

**California Department of Parks and Recreation
Natural Resources Division**

Water Quality Monitoring using Stream Macroinvertebrates

May 2002

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Key Terms: Water Quality, Stream Invertebrates, Wilder Ranch State Park

Introduction

One of the goals of the California Department of Parks and Recreation is the preservation of natural biodiversity on State Park lands. In accordance with this the Inventory, Monitoring, and Assessment Program will attempt to gain a clear idea of the health and diversity of key natural resources in each park unit. Wilder Ranch State Park, located within the Santa Cruz District, was one of the first units addressed and will subsequently be used as a paradigm for further related inventory and monitoring activities in the state. The District Staff in Santa Cruz identified several questions relating to riparian habitat and water quality in their Environmental Condition Assessment of Wilder Ranch State Park. Of primary concern is a possible decrease in the quality of native riparian and aquatic habitat. Possible stressors have been identified as run-off from commercial operations and residences located outside park boundaries as well as erosion of trails and roads within the Wilder Ranch State Park boundaries. The watersheds of this unit are home to several sensitive species, including the red-legged frog, tide-water goby, coho salmon, and a wide array of benthic macroinvertebrate species. Water quality assessment using macroinvertebrates involves collecting aquatic insects from randomly selected areas along streambeds, identifying the insects to family or genus, and determining their density by counting or weighing. The abundance, diversity, trophic identity and functional role of the invertebrates collected are one representative of stream condition. The use of these samples as an indicator of stream health is an established procedure and has proven to compliment previously accepted methods of water quality assessment such as chemical analysis.

Wilder Ranch State Park is also notable because it encloses two other properties: the Santa Cruz City Landfill and Granite Rock Sand Quarry. In addition, agriculture is practiced year round on 600 leased acres of the parkland between Highway 1 and the Pacific Ocean. Adjoining the northeastern boundary of the park is the University of California Santa Cruz campus. The surface water of the park includes three permanent streams and two intermittent streams: Majors Creek, Baldwin Creek, Lombardi Creek, Sandy Flat Gulch, and Wilder Creek. The potential for negative impact on the aquatic ecosystem is apparent for all streams. One of the goals of water quality monitoring, either chemical or biological, is to be vigilant for any trends that might adversely effect the aquatic ecosystem over time.

One person trained in basic stream ecology and aquatic invertebrate collection researched and implemented a sampling methodology based upon established protocols of the U.S. Environmental Protection Agency and California Department of Fish and Game with regard to the use of macroinvertebrates in stream bioassessment. A field crew of two IMAP employees conducted all aquatic invertebrate sampling at Wilder Ranch State Park during the spring and fall months of 2001.

Methods

Each invertebrate sample was taken in conjunction with the following parameters:

GPS coordinates

Elevation

Water temperature

Specific Conductance

pH

Dissolved Oxygen

Reach Length

Riffle Length

Avg Riffle Depth

Avg Riffle Width

Riffle Velocity

Percent Canopy Cover

Percent Gradient

Substrate Composition and Complexity

Embeddedness

Physical Habitat Quality Score (uses a nationally standardized method to characterize a stream reach as excellent to poor based on a known reference condition)

Field Methodology used for Macroinvertebrate Collections:

1. At the start of the sample day inspect all equipment and fluids and divide between field crew to carry into the field. Calibrate the water quality meter using the calibration solution. Designate one person as the recorder. Label the sample jars and begin the data sheets.
2. From the access point walk the stream and determine the reach. A reach is defined as any section of stream that includes two or more flow regimes i.e pool, riffle, glide, cascade, or falls. It is best to include, if possible, five riffle/pool sequences in each reach. A riffle is defined as shallow fast moving water, whereas the water in a pool is comparatively deep and slow moving. Three riffles will be sampled randomly from the five included in the reach. Riffle one should always be the farthest downstream. You will work upstream from here. Take a GPS point at the start and the end of the reach. If a GPS reading is not possible due to canopy or steep canyon walls, estimate as best as possible the UTM's using a USGS topographic quad. Take four digital photos (N,E,S,W) at the start and the end of the reach.
3. Use the random #'s function on the calculator or a random #'s table to determine which of the riffles to sample. Use the first digit only and throw out #'s that are not applicable (i.e >5). If your reach has only three riffles, all of them will be sampled and this step can be eliminated.
4. Measure the length of the entire reach. Try to follow the meanders as best as possible. Look around as you walk and measure the reach, notice physical character of the reach itself, surrounding banks and vegetation. Before starting a sample, fill out the physical habitat quality datasheet and record the numeric score of the reach on the main datasheet.

The scores are subjectively based on professional judgement. It is best to discuss the scoring with all field members present to ensure consistent results.

5. Use the water quality meter to determine the chemical parameters of the water. Sample at any point within the reach (usually in a riffle) that is deep enough for the meter. Clean the meter with distilled water before returning it to its case. The meter should be stored overnight in distilled water or tap water if distilled water is not available.
6. Proceed to the first of the three randomly selected riffles to be sampled (the farthest downstream). Measure the length of the riffle and determine the top 1/3. Select a random # to determine the starting point of a transect across which three kicknet collections will be collected for each sample. The imaginary transects running across the top 1/3 of the riffle should be separated by one meter. For example, if the riffle is 15 M long, the top 1/3 includes 5 possible transects within the top 5M on the upstream end of the riffle. Randomly pick a number one through 5. If the number is 3, the sample would be taken 3 M from the top of the riffle. This is noted as the transect location on the data sheet. Note: Always round off the length of the riffle to the nearest whole #.
7. Set the kicknet down, with the mouth of the net facing upstream, three times across the chosen transect. The thalweg (deepest part of the stream) should always be included; as well as any areas close to fallen woody debris. If the transect is not wide enough for three collections, compensate using the other transects, while remembering to work upstream. The net should not be cleaned out between each of these collections. An area roughly the mirror image of the net itself in size should be disturbed in front of the net. Pick up and clean off all rocks and gravel in this area and channel the debris into the net. It is okay to dig up to six inches into the substrate or move large rocks (if possible) in order to dislodge insects. Do not stand directly in front of the net. Once all three of the components are collected, empty the net into a pan or sieve as best as possible by turning the net inside out. It helps to detach the net from the pole for balance. Pick out any large debris and replace into stream AFTER inspecting carefully for clinging organisms. The sample should be carefully transferred (we use a sieve followed by a tray) into a jar filled with 1/2 to 2/3 of 95% ethanol. The main idea is to minimize damage to the insects in transfer. Use a wash bottle of ethanol to wash the smaller particles into the sample jar. Do not use water as this will dilute the ethanol in the sample jar. Label the sample jar inside and out using write in the rain labels.
8. After the sample is complete, refer to the datasheet for riffle characteristics to be determined. Use the tape measure to determine average width and depth to the nearest cm. We measure width and depth randomly once for every three meters of the reach, and average these numbers. Use the flow meter to determine velocity. Use the densiometer to determine overstory canopy cover. Refer to the physical habitat quality data sheet #'s 1 and 2 to determine substrate complexity and embeddedness respectively. This is for the individual riffle NOT the entire reach. Use the Jacob staff and clinometer to determine gradient of the riffle.
9. Repeat steps 6, 7, and 8 for the next two riffles, working upstream. Ensure that all data is collected and equipment (and SAMPLE) is gathered before leaving a riffle.

10. A chain of custody form should be kept and updated with each sample. Chain of custody forms will always be kept with the stream samples. These forms will accompany samples to the contract laboratory for identification of the macroinvertebrates.

Materials Needed:

GPS
Camera
Compass
50M tape measure
25ft tape measure
D shaped KickNet
Sample Jars with Alcohol Proof Lids
Ethanol (95%)
Horiba U10 Water Quality Meter
Flow meter
Data Sheets and Chain of Custody forms (on write in the rain paper)
Labels for inside and outside of sample jars (on write in the rain paper)
Physical Habitat Analysis Parameters
Plastic Bags
Cardboard Boxes with dividers (wine boxes work here)
Wash bottles
Funnel
Pencils, Sharpies, and Tape (for labels)
Rubber Boots/Hip waders
Clinometer
Densimeter
Calculator
Clipboard
Random#'s Table
Counter

Laboratory Methods used for Macroinvertebrate identification:

The invertebrate samples were identified by a contracted entomological lab. The laboratory was responsible for sorting and identifying insects in the collections, calculating major indices and returning processed samples and voucher specimens to State Parks Headquarters. Data is stored in both raw and processed form in an excel database. Hardcopies of data were copied and filed at State Park Headquarters. Voucher specimens and remnant samples were clearly labeled and are stored in a flammables cabinet at State Park Headquarters.

Site Selection for Macroinvertebrate Collections

The gradient of watershed can be thought of as a continuum along which environmental factors and thus stream fauna will vary. In accordance with this idea, we sampled reaches at low, middle, and high elevations in six watersheds at Wilder Ranch State Park.

Major's Creek Watershed:

Low:

UTM: N 4092770.40 E 576597.16

Directions: From the Wilder Ranch State Park entrance, head North on Hwy. 1 for approximately 3.5 miles. Turn left on Scaroni Road. Proceed a short distance to a small bridge near a private campground. We sampled a reach below this bridge.

Mid:

UTM: no UTM's available due to poor satellite reception

From the Wilder Ranch State Park entrance, head North on Hwy 1 for approximately 3 miles. There is a faded green gate on the right that leads into Scaroni acquisition. Proceed through this gate (use the round key) and follow the water service intake road. At the fork, take a left and proceed along the riparian corridor until the road drops down to the dam.

High:

We sampled two different reaches for a high point on Major's creek. The first sampling point is not recommended due to accessibility issues.

Site one UTM: N 4097372.00 E 579490.60

Directions: From the Wilder Ranch State Park Entrance, proceed south on Hwy. 1, taking the first left on Western Drive. Follow this drive until it dead ends at High/Empire Grade. Make a left here and proceed several miles, passing the twin gates entrance to WRSP. Turn left onto Smith Grade. Several miles later a gate marks the entrance to Brian Carpenter's property. The park owns adjacent land and has a key to this gate. Proceed through the gate and stop just before or after the first small wooden bridge. Major's creek runs below this bridge and we sampled just after the confluence on the SW side. Sample off of confluence from Brian's road. Access from bridge and walk down to confluence. After traversing this area with all of the stream equipment, we opted to find another site to sample at high elevation on Major's creek.

Site two UTM: N 4097890.00 E 578627.00

Directions: From Smith grade (before Brian Carpenter's gate), there is a pull-off on the right side of the road. A state park's sign marks the property, and a small footpath leaves the area heading roughly NWW. Use a topographic map and a compass to navigate to the UTM coordinates.

Baldwin Watershed:

Low:

We sampled two different reaches for a low point on Baldwin Creek. Following the spring collection, we became aware of a restoration effort along Baldwin Creek south of Hwy. 1. Given this information, we changed the sampling site to a reach more proximal to this area.

Site one UTM: N 4092186.11 E 578019.67

Directions: From Wilder Ranch State Park Entrance, proceed North on Hwy. 1 approximately 1 mile, stopping at a pull-off on the right. A large dilapidated barn will be visible. Follow Baldwin Loop trail, cutting W through the vegetation at the point where the trail is closest to the stream.

Site two UTM: N 4091940.69 E 577970.76

Directions: Follow the above instructions, but rather than proceeding on Baldwin Loop Trail, cross Hwy 1 and follow the trail to the W towards the riparian corridor.

Mid:

UTM: N 4094189.66 E 579385.3

Directions: Drive up Wilder Ridge Loop trail to junction with Enchanted Loop trail. With equipment hike along Enchanted Loop trail until you near the stream. Cut through vegetation to access stream.

High:

We drove in on Brian's road to the head wall and it is very low flow. We were not able to access a high point for Baldwin Creek.

Lombardi Creek Watershed:

Low:

UTM: N 4091469.39 E 579175.22

Directions: We thought it would be interesting to sample above and below the dump and/or restoration site. The dump is at 300 ft and the restoration site is at sea level. Due to steep canyon walls we were unable to access Lombardi Creek above Hwy 1. We sampled directly below Hwy 1, within the restoration area.

Mid:

Inaccessible – see explanation above.

High:

The headwall of Lombardi Creek is not at high elevation, therefore there is no high sample point for Lombardi Creek.

Sandy Flat Gulch:

Low:

At low elevation Sandy Flat Gulch enters private property and is therefore inaccessible for sampling.

Mid:

UTM: N 4092307.17 E 580187.88

Directions: We had mistakenly identified Sandy Flat Gulch as Dairy Gulch in the Spring sampling; therefore, the samples from the Spring are labeled Dairy Gulch. Note, however, that the UTM's for the site are the same for both Spring and Fall. Drive up Wilder Ridge Loop trail, then hike down Zane Gray Cutoff to the junction of Wilder Ridge Loop trail and head west approximately 50 meters to small wooden footbridge. We sampled below this bridge.

High:

The headwall of Sandy Flat Gulch is not at high elevation, therefore there is no high sample point for Sandy Flat Gulch.

Peasley Creek Watershed:

Low:

Peasley Creek disappears at low elevation. It later reappears and merges with Wilder Creek, thus there is no "low" site on Peasley Creek.

Mid:

UTM: N 4092407.74 E 581485.67

Directions: Take Wagon Wheel trail (closed to public) until it crosses Peasley Creek.

High:

UTM: There are no UTM's available for Peasley High due to limited satellite availability.

Directions: Off of the E fork of Eucalyptus trail about .25 miles or less is an "area closed" sign with the "closed" faded. The trail goes down to Peasley Creek.

Wilder Creek Watershed:

Low:

UTM: N 40901498.02 E 581700.12

Directions: From the corral proceed east through meadow to Wilder Creek.

Mid:

UTM: There are no UTM's for Wilder Mid due to limited satellite availability.

Directions: Sample at the confluence of Wilder Creek and Cave Gulch. Drive down Chinquapin to Long Meadow, from Long Meadow near the Lime Kilns and before the junction of Englesman, there should be a small road to the east. Take this as far as possible and walk down from there.

High:

Above the confluence with Cave Gulch, Wilder Creek disappears into the bedrock, thus we were unable to sample a high point on Wilder Creek.

Discussion

The Shannon-Weiner Index of Diversity is a common measure of species richness and equitability. Many factors can influence the diversity of invertebrates found within a watershed. In general, however, a stream that supports a diverse array of insects is considered healthy. A diversity index such as Shannon-Weiner is most useful in noting changes in faunal assembly over time. Alteration in invertebrate richness and/or diversity over time at a particular sampling site can reflect changes in the surrounding environment. For example the Shannon Index of Diversity on the lower reaches of Lombardi and Baldwin Creeks changed notably between the Spring and the Fall of 2001, whereas the diversity in other reaches fluctuated only minimally with season. Repeated monitoring will establish trends from which events such as these can be more clearly understood.

The EPT (Ephemeroptera, Plecoptera, and Trichoptera) index is another biological metric used specifically in aqueous environments. Members of these invertebrate orders are known to be sensitive to stream conditions. A declining EPT index indicates disturbance in invertebrate habitat. Such an observation warrants closer investigation such as a point source sampling regime.

Most biological metrics are simply a different means by which to gauge the same information. Therefore, in theory, these metrics should be somewhat correlated. In assessing macroinvertebrate samples, it is useful to derive and compare several indices. The following tables summarize the most common metrics calculated when using invertebrate samples to gauge stream condition (Harrington & Born, 2001).

Useful Contacts
For
Water Quality Assessment using Stream Macroinvertebrates

The following people were contacted for guidance in developing the field or lab methodologies regarding the stream macroinvertebrate samples.

Dr. Richard Bottonoff – Aquatic Entomologist

I contracted Richard to sort and identify our insect collections. His performance was timely and outstanding.

1963 Toppewetah Street
South Lake Tahoe, CA 96150
530-577-1110
richbot@yahoo.com

Jim Harrington – Water Quality Biologist for CDFG

I attended a workshop on rapid bioassessment that was taught by Jim Harrington. The workshop was invaluable in the development of this project. Jim has written a book (see references page) that was extraordinarily helpful in developing my methodology.

Aquatic Bioassessment Laboratory
California Department of Fish and Game
2005 Nimbus Road
Rancho Cordova, CA 95670
phone (916) 358-2862, fax (916) 985-4301
jharring@ospr.dfg.ca.gov

Dr. Sharon Lawler – Aquatic Ecologist and Professor

I consulted Sharon for advice regarding general field methodology and invertebrate collection. She is familiar with the use of macroinvertebrates in rapid biological assessment, and was certainly helpful in developing the study.

364 Briggs Hall (Entomology Dept)
University of California at Davis
Davis, CA 95616
530 754 8341
splawler@ucdavis.edu

Karen Worcester – Regional Monitoring Program Coordinator

She is a valuable resource and very knowledgeable in monitoring and assessment of water quality measurements.

State Water Quality Control Board
San Luis Obispo, CA
805 549 3147
kworcest@rb3.swrcb.ca.gov

References

Chu, Ellen and James Karr. Restoring Life in Running Waters. Covelo, CA: Island Press, 1999.

Harrington, Jim and Monique Born. Measuring the Health of California Streams and Rivers. Sacramento, CA: Sustainable Land Stewardship Institute, 2000.

Hauer, Richard and Gary Lamberti. Methods in Stream Ecology. San Diego, CA: Academic Press, 1996.

Lawler, Sharon. Class lecture. Biology of Aquatic Insects. University of California at Davis, Briggs Hall. 01 May 2002.

Merritt, R.W. and K.W. Cummins. An introduction to the Aquatic Insects of North America. Dubuque, Iowa: Kendall/Hunt Publishing, 1996.

Data Management

The original datasheets are stored at IMAP headquarters, 1416th 9th Street, in Sacramento. Copies of the datasheets are located in the appendices, at the back of this report, and at headquarters as well. All digital data and databases are stored on the network shared drive at headquarters and can be accessed via the following path: N:\GIS\imap\reports\456\WSQAI. Accompanying this report is a CD containing the following files:

- A copy of this report,
- GPS and GIS data,
- Monitoring photos,
- All databases,
- Sample datasheet,
- Associated documents.

Equipment

The following pages contain information about purchasing and operating equipment used in the stream macroinvertebrate sampling. Also included is reference information about the parameters each particular piece of equipment measures.

1. Horiba U-10 Water Quality Meter

Manufacturer: Horiba Instruments Incorporated

Irvine Facility

17671 Armstrong Ave.

Irvine, CA 92714

Phone: (714) 250-4811

Website: http://global.horiba.com/analy_e/u-10/

Purchased from: EnviRent Corporation

404 Vosseller Ave.

Bound Brook, NJ 08805

Phone: (732) 560-9620

Website: <http://www.envirent.com/>

Price: \$2495

2. Calibration Solutions (for Horiba U-10) may be purchased from:

Compliance Technology

P. O. Box 31

South San Francisco, CA 94083

Phone: (800) 615-8870 or (650) 615-9100

Website: <http://www.compliancetechnology.com/>

Price: Auto-cal (one point)- \$35/ 4L

Level Two (two points)- \$73/ 1L

3. Global Water Flowmeter

Manufacturer: Global Water

11257 Coloma Road

Gold River, CA 95670

Phone: 800-876-1172 or 916-638-3429

Website: <http://www.globalw.com/gwprice.html>

Price: \$695, best to purchase from manufacturer

4. Spherical Densiometer

May be purchased from: Ben Meadows Company
PO Box 5277
Janesville WI 53547-5277
Phone: 1-800-241-6401
Website: <http://www.benmeadows.com>
Price: \$99.95

Appendices

The appendices to this report are separated by folder tabs, and are presented in the following order:

- Bioassessment Data - Spring 2001
- Bioassessment Data – Fall 2001
- Physical / Habitat Quality Data – Spring 2001
- Physical / Habitat Quality Data – Fall 2001
- Consolidated Data – Spring 2001
- Consolidated Data – Fall 2001
- Chain of Custody Forms – Spring & Fall 2001
- Blank Datasheets
- Entomologist's Notes – Spring 2001
- Entomologist's Notes – Fall 2001
- Taxa List – Spring 2001
- Taxa List – Fall 2001
- Taxa Abundance – Spring vs. Fall, 2001
- Biometrics by Transect – Spring 2001
- Biometrics by Transect – Fall 2001
- Biometrics by Reach – Spring 2001
- Biometrics by Reach – Fall 2001
- Biometrics Means – Spring vs. Fall, 2001