordan River, not included on the Utah 303(d) list.

2.0 Objectives

In 2009 Salt Lake County finalized the Salt Lake Countywide Water Quality Stewardship Plan (WaQSP), which identified the need for a greater body of water quality data in order to more completely and accurately assesses the condition of County waterways.

As a result, an expanded water quality data collection program was undertaken in 2009, and includes the following:

- Benthic Macroinvertebrate & Physical Habitat sampling program was initiated using the Utah Division of Water Quality and U.S. Environmental Protection Agency protocols
- *E.coli* sampling study was initiated in cooperation with the Utah Division of Water Quality
- Water chemistry data (real time) collected at all sampling sites (pH, DO %, DO mg/L, E, TDS, Salinity, Temperature and Turbidity)

This data provides valuable information for ongoing and future watershed planning, such as updates to the Water Quality Stewardship Plan, and is used by regulatory agencies at the federal, state and local levels.

2.1 Sampling Site Locations

Sampling locations and frequencies for *E. Coli* and Macroinvetebrates on detailed below and in the attached maps. These are proposed sampling locations and frequencies may change due to externalities such as, but not limited to, changes in Salt Lake County funding and staffing, weather, and stream flows.

Salt Lake County WPRP staff has coordinated with DWQ staff on the site locations to ensure benefit of the sites as well to avoid duplication of sampling efforts.

2.1.1 *E. Coli*

E. Coli sampling is performed monthly unless there are outlying issues that prevent as such. Also, *E. Coli* sampling is dry weather sampling and performed a minimum of 24 hours outside of a precipitation event. Proposed sites are detailed in Figure 2.

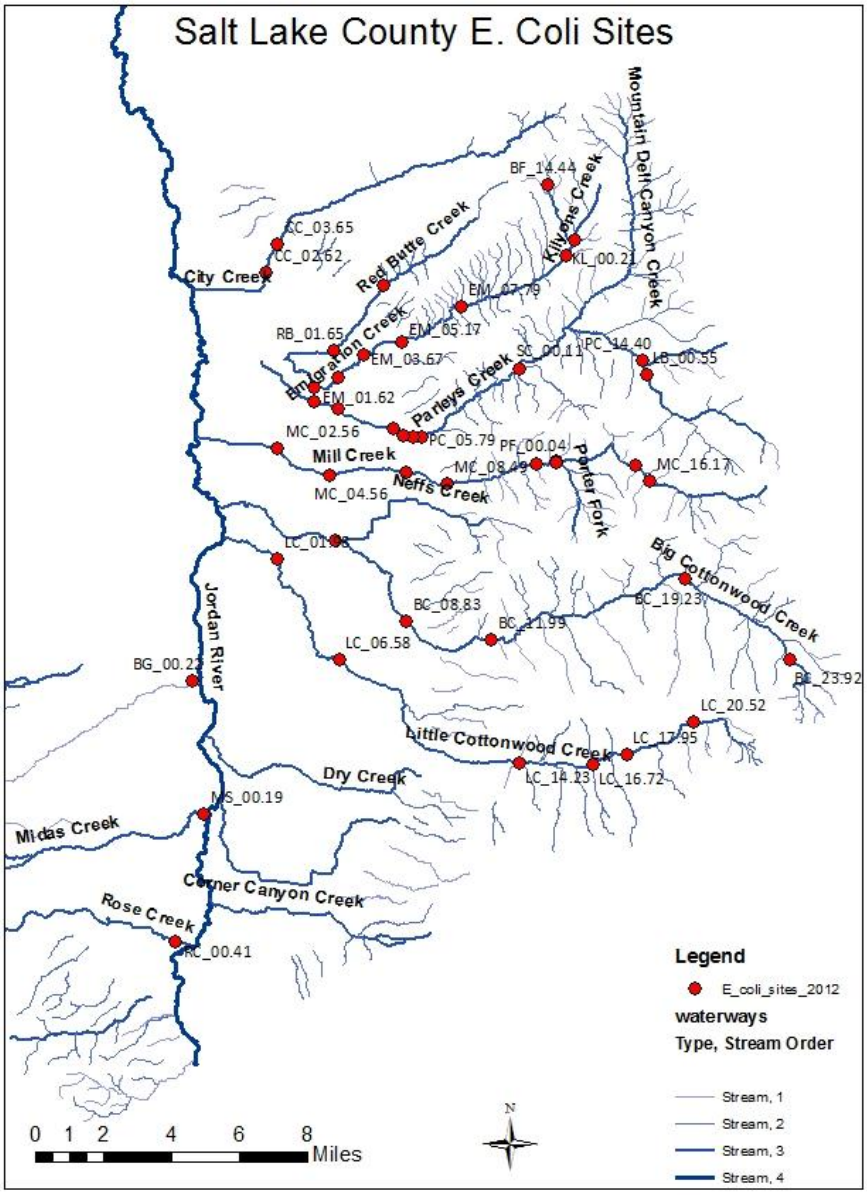


Figure 2. *E. Coli* Sampling Locations

2.1.2 Benthic Macroinvertebrates

Benthic macroinvetebrate sampling is performed annually unless there are outlying issues that prevent as such. Also, Macroinvetebrate sampling is performed during seasonal low flows; approximately July through November. Proposed sites are detailed in Figure 3.

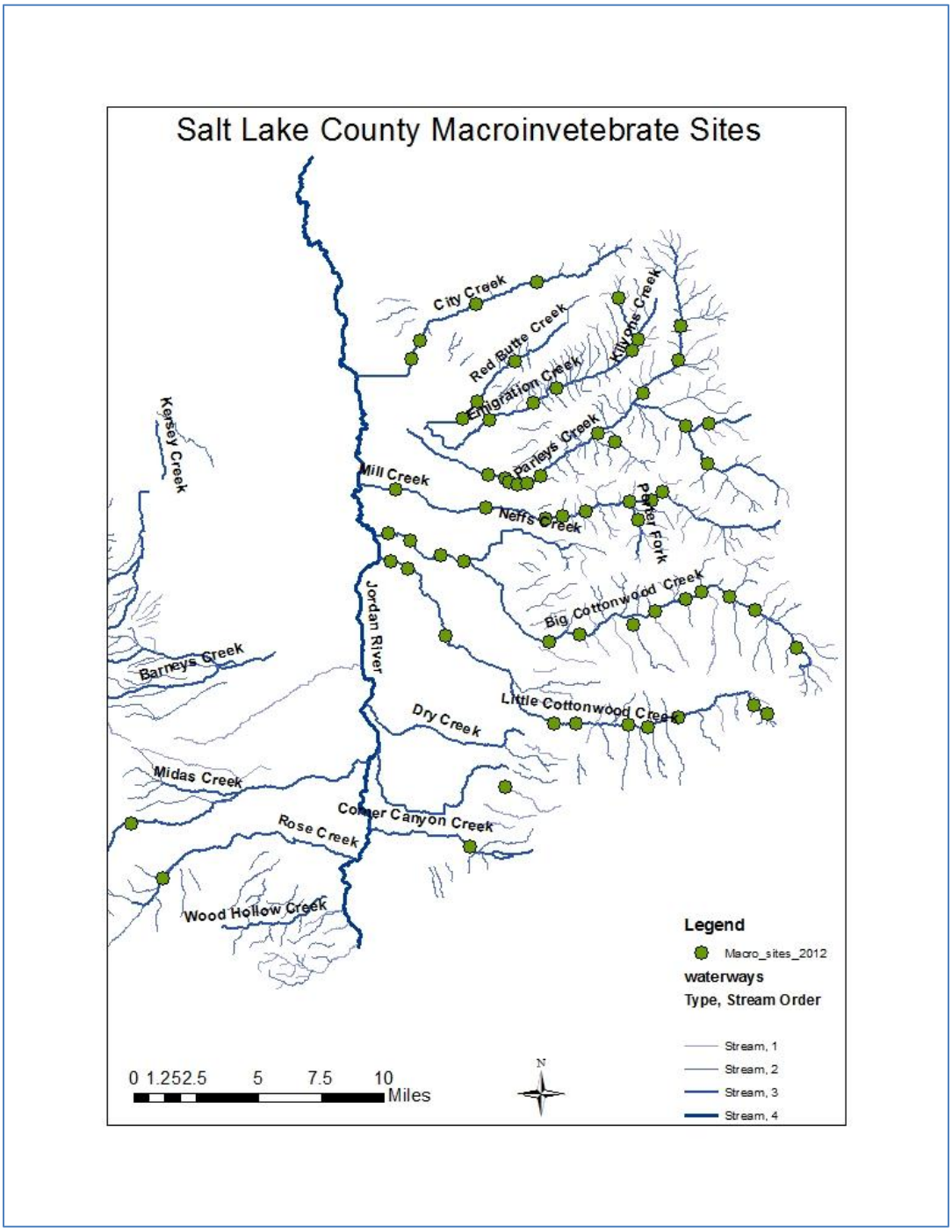


Figure 3: Sampling Macroinvetebrate Locations

2.1.3 Chemistry

Real time chemistry sampling is performed monthly unless there are outlying issues that prevent as such. Also, Chemistry sampling is dry weather sampling and performed a minimum of 24 hours outside of a precipitation event. Proposed sites are detailed in Figure 4.

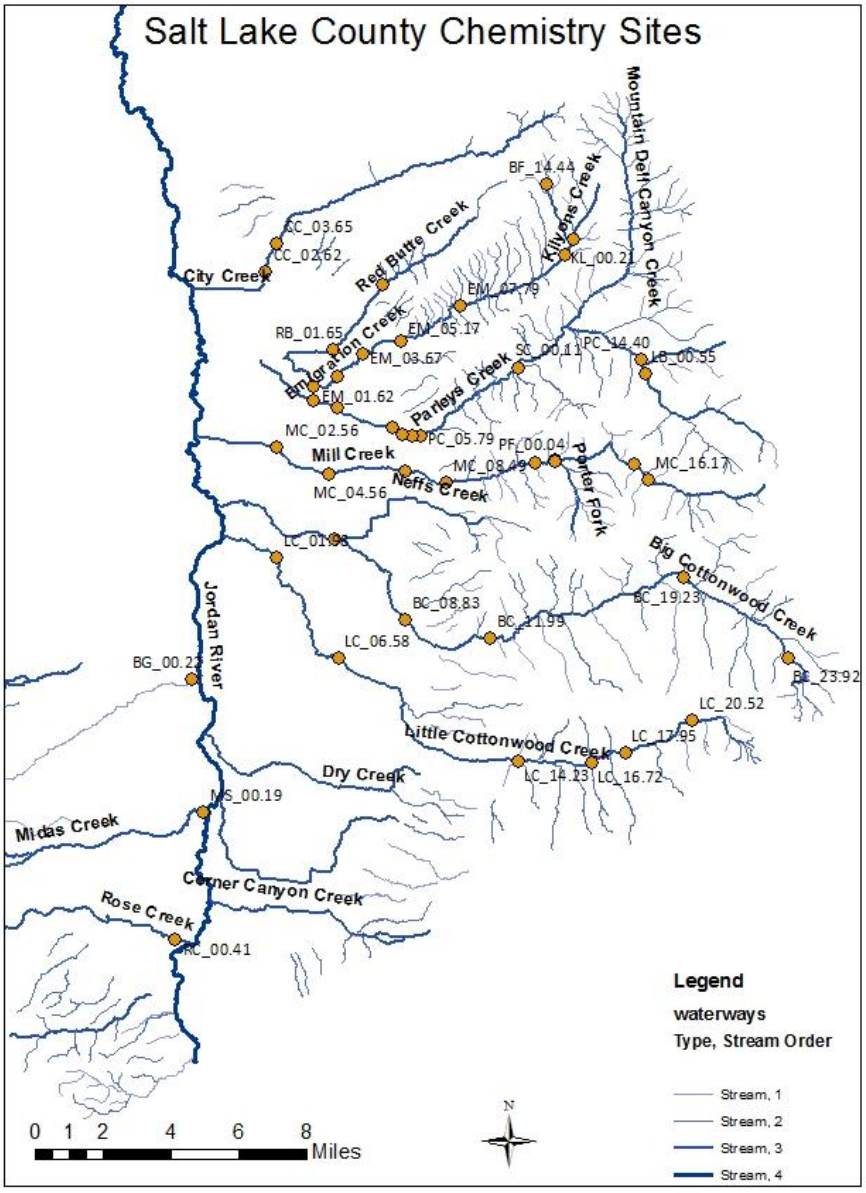


Figure 4: Sampling Chemistry Locations

3.0 Field Health & Safety Plan

The health and safety of field personnel and staff is an essential part of sampling and day to day work activities. Therefore all sampling sites are selected with health and safety as a priority.

3.1 General Safety Procedures

Appropriate safety gear such as waders, gloves, life jackets, etc. must be available and used when necessary. First aid kits and fire extinguishers must be readily available in the field. It is recommended to bring a cellular telephone in case of an emergency. Supplies such as anti-bacterial soap and an adequate supply of clean water will be available for cleaning exposed body parts that may have been contaminated by pollutants in the water. TecNu must be provided in areas with poison oak, poison ivy, etc. Personnel should be aware of and take caution when walking on uneven, rocky surfaces.

The following guidelines briefly outline important health and safety precautions for all field personnel. In order to minimize potential safety hazards, personnel are to exercise extra precautions when working around outfalls and avoid proceeding into areas which will compromise safety.

Emergency - Personnel Injury - If affected personnel can be moved safely, take him/her to nearest health care facility (see attached map). If there is a possibility of a head, neck, or back injury **do not** move the injured party; contact paramedics (**911)**. Notify supervisor as soon as possible.

Communication - Use mobile phone to stay in contact with team members.

Vehicle safety - Use caution at all times when driving as roads will be wet and may be slick. Park vehicles off the traveled way when possible. Always use safety cones and vehicle safety flashers to alert oncoming traffic of the parked vehicle.

Confined spaces - Under no circumstances are field personnel authorized to enter manholes, storm drains, culverts or any other confined spaces.

Steep embankments - A tie-off rope shall be used by all personnel required to descend embankments, and the rope shall be manned at the top of the embankment.

Water safety - Use basic water safety precautions around flowing streams and channels. Be aware of wet and slippery surfaces in and around the sampling locations.

Flooding and lightning - Be alert to high water or flash flooding conditions that may occur during a storm.

Do not stay out in the open or stand under trees if lightning is occurring in the vicinity. Enclosed automobiles and buildings are the safest places to be during lightning storms.

Visibility - Limited visibility will exist when sampling during nighttime and/or during a storm event. Wear reflective safety vest during all sampling events. Activate vehicle flashing hazard lights or beacons at all times vehicle is parked at a sampling site.

Proper lifting - To avoid back strain or injury, use team lifting techniques when possible. Lift with leg muscles, not with the back muscles by bending at the knees, not at the waist.

Cold exposure - Because sampling will occur during a various seasons, exposure to cold may be a potential hazard. To guard against cold injury, wear appropriate clothing; have warm shelter available; and carefully monitor field personnel and weather conditions. Some of the symptoms of cold stress include pain in an exposed extremity, and/or shivering.

If any symptoms of cold stress occur, the affected personnel should be removed from the cold environment. If the symptoms are not relieved, professional medical attention should be sought.

Heat stress - Heat stress is one of the most common (and potentially serious) illnesses which may affect field personnel. The potential for heat stress is dependent on a number of factors, including environmental conditions, clothing, workload, physical conditioning, and age. The effects of heat stress can range from mild symptoms, such as fatigue, irritability, and decreased mobility, to death. Some symptoms of heat stress include the following:

- **Heat rash:** A resultant of continuous exposure to heat and humidity, heat rash decreases the body's ability to tolerate heat.
- **Heat cramps:** A result of profuse perspiration with inadequate fluid intake and chemical replacement, heat cramps are signaled by muscle spasms and pain in the abdomen and the extremities.
- **Heat exhaustion:** A result of increased stress on various organs. The signs of heat exhaustion include elevated body temperature; shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and weakness.
- **Heat stroke:** The most severe form of heat stress, heat stroke must be relieved immediately to prevent severe injury or death. The signs of heat stroke are red, hot, dry skin; elevated body temperature; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and coma. The body must be cooled and professional medical attention sought immediately.

Preventive measures to preclude heat stress include regular work breaks during field activity, and regular water and food replenishment. Should one or more symptoms be detected, the affected worker should drink plenty of fluids, and seek professional medical attention, if required.

Material Safety Data Sheets (MSDS) for preservatives used in grab sample and composite sample bottles, Colilert, as well as TecNu are attached in Appendix A.

4.0 Field Sampling Methods

All sampling methodologies are EPA and Utah Division of Water Quality (DWQ) approved methodology. Salt Lake County personnel have received training from DWQ staff on Standard Operating Procedures (SOP).

4.1 *E. Coli* Sampling

Sampling of *E. Coli* and Fecal Coliform involves using the Idexx Colilert Quanti-Tray method of analysis **(Appendix B).** The minimum detection limit is > 1.0 MPN/100 mL and the maximum detection limit is 2419.6 MPN/100 mL. MPN stands for Most Probable Number and is analogous with Colony Forming Units (CFUs).

4.2 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates are collected from an undisturbed area using a D-net along a 150-500-m transect. Procedures are described in the SOP (**Appendix C**). Briefly, 11 equally spaced transects are surveyed through a longitudinal length 40 times the wetted width of the stream. Eight composited kick net samples are taken at riffles in marked transects. The samples are taken by placing the D-net firmly on the stream substrate, kicking the substrate in a 0.4 x 0.4 m square in front of the net for 30 seconds. The net is thoroughly rinsed with creek water into the composite bucket. Samples are placed into jars with 95% denatured ethanol as preservative and sent to the Buglab at Utah State University for final processing.

4.3 Chemistry

Sampling of water chemistry parameters involves two separate activities. *Field parameters* are measured using a multi-parameter probe as described in Table 1. This is typically one of the first activities performed during a site visit. Temperature, specific conductance, pH, DO and turbidity probes are used at all sites unless deemed unwise by field personnel. Multi-parameter probe (Table 1) data will be recorded on electronic field sheets once the results have been verified as acceptable by the field crew, and stored on the instrument; electronic field sheets will also include any notes about site conditions observed during the measurement or discarded measurements (Table 3).

4.4-Field Instrumentation

Table 1: Field Instruments

Instrument	Procedure	Special Considerations
Oakton Multiparameter 35	Hold in water for 30 seconds	Calibrate monthly
Orbeco B200 Turbidometer	Triple rinse sampling cuvette, index to lowest reading	Calibrate bi-monthly
YSI ProDO DO Meter	Hold in water for 30 seconds	Calibrate Monthly

Table 2: Sampling Equipment

Equipment	Procedure	Special Considerations
Trimble Yuma Tablet	MS Access database	Charge weekly
Trimble Geo XH GPS	Terra Sync GIS	Charge Daily

5.0 Record Keeping

Incidents

Due to the nature of field work, problems may arise in the field that will require corrective action. A person's best professional judgment should be used to correct issues that are not listed in this document. If a particular issue may interfere with the integrity of data, action must be validated and approved by a Salt Lake County Watershed Scientist/Planner.

Field Sheets

Several different types of field sheets, including electronic, are used in Salt Lake County's data collection. Care must be given to make sure these field sheets are properly handled and filed correctly, either electronically or hard copies. All data is entered in the field at the time of capture and 10% of all entries are randomly checked against field forms at the end of each sampling run for validity.

Table 3: Field Sheets

Field sheet	Handling
MS Access Data sheets	NA
E. *coli* sample sheet	New sheet each sample day, 1 set/month

6.0 Quality Assurance/Control Methods & Requirements

Field personnel are responsible for performing quality control checks on field equipment to ensure proper functionality. Along with routine calibration, duplicate QC samples are taken to double check accuracy. Re-calibration may have to be performed again if the field equipment is reading out of QC range. The following is a list of approved parameter ranges:

Table 4: Quality Control Corrective Actions

Parameter	Range	Corrective Action
Dissolved oxygen	≤ 100 % saturation	Recalibrate, Check Temp coefficient
pH	6.5 – 9.0	Recalibrate
Conductivity	2.00-20.00 ms	Recalibrate, Check Temp coefficient
Temperature	0-50 Celcius	Check temp coefficient, Recalibrate
TDS	0-99.9 ppm	Check TDS Factor, Recalibrate
Salinity	0-99.99 ppm	Recalibrate
Turbidity	.01-1100 NTU	Recalibrate

Following along with the DWQ's Quality Assurance Program Plan, the Salt Lake County utilizes the preceding chart (Table 5) to deal with bias, precision, and accuracy.

Table 5: Quality Control/Quality Assurance

Data Quality Indicator	QC Check/QC Sample	DWQ Goal
Precision	● Field duplicates/replicates ● Laboratory duplicates ● Detection limits	● Water samples: ±20% ● Adopt percent RPD for laboratory duplicates established by the analyzing laboratory. ● Adopt percent RPD for MS/MSD established by the analyzing laboratory
Bias & Accuracy	● Calibration of field water quality instruments ● Utilize pertinent SOPs ● Field/equipment & Trip blanks ● Nutrient split samples	● 100% calibration compliance ● All data collected following SOPs. ● Blank results < detection limit. ● Splits: Sample & QC results should be similar.

RPD: Relative Percent Difference

Data quality assurance reviews (Table 6) will be performed during the sampling time frame. The following outline explains how each review will be executed.

Table 6: Quality Assurance Reviews

Data quality review	QC check	Evaluation criteria	DWQ Goal
Representativeness	● SOPs ● SAP requirements ●Field sheets ● Sample holding times ● Field duplicates ● Blanks	● Field audits ● Adherence to SAP ● Review of sheets ● Holding times ● Meet RPD ● Detection limits	●All data following SOP. ● 100 % SAP compliance ● 100% compliance ● Meet holding times ● Water samples: ±20% for duplicates ● Blank results < detection limit.
Comparability	● SOPs ●Holding times ● Analytical methods ● Frequency & types of QC samples	● Determine adherence to SOPs ● Holding times ●EPA or DWQ approved methods ● Verify	● All data following SOP ● Meet holding times ● 100% use of approved methods ● Evaluate for comparability
Completeness	● Complete sampling	● Percent of valid data	●95% completeness with respect to planned data set

RPD: Relative Percent Difference

7.0 Data Analysis and Reporting

All data collected will be housed within the Salt Lake County's Water Quality Database. In addition, per the request of Utah Division of Water Quality (DWQ) Salt Lake County will share the data, which will be hosted on the DWQ Water Quality database for internal and external use. The data serves as indication for watershed planning purposes. Data that was unable to be collected will not be included within the entire dataset. Depending on the interest of data users, sites may be re-visited to attempt to collect missing data.

The Salt Lake County database is constantly being updated and QA/QC measures are built in to the design of the database. Salt Lake County Uses an MS Access Database set up as a one to many database with the master table being Location ID; this only allows users to enter valid pre-existing site information. All relationships are pre-determined with allowable tolerances built in to the tables thus entries outside those parameters will not be accepted. The new data is downloaded from pre-determined paths so only new data is imported. The database is also backed-up monthly so any systemic errors can only reach back one month.

APPENDIX A

MSDS

MATERIAL SAFETY DATA SHEET

Colilert 98-12972-00, 98-12973-00, 98-14523-00, 98-14770-00, 98-14771-00 98-26016-00, 98-26017-00, 98-27163-00

1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product name(s)	Colilert
Product code(s)	98-12972-00, 98-12973-00, 98-14523-00, 98-14770-00, 98-14771-00, 98-26016-00, 98-26017-00, 98-27163-00 WP020I, WP200I, WB100I, W100I, W200I, WB250-20I, WB250-100I, WP100I
Recommended uses and restrictions	Water microbiology.

Company	IDEXX Laboratories, Inc One IDEXX Drive Westbrook ME 04092 United States	IDEXX Laboratories Pty Ltd. Metro Centre Unit 20, 38-46 South Street Rydalmere, NSW 2116 Australia	IDEXX Europe B.V. Scorpius 60 Building F Hoofddorp 2132 LR The Netherlands
Telephone	1-800-548-6733	1-800-655-978	00800 727 43399
Fax	1-207-556-4346	0-800-634-409	00800 433 99329

24 hour Emergency Phone # CHEMTREC 1-800-424-9300
Outside U.S 1-703-527-3887

2. HAZARDS IDENTIFICATION

According to Regulation (EC) No1272/2008
Eye Irritation, Category 2
Pictogram

Signal Word	Warning	
Hazard statement(s)	H319	Causes serious eye irritation.
Precautionary statement(s)	P264	Wash thoroughly after handling.
	P280	Wear eye protection.
	P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
	P337+P313	If eye irritation persists: Get medical advice/attention.

According to European Directive 67/548/EEC as amended.
This substance is not classified as dangerous.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance	CAS-No.	EC-No.	Index-No.	RTECS-No.	Concentration
Trade Secret 1	-	-	-	-	< 35%
Trade Secret 2	-	-	-	-	< 20%

4. FIRST AID MEASURES

IF INHALED:	Remove victim to fresh air and keep at rest in a position comfortable for breathing.
IF ON SKIN:	Wash with plenty of soap and water. If skin irritation or rash occurs: Get medical advice/attention. Take off contaminated clothing and wash before reuse.

IF IN EYES:	Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.
IF SWALLOWED:	Rinse mouth. Do NOT induce vomiting.

5. FIRE FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self contained breathing apparatus for firefighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment as required. Avoid breathing dust/fume/gas/mist/vapors/spray.

Environmental precautions
Avoid release to the environment.

Methods and materials for containment and cleaning up
Wipe up with absorbent material.

7. HANDLING AND STORAGE

Precautions for safe handling
Use personal protective equipment as required. Avoid breathing dust/fume/gas/mist/vapors/ spray. Wash thoroughly after handling. Take off contaminated clothing and wash before reuse.

Conditions for safe storage
Store in a well-ventilated place. Keep container tightly closed.

8. EXPOSURE CONTROLS / PERSONNAL PROTECTION

Personal protective equipment

Respiratory protection	In case of inadequate ventilation, wear respiratory protection.
Hand protection	Handle with gloves.
Eye protection	Safety glasses.
Hygiene measures	Wash thoroughly after handling. Do not get in eyes, on skin, or on clothing.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	solid
Color (Colour)	white
Odor (Odour)	odorless
pH	not applicable
Melting point	no data available
Boiling point	no data available
Flash point	not applicable
Flammability	not applicable
Explosive properties	not applicable
Oxidizing properties	not applicable

Vapor (Vapour) pressure	no data available
Density	no data available
Water solubility	soluble

10. STABILITY AND REACTIVITY

Chemical stability	Stable under recommended storage conditions.
Materials to avoid	Oxidizing agents, Strong acids.
Hazardous decomposition products	Carbon oxides, Nitrogen oxides, Sulpher oxides, Sodium oxides, Hydrogen chloride gas.

11. TOXICOLOGICAL INFORMATION

Trade Secret 1

Acute toxicity	LD50 Oral - rat - 3,000 mg/kg LC50 Inhalation - rat - 1 h - > 42,000 mg/m3 LD50 Dermal - rabbit - > 10,000 mg/kg
Skin corrosion/irritation	Skin - rabbit - Mild skin irritation - 24 h
Serious eye damage/eye irritation	Eyes - rabbit - Mild eye irritation - Draize Test
Respiratory or skin sensitization	no data available
Germ cell mutagenicity	no data available
Carcinogenicity	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
Reproductive toxicity	no data available
Specific Target Organ Toxicity –Single Exposure	no data available
Specific Target Organ Toxicity – Repeated Exposure	no data available
Aspiration hazard	no data available

Trade Secret 2

Acute toxicity	LD50 Oral - rat - 2,840 mg/kg
Skin corrosion/irritation	Skin - rabbit - No skin irritation
Serious eye damage/eye irritation	Eyes - rabbit - No eye irritation
Respiratory or skin sensitization	no data available
Germ cell mutagenicity	no data available
Carcinogenicity	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
Reproductive toxicity	no data available
Specific Target Organ Toxicity –Single Exposure	no data available
Specific Target Organ Toxicity – Repeated Exposure	no data available
Aspiration hazard	no data available

12. ECOLOGICAL INFORMATION

Trade Secret 1

Toxicity to fish	LC50 - Lepomis macrochirus (Bluegill) - 1,294.6 mg/l - 96 h

	NOEC - Pimephales promelas (fathead minnow) - 4,000 mg/l - 7 d
Toxicity to daphnia and other aquatic invertebrates.	NOEC - Daphnia - 1,500 mg/l - 7 d LC50 - Daphnia magna (Water flea) - 1,661 mg/l - 48 h
Persistence and degradability	no data available
Bioaccumulative potential	no data available
Mobility in soil	no data available
PBT and vPvB assessment	no data available

Trade Secret 2

Toxicity to fish	LC50 - Oncorhynchus mykiss (rainbow trout) - 36.7 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates.	LC50 - Daphnia magna (Water flea) - 433 mg/l - 50 h
Persistence and degradability	no data available
Bioaccumulative potential	no data available
Mobility in soil	no data available
PBT and vPvB assessment	no data available

13. DISPOSAL CONSIDERATIONS

Dispose of contents in accordance with local/regional/national/international regulations.

14. TRANSPORT INFORMATION

DOT (US)	Not a dangerous good
ICAO/IATA	Not a dangerous good
IMDG	Not a dangerous good
ADR/RID	Not a dangerous good

15. REGULATORY INFORMATION

This safety datasheet complies with the requirements of Regulation (EC) No. 1907/2006.

Trade Secret	**1**	**2**
Australia (AICS)	Listed	Listed
Canada (DSL)	Listed	Listed
(NDSL)	No	No
Europe (ELINCS)	No	No
Germany (WGK)	1	1
Japan (ENCS)	Listed	Listed
Korea (ECL)	Listed	Listed
New Zealand (NZIoC)	Listed	Listed
Philippines (PICCS)	Listed	Listed
United States (TSCA)	Listed	Listed

16. OTHER INFORMATION

HMIS Rating

Health hazard	1	Flammability	0	Physical hazard	0

1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product name(s)	Quanti-Tray
Product code(s)	98-21378-00, 98-21675-00 WQT100, WQT2K
Recommended uses and restrictions	Water Microbiology

Company	IDEXX Laboratories, Inc. One IDEXX Drive Westbrook, ME 04092 United States	IDEXX Laboratories Pty Ltd. Metro Centre Unit 20, 38-46 South Street Rydalmere, NSW 2116 Australia	IDEXX Europe B.V. Scorpius 60 Building F Hoofddorp 2132 LR The Netherlands
Telephone	1-800-548-6733	1-800-655-978	00800 727 43399
Fax	1-207-556-4346	1-800-634-409	00800 433 99329

24 hour Emergency Phone # CHEMTREC 1-800-424-9300
Outside U.S 1-703-527-3887

2. HAZARDS IDENTIFICATION

According to Regulation (EC) No1272/2008

Not a hazardous substance or mixture according to Regulation (EC) No 1272/2008.

According to European Directive 67/548/EEC as amended.

This substance is not classified as dangerous according to Directive 67/548/EEC.

3. COMPOSITION/INFORMATION ON INGREDIENTS

This substance is not classified as dangerous.

4. FIRST AID MEASURES

IF INHALED:	Remove victim to fresh air and keep at rest in a position comfortable for breathing.
IF ON SKIN:	Wash with plenty of soap and water.
IF IN EYES:	Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
IF SWALLOWED:	Rinse mouth.

5. FIRE FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self contained breathing apparatus for firefighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment as required. Wash thoroughly after handling.

Environmental precautions
Avoid release to the environment.

Methods and materials for containment and cleaning up
Wipe up with absorbent material.

7. HANDLING AND STORAGE

Precautions for safe handling
Use personal protective equipment as required. Wash thoroughly after handling.

Conditions for safe storage
Keep container tightly closed.

8. EXPOSURE CONTROLS / PERSONNAL PROTECTION

Personal protective equipment

Respiratory protection	In case of inadequate ventilation, wear respiratory protection.
Hand protection	Handle with gloves.
Eye protection	Safety glasses.
Skin protection	Wear protective clothing.
Hygiene measures	Wash thoroughly after handling. Do not get in eyes, on skin, or on clothing.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	solid
Color (Colour)	no data available
Odor (Odour)	odorless
pH	not applicable
Melting point	no data available
Boiling point	no data available
Flash point	not applicable
Flammability	not applicable
Explosive properties	not applicable
Oxidizing properties	not applicable
Vapor (Vapour) pressure	no data available
Density	no data available
Water solubility	no data available

10. STABILITY AND REACTIVITY

Chemical stability	Stable under recommended storage conditions.
Materials to avoid	Oxidizing agents.
Hazardous decomposition products	Carbon oxides, Nitrogen oxides.

11. TOXICOLOGICAL INFORMATION

Acute toxicity	no data available
Skin corrosion/irritation	no data available
Serious eye damage/eye irritation	no data available
Respiratory or skin sensitization	no data available
Germ cell mutagenicity	no data available
Carcinogenicity	no data available
Reproductive toxicity	no data available
Specific Target Organ Toxicity –Single Exposure	no data available

Specific Target Organ Toxicity –Repeated Exposure	no data available
Aspiration hazard	no data available

12. ECOLOGICAL INFORMATION

Toxicity to fish	no data available
Toxicity to daphnia and other aquatic invertebrates.	no data available
Toxicity to algae	no data available
Persistence and degradability	no data available
Bioaccumulative potential	no data available
Mobility in soil	no data available
PBT and vPvB assessment	no data available

13. DISPOSAL CONSIDERATIONS

Dispose of contents in accordance with local/regional/national/international regulations.

14. TRANSPORT INFORMATION

DOT (US) Not a dangerous good
ICAO/IATA Not a dangerous good
IMDG Not a dangerous good
ADR/RID Not a dangerous good

15. REGULATORY INFORMATION

This safety datasheet complies with the requirements of Regulation (EC) No. 1907/2006.

16. OTHER INFORMATION

HMIS Rating

Health hazard	0	Flammability	0	Physical hazard	0

View MSDS : 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

SECTION 1 - IDENTIFICATION

Product Name:	**Polystyrene Vessels**
Product Code:	WV120SBST, WV120ST, WV150SBST, WV290SBST, WV120SBAF, WV120SB, WV120, WV150SB, WV290SB
Manufacturer Name:	IDEXX Laboratories, Inc.
Address:	One IDEXX Drive Westbrook, ME 04092
General Phone Number:	1-800-548-6733
General Fax Number:	1-207-556-4346
Health Issues Information:	safety@idexx.com
Technical Product Information:	1-800-248-2483
CHEMTREC:	For emergencies in the US, call CHEMTREC: 800-424-9300
Canutec:	In Canada, call CANUTEC: (613) 996-6666 (call collect)
Website:	idexx.com
Distributor Name:	IDEXX Laboratories Pty Ltd
Address:	ABN31 063 164352 Unit 20, 38-46 South St, Rydalmere, NSW 2116
General Phone Number:	1-800-655-978 (AU) 0-800-102-084 (NZ)
General Fax Number:	1-800-634-409 (AU) 0-800-448-443 (NZ)
CHEMTREC:	For emergencies in the US, call CHEMTREC: 800-424-9300
Canutec:	In Canada, call CANUTEC: (613) 996-6666 (call collect)
Website:	www.idexx.com.au
MSDS Creation Date:	05/07/2009
MSDS Revision Date:	12/14/2009

SECTION 2 - HAZARD(S) IDENTIFICATION

Applies to all Ingredients: :

Emergency Overview:	Non hazardous.
Potential Health Effects:	No information.
Carcinogenicity:	This product is not considered carcinogenic.

SECTION 3 - COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS#	Ingredient Percent

Notes : Some may contain trace amounts of sodium thiosulfate and antifoam.

SECTION 4 - FIRST AID MEASURES

Eye Contact:	Flush eyes with water as a precaution.
Skin Contact:	Wash with mild soap and running water.
Inhalation:	Not applicable.
Ingestion:	Rinse mouth. Drink 1 or 2 glasses of water. Call a physician immediately.

SECTION 5 - FIRE FIGHTING MEASURES

Flammable Properties:	Non Flammable.
Flash Point:	Not applicable.
Extinguishing Media:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

SECTION 6 - ACCIDENTAL RELEASE MEASURES

Environmental Precautions:	Not applicable.

SECTION 7 - HANDLING and STORAGE

Handling:	No special handling procedures are required for this material.
Storage:	No special procedures are required. Store at ambient temperature.

SECTION 8 - EXPOSURE CONTROLS, PERSONAL PROTECTION - EXPOSURE GUIDELINES

Engineering Controls:	Not applicable.
Eye/Face Protection:	Not applicable.
Skin Protection Description:	Not applicable.
Respiratory Protection:	Not applicable.

EXPOSURE GUIDELINES

SECTION 9 - PHYSICAL and CHEMICAL PROPERTIES

Physical State Appearance:	Solid.
Color:	White
Boiling Point:	Not applicable.
Melting Point:	Not applicable.
Solubility:	Insoluble
pH:	Not applicable.
Flash Point:	Not applicable.
VOC Content:	Not applicable.

SECTION 10 - STABILITY and REACTIVITY

Chemical Stability:	Stable under normal conditions.
Hazardous Polymerization:	None under normal processing.

SECTION 11 - TOXICOLOGICAL INFORMATION

Applies to all Ingredients: :

Chronic Effects:	No information.

SECTION 12 - ECOLOGICAL INFORMATION

Applies to all Ingredients: :

Ecotoxicity:	No ecotoxicity data was found for the product.

SECTION 13 - DISPOSAL CONSIDERATIONS

Applies to all Ingredients: :

Waste Disposal:	Dispose of in accordance with Local, State, Federal and Provincial regulations.

SECTION 14 - TRANSPORT INFORMATION

DOT Shipping Name:	Non regulated.
IATA Shipping Name:	Non regulated.
IMDG Shipping Name :	Non regulated.

SECTION 15 - REGULATORY INFORMATION

Applies to all Ingredients: :

EU Class:	Not applicable.

SECTION 16 - ADDITIONAL INFORMATION

MSDS Creation Date:	05/07/2009
MSDS Revision Date:	12/14/2009
Disclaimer:	To the best of our knowledge, the information above is accurate. However, IDEXX does not assume any liability for the accuracy or completeness of such information. Final determination of the suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described above, we cannot guarantee that these are the only hazards that exist.

MATERIAL SAFETY DATA SHEET

****

SECTION I - COMPANY AND PRODUCT INFORMATION

****

MANUFACTURER:
Tec Laboratories, Inc.
7100 Tec Labs Way SW
Albany, OR 97321

EMERGENCY TELEPHONE NUMBERS:
(541) 926-4577
24 Hour Emergency Assistance
1-800-535-5053

PRODUCT DESCRIPTION:
Cleanser for removal of poison plant oils.

PRODUCT NAME:
Tecnu® Outdoor Skin Cleanser

CHEMICAL FAMILY:
Detergent

CAS NUMBER:
Not available for this mixture

****

SECTION II - HAZARDOUS INGREDIENTS

****

**********NO HAZARDOUS INGREDIENTS**********

HAZARDOUS SUMMARY

Rating		Definitions
Health	0	0 - least
Fire	2	1 - slight
Reactivity	0	2 - moderate
		3 - high
		4 - extreme

****

SECTION III - COMPOSITION

****

CAS NUMBER	CHEMICAL NAME	PERCENT BY WEIGHT
64741-65-7	Odorless mineral spirits	PI*
7732-18-5	Water	"
57-55-6	Propylene glycol	"
9036-19-5	Octylphenoxy-polyethoxyethanol surfactant	"
61790-12-3	Mixed fatty acid soap	"
N/A	Fragrance	"

*PI = Proprietary information

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SECTION IV - HEALTH HAZARD AND FIRST AID INFORMATION

****

OCCUPATION EXPOSURE LIMIT: Not established

CARCINOGENICITY: Not listed by NTP, IARC or OSHA

PRIMARY ROUTES OF ENTRY: Skin, eyes

SYMPTOMS AND EFFECTS OF OVEREXPOSURE	ROUTE OF ENTRY	EMERGENCY AND FIRST AID PROCEDURES
Causes minimal to mild irritation with possible conjunctivitis. Irritation should subside with complete recovery in 48-96 hours.	EYES	Immediately flush with large amounts of water for 15 minutes. If irritation persists, get medical attention.
Extended use may cause drying of skin. Prolonged contact may cause dermatitis or chemical burns on sensitive skin.	SKIN	Immediately flush skin with running water. If irrita-tion persists, get medical attention.
Not likely.	INHALATION	Remove to fresh air.
Will cause nausea if swallowed. Stomach cramps may also occur.	INGESTION	DO NOT INDUCE VOMITING. Call doctor immediately. Treat for petroleum jelly ingestion.

NOTE TO PHYSICIAN: There is no specific antidote. Treatment of over-exposure should be directed at the control of symptoms and the clinical condition.

****
SECTION V - PERSONAL PROTECTION INFORMATION
****

--WHEN HANDLING BULK QUANTITIES--

EYE PROTECTION: OSHA approved safety glasses.

PROTECTIVE CLOTHING: Wear rubber gloves. To avoid excessive exposure, wear impervious boots and clothing.

RESPIRATORY PROTECTION: Not necessary.

--WHEN USING PRODUCT ACCORDING TO DIRECTIONS FOR USE--

EYE PROTECTION: Avoid applying product in and around eyes.

PROTECTIVE CLOTHING: None required for normal use.

VENTILATION: Normal room ventilation is satisfactory.

RESPIRATORY PROTECTION: None required for normal use.

****
SECTION VI - STORAGE AND SPECIAL HANDLING INFORMATION
****

Keep away from heat, sparks, and flame. Avoid contact with eyes. Store at room temperature.

****
SECTION VII - SPILL OR LEAK RESPONSE INFORMATION
****

PRECAUTIONS IN CASE OF SPILLS OR LEAKS: Material is not considered toxic. Absorb with dry sand or oil absorbents. All materials are bio-degradable. Clean spill area with detergent solution and flush down sewer with water.

WASTE DISPOSAL METHOD: Waste materials should be dumped or buried in an approved industrial waste landfill. Large quantities may be disposed of by incineration.

RCRA/CERCLA HAZARDOUS WASTE: This product contains no hazardous waste.

****
SECTION VIII - FIRE AND EXPLOSION HAZARD INFORMATION
****

FLASH POINT (open cup): >158° F

FLAMMABLE LIMITS: Unknown.

EXTINGUISHING MEDIA: Foam for large fires; carbon dioxide or dry chemical for small fires.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Smoke may be generated when burning.

SPECIAL FIRE FIGHTING PROCEDURES: Keep away from heat or hot surfaces above 150°F, treat vapors as you would odorless spirits. Treat as oil fire.

****
SECTION IX - REACTIVITY INFORMATION
****

STABILITY: Stable.

INCOMPATIBILITY (MATERIALS TO AVOID): Strong oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS: Waxy mixed alkanes at high temperatures.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: None.

****
SECTION X - PHYSICAL DATA
****

APPEARANCE: Creamy white, slightly viscous

ODOR: Lavender

SOLUBILITY IN WATER (% by weight): 100%

SPECIFIC GRAVITY: 0.916 @ 25°C

BOILING POINT: 164°F

WEIGHT PER GALLON: 7.65 lbs.

VISCOSITY: 525 - 1161 cps

AUTO IGNITION TEMPERATURE: Unknown

APPENDIX B

E.Coli SOP

Standard Operating Procedure for *Escherichia coli (E. coli)* and Total Coliform Quantification using the IDEXX Quanti-Tray/2000 System[1]

1. Scope and Applicability
    a. The Colilert Quanti-Tray 2000 method, approved by the United States Environmental Protect Agency in 2000, describes the process for the collection and analysis for the quantification of Total coliform and *E. coli* bacteria in water samples.
    b. The detection limit for this test ranges from 1 Most Probable Number (MPN) per 100mL of sample to >2419.6 MPN per 100mL sample.
    c. This method is suitable for use with surface water samples.
2. Summary of Procedure
    a. Surface water samples are collected in sterile 100mL polypropylene bottles containing sodium thiosulfate and stored on wet ice up to 8 hours for source waters and 30 hours for drinking water.
    b. Pour one packet of Colilert reagent into each 100mL sample. Shake to dissolve. Samples are transferred to Quanti-Trays/2000 and sealed using the Quanti-Tray sealer.
    c. The samples are incubated at 35 ± 0.5°C for 24 -28 hours.
    d. A color change from clear to yellow observed under ambient lighting indicates the presence of Total coliform bacteria and fluorescence under UV lighting of the same wells indicates presence of *E. coli*. Counts of small and large yellow and fluorescence wells are used in conjunction with the IDEXX MPN table to determine number of each type of bacteria. Alternatively, the "MPN Generator" software provided by IDEXX can be used to calculate MPN values. Results are reported as MPN/100mL.
3. Definitions
    a. *E. coli* – A type of bacteria belonging to the fecal coliform group of bacteria found primarily in the gut and feces of warm blooded animals. Most *E. coli* strains are harmless, but some can cause food poisoning in humans. Of the several types of bacteria in the total colifom group, *E. coli* does not typically reproduce in soil and water environments. Their ability to survive for brief periods outside the body makes them an ideal indicator organism to test environmental samples for fecal contamination.
    b. Trip blank – A sample of sterilized deionized water which is treated and processed in the exact manner as surface water samples, utilizing the Colilert method. The purpose of blanks is to ensure that no contamination or interferences are present during the sampling process.
    c. Field duplicate – Two samples taken at the same time and place that are treated identically throughout all procedures. The purpose of duplicates is to ensure precision associated with sample collection, storage, and analysis.
    d. MPN – Most Probable Number determined by the MPN table or MPN Generator software.

[1] Reviewed by UDWQ and State Health Laboratory. Approved by EPA Region 8.

e. Total coliform- Rod-shaped gram-negative bacteria which ferment lactose and contain the enzyme β-D-galactosidase. They are abundant in the feces of warm- blooded animals and include bacteria that are naturally present in the soil and water environment. They are not the cause of sickness, but their presence is used to indicate contamination in water quality.

4. Health and Safety Warnings
    a. Samples could contain pathogenic microorganisms. Personnel who collect and/or process the samples should protect themselves from water borne illnesses by wearing clean disposable gloves and washing their hands frequently.
    b. Use caution when using the Quanti-Tray Sealer as it might be hot.
    c. When opening the Colilert reagent snap pack, open the pack so that the pack is facing away from you. Note: The Colilert reagent is not hazardous according to the manufacturer's MSDS.
    d. Do not look directly into the UV light.
5. Interferences
    a. Samples may contain material that affects the color of the sample. If this situation does arise, compare inoculated trays to a control tray containing only water.
    b. Test sensitivity maybe affected by taking the samples out of the incubator too soon ending with false negatives. Test samples should be incubated for the full term.
    c. Autoflourescent plasticware or glassware may produce false positives. Check sample containers prior to sampling and processing.
6. Equipment and Supplies
    a. Note: All Colilert supplies are purchased through IDEXX. Check expiration dates.
    b. Colilert Quanti-Tray/2000: 100 trays containing 97 wells each. (Cat # WQT-2K).
    c. Colilert Quanti-Tray Sealer. (Cat # WQTS2X-115). Note: Includes Quanti-Tray/2000 Rubber Insert (Cat # WQTSRBR-2K).
    d. Colilert Comparator. (Cat # WQT2KC).
    e. Shrink Banded Disposable Vessels: 120mL with 10g sodium thiosulfate. (Cat # WV120SBST-200).
    f. Colilert Reagent: Snap packets for 100mL water samples. (Cat # WP200).
    g. Quanti-Cult. (Cat # WKIT1001).
    h. Handheld 6-watt long wave UV lamp: 115 volts. Spectronics Corporation. (Cat # 1608994).
    i. Autoclave Biohazard Bags. (VWR Cat #14220-086).
    j. Elastic Closures (for Biohazard Bags). (Fisher Scientific #D18158).
    k. Bottle Carboy. 50L. (VWR Cat #16101-481)
    l. 10 mL Disposable Sterile Pipets (VWR # 53283-708).
    m. 50 mL Disposable Sterile Pipets (VWR # 53283-712).
    n. 10mL Pipetting Device. (VWR#47751-780).
    o. 50mL Pipetting Device. (VWR#47751-784).

p. Incubator. Note: Programmable temperature is strongly recommended.

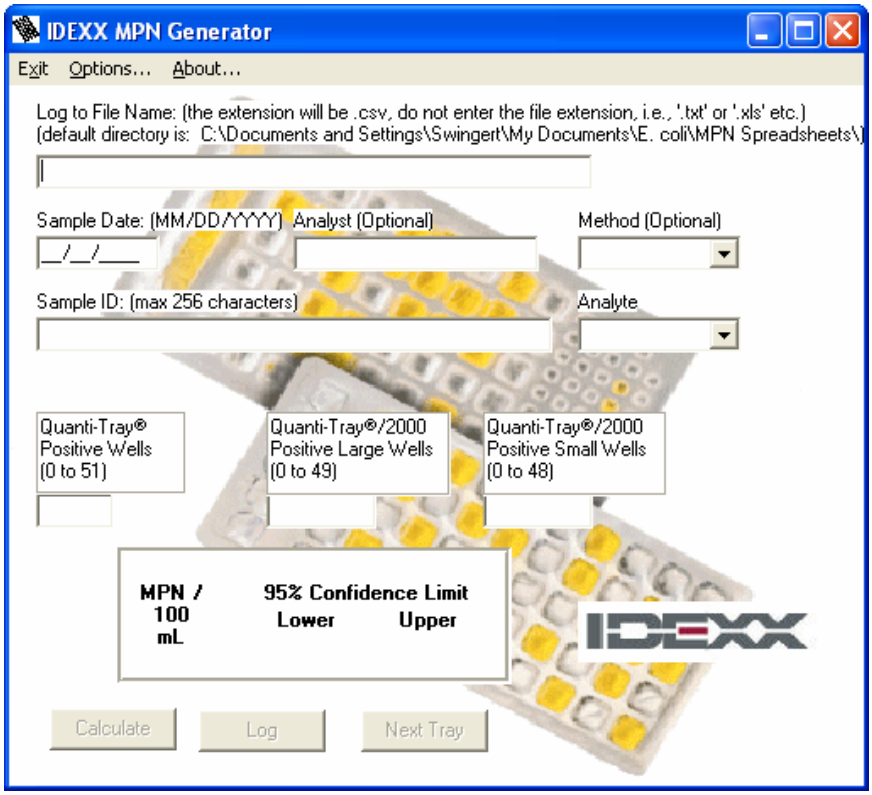
7. Sample Collection, Preservation, and Storage
    a. For sample collection, see the Bacteriological Monitoring Plan. Note: 100mL of surface water must be collected. Do not over or under fill bottles.
    b. Store the samples in a cooler with wet ice for a max of 8 hours for source water and 30 hours for drinking water. Note: Make sure temperature inside cooler is approximately 4°C.
    c. Process samples either in the field or indoors to ensure holding times are met or transport the samples to the State Health Lab at the University of Utah.
8. Quality Control and Quality Assurance
    a. Sign form indicating each analyst has read this SOP annually. Keep documentation with the latest version of SOP.
    b. Each analyst should complete a Demonstration of Capability (DOC) to detect and enumerate *E. coli* by the approved Colilert method annually.
    c. Record the temperature of the incubator at least two times per day at least 4 hours apart.
    d. Maintain the temperature at 35 ± 0.5°C for the incubator.
    e. Verify testing conditions by testing for controls and field duplicates. Controls include a trip blank (traveling blank) and rinsate blank (deionized water). Test for duplicates at 10% of samples collected daily.
    f. Use the carboys to contain the deionized water for the blanks. Make sure the carboy is autoclaved prior to use. Fill with sterilized deionized water. Store in sterile environment.
    g. Use media within the expiration date. Store media in a cool, dark place.
    h. Check thermometers annually against NIST-certified thermometer and replace if the difference is greater than 1°C.
9. Procedures
    a. Preliminary Procedures
        i. Plug in the incubator at start of each sampling period.
        ii. Immediately prior to processing the samples, verify that the temperature of the incubator is 35 ± 0.5°C.
        iii. Turn the sealer on. Wait for the green light to come on before you start to process the samples.
        iv. Warm samples in a 35°C water-bath for 30 minutes.
    b. Instrument Calibration and Standardization
        i. Plug in the incubator and program the temperature to 35 ± 0.5°C.
        ii. Turn on the Quanti-Tray Sealer and allow it to warm up. If the orange light is on, then the sealer is on. If the green light is on, then the sealer is ready.
        iii. Check the temperature on the incubator. The temperature must be set for 35 ± 0.5°C. Check frequently to ensure constant temperature. To ensure proper temperature, store incubator in a location not likely to experience fluctuations in ambient temperature.

c. Sample Preparation
    i. Fill out the labels (N:\MONITORS\Labels) with the Storet number, Site ID, Date, and time. Place the labels on the back of the trays. Make sure the information on each sample bottle correctly matches the labeled tray.
    ii. One Colilert Reagent snap packets will be required per 100mL water sample. Separate one snap pack from the Colilert Reagent strip. Tap to ensure the medium is in the bottom of the pack.
    iii. Aseptically snap-open the pack and transfer it to one 100mL sample bottle. Make sure you face the snap pack away from you before opening. Shake or swirl the sample bottle to dissolve the medium. Make sure the foam settles before continuing.
d. Colilert Quanti-Tray and Sealer
    i. Use one hand to hold a tray upright and squeeze the upper part so that it opens. Pour the sample/reagent solution directly into the tray. Tap the tray to dislodge any air bubbles inside the wells.
    ii. Place the tray into the rubber insert with the well side facing down.
    iii. Feed the rubber insert into the sealer with the open end of the tray facing away from the sealer.
    iv. Remove the sealed tray from the back of the sealer.
e. Incubation
    i. Fill out bench sheets including the sample ID, volume tested, start time and date of incubation, and start and end temperature of incubation.
    ii. Invert the sealed tray and incubate it in the 35 ± 0.5°C incubator for 24hrs. Note: Do not stack the trays more than 5 high in the incubator.
    iii. Repeat this process for all other samples, field blank, rinsate blank, and duplicates.
    iv. Record the temperature of the incubator on the bench sheets at least two times per day with an interval of at least four hours.
    v. Record the end of incubation time when trays are taken out of incubator.
f. Interpretation
    i. When reading the trays, contrast the results with the Colilert Comparator which shows the lowest level of yellow and fluorescence that is considered positive for total coliform and *E. coli* counts.
    ii. Count the number of large and small wells that are yellow under normal lighting. Record these counts. The yellow color is indicative of the presence of total coliforms.
    iii. If the sample is yellow but lighter than the Comparator, then it needs to be incubated for 4 more hours (a total of 28hrs). Reread the tray. If the same color intensifies, it is considered positive for total coliforms. If the color does not intensify, then it is negative.

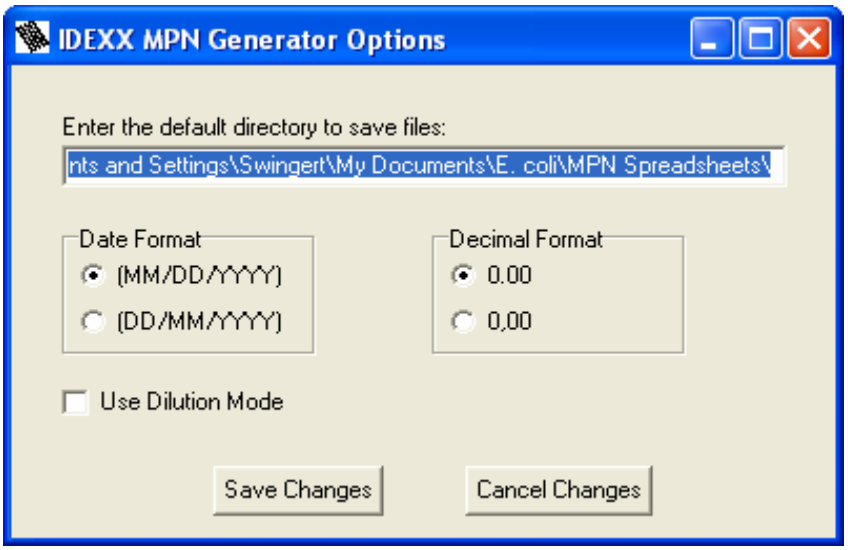
iv. If the yellow wells are present, check the same wells for fluorescence by using the UV light. Hold the UV light 5 inches from the tray. If the color is equal to or greater than the Comparator then count and record the number of blue fluorescent wells, both large and small. Blue fluorescent wells are indicative of *E. coli*.
v. When reading the trip blank and the sterile blank, both should remain colorless and nonfluorescent through out the 24h.

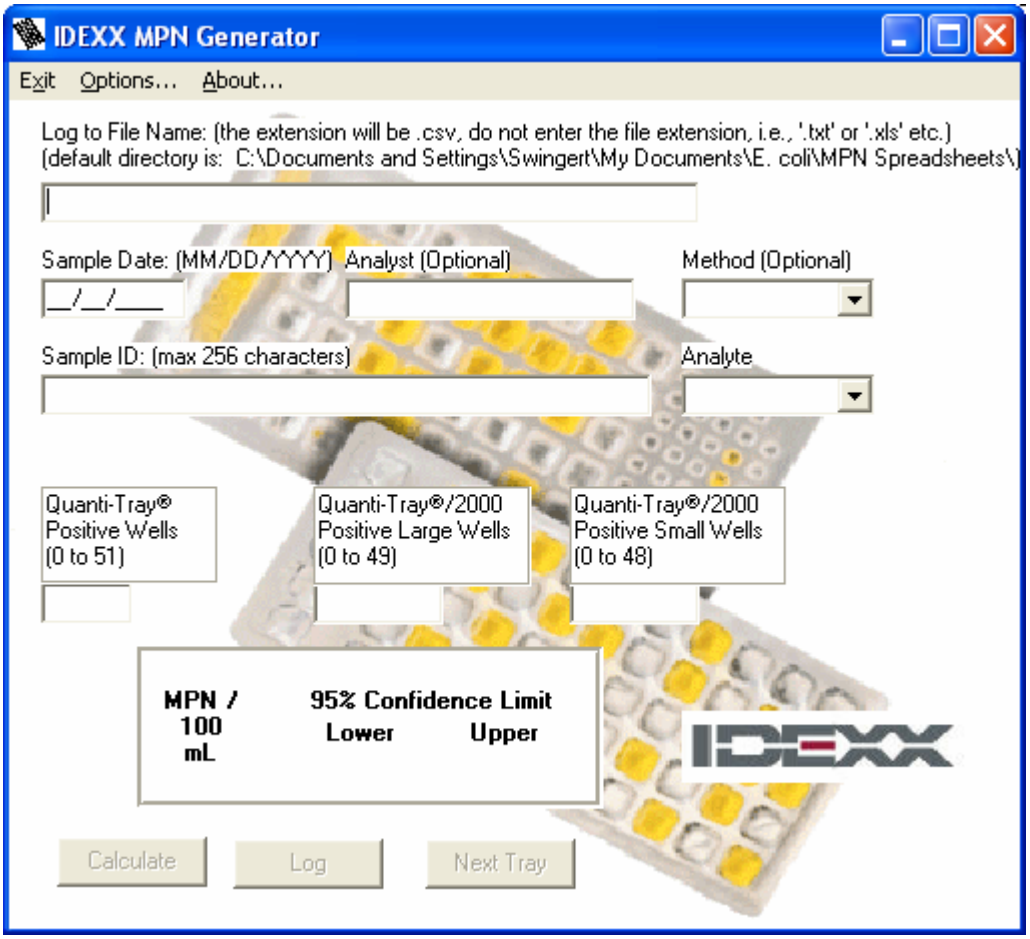
g. Dilutions
   i. There are situations when the numerical value from the bacteriological analysis needs to be an actual number. Thus samples that exceed the threshold, those with concentrations > 2419.6, should be diluted before analysis takes place when possible.
   ii. A knowledge of the source water to be sampled, seasonal variability, storm events, or known influences can be helpful when dilutions need to be made.
   iii. If it is unknown if or how much a sample needs to be diluted, Take two samples at the sampling site and perform a 1:1 and a 1:10 dilution from one bottle and process the other bottle as a whole sample.
   iv. 1:1 dilutions are made by pipeting 50 mLs of sample with a 50 mL sterile disposable pipet into a new sample bottle and then fill the bottle to the 100 mL line with sterile distilled or deionized water from a dedicated carboy or known clean supply. Process the sample as you would a whole sample.
   v. 1:10 dilutions are made by pipeting 10 mLs of sample with a 10 mL sterile disposable pipet into a new sample bottle and then fill the bottle to the 100 mL line with sterile distilled or deionized water from a dedicated carboy or known clean supply. Process the sample as you would a whole sample.
   vi. When interpreting the results from diluted samples remember to multiply the results by the appropriate factor.
   vii. Multiply the MPN results from 1:1 diluted samples by 2, and multiply the results from 1:10 samples by 10 to get the correct results from the diluted samples.

10. Data Analysis and Calculations
    a. The determination of the MPN/ 100mL of both total coliforms and *E. coli* can be done in one of two ways:
       i. Use the MPN tables
       ii. Use the IDEXX MPN Generator 3.1. This is the preferred method.
          1. Download the Generator from IDEXX's website. www.idexx.com/water/quantitray/index.jsp
          2. Follow the directions below.
             a. Click Options



b. Enter the file directory of where you want your MPN spreadsheet to be stored. Then click "Save Changes".





c. Enter your sample date, analyst, and method (Colilert). Type in the name of your Sample ID (Ex. 4992510 *E. coli*). Note: You might want to label which sample is for your *E. coli* and total coliforms here. Choose which analyte (either total coliforms or E. coli) you are calculating. Skip the box for "Quanti-Tray Positive Wells (0 to 51)". This is for a different method.

d. For Total Coliforms, choose total coliforms for your analyte. Enter the number of large yellow (positive) wells in the "Quanti-Tray/2000 Positive Large Wells (0-49)" space and the number of small yellow wells in the "Quanti-Tray/2000 Positive Small Wells (0-48)" space. Click on the "Calculate" button. The results are recorded in MPN/100mL. Record these results on the bench sheets. The MPN Generator also gives you the 95% confidence limits.

e. Click on the "Log" button to store these results in the automatically created spreadsheet.

f. For *E. coli*, Choose *E. coli* for your analyte. Enter the number of large wells that are both yellow and

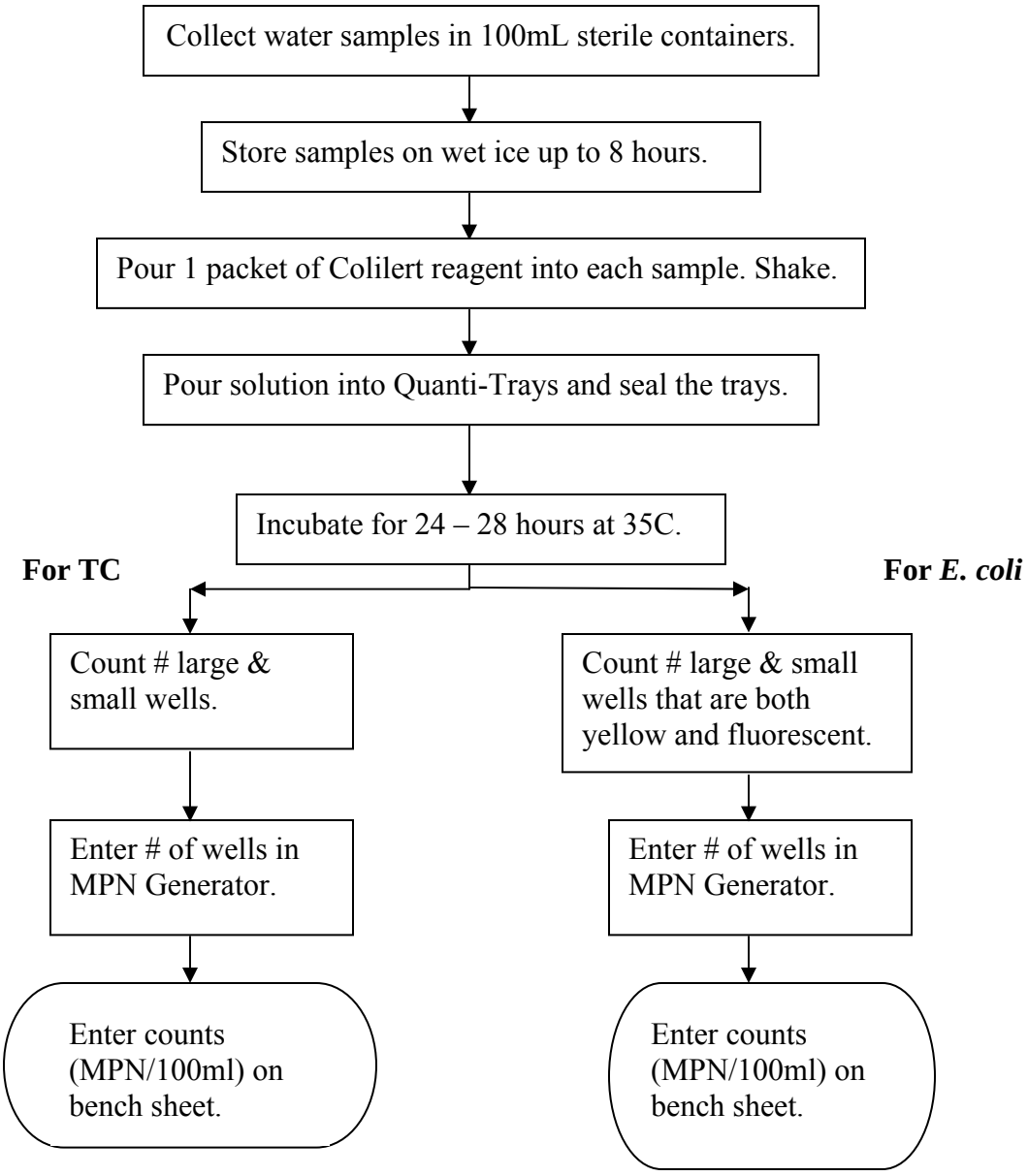
fluorescent in the "Quanti-Tray/2000 Positive Large Wells (0-49)" space and the number of small wells are both yellow and fluorescent in the "Quanti-Tray/2000 Positive Small Wells (0-48)" space. Click on the "Calculate" button. The results are recorded in MPN/100mL. Record these results on the bench sheets. The MPN Generator also gives you the 95% confidence limits.

g. Click on the "Log" button to store these results in the automatically created spreadsheet.

b. To calculate for duplicate precision follow the steps outlined in the "Standard Methods for the Examination of Water and Wastewater" (20th Edition). See attached Appendix.
c. The blank samples should have a value of <1 MPN/100mL (detection limit). If the blank value exceeds <1MPN/100mL, then write in comment field that the data associated with the blank exceeds detection limit.

11. Disposal
    a. All vessels used during the experiment should be soaked for an hour in a disinfectant (Lysol or Clorox) prior to disposal.
    b. All cultures, samples, contaminated disposable items, and contaminated glassware must be placed in a Biohazard bag and autoclaved for at least 30 minutes prior to disposal.
12. References
    a. Colilert package insert and MPN tables. IDEXX Laboratories, Inc., Westbrook, Maine.
    b. User Manual, Quanti-Tray Sealer. IDEXX Laboratories, Inc., Westbrook, Maine.
    c. User Manual, Quanti-Tray/2000. IDEXX Laboratories, Inc., Westbrook, Maine.
    d. Standard Methods for the Examination of Water and Wastewater. 20th edition. Edited by Clesceri *et a*l.

Figure 1. Overview of *E. coli* and Total coliform Quantification.



Colilert Quanti-Tray Method Bench Sheet

Project/Run:	
Analyst:	
Date and Start Time:	
Date and End Time:	
Start Temp:	
Mid Temp:	
End Temp:	

Sample ID	# Lg Yellow Wells	# Sm Yellow Wells	# Lg Fluor. Wells	# Sm Fluor. Wells	MPN for TC	MPN for E.coli	Duplicate

Standard Operating Procedure (SOP) Agreement Form

Document Title:	Standard Operating Procedure for *Escherichia coli (E. coli)* and Total Coliform Quantification using the IDEXX Quanti-Tray/2000 System
Document Revision Number:	
Document Revision Date:	

Note: The current SOP must be read and SOP Agreement Form signed annually. This form must be kept with the latest version of the SOP.

I have read and understood the above referenced laboratory document. I agree to perform the procedures described within in accordance with the document until such time that it is superseded by a more recent approved revision.	
Analyst Name (print):	
Analyst Signature:	
Date of Agreement:	

Management Approval

Mgt Approval (print):	
Mgt Signature:	
Approval Date:	

Demonstration of Capability (DOC) Form for Bacteriology Testing

Note: DOC must be completed annually per analyst.

Analyst Name (print):	
Analyst Signature:	
DOC Type:	☐ Initial Demonstration ☐ Continuing Demonstration
Date of DOC:	
Analytical Method(s):	
Target Organisms:	☐ Total Coliform ☐ E. coli ☐ Other:
Reported Units:	

Sample Type	**# Large Yellow Wells**	**# Small Yellow Wells**	**# Large Flouro. Wells**	**# Small Flouro. Wells**	**Reported Value, MPN**	**True Value, MPN (range)**

☐ **PASS** ☐ **FAIL**

Trainer Approval (print):	
Trainer Signature:	
Approval Date:	
Mgt Approval (print):	
Mgt Signature:	
Approval Date:	

APPENDIX C

Benthic Macroinvertebrates SOP

7 BENTHIC MACROINVERTEBRATE PROTOCOLS

Rapid bioassessment using the benthic macroinvertebrate assemblage has been the most popular set of protocols among the state water resource agencies since 1989 (Southerland and Stribling 1995). Most of the development of benthic Rapid Bioassessment Protocols (RBPs) has been oriented toward RBP III (described in Plafkin et al. 1989). As states have focused attention on regional specificity, which has included a wide variety of physical characteristics of streams, the methodology of conducting stream surveys of the benthic assemblage has advanced. Some states have preferred to retain more traditional methods such as the Surber or Hess samplers (e.g., Wyoming Department of Environmental Quality [DEQ]) over the kick net in cobble substrate. Other agencies have developed techniques for streams lacking cobble substrate, such as those streams in coastal plains. State water resource agencies composing the Mid-Atlantic Coastal Streams (MACS) Workgroup, i.e., New Jersey Department of Environmental Protection (DEP), Delaware Department of Natural Resources and Environmental Control (DNREC), Maryland Department of Natural Resources (DNR) and Maryland Department of the Environment (MDE), Virginia DEQ, North Carolina Department of Environmental Management (DEM), and South Carolina Department of Health and Environmental Control (DHEC), and a workgroup within the Florida Department of Environmental Protection (DEP) were pioneers in this effort. These 2 groups (MACS and FLDEP) developed a multihabitat sampling procedure using a D-frame dip net. Testing of this procedure by these 2 groups indicates that this technique is scientifically valid for low-gradient streams. Research conducted by the U.S. Environmental Protection

STANDARD BENTHIC MACROINVERTEBRATE SAMPLING GEAR TYPES FOR STREAMS
(assumes standard mesh size of 500 µ nytex screen)

- **Kick net:** Dimensions of net are 1 meter (m) x 1 m attached to 2 poles and functions similarly to a fish kick seine. Is most efficient for sampling cobble substrate (i.e., riffles and runs) where velocity of water will transport dislodged organisms into net. Designed to sample 1 m^2 of substrate at a time and can be used in any depth from a few centimeters to just below 1m (Note -- Depths of 1m or greater will be difficult to sample with any gear).

- **D-frame dip net:** Dimensions of frame are 0.3 m width and 0.3 m height and shaped as a "D" where frame attaches to long pole. Net is cone or bag-shaped for capture of organisms. Can be used in a variety of habitat types and used as a kick net, or for "jabbing", "dipping", or "sweeping".

- **Rectangular dip net:** Dimensions of frame are 0.5 m width and 0.3 m height and attached to a long pole. Net is cone or bag-shaped. Sampling is conducted similarly to the D-frame.

- **Surber:** Dimensions of frame are 0.3 m x 0.3 m, which is horizontally placed on cobble substrate to delineate a 0.09 m^2 area. A vertical section of the frame has the net attached and captures the dislodged organisms from the sampling area. Is restricted to depths of less than 0.3 m.

- **Hess:** Dimensions of frame are a metal cylinder approximately 0.5 m in diameter and samples an area 0.8 m^2. Is an advanced design of the Surber and is intended to prevent escape of organisms and contamination from drift. Is restricted to depths of less than 0.5 m.

Agency (USEPA) for their Environmental Monitoring and Assessment Program (EMAP) program and the United States Geological Survey (USGS) for their National Water Quality Assessment Program (NAWQA) program have indicated that the rectangular dip net is a reasonable compromise between the traditional Surber or Hess samplers and the RBP kick net described the original RBPs.

From the testing and implementation efforts that have been conducted around the country since 1989, refinements have been made to the procedures while maintaining the original concept of the RBPs. Two separate procedures that are oriented toward a "single, most productive" habitat and a multihabitat approach represent the most rigorous benthic RBP and are essentially a replacement of the original RBP III. The primary differences between the original RBP II and III are the decision on field versus lab sorting and level of taxonomy. These differences are not considered sufficient reasons to warrant separate protocols. In addition, a third protocol has been developed as a more standardized biological reconnaissance or screening and replaces RBP I of the original document.

Kicknet

D-frame Dipnet

Rectangular Dipnet

Hess sampler

(*Mary Kay Corazalla, Univ. of Minnesota*)

7.1 SINGLE HABITAT APPROACH: 1 METER KICK NET

The original RBPs (Plafkin et al. 1989) emphasized the sampling of a single habitat, in particular riffles or runs, as a means to standardize assessments among streams having those habitats. This approach is still valid, because macroinvertebrate diversity and abundance are usually highest in cobble substrate (riffle/run) habitats. Where cobble substrate is the predominant habitat, this sampling approach provides a representative sample of the stream reach. However, some streams naturally lack the cobble substrate. In cases where the cobble substrate represents less than 30% of the sampling reach in reference streams (i.e., those streams that are representative of the region), alternate habitat(s) will need to be sampled (See Section 7.2). The appropriate sampling method should be selected based on the habitat availability of the reference condition and not of potentially impaired streams. For example, methods would not be altered for situations where the extent of cobble substrate in streams influenced by heavy sediment deposition may be substantially reduced from the amount of cobble substrate expected for the region.

7.1.1 Field Sampling Procedures for Single Habitat

FIELD EQUIPMENT/SUPPLIES NEEDED FOR BENTHIC MACROINVERTEBRATE SAMPLING —SINGLE HABITAT APPROACH

- standard kick-net, 500 μ opening mesh, 1.0 meter width
- sieve bucket, with 500 μ opening mesh
- 95% ethanol
- sample containers, sample container labels
- forceps
- pencils, clipboard
- Benthic Macroinvertebrate Field Data Sheet*
- first aid kit
- waders (chest-high or hip boots)
- rubber gloves (arm-length)
- camera
- Global Positioning System (GPS) Unit

* It is helpful to copy fieldsheets onto water-resistant paper for use in wet weather conditions

1. A 100 m reach representative of the characteristics of the stream should be selected. Whenever possible, the area should be at least 100 meters upstream from any road or bridge crossing to minimize its effect on stream velocity, depth, and overall habitat quality. There should be no major tributaries discharging to the stream in the study area.

2. Before sampling, complete the physical/chemical field sheet (see Chapter 5; Appendix A-1, Form 1) to document site description, weather conditions, and land use. After sampling, review this information for accuracy and completeness.

3. Draw a map of the sampling reach. This map should include in-stream attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) and important structures, plants, and attributes of the bank and near stream areas. Use an arrow to indicate the direction of flow. Indicate the areas that were sampled for macroinvertebrates on the map. Estimate "river mile" for sampling reach for probable use in data management of the water resource agency. If available, use hand-held Global Positioning System (GPS) for latitude and longitude determination taken at the furthest downstream point of the sampling reach.

4. All riffle and run areas within the 100-m reach are candidates for sampling macroinvertebrates. A composite sample is taken from individual sampling spots in the riffles and runs representing different velocities. Generally, a minimum of 2 m^2 composited area is sampled for RBP efforts.

5. Sampling begins at the downstream end of the reach and proceeds upstream. Using a 1 m kick net, 2 or 3 kicks are sampled at various velocities in the riffle or series of riffles. A *kick* is a stationary sampling accomplished by positioning the net and disturbing one square meter upstream of the net. Using the toe or heel of the boot, dislodge the upper layer of cobble or gravel and scrape the underlying bed. Larger substrate particles should be picked up and rubbed by hand to remove attached organisms. If different gear is used (e.g., a D-frame or rectangular net), a composite is obtained from numerous kicks (See Section 7.2).

ALTERNATIVES FOR STREAM REACH DESIGNATION

- **Fixed-distance designation**—A standard length of stream, such as a reach, is commonly used to obtain an estimate of natural variability. Conceptually, this approach should provide a mixture of habitats in the reach and provide, at a minimum, duplicate physical and structural elements such as a riffle/pool sequence.

- **Proportional-distance designation**—Alternatively, a standard number of stream "widths" is used to measure the stream distance, e.g., 40 times the stream width is defined by EMAP for sampling (Klemm and Lazorchak 1995). This approach allows variation in the length of the reach based on the size of the stream.

6. The jabs or kicks collected from different locations in the cobble substrate will be composited to obtain a single homogeneous sample. After every kick, wash the collected material by running clean stream water through the net 2 to 3 times. If clogging does occur, discard the material in the net and redo that portion of the sample in a different location. Remove large debris after rinsing and inspecting it for organisms; place any organisms found into the sample container. Do not spend time inspecting small debris in the field. [Note — an alternative is to keep the samples from different habitats separated as done in EMAP (Klemm and Lazorchak 1995).]

7. Transfer the sample from the net to sample container(s) and preserve in enough 95 percent ethanol to cover the sample. Forceps may be needed to remove organisms from the dip net. Place a label indicating the sample identification code or lot number, date, stream name, sampling location, and collector name into the sample container. The outside of the container should include the same information and the words "preservative: 95% ethanol". If more than one container is needed for a sample, each container label should contain all the information for the sample and should be numbered (e.g., 1 of 2, 2 of 2, etc.). This information will be recorded in the "Sample Log" at the biological laboratory (Appendix A-3, Form 2).

8. Complete the top portion of the "Benthic Macroinvertebrate Field Data Sheet" (Appendix A-3, Form 1), which duplicates the "header" information on the physical/chemical field sheet.

9. Record the percentage of each habitat type in the reach. Note the sampling gear used, and comment on conditions of the sampling, e.g., high flows, treacherous rocks, difficult access to stream, or anything that would indicate adverse sampling conditions.

10. Document observations of aquatic flora and fauna. Make qualitative estimates of macroinvertebrate composition and relative abundance as a cursory estimate of ecosystem health and to check adequacy of sampling.

11. Perform habitat assessment (Appendix A-1, Form 2) after sampling has been completed; walking the reach helps ensure a more accurate assessment. Conduct the habitat assessment with another team member, if possible.

12. Return samples to laboratory and complete log-in form (Appendix A-3, Form 2).

QUALITY CONTROL (QC) IN THE FIELD

1. Sample labels must be properly completed, including the sample identification code, date, stream name, sampling location, and collector's name, and placed into the sample container. The outside of the container should be labeled with the same information. Chain-of-custody forms, if needed, must include the same information as the sample container labels.

2. After sampling has been completed at a given site, all nets, pans, etc. that have come in contact with the sample should be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should be examined again prior to use at the next sampling site.

3. Replicate (1 duplicate sample) 10% of the sites to evaluate precision or repeatability of the sampling technique or the collection team.

7.2 MULTIHABITAT APPROACH: D–FRAME DIP NET

Streams in many states vary from high gradient, cobble dominated to low gradient streams with sandy or silty sediments. Therefore, a method suitable to sampling a variety of habitat types is desired in these cases. The method that follows is based on Mid-Atlantic Coastal Streams Workgroup recommendations designed for use in streams with variable habitat structure (MACS 1996) and was used for statewide stream bioassessment programs by Florida DEP (1996) and Massachusetts DEP (1995). This method focuses on a multihabitat scheme designed to sample major habitats in proportional representation within a sampling reach. Benthic

FIELD EQUIPMENT/SUPPLIES NEEDED FOR BENTHIC MACROINVERTEBRATE SAMPLING —MULTI-HABITAT APPROACH

- standard D-frame dip net, 500 μ opening mesh, 0.3 m width (~ 1.0 ft frame width)
- sieve bucket, with 500 μ opening mesh
- 95% ethanol
- sample containers, sample container labels
- forceps
- pencils, clipboard
- Benthic Macroinvertebrate Field Data Sheet*
- first aid kit
- waders (chest-high or hip boots)
- rubber gloves (arm-length)
- camera
- Global Positioning System (GPS) Unit

* It is helpful to copy fieldsheets onto water-resistant paper for use in wet weather conditions

macroinvertebrates are collected systematically from all available instream habitats by kicking the substrate or jabbing with a D-frame dip net. A total of 20 jabs (or kicks) are taken from all major habitat types in the reach resulting in sampling of approximately 3.1 m^2 of habitat. For example, if the habitat in the sampling reach is 50% snags, then 50% or 10 jabs should be taken in that habitat. An organism-based subsample (usually 100, 200, 300, or 500 organisms) is sorted in the laboratory and identified to the lowest practical taxon, generally genus or species.

7.2.1 Habitat Types

The major stream habitat types listed here are in reference to those that are colonized by macroinvertebrates and generally support the diversity of the macroinvertebrate assemblage in stream ecosystems. Some combination of these habitats would be sampled in the multihabitat approach to benthic sampling.

Cobble (hard substrate) - Cobble will be prevalent in the riffles (and runs), which are a common feature throughout most mountain and piedmont streams. In many high-gradient streams, this habitat type will be dominant. However, riffles are not a common feature of most coastal or other low-gradient streams. Sample shallow areas with coarse (mixed gravel, cobble or larger) substrates by holding the bottom of the dip net against the substrate and dislodging organisms by kicking the substrate for 0.5 m upstream of the net.

Snags - Snags and other woody debris that have been submerged for a relatively long period (not recent deadfall) provide excellent colonization habitat. Sample submerged woody debris by jabbing in medium-sized snag material (sticks and branches). The snag habitat may be kicked first to help dislodge organisms, but only after placing the net downstream of the snag. Accumulated woody material in pool areas are considered snag habitat. Large logs should be avoided because they are generally difficult to sample adequately.

Vegetated banks - When lower banks are submerged and have roots and emergent plants associated with them, they are sampled in a fashion similar to snags. Submerged areas of undercut banks are good habitats to sample. Sample banks with protruding roots and plants by jabbing into the habitat. Bank habitat can be kicked first to help dislodge organisms, but only after placing the net downstream.

Submerged macrophytes - Submerged macrophytes are seasonal in their occurrence and may not be a common feature of many streams, particularly those that are high-gradient. Sample aquatic plants that are rooted on the bottom of the stream in deep water by drawing the net through the vegetation from the bottom to the surface of the water (maximum of 0.5 m each jab). In shallow water, sample by bumping or jabbing the net along the bottom in the rooted area, avoiding sediments where possible.

Sand (and other fine sediment) - Usually the least productive macroinvertebrate habitat in streams, this habitat may be the most prevalent in some streams. Sample banks of unvegetated or soft soil by bumping the net along the surface of the substrate rather than dragging the net through soft substrates; this reduces the amount of debris in the sample.

7.2.2 Field Sampling Procedures for Multihabitat

1. A 100 m reach that is representative of the characteristics of the stream should be selected. Whenever possible, the area should be at least 100 m upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality. There should be no major tributaries discharging to the stream in the study area.

2. Before sampling, complete the physical/chemical field sheet (see Chapter 5; Appendix A-1, Form 1) to document site description, weather conditions, and land use. After sampling, review this information for accuracy and completeness.

ALTERNATIVES FOR STREAM REACH DESIGNATION

- **Fixed-distance designation**—A standard length of stream, such as a reach, is commonly used to obtain an estimate of natural variability. Conceptually, this approach should provide a mixture of habitats in the reach and provide, at a minimum, duplicate physical and structural elements such as a riffle/pool sequence.

- **Proportional-distance designation**—Alternatively, a standard number of stream "widths" is used to measure the stream distance, e.g., 40 times the stream width is defined by EMAP for sampling (Klemm and Lazorchak 1995). This approach allows variation in the length of the reach based on the size of the stream.

3. Draw a map of the sampling reach. This map should include in-stream attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) and important structures, plants, and attributes of the bank and near stream areas. Use an arrow to indicate the direction of flow. Indicate the areas that were sampled for macroinvertebrates on the map. Approximate "river mile" to sampling reach for probable use in data management of the water resource agency. If available, use hand-held GPS for latitude and longitude determination taken at the furthest downstream point of the sampling reach.

4. Different types of habitat are to be sampled in approximate proportion to their representation of surface area of the total macroinvertebrate habitat in the reach. For example, if snags comprise 50% of the habitat in a reach and riffles comprise 20%, then 10 jabs should be taken in snag material and 4 jabs should be take in riffle areas. The remainder of the jabs (6) would be taken in any remaining habitat type. Habitat types contributing less than 5% of the stable habitat in the stream reach should not be sampled. In this case, allocate the remaining jabs proportionately among the predominant substrates. The number of jabs taken in each habitat type should be recorded on the field data sheet.

5. Sampling begins at the downstream end of the reach and proceeds upstream. A total of 20 jabs or kicks will be taken over the length of the reach; a single *jab* consists of forcefully thrusting the net into a productive habitat for a linear distance of 0.5 m. A *kick* is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance of 0.5 m upstream of the net.

6. The jabs or kicks collected from the multiple habitats will be composited to obtain a single homogeneous sample. Every 3 jabs, more often if necessary, wash the collected material by running clean stream water through the net two to three times. If clogging does occur that may hinder obtaining an appropriate sample, discard the material in the net and redo that portion of

the sample in the same habitat type but in a different location. Remove large debris after rinsing and inspecting it for organisms; place any organisms found into the sample container. Do not spend time inspecting small debris in the field.

7. Transfer the sample from the net to sample container(s) and preserve in enough 95% ethanol to cover the sample. Forceps may be needed to remove organisms from the dip net. Place a label indicating the sample identification code or lot number, date, stream name, sampling location, and collector name into the sample container. The outside of the container should include the same information and the words “preservative: 95% ethanol”. If more that one container is needed for a sample, each container label should contain all the information for the sample and should be numbered (e.g., 1 of 2, 2 of 2, etc.). This information will be recorded in the "Sample Log" at the biological laboratory (Appendix A-3, Form 2).

8. Complete the top portion of the “Benthic Macroinvertebrate Field Data Sheet” (Appendix A-3, Form 1), which duplicates the “header” information on the physical/chemical field sheet.

9. Record the percentage of each habitat type in the reach. Note the sampling gear used, and comment on conditions of the sampling, e.g., high flows, treacherous rocks, difficult access to stream, or anything that would indicate adverse sampling conditions.

10. Document observations of aquatic flora and fauna. Make qualitative estimates of macroinvertebrate composition and relative abundance as a cursory estimate of ecosystem health and to check adequacy of sampling.

11. Perform habitat assessment (Appendix A-1, Form 3) after sampling has been completed. Having sampled the various microhabitats and walked the reach helps ensure a more accurate assessment. Conduct the habitat assessment with another team member, if possible.

12. Return samples to laboratory and complete log-in forms (Appendix A-3, Form 2).

QUALITY CONTROL (QC) IN THE FIELD

1. Sample labels must be properly completed, including the sample identification code, date, stream name, sampling location, and collector’s name and placed into the sample container. The outside of the container should be labeled with the same information. Chain-of-custody forms, if needed, must include the same information as the sample container labels.

2. After sampling has been completed at a given site, all nets, pans, etc. that have come in contact with the sample should be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should be examined again prior to use at the next sampling site.

3. Replicate (1 duplicate sample) 10% of the sites to evaluate precision or repeatability of sampling technique or collection team.

7.3 LABORATORY PROCESSING FOR MACROINVERTEBRATE SAMPLES

Macroinvertebrate samples collected by either intensive method, i.e., single habitat or multihabitat, are best processed in the laboratory under controlled conditions. Aspects of laboratory processing include subsampling, sorting, and identification of organisms.

All samples should be dated and recorded in the "Sample Log" notebook or on sample log form (Appendix A-3, Form 2) upon receipt by laboratory personnel. All information from the sample container label should be included on the sample log sheet. If more than one container was used, the number of containers should be indicated as well. All samples should be sorted in a single laboratory to enhance quality control.

LABORATORY EQUIPMENT/SUPPLIES NEEDED FOR BENTHIC MACROINVERTEBRATE SAMPLE PROCESSING

- log-in sheet for samples
- standardized gridded pan (30 cm x 36 cm) with approximately 30 grids (6 cm x 6 cm)
- 500 micron sieve
- forceps
- white plastic or enamel pan (15 cm x 23 cm) for sorting
- specimen vials with caps or stoppers
- sample labels
- standard laboratory bench sheets for sorting and identification
- dissecting microscope for organism identification
- fiber optics light source
- compound microscope with phase contrast for identification of mounted organisms (e.g., midges)
- 70% ethanol for storage of specimens
- appropriate taxonomic keys

7.3.1 Subsampling and Sorting

Subsampling benthic samples is not a requirement, and in fact, is frowned upon by certain scientists. Courtemanch (1996) provides an argument against subsampling, or to use a volume-based procedure if samples are to be subsampled. Vinson and Hawkins (1996) and Barbour and Gerritsen (1996) provide arguments for a fixed-count method, which is the preferred subsampling technique for RBPs.

Subsampling reduces the effort required for the sorting and identification aspects of macroinvertebrate surveys and provides a more accurate estimate of time expenditure (Barbour and Gerritsen 1996). The RBPs use a fixed-count approach to subsampling and sorting the organisms from the sample matrix of detritus, sand, and mud. *The following protocol is based on a 200-organism subsample, but it could be used for any subsample size (100, 300, 500, etc.)*. The subsample is sorted and preserved separately from the remaining sample for quality control checks.

1. Prior to processing any samples in a lot (i.e., samples within a collection date, specific watershed, or project), complete the sample log-in sheet to verify that all samples have arrived at the laboratory, and are in proper condition for processing.

2. Thoroughly rinse sample in a 500 µm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all

containers for a given sample should be combined at this time. Gently mix the sample by hand while rinsing to make homogeneous.

SUBSAMPLE PROCEDURE MODIFICATIONS

Subsampling procedures developed by Hilsenhoff (1987) and modified by Plafkin et al. (1989) were used in the original RBP II and RBP III protocols. As an improvement to the mechanics of the technique, Caton (1991) designed a sorting tray consisting of two parts, a rectangular plastic or plexiglass pan (36 cm x 30 cm) with a rectangular sieve insert. The sample is placed on the sieve, in the pan and dispersed evenly.

When a random grid(s) is selected, the sieve is lifted to temporarily drain the water. A "cookie-cutter" like metal frame 6 cm x 6 cm is used to clearly define the selected grid; debris overhanging the grid may be cut with scissors. A 6 cm flat scoop is used to remove all debris and organisms from the grid. The contents are then transferred to a separate sorting pan with water for removal of macroinvertebrates.

These modifications have allowed for rapid isolation of organisms within the selected grids and easy removal of all organisms and debris within a grid while eliminating investigator bias.

3. After washing, spread the sample evenly across a pan marked with grids approximately 6 cm x 6 cm. On the laboratory bench sheet, note the presence of large or obviously abundant organisms; *do not remove them from the pan*. However, Vinson and Hawkins (1996) present an argument for including these large organisms in the count, because of the high probability that these organisms will be excluded from the targeted grids.

4. Use a random numbers table to select 4 numbers corresponding to squares (grids) within the gridded pan. Remove all material (organisms and debris) from the four grid squares, and place the material into a shallow white pan and add a small amount of water to facilitate sorting. If there appear (through a cursory count or observation) to be 200 organisms ± 20% (cumulative of 4 grids), then subsampling is complete.

Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organism is considered to be in the grid containing most of its body.

If the density of organisms is high enough that many more than 200 organisms are contained in the 4 grids, transfer the contents of the 4 grids to a second gridded pan. Randomly select grids for this second level of sorting as was done for the first, sorting grids one at a time until 200 organisms ± 20% are found. If picking through the entire next grid is likely to result in a subsample of greater than 240 organisms, then that grid may be subsampled in the same manner as before to decrease the likelihood of exceeding 240 organisms. That is, spread the contents of the last grid into another gridded pan. Pick grids one at a time until the desired number is reached. The total number of grids for each subsorting level should be noted on the laboratory bench sheet.

TESTING OF SUBSAMPLING

Ferraro et al. (1989) describe a procedure for calculating the "power-cost efficiency" (PCE), which incorporates both the number of samples and the cost (i.e. time or money) for each alternative sampling scheme. With this analysis, the optimal subsampling size is that by which the costs of increased effort are offset by the lowest theoretical number of samples predicted from the power analysis to provide reliable resolution (Barbour and Gerritsen 1996).

There are 4 primary steps in assessing the PCE of a suite of alternative subsampling strategies:

Step 1: For each subsampling strategy (i.e., 100-, 200-, 300- organism level, or other) collect samples at several reference and impaired stations. The observed differences in each of the core metrics is defined to be the magnitude of the difference desired to be detected. The difference is the "effect size" and is equivalent to the inverse coefficient of variation (CV).

Step 2: Assess the "cost" (c_i), in time or money, of each subsampling scheme *i* at each site. The cost can include labor hours for subsampling, sorting, identification, and documentation. Total cost of each subsampling alternative is the product of cost per site and required sample size.

Step 3: Conduct statistical power analyses to determine the minimum number of replicate samples (n_i) needed to detect the effect size with an acceptable probability of Type I ($\propto$; the probability that the null hypothesis [e.g., "sites are good"] is true and it is rejected. Commonly termed the significance level.) and Type II (β; the probability that the null hypothesis is false and it is accepted) error. Typically, $\propto$ and β are set at 0.05. This step may be deleted for those programs that already have an established number of replicate samples.

Step 4: Calculate the PCE for each sampling scheme by:

$$PCE_i = \frac{(n \mathrm{X} c)_{\min}}{(n_i \mathrm{X} c_i)}$$

where $(n \mathrm{X} c)_{min}$ = minimum value of (n X c) among the *i* sampling schemes. The PCE formula is equivalent to the "power efficiency" ratio of the sample sizes attained by alternative tests under similar conditions (Ferraro et al. 1989) with the n's multiplied by the "cost" per replicate sample. Multiplying n by c puts efficiency on a total "cost" rather than on a sample size basis. The reciprocal of PCE_i is the factor by which the optimal subsampling scheme is more efficient than alternative scheme *i*. When PCE is determined for multiple metrics, the overall optimal subsampling scheme may be defined as that which ranks highest in PCE for most metrics of interest.

5. Save the sorted debris residue in a separate container. Add a label that includes the words "sorted residue" in addition to all prior sample label information and preserve in 95% ethanol. Save the remaining unsorted sample debris residue in a separate container labeled "sample residue"; this container should include the original sample label. Length of storage and archival is determined by the laboratory or benthic section supervisor.

6. Place the sorted 200-organism (± 20%) subsample into glass vials, and preserve in 70% ethanol. Label the vials inside with the sample identifier or lot number, date, stream name, sampling location and taxonomic group. If more than one vial is needed, each should be labeled separately and numbered (e.g., 1 of 2, 2 of 2). For convenience in reading the labels inside the

vials, insert the labels left-edge first. If identification is to occur immediately after sorting, a petri dish or watch glass can be used instead of vials.

7. Midge (Chironomidae) larvae and pupae should be mounted on slides in an appropriate medium (e.g., Euperal, CMC-9); slides should be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled.

8. Fill out header information on Laboratory Bench Sheet as in field sheets (see Chapter 5). Also check subsample target number. Complete back of sheet for subsampling/sorting information. Note number of grids picked, time expenditure, and number of organisms. If QC check was performed on a particular sample, person conducting QC should note findings on the back of the Laboratory Bench Sheet. Calculate sorting efficiency to determine whether sorting effort passes or fails.

9. Record date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of completion of sample lot.

QUALITY CONTROL (QC) FOR SORTING

1. Ten percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. (A lot is defined as a special study, basin study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC worker finds less than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, a second 10% of the sample lot will be checked by the QC worker. Sorters in-training will have their samples 100% checked until the trainer decides that training is complete.

2. After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

7.3.2 Identification of Macroinvertebrates

Taxonomy can be at any level, but should be done consistently among samples. In the original RBPs, two levels of identification were suggested — family (RBP II) and genus/species (RBP III) (Plafkin et al. 1989). Genus/species provides more accurate information on ecological/ environmental relationships and sensitivity to impairment. Family level provides a higher degree of precision among samples and taxonomists, requires less expertise to perform, and accelerates assessment results. In either case, only those taxonomic keys that have been peer-reviewed and are available to other taxonomists should be used. Unnamed species (i.e., species A, B, 1, or 2) may be ecologically informative, but may be inconsistently handled among taxonomists and will, thus, contribute to variability when a statewide database is being developed.

1. Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Midges (Diptera: Chironomidae) are

mounted on slides in an appropriate medium and identified using a compound microscope. Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

2. Labels with specific taxa names (and the taxonomist's initials) are added to the vials of specimens by the taxonomist. (Note that individual specimens may be extracted from the sample to be included in a reference collection or to be verified by a second taxonomist.) Slides are initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.

3. Record the identity and number of organisms on the Laboratory Bench Sheet (Appendix A-3, Form 3). Either a tally counter or "slash" marks on the bench sheet can be used to keep track of the cumulative count. Also, record the life stage of the organisms, the taxonomist's initials and the Taxonomic Certainty Rating (TCR) as a measure of confidence.

4. Use the back of the bench sheet to explain certain TCR ratings or condition of organisms. Other comments can be included to provide additional insights for data interpretation. If QC was performed, record on the back of the bench sheet.

5. For archiving samples, specimen vials, (grouped by station and date), are placed in jars with a small amount of denatured 70% ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70% ethanol).

QUALITY CONTROL (QC) FOR TAXONOMY

1. A voucher collection of all samples and subsamples should be maintained. These specimens should be properly labeled, preserved, and stored in the laboratory for future reference. A taxonomist (the reviewer) not responsible for the original identifications should spot check samples corresponding to the identifications on the bench sheet.

2. The reference collection of each identified taxon should also be maintained and verified by a second taxonomist. The word "val." and the 1st initial and last name of the person validating the identification should be added to the vial label. Specimens sent out for taxonomic validations should be recorded in a "Taxonomy Validation Notebook" showing the label information and the date sent out. Upon return of the specimens, the date received and the finding should also be recorded in the notebook along with the name of the person who performed the validation.

3. Information on samples completed (through the identification process) will be recorded in the "sample log" notebook to track the progress of each sample within the sample lot. Tracking of each sample will be updated as each step is completed (i.e., subsampling and sorting, mounting of midges and worms, taxonomy).

4. A library of basic taxonomic literature is essential in aiding identification of specimens and should be maintained (and updated as needed) in the taxonomic laboratory (see attached list). Taxonomists should participate in periodic training on specific taxonomic groups to ensure accurate identifications.

7.4 BENTHIC METRICS

Benthic metrics have undergone evolutionary developments and are documented in the Invertebrate Community Index (ICI) (DeShon 1995), RBPs (Shackleford 1988, Plafkin et al. 1989, Barbour et al. 1992, 1995, 1996b, Hayslip 1993, Smith and Voshell 1997), and the benthic IBI (Kerans and Karr 1994, Fore et al. 1996). Metrics used in these indices evaluate aspects of both elements and processes within the macroinvertebrate assemblage. Although these indices have been regionally developed, they are typically appropriate over wide geographic areas with minor modification (Barbour et al. 1995).

The process for testing the efficacy and calibrating the metrics is described in Chapter 9. While the candidate metrics described here are ecologically sound, they may require testing on a regional basis. Those metrics that are most effective are those that have a response across a range of human influence (Fore et al. 1996, Karr and Chu 1999). Resh and Jackson (1993) tested the ability of 20 benthic metrics used in 30 different assessment protocols to discriminate between impaired and minimally impaired sites in California. The most effective measures, from their study, were the richness measures, 2 community indices (Margalef's and Hilsenhoff's family biotic index), and a functional feeding group metric (percent scrapers). Resh and Jackson emphasized that both the measures (metrics) and protocols need to be calibrated for different regions of the country, and, perhaps, for different impact types (stressors). In a study of 28 invertebrate metrics, Kerans and Karr (1994) demonstrated significant patterns for 18 metrics and used 13 in their final B-IBI (Benthic Index of Biotic Integrity). Richness measures were useful as were selected trophic and dominance metrics. One of the unique features of the fish IBI presently lacking in benthic indices is the ability to incorporate metrics on individual condition, although measures evaluating chironomid larvae deformities have recently been advocated (Lenat 1993).

Four studies that were published from 1995 through 1997 serve as a basis for the most appropriate candidates for metrics, because the metrics were tested in detail in these studies (DeShon 1995, Barbour et al. 1996b, Fore et al. 1996, Smith and Voshell 1997). These metrics have been evaluated for the ability to distinguish impairment and are recommended as the most likely to be useful in other regions of the country (Table 7-1). Other metrics that are currently in use in various states are listed in Table 7-2 and may be applicable for testing as alternatives or additions to the list in Table 7-1.

Taxa richness, or the number of distinct taxa, represents the diversity within a sample. Use of taxa richness as a key metric in a multimetric index include the ICI (DeShon 1995), the fish IBI (Karr et al. 1986), the benthic IBI (Kerans et al. 1992, Kerans and Karr, 1994), and RBP's (Plafkin et al. 1989, Barbour et al. 1996b). Taxa richness usually consists of species level identifications but can also be evaluated as designated groupings of taxa, often as higher taxonomic groups (i.e., genera, families, orders, etc.) in assessment of invertebrate assemblages. Richness measures reflect the diversity of the aquatic assemblage (Resh et al. 1995). The expected response to increasing perturbation is summarized, as an example, in Table 7-2. Increasing diversity correlates with increasing health of the assemblage and suggests that niche space, habitat, and food source are adequate to support survival and propagation of many species. Number of taxa measures the overall variety of the macroinvertebrate assemblage. No identities of major taxonomic groups are derived from the total taxa metric, but the elimination of taxa from a naturally diverse system can be readily detected. Subsets of "total" taxa richness are also used to accentuate key indicator groupings of organisms. Diversity or variety of taxa within these groups are good indications of the ability of the ecosystem to support varied taxa. Certain indices that focus on a pair-wise site comparison are also included in this richness category.

Table 7-1. Definitions of best candidate benthic metrics and predicted direction of metric response to increasing perturbation (compiled from DeShon 1995, Barbour et al. 1996b, Fore et al. 1996, Smith and Voshell 1997).

Category	Metric	Definition	Predicted response to increasing perturbation
Richness measures	Total No. taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	No. EPT taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa (usually genus or species level)	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa (usually genus of species level)	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa (usually genus or species level)	Decrease
Composition measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/Intolerance measures	No. of Intolerant Taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding measures	% Filterers	Percent of the macrobenthos that filter FPOM from either the water column or sediment	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habit measures	Number of Clinger Taxa	Number of taxa of insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease

Composition measures can be characterized by several classes of information, i.e., the identity, key taxa, and relative abundance. Identity is the knowledge of individual taxa and associated ecological patterns and environmental requirements (Barbour et al. 1995). Key taxa (i.e., those that are of special interest or ecologically important) provide information that is important to the condition of the targeted assemblage. The presence of exotic or nuisance species may be an important aspect of biotic interactions that relate to both identity and sensitivity. Measures of composition (or relative abundance) provide information on the make-up of the assemblage and the relative contribution of the

populations to the total fauna (Table 7-2). Relative, rather than absolute, abundance is used because the relative contribution of individuals to the total fauna (a reflection of interactive principles) is more informative than abundance data on populations without a knowledge of the interaction among taxa (Plafkin et al. 1989, Barbour et al. 1995). The premise is that a healthy and stable assemblage will be relatively consistent in its proportional representation, though individual abundances may vary in magnitude. Percentage of the dominant taxon is a simple measure of redundancy (Plafkin et al. 1989). A high level of redundancy is equated with the dominance of a pollution tolerant organism and a lowered diversity. Several diversity indices, which are measures of information content and incorporate both richness and evenness in their formulas, may function as viable metrics in some cases, but are usually redundant with taxa richness and % dominance (Barbour et al. 1996b).

Table 7-2. Definitions of additional potential benthic metrics and predicted direction of metric response to increasing perturbation.

Category	Metric	Definition	Predicted response to increasing perturbation	References
Richness measures	No. *Pteronarcys* species	The presence or absence of a long-lived stonefly genus (2-3 year life cycle)	Decrease	Fore et al. 1996
	No. Diptera taxa	Number of "true" fly taxa, which includes midges	Decrease	DeShon 1995
	No. Chironomidae taxa	Number of taxa of chironomid (midge) larvae	Decrease	Hayslip 1993, Barbour et al. 1996b
Composition measures	% Plecoptera	Percent of stonefly nymphs	Decrease	Barbour et al. 1994
	% Trichoptera	Percent of caddisfly larvae	Decrease	DeShon 1995
	% Diptera	Percent of all "true" fly larvae	Increase	Barbour et al. 1996b
	% Chironomidae	Percent of midge larvae	Increase	Barbour et al. 1994
	% Tribe Tanytarsini	Percent of Tanytarisinid midges to total fauna	Decrease	DeShon 1995
	% Other Diptera and noninsects	Composite of those organisms generally considered to be tolerant to a wide range of environmental conditions	Increase	DeShon 1995
	% *Corbicula*	Percent of asiatic clam in the benthic assemblage	Increase	Kerans and Karr 1994
	% Oligochaeta	Percent of aquatic worms	Variable	Kerans and Karr 1994
Tolerance/ Intolerance measures	No. Intol. Snail and Mussel species	Number of species of molluscs generally thought to be pollution intolerant	Decrease	Kerans and Karr 1994
	% Sediment Tolerant organisms	Percent of infaunal macrobenthos tolerant of perturbation	Increase	Fore et al. 1996

Table 7-2. Definitions of additional potential benthic metrics and predicted direction of metric response to increasing perturbation (continued).

Category	Metric	Definition	Predicted response to increasing perturbation	References
	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution. Originally designed to evaluate organic pollution	Increase	Barbour et al. 1992, Hayslip 1993, Kerans and Karr 1994
Tolerance/ Intolerance measures (continued)	Florida Index	Weighted sum of intolerant taxa, which are classed as 1 (least tolerant) or 2 (intolerant). Florida Index = 2 X Class 1 taxa + Class 2 taxa	Decrease	Barbour et al. 1996b
	% Hydropsychidae to Trichoptera	Relative abundance of pollution tolerant caddisflies (metric could also be regarded as a composition measure)	Increase	Barbour et al. 1992, Hayslip 1993
Feeding measures	% Omnivores and Scavengers	Percent of generalists in feeding strategies	Increase	Kerans and Karr 1994
	% Ind. Gatherers and Filterers	Percent of collector feeders of CPOM and FPOM	Variable	Kerans and Karr 1994
	% Gatherers	Percent of the macrobenthos that "gather"	Variable	Barbour et al. 1996b
	% Predators	Percent of the predator functional feeding group. Can be made restrictive to exclude omnivores	Variable	Kerans and Karr 1994
	% Shredders	Percent of the macrobenthos that "shreds" leaf litter	Decrease	Barbour et al. 1992, Hayslip 1993
Life cycle measures	% Multivoltine	Percent of organisms having short (several per year) life cycle	Increase	Barbour et al. 1994
	% Univoltine	Percent of organisms relatively long-lived (life cycles of 1 or more years)	Decrease	Barbour et al. 1994

Tolerance/Intolerance measures are intended to be representative of relative sensitivity to perturbation and may include numbers of pollution tolerant and intolerant taxa or percent composition (Barbour et al. 1995). Tolerance is generally non-specific to the type of stressor. However, some metrics such as the Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987, 1988) are oriented toward detection of organic pollution; the Biotic Condition Index (Winget and Mangum 1979) is useful for evaluating sedimentation. The Florida Index (Ross and Jones 1979) is a weighted sum of intolerant taxa (insects and crustaceans) found at a site (Beck 1965) and functions similarly to the HBI (Hilsenhoff 1987) used in other parts of the country. The tolerance/intolerance measures can be independent of taxonomy or can be specifically tailored to taxa that are associated with pollution tolerances. For example, both the percent of Hydropsychidae to total Trichoptera and percent Baetidae to total Ephemeroptera are estimates of evenness within these insect orders that generally are considered to be sensitive to pollution. As these families (i.e., Hydropsychidae and Baetidae) increase in relative abundance, effects of pollution (usually organic) also increase. Density (number of

individuals per some unit of area) is a universal measure used in all kinds of biological studies. Density can be classified with the trophic measures because it is an element of production; however, it is difficult to interpret because it requires careful quantification and is not monotonic in its response (i.e., density can either decrease or increase in response to pollution) and is usually linked to tolerance measures.

Feeding measures or trophic dynamics encompass functional feeding groups and provide information on the balance of feeding strategies (food acquisition and morphology) in the benthic assemblage. Examples involve the feeding orientation of scrapers, shredders, gatherers, filterers, and predators. Trophic dynamics (food types) are also included here and include the relative abundance of herbivores, carnivores, omnivores, and detritivores. Without relatively stable food dynamics, an imbalance in functional feeding groups will result, reflecting stressed conditions. Trophic metrics are surrogates of complex processes such as trophic interaction, production, and food source availability (Karr et al. 1986, Cummins et al. 1989, Plafkin et al. 1989). Specialized feeders, such as scrapers, piercers, and shredders, are the more sensitive organisms and are thought to be well represented in healthy streams. Generalists, such as collectors and filterers, have a broader range of acceptable food materials than specialists (Cummins and Klug 1979), and thus are more tolerant to pollution that might alter availability of certain food. However, filter feeders are also thought to be sensitive in low-gradient streams (Wallace et al. 1977). The usefulness of functional feeding measures for benthic macroinvertebrates has not been well demonstrated. Difficulties with the proper assignment to functional feeding groups has contributed to the inability to consider these reliable metrics (Karr and Chu 1997).

Habit measures are those that denote the mode of existence among the benthic macroinvertebrates. Morphological adaptation among the macroinvertebrate distinguishes the various mechanisms for maintaining position and moving about in the aquatic environment (Merritt et al. 1996). Habit categories include movement and positioning mechanisms such as skaters, planktonic, divers, swimmers, clingers, sprawlers, climbers, burrowers. Merritt et al. (1996) provide an overview of the habit of aquatic insects, which are the primary organisms used in these measures. Habit measures have been found to be more robust than functional feeding groups in some instances (Fore et al. 1996).

7.5 BIOLOGICAL RECONNAISSANCE (BioRecon) OR PROBLEM IDENTIFICATION SURVEY

The use of biological survey techniques can serve as a screening tool for problem identification and/or prioritizing sites for further assessment, monitoring, or protection. The application of biological surveys in site reconnaissance is intended to be expedient, and, as such, requires an experienced and well-trained biologist. Expediency in

FIELD EQUIPMENT/SUPPLIES NEEDED FOR BENTHIC MACROINVERTEBRATE SAMPLING —BIORECON

- standard D-frame dip net, 500 μ opening mesh, 0.3 meter width (~ 1.0 ft frame width)
- sieve bucket, with 500 μ opening mesh
- 95% ethanol
- sample containers
- sample container labels
- forceps
- field data sheets*, pencils, clipboard
- first aid kit
- waders (chest-high or hip boots), rubber gloves (arm-length)
- camera
- Global Positioning System (GPS) Unit

* It is helpful to copy fieldsheets onto water-resistant paper for use in wet weather conditions

this technique is to minimize time spent in the laboratory and with analysis. The "turn-around" time from the biosurvey to an interpretation of findings is intended to be relatively short. The BioRecon is useful in discriminating obviously impaired and non-impaired areas from potentially affected areas requiring further investigation. Use of the BioRecon allows rapid screening of a large number of sites. Areas identified for further study can then either be evaluated using more rigorous bioassessment methods for benthic macroinvertebrates and/or other assemblages, or ambient toxicity methods.

Because the BioRecon involves limited data generation, its effectiveness depends largely on the experience of the professional biologist performing the assessment. The professional biologist should have assessment experience, a knowledge of aquatic ecology, and basic expertise in benthic macroinvertebrate taxonomy.

The BioRecon presented here is refined and standardized from the original RBP I (Plafkin et al. 1989), and is based on the technique developed by Florida DEP (1996), from which the approach derives its name. This biosurvey approach is based on a multihabitat approach similar to the more rigorous technique discussed in Section 7.2. The most productive habitats, i.e., those that contain the greatest diversity and abundance of macroinvertebrates, are sampled in the BioRecon. As a general rule, impairment is judged by richness measures, thereby emphasizing the presence or absence of indicator taxa. Biological attributes such as the relative abundance of certain taxa may be less useful than richness measures in the BioRecon approach, because samples are processed more quickly and in a less standardized manner.

7.5.1 Sampling, Processing, and Analysis Procedures

1. A 100 m reach representative of the characteristics of the stream should be selected. For the BioRecon, it is unlikely that the alternative reach designation approach (i.e., x times the stream width), will improve the resolution beyond a standard 100 m reach. Whenever possible, the area should be at least 100 meters upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality. There should be no major tributaries discharging to the stream in the study area.

2. Before sampling, complete the "Physical Characterization/Water Quality Field Data Sheet" (Appendix A-1, Form 1) to document site description, weather conditions, and land use. After sampling, review this information for accuracy and completeness.

3. The major habitat types (see 7.2.1 for habitat descriptions) represented in the reach are to be sampled for macroinvertebrates. A total of 4 jabs or kicks will be taken over the length of the reach. A minimum of 1 jab (or kick) is to be taken in each habitat. More than 1 jab may be desired in those habitats that are predominant. Habitat types contributing less than five percent of the stable habitat in the stream reach should not be sampled. Thus, allocate the remaining jabs proportionately among the predominant substrates. The number of jabs taken in each habitat type should be recorded on the field data sheet.

4. Sampling begins at the downstream end of the reach and proceeds upstream. A total of four jabs or kicks will be taken over the length of the reach; a single *jab* consists of forcefully thrusting the net into a productive habitat for a linear distance of 0.5 m. A *kick* is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance of 0.5 m upstream of the net.

5. The jabs or kicks collected from the multiple habitats will be composited into a sieve bucket to obtain a single homogeneous sample. If clogging occurs, discard the material in the net and redo that portion of the sample in the same habitat type but in a different location. Remove large debris after rinsing and inspecting it for organisms; place any organisms found into the sieve bucket.

6. Return to the bank with the sampled material for sorting and organism identifications. Alternatively, the material can be preserved in alcohol and returned to the laboratory for processing (see Step 7 in Section 7.1.1 for instructions).

7. Transfer the sample from the sieve bucket (or sample jar, if in laboratory) to a white enamel or plastic pan. A second, smaller, white pan may be used for the actual sorting. Place small aliquots of the detritus plus organisms in the smaller pan diluted with a minimal amount of site water (or tap water). Scan the detritus and water for organisms. When an organism is found, examine it with a hard lens, determine its identity to the lowest possible level (usually family or genus), and record it on the Preliminary Assessment Score Sheet (PASS) (Appendix A-3, Form 4) in the column labeled "tally." Place representatives of each taxon in a vial, properly labeled and containing alcohol.

QUALITY CONTROL (QC)

1. Sample labels must be properly completed, including the sample identification code date, stream name, sampling location, and collector's name and placed into the sample container. The outside of the container should be labeled with the same information. Chain-of-custody forms, if needed, must include the same information as the sample container labels.

2. After sampling has been completed at a given site, all nets, pans, etc. that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers. The equipment should be examined again prior to use at the next sampling site.

3. A second biologist familiar with the recognition and taxonomy of the organisms should check the sample to ensure all taxa are encountered and documented.

8. If field identifications are conducted, verify in the lab and make appropriate changes for misidentifications.

9. Analysis is done by determining the value of each metric and comparing to a predetermined value for the associated stream class. These value thresholds should be sufficiently conservative so that "good" conditions or non-impairment is verified. Sites with metric values below the threshold(s) are considered "suspect" of impairment and may warrant further investigation. These simple calculations can be done directly on the PASS sheet.

7.6 TAXONOMIC REFERENCES FOR MACROINVERTEBRATES

The following references are provided as a list of taxonomic references currently being used around the United States for identification of benthic macroinvertebrates. Any of these references cited in the text of this document will also be found in Chapter 11 (Literature Cited).

Allen, R.K. 1978. The nymphs of North and Central American Leptohyphes. *Entomological Society of America* 71(4):537-558.

Allen, R.K. and G.F. Edmunds. 1965. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). VIII. The subgenus *Ephemerella* in North America. *Miscellaneous Publications of the Entomological Society of America* 4:243-282.

Allen, R.K. and G.F. Edmunds. 1963. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). VI. The subgenus *Seratella* in North America. *Annals of the Entomological Society of America* 56:583-600.

Allen, R.K. and G.F. Edmunds. 1963. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). VII. The subgenus *Eurylophella*. *Canadian Entomologist* 95:597-623.

Allen, R.K. and G.F. Edmunds. 1962. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). V. The subgenus *Drunella* in North America. *Miscellaneous Publications of the Entomological Society of America* 3:583-600.

Allen, R.K. and G.F. Edmunds. 1961. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). III. The subgenus *Attenuatella*. *Journal of the Kansas Entomological Society* 34:161-173.

Allen, R.K. and G.F. Edmunds. 1961. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). II. The subgenus *Caudatella*. *Annals of the Entomological Society of America* 54:603-612.

Allen, R.K. and G.F. Edmunds. 1959. A revision of the genus *Ephemerella* (Ephemeroptera: Ephemerellidae). I. The subgenus *Timpanoga*. *The Canadian Entomologist* 91:51-58.

Anderson, N.H. 1976. The distribution and biology of the Oregon Trichoptera. *Oregon Agricultural Experimental Station Technical Bulletin* 134:1-152.

Barr, C.B. and J.B. Chapin. 1988. The Aquatic Dryopoidea of Louisiana (Coleoptera:Psepheniae, Dryopidae, Elmidae). *Tulane Studies in Zoology and Botany* 26:89-164.

Baumann, R.W. 1975. Revision of the Stonefly Family Nemouridae (Plecoptera): A Study of the World Fauna at the Generic Level. *Smithsonian Contributions to Zoology* 211. 74 pp.

Baumann, R.W., A.R. Gaufin, and R.F. Surdick. 1977. The stoneflies (Plecoptera) of the Rocky Mountains. *Memoirs of the American Entomological Society* 31:1-208.

Beck, E.C. 1962. Five new Chironomidae (Diptera) from Florida. *Florida Entomologist* 45:89-92.

Beck, W.M., Jr. and E.C. Beck. 1970. The immature stages of some Chironomini (Chironomidae). *Quarterly Journal of the Academy of Biological Science* 33:29-42.

Beck, E.C. and W.M. Beck, Jr. 1969. Chironomidae (Diptera) of Florida. III. The *Harnischia* complex (Chironomidae). Bulletin of the Florida State Museum of Biological Sciences 13:277-313.
Beck, W.M. and E.C. Beck. 1964. New Chironomidae from Florida. *Florida Entomologist.* 47:201-207.

Beck, W.M., Jr. and E.C. Beck. 1966. Chironomidae (Diptera) of Florida. I. Pentaneurini (Tanypodinae). *Bulletin of the Florida State Museum* 10: 305-379.

Bednarik, A.F. and W.P. McCafferty. 1979. Biosystematic revision of the genus *Stenonema* (Ephemeroptera:Heptageniidae). *Canadian Bulletin of Fisheries and Aquatic Sciences* 201:1-73.

Bergman, E.A. and W.L. Hilsenhoff. 1978. *Baetis* (Ephemeroptera:Baetidae) of Wisconsin. *The Great Lakes Entomologist* 11:125-35.

Berner, L. 1977. Distributional patterns of southeastern mayflies (Ephemeroptera). *Bulletin of the Florida State Museum of Biological Sciences* 22:1-55.

Berner, L. 1975. The Mayfly Family Leptophlebiidae in the Southeastern United States. *The Florida Entomologist* 58:137-156.

Berner, L. 1956. The genus *neoephemera* in North America (Ephemeroptera:Neoephemeridae). *Entomological Society of America* 49:33-42.

Berner, L. and M.L. Pescador. 1988. *The Mayflies of Florida*. University Presses of Florida. Pp. 415.

Boesel, M.W. 1985. A brief review of the genus *Polypedilum* in Ohio, with keys to the known stages of species occuring in Northeastern United States (Diptera:Chironomidae). *Ohio Journal of Science* 85:245-262.

Boesel, M.W. 1983. A review of the genus *Cricotopus* in Ohio, with a key to adults of species in the northeastern United States (Diptera:Chironomidae). *Ohio Journal of Science* 83:74-90.

Boesel, M.W. 1974. Observations on the Coelotanypodini of the northeastern states, with keys to the known stages (Diptera: Chironomidae: Tanypodinae). *Journal of the Kansas Entomology Society* 47:417-432.

Boesel, M.W. 1972. The early stages of *Ablabesmyia annulata* (Say) (Diptera:Chironomidae). *Ohio Journal of Science* 72:170-173.

Boesel, M.W. and R.W. Winner. 1980. Corynoneurinae of Northeastern United States, with a key to adults and observations on their occurrence in Ohio (Diptera:Chironomidae). *Journal of the Kansas Entomology Society* 53:501-508.

Brigham, A.R., W.U. Brigham, and A. Gnilka (eds.). 1982. *Aquatic insects and Oligochaetes of North and South Carolina*. Midwest Aquatic Enterprises, Mahomet, IL.

Brinkhurst, R.O. 1986. Guide to the freshwater microdrile Oligochaetes of North America. *Canada Special Publications Fisheries Aquatic Science* 84:1-259.

Brinkhurst, R.O. and B.G.M. Jamieson. 1971. *Aquatic Oligochaeta of the World*. Univ. Toronto Press, 860 pp.

Brittain, J.E. 1982. Biology of Mayflies. *Annual Review of Entomology* 27:119-147.

Brown, H.P. 1987. Biology of riffle beetles. *Annual Review of Entomology* 32:253-273.

Brown, H.P. 1976. *Aquatic dryopoid beetles (Coleoptera) of the United States*. USEPA. Water Pollution Control Research Series 18050 ELD04/72.

Brown, H.P. 1972. *Aquatic dryopoid beetles (Coleoptera) of the United States*. Biota of freshwater ecosystems identification manual no. 6. Water Pollution Control Research Series, EPA, Washington, D.C.

Brown, H.P. and D.S. White. 1978. Notes on Separation and Identification of North American Riffle Beetles (Coleoptera:Dryopoidea:Elmidae). *Entomological News* 89:1-13.

Burch, J.B. 1982. *Freshwater snails (Mollusca: Gastropoda) of North America*. EPA-600/3-82-026. USEPA, Office of Research and Development, Cincinnati, Ohio.

Burch, J.B. 1972. *Freshwater sphaeriacean clams (Mollusca: Pelecypoda) of North America*. EPA Biota of freshwater ecosystems identification manual No. 3. Water Pollution Control Research Series, EPA, Washington, DC.

Caldwell, B.A. 1986. Description of the immature stages and adult female of *Unniella multivirga* Saether (Diptera: Chironomidae) with comments on phylogeny. *Aquatic Insects* 8:217-222.

Caldwell, B.A. 1985. *Paracricotopus millrockensis,* a new species of Orthocladiinae (Diptera: Chironomidae) from the southeastern United States. *Brimleyana* 11:161-168.

Caldwell, B.A. 1984. Two new species and records of other chironomids from Georgia (Diptera: Chironomidae) with some observations on ecology. *Georgia Journal of Science* 42:81-96.

Caldwell, B.A. and A.R. Soponis. 1982. *Hudsonimyia parrishi,* a new species of Tanypodinae (Diptera: Chironomidae) from Georgia. *Florida Entomologist* 65:506-513.

Carle, F.L. 1978. A New Species of *Ameletus* (Ephemeroptera:Siphlonuriae) from Western Virginia. *Entomological Society of America* 71:581-584.

Carle, F.L. and P.A. Lewis. 1978. A new species of *Stenonema* (Ephemeroptera:Heptageniidae) from Eastern North America. *Annals of the Entomological Society of America* 71:285-288.

Clark, W. 1996. *Literature pertaining to the identification and distribution of aquatic macroinvertebrates of the Western U.S. with emphasis on Idaho*. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, Idaho.

Cranston, P.S. 1982. *A key to the larvae of the British Orthocladiinae (Chironomidae)*. Freshwater Biological Association Scientific Publication No. 45:1-152.

Cranston, P.S. and D.D. Judd. 1987. *Metriocnemus* (Diptera: Chironomidae)-an ecological survey and description of a new species. *Journal New York Entomology Society* 95:534-546.

Cummins, K.W. and M.A. Wilzbach. 1985. *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates*. Contribution 1611. Appalachian Environmental Laboratory, University of Maryland, Frostburg, Maryland.

Davis, J.R. 1982. New records of aquatic Oligochaeta from Texas, with observations on their ecological characteristics. *Hydrobiologia* 96:15-29.

Edmunds, G.F. and R.K. Allen. 1964. The Rocky Mountain species of *Epeorus* (Iron) Eaton (Ephemeroptera: Heptageniidae). *Journal of the Kansas Entomological Society*. 37:275-288.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. *The mayflies of North and Central America.* University of Minnesota Press, Minneapolis.

Epler, J.H. 1988. Biosystematics of the genus *Dicrotendipes* Kieffer, 1913 (Diptera: Chironomidae: Chironominae) of the world. *Memoirs of the American Entomology Society* 36:1-214.

Epler, J.H. 1987. Revision of the nearctic *Dicrotendipes* Kieffer, 1913 (Diptera: Chironomidae). *Evolutionary Monographs*: 1-101.

Etnier, D.A. and G.A. Schuster. 1979. An annotated list of Trichoptera (Caddisflies) of Tennessee. *Journal of the Tennessee Academy of Science* 54:15-22.

Faulkner, G.M. and D.C. Tarter. 1977. Mayflies, or Ephemeroptera, of West Virginia with emphasis on the nymphal stage. *Entomological News* 88:202-206.

Ferrington, L.C. 1987. *Collection and identification of floating exuviae of Chironomidae for use in studies of surface water quality*. SOP No. FW 130A. U.S. Environmental Protection Agency, Region VII, Kansas City, Kansas.

Flint, O.S. 1984. *The genus Brachycentrus in North America, with a proposed phylogeny of the genera of Brachycentridae (Trichoptera)*. Smithsonian Contributions to Zoology.

Flint, O.S. Jr. 1964. Notes on some nearctic Psychomyiidae with special reference to their larvae (Trichoptera). *Proceeding of the United States National Museum* 115:467-481.

Flint, O.S. Jr. 1962. The immature stages of *Paleagapetus celsus* Ross (Trichoptera: Hydroptilidae). *Bulletin of the Brooklyn Entomological Society* LVII:40-44.

Flint, O.S. Jr. 1962, Larvae of the caddis fly genus *Rhyacophila* in Eastern North America (Trichoptera: Rhyacophilidae). *Proceedings of the United States National Museum* 113:465-493.

Flint, O.S. Jr. 1960. Taxonomy and biology of nearctic limnephilid larvae (Trichoptera), with special reference to species in Eastern United States. *Entomologicia Americana* XL:1-117.

Flowers, R.W. 1980. Two new genera of nearctic Heptageniidae (Ephemeroptera). *The Florida Entomologist*. 63:296-307.

Flowers, R.W. and W.L. Hilsenhoff. 1975. Heptageniidae (Ephemeroptera) of Wisconsin. *The Great Lakes Entomologist* 8:201-218.

Floyd, M.A. 1995. *Larvae of the caddisfly genus Oecetis (Trichoptera: Leptocerida) in North America*. Bulletin of the Ohio Biological Survey.

Fullington, K.E. and K.W. Stewart. 1980. Nymphs of the stonefly genus *Taeniopteryx* (Plecoptera: Taeniopterygidae) of North America. *Journal of the Kansas Entomological Society* 53(2):237-259.

Givens, D.R. and S.D. Smith. 1980. A synopsis of the western Arctopsychinae (Trichoptera: Hydropsychidae). *Melanderia* 35:1-24.

Grodhaus, G. 1987. Endochironmus Kieffer, Tribelos Townes, Synendotendipes, n. ge., and Endotribelos, n. gen. (Diptera: Chironomidae) of the nearctic region. *Journal of the Kansas Entomological Society* 60:167-247.

Hamilton, A.L. and O.A. Saether. 1969. A classification of the nearctic Chironomidae. *Journal of the Fisheries Research Board of Canada* Technical Report 124:1-42.

Hatch, M.H. 1965. *The beetles of the Pacific Northwest, Part IV, Macrodactyles, Palpicornes, and Heteromera.* University of Washington Publications in Biology, Volume 16.

Hatch, M.H. 1953. *The beetles of the Pacific Northwest, Part I, Introduction and Adephaga*. University of Washington Publications in Biology, Volume 16.

Hilsenhoff, W.L. 1973. Notes on *Dubiraphia* (Coleoptera: Elmidae) with descriptions of five new species. *Annals of the Entomolgical Society of America* 66:55-61.

Hitchcock, S.W. 1974. Guide to the insects of Connecticut: Part VII. The Plecoptera or stoneflies of Connecticut. *State Geological and Natural History Survey of Connecticut Bulletin* 107:191-211.

Hobbs, H.H., Jr. 1981. The crayfishes of Georgia. *Smithsonian Contribution in Zoology* 318:1-549.

Hobbs, H.H., Jr. 1972. *Crayfishes (Astacidae) of North and Middle America*. Biota of freshwater ecosystems identification manual no. 9. Water Pollution Control Research Series, E.P.A., Washington, D.C.

Holsinger, J.R. 1972. *The freshwater amphipod crustaceans (Gammaridae) of North America*. Biota of freshwater ecosystems identification manual no. 5. Water Pollution Control Research Series, E.P.A., Washington, D.C.

Hudson, P.A. 1971. The Chironomidae (Diptera) of South Dakota. *Proceedings of the South Dakota Academy of Sciences* 50:155-174.

Hudson, P.A., D.R. Lenat, B.A. Caldwell, and D. Smith. 1990. Chironomidae of the southeastern United States: a checklist of species and notes on biology, distribution, and habitat. *Fish and Wildlife Research.* 7:1-46.

Hudson, P.L., J.C.Morse, and J.R. Voshell. 1981. Larva and pupa of *Cernotina spicata*. *Annals of the Entomological Society of America* 74:516 -519

Jackson, G.A. 1977. Nearctic and palaearctic *Paracladopelma* Harnisch and *Saetheria* n.ge. (Diptera:Chironomidae). *Journal of the Fisheries Research Board of Canada* 34:1321-1359.

Jensen, S.L. 1966. *The mayflies of Idaho*. Unpublished Master's Thesis, University of Utah.

Kenk, R. 1972. *Freshwater planarians (Turbellaria) of North America*. Biota of freshwater ecosystems identification manual no. 1. Water Pollution Control Research Series, U.S. Environmental Protection Agency, Washington, D.C.

Kirchner, R.F. and B.C. Kondratieff. 1985. The nymph of *Hansonoperla appalachia* Nelson (Plecoptera: Perlidae). *Proceedings of the Entomological Society of Washington*. 87(3):593-596.

Kirchner, R.F. and P.P. Harper. 1983. The nymph of *Bolotoperla rossi* (Frison) (Plecoptera: Taeniopterygidae: Brachypterinae). *Journal of the Kansas Entomological Society* 56(3): 411-414.

Kirk, V.M. 1970. A list of beetles of South Carolina, Part 2-Mountain, Piedmont, and Southern Coastal Plain. *South Carolina Agricultural Experiment Station Technical Bulletin* 1038:1-117.

Kirk, V.M. 1969. A list of beetles of South Carolina, Part 1-Northern Coastal Plain. *South Carolina Agricultural Experiment Station Technical Bulletin* 1033:1-124.

Klemm, D.J. 1982. *Leeches (Annelida:Hirudinea) of North America*. EPA-600/3-82-025. Office of Research and Development, Cincinnati, Ohio.

Klemm, D.J. 1972. *Freshwater leeches (Annelida: Hirudinea) of North America*. Biota of freshwater ecosystems identification manual no. 8. Water Pollution Control Research Series, U.S. Environmental Protection Agency, Washington, D.C.

Kondratieff, B.C. 1981. Seasonal distributions of mayflies (Ephemeroptera) in two piedmont rivers in Virginia. *Entomological News* 92:189-195.

Kondratieff, B.C. and R.F. Kirchner. 1984. New species of *Taeniopteryx* (Plecoptera: Taeniopterygidae) from South Carolina. *Annals of the Entomological Society of America* 77(6):733-736.

Kondratieff, B.C. and R.F. Kirchner. 1982. *Taeniopteryx nelsoni*, a new species of winter stonefly from Virginia (Plecoptera: Taeniopterygidae). *Journal of the Kansas Entomological Society* 55(1):1-7.

Kondratieff, B.C. and J.R. Voshell, Jr. 1984. The north and Central American species of *Isonychia* (Epnemeroptera: Oligoneuriidae). *Transactions of the American Entomological Society.* 110:129-244.

Kondratieff, B.C. and J.R. Voshell, Jr. 1983. A checklist of mayflies (Ephemeroptera) of Virginia, with a review of pertinent taxonomic literature. *University of Georgia Entomology Society* 18:213-279.

Kondratieff, B.C, R.F. Kirchner and K.W. Stewart. 1988. A review of *Perlinella* Banks (Plecoptera: Perlidae). *Annals of the Entomological Society of America* 81(1):19-27.

Kondratieff, B.C., J.W.W. Foster, III, and J.R. Voshell, Jr. 1981. Description of the Adult of *Ephemerella berneri* Allen and Edmunds (Ephemeroptera: Ephemerellidae). *Biological Notes.* 83(2):300-303.

Kondratieff, B.C., R.F. Kirchner and J.R. Voshell Jr. 1981. Nymphs of *Diploperla. Annals of the Entomological Society of America* 74:428-430.

Lago, P.K. & S.C. Harris. 1987. The *Chimarra* (Trichoptera: Philopotamidae) of eastern North America with descriptions of three new species. *Journal of the New York Entomological Society* 95:225-251.

Larson, D.J. 1989. Revision of North American *Agabus* (Coleoptera: Dytiscidae): introduction, key to species groups, and classification of the *ambiguus*-, *tristis*-, and *arcticus*-groups. *The Canadian Entomologist* 121:861-919.

Lenat, D.R. and D.L. Penrose. 1987. New distribution records for North Carolina macroinvertebrates. *Entomological News* 98:67-73.

LeSage, L. and A.D. Harrison. 1980. Taxonomy of *Cricotopus* species (diptera: Chironomidae) from Salem Creek, Ontario. *Proceedings of the Entomological Society of Ontario* 111:57-114.

Lewis, P.A. 1974. Three new Stenonema species from Eastern North America (Heptageniidae: Ephemeroptera). *Proceedings of the Entomological Society of Washington* 76:347-355.

Loden, M.S. 1978. A revision of the genus *Psammoryctides* (Oligochaeta: Tubificidae) in North America. *Proceedings of the Biological Society of Washington* 91:74-84.

Loden, M.S. 1977. Two new species of *Limnodrilus* (Oligochaeta: Tubificidae) from the Southeastern United States. *Transactions of the American Microscopal Society* 96:321-326.

Mackay, R.J. 1978. Larval identification and instar association in some species of *Hydropsyche* and *Cheumatopsyche* (Trichoptera: Hydropsychidae). *Annals of the Entomological Society of America* 71:499-509.

Mason, P.G. 1985. The larvae and pupae of *Stictochironomus marmoreus* and *S. quagga* (Diptera: Chironomidae). *Canadian Entomologist* 117:43-48.

Mason, P.G. 1985. The larvae of *Tvetenia vitracies* (Saether) (Diptera: Chironomidae). *Proceedings of the Entomological Society of Washington* 87:418-420.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood (coords.). 1989. *Manual of nearctic Diptera, Vol. 3*. Research Branch of Agriculture Canada, Monograph 28.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood (coords.). 1987. *Manual of nearctic Diptera, Vol. 2*. Research Branch of Agriculture Canada, Monograph 28.

McAlpine, J.F., B.V. Peterson, G.E. Shewell, H.J. Teskey, J.R. Vockeroth, and D.M. Wood (coords.). 1981. *Manual of nearctic Diptera, Vol. 1*. Research Branch of Agriculture Canada, Monograph 27.

McCafferty, W.P. 1990. A new species of *Stenonema* (Ephemeroptera: Heptageniidae) from North Carolina. *Proceedings of the Entomological Society of Washington* 92:760-764.

McCafferty, W.P. 1984. The relationship between North and Middle American *Stenonema* (Ephemeroptera: Heptageniidae). *The Great Lakes Entomologist* 17:125-128.

McCafferty, W.P. 1977. Newly associated larvae of three species of *Heptagenia* (Ephemeroptera: Heptageniidae). *Journal of the Georgia Entomology Society*. 12(4):350-358.

McCafferty, W.P. 1977. Biosystematic of *Dannella* and Related Subgenera of *Ephemerella* (Ephemeroptera: Ephemerellidae). *Annals of the Entomological Society of America* 70:881-889.

McCafferty, W.P. 1975. The burrowing mayflies (Epnemeroptera: Ephemeroidea) of the United States. *Transactions of the American Entomological Society* 101:447-504.

McCafferty, W.P. and Y.J. Bae. 1990. *Anthopotamus,* a new genus for North American species previously known as *Potamanthus* (Ephemeroptera: Potamanthidae). *Entomological News* 101(4):200-202.

McCafferty, W.P., M.J. Wigle, and R.D. Waltz. 1994. Contributions to the taxonomy and biology of *Acentrella turbida* (McDunnough) (Ephemeroptera: Baetidae). *Pan-Pacific Insects* 70:301-308.

Merritt, R.W. and K.W. Cummins (editors). 1996. *An introduction to the aquatic insects of North America, 3rd ed.* Kendall/Hunt Publishing Company, Dubuque, Iowa.

Merritt, R.W., D.H. Ross, and B.V. Perterson. 1978. Larval ecology of some lower Michigan blackflies (Diptera: Simuliidae) with keys to the immature stages. *Great Lakes Entomologist* 11:177-208.

Milligan, M.R. 1986. Separation of *Haber speciosus* (Hrabe) (Oligochaeta: Tubificidae) from its congeners, with a description of a new form from North America. *Proceedings of the Biological Society of Washington* 99:406-416.

Moore, J.W. and I.A. Moore. 1978. Descriptions of the larvae of four species of *Procladius* from Great Slave Lake (Chironomidae: Diptera). *Canadian Journal of Zoology* 56:2055-2057.

Morihara, D.K. and .W.P. McCafferty. 1979. The *Baetis* larvae of North America (Ephemeroptera: Baetidae). *Transactions of the American Entomological Society* 105:139-221.

Murray, D.A. and P. Ashe. 1981. A description of the larvae and pupa of *Eurycnemus crassipes* (panzer) (Diptera: Chironomidae) *Entomologica Scandinavica* 12:357-361.

Nelson, H.G. 1981. Notes on Nearctic Helichus (Coleoptera: Drypodidae). *Pan-Pacific Entomologist Vol 57*:226-227.

Oliver, D.R. 1982. *Xylotopus,* a new genus of Orthocladiinae (Diptera: Chironomidae). *Canadian Entomologist* 114:163-164.

Oliver, D.R. 1981. Description of Euryhapsis new genus including three new species (Diptera: Chironomidae). *Canadian Entomologist* 113:711-722.

Oliver, D.R. 1977. Bicinctus-group of the genus *Cricotopus* Van der Wulp (Diptera: Chironomidae) in the nearctic with a description of a new species. *Journal of the Fisheries Research Board of Canada* 34:98-104

Oliver, D.R. 1971. Description of *Einfeldia synchrona* n.sp. (Diptera: Chironomidae) *Canadian Entomologist* 103:1591-1595.

Oliver, D.R. and R.W. Bode. 1985. Description of the larvae and pupa of *Cardiocladius albiplumus* Saether (Diptera: Chironomidae). *Canadian Entomologist* 117:803-809.

Oliver, D.R. and M.E. Roussel. 1982. The larvae of *Pagastia* Oliver (Diptera: Chironomidae) with descriptions of the three nearctic species. *Canadian Entomologist* 114:849-854.

Parker, C.R. and G.B. Wiggins. 1987. *Revision of the caddisfly genus Psilotreta (Trichoptera: Odontoceridae)* Royal Ontario Museum Life Sciences Contributions 144. 55pp.

Pennak, R.W. 1989. *Freshwater invertebrates of the United States, 3rd ed.* J. Wiley & Sons, New York.

Pescador, M.L. 1985. Systematics of the nearctic genus *Pseudiron* (Ephemeroptera: Heptageniidae: Pseudironinae). *The Florida Entomologist* 68:432-444.

Pescador, M. L. and L. Berner. 1980. The mayfly family Baetiscidae (Ephemeroptera). Part II Biosystematics of the Genus *Baetisca. Transactions American Entomological Society* 107:163-228.

Pescador, M.L. and W.L. Peters. 1980. A Revisions of the Genus *Homoeoneuria* (Ephemeroptera: Oligoneuriidae). *Transactions of the American Entomological Society* 106:357-393.

Plotnikoff, R.W. 1994. *Instream biological assessment monitoring protocols: benthic macroinvertebrates.* Washington State Department of Ecology, Environmental Investigations and Laboratory Services, Olympia, Washington, Ecology Publication No. 94-113.

Provonsha, A.V. 1991. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). *Transactions of the American Entomological Society* 116:801-884.

Provonsha, A.V. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). *Transactions of the American Entomological Society* 116(4):801-884.

Resh, V.H. 1976. The biology and immature stages of the caddisfly genus *Ceraclea* in eastern North America (Trichoptera: Leptoceridae). *Annals of the Entomological Society of America* 69:1039-1061.

Ricker, W.E. and H.H. Ross. 1968. North American species of *Taeniopteryx* (Plecoptera, Insecta). *Journal Fisheries Research Board of Canada*. 25(7):1423-1439.

Roback, S.S. 1987. The immature chironomids of the eastern United States IX. Pentaneurini - Genus *Labrundinia* with the description of a new species from Kansas. *Proceedings of the Academy of Natural Sciences in Philadelphia* 138:443-465.

Roback, S.S. 1986. The immature chironomids of the eastern United States VII. Pentaneurini - Genus *Nilotanypus*, with description of some neotropical material. *Proceedings of the Academy of Natural Sciences in Philadelphia* 139:159-209.

Roback, S.S. 1986. The immature chironomids of the Eastern United States VII. Pentaneurini - Genus *Monopelopia*, with redescriptions of the male adults and description of some neotropical material. *Proceedings of the Academy of Natural Sciences in Philadelphia* 138:350-365.

Roback, S.S. 1985. The immature chironomids of the eastern United States VI. Pentaneurini - Genus *Ablabesmyia*. *Proceedings of the Academy of Natural Sciences in Philadelphia* 137:153-212.

Roback, S.S. 1983. *Krenopelopia hudsoni:* a new species from the Eastern United States (Diptera: Chironomidae: Tanypodinae). *Proceedings of the Academy of Natural Sciences in Philadelphia* 135:254-260.

Roback, S.S. 1981. The immature chironomids of the Eastern United States V. Pentaneurini-Thienemannimyia group. *Proceedings of the Academy of Natural Sciences in Philadelphia* 133:73-128.

Roback, S.S. 1980. The immature chironomids of the Eastern United States IV. Tanypodinae-Procladiini. *Proceedings of the Academy of Natural Sciences in Philadelphia* 132:1-63.

Roback, S.S. 1978. The immature chironomids of the eastern United States III. Tanypodinae-Anatopyniini, Macropelopiini and Natarsiini. *Proceedings of the Academy of Natural Sciences in Philadelphia* 129:151-202.

Roback, S.S. 1977. The immature chironomids of the eastern United States II. Tanypodinae - Tanypodini. *Proceedings of the Academy of Natural Sciences in Philadelphia* 128:55-87.

Roback, S.S. 1976. The immature chironomids of the eastern United States I. Introduction and Tanypodinae-Coelotanypodini. *Proceedings of the Academy of Natural Sciences in Philadelphia* 127:147-201.

Roback, S.S. 1975. New Rhyacophilidae records with some water quality data. *Proceedings of the Academy of Natural Sciences of Philadelphia* 127:45-50.

Roback, S.S. and W.P. Coffman. 1983. Results of the Catherwood Bolivian-Peruvian Altiplano expedition Part II. Aquatic Diptera including montane Diamesinae and Orthocladiinae (Chironomidae) from Venezuela. *Proceedings of the Academy of Natural Sciences in Philadelphia 135:9-79.*

Roback, S.S. and L.C. Ferrington, Jr. 1983. The immature stages of *Thienemannimyia barberi* (Coquillett) (Diptera: Chironomidae: Tanypodinae). *Freshwater Invertebrate Biology* 5:107-111.

Ruiter, D.E. 1995. The adult *Limnephilus* Leach (Trichoptera: Limnephiliae) of the New World. *Bulletin of the Ohio Biological Survey*, New Series 11 no. 1.

Saether, O.A. 1983. The larvae of *Prodiamesinae* (Diptera: Chironomidae) of the holarctic region - keys and diagnoses. *Entomologica Scandinavica Supplement* 19:141-147.

Saether, O.A. 1982. Orthocladiinae (Diptera: Chironomidae) from the SE U.S.A., with descriptions of *Plhudsonia, Unniella* and *Platysmittia* n. genera and *Atelopodella* n. subgen. *Entomologica Scandinanvia Supplement* 13:465-510.

Saether, O.A. 1980. Glossary of chironomid morphology terminology (Diptera: Chironomidae) *Entomologica Scandinanvica Supplement* 14:1-51.

Saether, O.A. 1977. Taxonomic studies on Chironomidae: *Nanocladius, Pseudochironomus,* and the *Harnischia* complex. *Bulletin of the Fisheries Research Board of Canada* 196:1-143.

Saether, O.A. 1976. Revision of *Hydrobaenus, Trissocladius, Zalutschia, Paratrissocladius,* and some related genera (Diptera: Chironomidae). *Bulletin of the Fisheries Research Board of Canada* 195:1-287.

Saether, O.A. 1975. Nearctic and Palaearctic *Heterotrissocladius* (Diptera:Chironomidae). *Bulletin of the Fisheries Research Board of Canada* 193:1-67.

Saether, O.A. 1975. Twelve new species of *Limnophyes* Eaton, with keys to nearctic males of the genus (Diptera: Chironomidae). *Canadian Entomologist* 107:1029-1056.

Saether, O.A. 1975. Two new species of *Protanypus* Kieffer, with keys to nearctic and palaearctic species of the genus (Diptera: Chironomidae). *Journal of the Fisheries Research Board of Canada* 32:367-388.

Saether, O.A. 1973. Four species of *Bryophaenocladius* Thien., with notes on other Orthocladiinae (Diptera: Chironomidae). *Canadian Entomologist* 105:51-60.

Saether, O.A. 1971. Four new and unusual Chironomidae (Diptera). *Canadian Entomologist* 103:1799-1827.

Saether, O.A. 1971. Nomenclature and phylogeny of the genus *Harnischia* (Diptera: Chironomidae). *Canadian Entomologist* 103:347-362.

Saether, O.A. 1971. Notes on general morphology and terminology of the Chironomidae (Diptera). *Canadian Entomologist* 103:1237-1260.

Saether, O.A. 1969. Some nearctic Podonominae, Diamesinae, and Orthocladiinae (Diptera: Chironomidae) *Bulletin of the Fisheries Research Board of Canada* 170:1-154.

Sawyer, R.T. and R.M. Shelley. 1976. New records and species of leeches (Annelida: Hirudinea) from North and South Carolina. *Journal of Natural History* 10:65-97.

Schefter, P.W. and G.B. Wiggins. 1986. *A systematic study of a the nearctic larvae of the Hydropsyche morosa group (Trichoptera: Hydropsychidae).* Miscellaneous Publications of the Royal Ontario Museum, Toronto, Canada.

Schmid, F. 1970. Le genre *Rhyacophila* et le famille des Rhyacophilidae (Trichoptera). *Memoirs of the Entomological Society of Canada* 66:1-230.

Schuster, G.A. and D.A. Etnier. 1978. *A manual for the identification of the larvae of the caddisfly genera Hydropsyche Pictet and Symphitopsyche Ulmer in eastern and central North America* (Trichoptera: Hydropsychidae). EPA-600/4-78-060.

Sherberger, F.F. and J.B. Wallace. 1971. Larvae of the southeastern species of *Molanna*. *Journal of the Kansas Entomological Society* 44:217-224.

Simpson, K.W. 1982. A guide to the basic taxonomic literature for the genera of North American Chironomidae (Diptera) - Adults, pupae, and larvae. *New York State Museum Bulletin* No.447: 1-43.

Simpson, K. W. and R.W. Bode. 1980. Common larvae of Chironomidae (Diptera) from New York State streams and rivers. *New York State Museum Bulletin* 439:1-105.

Smith, S.D., unpublished 1995. *Revision of the genus Rhyacophilia* (Trichoptera: Rhyacophilidae). Central Washington University, Ellensburg, Washington.

Smith, S.D. 1985. Studies of Nearctic *Rhyacophila* (Trichoptera: Rhyacophilidae): Synopsis of *Rhyacophila Nevadensis* Group. *Pan-Pacific Entomologist* 61:210-217.

Smith, S.D. 1968. The *Rhyacophila* of the Salmon River drainage of Idaho with special reference to larvae. *Annals of the Entomological Society of America* 61:655-674.

Soponis, A.R. and C.L. Russell. 1982. Identification of instars and species in some larval *Polypedilum* (Diptera: Chironomidae). *Hydrobiologia* 94:25-32.

Stark, B.P. 1986. The nearctic species of *Agnetina* (Plecoptera: Perlidae). *Journal of the Kansas Entomological Society*. 59(3):437-445.

Stark, B.P. 1983. A review of the genus *Soliperla* (Plecoptera: Peltoperlidae). *Great Basin Naturalist* 43:30-44.

Stark, B.P. and C.H. Nelson. 1994. Systematics, phylogeny, and zoogeography of the genus *Yoraperla* (Plecoptera: Peltoperliae). *Entomologica Scandinavica* 25:241-273.

Stark, B.P. and D.H. Ray. 1983. A Revision of the Genus *Helopicus* (Plecoptera: Perlodidae). *Freshwater Invertebrate Biology* 2(1):16-27.

Stark, B.P. and K.W. Stewart. 1982. *Oconoperla*, a new genus of North American Perlodinae (Plecoptera: Perlodidae). *Proceedings of the Entomological Society of Washington*. 84(4):747-752.

Stark, B.P. and K.W. Stewart. 1981. The nearctic genera of Peltoperlidae (Plecoptera). *Journal of the Kansas Entomological Society* 54:285-311.

Stark, B.P. and S.W. Szczytko. 1981. Contributions to the Systematics of *Paragnetina* (Plecoptera: Perlidae). *Journal of the Kansas Entomological Society* 54(3):625-648.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North American stonefly genera (Plecoptera). Thomas Say Foundation Series, *Entomological Society of America* 12:1-460.

Stewart, K.W. and B.P. Stark. 1984. Nymphs of North American Perlodinae genera (Plecoptera: erlodidae). *The Great Basin Naturalist* 44(3):373-415.

Stimpson, K.S. , D.J. Klemm and J.K. Hiltunen. 1982. *A guide to the freshwater Tubificidae (Annelida: Clitellata: Oligochaeta) of North America.* EPA-600/3-82-033, 61 pp.

Sublette, J.E. 1964. Chironomidae (Diptera) of Louisiana I. Systematics and immature stages of some lentic chironomids of West-central Louisiana. *Tulane Studies in Zoology* 11:109-150.

Szczytko, S.W. and K.W. Stewart. 1979. The genus *Isoperla* of western North America; holomorphology and systematics, and a new stonefly genus Cascadoperla. *Memoirs of the American Entomological Society* 32:1-120.

Thompson, F. G. 1983. *An identification manual of the freshwater snails of Florida*. Florida State Museum, Gainesville, Florida.

Thorp, J.H. and A.P. Covich (editors). 1991. *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, New York, New York.

Torre-Bueno, J.R. de la. 1989. *The Torre-Bueno Glossary of Entomology, Revised Edition*. The New York Entomological Society, New York.

Traver, J.R. 1937. Notes on mayflies of the Southeastern states (Ephemeroptera). *Journal of the Elisha Mitchell Scientific Society* 53:27-86.

Traver, J.R. 1933. Mayflies of North Carolina Part III. The Heptageniinae. *Journal of the Elisha Mitchell Scientific Society* 48:141-206.

Usinger, R.L. (editor). 1956. *Aquatic insects of California*. University of California Press, Berkeley, California.

Vineyard, R.N. and G.B. Wiggins. 1987. Seven new species from North America in the caddisfly genus *Neophylax* (Trichoptera: Limnephilidae). *Annals of the Entomological Society* 80:62-73.

Waltz, R.D. & W.P. McCafferty. 1987. Systematics of *Pseudocloeon, Acentrella, Baetiella,* and *Liebebiella,* new genus (Ephemeroptera: Baetidae). *Journal of New York Entomology Society*. 95(4):553-568.

Waltz, R.D., W.P. McCafferty, and J.H. Kennedy. 1985. *Barbaetis:* a new genus of eastern nearctic Mayflies (Ephemeroptera: Baetidae). *The Great Lakes Entomologist*:161-165.

Weaver, J.S., III. 1988. *A synopsis of the North American Lepidostomatidae (Trichoptera).* Contributions to the American Entomological Institute 24.

Weaver, J.S. III, and T.R. White. 1981. Larval description of *Rhyacophila appalachia* Morse and Ross (Trichoptera: Rhyacophilidae). *Journal of the Georgia Entomological Society* 16:269-271.

Wetzel, M.J. 1987. *Limnodrilus tortilipenis,* a new North American species of freshwater Tubificidae (Annelida:Clitellata:Oligochaeta). *Proceedings of the Biological Society of Washington* 100:182-185.

White, D S. 1978. A revision of the nearctic *Optioservus* (Coleoptera: Elmidae), with descriptions of new species. *Systematic Entomology* 3:59-74.

Wiederholm, T. (editor). 1986. Chironomidae of the Holartic region. Keys and diagnoses. Part 2. Pupae. *Entomologica Scandinavica Supplement* 28: 1-482.

Wiederholm, T. (editor). 1983. Chironomidae of the holarctic region. Keys and diagnoses, Part 1, Larvae. *Entomologica Scandinavica Supplement no. 19*, 1-457.

Wiggins, G.B. 1995. *Larvae of the North American caddisfly genera (Trichoptera), 2nd ed.* University of Toronto Press, Toronto, Canada.

Wiggins, G.B. 1977. *Larvae of the North American caddisfly genera (Trichoptera)*. University of Toronto Press, Toronto, Canada.

Wiggins, G.B. 1965. Additions and revisions to the genera of North American caddisflies of the family Brachycentridae with special reference to the larval stages (Trichoptera). *Canadian Entomologist* 97:1089-1106.

Wiggins, G.B. and J.S. Richardson. 1989. Biosystematics of *Eocosmoecus,* a new Nearctic caddisfly genus (Trichoptera: Limnephilidae: dicosmoecinae). *Journal of the North American Benthological Society* 8:355-369.

Wiggins, G.B. and J.S. Richardson. 1982. Revision and synopsis of the caddisfly genus *Dicosmoecus* (Trichoptera: Limnephilidae: Dicosmoecinae). *Aquatic Insects* 4:181- 217.

Wold, J.L. 1974. *Systematics of the genus Rhyacophila (Trichoptera: Rhyacophilidae).* Unpublished Master's Thesis, Oregon State University, Corvallis, Oregon.

Wolf, W.G. and J.F. Matta. 1981. Notes on nomenclature and classification of *Hydroporus* subgenera with the description of a new genus of Hydroporinia (Coleoptera: Dytiscidae). *Pan-Pacific Entomologist* 57:149-175.

Yamamoto, T. and G.B. Wiggins. 1964. A comparative study of the North American species in the caddisfly genus *Mystacides* (Trichoptera: Leptoceridae). *Canadian Journal of Zoology* 42:1105-1210.

Young, F. N. 1954. *The water beetles of Florida*. University of Florida Press, Gainesville, Florida.

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Sample Date	Analyst	Method	Sample ID	Analyte	Quanti-Tra	Quanti-Tra	Quanti-Tra	MPN/tray	Lower/tray	Upper/tray	Note
6/10/2014	MLH	Colilert	Gage1	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Gage2	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Below Pond	Coliforms		49	48	> 2419.6	1439.5	infini.e	EM_5.17
6/10/2014	MLH	Colilert	Below Pond2	Coliforms		49	48	> 2419.6	1439.5	infini.e	EM_5.17
6/10/2014	MLH	Colilert	Above Pond1	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Above Pond2	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Bottom Sunnydale1	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Bottom Sunnydale2	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Killyons1	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Killyons2	Coliforms		49	48	> 2419.6	1439.5	infini.e	
6/10/2014	MLH	Colilert	Gage1	E. coli		30	10	60.5	43.1	81.4	
6/10/2014	MLH	Colilert	Gage2	E. coli		35	7	70.3	50.1	94.6	
6/10/2014	MLH	Colilert	Below Pond1	E. coli		24	5	38.8	26.1	54.7	EM_5.17
6/10/2014	MLH	Colilert	Below Pond2	E. coli		23	3	34.1	22.3	49.2	EM_5.17
6/10/2014	MLH	Colilert	Above Pond1	E. coli		36	9	78	55.6	103.8	
6/10/2014	MLH	Colilert	Above Pond1	E. coli		31	6	56.3	39.1	77.6	
6/10/2014	MLH	Colilert	Bottom Sunnydale1	E. coli		33	10	69.5	50.9	93.9	
6/10/2014	MLH	Colilert	Bottom Sunnydale2	E. coli		31	1	47.9	32.3	67.5	
6/10/2014	MLH	Colilert	Killyons1	E. coli		24	1	33.1	21.7	48.1	
6/10/2014	MLH	Colilert	Killyons2	E. coli		22	1	29.5	18.8	44	

Sample Date	Analyst	Method	Sample ID	Analyte	Quanti-Tra	Quanti-Tra	MPN/tray	Lower/tray	Upper/tray
7/30/2014	MLR	Colilert	Blank	Coliforms	0	0	< 1.0	0	3.7
7/30/2014	MLR	Colilert	Blank	E. coli	0	0	< 1.0	0	3.7
7/30/2014	MLR	Colilert	Below Pond_2	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Above Pond_1	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Above Pond_2	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Sunnydale_1	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Sunnydale_2	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Killyons_1	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Killyons_2	Coliforms	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Below Pond_1	E. coli	49	43	1413.6	924.9	2101.6
7/30/2014	MLR	Colilert	Below Pond_2	E. coli	49	35	816.4	550.1	1174.6
7/30/2014	MLR	Colilert	Above Pond_1	E. coli	49	30	613.1	401.2	879.2
7/30/2014	MLR	Colilert	Above Pond_2	E. coli	49	34	770.1	549	1094
7/30/2014	MLR	Colilert	Sunnydale_1	E. coli	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Sunnydale_2	E. coli	49	48	> 2419.6	1439.5	infini.e
7/30/2014	MLR	Colilert	Killyons_1	E. coli	49	42	1299.7	850.4	1896.6
7/30/2014	MLR	Colilert	Killyons_2	E. coli	49	43	1413.6	924.9	2101.6

Sample Date	Analyst	Method	Sample ID	Analyte	Quanti-Tra	Quanti-Tra	MPN/tray	Lower/tray	Upper/tray
10/23/2014	MLHR	Colilert	Stram Gage	Coliforms	49	48	> 2419.6	1439.5	infini.e
10/23/2014	MLHR	Colilert	Stream Gage	E. coli	33	4	58.3	40.5	80.6
10/23/2014	MLHR	Colilert	Below Pond	Coliforms	49	48	> 2419.6	1439.5	infini.e
10/23/2014	MLHR	Colilert	Below Pond	E. coli	38	6	79.4	56.6	107.7
10/23/2014	MLHR	Colilert	Above Pond	Coliforms	49	48	> 2419.6	1439.5	infini.e
10/23/2014	MLHR	Colilert	Above Pond	E. coli	22	1	29.5	18.8	44
10/23/2014	MLHR	Colilert	Sunnydale	Coliforms	49	48	> 2419.6	1439.5	infini.e
10/23/2014	MLHR	Colilert	Sunnydale	E. coli	8	0	8.6	4.5	16.9