BATTLE CREEK STREAM CONDITION MONITORING

2006 Data Analysis Report and Correction to the 2001 and 2002 Watershed Assessment

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DISTRIBUTION

Copies of this report (file name = Terraqua Inc 2008.pdf) and raw data, including site-specific metric and index values and site-specific taxonometric counts, will be available on the internet by spring 2009 at http://krisweb.com/ under the Battle Creek Project.

CORRECTIONS TO 2001-2002 WATERSHED ASSESSMENT

In the preparation of this document, errors in a minor part of the analysis of two of four macroinvertebrate indices were found to exist in the Battle Creek Watershed Assessment (Ward and Moberg 2004). These errors are more specifically documented in Appendix A of this document. Original macroinvertebrate data upon which Ward and Moberg (2004) were based have been confirmed to be correct as published in Ward and Kvam (2003). The errors described in Appendix A do not significantly alter the conclusions of Ward and Moberg (2004).

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ACRONYMS USED IN THIS REPORT

AREMP Aquatic and Riparian Effectiveness Monitoring Program

B-IBI Benthic Index Biotic Integrity

BCWC Battle Creek Watershed Conservancy

BCWG Battle Creek Working Group

CSBP California Stream Bioassessment Protocol

EMDS Ecosystem Management Decision System

ODEQ-BI Oregon Department of Environmental Quality Biotic Index

PG&E Pacific Gas and Electric

PSTT Percent Sediment Tolerant Taxa

RIVPACS River Invertebrate Prediction and Classification System

SCI Stream Condition Inventory

SCMP Stream Condition Monitoring Program

SEM standard error about the mean

SSTR Sediment Sensitive Taxa Richness

SWRCB State Water Resources Control Board

TAC Technical Advisory Committee

USFS U.S. Forest Service

INTRODUCTION

The purpose of this document is to report the results of stream condition monitoring conducted within the Battle Creek watershed in 2006 on behalf of the Battle Creek Watershed Conservancy (BCWC) by Terraqua, Inc. Monitoring results for 2006 are compared to the results of the watershed assessment conducted in 2001 and 2002. This data was collected under the BCWC's Stream Condition Monitoring Program (SCMP), which is designed to monitor the status and trends in stream conditions within the Battle Creek watershed. This program is intended to be sensitive enough to promptly alert watershed managers to short-term, acute changes and to longer-term, chronic changes, and to be able to aggregate conditions at the watershed-scale but also be able to identify within-watershed variation.

The Battle Creek SCMP includes monitoring in five subject areas: biological monitoring through macroinvertebrate surveys and riparian condition surveys, physical stream condition surveys, water temperature monitoring, meteorological monitoring, and monitoring of changes in land cover. Monitoring in 2006 focused on the monitoring of macroinvertebrate communities, and the physical characteristic of the stream channel.

The animals living in a stream may provide the best indicators of that stream's overall ecological condition. Changes in the natural processes of watersheds can have immediate and long-lasting effects on the animals that live in streams (Karr 1997; Fore 1998). Macro-invertebrate communities are usually the most sensitive indicators of changes to chemical and physical stream conditions, particularly considering that the usual threshold of significance for these physical and chemical changes is whether aquatic life is affected (Karr 1997). Therefore, macroinvertebrate communities are a relatively direct index of physical and chemical conditions that can be sampled cost-effectively and processed promptly enough to alert watershed managers to short-term, acute changes.

Stream macroinvertebrate communities are comprised of an enormous diversity of individual species, each with its own specific ecological requirements, and can illustrate the condition of a broad spectrum of ecosystem processes taking place within a watershed or stream. The relative abundance of specific taxa can indicate specific changes in stream conditions. Biological metrics and multimetric indices[1] that summarize the relative abundance of macroinvertebrate taxa have been linked with specific physical (Bollman 1996; Plotnikoff 1998), chemical and biological changes (Plotnikoff 1998; Fore 1998) in stream conditions.

Invertebrate monitoring is an excellent surrogate for expensive and time-consuming physical metrics used to determine stream condition and water quality. Aquatic macroinvertebrates are versatile in that they can be easily and efficiently sampled to address changes in sediment delivery, point source and non-point source pollution, and climate change.

[1] Multimetric indices, such as those used in Terraqua and Kvam (2003), like the Benthic-Index of Biotic Integrity and Oregon Department of Environmental Quality Biotic Index, are believed to be better at detecting habitat or macroinvertebrate community disturbances than single metrics (e.g., presence or absence of indicator species) because they use a number of biological attributes that integrate information from ecosystem, community, population, and individual levels (Barbour et al. 1999).

Physical monitoring of the Battle Creek watershed is necessary and complimentary to biological monitoring to determine the status and trends of stream networks and the effectiveness of restoration projects. Monitoring physical conditions can also aid in identifying the causal mechanisms driving changes in the status of fish and macroinvertebrates. Physical monitoring in 2006 included: 1) physical habitat mapping to yield longitudinal channel profiles, residual pool depths and pool frequencies; 2) stream bed particle size; 3) fine sediment; and 4) large woody debris. Other metrics both physical (e.g., channel longitudinal and cross-sectional profiles) and biological (e.g., riparian shading) were observed and recorded but are not analyzed in this report.

BACKGROUND

Ecosystem Processes: The Battle Creek watershed is the focal area for major programs to restore populations of Chinook salmon and steelhead. These populations of fish depend on a number of biological and physical (including chemical) processes within the Battle Creek watershed. Streams within the Battle Creek watershed are the conduits for the flow of water, sediment, nutrients, and energy that influence the productive capacity of local fish populations. The physical and biological condition of these streams can both influence and indicate how these ecosystem processes may affect Battle Creek fish populations. Therefore, an understanding of the condition of streams is important for understanding the status and trends of fish populations as well as the effectiveness of actions taken to restore these populations.

Geographical and Institutional Setting: Battle Creek drains a watershed area of approximately 370 square miles in central Northern California. The watershed includes the southern slopes of the Latour Buttes, the western slope of Lassen Peak, and the mountains south of Mineral, California. Nearly 350 miles of streams in the Battle Creek watershed drain land at elevations as high as 10,400 feet and cascade steeply down through basalt canyons and foothills to the confluence with the Sacramento River near Cottonwood, California, at an elevation of 335 feet. Approximately 250 miles of stream are fish bearing and 87 miles of stream were historically accessible to anadromous fishes such as Chinook salmon and steelhead. Land use in Battle Creek is predominately industrial timber harvest, livestock ranch lands, and agricultural development, with areas of dense residential development and undeveloped wilderness areas within Lassen National Park.

Battle Creek is widely recognized as a watershed critical to the survival and restoration of populations of Chinook salmon and steelhead, which are listed under state and federal endangered species acts. Restoration efforts in the Battle Creek watershed were initiated in 1997 by the Battle Creek Working Group (BCWG), and have resulted in the implementation (to begin in 2008) of the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). The Restoration Project is a multi-agency effort to improve fish passage conditions and habitat within the portion of the watershed encompassed by Pacific Gas and Electric (PG&E) Company's Battle Creek Hydroelectric Project.

Since its inception in 1997, the BCWC has facilitated local participation in the development of the Restoration Project. The BCWC continues to support the goals of the Restoration Project by working to improve reach-scale and watershed-scale factors that might jeopardize the goal of restoring local runs of Chinook salmon and steelhead to Battle Creek.

The BCWC, with funds provided by the Anadromous Fisheries Restoration Project as part of BCWC's Stewardship Program, commissioned an assessment of conditions in the Battle Creek watershed in 2001. The BCWC recognized the likelihood that in-channel stream conditions, in addition to the more widely recognized hydropower- and hatchery-related limiting factors, may also influence the productive capacity of salmon and steelhead in Battle Creek. While the Restoration Project and other agency efforts have been mainly focused on hydropower-related limiting factors, the BCWC believed that it was critical to pay attention to stream conditions and their potential effects on the goals of the Restoration Project. To that end, the BCWC's watershed assessment 1) documented existing stream conditions and developed a baseline against which future conditions may be compared, and 2) identified, and prioritized for treatment, sediment sources within Battle Creek.

On behalf of the BCWC, Terraqua, Inc. conducted an assessment of the Battle Creek watershed in 2001-2002 (Ward and Moberg 2004). This assessment followed the field methodologies and reference criteria established by the U.S. Forest Service's (USFS) Aquatic and Riparian Effectiveness Monitoring Program (AREMP; Gallo et al. 2001). Ward and Moberg (2004) determined baseline conditions for selected biological and physical stream attributes present in the Battle Creek watershed through an intensive study of stream conditions by surveying at 50 randomly selected sites and concluded that:

- Fine sediment levels were high. In most cases, sediment levels were higher than levels favorable for salmonid production, higher than unmanaged California streams, and higher than USFS standards – but were similar to other managed watersheds on USFS lands in California.
- A storm event in January 1997 was the primary sediment source factor affecting aspects of stream condition such as fine sediment levels, particle size, pool frequency, pool depth, and geomorphic channel conditions like bank erosion and channel avulsions.
- While roads or other land use factors were not ruled out as possible sediment sources, there was little direct evidence that road factors (density, near-stream density, road-stream crossing frequency) or other land-use factors (forest cover and near-stream meadow area) played a significant role in explaining the variability of three key stream condition indices at the watershed scale.

Ascertaining the status of biological and physical stream attributes in Battle Creek was an important product of the 2001 watershed assessment. However, the primary benefit of that work was to provide a reference against which to compare future conditions in order to understand trends in watershed-scale stream conditions. Understanding these trends, and comparing them to anticipated changes in fish populations during and after implementation of the Restoration Project, will magnify the power of the original 2001 work. The effectiveness of the Restoration Project will be determined largely by tracking trends in fish population levels. Unexpected results in fish population trends, which could result from problems in watershed conditions, will be fully explainable only through consideration of possible changes in the watershed's productive capacity as indicated by a time series of stream condition indicators. On the other hand, demonstrating that changes in fish population trends are a result of Restoration Project or adaptive management actions will require that changes in watershed conditions can be ruled out, which requires a time series of stream condition information.

Restoration Project managers also recognized the important link between successful adaptive management of the Restoration Project and watershed conditions. The Adaptive Management Plan (Terraqua 2004) for the Restoration Project highlighted the role of BCWC in monitoring watershed conditions, sediment processes, water temperature and climate. It also called for very close coordination of the BCWC's stream condition monitoring and the Restoration Project's adaptive management (Terraqua 2004).

The BCWC recognizes that the 2001 watershed assessment provides a robust and statistically valid baseline against which future changes in conditions can be compared through periodic, and statistically valid, monitoring. Therefore, BCWC's Stewardship Program applied for and was awarded a grant from Proposition 50 monies managed by the California State Water Resources Control Board (SWRCB) to design and implement a plan to monitor stream condition among other things. Terraqua, Inc. was hired by BCWC to accomplish these objectives and to produce the SCMP. Terraqua has been assisted by a Technical Advisory Committee (TAC), comprised of private and public sector experts in fisheries and watershed processes, who closely overlap with the management of the Battle Creek Salmon and Steelhead Restoration Project that has advised on the development of the plan.

The initial implementation of the SCMP was funded by Proposition 50/SWRCB and began in 2006. In 2006, based on a draft of the SCMP and discussions with the TAC, stream-condition work was initiated. Terraqua conducted habitat sampling at 10 of the sites sampled in 2001-2002 and collected macroinvertebrates at all 50 sites sampled in 2001-2002. The results of the 2006 monitoring with comparisons to 2001-2002 results are reported in this document.

MATERIALS AND METHODS

In 2001-2002 Terraqua, Inc. performed sampling to characterize the aquatic macroinvertebrate diversity (Terraqua and Kvam 2003) and stream channel conditions within the Battle Creek watershed to support the Watershed Assessment (Ward and Moberg 2004) and the development of the SCMP (Ward et al. 2008). Stream condition monitoring performed in 2006 used the same methods implemented in 2001-2002 though the sampling design was refined to attain the status and long-term trend monitoring goals of the SCMP (Ward et al. 2008). The objectives of the SCMP are not limited to detecting changes between two groups of samples (e.g., comparing 2 years) but are primarily focused on detecting trends in stream conditions.

Sampling Design

The sampling frame used in the original 2001-2002 watershed assessment, which included all fish bearing waters of the Battle Creek watershed, meets the goals of this stream condition monitoring program to describe status and trends at the watershed scale (Ward and Moberg 2004). The sampling sites used in the original 2001-2002 watershed assessment were randomly selected using an unequal probability random tessellation stratified survey design for a continuous linear network population (Olsen 2001). This design remains the standard in selecting randomized locations for ecological sampling based on geographical considerations and continues to meet SCMP goals (Ward and Moberg 2004). Therefore, the 50 sample sites studied in the original watershed assessment were adopted as the permanent collection of SCMP sample sites (**Figure 1**).

The sampling design for macroinvertebrate monitoring in 2006 followed the recommendations of the SCMP which prescribes annual macroinvertebrate sampling at all 50 sites (Ward et al. 2008). The locations of these sites are depicted as blue circles in **Figure 1**. Physical habitat monitoring performed in 2006 was implemented at 10 fixed sites following the rotating panel design proposed in the SCMP (Ward et al. 2008). These sites include site numbers S001, S002, S003, S004, S005, S006, S007, S009, S010, and S011 (**Figure 1**)[2].

The rotating panel design prescribes physical stream condition surveys at 20 sites per year to achieve monitoring of all 50 sites once every 4 years. This rotating panel design would include an annual panel of 10 "fixed-sites" and four rotating panels of 10 additional sites each which would be sampled once every 4 years. In this manner, all 50 sites would be surveyed at least once every 4 years (**Figure 2**). The monitoring of physical habitat metrics in 2006 was only performed at the 10 "fixed-sites" as funds were limited and did not allow monitoring of the additional 10 site rotating panel that is recommended.

[2] Site number S008 was considered and rejected as not meeting the sampling criteria in the Battle Creek Watershed Assessment (Ward and Moberg 2004) and therefore is not included as a permanent site for ongoing monitoring.

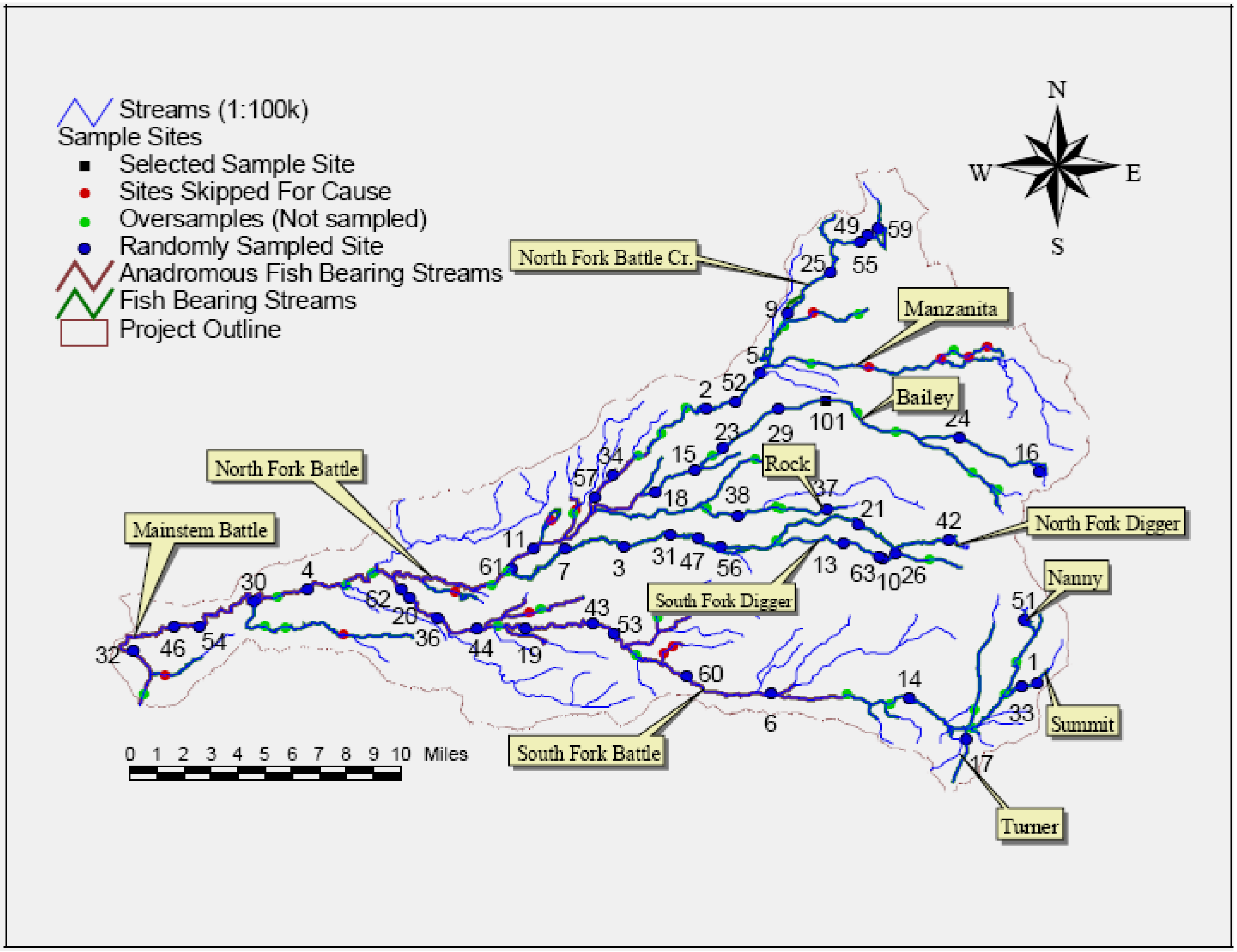

Figure 1. A map of the Battle Creek watershed depicting sample sites locations (blue and black), site numbers, and the names of streams with sites that were sampled. Oversamples (green) and sites skipped for cause (red) are also depicted. The depicted stream network is based on a 1:100,000 scale hydrography layer.

	Year															
Panel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	10				10				10				10			
3		10				10				10				10		
4			10				10				10				10	
5				10				10				10				10

Figure 2. Rotating panel design for status/trend monitoring within Battle Creek. Shading indicates the years in which sites within each panel are sampled and the number indicates the number of sites to be sampled. For example, sites in panel 1 are visited every year, while sites in panel 2 are visited only in years 1, 5, 9, 13, and 17, assuming a 20-year sampling frame.

Site Layout

Physical and biological measurements were made at locations within sites as specified by Gallo et al. (2001). The length of sampled sites depended on the bankful channel width. The default length of stream sampled was equal to 20 times the bankful width. A minimum length of 150 meters and a maximum length of 500 meters of stream were sampled at sites less than 7.5 meters wide or greater than 25 meters wide, respectively. Gallo et al. (2001) specified surveying cross sections at either six or 11 transects, depending on whether a site was "constrained" or "non-constrained,"[3] respectively, as determined in the field prior to site surveying. All sites surveyed in 2006 met the criteria for "constrained" reaches and transects were surveyed accordingly.

Macroinvertebrate Surveys

Terraqua and Kvam (2003) used the AREMP River Invertebrate Prediction and Classification System (RIVPACS) protocol to sample macroinvertebrates which is similar to the protocol used by the Lassen National Forest Stream Condition Inventory (SCI). This protocol is sufficient to generate multiple Index of Biotic Integrity metrics and results can be modified for comparison to results derived through California Stream Bioassessment Protocol (CSBP) protocols. A comparative study by Herbst and Silldorff (2006) in the eastern Sierra Nevada determined that RIVPACS methods performed similar to methods employed by either CSBP or the University of California-Sierra Nevada Aquatic Resource Laboratory methodologies for detecting impaired biological condition. Data from these three methods can potentially be used interchangeably for cross-validation (Herbst and Silldorff 2006).

Aquatic macroinvertebrates were collected using the AREMP RIVPACS sampling protocol advocated by Gallo et al. (2001) and developed by Hawkins et al. (2001). The field methods in the 2006 AREMP Field Protocol Manual (AREMP 2006) were used for the collection of benthic macroinvertebrates in the fall of 2006. Within each monitoring reach, benthic macroinvertebrates were collected with two fixed area kick net samples at each of four riffle habitats for a total of eight samples. These eight samples were combined to generate a single macroinvertebrate sample for the monitoring site.

The characteristics of macroinvertebrate communities identified through sampling are often described in terms of "metrics". For example, Taxa Richness is a metric calculated as the total number of macroinvertebrate taxa present in a sample. Some metrics change in predictable ways in response to habitat disturbance and therefore serve as useful indicators of stream condition. Consistent with the methods used in the Watershed Assessment (Ward and Moberg 2004), two metrics and two multimetric indices were characterized for each sample that was analyzed. The metrics include Sediment Sensitive Taxa Richness (SSTR) and Percent Sediment Tolerant Taxa (PSTT). The indices include the Benthic Index of Biotic Integrity (B-IBI) and the

[3] "Constrained" reaches are those with relatively narrow floodplains (i.e., floodplains are constrained by a narrow valley bottom) whereas "non-constrained" reaches have well developed flood plains. Non-constrained reaches are defined as reaches that have an entrenchment ratio (flood prone width-to-bankfull width) greater than 2.2 and a slope gradient less than 3 percent. All other reaches were considered constrained.

Oregon Department of Environmental Quality Biotic Index (ODEQ-BI). These metrics and indices are described in the following subsections.

Metrics

- *Sediment Sensitive Taxa Richness (SSTR)* - These are taxa that are sensitive to inputs of fine sediment. Zero or a low number of sediment sensitive taxa suggests that sediment loading is influencing the macroinvertebrate community.

- *Percent Sediment Tolerant Taxa (PSTT)* - This is the relative abundance of taxa tolerant of fine sediment. A high percentage of sediment tolerant taxa suggest unusually high fine sediment loading.

Indices

Multimetric indices like the B-IBI and ODEQ BI are believed to be better at detecting habitat or macroinvertebrate community disturbances than single metrics (e.g., presence or absence of indicator species) because they use a number of biological attributes that integrate information from ecosystem, community, population, and individual levels (Barbour et al. 1999).

- *Benthic-Index Biotic Integrity (B-IBI)* - The B-IBI is a multimetric index used to assess the biotic integrity of streams. The B-IBI is a modified version of the IBI that was first developed to study fish communities in Midwestern streams (Karr 1991). The modification involves the use of 10 aquatic macroinvertebrate metrics rather than fish metrics to identify artificial or human disturbances. The metrics used in the calculation of the B-IBI include: 1) total taxa richness, 2) Ephemeroptera taxa richness, 3) Plecoptera taxa richness, 4) Trichoptera taxa richness, 5) intolerant taxa richness, 6) long-lived species taxa richness, 7) percentage of tolerant taxa, 8) percentage of predators, 9) clinger taxa richness, and 10) percentage of the three most numerically dominant taxa. Each metric in the B-IBI is given a score to reflect the level of disturbance that is detected by the metric (5 for minimal, 3 for moderate, and 1 for severe disturbance). Each metric score is summed to calculate the total B-IBI value. Higher B-IBI scores (total possible score of 50) indicate lower levels of physical and/or biological impairment.

- *Oregon Department of Environmental Quality-Benthic Index (ODEQ-BI)* - The ODEQ-BI recommends the use of either a multivariate or multimetric analytical procedure for the comparison of macroinvertebrate samples among sites as part of their Level 3 protocol (Hafele and Mulvey 1998). The ODEQ-BI incorporates 10 key biotic metrics, some of which are identified above (e.g., taxa richness, sensitive taxa richness, sediment sensitive taxa richness, percent sediment tolerant taxa, and percent dominant taxon) into an impairment score, which is used to describe overall stream condition or health. The impairment score is generated by summing individual metric scores for a total possible score of 50. The higher the total score, the lower the impairment. ODEQ-BI impairment scores were developed with data collected from first to third order streams in coastal Oregon (Hafele and Mulvey 1998).

Statistical Reporting and Testing

Graphical comparisons and statistical tests were used to determine if biological stream conditions in 2006 had improved in condition relative to those observed in 2001-2002. Graphical and tabular comparisons of biological metrics and indices indicate the mean and the standard error about the mean (SEM). One-tailed Mann-Whitney tests were used to test for significant differences using the StatTool v5.0.0 (Palisade Inc.) add-in for Microsoft Excel. An alpha level of 0.05 was used to avoid type I errors and to determine statistical significance. Additionally, for the Ecosystem Management Decision Support (EMDS) model results of overall biological condition, a Wilcoxon paired signed rank test (Zar 1999) was employed to determine the statistical significance of a potential increase in EMDS condition. The Wilcoxon signed rank test was used by Gallo et al. (2005) to test for the direction of change in EMDS condition score distributions between two time periods.

Physical Monitoring

The AREMP RIVPACS monitoring protocols (Gallo et al. 2001, Gallo 2002) were implemented in 2006 for the long-term monitoring of trends in Battle Creek stream channel condition and have been shown to perform as-well-as or better-than several other protocols commonly used for monitoring physical stream conditions (Lanigan et al. 2006). These protocols were previously implemented in 2001-2002 for the Battle Creek watershed assessment (Terraqua and Kvam 2003, Ward and Moberg 2004) and include the following components: physical habitat mapping (width-to-depth ratios, pool frequencies, channel longitudinal and cross-sectional profiles), measuring stream bed particle size (e.g., D_{50}), embeddedness, estimating the percentage of fine sediment, the frequency of large woody debris, and riparian canopy cover. Ongoing repeat sampling of initial randomized sites sampled in 2001-2002 enable the assessment of status and trends in physical stream conditions of fish bearing streams of the entire watershed.

Substrate– Stream bed particle size was measured following pebble count protocols in Gallo et al. (2001) except that we apportioned the 10 pebble counts per transect among all channels at transects with multiple bankful channels relative to the total transect bankful width as described above. Fine sediment was sampled by counting fine sediment under a string grid per Gallo et al. (2001) except that fine sediment counts were not made in cases where algae or other debris obscured the streambed. Site-averaged quantification of fine sediment was determined only using those string intersections where the streambed was not obscured by algae or other debris. We used a mask and snorkel to better observe the stream bed at all but the shallowest locations. Embeddedness data was also collected at sites following the Gallo et al. (2001) protocol and although it is not reported here it will be analyzed in the first comprehensive SCMP analysis.

Physical Habitat Mapping – Physical habitat mapping was performed at the 10 “fixed-sites” following the methods of Gallo et al. (2001) and included: channel cross sections, channel longitudinal profiles of selected channel features, width-to-depth ratios, and pool frequencies. The channel longitudinal and cross-sectional profiles are not presented in this document. It is anticipated they will be analyzed and reported in the first comprehensive analysis performed after the completion of a full rotating panel sequence in 4 years. The methods used for physical habitat mapping closely followed Gallo et al. (2001) with the following exceptions:

- Gallo et al. (2001) specifies surveying longitudinal profiles at increments of approximately 1/5 of the average bankfull width along the stream thalweg in addition to surveying longitudinal pool features. Fine-scale increments were dropped from longitudinal profiles following the methods implemented in the watershed assessment (Ward and Moberg 2004), which documents the lack of utility of these fine longitudinal increments. Longitudinal surveys at all sampled sites included pool features specified by Gallo et al. (2001).

- Gallo et al. (2001) assumes that multiple channels separated by islands higher than bankfull stage were "unusual situations" and recommended surveying the cross section of only the channel "with the most flow." Past surveys have documented that multiple channels are not uncommon and determinations of channels with the most flow (especially at bankfull stage when flow and channel geomorphology are most closely related) has been particularly difficult. Following the procedures implemented in the watershed assessment (Ward and Moberg 2004) cross sections were surveyed spanning all channels. Variables, such as bankfull width and average depth, were determined individually by channel and were summed across all channels for transect-specific values. This complicated surveying and data processing but provided a more consistent and geomorphologically more appropriate characterization of stream reaches with multiple channels.

- Specific definitions of pools were obtained from AREMP (Moyer pers. comm.) because they were not provided in Gallo et al. (2001). Pools were identified in the field if they were 1) longer than the average wetted width, 2) channel spanning, and 3) at least 25 percent of the surface area was scoured. In addition to pools meeting these criteria, low gradient habitat units in high gradient stream reaches were classified as "pools" if they provided biologically significant fish habitat compared with other habitat within the reach. Scour pools (where fine sediments were sampled) were defined as pools where depth was controlled by depositional materials but not by wood, bedrock or boulders.

Large Woody Debris – Protocols in Gallo et al. (2001) specified collecting much more information than are actually used in EMDS models, so we chose to forego characterization of debris configuration, type, and location. We collected data for all wood that met the minimum size criteria and measured those pieces that were close to criteria cut-off values, but otherwise estimated whether pieces met size criteria. We did not conduct the size estimation validation procedure described in Gallo et al. (2001). Because we counted or estimated the number of pieces within debris jams and included these in total site counts, our counts of large wood could be positively biased compared to counts of wood by other researchers using Gallo et al. (2001) protocols at sites with large debris jams.

Riparian Canopy Cover – Riparian canopy covered was measured along physical habitat mapping transects using a densiometer and following the canopy cover protocol of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (Peck et al. 2003). Riparian canopy cover results are not report within this document but are anticipated to be analyzed and reported in the first comprehensive analysis of the SCMP.

Statistical Testing - Due to the limited sample size of sites monitored in 2006 (n = 10) statistical tests were not applied to physical habitat metrics to detect potential changes in watershed conditions since 2001-2002. Instead, tabular and graphical comparisons were made between sample periods.

Stream Condition Characterization

Four physical variables were analyzed to characterize physical stream condition at each of the 10 sample sites: fine sediment, particle size, pool frequency, and large woody debris. Biological stream condition was characterized at 50 sites with four biological metrics derived from analysis of macroinvertebrate communities. Results for variables and metrics are presented as actual values and as truth values derived from EMDS models. EMDS characterization of in-channel conditions are based on standards in the AREMP and were previously utilized in the Battle Creek Watershed Assessment (Ward and Moberg 2004). The composite EMDS truth value for physical stream condition is the unweighted average of substrate (fine sediment and particle size), pool frequency, and large woody debris (Figure 3). Watershed-scale biological stream condition was calculated as the unweighted average of the EMDS truth values for the four macroinvertebrate metrics (Figure 3). Truth values for each measurement variable are determined based on evaluation criteria (e.g., see **Table 1**). Truth values at each evaluation node equal unweighted averages of all nodes/variables in the next subordinate tier. For example, the truth value for "physical condition" equals the unweighted average of "substrate," "pool frequency," and "wood frequency."

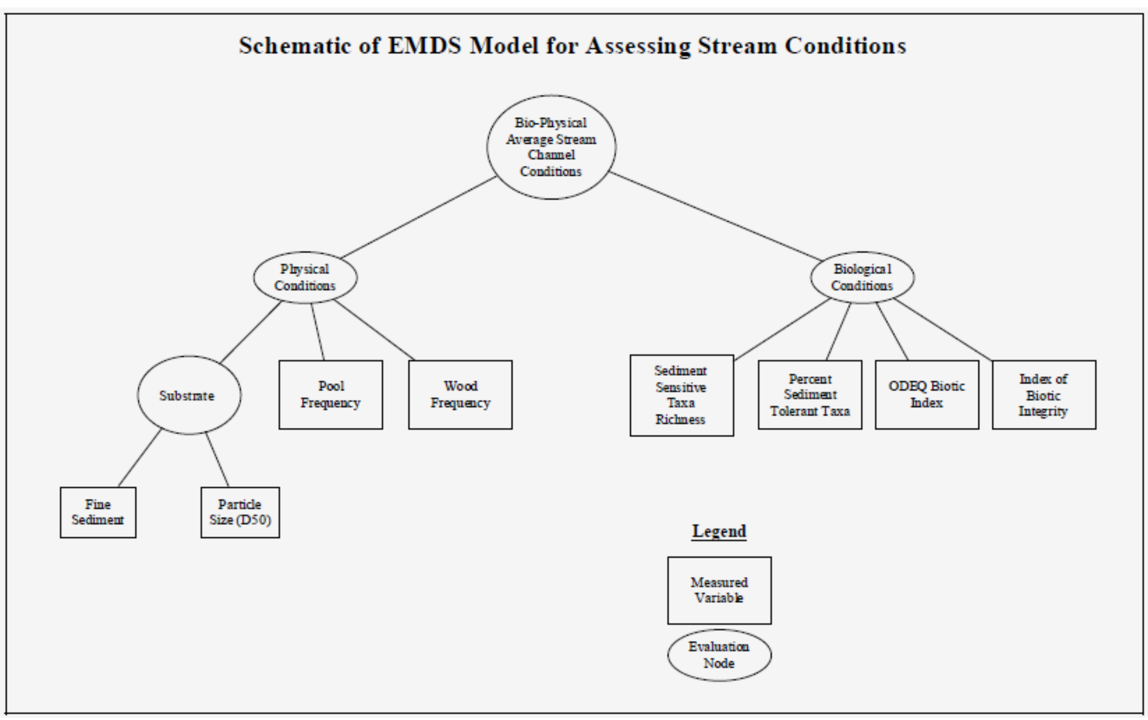

Figure 3. Schematic of the Ecosystem Management Decision Support (EMDS) model used to assess stream conditions in the Battle Creek watershed.

Understanding EMDS Truth Values

EMDS is a linguistic model which evaluates the "truth" of a premise about an observed condition and returns a measure of certainty (a "truth value") that the premise is true or false. The AREMP version of the EMDS model is structured to test premises that fit the following pattern: *"At site number X, the magnitude of variable Y is favorable for salmonid production"* (Gallo pers. comm.; Reeves pers. comm.; Gallo et al. 2001). The EMDS model compares the magnitude of variable Y at site X against known relationships between that variable and the related aspects of salmonid production (**Table 1**). From this comparison to known relationships, EMDS determines how certain we can be that variable Y is "fully favorable for salmonid production," or, at the opposite end of the spectrum, how certain we can be that variable Y may be "fully unfavorable for salmonid production." The output of each of these tests in EMDS are numerical "truth values" that range between –1.0 and 1.0. EMDS truth values are calculated for each measurement variable and evaluation node included in the model (**Figure 3**). EMDS evaluation criteria curves may take many shapes. In this analysis, most evaluation curves (e.g., fine sediment, macroinvertebrate metrics and indices) are linear relationships that map a high and low value to +1 and –1 in a one-to-one linear relationship (**Table 1**). The evaluation curve for particle size is bell-shaped (**Figure 4**; **Table 1**). Evaluation curves for pool frequency and large woody debris are based on logarithmic relations. **Table 2** describes how EMDS truth values generated with Battle Creek data are interpreted in this report.

Table 1. Evaluation criteria used in the EMDS model based on AREMP reference standards.

	Lower Value		Upper Value		
Variable	**Fully Unfavorable**	**Fully Favorable**	**Fully Favorable**	**Fully Unfavorable**	**Source**
			Physical Habitat		
Fine Sediment	≥17%	≤11%	na	na	Hicks 2000 per Gallo et al. 2001
Median Particle Size (D_{50})	≤45 mm	>65 mm	<95 mm	≥ 128 mm	Knopp 1993 per Gallo et al. 2001
Pool Frequency	Logarithmic curve dependent on bankfull width				Gallo et al. 2001; Bilby and Ward 1991
Large Wood Frequency	Logarithmic curve dependent on bankfull width				Gallo et al. 2001; Bilby and Ward 1991
			Biological/Macroinvertebrate		
Percent Sediment Tolerant Taxa (PSTT)	≥25%	≤10%	na	na	Hafele and Mulvey 1998 per Ward and Kvam 2003
Sediment Sensitive Taxa Richness (SSTR)	0	≥2	na	na	Hafele and Mulvey 1998 per Ward and Kvam 2003
Oregon Department of Environmental Quality Biotic Index (ODEQ-BI)	≤20	≥39	na	na	Hafele and Mulvey 1998 per Ward and Kvam 2003
Benthic Index of Biotic Integrity (B-IBI)	≤27	≥44	na	na	Karr 1991 per Ward and Kvam 2003

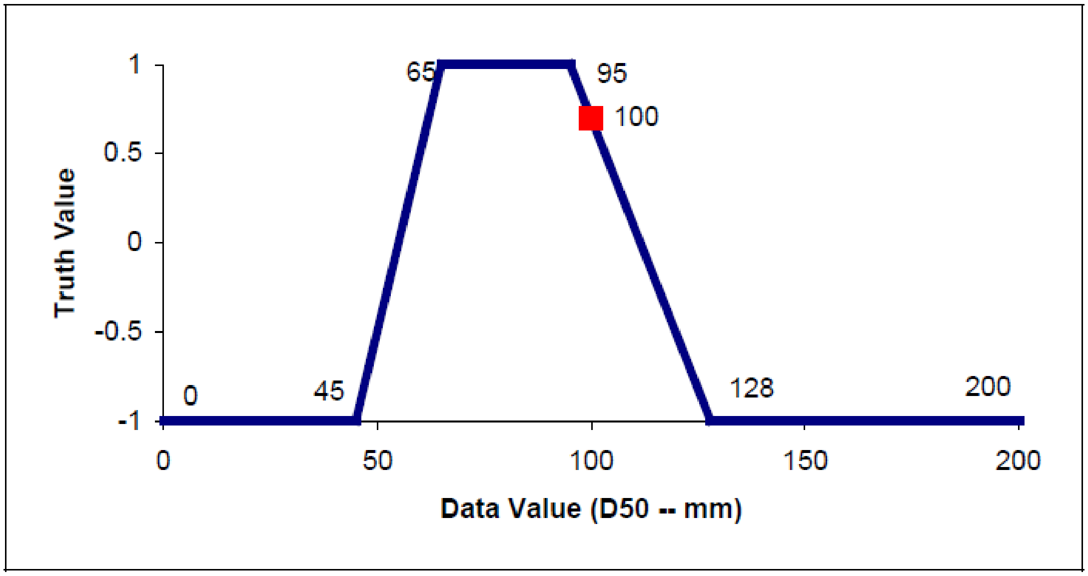

Figure 4. An example of a bell-shaped EMDS evaluation curve. In this case (the red point on the curve), the Ecosystem Management Decision Support (EMDS) model returns a truth value of 0.70 for a D_{50} of 100 mm.

Table 2. Interpretations of truth values generated by the Ecosystem Management Decision Support (EMDS) model as applied to data collected in Battle Creek in 2001-2002 and 2006.

Truth Value	Formal Linguistic Meaning (pertaining to linguistic premise)	Interpretation (pertaining to a specific condition for salmonid production)	Color of Symbols in Maps and Graphs
1.0	Observed conditions provide high certainty that the premise is true	Fully favorable	Dark Green
0.5 to 0.99	Observed conditions provide reasonable certainty that the premise is true	Likely favorable	Light Green
-0.5 to 0.5	Observed conditions provide low certainty regarding the premise	Moderately favorable	Grey
-0.99 to –0.5	Observations provide reasonable certainty that the premise is false	Likely unfavorable	Light Red
-1.0	Observations provide high certainty that the premise is false	Fully unfavorable	Dark Red

RESULTS

Stream condition monitoring efforts in Battle Creek are designed to investigate biological and physical conditions relevant to stream conditions at the watershed scale. Four biological and five physical metrics were used to reflect overall watershed condition in 2006. Watershed conditions in 2006 are compared to similar stream condition sampling performed in 2001-2002.

Biological Monitoring: Macroinvertebrate Communities

Watershed-averaged biological metrics were generated from macroinvertebrates indices at 50 sites in 2006. These results are compared to the average metric values generated from 43 of the same sites sampled in 2001-2002.

In 2006, the watershed-averaged PSTT metric was 4.5 percent and ranged from 0.4 to 14.0 percent (**Figure 5**). The difference in PSTT values between 2001and 2002 (mean = 4.8 percent, n = 43) and 2006 (n = 50) are not statistically significant (p = 1.00). The watershed-averaged EMDS truth value for PSTT was 0.97 in 2006 compared to 0.85 in 2001-2002. EMDS analysis indicates with high certainty that PSTT scores in 2006 were fully favorable for salmonid production at 45 sites with no sites being fully unfavorable.

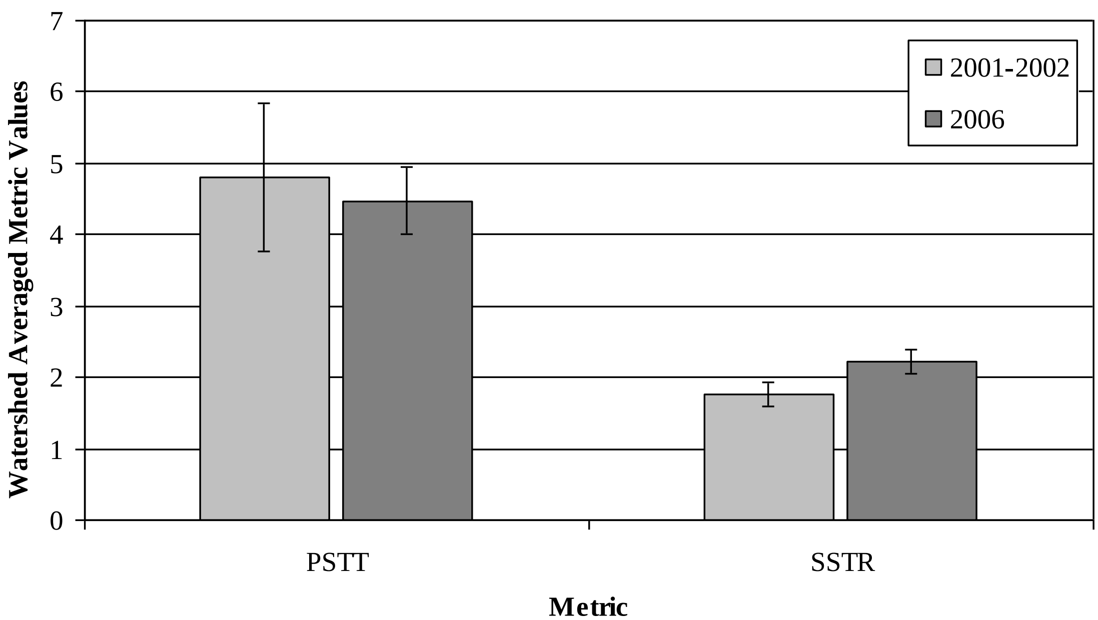

Figure 5. Comparison of watershed averaged Percent Sediment Tolerant Taxa (PSTT) and Sediment Sensitive Taxa Richness (SSTR) metrics for 2001-2002 (44 sites) and 2006 (50 sites) in the Battle Creek watershed, CA.

Watershed-averaged SSTR was 2.22 in 2006 and values ranged from 0 to 4 (**Figure 5**) compared to 1.77 in 2001-2002. The increase in SSTR observed in 2006 is statistically significant (p = 0.04). The watershed-averaged SSTR EMDS truth value was 0.60 in 2006 compared to 0.44 in 2001-2002. EMDS analysis indicates with high certainty that SSTR scores were fully favorable for salmonid production at 32 sites and fully unfavorable at 2 sites.

B-IBI values in 2006 averaged 41.76 and ranged from 26 to 46 (**Figure 6**). Watershed-averaged B-IBI scores in 2001-2002 were 37.95. The increase in B-IBI observed in 2006 is statistically significant ($p < 0.001$). Watershed-averaged EMDS truth values for B-IBI were 0.66 in 2006 compared to 0.28 in 2001-2002. EMDS analysis indicates with high certainty that B-IBI scores were fully favorable for salmonid production at 28 sites and fully unfavorable at 1 site.

ODEQ-BI scores averaged 42.54 and ranged from 24 to 50 (**Figure 6**). Watershed-averaged ODEQ-BI scores in 2001-2002 were 39.77. The increase in ODEQ-BI observed in 2006 is statistically significant ($p = 0.005$). Watershed-averaged EMDS truth values for ODEQ-BI were 0.82 in 2006 compared to 0.78 in 2001-2002. EMDS analysis indicates with high certainty that B-IBI scores were fully favorable for salmonid production at 35 sites with no sites being fully unfavorable.

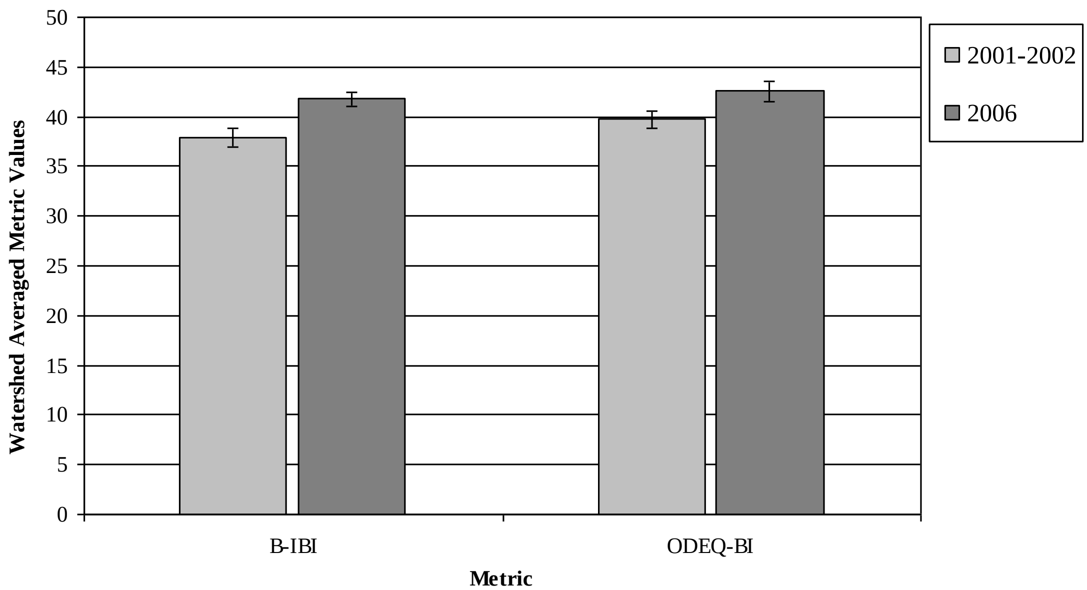

Figure 6. Comparison of watershed averaged Oregon Department of Environmental Quality-Biotic Index (ODEQ-BI) and Benthic-Index of Biotic Integrity (B-IBI) metrics for 2001-2002 (43 sites) and 2006 (50 sites) in the Battle Creek watershed, CA.

Overall Biological Stream Condition

The biological condition of the Battle Creek watershed, expressed as the average of all four biological EMDS truth values, was 0.76 in 2006 as compared to 0.59 in 2001-2002 (**Figure 7**). The increase in biological EMDS truth values from 2001-2002 ($n = 43$) to 2006 ($n = 50$) are statistically significant ($p < 0.005$). Results of a Wilcoxon paired signed rank test (Zar 1999) for 43 paired sites (same sites in 2001-2002 and 2006) also supports the significance of the EMDS condition increase (**Figure 8**) observed in 2006 ($p < 0.005$, one-tailed) EMDS truth value.

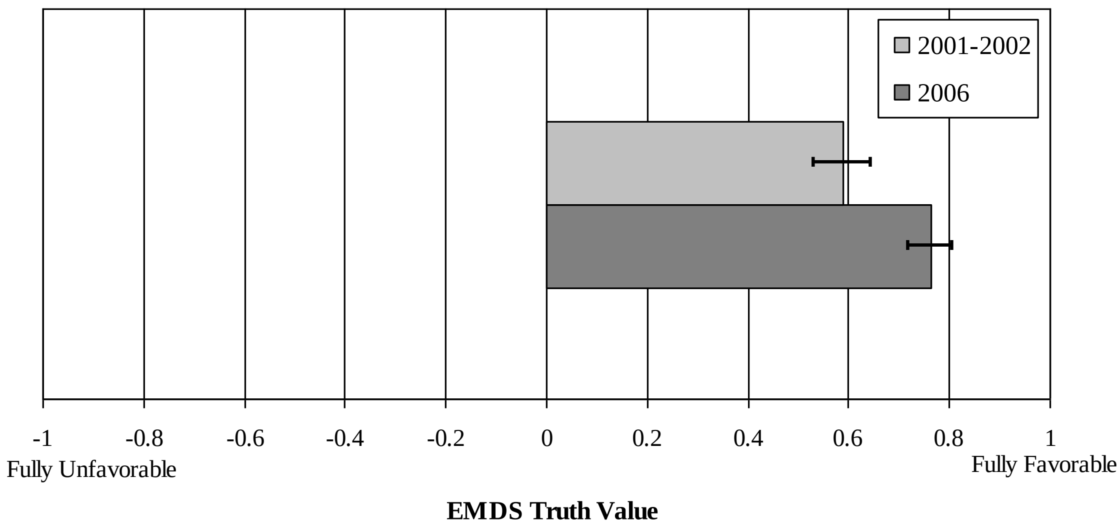

Figure 7. Comparison of watershed averaged Ecosystem Management Decision Support (EMDS) truth values as an average of all four BMI metrics (Percent Sediment Tolerant Taxa (PSTT), Sediment Sensitive Taxa Richness (SSTR), Oregon Department of Environmental Quality-Biotic Index (ODEQ-BI) and Benthic-Index Biotic Integrity (B-IBI)) for 2001-2002 (43 sites) and 2006 (50 sites) in the Battle Creek watershed, CA.

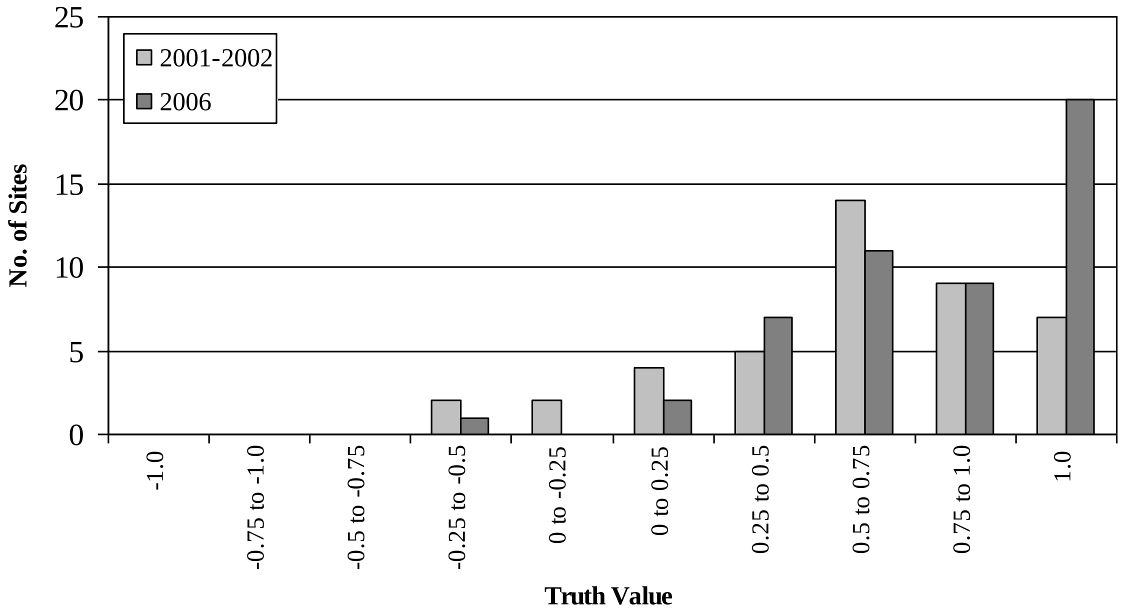

Figure 8. Distribution of watershed averaged Ecosystem Management Decision Support (EMDS) truth values as an average of all four BMI metrics (Percent Sediment Tolerant Taxa (PSTT), Sediment Sensitive Taxa Richness (SSTR), Oregon Department of Environmental Quality-Biotic Index (ODEQ-BI) and Benthic-Index Biotic Integrity (B-IBI)) for 2001-2002 (43 sites) and 2006 (50 sites) in the Battle Creek watershed, CA.

Physical Monitoring

Physical monitoring results reported here include: the percentage of fine sediment in scour pool tailouts, stream bed particle size (D_{50}), pool frequencies, residual pool depths, and the frequency of large woody debris.

Fine Sediment

Fine sediment was quantified at 10 sample sites as the percent of streambed (measured in scour pool tails) comprised of particles less than 2.0 mm. The mean percent fine sediment was 17 percent and ranged from 0 to 34 percent (**Table 3**). Data from fine sediment sampling performed in 2001-2002 was only available for five of these 10 sites.[4] These five sites in 2001-2002 had a mean percent fine sediment of 27 percent and in 2006 had a mean percent fine sediment of 12 percent (**Table 3**). For the same five sites sampled in both 2001-2002 and 2006, the distributions of fine sediment percentages at sites are presented in **Figure 9**. The average EMDS fine sediment value for all sites sampled in 2006 was -0.20. EMDS analysis indicates with high certainty that fine sediment scores were fully favorable for salmonid production at four sites and fully unfavorable at six sites. For the five shared sites, fine sediment EMDS was 0.20 in 2006 and -0.27 in 2001-2002.

Table 3. Percent of streambed in scour pool tails comprised of fine particles less than 2.0 mm in size [mean +/- SEM (n)] for the Battle Creek watershed by reach type. Results are provided for both five of the same sites and all sites sampled in 2001-2002 and 2006.

Year	*Same Sites*	*All Sites*
2001-2002	27 +/- 9 (5)	31 +/- 23 (35)
2006	12 +/- 4 (5)	17 +/- 4 (10)

[4] In 2001-2002 scour pools only occurred at five of the 10 sites that were monitored in 2006, therefore fine sediment data for scour pool tailouts are only available for five sites.

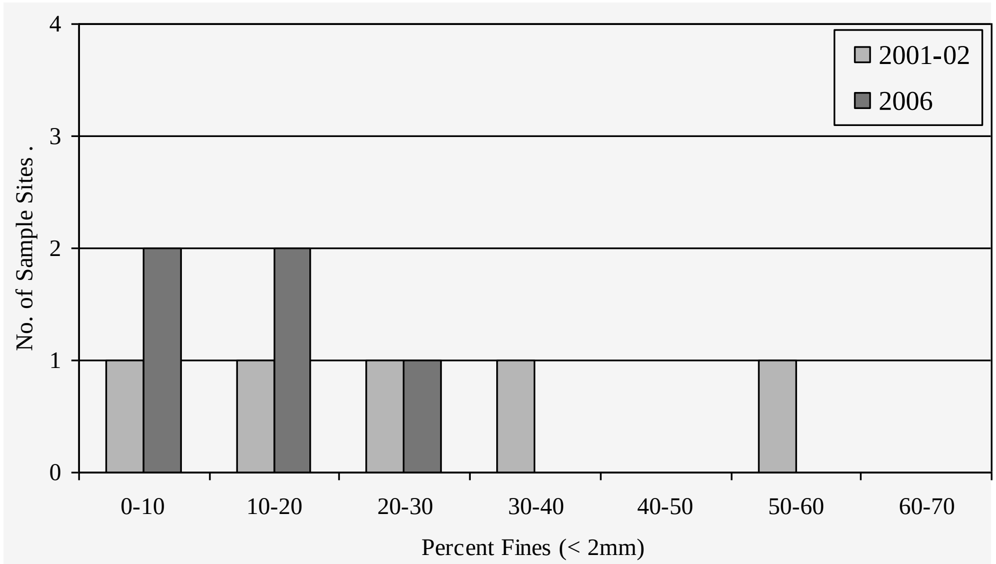

Figure 9. Histogram of the percent of fine sediment (< 2 mm) at the same five Battle Creek sites sampled in 2001-2002 and 2006.

<u>Particle Size</u>

In 2006 the median particle size (D_{50}) of stream bed sediment was quantified at 10 sites. The mean particle size for all 10 sites in 2006 ranged from 26 mm to 246 mm and averaged 111 mm (**Table 4**). The mean particle size in 2006 response reaches (reaches with slopes less than 3 percent) was 64 mm and in transport reaches (reaches with slopes of 3 percent or greater) was 144 mm (**Table 4**).

Mean particle sizes (D_{50}) in 2006 were compared to mean particle sizes quantified in 2001-2002 at the same sampling sites (**Figure 10**). For all reach types at 10 sites, the mean particle size in 2001-2002 averaged 77 mm and in 2006 averaged 111 mm (**Table 4**).

The average EMDS mean particle size truth value for the 10 sites sampled was -0.19 in 2006 and -0.47 in 2001-2002. EMDS analysis indicates with high certainty that D_{50} scores in 2006 were fully favorable for salmonid production at three sites with five sites being fully unfavorable.

Table 4. Mean particle size [mm; mean +/- SEM (n)] for the Battle Creek watershed by reach type in years 2001-2002 and 2006.

	Same Sites			*All Sites*
Year	Response Reaches	Transport reaches	All Reach Types	
2001-2002	54 +/- 28 (4)	114 +/- 74 (4)	77 +/- 32 (10)	92 +/- 90 (47)
2006	64 +/- 17 (4)	144 +/- 52 (4)	111 +/- 25 (10)	111 +/- 25 (10)

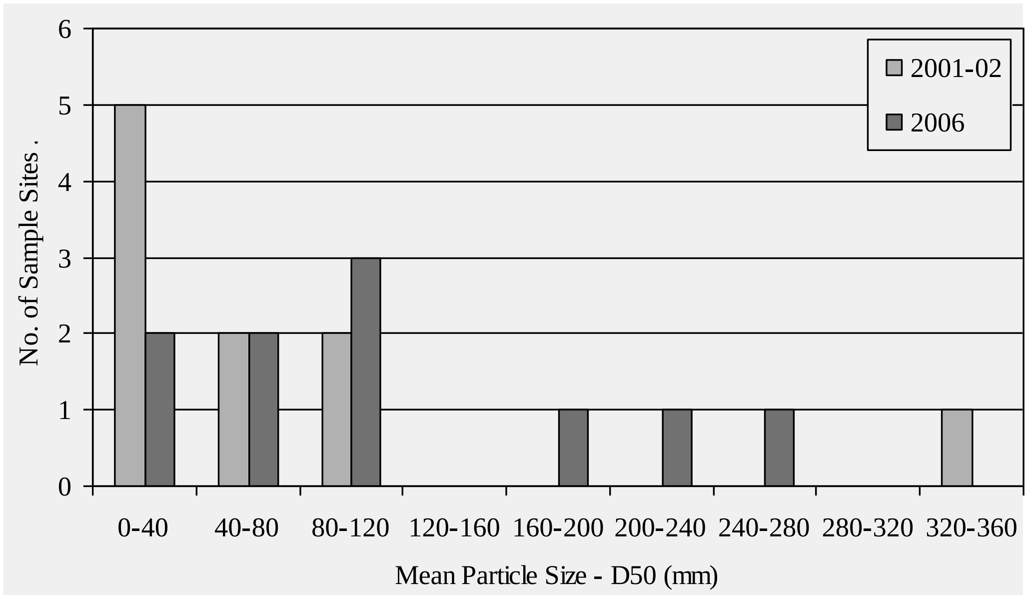

Figure 10. Histogram of median particle size (D_{50}, mm) at the same 10 Battle Creek sites sampled in 2001-2002 and 2006.

Pool Frequency

Scour pool frequency averaged 1.14 pools per 100 m of stream reach at 10 sites in 2006 and ranged from 0.4 to 2.0 (**Table 5**). In comparison, scour pool frequencies at the same 10 sites in 2001-2002 averaged 0.86 pools per 100 m of stream and ranged from 0 to 3.3 (**Table 5**). Five of the sites sampled in 2006 had developed pools where none were present in 2001-2002 (**Figure 11**). The average EMDS pool frequency truth value for the 10 sites sampled was -0.76 in 2006 and -0.80 in 2001-2002. EMDS analysis indicates with high certainty that pool frequency scores in 2006 were fully unfavorable for salmonid production at eight sites with no sites being fully favorable.

Table 5. Scour pool frequency [numbers per 100 m of stream; mean +/- SEM (n)] for the Battle Creek watershed in 2001-2002 and 2006.

Year	*Same Sites*	*All Sites*
2001-2002	0.86 +/- 0.38 (10)	1.71 +/- 0.22 (50)
2006	1.14 +/- 0.16 (10)	1.14 +/- 0.16 (10)

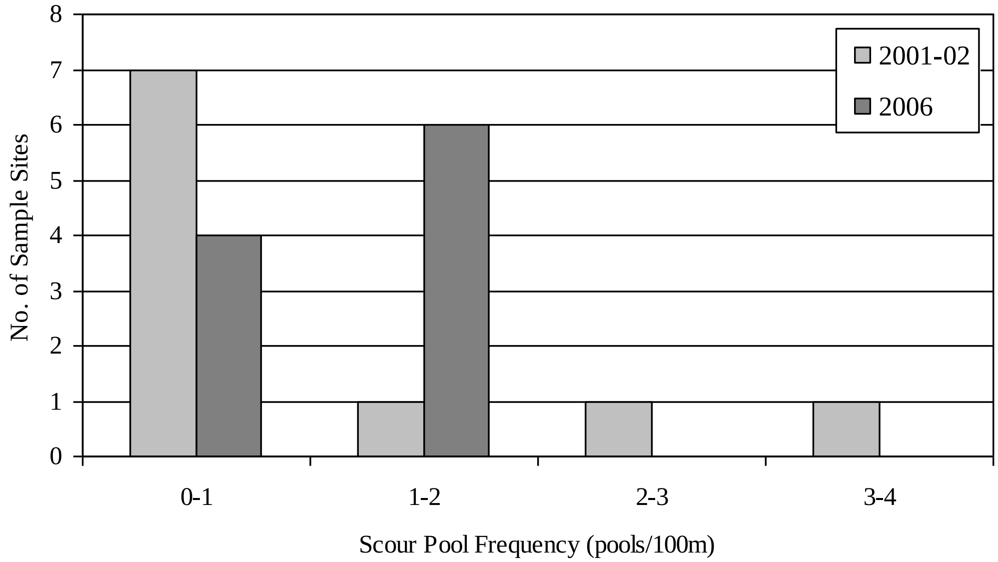

Figure 11. Histogram of scour pool frequency (pools/100 m) at the same 10 Battle Creek sites sampled in 2001-2002 and 2006.

Residual Pool Depth

In 2006 the residual depths for scour pools was quantified at 10 sites. Residual pool depths in 2006 averaged 0.50 m and ranged from 0.15 m to 0.96 m (**Table 6**). At four sampling sites, scour pool residual depths in 2001-2002 were 0.71 m and 0.62 m in 2006 (**Table 6**). Five sites in 2001-2002 lacked scour pools preventing 2006 comparisons.

Table 6. Residual pool depth [m; mean +/- SEM (n)] for the Battle Creek watershed in 2001-2002 and 2006.

Year	*Depth (m) Same Sites*	*Depth (m) All Sites*
2001-2002	0.71 +/- 0.19 (4)	0.66 +/- 0.06 (41)
2006	0.62 +/- 0.18 (4)	0.50 +/- 0.08 (10)

Large Woody Debris

Large woody debris frequency was characterized at 10 sites in 2006. In 2006, large woody debris frequency averaged 25 pieces of large woody debris per 1000 m of stream channel and ranged from 0 to 102 pieces as compared to an average of 40 pieces per 1000 m in 2001-2002 (**Table 7**). The average EMDS truth value for large woody debris was 0.23 in 2006 and averaged 0.18 for nine of the same 10 sites in 2001-2002. EMDS analysis indicates with high certainty that large woody debris scores were fully favorable for salmonid production at 1 site and fully unfavorable at 1 site.

Table 7. Large woody debris frequency [#/1000 m; mean +/- SEM (n)] for the Battle Creek watershed in 2006.

Year	*Same Sites*	*All Sites*
2001-2002	40 +/- 17 (10)	96 +/- 13 (49)
2006	25 +/- 10 (10)	25 +/- 10 (10)

Overall Physical Stream Condition

The EMDS model results for overall physical stream conditions (unweighted average of substrate, pool frequency, wood frequency, Figure 3) was -0.24 in 2006 and -0.31 in 2001-2002 at the same 10 sites (**Figure 12**). The distribution of physical stream condition EMDS scores for the same 10 sites sampled both in 2001-2002 and 2006 are presented in **Figure 13**.

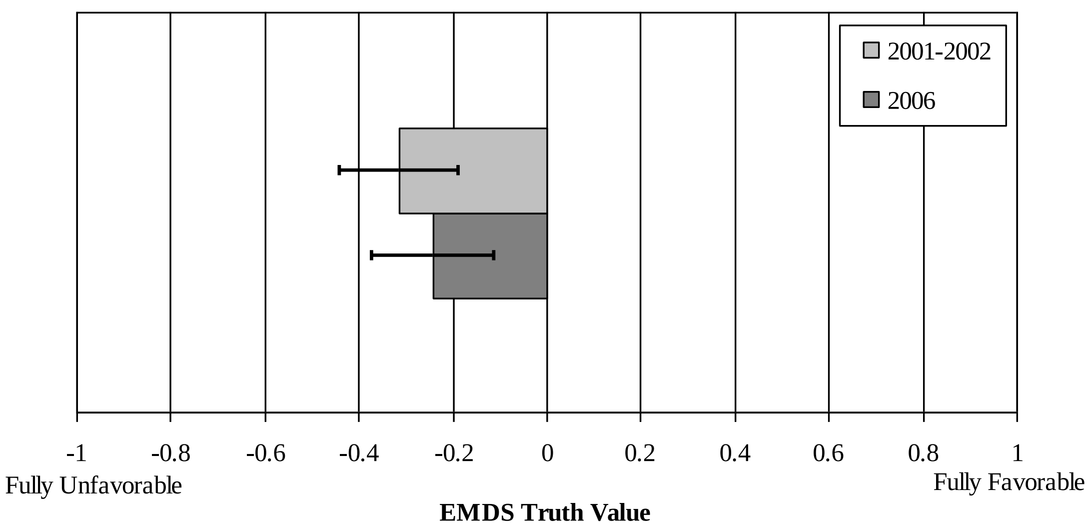

Figure 12. Ecosystem Management Decision Support (EMDS) physical stream conditions (unweighted average of substrate, pool frequency, and wood frequency) in 2006 and 2001-2002 at the same 10 sites in the Battle Creek watershed, CA. Error bars represent +/- SEM.

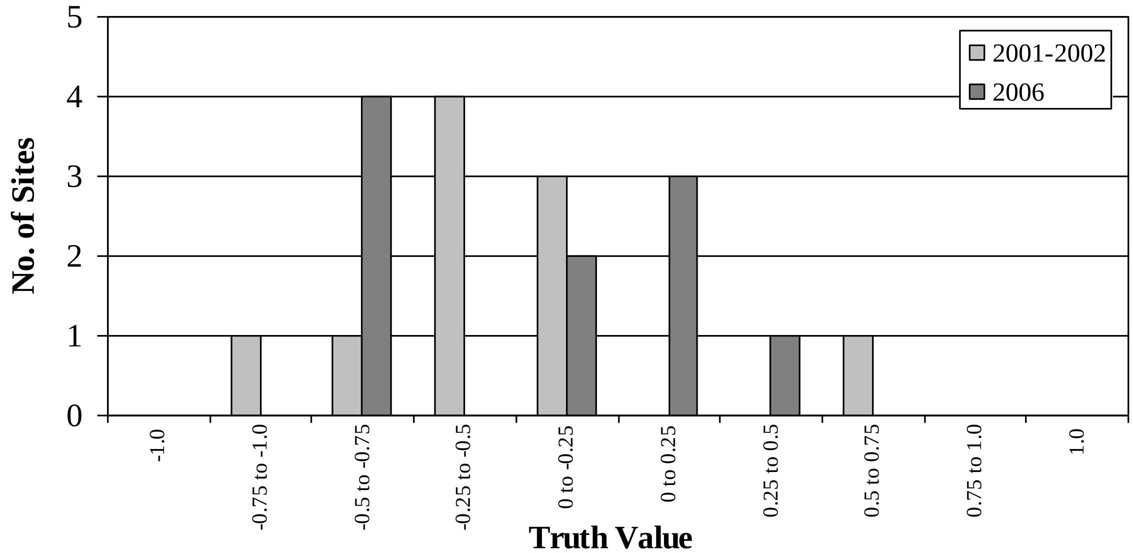

Figure 13. Distribution of Ecosystem Management Decision Support (EMDS) model physical stream conditions (unweighted average of substrate, pool frequency, and wood frequency) in 2006 and 2001-2002 at the same 10 sites in the Battle Creek watershed, CA.

DISCUSSION

Biological stream condition metrics and indices provide evidence of an improvement in watershed condition in 2006 from the 2001-2002 sample period. The watershed-scale EMDS truth value for 2006 (0.76) indicates that there is reasonable certainty regarding the premise of biological watershed condition and that conditions are "likely favorable" for salmonid production and indicates a higher level of certainty than did the truth value of 0.59 from 2001-2002. The watershed assessment (Ward and Moberg 2004) concluded that a large storm event in January 1997 was the primary sediment source factor affecting physical aspects of stream condition. While the background annual variability in biological watershed conditions has not yet been established, the observed increase in biological conditions at the watershed scale is consistent with recovery in watershed conditions from the 1997 event since previous sampling in 2001-2002.

Changes in physical condition at the watershed scale are also consistent with recovery in watershed conditions since 2001 and 2002, although it is not possible to assign statistical significance to changes in physical habitat conditions from the 2001-2002 time period due to the limited amount of data collected in 2006, when only 10 sites were sampled. For example, we observed less fine sediment in scour pool tails, larger mean streambed particle sizes, and more scour pools in 2006 compared to the earlier sampling period, but we also found that scour pools were shallower and that less large woody debris was present. None-the-less, our certainty that physical conditions are favorable for salmonid production remains low (i.e., the EMDS physical condition truth value for 2006 is -0.24) but not as low as in 2001-2002 (i.e., when the truth value was -0.31).

Ongoing monitoring following the SCMP (Ward et al. 2008) design will provide the necessary data to determine the current status and long-term trends in the stream conditions of the Battle Creek watershed. The recommended sample size of 20 annual physical habitat monitoring sites following the rotating panel design will provide more data annually to determine physical watershed status than what was available in this report (i.e., 10 sites in 2006) and provide for effective trend monitoring. The continued use of 50 sites annually for the monitoring of biological stream conditions will not only establish biological condition trends, but will enable the robust detection of potential acute short-term changes in stream conditions similar to analyses within this report that tested the difference between two time periods (i.e., 2001-2002 and 2006).

While this report provides a summary of the highlights of 2006 monitoring data, further monitoring and analysis is an ongoing collaborative process of the Technical Advisory Committee (TAC) to insure that information generated can inform watershed management decision making. The TAC has identified two areas of interest to explore in future analyses. The first is to explore the development of a Battle Creek specific Index of Biotic Integrity (IBI) to determine which metrics best detect disturbance within the watershed. The second is to use existing and ongoing monitoring data to explore changes in condition at specific sites to determine which areas within the watershed are changing in condition and to discern potential patterns in changes (e.g., relative to stream order, gradient, land use etc.).

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PERSONAL COMMUNICATIONS

Gallo, K. Scientist, U.S. Forest Service, Aquatic and Riparian Effectiveness Monitoring Program, Corvallis, OR. Personal Communication -- multiple phone calls, emails, and meetings from 2001 through 2004.

Reeves, G. Research Fish Biologist, U.S. Forest Service, Pacific Northwest Research Station, Corvallis, OR. Personal Communication -- review of administrative draft report and a telephone conversations on July 20, 2004 and August 9, 2004.

APPENDIX A. CORRECTIONS TO 2001-2002 WATERSHED ASSESSMENT

In the preparation of this document, errors in a minor part of the analysis of two of four macroinvertebrate indices were found to exist in the Battle Creek Watershed Assessment (Ward and Moberg 2004) published in 2004. These errors do not significantly alter the conclusions of Ward and Moberg (2004) and are described in this Appendix in order to bring these errors to the attention of other researchers and to facilitate future the analysis of trends in macroinvertebrate communities in Battle Creek.

The original macroinvertebrate data upon which Ward and Moberg (2004) were based have been confirmed to be correct as published in Ward and Kvam (2003).

The purposes of the Watershed Assessment conducted by Ward and Moberg (2004) were to 1) document existing stream conditions and develop a baseline against which future conditions may be compared, and 2) to identify and prioritize for treatment sediment sources within Battle Creek. To meet these purposes, Ward and Moberg (2004) analyzed a suite of physical and biological data using the EMDS model. This model evaluates raw data and generates "truth values" which describe the level of certainty with which a scientific premise regarding an observed condition can be viewed. The EMDS model was used to evaluate a hierarchy of data, with certain biological and physical data at the bottom of the pyramidal hierarchy and watershed condition at the top of the pyramid (**Figure 14**).

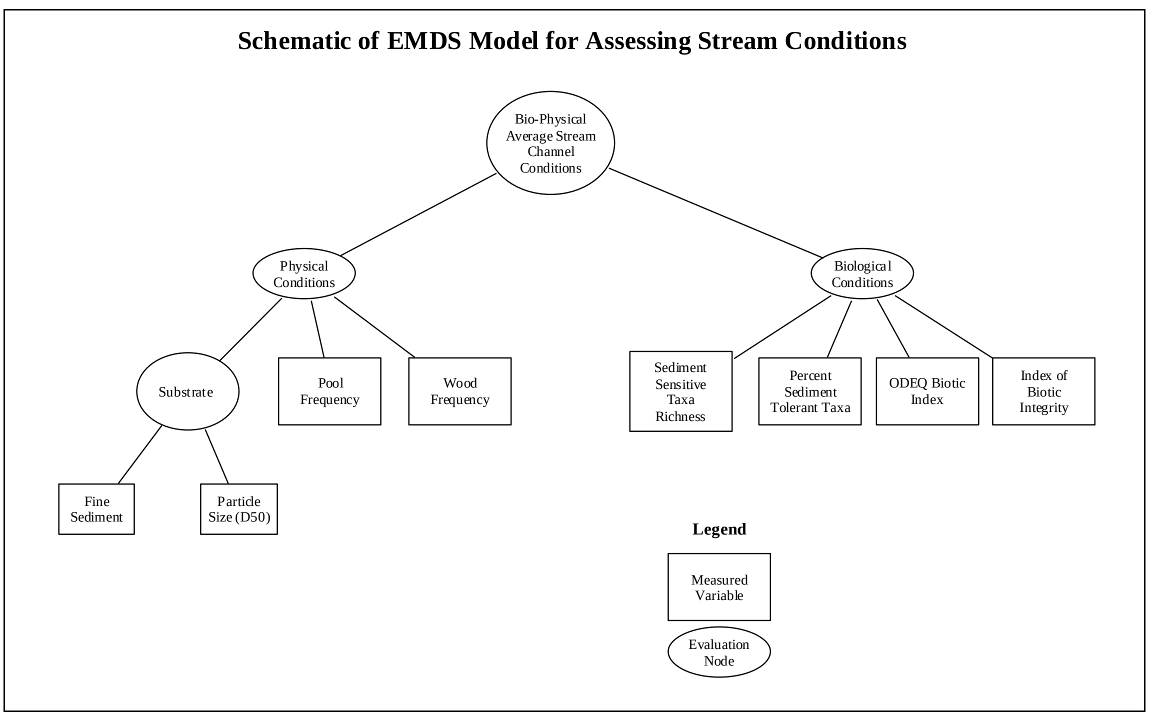

Figure 14. Schematic of the Ecosystem Management Decision Support (EMDS) model used to assess stream conditions in the Battle Creek watershed.

Part of the biological data set was macroinvertebrate community metrics extracted from Ward and Kvam (2003) and included the PSTT index, the SSTR index, the ODEQ-BI and the B-IBI.

EMDS interpretations in Ward and Moberg (2004) of PSTT and SSTR (but not ODEQ-BI or B-IBI) and those levels of the hierarchy above the biological metrics, namely, Biological Condition and Bio-Physical Average Stream Conditions ("Watershed Averaged Conditions"), were flawed due to a simple cut-and-paste error in one spreadsheet used to generate the EMDS truth values for these metrics.

After reanalyzing the conclusions of Ward and Moberg (2004) in light of the corrected data, no significant changes to the conclusions of this work appear to be necessary. Corrections to the original Ward and Moberg (2004) conclusions as presented in that document are as follows:

- The fourth paragraph on page 29 in Ward and Moberg (2004) should be corrected to read: "Sediment sensitive taxa richness (SSTR) scores averaged 1.8 taxa [versus the erroneous value of 6 taxa] and ranged from 0 to 4 sediment sensitive taxa [versus the erroneous range of 0 to 17 taxa] at each site. EMDS analysis indicates with reasonable or high certainty that SSTR scores were fully favorable for salmonid production at 23 sites and were fully unfavorable at 4 sites [versus the erroneous interpretations of favorable at 36 sites and unfavorable at 4 sites]. A reanalysis of geographical patterns in this data was not completed for this correction.
- The fifth paragraph on page 29 in should be corrected to read: "Percent Sediment Tolerant Taxa (PSTT) scores averaged 4.8 percent [versus the erroneous value of 16 percent] and ranged from less than 1 to 33 percent [versus the erroneous range of 0 to 37 percent]. EMDS analysis indicates, with reasonable or high certainty that PSTT scores were favorable for salmonid production at 39 sites and were unfavorable at 1 site [versus the erroneous interpretations of favorable at 20 sites and unfavorable at 16 sites]." A reanalysis of geographical patterns in this data was not completed for this correction.
- Elements of Table 4 of Ward and Moberg (2004) should be corrected to read:
  - The watershed averaged truth value for SSTR is 0.38 – which is interpreted as moderately favorable [versus the erroneous 0.64 interpreted as likely favorable].
  - The watershed averaged truth value for PSTT is 0.73 – which is interpreted as likely favorable [versus the erroneous 0.10 interpreted as moderately favorable].
  - The watershed averaged truth value for biological condition is 0.51 – which is interpreted as likely favorable [versus the erroneous 0.41 interpreted as likely favorable].
  - The watershed averaged truth value for bio-physical averaged stream conditions is 0.13 – which is interpreted as moderately favorable [versus the erroneous 0.08 interpreted as moderately favorable].

The corrected data will be available on the internet by spring 2009 at http://krisweb.com/ under the Battle Creek Project.