STATE OF NEW MEXICO

PROCEDURES FOR ASSESSING STANDARDS ATTAINMENT FOR THE INTEGRATED §303(d) /§305(b) WATER QUALITY MONITORING AND ASSESSMENT REPORT:

ASSESSMENT PROTOCOL

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Appendices

1.0 ASSESSMENT PROCESS OVERVIEW

Pursuant to Section 106(e)(1) of the Federal Clean Water Act (CWA), the Surface Water Quality Bureau (SWQB) has established appropriate monitoring methods, quality assurance/ quality control (QA/QC) procedures, and assessment methodologies in order to compile and analyze data on the quality of the surface waters of New Mexico. In accordance with the *New Mexico Water Quality Act* (NMSA 1978), the SWQB has developed and implemented a comprehensive water quality monitoring strategy for the surface waters of the State. The monitoring strategy establishes methods of identifying and prioritizing water quality data needs, specifies procedures for acquiring and managing water quality data, and describes how these data are used to progress toward three basic monitoring objectives: to develop water quality-based controls, to evaluate the effectiveness of such controls, and to conduct water quality assessments.

Similar to most other states, SWQB currently utilizes a rotating basin system approach to water quality monitoring. Using this approach, a select number of watersheds are intensively monitored each year with an established return frequency of approximately every eight years. Revisions to the schedule may be occasionally necessary based on staff and monetary resources that fluctuate on an annual basis. It should also be noted that a watershed is not necessarily ignored during the years in between intensive sampling. The rotating basin program will be supplemented with other data collection efforts such as the funding of long-term USGS water quality gaging stations for long-term trend data.

SWQB maintains current quality assurance and quality control plans that cover all monitoring activities. This document called the *Quality Assurance Project Plan* (QAPP) is updated and certified annually by EPA Region 6. When an intensive survey is completed, all data are checked against QA/QC measures identified in the QAPP and assessed to determine whether or not designated uses detailed in the current *State of New Mexico Standards of Interstate and Intrastate Surface Waters* (20.6.4 NMAC) are being met. In New Mexico, surface water data are assessed according to this document -- *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report* (otherwise known as the "assessment protocol"). The purpose of this document is to detail the decision process that the SWQB employs to determine whether or not designated uses are being attained in surface waters of the state. The United States Environmental Protection Agency (USEPA) does not officially approve individual state's assessment protocols, but they do provide review and comment and consult the document when reviewing the state's draft Integrated List. The assessment protocol is periodically updated and is generally based on current EPA assessment guidance (USEPA 2005).

All summary assessment data are housed in the USEPA-developed Assessment Database version 2.1.4 (ADB v.2.1.4). Use attainment decisions are then summarized in the *Integrated CWA §303(d)/305(b) Water Quality Monitoring and Assessment Report*. This report is prepared every even numbered calendar year as required by the CWA. Category 5 assessment units on this Integrated List (see Section 4.0) constitute the *CWA §303(d) List of Impaired Waters*. The Integrated List portion of the report is opened for a minimum 30-day public comment period. Response to Comments are prepared by SWQB and submitted to USEPA Region 6 for review. SWQB also updates and submits the Record of Decision (ROD) document. The ROD is an additional, non-required document that SWQB provides to USEPA and the public, which explains why, and when a particular AU was added and, if applicable, why and when it was removed from Category 5 of the Integrated List. An outline of the basic assessment process that SWQB Project Leaders and the §303(d) Coordinator follow when performing assessments is contained in Appendix B. All the above-mentioned documents developed and maintained by the SWQB are available on the SWQB web page: http://www.nmenv.state.nm.us/swqb/swqb.html.

1.1 Monitored Data Assessments

The most rigorous level of assessment is the **Monitored Data Assessment**. It forms the basis of designated use support decisions. Monitored assessments are based on data that reasonably reflect current ambient surface water quality conditions. These data are compared to current USEPA-approved water quality standards (WQS) for the state of New Mexico (NMAC 20.6.4). SWQB intensively surveys watersheds in the state on an approximately 8-year rotational basis. Data types may include chemical/physical, biological, habitat, or toxicological data. In general, data collected by SWQB during these intensive water quality surveys is combined with all readily available data collected during the same reporting cycle by other entities partially listed below, provided the organizations' sampling methods and data analysis procedures meet state QA/QC requirements as detailed in the *Quality Assurance Project Plan* (QAPP) (SWQB/NMED 2005). This collated data set forms the basis of impairment decisions.

Additional current data will be considered in the analysis, particularly available data from the critical condition of the individual parameter of concern, because the CWA requires water quality standards be protective of designated uses during critical conditions such as years with below average stream flow. This distinction is important to mention because it would not meet the intent of the Clean Water Act to use data collected in non-drought conditions to draw a conclusion of no impairment when available data collected during low flow conditions indicates impairment. SWQB arbitrarily defines current data as data less than five calendar years old. Additional data between 5 and 10 years old may also be considered for large mainstem rivers, such as the San Juan River, Rio Grande, and Pecos River (which tend to have greater amounts of outside data) so that the entire range of hydrologic conditions can be examined.

Outside sources of available data are solicited via public notice of a minimum 30-day period before the draft Integrated List of surface waters is prepared. All submitted data that meets state QA/QC standards will be considered. Submitted data must include sufficient QA/QC information to ensure the data meets state QA/QC requirements. Data packages submitted after the solicitation period and/or related to other watersheds in the state may be considered during development of subsequent Integrated Lists.

Data sources could include, but are not limited to:

- New Mexico Environment Department (NMED) SWQB chemical/physical, biological, habitat, or toxicological monitoring data collected during intensive watershed surveys using approved or otherwise accepted quantitative methods;

- Chemical/physical data from recent studies by NMED or other organizations, contractors, or individuals;

- United States Geological Survey (USGS) water quality data that has met USGS QA/QC requirements (i.e., provisional data shall not be used to make use determinations);

- Benthic macroinvertebrate, fish community, and/or fish tissue data collected by NMED or other organizations, contractors, or individuals;

- General Aquatic Wildlife Survey (GAWS), Rapid Bioassessment Protocols (RBP), Thalweg-Watershed Area Link (T-WALK), or other biological/habitat data collected by NMED and other qualified organizations, contractors, or individuals;

- National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) data and in-stream monitoring data collected during NMED effluent monitoring efforts;

- NPDES storm water permit compliance monitoring data;
- In-stream water quality data from other NMED bureaus such as the Drinking Water, Ground Water, and/or DOE Oversite bureaus;
- Citizen or volunteer monitoring data from a program with a state approved QA/QC plan.

1.2 Documented Observed Effects

Even if water quality data are limited or not available, it is possible to conduct an evaluated assessment based on information other than current site-specific monitoring results. Sources of data could include, but are not limited to:

- Documentation of narrative surface water quality standards non-compliance that may include photographs, video, and results of qualitative assessments that can be definitively linked to a standard exceedence;
- Monitoring data between five and ten years old for streams/lakes and between ten and fifteen years old for large rivers;
- Advisories currently in effect related to fishing, swimming, or drinking water.

These types of information will be housed under the "Observed Effects" field in the Assessment Database version 2 (ADB v.2.1.4). An observed effect can be any parameter that the state monitors, but that is not defined as an impairment to a designated use in the state's water quality standards (RTI 2002). One example would be a fish kill whose cause was indeterminate.

2.0 DATA USABILITY AND QUALITY DETERMINATIONS

2.1 Data Management Rules

2.1.1 Data qualifiers and validation codes

SWQB has developed an in-house water quality database to house ambient water quality data as it is collected in the field and/or received from the State Laboratory Division (SLD). This database also contains data qualifiers received from SLD as well as internal validation codes that are added during the data validation process (SWQB/NMED 2005). Chemical/physical data collected by SWQB are eventually uploaded to the national STORET database. The current version of STORET does not have a standard lab remark code field. Per suggestion of the STORET user's group, SWQB will put user-defined information on data qualifiers and internal validation codes into STORET field entitled "Results Comments." Any data with a qualifier code or data validation code that is used in an assessment should be noted. Refer to the current version of the QAPP (SWQB/NMED 2005) for the current definition of all data qualifier and data validation codes as they periodically may change.

- Qualifier codes (lab) – In the past, sets of qualifier codes have varied between the individual sections at State Laboratory Division (SLD) and these codes have changed between years. SWQB is working with SLD to determine a unified set of codes that will be reported consistently by all SLD sections. Standard SWQB data validation codes are defined in the QAPP (SWQB/NMED 2005). All data flagged as "rejected" during internal laboratory QA procedures will not be used for assessment purposes. Other flagged results are usable provided the appropriate caveats are documented and uncertainties in the data are discussed.

  When a value is reported as "less than" the minimum quantitation limit (ML) and a statistic such as a mean must be calculated to determine impairment, the ML for this result will be multiplied by 0.5 (Gilbert 1987). This calculated value shall be used in the statistical calculation for non-detects. Sometimes, data are marked with a data qualifier that means the data were off the high end of the scale. These data should be used for assessment purposes. Concentrations detected below ML but above the method detection limit (MDL) are typically flagged with a "J" qualifier that indicates the reported concentration is estimated. The concentration is reported as estimated because the concentration being detected is below the lowest concentration on the calibration curve. There is certainty as to the identification of the chemical but uncertainty as to the reported concentration. These values may be used in an assessment.

- Data validation codes (internal) – SWQB validates data after all data for a particular intensive water quality survey is received from SLD. Internal data validation procedures are detailed in Appendix E of the QAPP (SWQB/NMED 2005). All data with internal SWQB validation codes will still be used for assessment purposes except data flagged as "rejected" (R1, R2, R3, or R4).

  Results from samples that are flagged by the laboratory as "exceeded holding time" will be considered estimates and will be used during the assessment process unless the result is deemed "rejected" based on professional judgment. Method holding times are different for different sample parameters. Sample analysis after the allowed holding time for a sample or sample set may be a result of laboratory oversight, delayed sample shipment, need for reanalysis, or poor planning. The data validator will evaluate the impact of utilizing results from analytical tests where the allowable holding time was exceeded, taking into account the nature of the analysis, the extent of the noncompliance (for example, considering the method holding time limit and whether the holding time was exceeded for one day vs. one month), the sample matrix, any supporting data and the purpose and goals of the sampling and analysis program (USEPA 2002d). From USEPA's perspective, the time and expense associated with the sample collection and processing is forfeited when data exceeding the holding time is rejected even though the analytical results may in fact be accurate and usable (USEPA 2002e).

2.1.2 Duplicates and compliance monitoring sampling data

There may be cases where there are multiple data values on the same day. For example, compliance monitoring of human health criteria requires that three samples be consecutively collected (separated by at least 15 minutes) during the same sampling event at the same location (SWQB/NMED 2003 Work Element 10). Results that indicate two or three exceedences of data taken in this manner will be counted as one exceedence of the criterion for use attainability determinations.

Regarding numeric chemical/physical data with field duplicates, variability between duplicates will first be determined (and flagged if outside of pre-defined precision limits) using the methods detailed in section entitled *Quality Objectives and Criteria for Measurement Data* and Appendix E of the QAPP (SWQB/NMED 2005). The results from field duplicates will be averaged into one value for designated use attainment decisions.

2.1.3 Continuous recording equipment (thermographs and sondes)

Prior to 1998, water temperature was measured once during each site visit and designated use support status related to temperature criteria was determined by applying a percent-of-exceedences formula to these instantaneous temperature data. Periodic instantaneous temperature data do not provide information on maximum daily temperatures, duration of excessive temperatures, or the diurnal and seasonal fluctuations of water temperature. These aspects of temperature are pertinent to aquatic life use. Continuously recording temperature data loggers (i.e., thermographs) are now readily available and provide an extensive multiple-day record of hourly temperatures over the critical time period when temperatures are generally highest. The percent-of-exceedences formula previously used with instantaneous temperature data are inappropriate for assessment of thermograph data and was not designed for that purpose.

The SWQB has been deploying thermographs and applying the temperature assessment protocol since the 2000-2002 CWA §303(d) listing cycle (see Appendix C). This protocol developed by a multi-agency workgroup is more technically sound than simply applying percentages to limited instantaneous temperature data and better addresses the intent of the Clean Water Act to use best available technology and to incorporate magnitude and duration concerns into water quality monitoring, assessment, and standards development. This protocol addresses biases introduced when using instantaneous data to assess water quality parameters with significant diurnal fluctuation. Based on the success of this effort, the SWQB has developed additional large data set protocols to address other parameters with known diurnal fluxes, such as pH and dissolved oxygen (see Appendices F and G). These protocols are used to assess pH and dissolved oxygen data for potential impairment when sonde data are available. When sonde data are not available, the method detailed in Table 3.2 is used to determine impairment.

2.1.4 Limited data sets

SWQB does not require a minimum number of data points to make use attainment decisions. USEPA does not recommend the use of rigid, across the board, minimum sample size requirements in the assessment process. Target sample sizes should not be applied in an assessment methodology as absolute exclusionary rules (USEPA 2003, 2005). The use of limited data sets is acceptable to USEPA and commonly used in other states as limited financial resources, and both limited field and laboratory staff resources, often dictate the number of samples that can be collected and analyzed (USEPA 2002a). The situation of limited data sets for physical/chemical and fecal coliform parameters is addressed in the assessment tables (Section 3). If there are fewer than seven data points, the assessment is made based on the number of exceedences versus the percent-of-exceedence rate. In New Mexico, SWQB is allocated a specific number of "WTUs" from the State Laboratory Division (SLD) each year which cover the costs of chemical analyses. SLD performs the vast majority of chemical analyses for SWQB. They have a limited capacity because they support several state agencies that require water and soil analyses. Therefore, laboratory capacity, staff resources, and financial resources (for items such as field supplies and travel expenses) often result in limited sample size.

2.1.5 Application of WQS during low flow conditions

Data collected during all flow conditions, including low flow conditions (i.e., flows below the 4Q3), will be used to determine designated use attainment status during the assessment process. 4Q3 values are to be utilized as minimum dilution assumptions for developing discharge permit effluent limitations. In terms of assessing designated use attainment in ambient surface waters, WQS apply at all times under all flow conditions. The intent of the Clean Water Act would not be met if some entity would suddenly be allowed to dump pollutants into a stream in violation of the WQS simply because the stream was currently below some pre-established low flow value.

2.1.6 Assessing chronic WQS when composite data are unavailable

During the 2000 and 2001 SWQB intensive watershed surveys, the sampling regime consisted of two consecutive days of sampling in the spring, three days in the summer, and three days in the fall in order to gather consecutive day data. Starting with the 2002 SWQB intensive watershed survey, the sampling regime was adjusted to sample once per month over an eight-month period in order to 1) better characterize the waterbody throughout most of the hydrograph, and 2) acquire data points that are statistically independent with respect to time. Because of this sampling scheme, consecutive-day data are usually not available to calculate 4-day averages. Few states and tribes are obtaining composite data over a 4-day sampling period for comparison to chronic criteria due primarily to budgetary and staff time constraints. USEPA believes that 4-day composites are not an absolute requirement for evaluating whether chronic criteria are being met when determining use attainment status. Therefore, USEPA affords states and tribes the flexibility to define how they will assess use attainment when 4-day composite data are not available (USEPA 1997). If consecutive day data are not available, a chronic screening level of 1.5 times the chronic criterion will first be calculated. The multiplier of 1.5 was also derived as a way of addressing small data sets (USEPA 1991). This chronic screening level value will then be compared to individual grab sample results as explained in the assessment tables (Section 3.0).

2.2 Data Quality Levels

2.2.1 Aquatic life use data types

It is recognized that not all data of a certain type are of equal quality or rigor. The following tables describe defined levels of data quality or confidence for each type of data recognized for use in making aquatic life support determinations. These tables are adapted from the *Consolidated Assessment and Listing Methodology: Towards a Compendium of Best Practices* guidance document (USEPA 2002a). Tables for determining the level of confidence for biological, habitat, chemical/physical, and toxicological data types are presented. It is necessary to evaluate data quality when an assessment performed with more than one data type results in conflicting use attainment decisions (see Section 3.1.4 for more detail). These tables are included only for aquatic life use determinations because it is the only use for which multiple data types are currently recognized. While data quality tables are not available for other designated uses, it is possible to apply the general guidelines to other data to determine if they are of sufficient quality to support use designations. For example, the table for chemical/physical determinations may be used to assign a level of confidence to data used for making a determination of drinking water supply use attainment.

Tables 2.1 through 2.4 classify the data level or rigor of a data type by its technical components and describe the level of effort (spatial or temporal coverage) necessary to achieve each level. Level 4 represents data of the highest rigor and the highest level of confidence while Level 1 represents the lowest acceptable level of confidence. Information of data confidence is housed in ADB v.2.1.4.

Table 2.1 Hierarchy of bioassessment approaches for evaluation of aquatic life use attainment

LEVEL OF INFO	TECHNICAL COMPONENTS	SPATIAL/TEMPORAL COVERAGE	DATA QUALITY
1 LOW	Visual observation of biota; reference conditions not used; simple documentation	Limited monitoring; extrapolation from other sites	Unknown or low precision and sensitivity; professional biologist not required.
2 FAIR	One assemblage (usually invertebrates); reference conditions pre-established by professional biologist; biotic index or narrative evaluation of historical records	Limited to a single sampling; limited sampling for site-specific studies; identifications to family level	Low to moderate precision and sensitivity; professional biologist may provide oversight
3 GOOD	Single assemblage usually the norm; reference conditions may be site specific, or composite of sites; biotic index (interpretation may be supplemented by narrative evaluation of historical records)	Monitoring of targeted sites during a single season*; may be limited sampling for site-specific studies; may include limited spatial coverage for watershed-level assessments; identifications to genus and species level	Moderate precision and sensitivity; professional biologist performs survey or provides training for sampling; professional biologist performs assessment
4 EXLNT	Generally two assemblages, but may be one if high data quality; regional (usually based on sites) reference conditions used; biotic index (single dimension or multi metric index)	Monitoring during 2 sampling seasons*; broad coverage of sites for either site-specific or watershed assessments; identifications to genus and species level; conducive to regional assessments using targeted or probabilistic design	High precision and sensitivity; professional biologist performs survey and assessment

NOTES: *Seasons are defined as October – December, January – March, April – June, and July – September.

Table 2.2 Hierarchy of habitat assessment approaches for evaluation of aquatic life use attainment

LEVEL OF INFO	TECHNICAL COMPONENTS	SPATIAL/TEMPORAL COVERAGE	DATA QUALITY
1 LOW	Visual observation of habitat characteristics; no true assessment; documentation of readily discernable land use characteristics that might alter habitat quality; no reference conditions	Sporadic visits; sites are mostly from road crossings or other easy access	Unknown or low precision and sensitivity; professional scientist not required.
2 FAIR	Visual observation of habitat characteristics and simple assessment; use of land use maps for characterizing watershed condition; reference conditions pre-established by professional scientist	Limited to annual visits non-specific to season; generally easy access; limited spatial coverage and/or site-specific studies	Low precision and sensitivity; professional scientist not involved, or only by correspondence
3 GOOD	Visual-based habitat assessment using standard operating procedures (SOPs); may be supplemented with quantitative measurements of selected parameters; conducted with bioassessment; data on land use may be compiled and used to supplement assessment	Assessment during single season usually the norm; spatial coverage may be limited sampling or broad and commensurate with biological sampling; assessment may be regional or site-specific	Moderate precision and sensitivity; professional scientist performs survey or provides oversite and training
4 EXLNT	Assessment of habitat based on quantitative measurements of instream parameters, channel morphology, and floodplain characteristics; conducted with bioassessment; data on land use compiled and used to supplement assessment; reference condition used as a basis for assessment	Assessment during 1-2 seasons; spatial coverage broad and commensurate with biological sampling; assessment may be regional or site-specific	High precision and sensitivity; professional scientist performs survey and assessment

Table 2.3 Hierarchy of chemical/physical data levels for evaluation of use attainment

LEVEL OF INFO	TECHNICAL COMPONENTS	SPATIAL/TEMPORAL COVERAGE	DATA QUALITY
1 LOW	Any one of the following: • Water quality monitoring using grab sampling • Water data extrapolated from up stream or downstream station where homogeneous conditions are expected • BPJ based on land use data, location of sources	Low spatial and temporal coverage: • Quarterly or less frequent sampling with limited period of record (e.g., 1 day) • Limited data during key periods or at high or low flow (critical hydrological regimes) • Data are >5 years old and likely not reflective of current conditions	Approved QA/QC protocols are not followed or QA/QC results are inadequate Methods not documented Inadequate metadata
2 FAIR	Any one of the following: • Water quality monitoring using grab sampling • Rotating basin surveys involving single visits • Synthesis of existing or historical information on fish tissue contamination levels • Screening models based on loadings data (not calibrated or verified) • Verified volunteer monitoring data	Moderate spatial and temporal coverage: • Bimonthly or quarterly sampling at fixed stations • Sampling during a key period (e.g. fish spawning seasons, high and/or low flow) • Stream basin coverage, multiple sites in a basin	Low precision and sensitivity QA/QC protocols followed, QA/QC results adequate Approved SOPs used for field and lab; limited training Adequate metadata
3 GOOD	Any one of the following: • Water quality monitoring using grab sampling • Rotating basin surveys involving multiple visits or automatic sampling • Calibrated models (calibration data <5 years old) • Limited use of continuous monitoring instrumentation	Broad spatial and temporal coverage of site with sufficient frequency and coverage to capture acute events: • Monthly sampling during key periods (e.g. critical hydrological regimes and fish spawning seasons), multiple samples at high and low flows • Period of sampling adequate to monitor for chronic concerns* • Lengthy period of record for fixed station sites (sampling over a period of months)	Moderate precision and sensitivity QA/QC protocols followed, QA/QC results adequate Approved SOPs used for field and lab Adequate metadata
4 EXLNT	All of the following: • Water quality monitoring using composite samples, series of grab samples, and continuous monitoring devices • Limited follow-up sediment quality sampling or fish tissue analyses at sites with high probability of contamination	Broad spatial coverage (several sites) and temporal (long-term, e.g. 5-years) coverage of fixed sites with sufficient frequency and coverage to capture acute events, chronic conditions, and all other potential chemical/physical impacts: • Monthly sampling during key periods (e.g., spawning, critical hydrological regimes) including multiple samples at high and low flows • Continuous monitoring (e.g. use of thermographs, sondes, or similar devices)	High precision and sensitivity QA/QC protocols followed, QA/QC results adequate Approved SOPs used for field and lab; samplers well trained Adequate metadata

NOTE: *See section 2.1.6 for additional information.

Table 2.4 Hierarchy of toxicological approaches and levels for evaluation of aquatic life use attainment

LEVEL OF INFO	TECHNICAL COMPONENTS	SPATIAL/TEMPORAL COVERAGE	DATA QUALITY
1 LOW	Any one of the following: • Acute or chronic WET for effluent dominated channel • Acute ambient • Acute sediment	1 ambient or sediment sample tested in an assessment unit or site	Unknown/Low; minimal replication used; laboratory quality or expertise unknown
2 FAIR	Any one of the following: • Acute or chronic ambient • Acute sediment • Acute and chronic WET for effluent dominated channel • Chronic ambient or acute or chronic sediment	2 ambient or sediment sample tested in an assessment unit or site on 2 different dates	Low/moderate; little replication used within a site; laboratory quality or expertise unknown or low
3 GOOD	Any one of the following: • Acute and chronic WET for effluent dominated system • Chronic ambient or acute or chronic sediment	3 ambient or sediment sample tested in an assessment unit or site on 3 different dates	Moderate/high; replication used; trained personnel and good laboratory quality
4 EXLNT	Both of the following: • Acute and chronic ambient and • Acute or chronic sediment	≥ 4 tests in total based on samples collected in a assessment unit or site on 4 different dates	High; replication used; trained personnel and good lab quality

2.2.2 Contact use data type

Pathogen data are used to make determine use support for Primary Contact and Secondary Contact designated uses. ADB v.2.1.4 also houses information on pathogen data quality levels. Pathogen data typically consists of fecal coliform and/or E. coli data. The CALM guidance does not contain any examples of data quality criteria to discern low to excellent data quality (USEPA 2002a). In reality, there is no need to evaluate pathogen data quality because there cannot be conflicting contact use attainment conclusions from various types of data as there can in aquatic life use attainment decisions. The only data type used to make contact use attainment decisions in New Mexico is pathogen data because there are no contact use water quality standards for non-pathogen data.

3.0 INDIVIDUAL DESIGNATED USE SUPPORT DETERMINATIONS

Water Quality Standards (WQS) are actually a triad of elements that work in concert to provide water quality protection. These three elements are: designated uses, numerical and narrative criteria, and an antidegradation policy. Designated uses are the defined uses of a particular surface water body. Each water body has several designated uses. For example, Domestic Water Supply is a designated use. Designated use definitions and their assignment to various stream segments in New Mexico can be found in the *Standards for Interstate and Intrastate Surface Waters* (20.6.4 NMAC). Numeric and narrative criteria have been adopted to protect these designated uses. There are both site-specific criteria and use-specific criteria in New Mexico's WQS document. All references to criteria throughout this document refer to these state-adopted, USEPA-approved numerical limits found in 20.6.4. NMAC. The antidegradation policy ensures that existing uses and levels of water quality necessary to protect these uses will be maintained and protected (NMAC 20.6.4.8).

WQS segments defined in NMAC 20.6.4 are further divided into assessment units (AUs) for use impairment determination and linked to the National Hydrographic Dataset (NHD) for national electronic reporting requirements. AUs are stream reaches, lakes, or reservoirs defined by hydrologic boundaries, WQS, geology, topography, incoming tributaries, surrounding land use/ land management, etc. As stated in Section 1.0, data collected at representative stations during SWQB intensive surveys along with outside data form the basis of use support determinations for each AU. Stations are chosen to reflect current ambient conditions. The following subsections provide guidelines used to interpret available data. These guidelines will be used to make determinations of use support for each designated use in each AU, utilizing the previously described data sets. Some level of flexibility is built into these guidelines to account for uncertainties such as the natural variability of water quality, the lack of extensive data necessary to make more definitive assessments, and the transitory nature of many pollutants. Each designated use has one or more tables with specific requirements for determining use attainment based on the type of data being evaluated. Each type of data are first evaluated separately when determining aquatic life use support. Guidance on how to reconcile two or more data types with differing use attainment determinations is found in Section 3.1.4. In addition to the following subsections, several specific assessment protocols for temperature, sedimentation/siltation (stream bottom deposits), nutrients, dissolved oxygen, and pH have been developed. These protocols are included in appendices C through G.

In previous New Mexico §305(b) reports and §303(d) lists, five designated use determinations were possible according to earlier versions of the SWQB assessment protocol: Full Support, Full Support Impacts Observed, Partial Support, Not Supported, or Not Assessed. These determinations were modified from recommendations in the §305(b) report guidance (USEPA 1997). The most recent guidance from USEPA recommends the following use attainment categories (USEPA 2001, USEPA 2002a, USEPA 2003, USEPA 2005): **Fully Supporting, Not Supporting, Insufficient Information, and Not Assessed.** For every assessment unit, one of these four categories is assigned to every designated use applicable to that given assessment unit.

No determination of Fully Supporting or Not Supporting may be made in the absence of monitored data. It is understood that any assessment, particularly when using biological and/or habitat data, may involve some level of best professional judgment (BPJ). However, evaluations based solely on professional judgment, literature statements, or public comments without reliable data to support the decision shall not be the only basis for a listing or de-listing. For segments where there are no monitored data but for which reliable and documented evaluated data that suggest impairment, the potential impairment will be noted in the "Observed Effects" portion of ADB v.2.1.4. To those AUs for which there are no reliable monitored data for any criteria within an applicable designated use, a designation of Not Assessed will be assigned that designated use.

3.1 Assessing Aquatic Life Use Support

Use assessment decisions should consider and integrate, whenever possible and appropriate, results of various monitoring data types. These include biological, habitat/stream channel condition, chemical/physical, and toxicological monitoring data. Data quality associated with these types can be found in Section 2.1.1.

3.1.1 Biological and habitat data

Table 3.1 explains how to interpret biological and habitat data to assess aquatic life use support. Currently benthic macroinvertebrate sampling is the primary form of biomonitoring utilized by the state of New Mexico. SWQB also monitors fish assemblages and algae in a limited number of streams. Expanded assessment protocols for sedimentation/siltation (stream bottom deposits) and plant nutrient narrative criteria that incorporate benthic macroinvertebrate sampling can be found in Appendices D and E, respectively. To determine impairment due to excessive sedimentation, the assessment approach is based on the concept of comparing the actual conditions of a specific stream with the expected conditions (i.e., reference stream) to determine use attainment of the narrative stream bottom deposit standard. This rapid bioassessment protocol (RBP) approach is consistent with USEPA guidance.

When the RBP method was first introduced, the concept of reference condition was typically limited to pristine streams (Plafkin et al. 1989). This concept was updated to acknowledge the reality of a wider range of aquatic conditions that reflect more than minimal impacts, including historic and dominate land and water use activities (Barbour et al. 1999). This broader definition of reference condition still allows for the definition of reasonable and attainable targets or goals to assess potential impairment to the aquatic community. Full utilization of this updated approach requires state and tribes to develop their own region-specific biocriteria. SWQB is in the process of reassessing and refining current biomonitoring and habitat assessment protocols to better determine reference conditions in New Mexico surface waters and to eventually determine numeric biocriteria. The process of developing biocriteria began in 2002 with assistance from USEPA Region 6 and TetraTech.

While biocriteria is not yet developed to assess numeric criteria, we continue to utilize benthic macroinvertebrate data to determine attainment of certain narrative criteria, such as excessive sedimentation (i.e., bottom deposits) (Appendix D). Until biocriteria development is complete, we will continue to utilize the guidance percentage listed in the original RBP document (Plafkin et al. 1989) and will limit the use of benthic macroinvertebrates in use support determinations to assessing excessive sedimentation, excessive nutrients, and cases of marginal turbidity exceedences where the exceedences are temporary and due to natural causes (i.e., snowmelt runoff or high intensive summer thunderstorms).

Table 3.1 Interpreting biological and habitat data to assess Aquatic Life Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Biological assemblages**	Reliable data indicate functioning, sustainable biological assemblages not modified significantly beyond the natural range of reference condition (>83% of reference condition).*	At least one biological assemblage indicates moderate to severe impairment when compared to reference condition (≤79% of reference conditions). *	Currently, these percentages are applied to benthic macroinvertebrates data only. Reference condition is defined as the best situation to be expected within an ecoregion (watershed reference site). Reference sites have balanced trophic structure and optimum community structure (composition & dominance) for stream size and habitat quality.
•**Habitat Measurements**	• Data indicate channel morphology, substrate composition, bank/riparian structure, and flow regime are similar to reference reach. • The stream has riparian vegetation approaching that of reference reach. • Measurements indicate that the stream geomorphology is similar to reference condition.	• Moderate to severe habitat alteration by channelization and dredging, bank failure, heavy watershed erosion, or alteration of flow. • Removal of riparian vegetation widespread; substantial encroachment of undesirable, non-indigenous species. • Measurements indicate that the stream is extremely unstable -- Type F, G, or D) (Rosgen 1996).	Vegetation may include desirable, non-indigenous species.

NOTE: *Percentages are based on Plafkin et al (1989). The 4% gap allows for some best professional judgment.

3.1.2 Chemical/physical data

Table 3.2 explains how to interpret chemical/physical data to assess aquatic life use support. Refer to Sections 20.6.4.900.H, 20.6.4.900.I, 20.6.4.900.K, and 20.6.4.900.L of the Water Quality Standards for the numeric standards for basic chemical/physical, hardness-dependent metals, and ammonia criteria, respectively, and Sections 20.6.4.900.J for chronic and acute metal and toxic substance criteria. Refer to the appropriate stream segment number and the appropriate aquatic life use category in Section 206.4.900 of the Water Quality Standards for numeric standards for conventional chemical/physical parameters that may differ from those listed in 20.6.4.900.H. Conventional parameters monitored to determine aquatic life use support include: temperature, turbidity, pH, dissolved oxygen, specific conductance, and total phosphorus. Expanded assessment protocols for temperature for coldwater aquatic life use when thermograph data are available, and large data set protocols for dissolved oxygen (DO), and pH, are found in Appendices C, F, and G respectively. Table 3.2 will be applied to when large dissolved oxygen and pH data sets are not available to determine potential impairment.

In 2005, the turbidity criteria associated with aquatic life designated uses was significantly changed. Prior to the 2005 triennial review, there were site specific numeric criteria for turbidity in NMAC 20.6.4.101 through 20.6.4.806. These were removed and the General Criteria section was expanded to the following (20.6.4.13.J):

> ***Turbidity****: Turbidity attributable to other than natural causes shall not reduce light transmission to the point that the normal growth, function, or reproduction of aquatic life is impaired or that will cause substantial visible contrast with the natural appearance of the water. Turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or increase more than 20 percent when the background turbidity is more than 50 NTU. Background turbidity shall be measured at a point immediately upstream of the turbidity-causing activity. However, limited-duration activities necessary to accommodate dredging, construction or other similar activities and that cause the criterion to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and all appropriate permits and approvals have been obtained.*

The turbidity standard was changed to improve NMED's ability to monitor and assess the impacts of temporary channel disturbing activities and permitting activities. This new language requires a revision in ambient monitoring strategies in order to determine background levels. SWQB is in the process of developing a new assessment protocol for this new turbidity language. In the interim, SWQB will retain historic turbidity listings that were determined using the methods in Table 3.2 on the Integrated List, with a footnote noting the change in water quality standards and the subsequent need for a change in assessment protocols. Regarding new data examined during development of the 2006 list, SWQB will assessed these turbidity data for impairment if adequate data are available to determine background as required by the new standard.

Table 3.2 Interpreting chemical/physical data to assess Aquatic Life Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Conventional parameters** (e.g., pH, temperature, DO, specific conductance, turbidity**, total phosphorus) **A)** 1 to 7 samples **B**) > 7 samples	**A**) For any one pollutant, no more than one exceedence of the criterion. **B**) For any one pollutant, criterion exceeded in <15% of measurements.	**A**) For any one pollutant, more than one exceedence of the criterion. **B**) For any one pollutant, criterion exceeded in ≥ 15% of measurements.	Biases in DO, pH, and temperature sampling (such as diurnal flux) should be addressed by sampling with continuously-recording sondes and thermographs whenever possible.* Turbidity exceedence attributable to natural causes are not considered exceedences of the criteria.[a] **
•**Toxic substance** (e.g., priority pollutants, ammonia***, chlorine, metals)	For any one pollutant, no more than one exceedence of the acute criterion, and no more than one exceedence of the chronic criterion or chronic screening level in three years.	For any one pollutant, more than one exceedence of the acute criterion, or more than one exceedence of the chronic criterion or chronic screening level in three years.	The **chronic criterion** shall be applied to the arithmetic mean of the analytical results of consecutive-day samples. Consecutive-day samples are often not available. When this is the case, the **chronic screening level** of 1.5 times the chronic criterion shall be first be calculated and then compared to individual grab sample result to determine whether an exceedence has occurred (see Section 2.1.6).

NOTES:
*See appendices C, F, and G.
**See above paragraph regarding the change in turbidity standards. The use of percentages to determine potential turbidity impairment only applies to data assessments that were completed during prior listing cycles.
[a]When available, benthic macroinvertebrate data are used to verify that aquatic life is not impaired according to Table 3.1.
***New Mexico's WQS as amended through July 17, 2005, now require consideration of the presence of salmonids to assess against acute ammonia criteria, and the presence of fish early life stages to assess against chronic ammonia criteria. To apply Table 20.6.4.900.K for assessment purposes, all waters designated as HQCWAL or CWAL will be assumed "Salmonids Present," while all other AL uses will be assumed "Salmonids Absent." If actual or historic fisheries documentation indicate the presence of salmonids, the "Salmonids Present" column will be used regardless of the designated AL use. To decide whether to apply Table 20.6.4.900.L or M for assessment purposes, "Fish Early Life Stages" will be assumed present from November 1 to June 30 for HQCWAL and CWAL. "Fish Early Life Stages" will be assumed present from March 1 to August 31 for all other AL uses. If actual fisheries documentation generated during the time of ammonia sample collection, or historic fisheries documentation generated during the same date in a pervious year, indicate the presence of early life stages outside of these date windows, the criteria in table 20.6.4.900.L will be applied regardless of the date of collection. If conflicting designated uses exist, use the most stringent criteria per 20.6.4.11.F.

3.1.3 Toxicological data

Table 3.3 explains how to interpret toxicological data to assess aquatic life use support. Refer to NMAC 20.6.4.12.F for the narrative general standards which states "Surface waters of the state shall be free of toxic pollutants from other than natural causes in amounts, concentrations or combinations which affect the propagation of fish…" Toxicity is a valuable indicator for assessing and protecting against impacts on water quality and designated uses caused by the aggregate toxic effect of pollutants. Contaminants may flow directly from industrial and municipal waste dischargers, may come from polluted runoff in urban and agricultural areas, or may collect in the sediments. Toxicity evaluations can be used to assess the type and extent of degraded water quality (USEPA 2002a). Acute toxicities of substances are determined using at least two species tested in whole effluent and/or ambient stream water as well as a series of dilutions.

Table 3.3 Interpreting toxicological data to assess Aquatic Life Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Acute and/or chronic toxicity testing**	Significant effect noted in no more than one acute tests as compared to controls or reference conditions, and in no more than one chronic test in three years as compared to controls or reference conditions.	Significant effect noted in more than one acute tests as compared to controls or reference conditions, or in more than one chronic test in three years as compared to controls or reference conditions.	Significant effect refers to a statistically significant difference as defined in the latest USEPA procedures documents for acute and chronic toxicity testing (USEPA 2002b, 2002c). Reference controls will be used to compensate for possible toxic effects from naturally occurring conditions (i.e. high salinity).

3.1.4 Fish consumption advisories

Per USPA guidance, USEPA considers fish or shellfish consumption advisories and supporting fish tissue data to be existing and readily available data that demonstrate non-attainment of CWA goals stating that waters should be "fishable" (CWA Section 101(a), USEPA 2005). New Mexico's current fish consumption advisory are based solely on mercury levels in fish (NMDOH 2001). Therefore, all water bodies listed in the advisory are listed as impaired due to "Mercury in Fish Tissue" on the Integrated List. The Integrated List will be updated whenever the advisory is revised.

3.1.5 Conflicting aquatic use support determinations

For aquatic life use assessments, it is possible that data of differing types may lead to differing use attainment determinations for the same assessment unit. For example, there may be chemical/physical data that indicate **Not Supporting** and biological data that indicate **Fully Supporting**. If more than two data types are available for assessment, a weight-of-evidence approach will be adopted. This approach will consider data type and data quality in reaching a final aquatic life use determination. Generally, data types with higher data quality will be given more weight. Once biocriteria are fully developed for the state of New Mexico, biological data will be given greater weight than other data types in making use support determinations when data quality levels are comparable, with the exception of toxic chemical data (see Figure 3.1). Biological assessments provide an integrated assessment of ecological health, are not as subject to transient variability as chemical assessments, and provide a direct measure of the designated goal of providing for the protection and propagation of fish, shellfish, and wildlife as stated in the CWA.

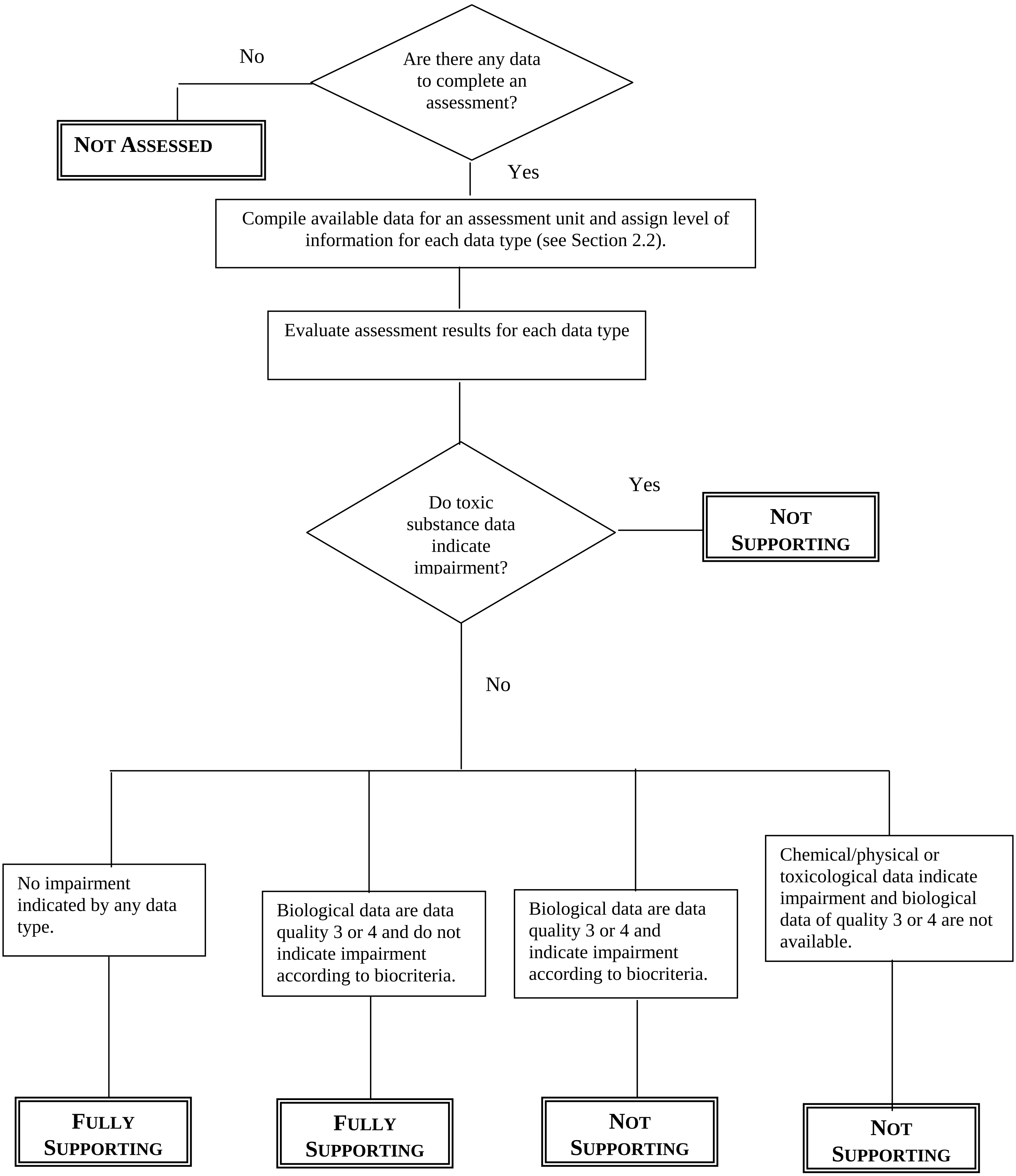

Figure 3.1 General flowchart for determining Aquatic Life Use Support

3.2 Assessing Domestic Water Supply Use Support

Table 3.4 explains how to interpret chemical/physical data to assess domestic water supply use support Refer to Section 20.6.4.900.B and Section 20.6.4.900.J of the Water Quality Standards for the numeric standards for domestic water supply.

Table 3.4 Interpreting chemical/physical data to assess Domestic Water Supply Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Toxic substance** (e.g., radionuclides, priority pollutants, metals)	For any one pollutant, no exceedence of the criterion.	For any one pollutant, one or more exceedence of the criterion.	
•**Nitrate**	No exceedence of the criterion.	One or more exceedences of the criterion.	

3.3 Assessing Primary and Secondary Contact Use Support

Table 3.5 explains how to interpret bacteriological data to assess contact use support Refer to Paragraph B under the appropriate stream segment number and to Sections 20.6.4.900.D and 20.6.4.900.E of the Water Quality Standards for standards to determine use support for primary and secondary contact recreation. The associated water quality criteria for contract use support was changed from fecal coliform to E. coli during the 2005 triennial review of New Mexico's water quality standards. Assessment units determined to be impaired prior to the 2006 listing cycle due to fecal coliform data will be noted as impaired for "bacteria" with a note indicating the change in water quality standards and need to collect data regarding E. coli levels before preparing TMDLs. There is no direct translator available to convert fecal coliform data to E. coli data.

Table 3.5 Interpreting bacteriological data to assess Contact Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Bacteria**			
A) 1 to 7 samples	**A**) No more than one exceedence of the single sample criterion.	**A**) More than one exceedence of the single sample criterion.	The monthly geometric mean shall be used in assessing attainment of criteria when a minimum of five samples is collected in a 30-day period (20.6.4.14.B). New Mexico replaced fecal coliform criteria with *E. coli* criteria during the 2005 triennial review process. USEPA guidance recommends a 10% exceedence rate to determine impairment (USEPA 2002a). Because short holding times often lead to a small total number of samples, USEPA Region 6 believes a 25% exceedence rate is acceptable.
B) > 7 samples	**B**) Single sample criterion is exceeded in <15% of samples and/or geometric mean criterion is met	**B**) Single sample criterion exceeded in ≥ 15% of measurements and/or geometric mean criterion is not met.	

3.4 Assessing Irrigation Use Support

Table 3.6 explains how to interpret chemical/physical data to assess irrigation use support Refer to Section 20.6.4.900.C and 20.6.4.900.J of the Water Quality Standards for the numeric standards for the protection of irrigation use.

Table 3.6 Interpreting chemical/physical to assess Irrigation Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Toxic substance** (e.g., metals)	For any one pollutant, no more than one exceedence of the criterion.	For any one pollutant, more than one exceedence of the criterion.	
•**Salinity parameters** (e.g., total dissolved solids, sulfate, chloride)			These are segment-specific criteria included in a few individual water quality standard segments.
A) 1 to 7 samples	**A**) For any one pollutant, no more than one exceedence of the criterion.	**A**) For any one pollutant, more than one exceedence of the criterion.	
B) > 7 samples	**B**) For any one pollutant, criterion exceeded in <15% of measurements.	**B**) For any one pollutant, criterion exceeded in ≥ 15% of measurements.	

3.5 Assessing Livestock Watering Support

Table 3.7 explains how to interpret chemical/physical data to assess livestock watering use support Refer to Section 20.6.4.900.F and 20.6.4.900.J of the Water Quality Standards for the numeric standards for the protection of livestock watering.

Table 3.7 Interpreting chemical/physical data to assess Livestock Watering Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Conventional parameters** (e.g., nitrite+nitrate) **A)** 1 to 7 samples **B**) > 7 samples	**A**) For any one pollutant, no more than one exceedence of the criterion. **B**) For any one pollutant, criterion exceeded in <15% of measurements.	**A**) For any one pollutant, more than one exceedence of the criterion. **B**) For any one pollutant, criterion exceeded in ≥ 15% of measurements.	
•**Toxic substance** (e.g., radionuclides, priority pollutants, metals)	For any one pollutant, no more than one exceedence of the criterion.	For any one pollutant, more than one exceedence of the criterion.	

3.6 Assessing Wildlife Habitat Use Support

Table 3.8 explains how to interpret chemical/physical data to assess wildlife habitat use support. Refer to Section 20.6.4.900.G of the Water Quality Standards for narrative criteria and 20.6.4.900.J for numeric criteria for the protection of wildlife habitat use.

Table 3.8 Interpreting chemical/physical data to assess Wildlife Habitat Use Support

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Toxic substance** (e.g., PCBs, DDT, cyanide, chlorine, metals)	For any one pollutant, no more than one exceedence of the criterion.	For any one pollutant, more than one exceedence of the criterion.	

3.7 Assessing Human Health Criteria

Human health criteria apply to all waters with a designated, existing or attainable aquatic life use. Human health criteria for persistent toxic pollutants as identified in 20.6.4.900.J NMAC also apply to all tributaries of waters (NMAC 20.6.4.11.G). Table 3.9 explains how to interpret chemical/physical data to determine if these criteria are met. Refer to Section 20.6.4.900.J of the Water Quality Standards for the numeric criteria for related to human health.

Table 3.9 Interpreting chemical/physical data to assess Human HealthCriteria

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Toxic substance** (e.g., cyanide, PAHs, pesticides, PCBs, metals)	For any one pollutant, no more than one exceedence of the criterion.	For any one pollutant, more than one exceedence of the criterion.	

4.0 ASSESSMENT UNIT CATEGORY DETERMINATIONS FOR INTEGRATED LIST

The determination of use support using Section 3.0 and other specified protocols are then combined to determine the overall water quality standard attainment category for each AU (USEPA 2001). The unique assessment categories for New Mexico are described as follows (see also Figure 4.1):

1. **Attaining the water quality standards for all designated and existing uses.** AUs are listed in this category if there are data and information that meet all requirements of the assessment and listing methodology and support a determination that the water quality criteria are attained.

2. **Attaining some of the designated or existing uses based on numeric and narrative parameters that were tested, and no reliable monitored data are available to determine if the remaining uses are attained or threatened.** AUs are listed in this category if there are data and information that meet requirements of the assessment and listing methodology to support a determination that some, but not all, uses are attained based on numeric and narrative water quality criteria that were tested. Attainment status of the remaining uses is unknown because there is no reliable monitored data with which to make a determination.

3. **No reliable monitored data and/or information to determine if any designated or existing use is attained.** AUs are listed in this category where data to support an attainment determination for any use are not available, consistent with requirements of the assessment and listing methodology.

4. **Impaired for one or more designated uses, but does not require development of a TMDL because:**

   A. **TMDL has been completed.** AUs are listed in this subcategory once all TMDL(s) have been developed and approved by USEPA that, when implemented, are expected to result in full attainment of the standard. Where more than one pollutant is associated with the impairment of an AU, the AU remains in Category 5A (see below) until all TMDLs for each pollutant have been completed and approved by USEPA.

   B. **Other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future**. Consistent with the regulation under 130.7(b)(i),(ii), and (iii), AUs are listed in this subcategory where other pollution control requirements required by local, state, or federal authority are stringent enough to implement any water quality standard (WQS) applicable to such waters.

   C. **Impairment is not caused by a pollutant.** AUs are listed in this subcategory if a pollutant does not cause the impairment. For example, USEPA considers flow alteration to be “pollution” vs. a “pollutant.”

5. **Impaired for one or more designated or existing uses**. The AU is not supporting one or more of its designated uses because one or more water quality standards are not attained according to current water quality standards and assessment methodologies. **This category constitutes the *CWA §303(d) List of Impaired Waters*.** In order to relay additional information to stakeholders including SWQB staff, Category 5 is further broken down into the following categories:

   A. **A TMDL is underway or scheduled.** AUs are listed in this category if the AU is impaired for one or more designated uses by a pollutant. Where more than one pollutant is associated with the impairment of a single AU, the AU remains in Category 5A until TMDLs for all pollutants have been completed and approved by USEPA.

   B. **A review of the water quality standard will be conducted.** AUs are listed in this category when it is possible that water quality standards are not being met because one or more current designated uses are inappropriate. After a review of the water quality standard is conducted, a Use Attainability Analysis (UAA) will be developed and submitted to USEPA for consideration, or the AU will be moved to Category 5A and a TMDL will be scheduled.

   C. **Additional data will be collected before a TMDL is scheduled.** AUs are listed in this category if there is not enough data to determine the pollutant of concern or there is not adequate data to develop a TMDL. For example, AUs with biological impairment will be listed in this category until further research can determine the particular pollutant(s) of concern. When the pollutant(s) are determined, the AU will be moved to Category 5A and a TMDL will be scheduled. If it is determined that the current designated uses are inappropriate, it will be moved to Category 5B and a UAA will be developed. If it is determined that "pollution" is causing the impairment (vs. a "pollutant"), the AU will be moved to Category 4C.

This change in reporting was developed in response to a recent National Research Council (NRC) report and a desire to provide a clearer summary of the nation's water quality status and management actions necessary to protect and restore them (NRC 2001, USEPA 2001). With a few additions and minor changes in terminology, the information requested in the *Integrated Listing* guidance (USEPA 2001) and CALM guidance (USEPA 2002a) were previously suggested in earlier 305(b) reporting guidance (USEPA 1997). The earlier guidance formed the basis of previous SWQB assessment protocols.

Assessment information is housed in ADB v.2.1.4 (RTI 2005). This database was designed to help states implement suggestions in the Integrated Listing guidance (USEPA 2001). The database is first populated with AU information, associated designated uses, comments, and any supporting documentation. Individual designated use attainment decisions (i.e., Full Support, Non Support, Not Assessed) are then entered for each AU. ADB v.2.1.4 then automatically determines the water quality standards attainment category for each AU based on the information entered for each applicable designated use.

Section 303(d)(1) requires states to establish a priority ranking for AUs determined to be impaired, and to schedule TMDL development in accordance with the priority ranking. New Mexico expresses this ranking in the form of a scheduled TMDL completion date per USEPA's recommendation (USEPA 2005). This information is housed in ADB v.2.1.4 and reported on the Integrated List.

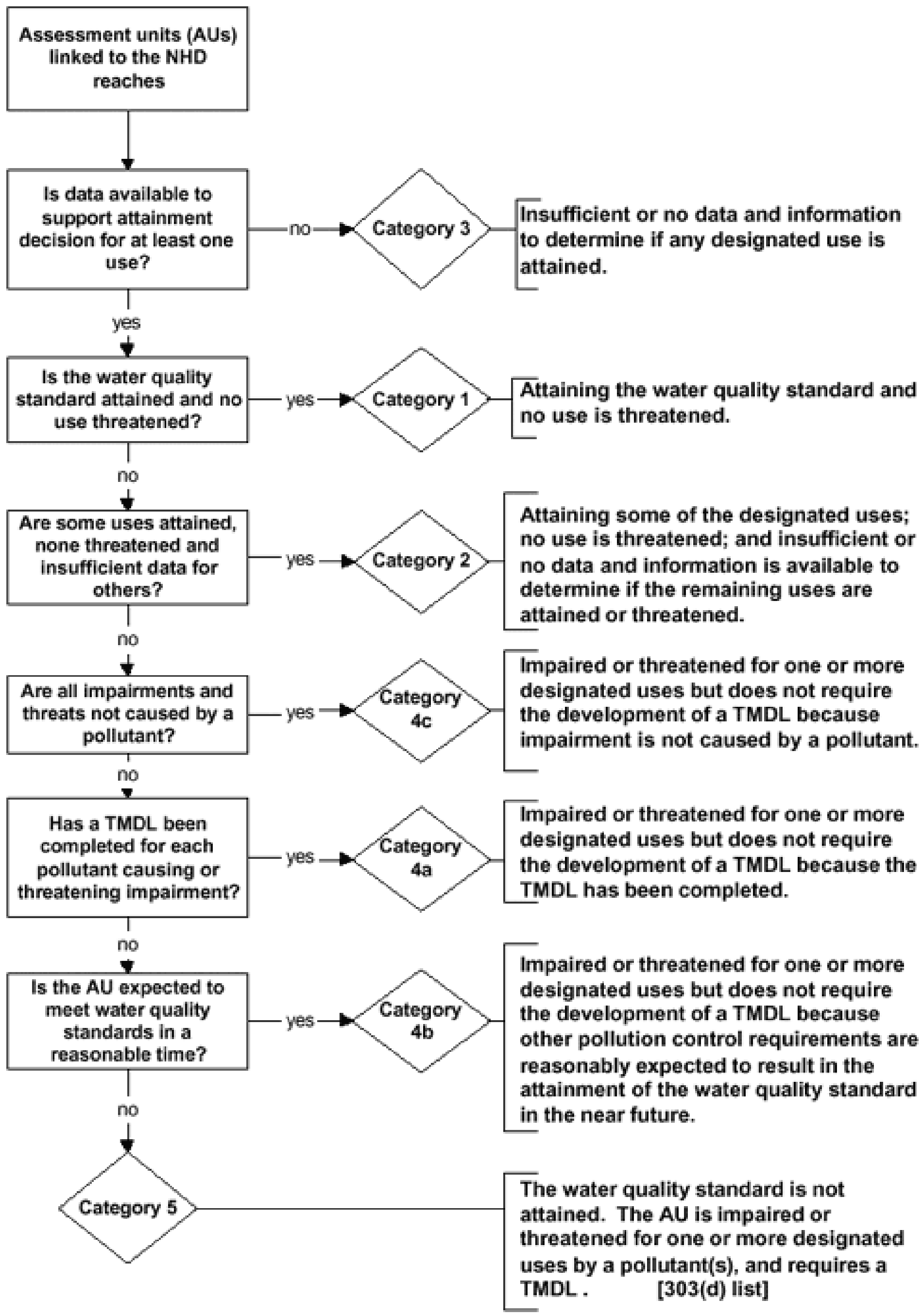

Figure 4.1. Generalized summary of logic for attainment categories (USEPA 2001). Category 5 was further expanded into categories 5A, 5B, and 5C.

5.0 PUBLIC PARTICIPATION

The assessment protocols are periodically revised based on new USEPA guidance, changes to the New Mexico Water Quality Standards, and the need to clarify various assessment procedures for staff. When the protocols are revised, a draft is sent to USEPA Region 6 for review and comment. If significant changes to the overall assessment procedures and/or format of the document are being proposed, SWQB also releases a public comment draft to solicit public review and comment. For example, a draft of the assessment protocol was opened for a 45-day public comment period on June 16, 2003. Since the assessment protocols are not formally approved by USEPA, SWQB does not prepare a formal response to comments. The majority of comments received during the 2003 comment period were considered and incorporated into the final version.

The final version of this protocol is provided to USEPA Region 6. They consider the assessment protocols in their review and approval of Category 5 waters in the integrated report. The assessment protocol is also posted on the SWQB website: http://www.nmenv.state.nm.us/swqb/protocols/index.html.

REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. USEPA, Office of Water; Washington, D.C.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold. John Wiley and Sons. New York, NY.

National Research Council (NRC). 2001. Assessing the TMDL approach to water quality management. Report to Congress. Washington, D.C.

New Mexico Department of Health (NMDOH), New Mexico Environment Department, and New Mexico Department of Game and Fish. 2001. Fish consumption guidelines due to mercury contamination. Revised February 2001. http://www.nmenv.state.nm.us/swqb/Mercury.pdf. Santa Fe, NM.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughs. 1989. Rapid bioassessment protocols for use in streams and rivers. USEPA. Office of Water Regulations and Standards. EPA/444/4-89-001. Washington, D.C.

Research Triangle Institute (RTI). 2002. Assessment Database (ADB) Version 2.0 for Microsoft Access User's Guide. Funded by USEPA Office of Water. Research Triangle Park, NC.

RTI. 2005. Assessment Database (ADB) Version 2.1.4 for Microsoft Access. Funded by USEPA Office of Water. Research Triangle Park, NC.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

Surface Water Quality Bureau (SWQB/NMED). 2003. Water quality management plan. Santa Fe, NM.

SWQB/NMED. 2005. 2005 Quality assurance project plan for water quality management programs. Santa Fe, NM.

United States Environmental Protection Agency (USEPA). 1991. Technical support document for water quality-based toxics control. EPA/505/2-90-001. Washington, D.C.

USEPA. 1996. Biological criteria: Technical guidance for streams and small rivers. EPA-822-B-96-001. Office of Water, Washington, D.C.

USEPA. 1997. Guidelines for preparation of the comprehensive state water quality assessments (305(b) reports) and electronic uptakes. EPA-841-B-97-002A. Washington, D.C.

USEPA. 2001. 2002 Integrated water quality monitoring and assessment report guidance. Memorandum from Robert H. Wayland, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

USEPA. 2002a. Consolidated Assessment and Listing Methodology (CALM): Towards a compendium of best practices. Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

USEPA. 2002b. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. 5th edition. EPA-821-R-02-012. Office of Water. Washington, D.C.

USEPA. 2002c. Short-Term methods for estimating the chronic toxicity of effluent and receiving waters to freshwater organisms. 4th edition. EPA-821-R-02-013. Office of Water. Washington, D.C.

USEPA. 2002d. Guidance on environmental data verification and data validation. EPA QA/G-8. http://www.epa.gov/quality/qs-docs/g8-final.pdf. Office of Environmental Information. Washington, D.C.

USEPA. 2002e. Characterization and Monitoring: Sample holding time re-evaluation. http://www.epa.gov/nerlesd1/cmb/tasks/holding.htm. National Exposure Research Laboratory Environmental Sciences. Washington, D.C.

USEPA. 2003. Guidance for 2004 assessment, listing and reporting requirements pursuant to sections 303(d) and 305(b) of the Clean Water Act. http://www.epa.gov/owow/tmdl/tmdl0103/. Watershed Branch, Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

USEPA. 2005. Guidance for 2006 assessment, listing and reporting requirements pursuant to sections 303(d), 305(b), and 314 of the Clean Water Act. Watershed Branch, Assessment and Watershed Protection Division, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

APPENDIX A

List of acronyms

4Q3	4-Day, 3-Year Low Flow
ADB	Assessment Database
AU	Assessment Unit
CALM	Consolidated Assessment and Listing Methodology
CWA	Clean Water Act
DO	Dissolved Oxygen
MDL	Method Detection Limit
NHD	National Hydrographic Dataset
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMSA	New Mexico Statues Annotated
NPDES	National Pollutant Discharge Elimination System
PAH	Poly Aromatic Hydrocarbon
PCBs	Polychlorinated Biphenyls
PQL	Practical Quantification Limit
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Protection
RBP	Rapid Bioassessment Protocols
ROD	Record of Decision
SLD	State Laboratory Division
STORET	Storage and Retrieval System
SWQB	Surface Water Quality Bureau
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WET	Whole Effluent Toxicity
WQCC	Water Quality Control Commission
WQS	Water Quality Standard

APPENDIX B

Outline of Data Assessment Procedure and Assessment Forms

New Mexico Environment Department
Surface Water Quality Bureau

Revised December 22, 2005

Introduction:

After completion of an intensive watershed survey, comprehensive assessments to determine designated use attainment status on an assessment unit basis are performed after all data have been received. In general, the Project Lead from the Chemical Team performs the chemical/physical and toxicological data assessments while a member of the Bio&Habitat Team performs the biological data assessments and the large dataset assessments (i.e., assessments using sonde and/or thermograph data).

__Chemical/Physical Data__

A. Pre-assessment steps (QA):

1. Ensure that all field data has been correctly entered, and that all SLD data have been received and uploaded into the in-house water quality database.
2. Perform the Data Validation steps detailed in Appendix E of the *Quality Assurance Project Plan* (SWQB/NMED 2004). Enter any necessary data validation codes into the database. Report any changes/problems/erroneous data, etc., to the QA Officer by completing the QA Checklist (Appendix D of the QAPP).
3. After the QA Officer and Database Manager have made any necessary changes to the database based on the QA Checklist and all Data Validation codes have been entered into the database, inform the Database Manager that the dataset is ready for upload to STORET and move on to Phase 2.

B. Assessment steps:

1. Search for any readily available sources of outside data (such as recent water quality from active USGS stream gages, USFS data, etc.) to incorporate into the assessment.
2. Start an electronic Administrative Record file by creating a directory on your hard drive to house all assessment documentation (Ex: Dry Cim 2000 Assessment)
3. If no one else is on the database, run the Exceedence Report for your study and save as an *.RFT (rich text format) file in the newly created directory. If others are using the database, ask the Database Manager to run the exceedence reports for you and send you the *.RFT file to avoid locking up the database. ***NOTE****: This report is a record of the data used to make your final assessment decisions. If data is changed (as a result of QA), if assessment units are split, if stations are re-assigned to a different assessment unit, etc., the report must be re-run and re-saved.*
4. Review the Exceedence Report to ensure that the data is being evaluated against the correct water quality criteria. Report any errors to the Database Manager. ***NOTE:*** *This will be particularly important while preparing assessments for the 2006-2008 list because SWQB is a triennial review year.*
5. Print a copy of final Exceedence Report for assessment hardcopy packet that will be submitted to the 303(d) Coordinator.
6. Fill out a Chemical/Physical Assessment Form for any AUs with any exceedences **AND** any AUs that are on the most recent 303(d) list (the most recent 303(d) list is on the SWQB web site). Determine use attainment status based on the most recent version of the *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report*. Include comments and notes regarding extraordinary field conditions that may have influenced results, Data Validation flags, the need for AU splits, questionable designated uses, etc., in the Comments section of this form. Add these sheets to the hardcopy packet that will be submitted to the 303(d) Coordinator. ***HINT****: Much of the data at the top of the form is repeated. Just fill out the top part of one and make photocopies.*

7. Submit the hardcopy packet and email electronic copies of the Exceedence Report and any other supporting information (such as USGS flow data) to the 303(d) Coordinator for the Administrative Record.

Toxicological Data

1. Download the most recent New Mexico toxicological data at http://www.epa.gov/earth1r6/6wq/ecopro/watershd/monitrng/toxnet/nm.pdf.
2. If there were any significant effects noted in any acute or chronic water or sediment tests in any AUs in your study, fill out an Ambient Toxicity Monitoring Assessment Form. Determine use attainment status based on the most recent version of the *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report*. Include comments and notes regarding extraordinary field conditions that may have influenced results, etc., in the Comments section of this form.
3. Submit any forms and supporting data to the 303(d) Coordinator for the Administrative Record.

Biological/Habitat Data (sedimentation determination)

1. Locate available benthic macroinvertebrate data, associated metrics, and pebble count data.
2. Determine appropriate reference station and locate associated data.
3. Determine %fines (% of pebble count with intermediate axis < 2mm) for both stations.
4. Fill out Stream Bottom Deposit Assessment form. Determine use attainment status using the most recent version of the **Protocol for the Assessment of Stream Bottom Deposits** in *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report*. Include comments and notes regarding extraordinary field conditions that may have influenced results, Data Validation flags, the need for AU splits, questionable designated uses, etc., in the Comments section of this form.
5. If there is more than one station in the Assessment unit, repeat steps 1-4 and fill out a new form.
6. Submit any forms and supporting data (such as pebble count graphics, USGS flow data, etc) to the 303(d) Coordinator for the Administrative Record.

Nutrient Data

1. See the most recent **Nutrient Assessment Protocol** and associated forms in the *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report* to determine impairment status

<u>Temperature, Dissolved Oxygen, and pH Large Data Sets</u>

A. Thermograph data:

1. Locate available thermograph MS Excel files in /SWQB-elibrary/thermographs/.
2. Fill out Thermograph Assessment form. Use the "Conditional Formatting" option, other MS Excel functions, and the most recent **Temperature Assessment Protocol** in the *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report* to determine impairment status.
3. Submit impairment conclusions and supporting electronic thermograph files to the 303(d) coordinator for the Administrative Record.

B. Sonde data

1. Locate available thermograph MS Excel files in /SWQB-elibrary/sondes/.
2. Fill out Large Data Set Assessment form. Use the most recent protocols in the appendices of the *State of New Mexico Procedures of Assessing Standards Attainment for the Integrated §303(d) /§305(b) Water Quality Monitoring and Assessment Report* to determine impairment status.
3. Submit impairment conclusions and supporting electronic thermograph files to the 303(d) coordinator for the Administrative Record.

Evaluator: ___________________
Date: ____________

Chemical/ Physical Data Assessment Form

Study Year/Study Name____

1. Name of assessment unit (stream reach) in the SWQB WQ database or 303d/305b list:

   ____

2. Segment number from NM WQ standards:_______________________________________

3. Parameter: ____

4. Designated use and associated criterion:____

5. Evaluation of data, expressed as a ratio of exceedences/number of samples:

Station(s) used in assessment	Spring	Summer	Fall	Outside source #1	Outside source #2	Exceedence Ratio

6. Outside data source #1: ____

7. Outside data source #2: ____
8. What is the use support designation according to the SWQB Assessment Protocol:

   ☐ Full support

   ☐ Not supported

Additional comments about the assessment:

Evaluator: __________________
Date: ___________

Stream Bottom Deposit Assessment Form

Study Year/Study Name____

1. Name of assessment unit (stream reach) in the SWQB WQ database or 303d/305b list:

   ____

2. Station location: ____

3. Reference location:____

% Fines at Station:_________ % Fines at Reference: ___________ **%Increase in fines**:______

Bio Score at Station:________ Bio score at Reference:_________ **Bio Score % of Ref**:______

Biological / **Physical**	**Impaired (Non Support)** 0-79%	**Non-impaired (Full Support)** 84-100%
Non-Support Fines or Embeddedness >28% increase	Non-Support	Full Support
Full Support Fines or embeddedness <27% increase[2]	Non-Support[1]	Full Support

[1] Reduction in the relative support level for the aquatic life use in this particular matrix cell is probably not due to sediment. It is most likely the result of some other impairment (temperature, D.O., pH, toxicity, etc.), alone or in combination with sediment. Label as Category 5C on the Integrated §303(d)/305(b) list to indicate that further study is needed.

[2] Raw percent values of ≤20% fines (pebble counts) and ≤ 33% embeddedness at a study site should be evaluated as fully supporting regardless of the percent attained at the reference site.

4. What is the use support designation according to the SWQB Assessment Protocol:

   ☐ Full support ☐ Not supported

Additional comments about the assessment:

*Attach associated flow, pebble count, and metric graphics and documentation.

Evaluator: ___________________
Date: ___________

Ambient Toxicity Monitoring Assessment Form

Study Year/Study Name____

1. Name of assessment unit (stream reach) in the SWQB WQ database or 303d/305b list:

____

2. Segment number from NM WQ standards:____________________________________

3. List all ambient toxicity monitoring test with significant differences compared to control:

Station Location*	Date of test	Acute or chronic[a] test?	Sample type (sediment or water)	Number of tests with significant difference

5. What is the use support designation according to the SWQB Assessment Protocol:

☐ Full support

☐ Not supported

Additional comments about the assessment:

[a]Chronic test durations are 7 days, while acute tests are 4 days according to USEPA Region 6.
*Attached printout of data related to this assessment unit from
http://www.epa.gov/earth1r6/6wq/ecopro/watershd/monitrng/toxnet/nm.pdf

Evaluator: __________________
Date: ___________

Temperature Data Logger (Thermograph) Assessment Form

Year/Watershed: ____

Assessment Unit: ____

Station name: ____

File name: ____

Lat: N_____________ Lon: W_______________ STORET ID: _________________________

WQS segment: 20.6.4. _____ Designated use: ______________________________________

First data point: Date _______________________ Time __________________________

Last data point: Date _______________________ Time __________________________

Recording interval: __________ Data points: n = _________ May – Sep n = ___________

Criterion: ________°C Exceedences (May – Sep): n = ________ % exceedences: ________

Maximum recorded: ______°C > 3 °C (HQCWAL) above criterion? no yes

> 4 °C (CWAL) above criterion? no yes

n (May – Sep) = ________ _______ %

HQCWAL: Criterion exceeded > 4 consecutive hours for > 3 consecutive days? no yes
CWAL: Criterion exceeded > 6 consecutive hours for > 3 consecutive days? no yes
All other designated uses: > 15% exceedences (May – Sep)? no yes

Use support designation: ❒ Supporting ❒ Non-supporting

Comments:

Evaluator: ___________________
Date: ____________

pH and Dissolved Oxygen Sonde Data Assessment Form

Year/Watershed: ____

Assessment Unit: ____

Station name: ____

File name: ____

STORET ID: ____

Lat: N___________________ Lon: W______________________ Elevation: _____________ m

WQS segment: 20.6.4. ___________ Designated use: _______________________________________

First data point: Date _____________________________ Time _________________________________

Last data point: Date _____________________________ Time _________________________________

Recording interval: _____________ Data points: n = ___________

---

pH Assessment

Criterion range: _______________________________

Minimum recorded: ___________ Maximum recorded: ___________ ≥ 0.5 units above criterion? ❒ no ❒ yes

Number of data points outside criterion: ___________ % data points outside criterion: _________

Maximum contiguous duration outside criterion: ________ hours

Use support designation: ❒ Supporting ❒ Non-supporting

Dissolved Oxygen Assessment

Applicable value: ❒ coldwater (early life stages) 8.0 mg/L; 95% **OR** 85%

❒ coldwater (other life stages) 6.0 mg/L; 90% **OR** 75%

❒ warmwater (all life stages) 5.0 mg/L; 90% **OR** 75%

Instantaneous minimum: _________ mg/L Corresponding percent saturation: _________ Exceedences: n = _______

Instantaneous minimum: _________ % saturation Exceedences: n = _______

Total exceedences: n = ________ Percent exceedences: ________

Combined values exceeded for > 3 hours contiguously? ❒ no ❒ yes

Minimum % saturation exceeded for > 3 hours contiguously? ❒ no ❒ yes

Use support designation: ❒ Supporting ❒ Non-supporting

Information pertinent to nutrient assessment:

Below DO concentration minimum? ❒ no ❒ yes If yes, maximum contiguous duration: _________ hours

> 120% saturation? ❒ no ❒ yes If yes, maximum contiguous duration: ___________ hours

< 75% saturation? ❒ no ❒ yes If yes, maximum contiguous duration: ___________ hours

Comments:

APPENDIX C

Temperature Assessment Protocol

New Mexico Environment Department
Surface Water Quality Bureau

Revised October 2005

RATIONALE FOR DEVELOPMENT OF TEMPERAURE ASSESSMENT PROTOCOL:

Prior to 1998, water temperature was measured once during each site visit and designated use support status related to temperature criteria was determined by applying a percent-of-exceedences formula to these instantaneous temperature data. Periodic instantaneous temperature data do not provide information on maximum daily temperatures, duration of excessive temperatures, or the diurnal and seasonal fluctuations of water temperature. These aspects of temperature are pertinent to aquatic life use. Continuously recording data loggers (thermographs) are now readily available and provide an extensive multiple-day record of hourly temperatures over the critical time period when temperatures are generally highest. The percent-of-exceedences formula previously used with instantaneous temperature data is inappropriate for assessment of thermograph data and was not designed for that purpose.

In 1998, the New Mexico Environment Department Surface Water Quality Bureau (SWQB) initiated an effort to review current temperature criteria and to determine the most appropriate method to monitor and assess potential aquatic life use impairment due to elevated water temperature. This effort involved: 1) convening an interdisciplinary multi-agency workgroup to review existing scientific literature and EPA guidance in order to recommend methods to assess current temperature criteria, and 2) development of a standard operating procedure for deployment of thermographs in each assessment unit during intensive water quality surveys.

The SWQB has been deploying thermographs and applying the following temperature assessment protocol since the 2000-2002 CWA §303(d) listing cycle. This protocol is more technically sound than simply applying percentages to limited instantaneous temperature data and better addresses the intent of the Clean Water Act to use best available technology and to incorporate magnitude and duration concerns into water quality monitoring, assessment, and standards development. This protocol addresses biases introduced when using instantaneous data to assess water quality parameters with significant diurnal fluctuation. Based on the success of this effort, the SWQB plans to formally incorporate these changes into the water quality standards and to initiate additional efforts to address other parameters with known diurnal fluxes, such as pH and dissolved oxygen.

Introduction

Water temperature influences the metabolism, behavior, and mortality of fish and other aquatic organisms that affect fish. Natural temperatures of a waterbody fluctuate daily and seasonally. These natural fluctuations do not eliminate indigenous populations, but may affect existing community structure and geographical distribution of species. In fact, such temperature cycles are often necessary to induce reproductive cycles and may regulate other aspects of life history (Mount, 1969). Behnke and Zarn (1976), in a discussion of temperature requirements for endangered western native trout, recognized that populations cannot persist in waters where maximum temperatures consistently exceed 21-22°C, but they may survive brief daily periods of higher temperatures (25.5-26.7°C). Anthropogenic impacts can lead to modifications of these natural temperature cycles, often leading to deleterious impacts on the fishery. Such modifications may contribute to changes in geographical distribution of species and their ability to persist in the presence of introduced species.

Historical Background

The Surface Water Quality Bureau (Bureau) of the New Mexico Environment Department convened a multi-agency workgroup to evaluate current temperature criteria and how the Bureau could best incorporate these criteria into its management activities. This exercise was undertaken as a result of changes in temperature monitoring procedures initiated by the Bureau in 1998, and the resulting data.

Prior to 1998, temperature monitoring by the Bureau was limited to instantaneous streamside measurements taken by a staff member conducting a water quality survey. This resulted in limited information concerning actual dynamics of temperature in New Mexico streams. During 1998, stream sampling surveys used a new device, the continuously recording thermograph, to collect more complete temperature data. These devices may be deployed in streams for extended periods of time, and collect data at preset intervals. Bureau protocols for use of these devices (Attachement A) call for deployment during the critical summer period of May through September, with a data collection interval of one hour. These devices were first deployed in mid-July 1998.

Following deployment, devices were collected and data were downloaded and interpreted. Data review indicated only one stream (Sulphur Creek) of more than 20 evaluated in 1998 had no exceedences of the 20°C standard. Many of these monitoring sites were established on what were considered to be minimally impacted stream reaches. These preliminary results seemed to indicate that the streams evaluated had temperatures that may not support their coldwater fishery designated use.

Procedures for assessing designated use support were conducted using 1997 Bureau protocols. Under these protocols, all physical parameters, including temperature, were evaluated based on a percent-of-exceedences formula. Review of data generated by thermographs brought into question the usefulness of this method of evaluation, as it did not recognize a maximum allowable temperature. In response, the Bureau convened the Temperature Workgroup.

The Workgroup was comprised of representatives from the US Environmental Protection Agency (EPA) Region 6, the US Department of Interior, Fish and Wildlife Service – New Mexico Ecological Services Field Office, New Mexico Department of Game and Fish – Conservation Services and Fisheries Management Divisions, and the Bureau. The Workgroup held four meetings beginning in December 1998. The Workgroup's task was to develop an assessment protocol that would evaluate designated use support status of New Mexico streams using detailed temperature data collected by the Bureau. The Workgroup was informed of implementation of new sampling procedures and given a general summary of preliminary results. It was the Bureau's wish that the Workgroup develop an assessment protocol independent of any data or *a priori* beliefs that could have been developed from a review of data collected. For this reason, the Workgroup was not given any specific thermograph data, nor were members made aware of specific data collection sites.

The Workgroup decided to conduct a literature review, and to base any recommendations on results of this review and internal discussions held with other agency or department staff. Information collected, that formed the basis for recommendations, is summarized below.

Review of the EPA Criteria Document for Temperature

Following is a summary of temperature information from EPA's September 1988 document "*Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria*."

Preamble: Temperature standards are set to control thermal pollution, or the amount of heated wastes discharged into a waterbody. The following guidelines were developed by the EPA and published in *"Quality Criteria for Water, 1986"* (Gold Book).

Freshwater Aquatic Life

For any time of year, there are two upper limiting temperatures for a location (based on the important sensitive species found there at that time):

1. One limit consists of a maximum temperature for short exposures that is time and species dependent, and

2. The second value is a limit on weekly average temperature that:

   a. In the cooler months, will protect against mortality of important species if the elevated plume temperature is suddenly dropped to the ambient temperature, with the limit being the acclimation temperature minus two °C when the lower lethal threshold temperature equals ambient water temperature;

or

   b. In the warmest months, is determined by adding to the physiological optimum temperature (for growth) a factor calculated as 1/3 of the difference between the ultimate upper incipient lethal temperature and the optimum temperature for the most sensitive species that are normally present at that location and time;

or

   c. During reproductive seasons, the limit is the temperature that meets site-specific requirements for successful migration, spawning, egg incubation, fry rearing, and other reproductive functions of important species. These local requirements should supersede all other requirements when applicable;

or

   d. There is a site-specific limit that is found necessary to preserve normal species diversity or prevent appearance of nuisance organisms.

Upper and lower limits have been established for many aquatic organisms. Tabulations of lethal temperatures for fish and other organisms are available. Factors such as diet, activity, age, general health, osmotic stress, and even weather contribute to the lethality of temperature. Aquatic species, thermal acclimation state, and exposure time are considered critical factors.

Effects of sublethal temperatures on metabolism, respiration, behavior, distribution and migration, feeding rate, growth, and reproduction have been summarized by De Sylva (1969). Brett (1960) illustrated that inside the tolerance zone, there is a more restrictive temperature range in which normal activity and growth occur, and an even more restrictive zone inside that in which normal reproduction occurs.

The upper incipient lethal temperature and the LT50 (the highest temperature at which 50% of a sample of organisms can survive) for any given species are determined at that species' highest sustainable acclimation temperature. Generally, the lower end of temperature accommodation for aquatic freshwater species is 0°C.

The following requirements are currently considered necessary and sufficient for development of a protective temperature criteria definition:

1. Maximum sustained temperatures are consistent with maintaining desirable levels of primary and secondary productivity.

2. Maximum levels of metabolic acclimation to warm temperatures that permit return to ambient winter temperatures should artificial sources of heat cease.

3. Time-dependent temperature limitations for survival of brief exposures to temperature extremes, both upper and lower.

4. Restricted temperature ranges for various states of reproduction, including (for fish) gametogenesis, spawning migration, release of gametes, development of embryo, commencement of independent feeding (and other activities) by juveniles, and temperature required for metamorphosis, emergence, or other activities of lower forms.

5. Thermal limits for diverse species composition of aquatic communities, particularly where reduction in diversity creates nuisance growth of certain organisms, or where important food sources are altered.

6. Thermal requirements of downstream aquatic life (in rivers) where upstream diminution of a coldwater resource will adversely affect downstream temperature requirements.

The temperature-time duration for short-term maximum (STM) exposure, such that there is 50% survival, is expressed mathematically by fitting experimental data with a straight line on a semi-logarithmic plot. Time is shown on the log scale; temperature is on the linear scale. To provide for safety, an experimentally derived safety factor of 2°C is applied. In equation form this is:

Equation 1. $$STM = (\log(time) - a)/b$$

Where:

STM = short-term maximum temperature

$\log_{10}$ = logarithm to base 10 (common log)

	a	=	intercept on "y" axis (or logarithmic axis) of the line fitted to experimental data that is available for some species from Water Quality Criteria 1972, Appendix II-C (US EPA, 1972).
	b	=	Slope of the line fitted to experimental data and available for some species from Water Quality Criteria 1972, Appendix II-C (US EPA, 1972).
	time	=	minutes.

For extensive exposure, the maximum weekly average temperature (MWAT) is expressed as:

Equation 2. MWAT = OT + ((UUILT - OT)/3)

Where:	MWAT	=	maximum weekly average temperature.
	OT	=	a reported optimum temperature for the particular life state or function.
	UUILT	=	ultimate upper incipient lethal temperature (the upper temperature at which tolerance does not increase with increasing acclimation temperature).

One caveat in determining maximum weekly average temperature is that the limit for short-term exposure must not be exceeded. Some calculated values are available in the literature for species considered important in New Mexico.

EPA Calculated Values for Maximum Weekly Average Temperatures for Growth and Short-term Maxima for Survival of Juveniles and Adults During Summer Months are given in the following table.

Species	Growth[a]	Maxima[b]
Rainbow trout	19	24
Brook trout	19	24
Brown trout	--	25

[a]Calculated according to the maximum weekly average formula (Equation 2).
[b]Based on the short term maximum formula (Equation 1), with acclimation at the weekly average temperature for summer growth (does not indicate exposure period).

Other Literature References

Numerous literature references (Armour, 1991; US EPA, 1986) also recognize the concept of using short-term maxima and weekly average temperatures to protect for temperature effects on fisheries. Of primary importance are protections necessary to support reproducing populations of salmonids in stream segments designated as high quality coldwater aquatic life.

Armour (1991) cited the following findings for the calculated short-term maxima (STM) = (log of time - *a*)/*b*. Values for *a* and *b*, intercept, and slope of a line from experimental data, are taken from National Academy of Sciences, Water Quality Criteria (1972) for juvenile brook trout (*Salvelinus fontinalis*), where time = 120 min. This yields a calculated STM of 25.6°C (25.5°C for juvenile brown trout, *Salmo trutta*). To provide a margin of safety for all organisms, this value was reduced by 2°C, resulting in a calculated STM of 23.6°C.

This calculated STM value is consistent with data found in other literature. US EPA (1986) short-term lethal threshold for brook trout and rainbow trout (*Oncorhynchus mykiss*) is given as 24°C, after reduction by the 2°C safety factor. Grande and Andersen (1991) experimentally determined in controlled studies a LT50 for brook trout, brown trout, and rainbow trout to be 25.2°C, 26.2°C, and 26.6°C, respectively. Applying a safety factor of 2°C results in 23.2°C, 24.2 °C, and 24.6°C, respectively, which are similar to US EPA findings. Eaton (1995) developed a Fish Temperature Database Matching System (FTDMS) to document temperatures at which various species were found in natural settings. He reported a 95th percentile temperature (i.e. 95% of all individuals collected were found at temperatures below this value) of 22.3°C for brook trout, 24.1°C for brown trout, and 24.0°C for rainbow trout.

Workgroup Recommendations

Given the broad literature support for temperature evaluations employing a concept of short-term thermal maximum and long-term average value, the Workgroup recommended such an approach be applied in New Mexico. Because the current criterion is 20°C, this value was used as the basis of the assessment protocol.

The specific recommendations from the Workgroup are as follows:

Temperature in High Quality Coldwater Aquatic Life (HQCWAL)

Full Support Instantaneous (hourly) temperatures do not exceed 3.0°C greater than the applicable temperature criterion, and temperatures do not exceed the applicable criterion for more than four consecutive hours in a 24-hour cycle for more than three consecutive days.

Non Support Instantaneous (hourly) temperatures exceed 3.0°C greater than the applicable temperature criterion, or temperatures exceed the applicable criterion for more than four consecutive hours in a 24-hour cycle for more than three consecutive days.

During reproductive seasons, temperatures must not impede successful migration, egg incubation, fry rearing, and other reproductive functions of target species.

Temperature in Coldwater Aquatic Life (CWAL)

Full Support Instantaneous (hourly) temperatures do not exceed 4.0°C greater than the applicable temperature criterion, and temperatures do not exceed the applicable criterion for more than six consecutive hours in a 24-hour cycle for more than three consecutive days.

Non Support Instantaneous (hourly) temperatures exceed 4.0°C greater than the applicable temperature criterion, or temperatures exceed the applicable criterion for more than six consecutive hours in a 24-hour cycle for more than three consecutive days.

Sampling for assessment of these criteria will be accomplished using continuously recording thermographs with a maximum interval of one hour. Data will be collected from May through September.

Other Recommendations

Additional recommendations by the Workgroup:

- Language should be included in any future standard indicating temperature limits are established to protect the entire aquatic community, not just fish species.
- Additional data should be collected on varying stream types, thought to be representative of least impacted streams, to establish an expected or reference range of temperatures.
- Fish population data should be collected on reference streams in order to evaluate appropriateness of designated uses.
- The need for a regionalized temperature standard should be reviewed.
- This proposal should be evaluated over time, and a new standard criterion should be developed from this review that will eventually be proposed to replace the single-value temperature criterion currently specified in the New Mexico Surface Water Quality

Standards.

References

Armour, C. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. US Fish and Wildlife Service, National Ecology Research Center. Biological Report 90 (22), December 1991.

Behnke, R.J. and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. USDA Forest Service, General Technical Report RM-28. Fort Collins, CO. 45 pp.

Brett, JR. 1960*. Thermal requirements of fish – three decades of study, 1940-1970. Pages 110-117 in C.M. Tarzwell, compiler. Biological problems in water pollution. US Department of Health, Education, and Welfare, Cincinnati, Ohio. 285 pp.

Eaton, J.G. et. al. 1995. A field information-based system for estimating fish temperature tolerances. Fisheries 20:10-18.

Grande, M. and S. Andersen. 1991. Critical thermal maxima for young salmonids. Journal of Freshwater Ecology 6(3): 275-279.

Mount, D.I. 1969. Developing thermal requirements for freshwater fishes. In P.A. Krenkel and F.L. Parker, eds. Biological aspects of thermal pollution. Vanderbilit University Press, Nashville, Tenn.

NMWQCC. 1995. Standards for Interstate and Intrastate Streams. New Mexico Water Quality Control Commission. 20 NMAC 6.1. January 23, 1995.

US EPA. 1972. Water quality criteria 1972. A Report of the Committee on Water Quality Criteria. National Academy of Sciences. Washington, D.C. 1972.

US EPA. 1986. Quality criteria for water: 1986. EPA 440/5-86-001. U.S. Environmental Protection Agency, Office of Water Regulations and Standards. Washington, D.C.

* The date on the publication that DM Tarzwell edited is 1960, Brett’s title conflicts.

Attachment A

New Mexico Environment Department/Surface Water Quality Bureau Protocol for Deployment and Evaluation of Long-term Thermographs

Monitoring Timing, Frequency and Duration

Monitoring for temperature should generally be conducted from May through September to be consistent with periods when incident solar radiation angles are high and ambient air temperatures are most likely to be at maximums. Knowledge of regional patterns is important if monitoring duration must be limited to periods shorter than the interval described above. Monitoring should always include the period of critical maximum expected temperatures.

When monitoring data are to be used to make assessments of designated use support maximums, duration and rate of temperature increase must be collected. For these purposes, the recording thermograph is the most useful tool. For a recording thermograph, monitoring frequency should be adequate to provide a realistic estimate of the maximum temperature and duration of criteria exceedences. If data are collected at too large an interval, maximum temperatures and durations are likely to be missed. **The SWQB maximum interval for monitoring for standards attainment, with a recording thermograph, is one hour.** Obviously, shorter intervals provide a more precise estimate of the duration of daily maximums. For this reason, shorter intervals may be used with no impact to data quality. However, this is a trade-off against data storage limitations. One approach to this problem is use of a pilot period of monitoring, with at least thirty-minute monitoring intervals, to determine how rapidly stream temperature may change. The need for a shorter monitoring interval is more important on smaller, coldwater streams than larger streams.

Monitoring Equipment

Thermographs must be waterproof and have a temperature range that is appropriate for the applicable standard. Devices should have a minimum temperature range of –5°C to 40°C, with minimum resolution and accuracy of ±0.5°C within this range. They should be capable of recording at a wide range of intervals with a minimum of no more than fifteen minutes and a maximum greater than two hours. The thermograph must be capable of direct download to a PC, creating a file that is exportable to currently available spreadsheet software.

Where to Monitor

Thermographs should be placed in stream locations that are representative of ambient stream conditions. For this reason, thermographs should not be placed in shallow riffles or in deep pools. Generally, the thermograph should be deployed in a transition between a riffle/run and a pool. If possible, the thermograph should be placed at the toe of a pool as it becomes more shallow, prior to entering a run or riffle. The thermograph should be placed such that under expected flow conditions it will be continuously submerged. If possible, the thermograph should be located under shading to eliminate direct solar gain.

Field Equipment

Actual situations encountered during thermograph deployment will vary. Consequently, this protocol offers only very general recommendations for thermograph deployment. Consideration should be given to the list of conditions in the section entitled "Where to Monitor."

Typical equipment that should be available includes:

- plastic zip ties
- surveyors marking tape
- iron rebar stakes (minimum 18 inches)
- sledge hammer
- wire cutters and knife
- portable computer and interface, as needed by your equipment
- auditing thermometer
- timepiece
- field book or data sheets
- camera and film

Precautions against vandalism, theft, and accidental disturbance should be considered when deploying equipment. In areas frequented by the public, it is advisable to secure or camouflage equipment. Visible tethers are not generally advisable, since they attract attention. If such tethers are deemed necessary, they should be buried or hidden.

Quality Assurance and Quality Control

The following procedures must be followed to ensure that temperature data are of acceptable quality. These procedures document instrument accuracy, test for proper functioning during the deployment period, and set criteria for data acceptance.

Accuracy Testing and Recording

A National Institute of Standards and Technology (NIST) traceable thermometer, with a resolution and accuracy of 0.1°C or better, should be used to test thermograph accuracy prior to deployment. The NIST thermometer should be checked annually, with a minimum of two temperatures. If a NIST thermometer is not available, a good quality thermometer checked against an NIST thermometer may be used. This thermometer should also be checked annually, with a minimum of two temperatures.

Accuracy of the thermograph must be tested pre- and post-deployment, at a minimum of two calibration temperatures between 0°C and 25°C. SWQB accomplishes this by testing all thermographs annually during the off-season. Testing is done using a stable thermal mass, such as an ice water bath or other controlled water bath. The stable temperature of the insulated water mass allows direct comparison of the unit's readout with that of the certified or checked thermometer. Accuracy should be within ±0.5°C. A log must be kept that documents each unit's calibration date, test result, and the reference thermometer used.

Data Review and Reduction

Data will be retained in raw form without post-processing. Only data that meet quality control requirements may be used for comparison to numeric temperature criteria. Data are considered valid if the thermograph from which they were generated has passed its annual test.

All data will be reviewed for any obvious anomalies. Since these devices are left for long periods of time without supervision, they may be subject to external forces or conditions that may render some of the data questionable. Examples of such conditions may include being picked up by persons other than sampling personnel or being exposed to ambient air temperature as water levels drop below the sensor. These problems can be minimized through proper deployment of the devices and a complete data review to document anomalous or apparently unnatural data. Frequently, viewing a graph of the data is the best way to reveal obvious anomalies.

APPENDIX D

Protocol for the Assessment of Stream Bottom Deposits (Sedimentation/Siltation) On Wadeable Streams

New Mexico Environment Department
Surface Water Quality Bureau

Revised
December 22, 2005

Introduction

Clean stream bottom substrates are essential for optimum habitat for many fish and aquatic insect communities. The most obvious forms of degradation (other than diminished stream flows and higher water temperatures) occurs when critical habitat components, such as spawning gravels (Chapman and McLeod, 1987) and cobble surfaces, are physically covered by fines thereby decreasing intergravel oxygen and reducing or eliminating the quality and quantity of habitat for fish, macro invertebrates, and algae (Lisle, 1989; Waters, 1995). Chapman and Mcleod (1987) found that bed material size is related to habitat suitability for fish and macroinvertebrates and that excess sediment decreased both density and diversity of aquatic insects. Specific aspects of sediment-invertebrate relationships may be described as follows: 1) invertebrate abundance is correlated with substrate particle size; 2) fine sediment reduces the abundance of original populations by reducing interstitial habitat normally available in large-particle substrate (gravel, cobbles); and 3) species type, species richness, and diversity all change as substrate particle size changes from large (gravel, cobbles) to small (sand, silt, clay) (Waters, 1995).

In addition, sediment loads that exceed a stream's sediment transport capacity often trigger changes in stream morphology (Leopold and Wolman, 1964). Streams that become overwhelmed with sediment often go through a period of accelerated channel widening and streambank erosion before returning to a stable form (Rosgen, 1996). These morphological changes tend to accelerate erosion, thereby reducing habitat diversity (pools, riffles, etc.) and placing additional stress on the designated water use.

This protocol was developed to support an interpretation of the New Mexico State Water Quality Standards (NMWQCC, 2000) narrative standard for stream bottom deposits. The current standard for the deposition of material on the bottom of a stream channel is listed in the *State Of New Mexico Standards for Interstate and Intrastate Surface Waters*, Section 1105.A General Standards:

> Bottom Deposits: Surface waters of the State shall be free of water contaminants from other than natural causes that will settle and damage or impair the normal growth, function, or reproduction of aquatic life or significantly alter the physical or chemical properties of the bottom.

The following protocol is similar to the approach proposed by the State of Colorado (CDPH&E, 1998) and represents a simple, but quantitative, three-step assessment procedure for determining whether the above narrative standard is being attained in a particular stream reach or segment by: 1) comparing changes or differences, if any, between the site of concern and a reference site; 2) directly evaluating instream habitat by measuring either of two stream bottom substrate parameters or indicators, namely substrate size (mainly fines, 2 mm or less) abundance or cobble embeddedness, and; 3) verifying or confirming results obtained in number 2 by assessing and comparing benthic macroinvertebrate communities (or fish) at the same sites. **This protocol is not designed to determine sources, locations, quantities, or causes of excess stream bottom sediment**.

1. Reference and Study Site

In order to properly assess a study site or stream reach for impairment(s) due to stream bottom deposits, a proper reference site must be selected and classified for comparison. Once this is accomplished, selected “indicators” such as percent fines, embeddedness, and biological integrity can be measured and compared between the two sites. Under this protocol, the reference site or condition serves as a quantitative and/or qualitative control or yardstick to which a study (or impacted site) may be statistically compared and evaluated. Reference conditions are used to scale the assessment to the “best attainable” situation. This approach is critical to the assessment because stream characteristics vary dramatically across different regions (Barbour *et al.*, 1996), watersheds, or even stream segments. **The ratio between the score for the study site and the reference site (or condition) provides a percent comparability measure for each station**. The station of interest is then classified on the basis of its similarity to expected conditions (reference condition) and its apparent potential to support an acceptable level of biological health (Barbour *et al.*, 1999).

Ideally, the reference and study sites should share similar or common characteristics such as elevation, geology, hydrology, hydraulics, watershed size, in-stream habitat (pools, substrate, etc), and riparian vegetation. However, if the study site is impaired, such things as channel hydraulics, habitat, and streamside vegetation may be different from the reference site simply because the differences observed may either be a cause or a result of a possible departure from the reference condition. Characteristics that cannot change over time should be used as primary attributes of similarity between reference and study sites. Examples of similar attributes are elevation, geology, and hydrology (precipitation, etc.). These three characteristics of similarity between a reference and study site can be ensured through the use of ecoregion designations. Simply put, **the study site and the reference site need to be in the same ecoregion**. Currently, the Surface Water Quality Bureau recognizes and/or uses two different ecoregion classifications. The first is a terrestrial system (Omernik, 1987) developed for the United States Environmental Protection Agency (USEPA) while the second is an evolving aquatic classification scheme based primarily on altitude and developed exclusively for New Mexico by its Department of Game and Fish (NMDGF) (Cowley *et al*., 1997). To ensure that enough similarity exists between a reference and study site so that a valid comparison can be made, both sites should be in the same terrestrial and aquatic ecoregion. For example, sampling site A could be used as a reference for study site B if both sites are located in Omernik ecoregion 21 and NMDGF ecoregion 1. If, however, only one ecoregion classification scheme can be matched between the reference and study site, it should be the aquatic ecoregion classification. For instance, if sites A and B are in NMDG&F ecoregion 1, but site A is located in Omerick ecoregion 21 while site B is in ecoregion 22, the two sites can still be compared.

Additional or secondary characteristics that can be used to supplement and further fine tune the ecoregion similarity between reference and study sites are those that can be readily measured at each site such as stream type (Rosgen, 1996) and channel cross-sectional area. In other words, reference and study sites in the same ecoregion, having the same stream type (McGarrell, 1998) and cross-sectional area are extremely similar and can be readily compared. Use of these secondary characteristics in evaluating similarities for pairing of sampling sites needs further study. However, their use as an additional tool for evaluation of sites is encouraged (Barbour et al, 1999). At a minimum, these data can be entered into a database that can later be used in a statistical analysis to determine whether use of these characteristics is valid in site selection protocols.

It should be pointed out that relative quality of every reference site is not equal based on location in a watershed. A tiered approach (CDPH&E, 1998) to establishing the reference condition is based on the quality of reference sites, and is consistent with USEPA technical guidance (Barbour *et al.*, 1996).

Tier 1. Reference sites are acceptable and are minimally disturbed or "natural" and described by EPA as the "biological integrity expectation." The following characteristics should be considered in selecting this group of reference sites: a) no upstream impoundments or diversions; b) no point discharges, spills, or hazardous waste sites; c) low human, agricultural, and road density, and; d) minimal nonpoint source impacts. An example would be a headwater mountain stream.

Tier 2. Reference sites are acceptable, but are more than minimally disturbed. Where no "natural" site or condition exists, the best available sites are sampled for determination of reference condition or selected based on best professional judgment for the best available site in the ecoregion. USEPA describes these sites as the "interim expectation" because of the potential for restoration to a minimally disturbed or "natural" condition listed in Tier 1.

Tier 3. Reference sites are not acceptable or no reference site exists. Reference conditions would be based on models, historical data, data from neighboring states, ecological information, and/or expert opinion as appropriate.

In summary, the classification of streams based on geographic region (ecoregions) and stream type (Rosgen 1994, 1996) is to reduce the complexity of biological information and improve the resolution or sensitivity of biological surveys by partitioning or accounting for variation between sites. Furthermore, the best classification variables are those that are readily obtained from maps or regional water characteristics such as ecoregion, gradient, alkalinity, and hardness. Stream characteristics that are readily affected by human activities or occur as a biological response to physical conditions (i.e., land use, habitat condition, or nutrient concentrations) should not be used as classification variables (McGarrell, 1998; Barbour *et al;* 1999).

2. <u>Physical Assessment</u>

In order to assess the stream bottom for contaminants (mainly sediment) that may damage or impair aquatic life and significantly alter the physical properties of the bottom, physical measurements of the stream bottom substrate must be made alongside measurements being made of the biological component. Physical measurements (or indicators) of the stream bottom need to take into account those attributes or characteristics that potentially promote the best physical habitat or environment for aquatic life independent of water quality. This concept can best be seen in Figure 1 (Plafkin *et al.*, 1989), which shows the relationship between habitat and biological quality. More specifically, substrate that is plentiful, sufficiently large and varied, and is not surrounded or buried by fines appears to offer the best attributes for habitat suitability for many aquatic organisms adapted to such conditions.

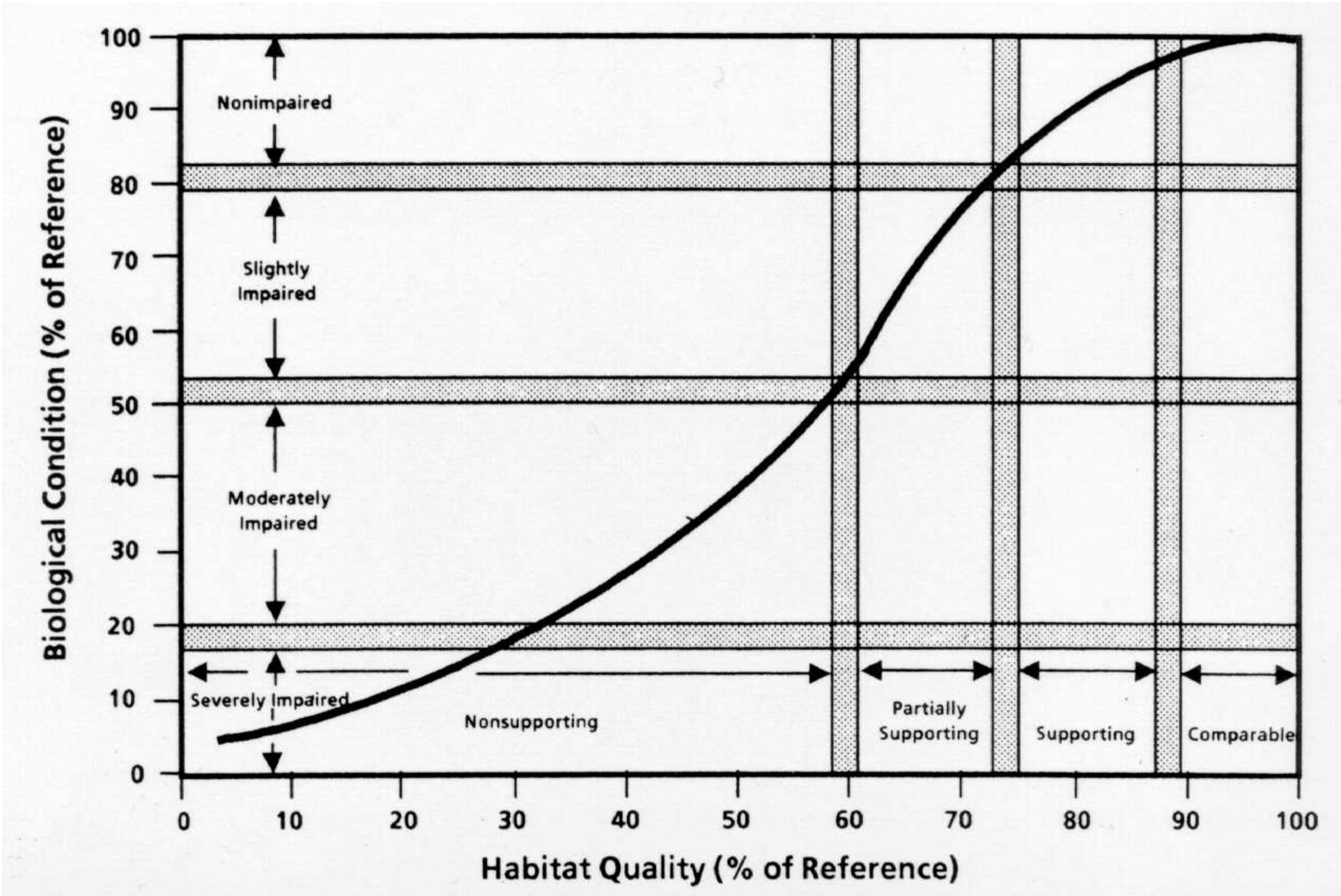

Figure 1. The relationship between habitat and biological condition (Plafkin *et al.*, 1989).

In a study of 562 streams located in four northwestern states, Relyea *et al.* (2000) suggested **that changes to invertebrate communities as a result of fine sediment (2mm or less) occur between 20-35% fines**. Chapman and McLeod (1987) suggest that geometric particle size and percent of the bed surface covered by fines should both be used to define habitat quality. These two criteria can be ascertained by performing a **pebble count**. The pebble count procedure provides not only particle size distributions (D50, D84, etc.) and percent class sizes (% sand, % cobble, etc.), but offers a relatively fast and statistically reliable method for obtaining this information. In addition, relatively rapid temporal and spatial comparisons can be made at a number of sites within a watershed.

Although sufficient and varied sizes of stream bottom substrate are necessary for biological colonization, protection, and reproduction, its full potential may not be realized if the substrate surfaces are surrounded by fine sediment. In streams with a large amount of sediment, the coarser particles become surrounded or partially buried by fine sediment. **Embeddedness** quantitatively measures the extent to which larger particles are surrounded or buried by fine sediment (Mc Donald *et al*., 1991). Studies by Bjorn *et al.* (1974, 1977) concluded **that approximately one-third embeddedness (33%) or less is probably the normal condition in proper functioning streams**. Above this condition, however, insect populations decline substantially as habitat spaces become smaller and filled. By performing a **pebble count** and/or measuring **cobble embeddedness**, the stream bottom can be characterized as an aquatic habitat, compared to a reference site, and then tentatively evaluated for impairment due to stream bottom deposits. **Confirmation** of impairment takes place when a stream site is **biologically assessed**.

A. Pebble Count

The pebble count (Wolman, 1954) may be performed separately or as part of a larger stream inventory and assessment study (Rosgen, 1996). **It is recommended that biological sampling and pebble counts always be performed concurrently**. The intermediate axis of particles should be measured **within the wetted perimeter of the channel** and tallied using standard Wentworth size classes (Bunte and Abt, 2001) from 10 equidistant transects (10 particles/transect as a minimum) selected along a longitudinal stream section of the **specific habitat type** being biologically sampled (riffle, run, pool) or evaluated. Pebble counts may be recorded, tallied, and represented either by using forms provided by Rosgen in the *Reference Reach* field book (Rosgen, 1998) or on a computer laptop at streamside using the *Reference Reach* (channel materials) software package (Mecklenberg, 1998) which can be downloaded from the State of Ohio Department of Natural Resources website (www.dnr.state.oh.us/odnr/soil+water/streammorphology.htm).

From the raw data, D35, D50, and D84 values can then be calculated along with percent composition values for six classes of channel materials ranging from fines (silt, clay, and sand) to bedrock. If a "Rosgen" Level II classification is being performed in addition to the sediment protocol assessment, a separate pebble count analysis should be done to account for the larger bankfull widths, increased longitudinal distances, and multiple habitats used in various "Rosgen" protocols.

In order to ascertain and/or evaluate increases in fines by pebble count methodology and its potential effect on aquatic life at the study (or impacted) site relative to the reference site, the following steps should be taken. First, download a copy of the pebble count software tool *Size-Class Pebble Count Analyzer V1 2001.xls* (651KB) by John Potyondi and Kristin Bunte from the US Forest Service's Stream System Technology Center (aka "Stream Team") website (www.stream.fs.fed.us) under their Download PDF Documents and Software Tools menu. Specific information concerning its use, application, sample size, data input, statistical analysis, and case studies are included in **various document sections of the software** and **should be read** prior to setting up a study and collecting any data. Next, select a reference site for each group of study sites being assessed or evaluated. Visit each reference site and collect the necessary biological samples (benthic macroinvertebrates) along with a pebble count (n≈200-300) from the same habitat unit(s) that the biological samples were collected. Using the USFS pebble count software (preferably streamside at the reference site) calculate the percent fines (< 2 mm) encountered at the reference site under the **data input tab**. The percent fines can be also calculated using the *Reference Reach* channel materials software (Mecklenberg, 1998) package. Using the percent fines value at the reference site, determine the increase in percent fines needed at the study site to classify them as non-supporting (28% increase) according to Figure 1 and Table 1. This can be accomplished by multiplying the percent fines at the reference site by 1.28. Under the **sample size tab** in the software package, the sample sizes of both the reference and study sites can be estimated for statistical significance by filling in the worksheet provided which requires the following fields to be filled: **1)** Type 1 error probability (use 0.1), **2)** Type 2 error probability (use 0.2), **3)** ratio of study site sample size to reference site sample size (1 is recommended, but unequal sample sizes can be used), **4)** reference site percent fines or proportion (entered as a decimal percent i.e. 0.1 for 10%) , **5)** and the study site percent fines or proportion (reference site fines plus 28%). Find the sampling number to cover a 28% increase. **If the percent value for fines at the reference site is determined to be 20% or less, calculate the percent fines to be used in step 5 (study site fines or proportion) by choosing the greater value between either a 28% increase (reference fines multiplied by 1.28) or the percent increase obtained by using 21% as a raw fines percent at the study site(s).** The program will then calculate an estimated reference and study site sample size necessary to determine whether an increase in fines of 28% is statistically valid at the 10% level of significance (90% confidence level). Once the statistical sampling size(s) of both the reference and study site has been determined, the data can be collected, entered, and compared under the analysis section of the software and then subsequently used according to Tables 1 and 3.

Study sites showing fines of **20% or less should be considered non-impaired (fully supporting)** regardless of the percent fines determined at the reference site. If the percent fines at the study site are lower than that of the reference site, one might consider using the study site as a new reference site provided that the other criteria mentioned previously for reference site nomination are equal or better.

B. Embeddedness (State of Idaho Procedure)

This method (Burton and Harvey, 1990) along with its accompanying software **should be used only on cobble-bottom or cobble-dominated streams** (D50 ≥64 mm or the greatest % fraction of any group is cobble). **Because this methodology is labor intensive, its use is recommended only when data from the pebble count and biological sampling does not provide a satisfactory answer as to the degree of impairment.** From the pebble count data, determine the D50 value of the stream bottom substrate. If it is found to be 64 mm or greater (or if the highest % fraction is cobble), proceed with the methodology described in the Idaho embeddedness protocol (Burton and Harvey, 1990). Embeddedness measurements should be performed on the same stream reach where the pebble count was performed. However, to avoid processing substrate previously disturbed from the pebble count, it is recommended that cross-sectional transects for the embeddedness measurements be located in between those used for the pebble count. For example, if the pebble count measurements were performed at cross-sectional transects listed as 0, 20, and 40 feet, etc. along the longitudinal profile of the river, the embeddedness measurements should be done at the distances of 10, 30, and 50 feet, etc. If a laptop computer is not used for field data entry and statistical determination of sample size adequacy, it is recommended that the substrate content of ten hoops (1/transect) be measured. After performing embeddedness measurements at both the reference and study site(s), the data should be entered and analyzed using computer program software developed for this procedure by the State of Idaho. The embeddedness derived from this procedure and subsequent analysis is termed a “weighted” embeddedness because it factors in percent fines along with the percent embeddedness of cobble within the hoop (Burton and Harvey, 1990; McDonald *et al.*, 1991). An additional calculation generated by this program is the interstitial-space index (ISI), which is a measure of unembedded substrate. This number should be used for inclusion in any database that statistically evaluates potential physical “indicators” of sedimentation and their relationship to biological integrity. As previously mentioned, studies by Bjornn indicate that approximately 33% embeddedness appears to be a “normal” stream condition. Therefore, **embeddedness percents of 33% or less encountered at a study site should be assessed as fully supporting** regardless of the values measured at the reference site. At values above 33%, a comparison of percent embeddedness between the reference and study sites can be performed using a T-test for significance in which the null hypothesis is s=s. If the hypothesis is accepted, then the percent mean embeddedness at both the reference and the study sites is similar and the aquatic life use is therefore supported or not impaired. If, however, the hypothesis is rejected (s≠s) then the study site mean should be divided by the reference mean (as mentioned previously with the pebble count) and multiplied by 100 to determine the percent increase in embeddedness at the study site. The increase in embeddedness and its effect on aquatic life use may be evaluated as follows: full support (comparable to reference), 0 to 27% and non-support ≥ 28% (Table 1).

Table 1 **Degree of aquatic life use support affected by stream bottom deposits (sediment) evaluated by increases in either fines or embeddedness, relative to a reference site.[1] Adapted and modified from Figure 1, i.e. 100 - 90% = 0 - 10%).**

Pebble Count Fines ≤ 2 mm (% increase over reference)[2]	**Embeddedness (% increase over reference)[2]**	**Degree of Aquatic Life Use Support (Presumptive[1])**
0 – 27%	0 – 27%	Full Support, Comparable to Reference [1,3]
≥ 28%	≥ 28%	Non-Support[1]

[1] Biological assessment is necessary for confirmation and statistical database.
[2] Raw data values used for these percent comparisons between reference and study sites needs to meet adequate sampling size requirements.
[3] Raw percent values of ≤20% fines (pebble counts) and ≤ 33% embeddedness at a study site should be evaluated as fully supporting regardless of the percent attained at the reference site.

3. <u>Biological Assessment (Macroinvertebrates)</u>

Since the narrative standard for stream bottom deposits is centered around a biological component, any assessment or evaluation of a stream bottom using physical criteria, such as pebble count and embeddedness, needs to be confirmed using some type of bioassessment. A biological assessment using EPA's Rapid Bioassessment Protocol (Plafkin *et al*, 1989; Barbour *et al.*, 1999) for macroinvertebrates must be included at the reference and study sites in which the pebble count and/or embeddedness procedures were performed to confirm the evaluations and to provide a database in which to infer or provide a statistical relationship between the physical and biological components. Prior to collection of macroinvertebrates, a habitat assessment (Plafkin *et al.*, 1989; Barbour *et al.*, 1999) of the site should be performed using both visual observation and measurements made in association with any other studies (pebble counts, embeddedness, Rosgen Level II or III, longitudinal profiles, etc.). This can be compared later with the habitat assessment at the reference site to yield additional information as to other potential sources of use impairment other than sediment. Habitat assessment categories are based on percentages derived from dividing the study site score by the reference site score. Assessment categories and the percent comparability to the reference site (Plafkin *et al.*, 1989) are as follows: comparable to reference and fully supporting, > 83%; and community structure less than expected to few species present and non-supporting, ≤79%. The missing 4% value between categories allows adjustments between categories based on best professional judgment.

Macroinvertebrates for analysis should be collected in a riffle area and may consist of either three quantitative samples using a Hess sampler or three composited kick samples (semi-quantitative) covering an area of approximately one meter for one minute. For valid comparisons and analysis, sampling procedures must be identical between the reference and study site(s). Procedures for preservation, sorting, enumeration, identification, and analysis need to follow standard Surface Water Quality Bureau and USEPA procedures (Barbour *et al.*, 1999;

NMED, 2000).

Application of the biological assessment or degree of impairment is a percentage comparison of the sum of selected metric scores at the study site compared to a selected reference condition (site). Biological groupings will be the same as those defined in the 1998 Surface Water Quality Bureau's document "Procedures for Assessing Standards Attainment" (NMED, 1998) and EPA guidance (Plafkin *et al.*, 1989). In Table 2, those sites achieving a biological assessment score greater than 83 percent of the reference condition will be termed non-impaired (full-support) and scores less than or equal to 79 percent will be determined to be impaired (non-support). Percentage values obtained that are in between the above ranges will require best professional judgment as to the correct placement (Plafkin *et al.*, 1989).

Table 2. Biological Integrity Attainment Matrix

% Comparison to Reference	Biological Condition Category	Attributes[1]
>83%	Non-impaired	Comparable to best situation to be expected within ecoregion (watershed reference site). Balanced trophic structure. Optimum community structure (composition & dominance) for stream size and habitat quality.
79 – 54%	Slightly Impaired	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
50– 21%	Moderately Impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<17	Severely Impaired	Few species present. Densities of organisms dominated by one or two taxa.

[1] Biological attributes from EPA's *Rapid Bioassessment Protocols for Use in Stream and Rivers, (*Plafkin *et al.*, 1989*)*. The Surface Water Quality Bureau has initiated a program of reassessing and refining the biomonitoring protocols and percentages used in this table to better reflect conditions in New Mexico waters. New Mexico has lumped all but the "non-impaired" category into "Non Support" per USEPA Region 6 suggestion.

Final Assessment: Combined Application of Physical and Biological Assessments

Upon completion of physical and biological assessments for stream bottom deposits (sediments), a final assessment can be determined from the following matrix table (Table 3). This is accomplished by taking the increases between percent fines or embeddedness and matching it with the appropriate physical assessment use support category in the far left column. The physical assessment use category can then be matched with the biological assessment use category located on the top row to obtain a use support category for aquatic life use based on biological and physical indicators of increased stream bottom sediment. **It is noteworthy that under certain situations, the physical indicators (fines and/or embeddness) may indicate full support, while the biological assessment may indicate non support. In these cases, factors other than sediment alone, such as extremes in pH, low oxygen, temperature, lack of stream flow, and toxicity, etc. may be responsible for a reduction in biological integrity at a particular site. In this case, the assessment unit should be listed under Category 5C with an impairment of "Benthic-Macroinvertebrate Bioassessments (Streams)" on the Integrated Clean Water Act §303(d)/305(b) list until the exact cause of impairment is determined. Potential causes of impairment such as those listed above will then be quantified by examining such things as chemical and physical data collected at or near the site in question.**

Table 3. Final assessment matrix for determining aquatic life use support categories by combining physical (% fines & embeddedness) and biological assessments as sediment indicators[1]

Biological / **Physical**	**Impaired (Non Support)** 0-79%	**Non-impaired (Full Support)** 84-100%
Non-Support Fines or Embeddedness >28% increase	Non-Support	Full Support
Full Support Fines or embeddedness <27% increase[3]	Non-Support[2]	Full Support

[1] In previous New Mexico §305(b) reports and §303(d) lists, New Mexico also had categories entitled Full Support Impacts Observed (Supporting) and Partial Support. The most recent guidance from USEPA recommends the following use attainment categories (USEPA 2001): Fully Supporting, Not Supporting, Insufficient Information, and Not Assessed. Also, UPEPA Region 6 requested that New Mexico lump all but the "Non Impaired" category in Plafkin et al. 1989 into the Non Support attainment category. Therefore, Full Support and Supporting terminology related to percent fines or embeddedness in previous versions of this protocol were condensed into Full Support, while Partial Support and Non Support were condensed into Non Support. Regarding terminology based on Plafkin et al. 1989, "Non Impaired" terminology related to benthic macroinvertebrates remains Full Support while "Slightly Impaired," "Moderately Impaired," and "Severely Impaired" were condensed into Non Support per USEPA Region 6's request.

[2] Reduction in the relative support level for the aquatic life use in this particular matrix cell is probably not due to sediment. It is most likely the result of some other impairment (temperature, D.O., pH, toxicity, etc.), alone or in combination with sediment. These waters will be labeled as Category 5C on the Integrated §303(d)/305(b) list to indicate that further study is needed to determine the exact cause of impairment.

[3] Raw percent values of ≤20% fines (pebble counts) and ≤ 33% embeddedness at a study site should be evaluated as fully supporting regardless of the percent attained at the reference site.

Step by step procedure for evaluating whether sediment is impairing the aquatic life use at a stream site.

1. Select study site(s) along with a comparable reference site.

2. Perform a bioassessment on the benthic macroinvertebrate community at each reference in which a pebble count and/or embeddedness procedure is to be performed.

3. Do a pebble count and/or embeddedness evaluation at the reference sites. Pebble counts should be done in the same habitat unit(s) where the macroinvertebrates were collected. When doing pebble count evaluations, it is important to determine the necessary sample size (see page7) needed at each study site based on the evaluated sample size and determined percent fines at each reference site. This calculation should preferably be done streamside at the reference site using the pebble count analyzer software so that sufficient data can be collected with one visit. However, it is acceptable to do the calculations in the office, but realize that an additional visit to the stream may be required if your sample size is inadequate.

4. Perform a bioassessment of the benthic macroinvertebrate community at each study site, accompanied by collection of either pebble count and/or embeddedness data of sufficient size to be statistically significant.

5. Compare the physical and biological data between the study and reference sites by dividing the results obtained at the study site by that of the reference site to obtain percent "comparability."

6. Using the final assessment matrix (Table 3), locate the proper support cells for both the physical and biological percentages calculated in step 5, and determine the final degree of support for the aquatic life use that is affected by sediment.

Data collection and interpretation

The various support categories along with the ranges of percents used to quantify the various categories are based on slight modifications of those used in EPA's Rapid Bioassessment Protocols (Plafkin *et al.*, 1989) and the State of Colorado Sediment Task Force (CDPH&E, 1998). **They are intended to provide an initial base or reference point from which to proceed in the collection and interpretation of data regarding the adverse effects of sediment on biological communities in the State of New Mexico.** As this guidance is applied and data from various sites are collected, it will be necessary to adjust the standards attainment matrices in terms of the percentage of reference conditions for physical stream bottom substrate "indicators" and biology. It is imperative to the validity, growth, and evolution of this document that the Surface Water Quality Bureau establishes a proper database from which the valid statistical treatment may be employed to strengthen and adjust the matrix tables when deemed necessary through the addition of data generated from this protocol. Also, it is critical that the metrics (EPT, diversity, standing crop, shredders/total, etc.) used for evaluating the macroinvertebrate communities also undergo review in order to select those metrics that are most sensitive to changes or increases in stream bottom sediment. In addition, it may be prudent to engage the services of a statistician to review and strengthen these endeavors.

Sandy Bottom Streams

Sandy bottom streams or **stream bottom channels consisting mostly of fines (D84 <2mm) will require different methodologies** for proper analysis **not described in this document**. For instance, the necessary data needed for comparison of the physical component (stream bottom substrate size and distribution) between reference and study sites may require sieving (using 2.0mm, 1.0mm, 0.5mm, 0.25mm, 12.5mm and 0.063mm sieve sizes) of a standardized weight of dry stream bottom fines (Bunte and Abt 2001) while the biological component (benthic macroinvertebrates) may require the combined use of both artificial substrate samplers and multihabitat sampling by kicking and jabbing using a D-frame dip net (Barbour *et al.*, 1999). At present, **the bureau does not have a methodology or protocol that it can use for either detecting or assessing the effect of stream bottom deposits on sandy bottom streams**. Instead, it is seeking input and guidance from outside sources for specific methods and protocols that are not only scientifically sound but also time and cost effective to address this specific assessment problem.

References

Barbour, M.T., J.B. Stribling, and J. Gerritsen, 1996. *Biological Criteria: Technical Guidance for Streams and Small Rivers*. Revised Edition. United States Environmental Protection Agency. EPA 822-B-96-001. Office of Water, Washington, D.C.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washinton, D.C.

Bjornn, T.C. and seven coauthors. 1974. *Sediment in streams and its effect on aquatic life*. University of Idaho, Water Resources Research Institute, Research Technical Completion Report Project B-025-IDA, Moscow, Idaho.

Bjornn, T.C. and seven coauthors. 1977. *Transport of granitic sediment in streams and its effects on insects and fish*. University of Idaho, College of Forestry, Wildlife and Range Science, Bulletin 17, Moscow, Idaho.

Burton, T. and G. Harvey. 1990. *Estimating Intergravel Salmonid Living Space Using the Cobble Embeddedness Sampling Procedure*. Report No. 2. Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau.

Bunte, K. and S. Abt. 2001. *Sampling Surface and Subsurface Particle-size Distributions in Wadable Gravel-and-Cobble-Bed Streams for Analysis in Sediment Transport, Hydraulics, and Streambed Monitoring.* Gen. Tech Report RMRS-GTR-74. United States Forest Service. Rocky Mountain Research Station. Fort Collins, Colorado.

Chapman, D.W. and K.P. McLeod. 1987. *Development of Criteria for Fine Sediment in Northern Rockies Ecoregion*. United States Environment Protection Agency, Water Division, Report 910/9-87-162, Seattle, Washington, USA.

Colorado Department of Public Health and Environment, Water Quality Control Commission. 1998. *Implementation Guidance for the Determination of Impacts to Aquatic Life in Streams and Rivers Caused by the Deposition of Sediment.*

Cowley, D.E., M.D. Hatch, S. Herrmann, G.Z. Jacobi, and J.E. Sublette. 1997. *Aquatic Ecoregions of New Mexico*. New Mexico Game and Fish Department. In draft.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. *Fluvial Processes in Geomorphology*. Dover Publications, Inc., New York.

Lisle, T. 1989. *Sediment Transport and Resulting Deposition in Spawning Gravels, North Coast California.* Wat. Resourc. Res. 25 (6):1303-1319.

MacDonald, L.H., A.W. Smart, and R.C. Wismer. 1991. *Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska.* United States Environmental Protection Agency, EPA/910/9-91-001. Center for Streamside Studies, AR-10, College of Forestry and College of Ocean and Fishery Sciences, University of Washington. Seattle, WA.

McGarrell, C.A. 1998. *Stream Reach Morphology as a Variable for Classifying Streams During Bioassessments*. Publication 189. Susquehanna River Basin Commission. Harrisburg, Pennsylvania.

Mecklenburg, D. 1999. *The Reference Reach Spreadsheet.* Software Version 2.1. Ohio Department of Natural Resources, Columbus, Ohio.

New Mexico Environment Department. 1998. *State of New Mexico Procedures for Assessing Standards Attainment for 303(d) List and 305(b) Report*. Surface Water Quality Bureau, Santa Fe, New Mexico.

New Mexico Environment Department. 1999. *Quality Assurance Project Plan for Water Quality Management Programs*. QTRCK Number 99-088.

New Mexico Water Quality Control Commission. 2000. *State of New Mexico Standards for Interstate and Intrastate Surface Waters*. 20 NMAC 6.1.

Omernik, J.M. 1987. *Ecoregions of the Conterminous United States*. Annu. Ass. Am. Geogr. 77(1):118-25.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughs. 1989. U.S. Environmental Protection Agency. *Rapid Bioassessment Protocols for Use in Streams and Rivers.* Office of Water Regulations and Standards. Washington, D.C. EPA/444/4-89-001.

Potyondy, J.P. 1988. *Boise National Forest Cobble Embeddedness Baseline Inventory: Results and Relationship to Management Activities*. Boise National Forest. 37 p.

Relyea, C.D., C. W. Marshall, and R.J. Danehy. 2000. *Stream Insects as Indicators of Fine Sediment.* Stream Ecology Center, Idaho State University, Pocatello, Idaho.

Rosenberg, D.M. and V.R. Resh. 1993. *Freshwater Biomonitoring and Benthic Macroinvertebrates*. Chapman and Hall. New York and London.

Rosgen, D.L. 1994. *A Classification of Natural Rivers*. Catena 22: 169-199. Elsevier Science, B.V. Amsterdam.

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, Colorado.

Rosgen, D.L. 1998. *The Reference Reach Field Book*. Wildland Hydrology. Pagosa Springs, Colorado.

United States Environmental Protection Agency (USEPA). 1996. *Biological Criteria: Technical Guidance for Streams and Small Rivers*. EPA 222-B-96-001.

USEPA. 2001. 2002 Integrated water quality monitoring and assessment report guidance. Memorandum from Robert H. Wayland, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

United States Forest Service, 2002. *Analyzing Pebble Count Data Collected by Size Classes.* Software Version 1.0a. Streams Systems Technology Center, Rocky Mountain Research Station. Fort Collins, Colorado.

Waters, T. 1995. *Sediment in Streams Sources, Biological Effects and Control*. American Fisheries Society Monograph 7. Bethesda, Maryland.

Wolman, M.G. 1954. *A Method of Sampling Coarse River-Bed Material*. Transactions of American Geophysical Union 35: 951-956.

APPENDIX E

GUIDANCE FOR
NUTRIENT ASSESSMENTS
OF STREAMS

New Mexico Environment Department
Surface Water Quality Bureau

Last Revision
December 2005

I. Purpose

This document establishes an assessment protocol for determining nutrient impairment status of wadeable streams. While a few streams have segment specific numeric criteria for total phosphorus, New Mexico currently has no general numeric criteria for nutrients. The narrative criterion in *State of New Mexico Standards for Interstate and Intrastate Surface Waters* states that, "Plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state" (NMWQCC 2005). This protocol will be used to determine if a stream reach (i.e., assessment unit) is meeting this criterion. If an assessment unit is determined to be impaired, it will be added to the Integrated Clean Water Act §303(d)/§305(b) List of Assessed Waters as impaired, and a total maximum daily load (TMDL) planning document will be written. This protocol is a dynamic document that will be refined as more data are collected, enabling more precise classification of streams and definition of relationships between nutrient concentrations, indicators, and impairment in New Mexico streams.

II. Background

The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for aquatic organisms. However, excessive aquatic vegetation is not beneficial to most stream life and may change the aquatic community structure. High nutrient concentrations may promote an overabundance of algae and floating and rooted macrophytes. The types and amounts of aquatic vegetation often reflect the level of nutrient enrichment. Algae are either the direct (excessive periphyton mats or surface plankton scums) or indirect (diurnal swings of dissolved oxygen and pH and high turbidity) cause of most problems related to excessive nutrient enrichment. In addition, algal blooms often cause taste and odor problems in drinking water supplies. Blooms of certain types of blue-green (cyanobacteria) and golden (*Prymnesium* spp.) algae can produce toxins that are detrimental to animal and human health. One of the most expensive problems caused by nutrient enrichment is increased treatment required for drinking water.

Some increases in primary productivity can increase the abundance of invertebrates and fish in streams. However, excessive plant growth and decomposition can limit aquatic populations by decreasing dissolved oxygen (D.O.) concentrations. Plant respiration and decomposition of dead vegetation consume D.O. Lack of D.O. stresses aquatic organisms and can cause fish kills. Nocturnal respiration can cause oxygen depletion in waters with high primary productivity and low reaeration rates. Even relatively small reductions in D.O. can have adverse effects on both invertebrate and fish communities (USEPA 1991). Dissolved oxygen saturation levels of greater than 120% may be harmful to aquatic life (Behar 1996). Development of anaerobic conditions will alter a wide range of chemical equilibria and may mobilize certain pollutants and generate noxious odors (USEPA 1991).

The variables referred to in this document are measurable water quality parameters that can be used to evaluate the degree of eutrophication in streams. The variables consist of causal variables (nutrient concentrations), and response variables (algal biomass, pH, and D.O.). Relationships between these variables are not as tightly coupled in rivers and streams as they are in lakes. Many other factors come into play in lotic systems, including flow regime, channel morphology, bed composition, degree of shading, and grazing by invertebrates. Many of these factors will be noted during the nutrient survey to aid in interpretation of measured variables.

The highly variable flows and spatially interrupted nature of many streams in arid landscapes can have great influence on both nutrient loading and biomass production. In the arid southwest, low and middle elevation streams may have naturally high levels of productivity due to the long growing season, high temperatures, open canopy, and the consequential tight cycling of available nutrients (AZDEQ 1996, Fisher and Grimm 1983).

III. Assessment Procedure

The primary question to be answered is: **Is this reach impaired due to nutrient enrichment?** Nutrient impairment occurs where algal and/or macrophyte growth interferes with designated uses, thus preventing the reach from supporting these uses. Algal biomass is the most important indicator of nutrient enrichment, as algae cause most problems related to excessive nutrient enrichment. Algae and macrophytes may be a nuisance when 1) there are large amounts of rotting algae and macrophytes in the stream; 2) the stream substrate is choked with algae; 3) large diurnal fluctuations in D.O. and pH occur; and/or 4) there is a release of sediment-bound toxins.

This protocol uses a two-tiered approach to nutrient assessment. The two levels of assessment are used in sequential order to determine if there is excessive nutrient enrichment. If a Level I assessment indicates nutrient enrichment, a Level II assessment will be used to test this finding and provide more quantitative indicators. Level I is a screening level assessment that is observational with limited measurements. It is based on a review of available data, including on-site observations and measurements of chemical parameters. Level II is based on quantitative measurements of selected indicators. If these measurements exceed ecoregion numeric nutrient criteria, indicate excessive primary production (i.e., large D.O. and pH fluctuation and/or high chlorophyll *a* concentration), and/or demonstrate an unhealthy benthic community, the reach is considered to be impaired. Both assessments use data that are collected during water quality and nutrient surveys and compiled on the Nutrient Survey Forms. These data, along with reports from the Surface Water Quality Bureau (SWQB) in-house water quality database, are used to complete the Nutrient Assessment Form and conduct the assessment.

In February of 2002, the US Environmental Protection Agency (EPA) released nine nutrient water quality criteria documents. These documents contained EPA's recommended criteria for total phosphorus (TP) and total nitrogen (TN) for aggregate ecoregions. The criteria were derived using procedures described in the *Rivers and Streams Nutrient Criteria Technical Guidance Manual* (USEPA 2000a) (http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html). These aggregate ecoregion nutrient criteria were intended as a starting point for states and authorized tribes to develop more refined nutrient criteria. Evan Hornig (EPA), previously a USGS employee, is assisting states in EPA Region 6 to develop nutrient criteria. He used regional nutrient data to derive criteria for Level III ecoregions in New Mexico using site medians and EPA procedures. These Ecoregion Nutrient Criteria for streams, shown in Table 1, will be used in the nutrient assessment. These criteria will continue to be refined as the New Mexico nutrient dataset grows and a higher resolution stream classification is developed.

Table 1. Ecoregion Nutrient Criteria for streams (mg/L), calculated using site medians and EPA procedures (Evan Hornig, unpublished data 2003)

	Southern Rockies	AZ/NM Mountains	AZ/NM Plateau	Chihuahuan Desert	SW Tablelands	Madrean Archipelago
TN	0.30	0.32	0.42	0.64	0.54	0.25
TP	0.025	0.020	0.070	0.062	0.025	0.105

SWQB has adopted a multi-indicator approach to conduct a more robust assessment and account for diverse lotic systems and dynamic nutrient cycling. Both cause and response variables are used. It is important to incorporate response variables into the assessment as ambient water column nutrient "concentrations cannot indicate supply because large biomass of primary producers may have a very high nutrient demand and render inorganic nutrient concentrations low or below detection" (Dodds and Welch 2000). The response variables of algal biomass, D.O., and pH are incorporated into the assessment. For D.O. concentration and pH, criteria are based on designated uses of an assessment unit, as indicated in the *State of New Mexico Standards for Interstate and Intrastate Surface Waters* (NMWQCC 2005) (Table 2).

Table 2. Criteria for dissolved oxygen concentration and pH

Designated Use	Dissolved Oxygen	pH
High Quality Coldwater Aquatic Life	6.0 mg/L	6.6 – 8.8
Coldwater Aquatic Life	6.0 mg/L	6.6 – 8.8
Marginal Coldwater Aquatic Life	6.0 mg/L	6.6 – 9.0
Warmwater Aquatic Life	5.0 mg/L	6.6 – 9.0
Marginal Warmwater Aquatic Life	5.0 mg/L	6.6 – 9.0

The assessment may use either a reference or threshold approach (USEPA 2000). For most streams, indicators will be compared to thresholds from published literature. If, however, the researcher feels that these thresholds are not appropriate for the class of stream being assessed, a reference site approach will be used. A suitable reference reach will be surveyed and indicators from the study reach will be compared to those of the reference reach rather than established thresholds. This is to account for streams that may have naturally high productivity because of regional geology, flow regime, or other natural causes.

A. Level I Nutrient Assessment

Level I Nutrient Assessment will use water quality data and field observations that have been compiled for each assessment unit. Data from the SWQB database, field sheets, and other readily available sources (such as USGS and NPDES permittees) should be utilized. These data are compiled on the Level I Nutrient Survey Form and used to complete the Level I Assessment Form. This assessment should be conducted in late August, just prior to the nutrient and benthic macroinvertebrate index period (September and October). The Level I assessment will be conducted at this time to utilize as much water quality survey data as possible and leave enough time to conduct the Level II Nutrient Survey at those sites that the Level I Assessment indicates the need. The following parameters are used in the Level I assessment:

Algae and Macrophyte Coverage:

Macrophyte is a general term that applies to many types of aquatic vegetation including flowering vascular plants, mosses, and ferns. Nutrients supplied from sediments combined with those in solution are usually adequate to meet nutritional demands of rooted aquatic plants, even in oligotrophic systems (Barko and Smart 1986). Macrophyte growth in streams is usually controlled by temperature, substrate characteristics, light limitation, or flow regimes. Phosphorus, nitrogen, and other nutrients may be taken up by submerged macrophytes from sediment, uncoupling rooted macrophyte growth from water column nutrient concentrations (Welch 1992). As bottom sediments act as the primary nutrient source for rooted macrophytes, they will not be used as indicators of nutrient enrichment. However, abundance of rooted macrophytes will be noted during nutrient surveys to explore their relationships with other variables.

Algae are non-vascular plants without true roots, stems, or leaves. They are mostly aquatic and range from tall stalks of kelp to fuzzy growths of green filamentous algae to microscopic, silica-encased diatoms. In the context of this document, “algae” refers to the visible growth of non-rooted aquatic vegetation attached to the stream substrate. The extent of algal coverage of a streambed can be an important indicator of algal biomass problems (USEPA 2000). As nutrient enrichment increases, the percent of streambed covered with algae increases (Welch et al. 1987, Lohman et al. 1992, Biggs 1996). The Level I assessment uses percent algal coverage as a qualitative indicator of algal biomass.

A visual estimate of the percent of both algal and macrophyte coverage will be recorded. Generally, this will be determined at each site once in the spring, summer, and fall as part of SWQB water quality surveys. Coverages of greater than 50% in any season may indicate nutrient enrichment. On the Nutrient Assessment Form, indicate if this 50% threshold is exceeded during any season.

Periphyton Abundance:

Periphyton is an assemblage of organisms that grow on underwater surfaces and includes a complex matrix of algae and heterotrophic microbes including bacteria, fungi, protozoa, and other organisms (Allaby 1985). Periphyton is composed primarily of microscopic organisms, while algae noted in the percent coverage is mainly macroalgae. The extent of periphyton coverage of a streambed can be an important indicator of algal biomass problems (USEPA 2000). A rating of periphyton abundance will be recorded during the nutrient survey. The rating is from 0 to 5 as follows: **0)** rough with no apparent growth; **1)** thin layer of periphyton is visible (tracks can be drawn in the film with the back of your fingernail); **2)** 0.5 to 1 mm thick; **3)** 1 to 5 mm thick; **4)** 5 to 20 mm thick; and **5)** >20 mm thick. Periphyton thickness of >l mm (rating of >2) may indicate nutrient enrichment. On the Nutrient Assessment Form, indicate if the rating is greater than 2 during any season.

Anaerobic conditions:

Anaerobic conditions can be indicative of excessive plant growth and decay. Decomposition of organic material uses oxygen, and excessive decomposition can create anoxic conditions. Anaerobic decomposition that takes place in anoxic conditions produces hydrogen sulfide with an associated "rotten egg" smell and black color. Note on the Nutrient Assessment Form if an anoxic layer is found under rocks and/or in depositional areas.

Dissolved Oxygen and pH:

High rates of primary production can cause D.O. supersaturation and high pH during the day. Photosynthesis and respiration alter the amount of carbon dioxide (CO_2) in water, which affects pH. Photosynthesis removes CO_2 from water, which forces buffers to remove hydrogen ions, increasing pH. Respiration takes place at night (when photosynthesis does not occur) and adds CO_2 to water resulting in an increase in the number of hydrogen ions, thereby lowering the pH. Diurnal pH fluctuation will be greater in streams with low buffering capacity, so this may not be a responsive indicator in many NM streams. Dissolved oxygen deficit and high pH are the algal related problems most affecting aquatic life (Dobbs and Welch 2000). Unfortunately, it is difficult to test for D.O. deficit, as it usually occurs in the early morning after respiration has been occurring all night. Thus, D.O. percent saturation, which typically peaks in late afternoon, will be used as an indicator in the Level I Assessment. The data set should include all of the measurements taken in the Assessment Unit. Note on the Nutrient Assessment Form if any D.O. saturation readings are above 120%. Determine if any pH readings exceed 8.8 for high quality coldwater and coldwater aquatic life uses and 9.0 for marginal coldwater and warmwater aquatic life uses.

Water Chemistry:

Print out and attach the Nutrient Report from the SWQB water quality database. Use the data in the report to calculate the exceedence ratio for TN and TP. The exceedence ratio is the number of times that the TN or TP concentration is above the ecoregion nutrient criteria (see Table 1), divided by the total number of samples in the data set. The data set should include all of the samples taken in the Assessment Unit, i.e. if more than one site occurs in the assessment unit, combine the data from all sites in calculating the exceedence ratio. It may also be helpful to calculate the exceedence ratio for individual sites in an assessment unit to determine where nutrient impairment and/or loading are occurring. Record the exceedence ratios for the entire dataset on the Level I nutrient Assessment Form. An exceedence ratio of >15% may indicate nutrient enrichment (SWQB/NMED 2006).

<u>Analysis and Interpretation</u>:

If **two or more** of the observations noted above indicate nutrient enrichment, a Level II Assessment should be conducted because attainment status is uncertain. If one or none of the above observations indicate enrichment, the assessment unit is considered to be Fully Supporting with respect to New Mexico's narrative nutrient standard.

B. Level II Nutrient Assessment

A Level II Assessment is based on quantitative measures of indicators. It is conducted if the Level I Assessment indicates potential nutrient impairment. The Level II Assessment uses data that will be collected during a Level II Nutrient Survey and compiled on the Level II Nutrient Survey Form.

Diurnal Cycles: Algal biomass above nuisance levels often produces large diurnal fluctuations in D.O. and pH (Figure 1). Photosynthesis and respiration by dense algal mats commonly cause water quality criteria exceedences. Dissolved oxygen concentration, local D.O. percent saturation, and pH are all used as indicators of nuisance levels of algal biomass. The magnitude of diurnal swings in D.O. and pH will depend on several factors, such as turbulence (which affects aeration), light, temperature, buffering capacity, and the amount and health of algal and/or macrophyte biomass. Higher temperatures tend to enhance algal growth and may increase photosynthesis and respiration, resulting in greater variation in diurnal D.O. and pH values. Observe pre-dawn measurements for minimum D.O. concentrations and afternoon hours for maximum pH and D.O. percent saturation. Aquatic organisms are most affected by maximum pH and minimum D.O., rather than by daily means of these variables (USEPA 2000).

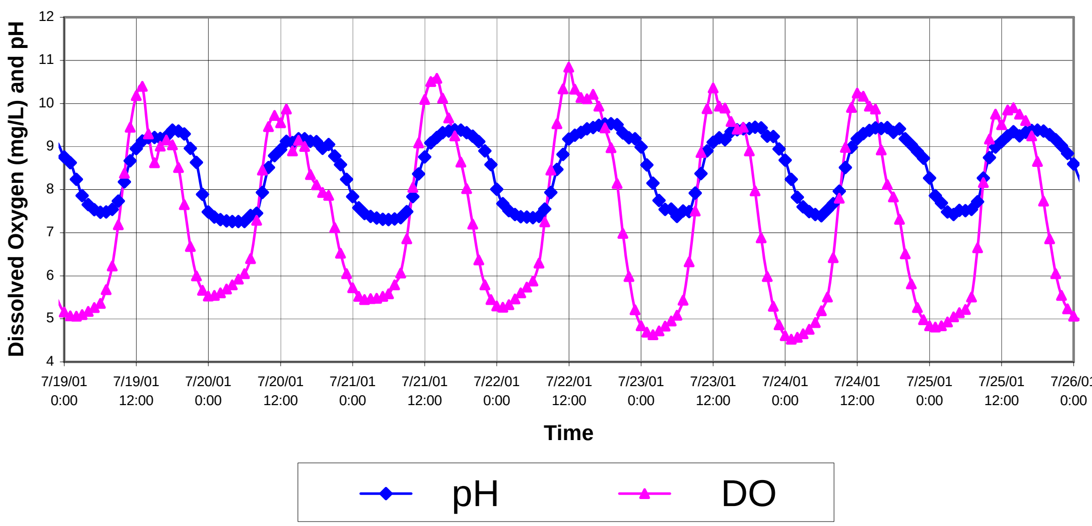

Figure 1. Diurnal patterns in dissolved oxygen and pH in East Fork Jemez, below La Jara Creek (July 18 - 26,2001)

Assessment of D.O. and pH may be made with large sonde dataset or from grab samples. Grab sample assessments will only be used when a large sonde data set is not available. Large sonde datasets are generated by deploying a sonde (multi-parameter, continuous recording device) set to take hourly readings of D.O., pH, specific conductance, temperature, and turbidity for multiple days. These datasets provide a more robust assessment as the diurnal cycles of D.O. and pH are recorded over multiple dates and times. The *Protocol for Assessment of Large pH Data Sets* and the *Protocol for Assessment of Dissolved Oxygen Data Collected with Continuous Recording Devices* should be used to assess pH and D.O. data from a sonde (appendix in SWQB/NMED 2006). The D.O. thresholds presented in Table 3 are based on both the designated use and the life stage present at the time of sampling. Based on these assessments, note on the Nutrient Assessment Form whether or not the designated use is being supported.

Table 3. Water Quality Values for dissolved oxygen

	Coldwater values		**Warmwater values**
	Early life stages (1 Nov - 31 Jul at ≥ 2750 m; 1 Nov - 30 Jun at < 2750 m)	**Other life stages**	**All life stages**
Combined Instantaneous Minimum	8.0 mg/L; 95% saturation	6.0 mg/L; 90% saturation	5.0 mg/L; 90% saturation
Local percent saturation instantaneous minimum	85	75	75

If a sonde was not deployed for multiple days, use field data from the water quality and nutrient surveys to calculate an exceedence ratio for pH, local D.O. percent saturation, and D.O. concentration. Be sure to use data from all of the sites in the assessment unit, not just the site where nutrient survey was conducted. For D.O. percent saturation, a threshold of 120% is used. For grab sample assessments, D.O. percent saturation is used in addition D.O. concentration as it tends to be collected during the day when D.O. is high and not during pre-dawn time period when low levels occur. The criteria for D.O. concentration and pH are based on designated use (see Table 2). For D.O., the criterion is 6 mg/L for coldwater aquatic life uses and 5 mg/L for warmwater aquatic life uses. The threshold value for pH is 8.8 for high quality coldwater and coldwater aquatic life uses and 9.0 for marginal coldwater and warmwater aquatic life uses. If an assessment unit has both warmwater and coldwater uses, the more stringent criterion should be used to be protective of all uses. An exceedence ratio of greater than 15% may indicate nutrient enrichment (SWQB/NMED 2006). Sondes will not be deployed if there is a high risk of damage to, or loss of, the instrument due to high flows or vandalism.

Water Chemistry: Use the nutrient report from the SWQB water quality database. Print and attach a current report so that all available data are used. Record the TN and TP concentrations collected during the nutrient survey as well as the exceedence ratio for the entire dataset. Be sure to use data from all of the sites in the assessment unit, not just the site where nutrient survey was conducted, i.e. if more than one site occurs in the assessment unit, combine the data from all sites in calculating the exceedence ratio. The exceedence ratio is the number of times that the TN or TP concentration is above the ecoregion nutrient criteria (Table 1), divided by the total number of samples in the dataset. An exceedence ratio of >15% may indicate nutrient enrichment (SWQB/NMED 2006).

Algal Sampling: In streams, benthic algae production and biomass are the most useful parameters in monitoring changes in water quality (USEPA 1991). Chlorophyll *a* concentration is used as a surrogate for algal biomass and is generally the most appropriate variable to monitor (USEPA 2000). Chlorophyll *a* is specific to algae, while Ash Free Dry Mass (AFDM) includes all living and non-living organic matter. Record the results of chlorophyll *a* concentration and AFDM analysis of benthic algae/periphyton samples. The units of the results must be in $\mu g/cm^2$. If more than one chlorophyll *a* or AFDM measurement was taken, record the average for each site visit. Do not average samples taken on different days.

In *Rapid Bioassessment Protocols (RBP) for Use in Streams and Wadeable Rivers* (USEPA 1999), nuisance levels of algal biomass are defined as: greater than 10 micrograms chlorophyll *a* per square centimeter (>10 $\mu g/cm^2$) and greater than 5000 micrograms AFDM per square centimeter (>5000 $\mu g/cm^2$). EPA's *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* lists a number of algal biomass thresholds ranging from 100 – 200 mg/m^2 (10 to 20 $\mu g/cm^2$) (USEPA 2000). The RBP thresholds will be used until SWQB is able to define region-specific values. Note if chlorophyll *a* and AFDM exceed these threshold values.

The ratio of AFDM to chlorophyll *a* (AFDM/chl *a*) is termed the autotrophic index for periphyton and is used to distinguish the relative response to inorganic (N and P) and organic (BOD) enrichment (USEPA 2000). Periphyton growing in surface water that is relatively free of organic matter contains approximately one to two percent chlorophyll *a* by weight. Surface water that is high in particulate organic matter may support large populations of bacteria, fungi, and other non-chlorophyll bearing microorganisms, and have a larger ratio of AFDM to chlorophyll *a*. Increased ratios indicate that heterotrophs utilizing organic substances comprise a larger percentage of AFDM than autotrophic periphyton that rely largely on inorganic nutrients to increase biomass (Weber 1973). Ratios of AFDM/chl *a* can vary over three orders of magnitude, with values >400 indicating organically polluted conditions (Collins and Weber 1978). Ratios of AFDM/chl *a* around 250 are more typical for streams enriched with inorganic nutrients that are likely to have existing or potential eutrophication problems (Watson and Gestring 1996, Biggs 1996). The autotrophic index should be used with caution, because non-living organic detrital material may artificially inflate the ratio.

Benthic Macroinvertebrates (OPTIONAL COMPONENT UNDER DEVELOPMENT): Samples of benthic macroinvertebrates should be collected from the reach being characterized and a suitable reference site. Indices employing macroinvertebrates as indicators of nutrient pollution have great potential. The benthic community will be assessed using the currently accepted NMED assessment protocol. Benthic macroinvertebrate Stream Condition Index (SCI) uses a number of metrics (e.g. number of taxa, percent EPT-mayflies, stoneflies, and caddisflies, percent predators, etc.). The advantages of the SCI include low variability, high sensitivity, and absolute background values for a no effect condition (USEPA 2000). In addition to the SCI as compared to a reference site, the Hilsenhoff Biotic Index (HBI), which is based on tolerance of organisms to organic and nutrient pollution may also be a useful indicator. According to Hilsenhoff (1987), an HBI value above 5.5 may indicate nutrient enrichment. However, nutrient tolerance ratings have not been determined for some southwestern organisms.

SWQB is currently in the process of developing a regional SCI and assigning tolerance values for macroinvertebrates of New Mexico. Once a SCI has been developed for New Mexico, and organism tolerance values and HBI threshold values are verified using a Southwestern data set, these biological indicators will be used in the weight of evidence nutrient assessment.

Algal Bioassays (OPTIONAL COMPONENT INCLUDED IF NECESSARY): If stream observations indicate that algal biomass may be a problem and/or there is an NPDES permit that discharges within the assessment unit, a limiting nutrient analysis and algal growth potential test may be performed. Currently, researchers at the University of New Mexico (UNM) are conducting these analyses for SWQB.

The procedures for determining limiting nutrients and algal growth potential are outlined in *The Selenastrum capricornutum Prinz Algal Assay Bottle Test* (USEPA 1978) and *Biostimulation and Nutrient Assessment Workshop* (USEPA 1975). Results are given in dry weight measurements in accordance with the EPA procedure. Dry weight is used to define the Productivity Classification as described in Table 4.

Table 4. Productivity Classifications from algal bioassay results.

Algal Growth (mg dry wt./L)	**Classification**
0.00 – 0.10	Low Productivity
0.11 - 0.80	Moderate Productivity
0.81 – 6.00	Moderately High Productivity
6.10 – 20.00	High Productivity

Moderately High Productivity and High Productivity may be indicative of nutrient enrichment.

Analysis and Interpretation:

Compare each indicator to the associated threshold value. Note those that exceed the threshold. If **three or more** indicators exceed the threshold, the assessment unit is determined to be not supporting.

If the study reach is believed to have naturally high productivity because of geology, flow regime, or other natural factors, a reference site approach may be used. Identify an appropriate reference reach for the study area and conduct a Level II Nutrient Survey of the reference reach near the same time that the study reach is surveyed. Whenever possible, select an existing survey site as a reference, as existing sites will have associated water quality data. Compare each indicator from the two sites, including algal biomass, and chemical and physical parameters, as well as benthic community composition, when appropriate. Use statistical tests to determine significant difference when feasible. When the number of samples from each site is sufficient (n is greater than 4), the rank-sum test (a.k.a. Wilcox or Mann-Whitney test) will be used to test if there is a high probability that the study site is different than the reference site. If the number of measurements is <5, then best professional judgment will be used to determine if the parameters are different at the sites (see notes on the Level II Assessment Using A Reference Site Form for general guidelines). If indicators from the sites are in the same range, the assessment unit will not be listed. If, however, two or more of the indicators are substantially different, the assessment unit will be determined to be not supporting.

Level I Nutrient Assessment Form

Assessment Unit:	
Site Location:	
Assessment date:	Ecoregion:
Evaluator:	Aquatic Life Uses:

Algae and Macrophytes: mark **True** if the indicator is present during one or more seasons.

Percent algal cover is greater than 50%: True False
Percent macrophyte cover is greater than 50%: True False

Periphyton and Substrate: mark **True** if the indicator is present during one or more seasons.

0 - rough with no apparent growth, **1 -** thin layer of periphyton is visible, **2 -** thickness of 0.5-1 mm, **3 -** 1 mm to 5 mm thick, **4 -** 5 mm to 20 mm thick, **5 -** >20 mm thick Rating of the periphyton on coarse substrate is >2: True False
Anoxic layer present (black, H_2S layer): True False

D.O. Percent Saturation and pH: mark **True** if the indicator is present at any time
The pH criterion is 8.8 for high quality coldwater and coldwater aquatic life (CWAL) uses, and 9.0 for marginal coldwater and warmwater aquatic life (WWAL) uses.

D.O. percent saturation (local) is greater then 120%: True False
pH value is greater then 8.8 for CWF or 9.0 for WWF: True False

Water Chemistry: attach nutrient report from SWQB database.

Total Nitrogen (mg/L):	**Total Phosphorus (mg/L):**
Ecoregion Criteria (see notes):	Ecoregion Criteria (see notes):
Exceedence Ratio:	Exceedence Ratio:

Move to a Level II Assessment if two or more of the following occur:

- ____ Algae cover on stable substrate is >50%
- ____ Periphyton rating is >2
- ____ Anoxic layer is present
- ____ D.O. percent saturation (local) is greater then 120%
- ____ pH value is greater then appropriate criterion
- ____ Total nitrogen is above the ecoregion criterion or exceedence ratio is >15%
- ____ Total phosphorus is above the ecoregion criterion or exceedence ratio is >15%

Conduct Level II Assessment: Yes No – Reach is Full Support for nutrients

Level II Nutrient Assessment Worksheet

Sonde: Use the *Protocol for Assessment of Large pH Data Sets* and the *Protocol for Assessment of Dissolved Oxygen Data Collected with Continuous Recording Devices* to assess pH and D.O. if multiple day Sonde data is available. Attach Assessment Form. If sonde data is not available, use grab sample data to calculate an exceedence ratio for pH, local D.O. percent saturation, and D.O. concentration.

Site Location:	
Multiple-day Deployment	**Grab Samples**
Assessment of dissolved oxygen:	D.O. % saturation exceedence ratio:
Supporting Not supporting	
Assessment of large pH datasets :	D.O. minimum exceedence ratio:
Supporting Not supporting	
DO fluctuations > 3mg/L: Yes No	pH exceedence ratio:
Notes:	

Nutrient Survey Water Chemistry: attach updated nutrient report from SWQB database and calculate the exceedence ration for the entire assessment unit.

Total Nitrogen (mg/L)	**Total Phosphorus (mg/L)**
Ecoregion Criteria (see notes):	Ecoregion Criteria (see notes):
Exceedence Ratio:	Exceedence Ratio:
Notes:	

Algal Sampling: record results of chlorophyll a and AFDM analysis and associated ratio.

Threshold Value chlorophyll *a*: 10 μg/cm^2	Threshold Value AFDM: 5000 μg /cm^2
Chlorophyll *a* (μg/cm^2):	Ash Free Dry Mass (μg /cm^2):
AFDM/chlorophyll *a* ratio:	
Notes:	

Benthic Macroinvertebrates: see notes on following page.

Date:	Sample method:
Reference site:	
Hilsenhoff Biotic Index (HBI):	
SCI Score:	
Notes:	

Algal Bioassays (OPTIONAL): Attach results.

Date collected:	Limiting nutrient:
Algal productivity: low moderate moderately high high	
Notes:	

Notes:

Total Nitrogen is calculated by adding Total Kjeldahl Nitrogen plus Nitrate + Nitrite. In the event that Nitrate + Nitrite or Total Kjeldahl Nitrogen are below the detection limit, a value of one half the detection limit will be used (Gilbert 1987).

Put NA (not available) in boxes for parameters that were not collected.

Ecoregion based **Stream Nutrient Criteria** (mg/L) (Evan Hornig, unpubl. data 2003) (calculated using site medians)

	Southern Rockies	AZ/NM Mountains	AZ/NM Plateau	Chihuahuan Desert	SW Tablelands	Madrean Archipelago
TN	0.30	0.32	0.42	0.64	0.54	0.25
TP	0.025	0.020	0.070	0.062	0.025	0.105

Benthic macroinvertebrate indicators will be added to the assessment once the index is developed and threshold values are verified for New Mexico:

____ HBI is greater than _____
____ SCI is ____

Level II Nutrient Assessment Form using Threshold Values

Assessment Unit:	
Site Location(s):	
Assessment date:	**Ecoregion:**
Evaluator:	**Aquatic life Uses:**

An Assessment Unit will be determined to be not supporting if **three or more** of the following indicators are present (if not all of the indicators have been measured, the presence of two of the following indicators will be assessed as not supporting). Check all indicators that exceed the threshold values below.

- ____ Total nitrogen is above the ecoregion criterion in >15% of samples
- ____ Total phosphorus is above the ecoregion criterion in >15% of samples
- ____ Dissolved Oxygen threshold is exceeded
  - o (____) determined to be **not supporting** using the assessment protocol for Data Collected with Continuous Recording Devices
  - o (____) >15% of grab samples exceeded 120%
  - o (____) >15% of grab samples are below the applicable standard
- ____ pH threshold is exceeded
  - o (____) determined to be **not supporting** using the assessment protocol for large pH data sets
  - o (____) >15% of grab samples exceeds appropriate criterion
- ____ The Algal Bioassay indicates moderately high or high algal production
- ____ Algal biomass threshold is exceeded
  - o (____) Chlorophyll *a* concentration is greater than 10 $\mu g/cm^2$
  - o (____) AFDM is greater than 5000 $\mu g/cm^2$

Circle One:	**Fully supporting**	**Not supporting**
Notes:		

Level II Assessment Using A Reference Site

Assessment Unit:	
Site Location(s):	
Reference Site:	
Assessment date:	**Ecoregion:**
Evaluator:	**Aquatic life Uses:**

If the study reach is believed to have naturally high productivity because of geology, flow regime, or other natural factors, a reference site approach may be used. An Assessment Unit will be determined to be **not supporting** if **two or more** of the following indicators of the study site are notably different from those of the reference site. If the number of samples from each site is sufficient (n >4), then the rank-sum test (a.k.a. Wilcox or Mann-Whitney test) will be used to test if there is a high (>75%) probability that the study site is different than the reference site. If the number of measurements is small (n ≤4), then best professional judgment utilizing the general guidelines in the table from the "notes" section below will be used to determine if the parameters are different at the sites.

Indicator	Reference Site	Study Site
D.O. saturation exceedence ratio*		
pH exceedence ratio*		
DO concentration exceedence ratio*		
Total nitrogen exceedence ratio		
Total phosphorus exceedence ratio		
Chlorophyll *a* concentration		
AFDM		
Algal Bioassay algal production		

* The exceedence ratio for large data sets refers to the number of days with exceedences over the number of full days that the sonde was deployed, not the number of data points. Use grab sample data if multiple day Sonde data is not available for both sites.

Circle One:	**Fully supporting**	**Not supporting**
Notes:		

Notes:

--Put NA (not available) in boxes for parameters that were not collected.

--Complete and attach a Level II Assessment Form for the reference site as well as the study site.

The table below provides general guidelines of what constitutes a "difference" between the reference and study site for parameters with < 5 measurement.

Indicator	Reference Site	Study Site
D.O. saturation exceedence ratio		> 1 exceedence more then reference
pH exceedence ratio		> 1 exceedence more then reference
DO concentration exceedence ratio		> 1 exceedence more then reference
Total nitrogen exceedence ratio*		> 1 exceedence more then reference*
Total phosphorus exceedence ratio*		> 1 exceedence more then reference*
Chlorophyll *a* concentration		≥20% difference
AFDM		≥20% difference
HBI		> 0.5 difference
M IBI Score % of reference	100	<70 % of reference

* Also consider how much greater the concentrations are at the study site, and how close the concentrations are to the detection limit. If the one or both of concentrations are <2 times the detection limit (DL), then a value of 4 times the reference site concentration would be considered "different". If either of the concentrations are >2 times the DL, then a concentration of 2 times the reference concentration would be considered "different."

References:

Allaby, M. 1985. The Oxford Dictionary of Natural History. Oxford University Press, Oxford, U.K.

Arizona Department of Environmental Quality (ADEQ). 1996. Implementation Guidelines for the Narrative Nutrient Standard. Phoenix, AZ.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. USEPA: Office of Water: Washington, D.C.

Barko, J. W. and R. M. Smart. 1986. Sediment-related mechanisms of growth limitation in submersed macrophytes. J. Ecol. 67(5):1328-1340.

Behar, S. 1996. Testing the Waters, River Water Network. http://www.gvsu.edu/wri/education/manual/oxygen.htm (April 15, 2004)

Biggs, B. J. F. 1996. Patterns in benthic algae of streams. In: Algal Ecology. Stevenson, J., M. L. Bothwell, and R. L. Lowe (eds.). Academic Press, San Diego, CA. pp. 31-51.

Biggs, B. J. F. and C. Kilroy. 2000. Stream Periphyton Monitoring Manual. NIWA, Christchurch, New Zealand.

Collins, G. B. and C. I. Weber. 1978. Phycoperiphyton (algae) as indicators of water quality. Trans. Am. Microscop. Soc. 97:36-43.

Dodds, W. K. and E. B. Welch. 2000. Establishing nutrient criteria in streams. J. N. Am. Benthol. Soc. 19:186-196.

Fisher, S. G. and N. B. Grimm. 1983. *Water Quality and Nutrient Dynamics of Arizona Streams*. OWRT Project Completion Report A-106-ARIZ. Office of Water Research and Technology.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. John Wiley and Sons. New York, NY.

Hilsenhoff, W.L. 1987. An improved Biotic Index of Organic Stream Pollution. The Great Lakes Entomol. 20(1): 31-39.

Hornig, Evan. 2003. Unpublished data. USGS, Austin, TX.

Lohman, K., J. R. Jones, and B. D. Perkins. 1992. Effects of nutrient enrichment and flood frequency on periphyton biomass in northern Ozark streams. Can. J. Fish. Aquat. Sci. 49:1198-1205.

Moulton, S. R. II, J. G. Kennen, R. M. Goldstein, and J. A. Hambrook. 2002. Revised Protocols for Sampling Algal, Invertebrate, and Fish Communities as Part of the National Water-Quality Assessment Program. USGS Open-File Report 02-150

NMWQCC. 2005. State of New Mexico Standards for Interstate and Intrastate Streams. As amended through July 17, 2005. Santa Fe, NM.

Snyder, D.T. and J. L. Morace. 1997. Nitrogen and Phosphorus Loading from Drained Wetlands Adjacent to Upper Klamath and Agency Lakes Oregon. USGS Water-Resources Investigations Report 97-4059.

SWQB/NMED. 1996b. Draft Pollutant Source Documentation Protocol.

SWQB/NMED. 2006. State of New Mexico Procedures for Assessing Standards Attainment for the Integrated §303(d)/§305(b) Water Quality Monitoring and Assessment Report. Available at: http://www.nmenv.state.nm.us/swqb/. Santa Fe, NM.

USDA. 1998. Stream Visual Assessment Protocol, National Water and Climate Center Technical Note 99-1. Washington, DC. 36pp.

USEPA. 1975. Biostimulation and Nutrient Assessment Workshop. EPA-660/3-75-034

USEPA. 1978. The Selenastrum Capricornutum Prinz Algal Assay Bottle Test. EPA-600/9-78-018

USEPA. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA-910-9-91-001. Seattle, WA.

USEPA. 1996. Biological Criteria. Technical Guidance for Streams Rivers Revised Edition. EPA 822-B-96-001.

USEPA. 2000. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002.

Watson, V. J. and B. Gestring. 1996. Monitoring algae levels in the Clark Fork River. Intermountain J.Sci. 2:17-26.

Weber, C. I. 1973. Recent developments in the measurement of the response of plankton and periphyton to changes in their environment. pp. 119-138 In: Bioassay Techniques and Environmental Chemistry. Glass, G. (ed.). Ann Arbor Science Publishers, Ann Arbor, MI.

Welch, E. B. 1992. Ecological Effects of Wastewater. Chapman and Hall, London.

Welch, E. B., J. M. Jacoby, R. R. Horner and M. R. Seeley. 1987. Nuisance biomass levels of periphytic algae in streams. Hydrobiologia 157:161-168.

APPENDIX F

Large Dissolved Oxygen Dataset Assessment Protocol

New Mexico Environment Department
Surface Water Quality Bureau

Revised October 2005

Introduction

Most of the information available concerning oxygen requirements of fish is based on salmonids, although a substantial number of studies also involve warmwater species. The consensus that has emerged from the literature is that salmonids and other coldwater species are generally more sensitive to low levels of dissolved oxygen than warmwater species, and that early life stages (embryos and larvae) of all species have higher dissolved oxygen requirements than their respective adult stages. Although few data are available on the effects of reduced dissolved oxygen on benthic macroinvertebrates, "historical consensus states that, if all life stages of fish are protected, the invertebrate communities, although not necessarily unchanged, should be adequately protected" (USEPA, 1986) although there may be exceptions to this generalization.

Based on the above statements, this protocol recommends values for coldwater and warmwater aquatic life uses, as well as early life stages and other life stages.

Oxygen content in fresh waters is determined by several factors acting in concert. These factors include temperature, atmospheric pressure, salinity, turbulence, and photosynthetic activity of algae and plants in the water. Healthy aquatic systems have dissolved oxygen content that at least approaches 100% saturation[1]. Oxygen content may fall substantially below 100% saturation during the night when respiration and oxidation of decaying organic matter exceed production from photosynthesis (Deas and Orlob, 1999). This type of situation is particularly pronounced in systems with excessive nutrient enrichment and resulting algal and plant growth.

Currently, New Mexico's criteria for dissolved oxygen are expressed only as mass per volume (mg/L). However, in certain circumstances, such as high altitude, where atmospheric pressure is comparatively low, or high temperatures that reduce oxygen solubility, criteria may be physically impossible to attain. For this reason, this assessment protocol proposes a combined assessment of both dissolved oxygen concentration (i.e., mg/L) and percent saturation, as this integrates several factors that influence the amount of oxygen that water can contain. Additionally, when the percent saturation drops too low, the resulting reduction of the oxygen tension gradient across the gill epithelium of a fish decreases the ease of oxygen diffusion from the water into the blood, with deleterious physiological effects (Davis, 1975). For this reason, this assessment protocol includes a minimum percent saturation value that is independent of oxygen concentration. Apparently, oxygen supersaturation has no negative impact on fish (Wiebe and McGavock, 1932), thus this protocol addresses only minimum saturation levels.

Procedures

Ideally, dissolved oxygen data should be collected using continuous recording devices (sondes) in order to observe diurnal fluctuations, as opposed to the "snapshot" that grab data provide. However, in some cases, grab sample data will be all that are available. In those cases, grab samples should be taken as near to sunrise as possible to ensure that the lowest concentration for a given day is recorded. Areas where excessive aquatic plant growth is evident should be prioritized for sonde deployment because diurnal fluctuations in dissolved oxygen concentrations will likely be greater due to variation in photosynthetic activity.

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[1] All references to saturation are defined as percent saturation at the local elevation, as opposed to global percent saturation (the percent saturation a given concentration would be at sea level).

Interstitial dissolved oxygen concentration may be substantially lower than that of the adjacent water column. In order to be protective of fish embryos and larvae that develop in the interstitial environment (e.g., salmonids), early life stages values are higher than those of other life stages (see Table 1). Early life stage values do not apply to the marginal coldwater aquatic life use, as this designated use is intended to protect cold season use of warm waters.

Early life stage values shall apply to data that are collected during the time period when early life stages are likely to occur in a given water body. The period of applicability for early life stages values shall be defined for high quality coldwater and coldwater aquatic life uses as 1 November through 31 July for elevations at or above 2750 m and 1 November through 30 June for elevations below 2750 m.

In Table 1, coldwater values apply to high quality coldwater, coldwater, and marginal coldwater aquatic life uses (with the exception, as noted above, that early life stages values do not apply to marginal coldwater aquatic life uses). Warmwater values include warmwater and limited warmwater aquatic life uses. All values are given in milligrams per liter (mg/L) and/or local percent saturation.

Table 1. Water Quality Values for dissolved oxygen

	COLDWATER VALUES		WARMWATER VALUES
	Early life stages (1 Nov - 31 Jul at ≥ 2750 m; 1 Nov - 30 Jun at < 2750 m)	**Other life stages**	**All life stages**
Combined Instantaneous Minimum	8.0 mg/L; 95% saturation	6.0 mg/L; 90% saturation	5.0 mg/L; 90% saturation
Local percent saturation instantaneous minimum	85	75	75

NOTE: When assessing data for the combined instantaneous minimum, only simultaneous data are considered. In other words, both the concentration and saturation values must fail to meet minimum values at the same time for an exceedence to occur. If the local percent saturation value falls below 85 during early life stages in coldwater streams or 75 at any other time or in warmwater streams, regardless of the corresponding concentration value, it shall be considered an exceedence.

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**Dissolved oxygen – continuously recorded data** (e.g., sonde data)	All of the following must be met: 1) Combined instantaneous minimum values are not exceeded simultaneously for more than three consecutive hours, and 2) minimum saturation value is not below 85% (coldwater early life stages) or 75% (coldwater other life stages and warmwater all life stages) for more than three consecutive hours.	Any one of the following is met: 1) Combined instantaneous minimum values are exceeded simultaneously for more than three consecutive hours, or 2) minimum saturation value is below 85% (coldwater early life stages) or 75% (coldwater other life stages and warmwater all life stages) for more than three consecutive hours.	When available, biological assessment data shall be considered in determination of support status. When single excursions substantially below minimum values occur; when such excursions occur during a critical life cycle period, such as during spawn periods for coldwater fish species; or when severe events lead to fish kills (or other serious water quality impairment), best professional judgment and other available data will be used to determine aquatic life use support status.

NOTE: Information derived from analysis of dissolved oxygen data according to the above protocol may be useful for purposes other than determining support status. Included on the form used to document dissolved oxygen assessment from data collected with continuous data logging devices is a section for information that can be used as a screening tool for nutrient assessments (see attached form).

References

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. *Journal of the Fisheries Research Board of Canada* 32(12):2295-2332.

Deas, M.L. and G.T. Orlob. 1999. Klamath River Modeling Project. Project #96-HP-01. Assessment of Alternatives for Flow and Water Quality Control in the Klamath River below Iron Gate Dam. University of California Davis Center for Environmental and Water Resources Engineering. Report No. 99-04. Report 236 pp.

US Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Dissolved Oxygen. EPA 440/5-86-003. Office of Water. Washington, DC.

Wiebe, A.H. and A.M. McGavock. 1932. The ability of several species of fish to survive on prolonged exposure to abnormally high concentrations of dissolved oxygen. *Transactions of Americ. Fisheries Soc.* 63: 267-274.

Evaluator: ___________________
Date: ____________

pH and Dissolved Oxygen Sonde Data Assessment Form

Year/Watershed: ____

Assessment Unit: ____

Station name: ____

File name: ____

STORET ID: ____

Lat: N__________________ Long: W______________________ Elevation: _____________ m

WQS segment: 20.6.4. ___________ Designated use: ____________________________

First data point: Date ______________________________ Time ______________________________

Last data point: Date ______________________________ Time ______________________________

Recording interval: ______________ Data points: n = ___________

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pH Assessment

Criterion range: ________________________________

Minimum recorded: ___________ Maximum recorded: ___________ ≥ 0.5 units above criterion? ❒ no ❒ yes

Number of data points outside criterion: ___________ % data points outside criterion: _________

Maximum contiguous duration outside criterion: ________ hours

Use support designation: ❒ Supporting ❒ Non-supporting

Dissolved Oxygen Assessment

Applicable value: ❒ coldwater (early life stages) 8.0 mg/L; 95% **OR** 85%

❒ coldwater (other life stages) 6.0 mg/L; 90% **OR** 75%

❒ warmwater (all life stages) 5.0 mg/L; 90% **OR** 75%

Instantaneous minimum: _________ mg/L Corresponding percent saturation: _________ Exceedences: n = _______

Instantaneous minimum: _________ % saturation Exceedences: n = _______

Total exceedences: n = _________ Percent exceedences: ________

Combined values exceeded for > 3 hours contiguously? ❒ no ❒ yes

Minimum % saturation exceeded for > 3 hours contiguously? ❒ no ❒ yes

Use support designation: ❒ Supporting ❒ Non-supporting

Information pertinent to nutrient assessment:

Below DO concentration minimum? ❒ no ❒ yes If yes, maximum contiguous duration: _________ hours

> 120% saturation? ❒ no ❒ yes If yes, maximum contiguous duration: ___________ hours

< 75% saturation? ❒ no ❒ yes If yes, maximum contiguous duration: ___________ hours

Comments:

APPENDIX G

Large pH Dataset Assessment Protocol

New Mexico Environment Department
Surface Water Quality Bureau

Revised October 2005

Introduction

The pH of a solution is a measure of its hydrogen ion concentration and is calculated as the inverse log of the hydrogen ion concentration (pH = – $\log_{10}$ [H^+]). A pH value of 7.0 is considered neutral. That is, at pH 7, the concentration of hydrogen ions ([H^+]) is equal to that of hydroxide ions ([OH^-]). In natural waters, pH is a measure of the acid-base equilibrium resulting from various dissolved compounds and gases. The principal system regulating pH in natural waters is the carbonate system, composed of carbon dioxide (CO_2), carbonic acid (H_2CO_3), bicarbonate ion (HCO_3), and carbonate ion (CO_3).

There is no absolute pH range outside of which there are detrimental effects to freshwater aquatic life. Rather, gradual deterioration occurs as pH values move away from neutral. A range of pH values from 5.0 to 9.0 is not directly lethal to fish; however, the toxicity of some pollutants (e.g., ammonia) can be substantially affected by pH changes within this range (USEPA, 1986). At pH values above 9.0, fish have difficulty excreting ammonia across the gill epithelium, but they are generally able to survive pH values up to 9.5 for 2-3 days (McKean and Nagpal, 1991). Benthic macroinvertebrates may be more sensitive to lower pH values than fish. A pH range from 6.5 to 9.0 appears to adequately protect both fish and benthic macroinvertebrates (USEPA, 1986).

In New Mexico, typical pH values in surface waters that are largely unaffected by anthropogenic disturbance vary approximately from 7.5 to 8.7. Some streams, depending on local geology, have documented natural background pH values as low as 3.0 (e.g., Sulphur Creek in the Jemez River watershed), but this is atypical on a statewide basis.

An increase in pH values can result from the decrease of carbonic acid when carbon dioxide, carbonate, and bicarbonate are used by plants during photosynthesis. Thus, when high levels of nutrients lead to excessive plant growth, pH values above 9.0 may occur during the daylight hours. During the night, when photosynthesis does not occur, the pH value drops. The result is a diurnal fluctuation of pH values that lags a few hours behind the diurnal fluctuation observed in dissolved oxygen concentrations. For this reason, it is best to use continuous recording devices (sondes) to record pH values where excessive aquatic plant growth is evident. If this is not possible, grab samples should be taken at the end of the day when pH values will be at their highest.

If exceedences of water quality criteria are to be detected, the use of grab samples for recording pH in areas of excessive aquatic plant growth poses a logistic problem when viewed with the need to also detect exceedences of the dissolved oxygen criterion. Dissolved oxygen is at its lowest (i.e., most likely to exceed criteria) in the early morning in areas of excessive aquatic plant growth. This is in contrast to the diurnal pattern of pH values, which are most likely to exceed criteria late in the day. This dilemma underscores the need to use sondes for collecting these kinds of data.

Recommendations

When continuously recorded pH data are available, instantaneous (hourly) pH values shall not be outside the range of the criterion for the water body in question in greater than 15% of the measurements, pH shall not exceed the range of the criterion for the water body in question for more than 24 contiguous hours, and pH shall never exceed 0.5 units above the upper limit of the criterion.

The following table shall be used to determine the degree of aquatic life use support.

TYPE OF DATA	FULLY SUPPORTING	NOT SUPPORTING	NOTES
•**pH – continuously recorded data** (e.g., sonde data)	All of the following must be met: 1) pH is outside the range of the criterion for the water body in question in <15% of measurements, 2) pH exceeds the upper limit of the range of the criterion by 0 to 0.5 units for less than 24 contiguous hours, and 3) pH is never 0.5 or more units above the upper limit of the criterion at any time.	Any one of the following is met: 1) pH is outside the range of the criterion for the water body in question in ≥ 15% of measurements, 2) pH exceeds the range of the criterion by 0 to 0.5 units for 24 or more contiguous hours, or 3) pH is 0.5 or more units above the upper limit of the criterion at any time.	Assessments shall be based upon floating 24-hour periods; data from partial 24-hour periods shall not be included in assessments in order to avoid skewing the percentage of exceedences. The only exception to this rule is if there is an instantaneous reading that exceeds 0.5 units above the upper limit of the criterion within the partial day data. When available, biological assessment data shall be considered in determination of support status. When single excursions substantially above the criteria occur; when such excursions occur during critical life cycle period, such as during spawn periods for coldwater fish species; or when severe events lead to fish kills (or other serious water quality impairment), best professional judgment and other available data will be used to determine aquatic life use support status.

References

McKean, C. J. and N. K. Nagpal. 1991. Ambient water quality criteria for pH. British Columbia Ministry of Environment, Water Quality Branch, Water Management Division. <http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/pH.html>

U.S. Environmental Protection Agency. 1986. Quality criteria for water 1986. EPA 440/5-86-001. Office of Water, Washington, D.C.