Chapter 2.15 Biological Beneficial Use Support Assessment Procedure

2.15.1. Introduction

Utah's biological beneficial uses require the protection of fish (e.g., cold- or warm-water species) and the organisms upon which they depend. In the past, DWQ has assessed these beneficial uses via water chemistry sampling and associated standards that assume to protect aquatic organisms. However, DWQ has recently developed an empirical model that directly assesses attainment of biological beneficial uses by quantifying the 'health' of macroinvertebrate assemblages. Measuring biological communities directly has the advantage that it integrates the combined effects of all pollutants which allows a direct examination of how pollutants are interacting to affect the condition of a stream ecosystem. (Karr, 1981). Moreover, because aquatic macroinvertebrates spend the majority of their life in aqueous environments, they are capable of integrating the effects of stressors over time providing a measure of past, transient conditions (Karr and Dudley, 1981).

Biological assessments are often conducted by comparing the biological assemblage *observed* at a site with the *expected* biological assemblage in the absence of human-caused disturbance. Ideally, these comparisons are made using historical data to measure changes to the current biological community. However, in most cases historical data are not available. As a result, biological conditions representing an absence of human-caused stress are typically set using reference sites as controls, or benchmarks, to establish the biological condition expected in the absence of human-caused disturbance. The biological integrity of sites can be evaluated by comparing the biological composition observed at a site against a subset of physically similar reference sites. Collectively, such comparisons are referred to as biological assessments.

In aquatic biological assessments, reference sites are selected to represent the best available condition for streams with similar physical and geographical characteristics (see Hughes et al 1986, Suplee et al. 1995, and the Western Center for Monitoring and Assessment of Freshwater Ecosystems website http://www.cnr.usu.edu/wmc for more details). When reference sites are selected for water quality programs, conditions vary regionally depending upon adjacent historical landuse. For example, reference sites in Utah mountains are generally more pristine than in valleys. As a result, biological benchmarks are higher in areas of the State that receive less man-made disturbance than those with more disturbances.

A numeric index is a useful tool that quantifies the biological integrity, or biological beneficial use of stream and river segments. Data obtained from biological collections are complex with hundreds of species found throughout Utah that vary both spatially and temporally. Similarly, the physical template upon which biota depends also varies considerably across streams. A robust index of biological integrity should simultaneously account for naturally occurring physical and biological variability and summarize these conditions with a single, easily interpretable number.

2.15.2. River Invertebrate Prediction and Classification System (RIVPACS) Models

DWQ employs the RIVPACS (River Invertebrate Prediction and Classification System) model approach (Wright 1995) to quantify biological integrity. RIVPACS is a classification of freshwater sites based on macroinvertebrate fauna that was first derived in 1977. In the early 1970's scientists and water managers recognized a need to understand the links between the ecology of running waters and macroinvertebrate communities. This began some of the very early biological assessment work in Europe. A four-year project was initiated to create a biological classification of unpolluted running waters in Great Britain based on the macroinvertebrate fauna (Furse et al., 1984, Wright 1995, Clarke et al., 1996, Moss et al., 1999). Over the past 30 years, equivalent RIVPACS models have been developed for aquatic ecosystems throughout the world including Australia (Metzeling et al., 2002, Marchant and Hehir, 2002, Davies et al., 2000) and Indonesia (Sudaryanti et al., 2001). In the United States scientists have developed RIVPACS models to assess the biological integrity of the country's aquatic habitats (Hawkins et al., 2000, Hawkins and Carlisle, 2001). Recently, many western states have adapted the RIVPACS model to determine beneficial uses of aquatic life in the rivers of State's such as Colorado (Paul et al., 2005), Montana (Feldman, 2006, Jessup et al., 2006) and Wyoming (Hargett et al., 2005).
RIVPACS-based methods for conducting biological assessments were initially developed in Great Britain (Wright, 1995) and have subsequently been used in numerous biological assessment programs worldwide. To quantify biological condition, RIVPACS models compare the list of taxa (the lowest practical taxonomic resolution to which taxonomic groups are identified) that are observed (O) at a site to the list of taxa expected (E) in the absence of human-caused stress. Predictions of E are obtained empirically from reference sites that together are assumed to encompass the range of ecological variability observed among streams in the region where the model was developed. In practice, these data are expressed as the ratio O/E, the index of biological integrity.

Interpretation of RIVPACS models requires an understanding of the O/E ratio. In essence, O/E quantifies loss of biodiversity. It is not a measure of raw taxa richness since O is constrained to include only those taxa that the model predicted to occur at a site. The fact that O/E only measures losses of native taxa is an important distinction because the stream ecological template changes in response to human-caused disturbance and taxa richness can actually increase as conditions become more advantageous to taxa that are more tolerant of the degraded condition. Despite the mathematical complexities of model development, O/E is easily interpreted as it simply represents the extent to which taxa have become locally extinct as a result of human activities. For example, an O/E ratio of 0.40 implies that, on average, 60% of the taxa have become locally extinct as a result of human-caused alterations to the stream.

O/E has some very useful properties as an index of biological condition. First, it has an intuitive biological meaning. Species diversity is considered the ecological capital on which ecosystem processes depend; thus, O/E can be easily interpreted by researchers, managers, policy-makers, and the public. Second, O/E is universally spatial which allows direct and meaningful comparison throughout the state (Figure 2.15.1). This is particularly important for Utah where streams vary considerably from high-altitude mountain environments to the arid desert regions of the state. Third, its derivation and interpretation does not require knowledge of stressors in the region; it is simply a biological measuring tool. Finally, the value of O/E provides a quantitative measure of biological condition.

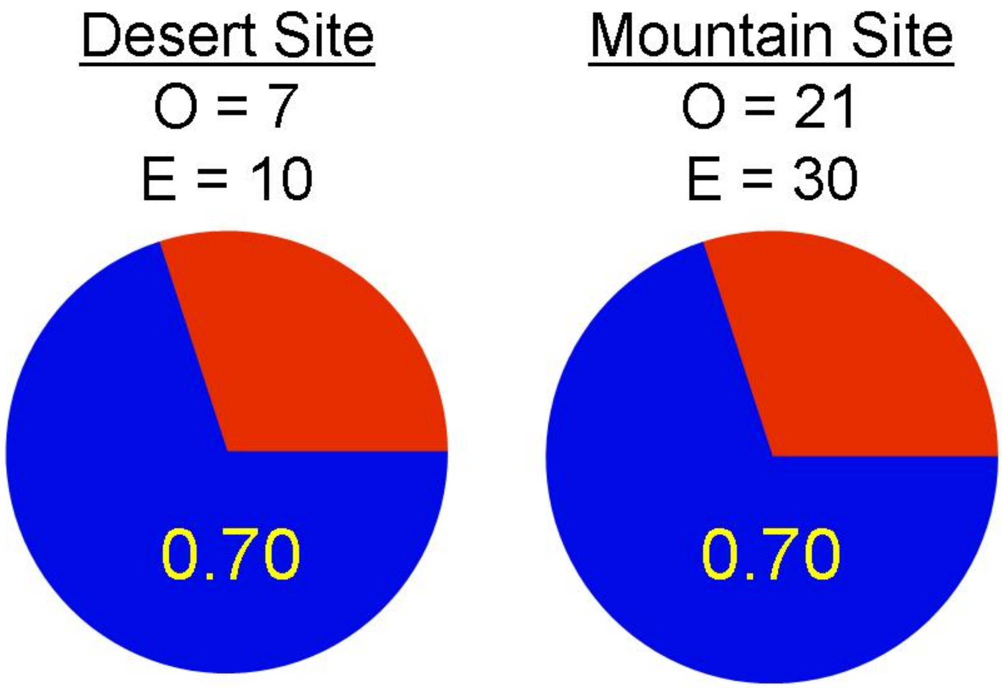

Figure 2.15.1. A hypothetical example of observed/expected (O/E) as a standardization of biological assessments in different natural environments using numbers benthic macroinvertebrate taxa.

In the desert site, 7 taxa were observed (O) from an expected number (based on reference) of 10 taxa (E). Thus, the O/E score was .70 or a loss of 30% of the taxa expected at the site.

2.15.3. Model Construction and Performance

Construction of a RIVPACS model for Utah began in 2002 which involved developing and evaluating dozens of models. Details of model development procedures can be found elsewhere (Wright et al. 1993, Wright 1995, Clarke et al., 1996, Moss et al. 1999). Here a brief summary is provided so Utah's model results and subsequent assessments are better understood.

As mentioned in the introduction, predictions of E are obtained empirically from reference site collections made throughout Utah. Reference sites were selected using experienced DWQ scientists who identified sites that represented the reference conditions in different biogeographical settings throughout Utah. The initial list of candidate reference sites was independently ranked by different scientists familiar with the streams. Only reference sites with a consensus representing best available conditions were used in model development.

Some of the calculations involved in obtaining E are complex. A heuristic description of the steps involved in predicting E provides some context of the assessment methodology. The first step in model development is to classify reference sites into groups of sites with similar taxonomic composition using a cluster analysis. Next, models are developed based on watershed descriptors (i.e., climatic setting, soil characteristics, stream size) to generate equations that predict the probability of a new site falling within each group of reference sites. These equations account for environmental heterogeneity and ensure that when a new site is assessed, it is compared against ecologically similar reference sites. When a new site is assessed, predictions of group membership are then coupled to the distributions of taxa across groups of reference sites to estimate the probability of capturing ($P_{c)}$ each taxon from the regional pool of all taxa found across all reference sites. E is then calculated as the sum of all taxa P_cs that had a greater than 50% chance of occurring at a site given the site's specific environmental characteristics.

The accuracy and precision of RIVPACS models depend in part on the ability of the models to discriminate among groups of biologically similar reference sites. An extensive list of 82 Geographic Information System (GIS)-based watershed descriptors were evaluated as potential predictor variables in models that predict the probability of membership within biological groups for sites not used in model construction. GIS-based predictor variables, such as soils, meteorology, and geography, instead of field-derived descriptors, were evaluated for a couple of reasons. First, GIS-based descriptors are unlikely to be influenced by human disturbance and are therefore unlikely to bias estimates of expected conditions (Hawkins, 2004). Second, these predictors are easily obtained for any site which allows inclusion of additional macroinvertebrate samples collected by others. Various subsets of potential predictors were evaluated in an iterative, analytical process that explored different combinations of predictors able to explain the biological variability among reference sites. The final analysis selected 15 variables that resulted in the most precisely predictive model (Table 2.15.1).

The RIVPACS model used for the 2007 assessments was both accurate and precise when evaluated by examining the range of O/E scores obtained from reference sites. If the model was perfectly accurate and precise, the O/E score for all reference sites would equal 1. Instead, reference O/E values are typically spread in a roughly normal distribution centered on 1 (Wright, 1995). Model precision is often expressed as the standard deviation (SD) of reference O/E values with lower SDs indicating higher model precision. The RIVPACS model used for the *2008*

Integrated Report assessments had a SD of 0.13 which is more precise than most traditionally 'accepted' water quality models. The average reference O/E score for Utah's model is 1.04 which means that the model is slightly biased to generate higher O/E values than expected (Figure 2.15.2). The accuracy of the model was evaluated by examining the distribution of reference O/E scores in different environmental settings and revealed reference O/E values were not biased by stream size, elevation, or ecoregion.

Table 2.15.1. Final predictor variables used in model construction.

General Category	Description
Geographical	Maximum watershed elevation (meters) from National Elevation Dataset
Geographical	Mean watershed elevation (meters) from National Elevation Dataset.
Geographical	Average slope calculated from Geographic Information System (GIS) data
Geographical	Watershed area in square kilometers.
Geology	Predicted potential for soil erosion based on lithology from state geology maps and estimated physical weathering rates based on known rock hardness.
Geology	Variable indicates dominant geology (1=yes; 2=no)
Soils	Watershed mean high values of available water capacity of soils (fraction) from State Soil Geographic (STATSGO) Database.
Soils	Watershed mean high values of soil bulk density of soils types within the basin (grams per cubic centimeter) from State Soil Geographic (STATSGO) Database.
Weather	Average of the annual minimum of the predicted mean monthly number of days with measurable precipitation (days) derived from PRISM (Parameter-elevation Regressions on Independent Slopes Model) data for all pixels in a watershed.
Weather	Watershed average of the mean day of year (1-365) of the first freeze derived from the PRISM data.
Weather	Watershed average of the mean day of year (1-365) of the last freeze derived from the PRISM data.
Weather	Annual minimum of predicted mean monthly precipitation (mm) derived from the PRISM data for the sampling site
Weather	Annual mean of the predicted mean monthly precipitation (mm) derived from the PRISM data for the sampling site.
Weather	Stream network average of the annual mean of the predicted mean monthly air temperature (tenths of degree Celsius) derived from PRISM data.
Weather	Watershed average of the annual mean of the predicted mean monthly air temperature (tenths of degree Celsius) derived from PRISM data.

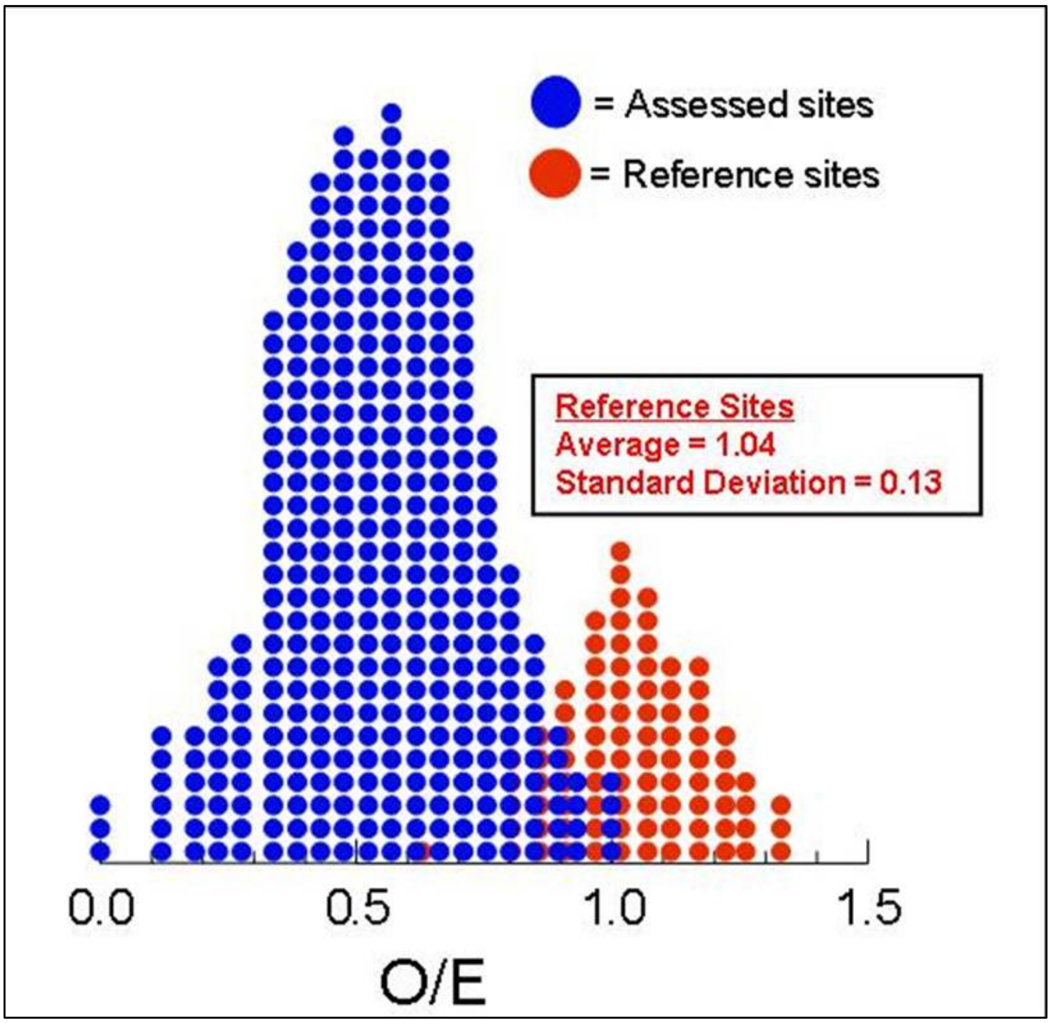

Figure 2.15.2. Distribution of reference and test O/E scores.

2.15.4. Assessing Biological Beneficial Use Support

Utah does not currently have numeric biological criteria. However, model outputs are used to guide assessments under the narrative standards of the Utah Clean Water Act (R317-2). To make the narrative assessments as rigorous as possible, a systematic procedure was devised to use the RIVPACS model O/E values to determine aquatic life beneficial use support (Figure 2.15.3). The goal of this assessment process is to characterize each Assessment Unit (AU) as *Fully Supporting* or *Not Supporting* aquatic life beneficial uses. The assessment methods are described below.

Utah currently assesses watersheds based on established Assessment Units (AUs). While many AUs contain a single biological collection site, some AUs contain multiple sites. In such instances, DWQ staff examined available data to determine if multiple sites within an AU occur in similar ecological settings. Data evaluated to make these comparisons include: stream hydrology, stream order, predominant riparian and upland vegetation, and/or major changes in habitat characteristics measured at each site. When comparisons suggest that sites within an AU are ecologically similar, O/E scores from all sites within an AU are averaged for assessment purposes provided that conclusions of biological condition are similar. If O/E scores differ appreciably among multiple sites within an AU, then DWQ will investigate possible explanations for such discrepancies. If DWQ finds multiple sites within an AU from different environmental settings AUs are subdivided into smaller watershed units whenever clear boundaries can be identified (e.g., political/landuse boundaries, tributary confluence).

To translate the O/E values into assessment categories it is necessary to devise impairment thresholds, or O/E scores that indicate whether or not a site is meeting biological beneficial uses (Table 2.15.2). For these assessments, DWQ determined that a mean O/E value less than 0.74 (26% loss of expected species) indicates non-support of beneficial uses if >3 samples are used to assess the site. The threshold of 0.74 represents a departure from 1 (no taxa loss) of two (2) standard deviations of reference O/E scores. For all sites with multiple years of data, the average difference between maximum and minimum O/E values is 0.2. At least 3 yearly samples are preferred for assessments because O/E scores can vary from year-to-year and assessments based on average conditions. Assessments based on the average condition of ≥3 samples reduces the possibility of making an error of biological beneficial use support as a result of an unusual sampling event (i.e., following a flash flood, improperly preserved sample).

One ramification of requiring at least three samples is that remediation efforts may be postponed for years because biological samples are only collected once per year. To minimize delayed response times, DWQ identified a second threshold value of 0.54 (0.74 – 0.20 average year-to-year variability) for sites with <3 samples (Table 2.15.2). This second threshold expedites environmental response at severely degraded sites where additional sampling would be unlikely to alter an assessment of impairment. Sites with < 3 samples that have a mean O/E score ≥0.54 and <0.74 will be placed in impairment category 3A, which indicates that there is insufficient data to make an assessment. All sites listed as 3A will be given a high priority for future biological monitoring.

Table 2.15.2 Beneficial use support determination for O/E values obtained from different sample sizes.

Sample Size	O/E Threshold	Use Determination	Comments
≥ 3 samples collected over 3 years	Mean O/E score ≥ 0.74	Fully Supporting	
≥ 3 samples collected over 3 years	Mean O/E score < 0.74	Not supporting	Threshold based on 2 SD of reference O/E scores
< 3 samples	Mean O/E score >0.54 – 0.74	Category 3A (insufficient data)	
< 3 samples	Mean O/E score <0.54	Not supporting	Original threshold with consideration for year-to-year variability of 0.20

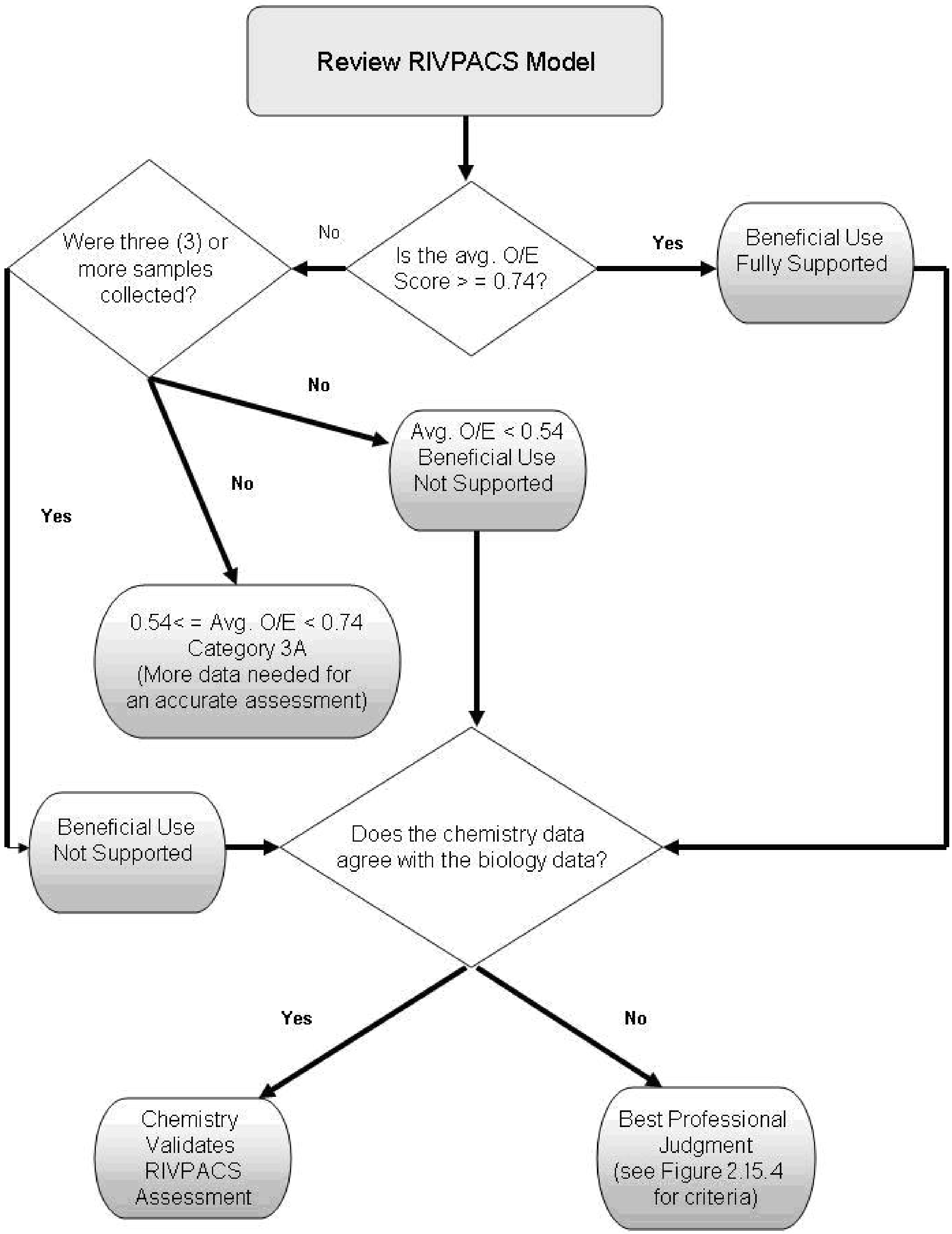

Figure 2.15.3. Flow diagram depicting decision tree for biological assessment.

2.15.5. Merging Biological and Chemical Assessments

For years, DWQ has assessed biological beneficial use attainment with water chemistry standards that are assumed to be protective of stream biota. Before making final decisions about biological beneficial use support, a comparison is made between impairment assessments obtained from stream biota with those obtained from stream chemistry. The primary goal behind these evaluations is to eliminate both false positive and false negative assessments. There are four potentially confounding factors that warrant a more careful scrutiny of incongruous biological and chemical assessments. These factors are summarized in a Best Professional Judgment (BPJ) framework (Figure 2.15.4) wherein disagreements between chemistry and biology assessments are objectively and systematically evaluated on a case-by-case basis. These judgment decisions are based in part on EPA's "Consolidated Assessment and Listing Methodology" (CALM) guidance published in 2002. The guidance provides a framework to weigh multiple types of data used for waterbody assessment. Specifically, the guidance refers to the policy of independent applicability which stresses that if any one type of applicable data indicates water quality standards are not attained the water body shall be identified impaired.

2.15.5.1. Were the chemical and biological samples collected in similar locations? Biological and chemical sample sites are not always co-located which may lead to different assessments if land-use or habitat is different among chemical and biological sampling sites. For instance, in one assessment unit a biological sample may have been collected in the upper watershed and represent the water quality in the headwaters versus a downstream water quality station that is potentially located in a different ecological setting. If the chemical and biological sample locations are clearly distinct, the assessment unit is divided at a clear boundary (e.g., Forest Service boundary, tributary convergence, water withdrawal) where they existed. However, in some cases, sites may be assessed as 3A (more data required) because clear boundaries are not immediately apparent from available data.

2.15.5.2. Is the model applicable to the site? One of the fundamental assumptions of RIVPACS models is that the suite of reference sites used in model construction encompasses the range of conditions observed in the sites that are to be assessed. All sites are evaluated to determine whether this assumption is met before a final assessment is made. For example, DWQ found a site located in a relatively undisturbed environmental setting with low O/E values. Investigations into this unexpected result revealed that the site was located in a large, sandy bottomed river, and that the current model cannot be appropriately applied to such sites because it based generated with few reference sites with similar characteristics. In instances where model results are suspect, the AU is placed into category 3A until additional reference sites can be sampled and incorporated into the model.

2.15.5.3 Were the chemical or biological samples collected during unusual environmental conditions? Conclusions of impairment can potentially be biased when samples are collected during unusual environmental conditions. For instance, both biological composition and chemical criteria are known to be altered by drought and data collected under these conditions may be suspect. Similarly, the composition of stream assemblages is known to be altered by flash floods and samples collected following these events are suspect. In these situations, the AU is placed into category 3A until additional data can be collected to corroborate assessment results.

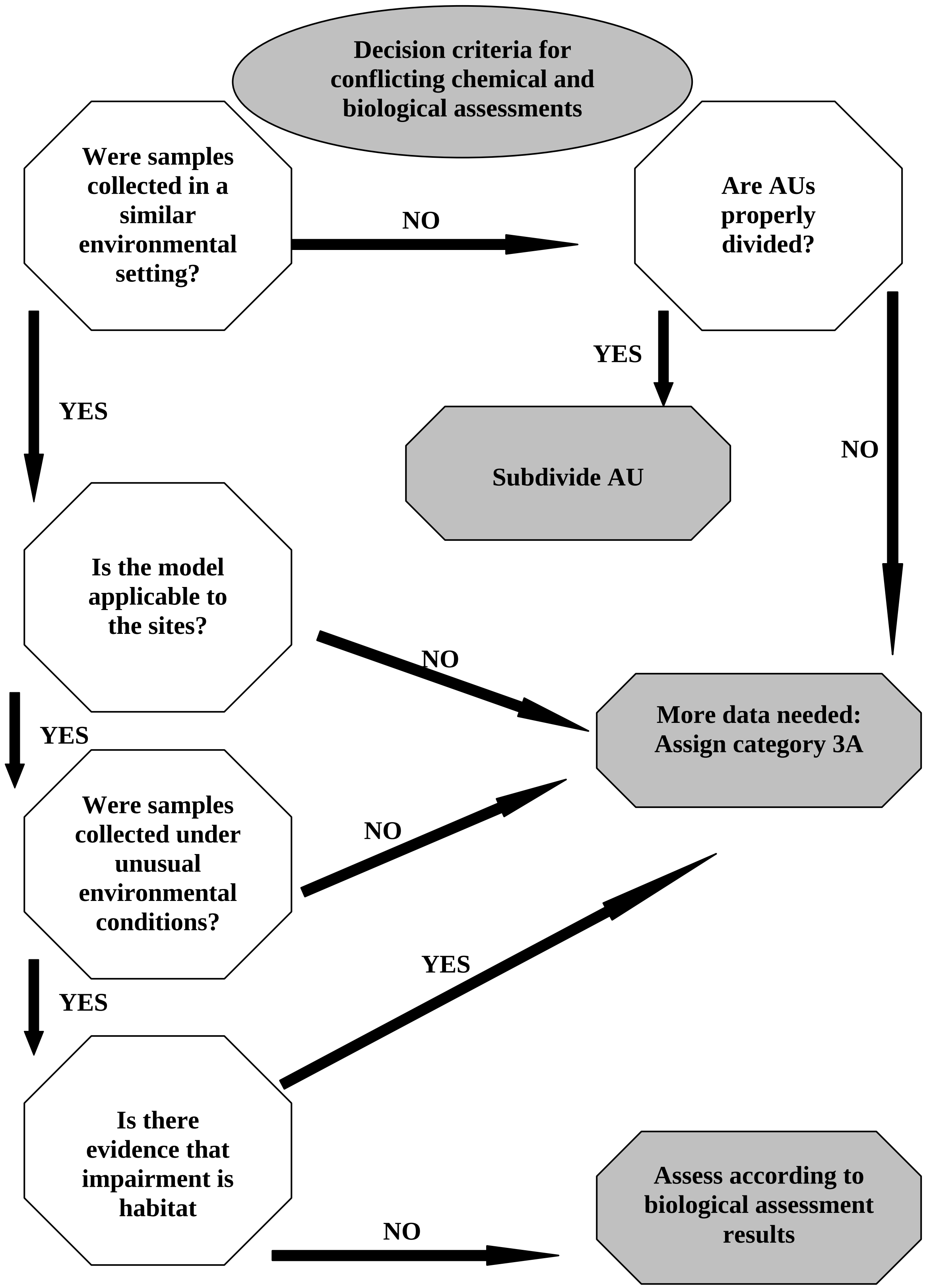

Figure 2.15.4. Best professional judgment criteria.

2.15.5.4 Is there strong evidence that impairment is habitat related? If biological assessments indicate impairment and chemistry data indicates full support, habitat degradation may be the source of impairment. Currently, DWQ does not have approved methodology to categorize nonsupport status because of impaired habitat. Therefore, additional data is required to better understand assessment discrepancies in the AU and was listed as 3A.

Finally, if an AU results in a 3A listing for either biological or chemical assessment, the assessment type with sufficient data to determine the listing will be used. For example, if the biological data of an AU indicates Full Support while chemical data indicates 3A, the AU will be listed as Full Support.

2.15.6. Results

To make assessments in this report, O/E values were calculated for 444 individual samples collected from 234 sites throughout the state for the 2008 assessments (Table 2.15.3). Biological assessments were conducted on 164 AUs, representing 5,116 miles of stream which is 36% of total perennial stream miles (14,250) in Utah. Some sites were sampled every year; however, the majority of sites were sampled in response to previously identified water quality concerns or on a rotating basin schedule. In general, samples used in these analyses were collected over the past 5 years. If there was evidence that major changes in land-use had not occurred since samples were collected, older data were used to corroborate more-recent findings. In addition, these analyses were limited to samples collected in the autumn (September to early November) to minimize seasonal changes in taxonomic composition.

O/E scores from all sampling events ranged from near 0.105 to 1.315 as shown in Figure 2.15.2. Based solely on the biological assessment of 164 AUs, 79 were fully supporting, 48 were non-supporting, and 37 were 3A. This is depicted graphically based on stream miles (Figure 2.15.5). The final aquatic life assessment (considering both biological and chemical data) concluded that 96 AUs were fully supporting, 63 AUs were non-supporting, 3 AUs required category 3A, and 2 AUs were identified as 4A (impairment with a completed TMDL). A look at the spatial distribution of the biological assessments revealed that biologically degraded sites occurred throughout the state, but with some localized clumping of degraded sites (Figure 2.15.6). Finally, the results were summarized as a function of the total number of stream miles assessed (Figure 2.15.7).

Table 2.15.3. Assessment Unit Biological Sampling O/E Values and Aquatic Life (Class 3) Assessments

Assessment Unit Name	Assessment Unit Number	Average O / E Score	Minimum O / E Score	Maximum O / E Score	Biological Data Assessment	Final Aquatic Life Assessment	Assessment Unit Stream Miles
American Fork River-1	UT16020201-001	1.184	1.184	1.184	Full Support	Full Support	14.1
American Fork River-2	UT16020201-002	0.675	0.610	0.915	3A*	Full Support	30.8
Antimony Creek	UT16030002-008	1.104	1.104	1.104	Full Support	Full Support	26.6
Asay Creek	UT16030001-011	0.546	0.455	0.637	3A*	Full Support	36.8
Bear River-2	UT16010204-008	0.328	0.328	0.328	Nonsupport	Nonsupport	41.5
Bear River-6	UT16010101-021	0.687	0.523	0.821	3A*	Full Support	17.0
Beaver Creek-1	UT16020101-029	0.645	0.645	0.645	3A*	Full Support	12.7
Beaver Creek-2	UT16020101-030	1.074	0.900	1.248	Full Support	Full Support	21.4
Beaver Creek-2	UT16030003-020	1.234	1.234	1.234	Full Support	Full Support	16.7
Beaver Dam Wash	UT15010010-002	0.698	0.698	0.698	3A*	Full Support	24.4
Beaver River-2	UT16030007-002	0.358	0.175	0.525	Nonsupport	Nonsupport	57.6
Beaver River-3	UT16030007-003	1.039	0.928	1.155	Full Support	Full Support	142.8
Benjamin Slough	UT16020202-030	0.588	0.588	0.588	3A*	Full Support	5.4
Big Cottonwood Creek-2	UT16020204-020	0.783	0.783	0.783	Full Support	Full Support	34.0
Birch Creek	UT14070005-002	0.668	0.668	0.668	3A*	Nonsupport	29.7
Blacksmiths Fork-1	UT16010203-020	1.041	1.041	1.041	Full Support	Full Support	10.4
Boulder Creek	UT14070005-018	0.788	0.788	0.788	Full Support	Full Support	51.8
Carter Creek	UT14040106-010	1.090	0.907	1.274	Full Support	Full Support	89.9
Castle Creek- 1	UT14030005-009	0.291	0.291	0.291	Nonsupport	Nonsupport	9.1
Castle Creek- 2	UT14030005-012	0.931	0.931	0.931	Full Support	Full Support	9.1
Chalk Creek-1	UT16020101-010	0.644	0.552	0.736	Nonsupport	Nonsupport	7.7
Chalk Creek-2	UT16020101-012	0.621	0.483	0.805	Nonsupport	Nonsupport	4.5
Chalk Creek-2	UT16030005-019	0.957	0.957	0.957	Full Support	Full Support	33.8
Chance Creek	UT14070006-004	0.105	0.105	0.105	Nonsupport	Nonsupport	16.7
Clarkston Creek	UT16010202-013	0.581	0.436	0.726	3A*	Full Support	57.8
Clear Creek	UT16020202-019	0.428	0.428	0.428	Nonsupport	Nonsupport	12.6
Clear Creek	UT16030003-018	1.091	1.082	1.100	Full Support	Full Support	101.4
Corn Creek	UT16030005-021	0.620	0.620	0.620	3A*	Full Support	45.9
Cub River	UT16010202-010	0.705	0.498	0.871	3A*	Nonsupport	14.3
Deep Creek	UT15010008-017	1.207	1.207	1.207	Full Support	Full Support	60.4
Diamond Fork-1	UT16020202-006	0.458	0.458	0.458	Nonsupport	Nonsupport	20.1
Diamond Fork-2	UT16020202-007	0.628	0.628	0.628	3A*	Full Support	4.5
Dolores River	UT14030004-001	0.941	0.743	1.139	Full Support	NonSupport	61.7
Dry Fork Creek	UT14060002-009	1.088	1.088	1.088	Full Support	Full Support	41.3
Duchesne River-1	UT14060003-001	0.373	0.373	0.373	Nonsupport	Nonsupport	19.5
Duchesne River-3	UT14060003-006	0.466	0.466	0.466	Nonsupport	Nonsupport	39.5
Duchesne River-4	UT14060003-017	1.070	1.070	1.070	Full Support	Full Support	67.5
East Canyon Creek -1	UT16020102-024	0.578	0.388	0.778	3A*	Full Support	15.3
East Canyon Creek-2	UT16020102-026	0.623	0.170	0.366	Nonsupport	Nonsupport	34.7
East Fork Chalk Creek	UT16020101-015	0.658	0.485	0.809	Nonsupport	Nonsupport	28.4
East Fork Little Bear-1	UT16010203-014	0.765	0.765	0.765	Full Support	Full Support	7.0
East Fork Little Bear-2	UT16010203-017	1.245	1.245	1.245	Full Support	Full Support	27.9
East Fork Sevier-1	UT16030002-010	0.343	0.343	0.343	Nonsupport	Nonsupport	31.8
East Fork Smiths Fork	UT14040107-005	1.035	0.972	1.099	Full Support	Full Support	48.4
East Fork Virgin-1	UT15010008-018	0.758	0.732	0.836	Full Support	Full Support	37.1
East Fork Virgin-3	UT15010008-020	0.866	0.866	0.866	Full Support	Full Support	28.8
Echo Creek	UT16020101-007	0.432	0.393	0.472	Nonsupport	Nonsupport	41.5
Echo Creek	UT16020101-031	1.212	1.212	1.212	Full Support	Full Support	2.6
Fremont River-1	UT14070003-004	0.799	0.695	0.903	Full Support	Full Support	7.7

Table 2.15.3. Assessment Unit Biological Sampling O/E Values and Aquatic Life (Class 3) Assessments

Assessment Unit Name	Assessment Unit Number	Average O / E Score	Minimum O / E Score	Maximum O / E Score	Biological Data Assessment	Final Aquatic Life Assessment	Assessment Unit Stream Miles
Fremont River-2	UT14070003-005	0.465	0.465	0.465	Nonsupport	Nonsupport	29.3
Fremont River-3	UT14070003-008	0.554	0.370	0.616	Nonsupport	Nonsupport	82.9
Green River-2	UT14060001-004	0.540	0.540	0.540	3A*	Full Support	91.4
High Creek	UT16010202-012	1.074	1.074	1.074	Full Support	Full Support	9.4
Huntington creek-2	UT14060009-004	0.628	0.536	0.763	3A*	Nonsupport	19.2
Indian Creek-2	UT14030005-002	0.930	0.743	1.095	Full Support	Full Support	15.5
JohImpairedon Creek	UT14080201-004	0.881	0.881	0.881	Full Support	Full Support	3.9
Jordan River-1	UT16020204-001	0.438	0.438	0.438	Nonsupport	Nonsupport	7.6
Jordan River-3	UT16020204-003	0.438	0.438	0.438	Nonsupport	Nonsupport	4.2
Jordan River-5	UT16020204-005	0.730	0.730	0.730	3A*	Nonsupport	1.6
Jordan River-6	UT16020204-006	0.517	0.436	0.727	Nonsupport	Nonsupport	10.3
Jordan River-7	UT16020204-007	0.271	0.000	0.542	Nonsupport	Nonsupport	4.2
Kimball Creek	UT16020102-027	0.495	0.475	0.554	Nonsupport	Nonsupport	13.0
LaSal Creek	UT14030002-001	1.016	0.786	1.247	Full Support	Full Support	18.0
Laverkin Creek	UT15010008-010	1.225	1.225	1.225	Full Support	Full Support	45.7
Leeds Creek	UT15010008-006	1.080	1.080	1.080	Full Support	Full Support	13.9
LF Huntington Creek	UT14060009-002	0.915	0.915	0.915	Full Support	Full Support	36.6
Little Bear River-1	UT16010203-009	0.516	0.348	0.718	Nonsupport	Nonsupport	16.5
Little Bear River-2	UT16010203-011	0.741	0.537	0.984	Full Support	Full Support	6.7
Little Cottonwood Creek-1	UT16020204-021	0.406	0.406	0.406	Nonsupport	Nonsupport	8.7
Little Cottonwood Creek-2	UT16020204-022	0.479	0.332	0.629	Nonsupport	Nonsupport	21.5
Logan River-1	UT16010203-005	0.741	0.595	0.887	3A*	4A*	35.8
Logan River-2	UT16010203-006	0.962	0.962	0.962	Full Support	Full Support	64.5
Lost Creek-2	UT16020101-003	1.088	1.043	1.132	Full Support	Full Support	47.6
Lower Currant Creek	UT14060004-009	0.676	0.676	0.676	3A*	Full Support	60.6
Lower Escalante	UT14070005-011	0.761	0.761	0.761	Full Support	Full Support	66.2
Lower Range Creek	UT14060005-006	0.834	0.751	1.001	Full Support	Full Support	9.0
Lower Red Creek	UT14060004-006	0.571	0.571	0.571	3A*	Full Support	5.2
Malad River-1	UT16010204-006	0.293	0.293	0.293	Nonsupport	Nonsupport	52.0
Mamie Creek	UT14070005-005	1.033	1.033	1.033	Full Support	Full Support	0.0
Mammoth Creek	UT16030001-009	0.534	0.403	0.644	Nonsupport	Nonsupport	22.3
Mammoth Creek - 2	UT16030001-015	0.934	0.934	0.934	Full Support	Full Support	21.8
Manning Creek	UT16030003-021	1.315	1.315	1.315	Full Support	Full Support	13.9
Middle Fork Ogden River	UT16020102-009	1.187	1.187	1.187	Full Support	Full Support	22.7
Middle Range Creek	UT14060005-005	0.880	0.880	0.880	Full Support	Full Support	19.4
Middle Red Creek	UT14060004-007	0.489	0.489	0.489	Nonsupport	Nonsupport	14.8
Mill Creek-2	UT14030005-006	1.184	1.184	1.184	Full Support	Full Support	29.6
Mill Creek-3	UT16020204-018	0.753	0.510	0.996	Full Support	Full Support	14.5
Moon Lake Tributaries	UT14060003-021	1.080	1.080	1.080	Full Support	Full Support	118.3
Nebo Creek	UT16020202-025	1.080	1.080	1.080	Full Support	Full Support	36.7
Negro Bill	UT14030005-008	0.807	0.807	0.807	Full Support	Full Support	10.1
Newton Creek	UT16010202-002	0.725	0.725	0.725	3A*	Nonsupport	5.2
North Creek	UT14070005-003	1.024	1.024	1.024	Full Support	Full Support	41.5
North Creek	UT15010008-014	1.010	1.010	1.010	Full Support	Full Support	32.7
North Fork Duchesne	UT14060003-019	0.802	0.615	1.040	Full Support	Full Support	58.3
North Fork Virgin River-1	UT15010008-015	1.044	1.044	1.044	Full Support	Nonsupport	38.3
Ogden River-1	UT16020102-005	0.305	0.184	0.669	Nonsupport	Nonsupport	9.7
Otter Creek-1	UT16030002-002	0.381	0.194	0.520	Nonsupport	Nonsupport	59.8
Otter Creek-2	UT16030002-004	1.015	1.015	1.015	Full Support	4A*	19.5

Table 2.15.3. Assessment Unit Biological Sampling O/E Values and Aquatic Life (Class 3) Assessments							
Assessment Unit Name	Assessment Unit Number	Average O / E Score	Minimum O / E Score	Maximum O / E Score	Biological Data Assessment	Final Aquatic Life Assessment	Assessment Unit Stream Miles
Panguitch Creek-2	UT16030001-006	0.685	0.685	0.685	3A*	3A*	30.0
Paria River-1	UT14070007-001	0.145	0.145	0.145	Nonsupport	Nonsupport	16.8
Paria River-3	UT14070007-005	0.126	0.126	0.126	Nonsupport	Nonsupport	9.2
Pine Creek	UT14070005-004	1.123	1.091	1.155	Full Support	Full Support	25.7
Pinto Creek	UT16030006-002	0.520	0.434	0.644	Nonsupport	Nonsupport	28.0
Piute Creek	UT16030001-013	0.408	0.349	0.466	Nonsupport	Nonsupport	4.0
Pole Creek	UT17040211-002	0.695	0.695	0.695	3A*	3A*	13.2
Price River-1	UT14060007-003	0.546	0.364	0.729	3A*	Full Support	78.8
Provo Deer Creek	UT16020203-013	0.480	0.480	0.480	Nonsupport	Nonsupport	19.1
Provo River-1	UT16020203-001	0.611	0.531	0.664	Nonsupport	Nonsupport	10.3
Provo River-2	UT16020203-002	0.727	0.727	0.727	3A*	Full Support	3.7
Provo River-6	UT16020203-006	0.752	0.513	0.940	Full Support	Full Support	83.4
Roc Creek	UT14030002-002	1.020	1.020	1.020	Full Support	Full Support	20.2
Rock Creek	UT14060005-008	0.984	0.984	0.984	Full Support	Full Support	0.01
Rudd Creek	UT16020102-052	1.269	1.269	1.269	Full Support	Full Support	0.01
Salina Creek-2	UT16030003-006	0.576	0.461	0.692	3A*	Full Support	133.9
Salt Creek-1	UT16020201-004	0.931	0.931	0.931	Full Support	Full Support	5.3
San Pitch-5	UT16030004-009	0.519	0.415	0.623	Nonsupport	Nonsupport	65.7
Sand Creek	UT14070005-006	0.985	0.985	0.985	Full Support	Full Support	32.9
Santa Clara-2	UT15010008-002	0.687	0.635	0.740	3A*	Nonsupport	25.0
Santa Clara-3	UT15010008-003	1.212	1.212	1.212	Full Support	Full Support	14.8
Scofield Reservoir Tribs	UT14060007-002	0.600	0.280	0.906	3A*	Full Support	77.7
Sevier River-17	UT16030003-012	0.248	0.248	0.248	Nonsupport	Nonsupport	45.2
Sevier River-20	UT16030005-025	0.485	0.442	0.500	Nonsupport	Nonsupport	34.4
Sevier River-3	UT16030001-005	0.579	0.579	0.579	3A*	Nonsupport	20.7
Sevier River-6	UT16030003-017	0.387	0.290	0.483	Nonsupport	Nonsupport	28.1
Sheep Creek	UT14040106-007	1.018	0.935	1.117	Full Support	Full Support	70.1
Silver Creek	UT16020101-020	0.538	0.382	0.814	Nonsupport	Nonsupport	21.4
Soldier Creek-1	UT16020202-012	0.580	0.387	0.774	3A*	Nonsupport	18.5
South Creek	UT16030004-004	1.118	1.118	1.118	Full Support	Full Support	21.2
South Fork Ogden River	UT16020102-012	1.192	1.122	1.261	Full Support	Full Support	32.7
South Fork Ogden River-1	UT16020102-010	1.028	1.028	1.028	Full Support	Full Support	15.6
South Junction Creek	UT17040210-003	0.603	0.527	0.678	3A*	3A*	22.7
Spring Creek	UT16010203-008	0.592	0.417	0.834	Nonsupport	Nonsupport	7.4
Starvation Creek	UT16020202-020	0.709	0.574	0.843	3A*	Full Support	19.5
Starvation Tribs	UT14060004-003	0.911	0.911	0.911	Full Support	Full Support	0.6
Strawberry River-3	UT14060004-010	0.742	0.678	0.775	Full Support	Full Support	20.2
Summit Creek	UT16010202-011	1.169	1.169	1.169	Full Support	Full Support	
Summit Creek	UT16030006-003	1.046	1.046	1.046	Full Support	Full Support	13.5
Thistle Creek-1	UT16020202-022	0.695	0.658	0.768	Nonsupport	Nonsupport	18.3
Thomas Creek	UT16020306-003	0.872	0.872	0.872	Full Support	Full Support	12.1
Threemile Creek	UT16030001-014	0.609	0.603	0.615	3A*	Nonsupport	19.9
Trout Creek	UT16020306-001	1.211	1.211	1.211	Full Support	Full Support	18.4
Twelve Mile Creek	UT16030004-002	0.567	0.567	0.567	3A*	Full Support	43.8
Uinta River-4	UT14060003-024	0.973	0.973	0.973	Full Support	Full Support	85.8
UM Creek	UT14070003-002	0.632	0.555	0.713	3A	Nonsupport	21.8
unnamed	UT14070001-089	1.098	1.098	1.098	Full Support	Full Support	2.0
Hopkins Slough	UT16010202-003	0.504	0.504	0.504	Nonsupport	Nonsupport	7.6
Upper Ashley Creek	UT14060002-007	0.863	0.863	0.863	Full Support	Full Support	60.9

Table 2.15.3. Assessment Unit Biological Sampling O/E Values and Aquatic Life (Class 3) Assessments

Assessment Unit Name	Assessment Unit Number	Average O / E Score	Minimum O / E Score	Maximum O / E Score	Biological Data Assessment	Final Aquatic Life Assessment	Assessment Unit Stream Miles
Upper Escalante	UT14070005-012	0.545	0.261	0.857	Nonsupport	Nonsupport	26.7
Upper Ferron Creek	UT14060009-009	0.790	0.790	0.790	Full Support	Full Support	83.6
Upper Range Creek	UT14060005-004	1.031	1.031	1.031	Full Support	Full Support	6.4
Upper San Rafael	UT14060009-013	0.532	0.532	0.532	Nonsupport	Nonsupport	23.3
Upper Whiterocks River	UT14060003-013	1.080	1.076	1.083	Full Support	Full Support	76.3
Upper Willow Creek	UT14060006-002	0.731	0.390	1.041	3A	Full Support	123.2
Upper Yellowstone	UT14060003-023	1.108	1.108	1.108	Full Support	Full Support	110.8
Virgin River-1	UT15010010-001	0.779	0.719	0.839	Full Support	Nonsupport	15.2
Weber River-1	UT16020102-001	0.623	0.534	0.668	Nonsupport	Nonsupport	60.2
Weber River-3	UT16020102-002	0.515	0.515	0.515	Nonsupport	Nonsupport	17.9
Weber River-6	UT16020102-022	0.531	0.531	0.531	Nonsupport	Nonsupport	12.4
Weber River-7	UT16020101-004	0.357	0.357	0.357	Nonsupport	Nonsupport	10.6
Weber River-8	UT16020101-017	0.964	0.964	0.964	Full Support	Full Support	10.7
Weber River-9	UT16020101-023	0.849	0.849	0.849	Full Support	Full Support	19.0
White River	UT14050007-001	0.635	0.635	0.635	3A*	Full Support	77.6
White River	UT14060007-001	0.672	0.672	0.672	3A*	Full Support	32.7
Yellow Creek	UT16010101-028	0.518	0.518	0.518	Nonsupport	Nonsupport	16.4
American Fork River-1	UT16020201-001	1.184	1.184	1.184	Full Support	Full Support	14.1

* note: 3A refers to assessments where more data are needed; 4A indicates a TMDL has been approved

2.15.7. Conclusions and Next Steps

The 2008 *Integrated Report* is the first time that biological monitoring has been incorporated into Utah's Water Quality Analyses for assessments of biological beneficial use support. While the biological assessment program remains in its infancy, this program represents a valuable new tool that better achieves the mandate to protect, maintain, and restore the quality of Utah's waters.

When interpreting the results of these assessments it is important to note that the sites were not randomly selected but in many cases deliberately selected to evaluate sites that were previously identified as being potentially degraded. For example, sites were targeted with elevated phosphorous because of the inability to list AUs based on DWQs phosphorous indicator value. Because sites were not randomly selected these results are not indicative of the overall condition of Utah's waters. Over the next couple of years DWQ plans to sample >50 randomly selected sites to allow more robust generalizations about the biological integrity of all of Utah's streams and rivers.

Development of the Utah RIVPACS model was an iterative process and for this first reporting period the best data available was used for these analyses. Over the past couple of years, additional reference sites were sampled encompass the diversity of sites throughout Utah. Currently, a new model is under development that will incorporate these additional data. The new model and subsequent results will be incorporated into the 2010 *Integrated Report*.

As stated earlier, this assessment represents a work in progress as additional gap improvements to the biological assessment process have been identified. For instance, DWQ plans to create similar biological assessment tools for diatoms. Diatoms have the potential to provide a clearer picture of biological conditions because these organisms are diverse and numerous throughout Utah. Moreover, diatoms are primary producers and data suggests may be more sensitive to some stressors (i.e., nutrients) than macroinvertebrates due to their role in stream ecosystems. Diatom samples have been collected at reference sites and sufficient data to begin development of tools that will allow us to use these assemblages to provide another measure of biological integrity. Just how resulting diatom assessment tools will be integrated with those obtained for diatoms will be determined as we evaluate these data.

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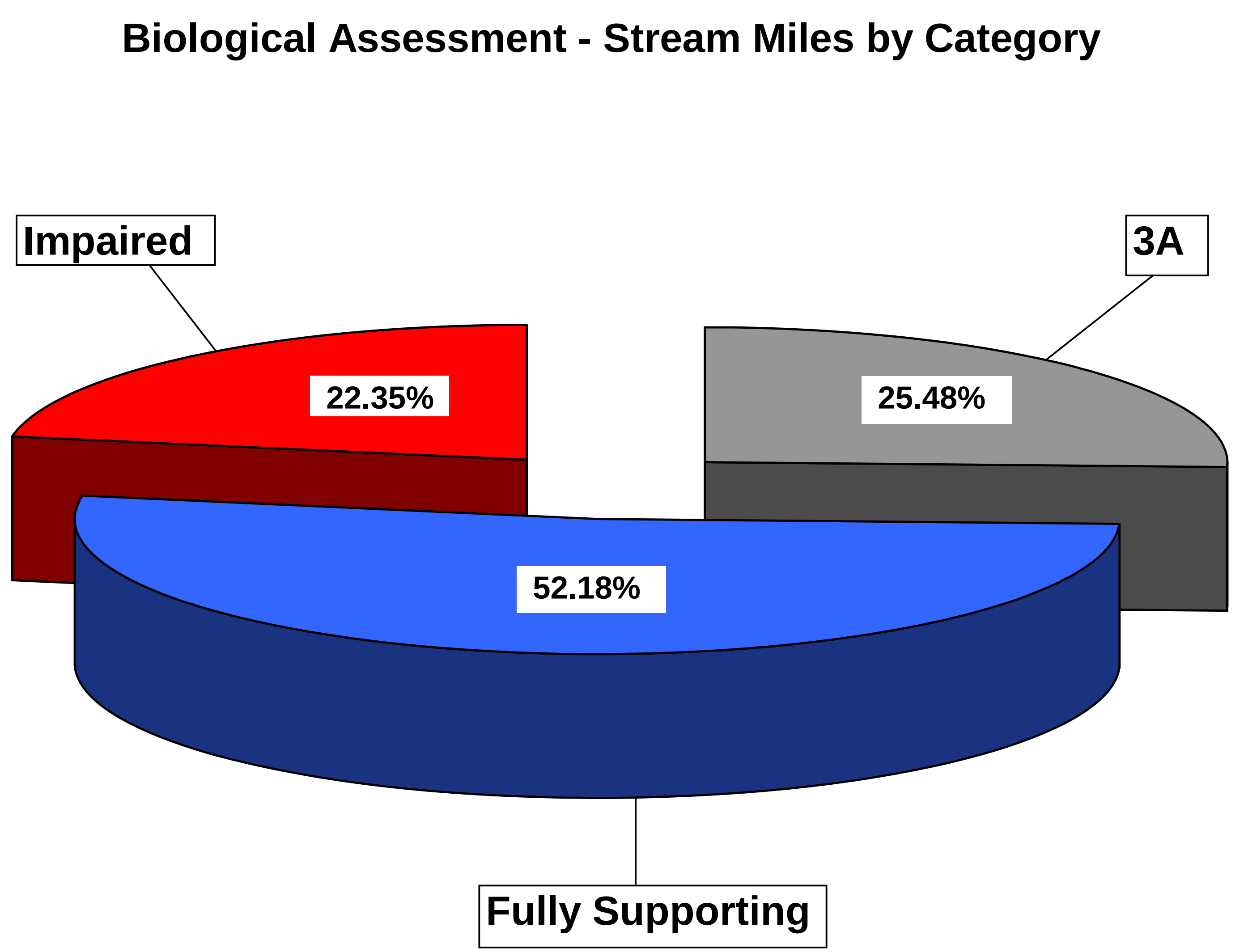

Figure 2.15.5. Biological assessment in percentage of stream miles.

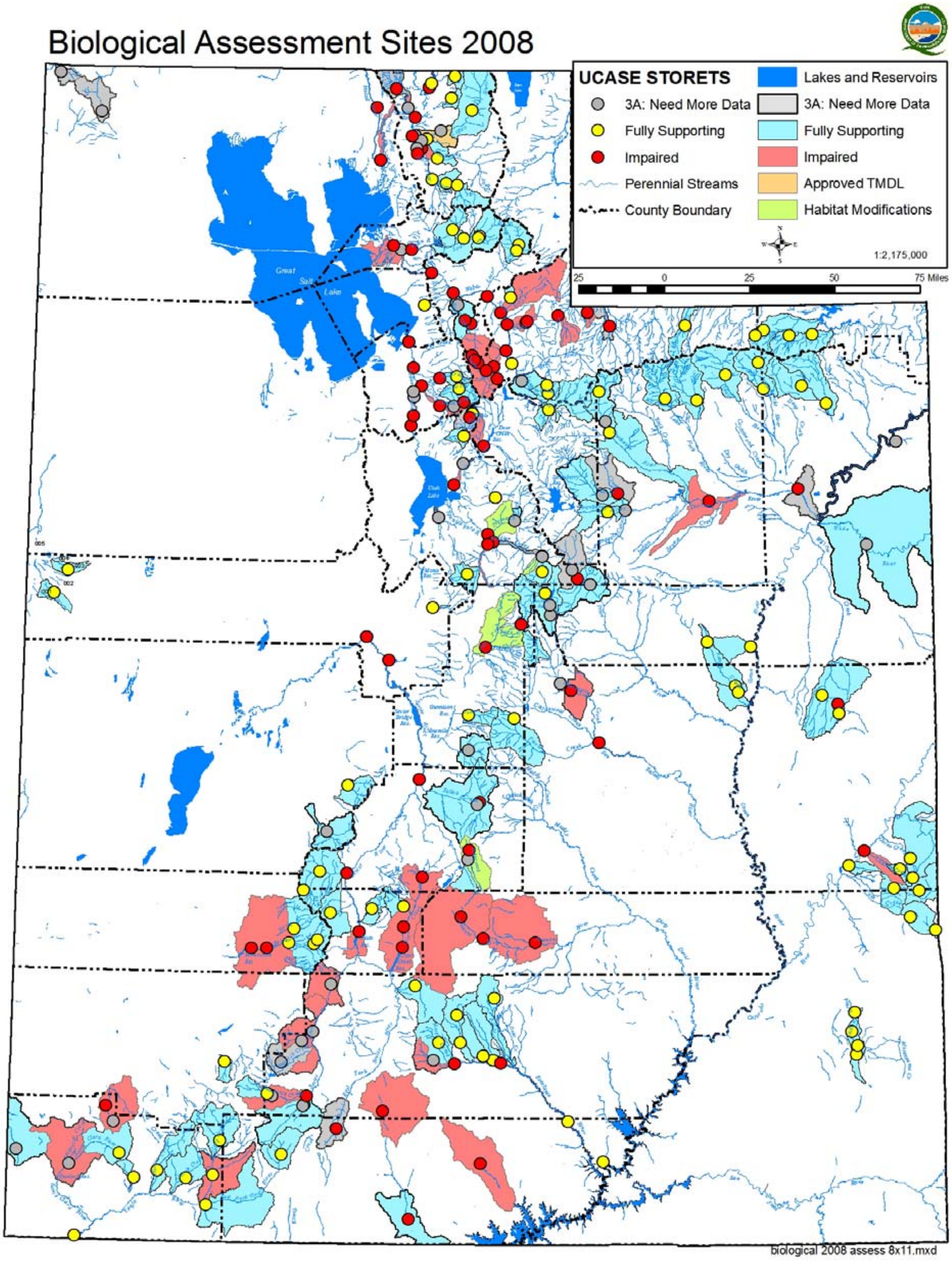

Figure 2.15.6. Final Class 3 aquatic life assessment for units with biological data.

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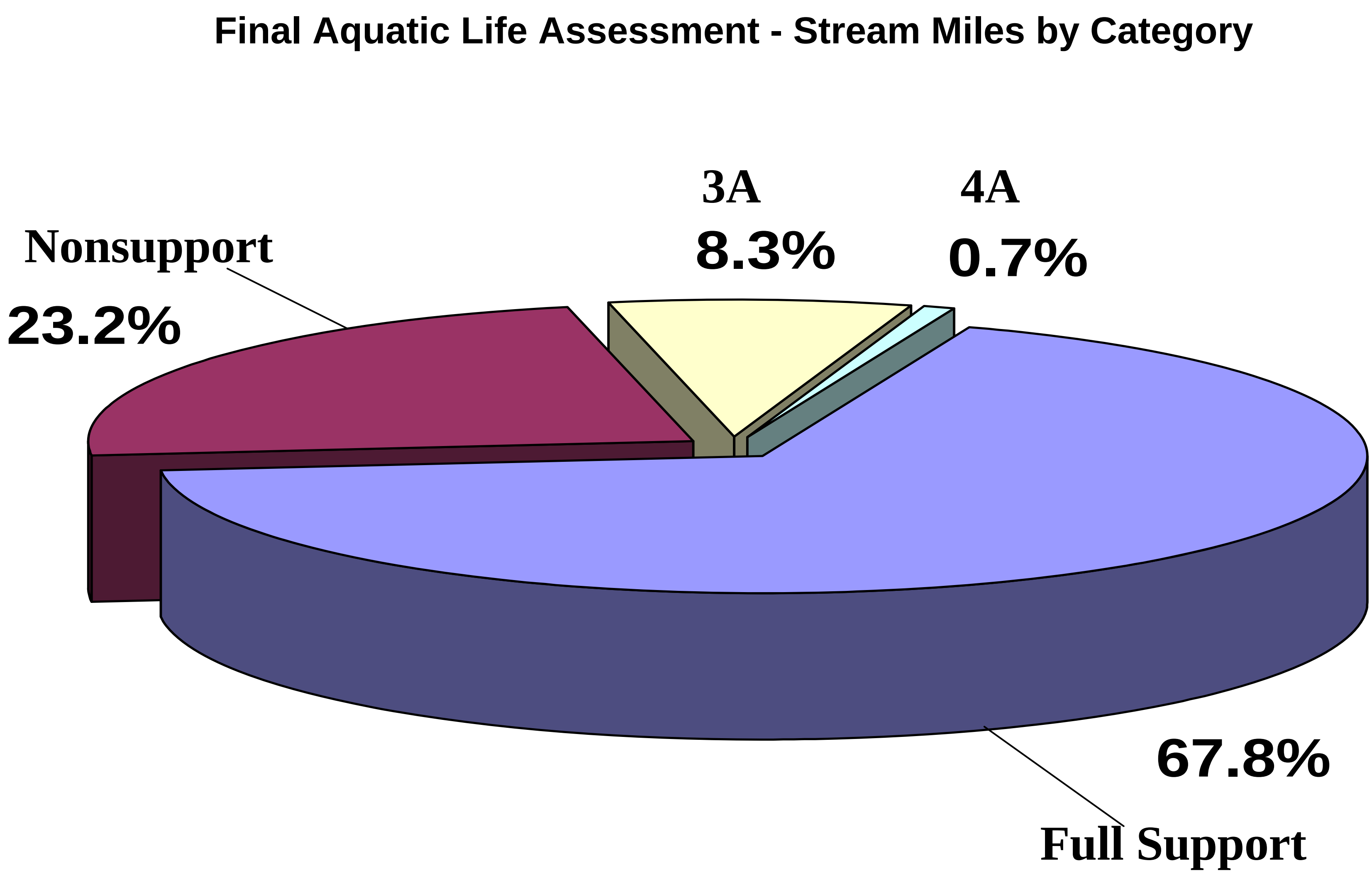

Figure 2.15.7. Final aquatic life assessment in percentage of stream miles.

2.15.8. References for Biological Beneficial Use Support Assessment Procedure

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