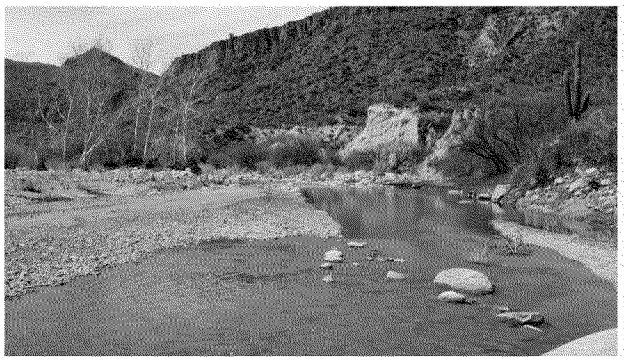
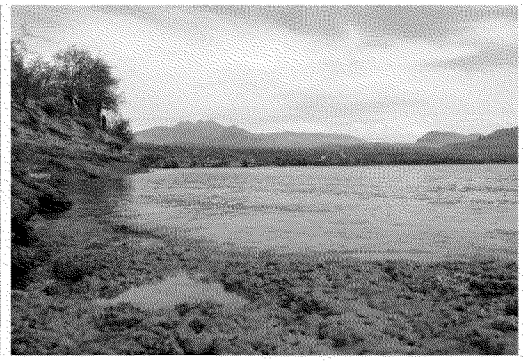
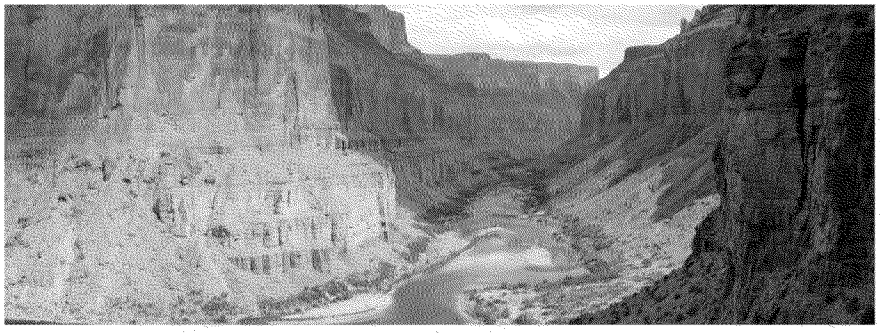
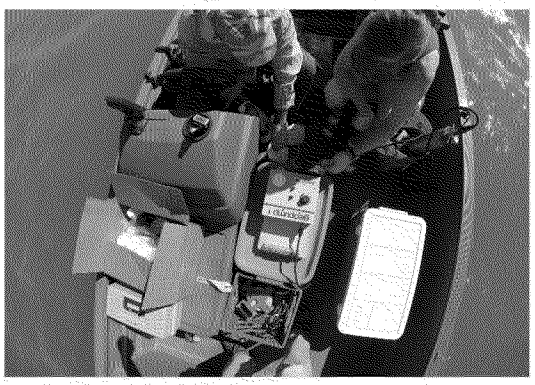
2016 Clean Water Act Assessment

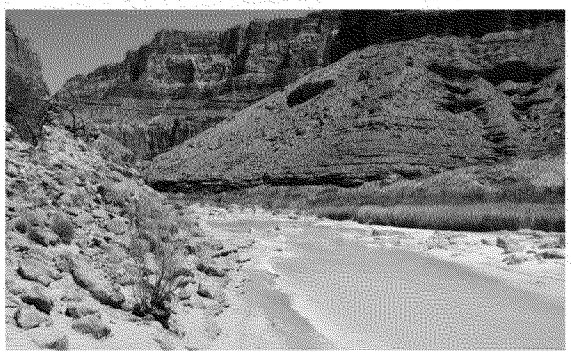
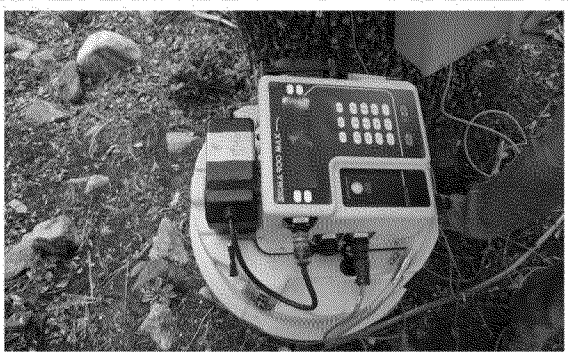
(July 1, 2010 to June 30, 2015)

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report

Revised December 2016



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A special thanks to ADEQ's monitoring staff that traveled across the state collecting the data used in this report:

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CHAPTER 1 – INTRODUCTION AND PURPOSE

The Arizona Department of Environmental Quality assesses the water quality of Arizona every two years as required by the Clean Water Act. The 2016 Clean Water Act Assessment covers data collected from July 1, 2010 to June 30, 2015. The purpose of this report is to conduct a comprehensive analysis of water quality data associated with Arizona's surface waters to determine whether surface water quality standards are being attained and designated uses are being supported. This integrated surface water assessment and impaired waters listing report serves three functions.

1. Nationally, it fulfills a reporting requirement of the Clean Water Act, and is submitted to the Environmental Protection Agency (EPA), and used to report on national water quality issues and concerns.
2. For ADEQ, it fulfills a mandate to compile environmental data and information from ADEQ's surface water quality monitoring and protection programs, as well as from other agencies, organizations, and individuals. This comprehensive evaluation of quality of water in Arizona is used to set priorities, allocate resources, and make decisions about land use activities, discharges to the water, future monitoring, and program initiatives.
3. For the public, it provides an opportunity to learn about and comment on the status of water quality in the state.

DOCUMENT ORGANIZATION

Chapter 1 – Introduction and Purpose
Chapter 2 – Methods and Technical Support
Chapter 3 – Summary Information
Chapter 4 – Action Plan
Watershed Assessments

- Bill Williams
- Colorado - Grand Canyon
- Colorado – Lower Gila
- Little Colorado
- Middle Gila
- Santa Cruz
- San Pedro
- Salt River
- Upper Gila
- Verde River

Appendix A – Alphabetical List of Waters Included in the Assessment
Appendix B – Waters Grouped by Assessment Category
Appendix C – Impaired Waters List
Appendix D – Critical Conditions
Appendix E – Delisting Impairments
Appendix F – Water Quality Improvements
Appendix G – TMDL Priority Ranking

WATER QUALITY ASSESSMENTS BY WATERSHED

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Assessment summaries are reported alphabetically by individual assessment units (stream reaches and lakes) in this chapter and grouped by the 10 watersheds, as illustrated on the following map: Bill Williams Watershed, Colorado /Grand Canyon Watershed, Colorado / Lower Gila Watershed, Little Colorado/San Juan Watershed, Middle Gila Watershed, Salt Watershed, San Pedro Watershed, Santa Cruz Watershed, Upper Gila Watershed, and Verde Watershed. If the reader is uncertain about which watershed to look in for assessment information, an alphabetical listing of surface waters assessed is provided in Appendix A.

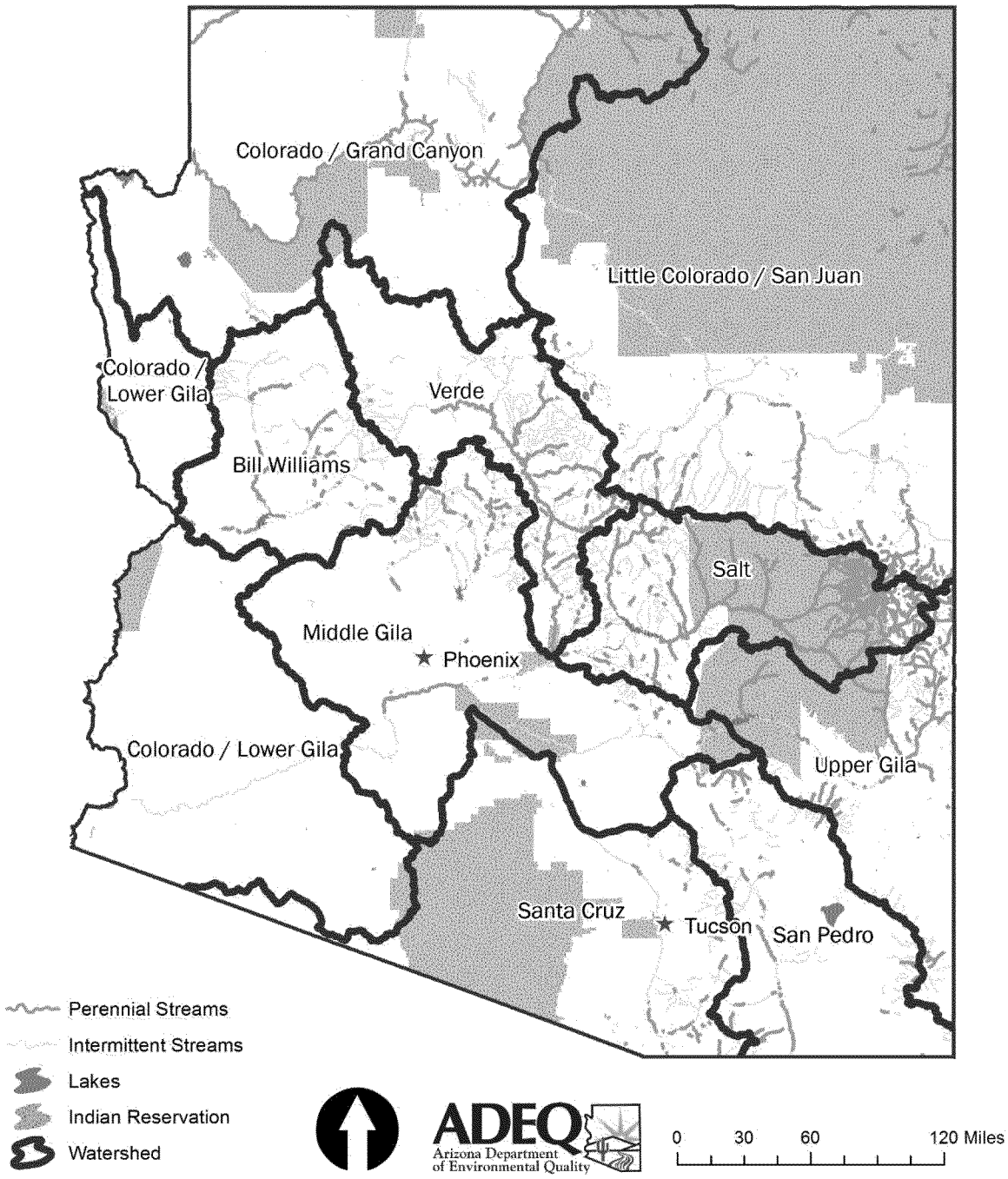

Figure 1-1. Arizona Watersheds.

ASSESSMENT INFORMATION

A summary page is provided for each assessed waterbody indicating:

- Designated use support and an overall assessment
- Impairment status and pollutant causing impairment (if applicable)
- Monitoring data used in the assessment
- List of Exceedances
- Data gaps and monitoring priorities.

The last page of this chapter provides an example summary page with information on "How to Read" the individual waterbody assessment pages.

WATERSHED INFORMATION

General background information and maps are provided for each watershed to provide some context for the assessments. One map (or a series of maps) shows the assessed surface waters.

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HOW TO READ AN ASSESSMENT SUMMARY PAGE

Waterbody Name
- Watershed Reports are organized by Waterbody Name

Assessment Unit Information
- Reach Description
- Waterbody ID (8 digit HUC + reach / lake number)
- Reach Length/ Lake Area

Overall Assessment Category
- The worst-case designated use support represents overall category for the assessment unit

BEAR WALLOW CREEK
North and South Forks of Bear Wallow - Indian Res.
15060101-023A
5.9 Miles

Category 2
Attaining some uses

Designated Use Support
- Based on exceedances and data gaps
- Impaired parameters will be listed for "Impaired" or "Not attaining" waterbodies

FC - Attaining • FBC - Attaining • AGL - Attaining
AWC - Inconclusive

Parameter Name
- Superscript "d" after a metal name denotes dissolved constituent
- No superscript after a metal name denotes total

Exceedances

Parameter	Applicable Standard	Date	Result	Designated use support comments
Biocriteria	IBI ≥ 52 attaining IBI 46 - 51 inconclusive IBI ≤ 45 violating	6/11/2013	IBI 31	AWC is inconclusive. Post Wallow Fire sample.
Bottom deposits	< 30% fines	6/11/2013	37%	AWC is inconclusive. Post Wallow Fire sample.

Parameter-Level Assessment Based on Exceedances
- Exceedances determine impairment (core parameters and seasonal coverage are not examined here. See data gaps.)
- Comments on assessment methods (e.g., binomial, 2 year median, etc.) and applicable assessment windows (e.g., 5-year assessment period vs. last 3 years)
- Comments on exemptions

Number and Types of Samples
- Number of events used in assessment
- An event is represented by samples collected at a site during a 7-day period

Monitoring Summary
Sampling period: 9/1/2010 - 6/11/2013

Site Name(s)	Site ID #	DEQ #	Sampling Agency	Purpose
BELOW SOUTH FORK BEAR WALLOW CREEK	SRBWL005.79	101198	ADEQ	Ambient Monitoring

Metal Samples	Nutrients & Related Samples	Other Samples
(4) Antimony, arsenic, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, selenium, zinc	(4) Ammonia, nitrite/nitrate, nitrogen, phosphorus, total Kjeldahl nitrogen	(1-4) Dissolved oxygen, *E. coli*, pH, SSC, total dissolved solids, biocriteria, bottom deposits

Data Gaps and Monitoring Needs

Exceedances Needing More Samples to Assess	Biocriteria, bottom deposits
Missing Core Parameters	None
Missing Seasonal Distribution	None
Lab Detection Limits Not Low Enough	Cadmium (dissolved), copper (dissolved), lead (dissolved), mercury (dissolved)

Priority	Monitoring Recommendations
Medium	Collect verification samples for biocriteria and bottom deposits. Use lower reporting limits for dissolved cadmium and dissolved copper - all samples had reporting limits greater than chronic criteria.

Monitoring Priority
- High, Medium or Low based on the criteria defined in Chapter 2 (Methods and Technical Support)

Data Gaps
- "Inconclusive" parameters with insufficient data to assess
- Core parameters and seasonal distribution determine attainment.
- Missing core parameters and/or seasonal distribution means inconclusive use support (even if parameter-level assessment is attaining).
- Parameters that could not be assessed due to detection limits higher than the standards.

CHAPTER 2 – METHODS AND TECHNICAL SUPPORT

SECTION 1 - GENERAL ASSESSMENT PROCESS AND REGULATORY FRAMEWORK

Every two years, ADEQ is required by the federal Clean Water Act to conduct a comprehensive analysis of water quality data associated with Arizona's surface waters to determine whether state surface water quality standards are being met and designated uses are being supported. This report is submitted to the U.S. Environmental Protection Agency (EPA) for approval. Once approved it is used to guide water resource management decisions.

The surface water quality assessment process can be summarized in a six step process as follows:

Step 1 – Assemble all readily available monitoring data and water quality related information. Determine whether the data meets requirements under the state's Impaired Water Identification Rule to be reasonably current, credible, scientifically defensible, and representative of water quality conditions in the surface water.
Step 2 – Determine the applicable designated uses and related numeric and narrative standards.
Step 3 – Analyze the data, determine exceedances of standards, and determine whether sufficient data exists to assess each designated use.
Step 4 – Assess the surface water, placing it in the appropriate assessment category and on the 303(d) List, if impaired and a TMDL is needed.
Step 5 – Determine monitoring priorities based on data gaps, needs for TMDL development, and effectiveness monitoring.
Step 6 – Provide public review of the integrated assessment and 303(d) listing report and revise the report as appropriate.

Water quality assessments should be seen as part of an interwoven set of water quality protection and improvement programs at ADEQ. The assessment process compares monitoring data to standards, identifies impaired waters, indicates where additional monitoring should be targeted, and initiates the TMDL loading analysis process.

ADEQ also works with watershed groups and interested parties to plan and implement actions so that surface water quality standards will be met. Grants are awarded to fund water quality improvement projects. Effectiveness monitoring following these projects is used during the next assessment cycle.

Facilities with permitted discharges may be asked to do additional monitoring when the surface water that receives the discharge is listed as impaired. This monitoring provides a scientific basis for modeling loading contributions (if any) from the discharge. Such data would also be used in the future assessments.

The assessment is therefore also acting as an evaluation of the water quality protection programs, a catalyst for focusing monitoring resources and, if necessary, encourages ADEQ to take other actions necessary so that surface water quality standards are being met.

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The Clean Water Act

In 1972, Congress passed Public Law 92-500, the Federal Water Pollution Control Act, commonly known as the Clean Water Act. The goal of this act was to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. ADEQ implements the Clean Water Act in Arizona, with oversight from EPA.

The mandate to conduct water quality assessments and determine which surface waters are impaired is a result of this act. This assessment methods document addresses federal monitoring, assessment, and listing requirements found in Sections (§) 106, 205, 303, 305, and 314 of the Clean Water Act.

- §106 and 205 require the states to compile, analyze, and annually submit a report on surface water quality. The report is to include monitoring conducted by ADEQ and other monitoring entities under grants and contracts with ADEQ
- Section 303 requires ADEQ to:
  - Adopt, with EPA approval, water quality standards and review these standards every three years.
  - Monitor waters and submit a list of surface waters where technology-based effluent limitations required by section 301 are not stringent enough to attain and maintain applicable water quality standards (impaired waters). These 303(d) listed waters are then prioritized for the development of a TMDL for each pollutant causing impairment. The establishment of TMDLs is required, regardless of whether the surface water is impaired by point sources, nonpoint sources, or a combination of both. As part of the TMDL process, ADEQ must either set appropriate controls or work with appropriate parties to implement actions that will improve water quality, so that the waters meet standards that support their designated uses.
- § 305 requires an assessment report that describes and analyzes water quality conditions of all surface waters in Arizona. This assessment report defines the extent that state waters are meeting water quality standards.
- § 314 adds further requirements specific to lakes.

Federal Regulations and Guidance

The Federal Code of Regulations § 122, 124, and 130.7 establish further and more specific federal requirements concerning the identification of impaired waters (referred to as "water quality limited waters"). No recent changes have occurred in these regulations.

In 2002, EPA published the Consolidated Assessment and Listing Methodology – Toward a Compendium of Best Practices (CALM). ADEQ has adopted many of the ideas published in this document, such as core parameter coverage. The CALM document provides information on monitoring network design and use of chemical, biological, toxicity, bacteria, and habitat data to support assessments. It also provides technical support such as statistical considerations for data quality objectives and hypothesis testing. This information can be downloaded from the EPA web site https://www.epa.gov/waterdata/consolidated-assessment-and-listing-methodology-calm .

Information Concerning 2016 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions was published by EPA to provide guidance for integrated report preparation. These documents provide EPA's policies concerning data interpretation, along with

recommended reporting format. A copy of this guidance can be downloaded at https://www.epa.gov/sites/production/files/2015-10/documents/2016-ir-memo-and-cover-memo-8_13_2015.pdf . Since 2001, EPA has recommended that the states submit an integrated report that includes both the assessment required under section 305(b) and the list of impaired waters required under 303(d).

More information about the methods involved is provided later in this document.

Arizona's Surface Water Standards and Designated Uses

Arizona sets narrative and numeric surface water standards for water quality based on the ways people and wildlife use the water. These "designated uses" are specified in the standards for individual surface waters, but if the surface water is not named in the rule, the designated uses are determined by the tributary rule. The tributary rule assigns designated uses based on flow regime and elevation (A.A.C. R18-11-105). A copy of the complete rules can be downloaded at the Secretary of States Office website at http://www.azsos.gov/public_services/table_of_contents.htm

Arizona's designated uses are:

- Aquatic Wildlife (coldwater, warmwater, effluent-dependent, or ephemeral)
- Fish Consumption
- Body Contact (Full or Partial)
- Domestic Water Source
- Agricultural Irrigation
- Agricultural Livestock Watering

Narrative surface water standards (A.A.C. R18-11-108) protect water quality when a numeric standard is not available or is insufficient. The state TMDL statute requires development of narrative implementation procedures before narrative standards can be applied to 303(d) listing decisions. Narrative implementation documents for bottom deposits and biocriteria were used in this assignment.

Some surface waters have special water quality standards that must be met. For example, site specific standards have been established for the following waters:

- Waters classified as "Outstanding Arizona Water" (an outstanding state resource water);
- Waters classified as effluent dependent waters (surface waters that would be ephemeral if not for the discharge of treated wastewater);
- Waters with moderating provisions established in their NPDES or AZPDES discharge permits (i.e., mixing zones or a pollutant-specific variance);
- Waters with nutrient standards, as specified in A.A.C. R18-11-109(F); and
- Colorado River reaches with salinity standards (three benchmark sites along the river between Hoover Dam and Imperial Dam) as specified in A.A.C. R18-11-110.

Site specific standards can also be developed for impaired waters where natural conditions alone would cause the standards to be exceeded. Currently ADEQ is developing such site specific standards for Pinto Creek.

Surface water quality standards are reviewed and revised on a three-year cycle. The standards approved in 2009 were used for this assessment and listing process.

Arizona's TMDL Statute

In 2000, the Arizona Legislature promulgated Arizona Revised Statues (A.R.S.) Title 49, Chapter 2, Article 2.1, (the TMDL Statute) which identifies a general process for making impairment decisions and for developing TMDLs. A copy of these statutes can be downloaded at the Secretary of State's Office website at: http://www.azleg.state.az.us/arizonarevisedstatutes.asp. The statute requires ADEQ to:

- Adopt, by rule, the methods used to identify impaired waters;
- Use only reasonably current, credible, and scientifically defensible data;
- Consider the nature of the water (e.g., ephemeral, intermittent, perennial, effluent dominated) in assessing whether an assessment unit is impaired;
- Determine whether pollutant loadings solely from naturally occurring conditions are sufficient to exceed a water quality standard; and
- Adopt narrative standards and biocriteria implementation procedures through a public process before using these to identify impaired waters.

The statute specifies a process for priority ranking, scheduling, developing, reviewing, and implementing TMDLs, and it mandates the development of rules to govern impaired water identification decisions.

Arizona's Impaired Water Identification Rule

Arizona developed the Impaired Water Identification Rules (A.A.C. R18-11-601 through 606) in 2002. These rules establish methods and criteria to:

- Identify an assessment unit as impaired;
- Determine when an assessment unit is no longer impaired (delisting);
- Prioritize the development of TMDLs;
- Determine whether a dataset is "credible," and therefore, used for assessments and TMDL development;
- Interpret data;
- Consider contextual information in a weight-of-evidence approach; and
- Determine the spatial extent of the surface water listing.

The Impaired Water Identification Rule establishes a process for identifying impaired waters; however, they do not establish methods for identifying waters that are attaining their uses. This assessment methods document goes the next step and integrates impairment and attainment methods and criteria.

SECTION 2 - MONITORING DATA

Data Sources

Monitoring data used in assessments come from a variety of sources: ADEQ's field staff, federal agencies, other state agencies, permitted discharge facilities, and even volunteer monitoring groups.

Because the objective for collecting the data and data quality varies, ADEQ reviews all readily available surface water quality related data, determines if it meets credible data requirements in the Impaired Water Identification Rule, and uses the scientifically supported data for assessment determinations. The STORET database was also queried. (STORET is EPA's storage and retrieval system for housing surface water data from federal and state agencies.)

ADEQ encourages the submittal of such water quality data from the general public, other agencies, and permitted dischargers throughout the year. When submitted, other pertinent information should be provided, such as: site locations, sampling and quality assurance plans, monitoring purpose, field observations, and lab notations.

To be considered in the assessment and listing process, data from agencies and other entities must be received by the applicable deadline and entered into ADEQ's water quality database. Therefore, data sets need to be submitted in an electronic format that can be readily uploaded into ADEQ's database.

Water quality related data includes, but are not limited to: water chemistry, contaminated sediments, bacteria, algae, bioassessments, fish tissue concentrations, fish kills, weed harvesting, physical habitat, beach closures, drinking water advisories, and riparian conditions. Although ADEQ cannot use narrative, physical habitat data, and other qualitative data for a listing decision until appropriate implementation procedures are adopted, such information is considered as "weight-of-evidence" during a listing decision, and has been used by EPA as evidence of impairment.

Any inherent bias in the data is considered when using the data using the weight-of-evidence approach. For example, if the monitoring objective was to establish pristine/reference conditions, exceedances should be rare and are more likely due to natural conditions. Whereas, if the objective was to determine the effectiveness of watershed improvements, the monitoring site locations and contextual conditions when the samples were collected need to be evaluated along with the data.

The Assessment Period

ADEQ assembles and evaluates all existing and readily available water quality related data and information collected during the assessment period. This focuses assessments on the most recent data to accurately portray the quality of the surface water in question. The 2016 Integrated Report considered data collected from July 1, 2010 to June 30, 2015.

ADEQ's Comprehensive Water Quality Monitoring Strategy

Arizona has developed a Comprehensive Water Quality Monitoring Strategy which outlines the objectives of each monitoring program. This report is available at http://www.azdeq.gov/environ/water/assessment/download/Comprehensive_WQ_Monitor_Strategy.pdf

Data Quality Assurance

Credible Data Requirements

A central objective of the assessment and 303(d) listing process is to identify impaired surface waters so that corrective actions can be taken. To accurately identify impairment, the data needs to be of high quality and must accurately reflect the surface water conditions. However, data potentially

available to ADEQ are of varying quantity, quality, and age. Therefore, all readily available data are reviewed to determine whether they meet the credible data requirements in the Impaired Water Identification Rule for being credible and scientifically defensible, and that they are representative of water quality conditions. These requirements are clearly defined in the rule (A.A.C. R18-11-602) but can be summarized as follows:

- Data must be collected and analyzed following an appropriate Quality Assurance Plan (QAP) and Sampling and Analysis Plan (SAP), by adequately trained personnel using approved field and laboratory methods.
- Data must be evaluated to determine whether it is reliable, accurately reflects current water quality conditions, and is valid. This is determined by considering factors such as:
    - Laboratory detection limits,
    - Lab notations or qualifiers,
    - Whether the sampling was representative and reproducible,
    - Whether approved sampling and analysis methods were used, and
    - Quality control of the data when collected and analyzed.
- The monitoring entity must submit documentation that these requirements have been met and other information necessary to assist ADEQ in interpreting and validating the data.

ADEQ is responsible for reviewing all data to ensure specified minimum quality assurance requirements are met. ADEQ must also review the adequacy of the QAP and SAP for the type of sampling undertaken. The rule provides ADEQ discretion in approving a QAP or SAP that does not contain all the required elements of R18-11-602(A) if ADEQ determines that the omitted element is not relevant to the sampling or its omission will not impact the quality of the results.

Technically, Arizona's credible data requirements apply only to the 303(d) listing process and not to the assessments of designated uses. Recognizing the federal mandate to consider all readily available data in making assessments, ADEQ decided that if the data could not meet credible data requirements the following actions would be taken:

- The assessment unit would be assessed as "inconclusive" if this was the only data available for the assessment;
- The assessment unit would be given higher priority for monitoring if an exceedance of standards had occurred; and
- A comment would be included in the assessment tables, indicating that other data was available and why the data were not used in the assessments.

Laboratory Reporting Limits and Standards

When the result is reported as less than the method reporting limit and that value is above the standard, the sample is not included in the sample count. For example, if the result is reported as <5 mg/L and the standard is 2 mg/L, the result is not counted in the assessments. A comment is provided in the data gap report when this occurred.

Field Sampling Equipment Precision

Several water quality parameters have very short holding times for analysis or present a more accurate representation of conditions if measured in the field. The parameters include dissolved oxygen, pH, total residual chlorine, turbidity, and temperature. However, field measurements are

often subject to more variability than other water quality measurements. Imprecision is addressed in the field through quality assurance/quality control procedures (e.g., calibration of the field equipment, placement of the instrument in the stream); however, other variations are inherent in natural systems and in the nature of the equipment used for testing.

Studies have shown that most aquatic organisms can tolerate small fluctuations over short periods of time for conventional water quality parameters without damaging effects. Therefore, the following field equipment tolerance values are used based on a survey of manufacturer's specification for accuracy in field equipment currently in use by ADEQ:

- pH ± 0.2 standard units
- Dissolved oxygen ± 0.2 mg/L
- Turbidity ± 2 NTU

For assessment purposes, this means that if the dissolved oxygen standard was 6.0 mg/L, a sample reported at 5.8 mg/L would not be counted as an exceedance. This practice acknowledges the tolerance range of the equipment available for these measurements. These tolerance values will be reviewed with each assessment cycle so as field equipment becomes more reliable, exceedances can accurately be called closer to the standard.

Precision in Escherichia coli (E. coli) Results

Both lab and field bacterial analyses provide an estimation of bacterial density, reported in terms of a "Most Probable Number" (MPN). For example, using the multiple tube technique, if the result is reported as 240 colony forming units (CFU), there is a 95 percent confidence level that the result is between 100 and 940 CFU (Standard Methods for Examination of Water and Wastewater, 20th Edition).

303(d) listing decisions are not based on results reported relatively near the single sample maximum standards of 235 CFU (for Full Body Contact) or 576 CFU (for Partial Body Contact). Instead, screening values of 300 and 630 CFU, respectively, are used for impairment decisions, so that minimum exceedances must be above these screening values.

For assessment purposes, all results above the standard are reported as exceedances in the assessment report; however, a comment is made when the result is below the screening value.

Also for assessment calculation purposes, all results reported as greater than the method reporting limit are converted to 1.5 times the reporting limit. For example, if a sample is reported as greater than 2419 CFU/100 mL, the result value used in the assessment and reported in the watershed assessment report would be 3628.5 CFU/100 mL.

Sample Values Less Than the Laboratory Reporting Limit

In the absence of pollutants or when pollutant concentrations and loadings are minimal, the results of a water sample analysis may be reported to be below the analytical method detection limit, which is reported as "not detected," "non-detect", or "less than." When the value is reported as not detected, we only know that the value is less than the applied technology can measure. The true value cannot be determined.

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The Impaired Water Identification Rule (A.A.C. R18-11-603.A.1.b) establishes how these data will be used. In some cases, the reporting limit is below the standard (e.g., the standard is 5 mg/L and result is <3 mg/L). In these cases, the data are meeting the water quality standard and should be used for assessment and listing purposes. The rules further describe that "less than" data can be used in trend analysis, descriptive statistics, or modeling as follows:

- If there are sufficient data to support statistically estimating the values reported as "less than" the reporting limit; or
- If there are not sufficient data to support statistically estimating the values reported as "less than" the reporting limit, then ADEQ will use one-half of the value of the RL.

If the reporting limit is above the standard and the laboratory result is at or below the reporting limit, the results cannot be used for a listing decision. For example, if the result is <8 mg/L and the standard is 5 mg/L, whether or not the analytical result exceeded the criteria is not known. These samples are not used in the assessment.

Reviewing Dissolved and Total Standards

Where only the dissolved fraction was analyzed (no total measurement), the dissolved result is compared to the "total" standard. Given the total value should equal the dissolved fraction plus any suspended portion, the dissolved fraction could equal but should not exceed the total standard.

In those cases where both total and dissolved fractions are provided, but the dissolved fraction is above the total value, the data is flagged as unreliable for listing decisions if the dissolved fraction is more than 10 percent higher than the total fraction.

ADEQ does not attempt to translate total results into estimates of the dissolved form because EPA has not provided a standardized methodology to use. When such methods become available, they will need to be reviewed to determine their reliability and applicability to the assessment and 303(d) listing process in Arizona.

Data Qualifiers

Water quality data and information may include data qualifiers or field comments that denote a deviation from acceptable sampling, handling, storage, or analytical procedures. Some data qualifiers invoke questions as to the accuracy of the data in representing the actual water quality conditions. For example, values reported by the laboratory as estimates are not used for listing decision. A case-by-case evaluation of the lab qualifiers is used to determine the reliability of the data.

Data Management

ADEQ tracks surface water quality data used in this assessment, including data collected by outside agencies, in an Oracle database. Surface water quality data is tracked by sites and related to an assessment unit. Data is routinely uploaded from this database to EPA's STORET system, a national repository of water quality information to facilitate public access to ADEQ's data.

Assessment Unit Delineation and Identification - An assessment unit is the delineated lake or stream reach being evaluated. A stream reach was derived from EPA's Reach File System which divided a

stream into segments based on intervening tributaries. Over the years, these reaches have been further segmented to reflect changes in designated uses or differences in impairment.

Each assessment unit is assigned a unique number (e.g., 15060202-028) using the 8-digit hydrologic unit code number (HUC) assigned by the Natural Resources Conservation Service (NRCS) for the drainage area, and

- A 3-digit stream reach number (derived from EPA's original Reach File System), or
- A 4-digit lake number (derived from AGFD's lake numbering system).

Reach 15060202-028 is also verbally delineated in the assessment report by tributaries or other boundaries. In this case, the assessment unit is Sycamore Creek, From Garland Spring Wash to Tule Canyon.

Site Identification

Surface water quality monitoring sites are identified in the database by their location along a stream or lake. Instead of using the latitude and longitude number for the site, ADEQ has devised a more user-friendly identification system using:

- Watershed code,
- Stream/lake code,
- A river mile number (miles upstream from the mouth of the stream) or
- Lake site descriptive code.

For example, on the reach used in the above example, a site identification number could be "VRSYW001.28." This ID indicates that the sample was collected in the Verde Watershed (VR), on Sycamore Creek (SYW), and 1.28 miles upstream from its confluence. This ID number provides a wealth of information for those who know how to decode it.

A similar coding system is used for lakes, except that the river mile system is replaced by a descriptive site code. The lake site ID "SCLAK – A" indicates that the site is in the Santa Cruz Watershed (SC), on Lakeside Lake (LAK), and at location A, which is usually the dam site. The location code generally follows this pattern:

A = Dam site
B = Mid lake
MAR = Marina
BR = Boat Ramp

Arizona Assessment Calculator (AZAC)

AZAC is a computer module developed for ADEQ by Tetra Tech, Incorporated to help automate assessments of data housed in ADEQ's database. In Phase I, the data was aggregated into 7-day intervals per site, data reliability issues were flagged, and exceedances of surface water quality standards were determined. Reports derived by AZAC were used for the first time in the 2006 assessment. Later phases are proposed to take the assessment process further, ultimately automating assessment reports.

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Electronic Assessment Reporting to EPA

After the EPA approves the final 303(d) List, ADEQ sends its assessments to a federal Assessment Database (ADB). This provides an electronic version of the assessment report, which is compiled by EPA with other state reports to create the national report to Congress on the status of water quality. Assessments are recorded for each designated use. Pollutants/stressors causing impairment and probable sources are identified for all impaired waters. The status of TMDL development is also tracked in this database to develop national statistics. EPA is in the process of redesigning the Assessment TMDL Tracking And Implementation System (ATTAINS) and replacing the distributed ADB with the new ATTAINS data flow starting in the 2018 assessment cycle (EPA, 2015).

ADEQ also sends a Geographic Information System (GIS) cover of the assessed waters to EPA with its electronic assessment. The new National Hydrography Dataset (NHD) is now being used to define the geographic location of assessment units. Attributes in the NHD, such as a reach number and the stream code abbreviations, are also used in ADEQ's Oracle database to identify the sites and surface waters.

SECTION 3 - DATA INTERPRETATION AND ASSESSMENT CRITERIA

Data Interpretation

Exceptions for Exceedances

Not all exceedances of a water quality criterion result in an assessment unit being identified as impaired. Certain situations are specifically exempted in the surface water quality standards or the Impaired Water Identification Rule as not applicable in determining impairment. Surface waters are not assessed as impaired when:

- Pollutant loadings from naturally occurring conditions alone are sufficient to cause a violation of water quality standards (A.A.C. R18.11.604.C(1));
- Water quality results were collected under a moderating provision of an NPDES/AZPDES permit, such as a mixing zone, and the result does not exceed any discharge limitation established in the permit (A.A.C. R18-11-604.C.(2)); or
- The non-attainment is due to an activity or situation exempted under the surface water quality standards in R18-11-117 (canals and municipal park lakes), R18-11-118 (dams and flood control structures) or R18-11-119 (natural background).

If an assessment unit is impaired solely due to naturally occurring conditions (no human-caused influences), the surface water is not listed based on the exemption provided by A.A.C. R18-11-119. However, if there is evidence that the surface water is impaired due to naturally occurring conditions and as a result of human activity, ADEQ will place the surface water on the 303(d) List for further investigation to determine what portion of the impairment is "natural" versus what is human-induced and therefore, eligible for reduction and allocation under a TMDL analysis.

The TMDL investigation can also determine whether a site-specific standard or use-attainability analysis should be developed to address the naturally occurring pollutant loadings. 40 CFR 131.10(g) provides that site-specific criteria can be adopted when waters cannot attain standards because of naturally occurring pollutant concentrations or legacy pollutants. However, the human-caused impacts would be subject to reduction and/or remediation through the TMDL process to bring the water quality back into attainment of the pollutant concentrations that would naturally occur.

The most common reasons for exempting exceedances due to the "natural conditions" exception are:

- Low dissolved oxygen occurring where the source of the flow is primarily ground water upwelling, which is naturally low in dissolved oxygen. In most cases, flows at these sites were less than 1 cubic feet per second (cfs). In such cases, the monitoring and assessment staff must document:
    - No obvious anthropogenic sources of nutrients which would use the oxygen (e.g., septic systems, point source discharges upstream, grazing, recreation);
    - No evidence of excess nutrients (algal blooms);
    - That ground water was the primary source of flow.

- Where data are available, nitrogen concentrations are less than 0.5 mg/L (i.e., much lower than standards and typical of levels found in unimpacted or native ground water); and
- Bacterial standards were not exceeded.

- High pollutant loading from a spring source, with no potential anthropogenic sources of the pollutant due to factors such as access, topography, geology, and restrictions established by the land management agency (e.g., spring fed reaches in the Grand Canyon tributaries).

Applying Narrative Standards

EPA has long suggested that all states develop implementation procedures for narrative water quality standards. Arizona's TMDL statute requires development of narrative implementation procedures before narrative water quality standards can be applied to 303(d) listing decisions (A.R.S. §49-232F). Several of these documents (e.g., narrative nutrients, narrative toxicity, and antidegradation) are currently under development, but were not available for this assessment; therefore ADEQ could not place an assessment unit on the 303(d) List based on evidence of narrative standard violations. If evidence of a narrative standard violation is present, the designated use is assessed as "inconclusive" and the assessment unit is identified as needing additional monitoring. For assessment purposes, evidence of narrative standard violations would include:

- Fish kill related to algal blooms, low dissolved oxygen, high pH, or pollutants;
- Fish consumption advisory issued for a specific assessment unit; or
- Swimming area closure due to bacteria or other pollutant.

Narrative standard implementation procedures will establish not only the type of evidence, but the amount and magnitude of evidence needed to determine whether a narrative standard is being violated and whether the surface water should be added to the 303(d) List. For example, would one fish kill merit listing? Perhaps if, for example, an algal bloom, low dissolved oxygen, and high pH were also occurring. It is envisioned that implementation procedure documents will address use of the standard in permitting, assessments, listing decisions, and compliance determinations.

Weight of Evidence

In addition to numeric standards there are many other factors that can be considered when making an impairment decision. A true weight-of-evidence approach considers multiple environmental indicators (biological, toxicological, physical, and chemical measurements) in assessing water quality. However, the 303(d) listing decisions are based primarily on chemical-physical measurements with numeric water quality standards, because until narrative standard implementation procedures are adopted, the TMDL Statute precludes the use of narrative standards or biocriteria in listing decisions. The weight of evidence approach in R18-11-605(B) allows ADEQ to consider contextual information during the assessment process, such as:

- Data quality –Newer or more reliable data is given more weight than data where quality is more questionable, especially where two different datasets may indicate conflicting results;
- Critical conditions – Data collected during critical conditions may be considered separately from the complete dataset (critical conditions are those conditions during which exceedances are most likely to occur based on past occurrences);
- Evidence of toxic impacts – Fish kills, fish consumption advisories, beach closures, bioaccumulation in prey species, and other evidence of toxic impacts;

- NPDES/AZPDES information – Water quality discharge data or compliance issues with the pollutant of concern;
- Anthropogenic influences – Activities in the watershed, especially adjacent to an assessment unit, that might be the source of a pollutant;
- Natural conditions and characteristics of the pollutant – Geomorphology, geology, hydrology, and characteristics of the pollutant are considered when establishing whether the exceedance was solely or primarily due to natural conditions or whether human activities may be contributing to the exceedance, or provide other support for listing decision; and
- Upstream or downstream exceedances – The existence of other narrative or numeric exceedances can also provide supporting evidence.

For example, flow conditions are a crucial piece of information when reviewing the data in lotic waters (streams and rivers). In the absence of precipitation, streams are subject to extreme low flows (i.e., 1Q10, 7Q10), as opposed to high flow events (floods) that occur in response to significant rain or other precipitation events. Along with precipitation, or the lack thereof, in some systems stream flow volume is regulated by impoundments and diversions to accommodate irrigation, industrial cooling water, or hydroelectric needs. Low flows may be the critical conditions when an adit or other point source discharge is the primary source of pollutant loadings.

More variable and less predictable are the high flows resulting from precipitation events. Duration, frequency, magnitude, time of year, land use, and applied treatments are all factors that influence the impact a precipitation event may have on stream flow volume and corresponding water quality. For nonpoint sources of pollutants, high flow conditions will frequently result in pollutant loading from the watershed.

Another issue during flood flows is bacterial contamination. Exceedances of standards should be expected, especially during the initial flush of highly turbid runoff. Therefore, using the weight-of-evidence approach, listing may be delayed while other samples are collected.

Based on evidence of narrative exceedances or toxic impacts, assessment units are given higher priority for future monitoring, even though no numeric standard violations were reported. In addition, EPA in its review of the report can choose to list additional waters based on information provided in the report. This is especially true where the state is precluded by law from using certain types of information in its assessment decisions.

These factors do not, however, supersede any minimum data requirements. Also, a single line of water quality evidence is sufficient to demonstrate that the assessment unit is impaired.

Representative Data

Appendix B of the CALM guidance (EPA, 2002) discusses the issue of representativeness of a site. It finds that samples taken close to each other in space tend to produce like results, as do samples taken close together in time. The best way to ensure that data is representative is to collect samples using an unbiased selection method with sufficient independent sampling sites to capture the variability inherent in surface water.

Methods for determining whether data are representative, reliable, and reproducible must be established in the data quality objectives established for the monitoring data in the QAP and SAP. ADEQ reviews the QAP and SAP as part of the credible data determination.

Unrepresentative sampling may occur as a result of selectively sampling from more accessible locations or even by excluding all storm event data. Non-representative data would also include water quality data collected at the end of a pipe, in street storm water drains, or in runoff outside of the stream channel.

Water collected in standing pools or in storm flow conditions would be representative of the variation in stream conditions. Such samples would need to meet surface water quality standards. However, if a large proportion of the data is collected during extreme high flow events, the dataset will be skewed and potentially result in unrealistic load reduction goals to account for such infrequent events. Therefore, ADEQ strives to collect data during a variety of flow conditions and performs assessments using a weight-of-evidence approach. During the assessment, samples collected during extreme high flow events are noted, if documented, and considered appropriately under the weight-of-evidence approach.

Rather than define the maximum coverage of a single station, Arizona's Impaired Water Identification Rule relies on minimum numbers of samples, spatial independence, and temporal independence. Samples are considered spatially independent if they are collected more than 200 meters apart; or if less than 200 meters apart, samples were taken to characterize the effect of an intervening tributary, outfall, pollution source, or significant hydrographic or hydrologic change. Samples are temporally independent if they are collected at least seven days apart (see 7-day Rule below).

Data Aggregation: The 7-Day Rule

Temporal separation of samples is important in the assessment process, because surface waters should be identified as impaired only if the exceedances of water quality standards are persistent or recurring. Impairment decisions should not be based on one-time events that cause a temporary elevation in pollutant concentrations that may never be repeated. Similarly, a decision of "attaining" should also not be made based on samples collected all at one time.

In order to ensure temporal separation of samples, ADEQ assumes that samples collected at a site within seven days represent one "event." Then ADEQ determines that multiple dates are represented by combining sites within the assessment unit. The following two steps occur in the process of data aggregation to ensure that samples are temporally independent.

Step 1 – Sample counting by site

If multiple samples are available at one site within a 7-day period, a representative value is determined. This value is then counted as one sample for that one-week period at that site. The following values are used:

PARAMETERS	REPRESENTATIVE 7-DAY VALUE
Dissolved oxygen	Minimum value

PARAMETERS	REPRESENTATIVE 7-DAY VALUE
Acute aquatic and wildlife criteria Nitrate and nitrate/nitrite criteria *E. coli* single sample maximum standard Phosphorus and nitrogen SSM	Maximum value
Chronic aquatic and wildlife criteria All other data	Use the mean value for the 7-day period.
pH	Minimum or maximum (the pH standard is a range of numbers)

The purpose of the 7-day aggregation is to ensure temporal separation of samples. For assessment purposes, the 7-day period is interpreted as Monday through Sunday. Although it is convenient to have a set time frame for assessment, it may not be the most logical way to group samples to ensure temporal independence. It is recommended that any exceedances that occur within a 7-day period be carefully examined for their temporal independence.

Step 2 – Sample counting by assessment unit

If multiple sites have been sampled within the assessment unit within a seven-day period, they are counted as one sample, and one worst-case exceedance is used as the representative exceedance for the assessment unit.

Exceptions to the 2-step data aggregation
Exception 1: Applying 90th Percentile standards to nutrient data or
Exception 2: Applying geometric mean standards to *E. coli* bacteria data

Data aggregation avoids over-counting exceedances (a type 1 error that would lead to listing when not impaired) and avoids over-counting samples collected during one week that could dilute out a problem (a type 2 error that would lead to not listing when impaired).

Note: Only aggregated exceedances determined in Step 2 are reported as exceedances in the assessment report with the first occurring sample date for that aggregation period. Similarly in the binomial analysis, the final numbers of aggregated samples and exceedances are used to determine impairment using the binomial-based exceedance table.

Critical Sites

Data or information collected at one or more sites may be considered separately from the complete dataset, when the data show that the assessment unit is impaired at those sites, but attaining at other sites. In such cases the data is not aggregated across the assessment unit. Not aggregating data in such cases avoids a type 2 error (failure to list when impaired).

Assessing Attainment

Assessing attainment of standards and assessing impairment of an assessment unit are two entirely different decision processes. Consider a toxic pollutant, such as copper, as an example. The acute dissolved copper standard for the Aquatic and Wildlife use is not to be exceeded more than one time in the last three years of an assessment period. This criterion for impairment is based on EPA

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guidance, which cites studies showing that aquatic life can recover from only one exceedance during this time period.

Assuming that one day equals one exceedance, to demonstrate attainment of this standard, ADEQ would need to show that all areas of the assessment unit attained the standard 1,093 days out of approximately 1,095 total days in a three-year period. To demonstrate impairment, ADEQ would need to show only that any one site in the assessment unit exceeded the standard two days out of 1,095 days. Thus, while two samples for one pollutant are sufficient to show impairment, the same cannot be said for determining attainment.

ADEQ cannot monitor every surface water, or even one surface water, every day for three years. Even with unlimited resources, it would not make sense to spend this much time monitoring one assessment unit when there are no indications of water quality problems. This would only delay the monitoring of other surface waters where impairment may be occurring.

For these reasons, EPA guidance recommends that states choose a set of "core indicators," and a minimum number of samples, necessary to assess attainment of designated uses. ADEQ has adopted this approach.

Core Parameters and Seasonal Distribution

Given staff and budget constraints, monitoring data are collected at sites and during conditions selected to be representative of the varying conditions. Since a water quality standard might be more likely to be exceeded during critical conditions such as high or low flows, or during seasonal conditions when recreation is more active, samples should be collected under different conditions to determine whether the surface water is really "attaining" its designated uses (seasonal distribution).

Although all parameters with numeric standards are used for assessment, ADEQ has chosen a set of indicators, called "core parameters," necessary to assess whether each designated use is attaining standards. Arizona's core parameters are shown in the table below.

Core parameters were selected based on EPA's CALM guidance (2002), although they are limited due to the lack of narrative standards implementation procedures. CALM guidance places strong emphasis on narrative water quality standards, suggesting that core indicators should include bioassessments, habitat assessments, ambient toxicity testing, contaminated sediment, health of individual organisms, nuisance plant growth, algae, sediments, and even odor and taste.

DESIGNATED USE	CORE PARAMETERS
Aquatic and Wildlife	Dissolved oxygen (not required if ephemeral) Stream flow (if a stream) Sample depth (if a lake) pH Total nitrogen (if nutrient standards established) Total phosphorus (if nutrient standards established) Dissolved cadmium, copper, and zinc and hardness

DESIGNATED USE	CORE PARAMETERS
Fish Consumption	Mercury in fish tissue (no minimum sample or seasonal distribution requirement). If fish tissue data is not available, use total mercury in water as a core parameter (minimum sample and seasonal distribution requirements apply).
Full Body or Partial Body Contact	Escherichia coli (not required if ephemeral) pH
Domestic Water Source	Nitrate/nitrite or nitrate pH Fluoride Total arsenic, chromium or chromium VI, and lead
Agricultural Irrigation	pH Total boron and manganese
Agricultural Livestock Watering	pH Total copper and lead

However, Arizona is currently limited to physical-chemical parameters. Arizona's choice of core parameters will change in future assessments as new numeric and narrative standards, criteria, and assessment tools are developed.

Core parameters were chosen using the following criteria:

- Frequently exceeded standards in past assessments;
- Routinely included in ambient monitoring suites;
- Lab reporting limits routinely below applicable surface water criteria;
- Critical toxicity recognized; and
- Standards and implementation procedures support application of the criteria.

For example, dissolved metals exceedances and low pH measurements are often found in historic mining areas. *E. coli* bacteria and nitrate were chosen because they can cause serious human illness or death if standards are exceeded, and they are important in determining support of Body Contact and Domestic Water Source designated uses.

Core parameters must be sampled at least three times and samples must be reasonably distributed at different times of the year to reflect seasonal changes (seasonally distributed). For assessment purposes, it is ensured that at least one sample is collected in each of the four seasons: winter (January – March), spring (April – June), summer (July – September), and fall (October – December). If this does not occur, and the designated use is not "impaired," then the designated use is assessed as "inconclusive."

Attainment decisions are not limited to these core parameters. All parameters with surface water quality criteria are considered. For example, along with the *E. coli* and pH samples (the two core parameters for Full Body Contact), the Full Body Contact criteria for metals (e.g., arsenic, cadmium, zinc) must also be considered when data is available. The assessment unit would be assessed as "attaining" Full Body Contact when all applicable criteria showed attainment.

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To assess a designed use, all core parameters must be represented seasonally. For example, although numerous *E. coli* bacteria samples were collected, the assessment unit is assessed as attaining Full Body Contact only if pH was also collected with seasonal distribution.

Note that core parameters and seasonal distribution are not required to determine impairment (see the Assessing Impairment subsection to follow).

ADEQ acknowledges that three sampling events are not enough to assess attainment with statistical confidence. However, three seasonally distributed samples with no exceedances indicate that monitoring resources may be better spent at other sites. Such attainment decisions reflect limited monitoring resources and ADEQ's focus on identifying and resolving water quality impairments.

Assessing Impairment

Minimum Data Requirements

As described above, determining impairment requires fewer samples than determining attainment. Especially for the most toxic pollutants, it takes very few exceedances to cause impairment of a designated use. Also, while it takes several parameters to assess attainment, it takes only one pollutant to cause impairment.

When trying to identify water quality problems, a larger dataset will often have a higher probability of detecting water quality criteria excursions than smaller datasets. However, as noted previously, resources restrict sampling efforts to the minimum needed to fulfill data quality objectives. Preparation of the 303(d) List and TMDLs must account for the varying quantities of data and associated confidence in that data to identify water quality concerns.

ADEQ understands the importance of data quantity in the water quality assessment process; however, staffing, budgets, and time often restrict the amount of data collected from a single assessment unit. Furthermore, EPA guidance calls for states to explore ways to achieve the most practical statewide coverage which translates to fewer measurements from a greater number of surface waters and use of extrapolation methods.

For most criteria, the Impaired Waters Identification Rule requires a minimum of 20 samples collected over three sampling events to determine impairment. This is based on a greater than 10 percent exceedance rate at a 90 percent confidence level, and is referred to as the "binomial approach." Exceptions to the 20-sample minimum are established in the rule and discussed below, but generally involve exceedances of criteria with acute human or aquatic life impacts (e.g., bacteria, toxics). Waters that are lacking sufficient data to determine if a designated use is "attaining" or "impaired" are classified as "inconclusive" and given a higher monitoring priority.

The following tables summarize the assessment criteria used to determine that a designed use is "impaired," "attaining," or "inconclusive." The methods for impairment determination vary by type of criteria and potential toxicity of the pollutant. A pollutant that exceeds an acute aquatic and wildlife standard even once, for example, may be lethal to aquatic life and wildlife. On the other hand, some of the human health standards were set at levels that protect for lifetime exposures. Several criteria use 'the last three years of monitoring'. This means using a three-year window from the last day of

the assessment window rather than the full five-year window. For the 2016 Assessment the last three years would be from July 1, 2012 to June 30, 2015.

	Exceedance Definition	Assessed As Impaired	Assessed As Inconclusive	Assessed As Attaining
ALL HUMAN HEALTH AND AGRICULTURE USE CRITERIA Body Contact, Fish Consumption, Domestic Water Source, Agriculture Irrigation, Agriculture Livestock Watering (Except those addressed below)	1 exceedance = 1 grab sample exceeds a criterion	At least 10% of samples exceed criterion at a 90% confidence rate; Minimum of 5 exceedances; and Minimum of 20 samples (See following binomial-based table)	If an exceedance, insufficient data to determine if impaired or attaining (see criteria to left); or Insufficient core parameter samples or seasonal coverage	No exceedances see following binomial-based table; and If a core parameter, at least 3 samples representing different seasons
ACUTE CRITERIA Aquatic and Wildlife	1 exceedance = 1 grab sample exceeds a criterion	Two or more exceedances during the last 3 years of monitoring	Only one exceedance during the last 3 years of monitoring; or Insufficient core parameter samples; or Insufficient seasonal coverage	No exceedances during the last 3 years of monitoring; and If a core parameter, at least 3 samples representing different seasons during the assessment period
CHRONIC CRITERIA Aquatic and Wildlife	1 exceedance = 1 grab sample exceeds a criterion and absence of contextual information indicating unstable conditions	Two or more exceedances during the assessment period	Only one exceedance during the assessment period; or Insufficient core parameter samples; or Insufficient seasonal coverage	No exceedances of any A&W chronic criterion during the assessment period; and If a core parameter, at least 3 samples representing different seasons
pH AND DISSOLVED OXYGEN CRITERIA Aquatic and Wildlife	1 exceedance = 1 grab sample exceeds a criterion	At least 10% of samples exceed criterion at a 90% confidence rate; Minimum of 5 exceedances; and Minimum of 20 samples (See binomial-based table below)	If an exceedance, insufficient data to determine if impaired or attaining (see criteria to left); or Insufficient core parameter samples or seasonal coverage	No exceedances-see binomial-based table below; and If a core parameter, at least 3 samples representing different seasons
NITRATE OR NITRATE/NITRITE CRITERIA Domestic Water Source	1 exceedance = 1 grab sample exceeds a criterion	Two or more exceedances during the last 3 years of monitoring	Only one exceedance during the last 3 years of monitoring. (Not a core parameter)	No exceedances (Not a core parameter) during the last 3 years of monitoring

	Exceedance Definition	Assessed As Impaired	Assessed As Inconclusive	Assessed As Attaining
E. COLI BACTERIA SINGLE SAMPLE MAXIMUM CRITERIA Body Contact	1 exceedance = 1 grab sample exceeds a single sample maximum criterion. However, for impairment decisions, the grab sample must exceed a screening value	Two or more non-storm exceedances during the last 3 years of monitoring; or If any exceedances are storm-related, a minimum of 10 samples is required and the exceedance rate over the entire assessment period must be greater than 10%.	Only one exceedance during the last 3 years of monitoring; or One or more exceedances outside the 3 year window and no data or insufficient data in the last 3 years; or Fewer than three samples*; or Insufficient seasonal coverage* during the assessment period	No exceedances during the last 3 years of monitoring; and If a core parameter*, at least 3 samples representing different seasons in the assessment period. If one or more exceedances outside the 3 year window, samples in the last 3 year period must satisfy the core parameter requirement.
E. COLI BACTERIA GEOMETRIC MEAN CRITERIA Body Contact	1 exceedance = the geometric mean of at least 4 samples taken during a 30-day period exceeds a criterion	Two or more exceedances during the assessment period	Only one exceedance during the assessment period	No exceedances (Sufficient data to calculate a monthly geometric mean is not required)
NITROGEN AND PHOSPHORUS SINGLE SAMPLE MAXIMUM CRITERIA Body Contact and Aquatic and Wildlife	1 exceedance = 1grab sample exceeds a criterion	At least 10% exceedance at a 90% confidence rate; Minimum of 5 exceedances; and Minimum of 20 samples (see binomial-based table below)	At least one exceedance, but insufficient data to determine if impaired or attaining (see criteria to left); or If standards apply, fewer than 3 samples collected or insufficient seasonal coverage	No exceedances -see binomial-based table below; and If standards apply, at least 3 samples represented different seasons
NITROGEN AND PHOSPHORUS ANNUAL MEAN CRITERIA Body Contact and Aquatic and Wildlife	1 exceedance = the annual mean of at least 3 monthly means exceeds a criterion	Two or more exceedances during the assessment period	Only one exceedance during the assessment period; or Many samples exceeded the criterion although the annual mean was not exceeded	No exceedances (Sufficient data to calculate an annual mean is not required)
NITROGEN AND PHOSPHORUS 90th PERCENTILE CRITERIA Body Contact and Aquatic and Wildlife	1 exceedance = the 90th Percentile of at least 10 samples collected at least 10 days apart exceeds a criterion.	Two or more exceedances during the assessment period	Only one exceedance during the assessment period; or Many samples exceeded the criterion although the 90th Percentile was not exceeded	No exceedances (Sufficient data to calculate a 90th Percentile is not required)

	Exceedance Definition	Assessed As Impaired	Assessed As Inconclusive	Assessed As Attaining
SUSPENDED SEDIMENT CONCENTRATION MEDIAN CRITERION Aquatic and Wildlife	1 exceedance = the median of at least 4 consecutive samples collected at least 7 days apart exceeds the criterion, excluding samples collected during or within 48 hours of a local storm event	Two or more exceedances during the assessment period	Only one exceedance during the assessment period; or Many samples exceeded the criterion, but the median did not exceed the criterion or could not be calculated due to insufficient data.	No exceedances (Sufficient data to calculate a median is not required)
TOTAL DISSOLVED SOLIDS FLOW-WEIGHTED ANNUAL MEAN CRITERIA On the Colorado River	1 exceedance = the flow-weighted mean of all samples collected during a 12 month period exceeds a site-specific criterion.	Two or more exceedances during the assessment period	Only one exceedance during the assessment period; or Many samples exceeded the criterion although the annual mean was not exceeded.	No exceedances (Sufficient data to calculate a flow-weight mean is not required)

* *E. coli* bacteria and dissolved oxygen are not required core parameters where Aquatic and Wildlife ephemeral and Partial Body Contact apply.

Note: If not a core parameter, no minimum samples are required to determine that a designated use is "attaining."

Samples Collected		Minimum Exceedances		Maximum Exceedances
FROM	TO	IMPAIRED (Binomial)	INCONCLUSIVE	ATTAINING
3	9	NA	NA	0
10	15	NA	3	2
16	19	NA	4	3
20	23	5	4	3
24	32	6	5	4
33	40	7	6	5
41	47	8	7	6
48	55	9	8	7
56	63	10	9	8
64	71	11	10	9
72	79	12	11	10
80	88	13	12	11
89	96	14	13	12
97	104	15	14	13
105	113	16	15	14
114	121	17	16	15
122	130	18	17	16
131	138	19	18	17
139	147	20	19	18
148	146	21	20	19
157	164	22	21	20

To determine impairment, the minimum number of exceedances is based on a minimum of 10 percent exceedance frequency with at least a 90 percent confidence level, using a binomial distribution. If not impaired, an assessment unit is considered inconclusive based on a 10 percent exceedance frequency with a minimum of 80 percent confidence level, also using a binomial distribution. Attainment occurs if sufficient samples are available and the maximum exceedances listed in the binomial-based exceedance table are not reached. Formulas to determine the minimum exceedances with any number of samples are included in the Impaired Water Identification Rule (R18-11-605).

Assessing When No Longer Impaired

When is an assessment unit no longer impaired? What is the minimum number of samples? What number of exceedances is acceptable? The Impaired Water Identification Rule currently provides limited criteria to determine when an assessment unit is no longer impaired (R18-11-605(F)).

An assessment unit is removed from the 303(d) List when the TMDL is completed or alternative pollution control requirements have made the development of a TMDL unnecessary. In EPA's terms, the surface water is moved from Category 5 to Category 4A or 4B, but it remains impaired.

To be "no longer impaired," one of the following criteria must be met:

- The water quality criterion is no longer exceeded due to a change in standard or designated use;
- New data indicate that the designated use is attaining, and the new data was collected during critical conditions;
- Reevaluation of the assessment information indicates an error or deficiency in the original analysis resulted in an inappropriate listing;
- Pollutant loadings from naturally occurring conditions are the sole cause of the criterion not being met; or
- The reach is split into 2 or more segments and no current or historic data exists that would support listing a portion of the impaired reach.

If the delisting is based on new data, then the number of samples required and the number of exceedances depend on the criteria used for listing, as shown in the following table:

	Assessed As No Longer Impaired	Exceedance Definition
ALL HUMAN HEALTH AND AGRICULTURE USE CRITERIA (Except those addressed below)	Minimum 10 samples and no more than the maximum exceedances shown in "Attaining" column in the binomial-based table (prior page)	1 exceedance = 1 grab sample exceeds a criterion
ACUTE CRITERIA Aquatic and Wildlife	No exceedances during the last three years of monitoring the parameter of concern	1 exceedance = 1 grab sample exceeds a criterion

	Assessed As No Longer Impaired	Exceedance Definition
CHRONIC CRITERIA Aquatic and Wildlife	No exceedances during the assessment period and parameter of concern samples were collected	1 exceedance = 1grab sample exceeds a criterion and absence of contextual information indicating unstable conditions
NITRATE OR NITRATE/NITRITE CRITERIA Domestic Water Source	No exceedances during the last three years of monitoring the parameter of concern	1 exceedance = 1 grab sample exceeds a criterion
E. COLI BACTERIA SINGLE SAMPLE MAXIMUM CRITERIA Body Contact	No exceedances during the last three years of monitoring the parameter of concern	1 exceedance = 1 grab sample exceeds a single sample maximum criterion
E. COLI BACTERIA GEOMETRIC MEAN CRITERIA Body Contact	Sufficient samples to determine at least two monthly geometric means and no exceedances	1 exceedance = the geometric mean of at least 4 samples taken during a 30-day period exceeds a criterion
NITROGEN AND PHOSPHORUS SINGLE SAMPLE MAXIMUM CRITERIA Body Contact and Aquatic and Wildlife	Minimum 10 samples and no more than the maximum exceedances shown in the "Attaining" column in the binomial-based table (prior page)	1 exceedance = 1 grab sample exceeds a criterion
NITROGEN AND PHOSPHORUS ANNUAL MEAN CRITERIA Body Contact and Aquatic and Wildlife	Sufficient samples to determine at least two annual means and no exceedances	1 exceedance = the annual mean of at least three monthly means exceeds a criterion
NITROGEN AND PHOSPHORUS 90th PERCENTILE CRITERIA Body Contact and Aquatic and Wildlife	Sufficient samples to determine at least two 90th Percentiles and no exceedances	1 exceedance = the 90th Percentile of at least 10 samples collected at least 10 days apart exceeds a criterion
SUSPENDED SEDIMENT CONCENTRATION GEOMETRIC MEAN CRITERION Aquatic and Wildlife	Sufficient samples to determine at least two geometric means and no exceedances	1 exceedance = the geometric mean of at least four consecutive samples exceeds the criterion, excluding all samples collected during elevated flows
TOTAL DISSOLVED SOLIDS FLOW-WEIGHTED ANNUAL MEAN CRITERIA On the Colorado River	Sufficient samples to determine at least two annual flow-weighted means and no exceedances	1 exceedance = the flow-weighted mean of all samples collected during a 12 month period exceeds a site-specific criterion

Trophic Status of Lakes

In the assessment report, ADEQ must also identify and classify public lakes according to trophic condition to fulfill requirements of section 314 of the Clean Water Act. Lakes can be classified in a continuum of lake trophic stages from low productivity to high productivity as nutrients accumulate or are depleted in the system, using the following terms:

- Oligotrophic – Clear lakes with low algal or plant productivity;

- Mesotrophic – Medium algal or plant productivity;
- Eutrophic – "Greener" lakes with high algal or plant productivity; and
- Hypereutrophic – Very high algal or plant productivity and light limited, as algae and macrophytes shade available light and inhibit further growth.

Trophic status is not used directly to assess designated use support. However, it may be used as further evidence of nutrient problems (weight-of-evidence), especially if a change in classification has occurred. For example, changes in status from mesotrophic to eutrophic might indicate that new sources of nutrients have been introduced into the lake system. Changing from hypereutrophic to eutrophic status could indicate successful implementation of nutrient source controls in the watershed.

Arizona's approach to deriving the Trophic State Index (TSI) is based on Patrick Brezonik's Trophic State Indices: Rationale for Multivariate Approaches (1984). Derivation of TSI scoring and associated water quality values is documented in Potential Nutrient-Related Targets for Lakes and Reservoirs in Arizona (Malcolm Pirnie, 2005). The mean value of samples collected at a lake during the past five years is used to determine a lake's trophic status based on the following matrix:

Trophic State	TSI	CHLOROPHYLL a (µg/L) (maximum)	SECCHI DEPTH (meters) (minimum)	TOTAL PHOSPHORUS (mg/L) (maximum)	TOTATL KJELDAHL NITROGEN (mg/L) (maximum)
Oligotrophic	0	0.3	5.2	0.013	0.3
	10	0.6	4.0	0.019	0.3
	20	1.2	3.1	0.027	0.4
Mesotrophic	30	2.5	2.4	0.037	0.6
	40	5.0	1.8	0.052	0.7
Eutrophic	50	10	1.4	0.074	1.0
	60	20	1.1	0.103	1.2
	70	40	0.8	0.145	1.6
Hypereutrophic	80	81	0.6	0.203	2.1
	90	161	0.5	0.285	2.7
	100	323	0.4	0.400	3.5

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SECTION 4 – FINAL LISTINGS

Assessment Categories

EPA created five categories for reporting assessments to provide a clearer summary of states' water quality status to Congress. New guidance gives the states an option of reporting an assessment unit in more than one category when TMDLs are completed. Note that EPA must approve of listings and changes to listings in Category 4A-C and 5 (the impaired water listings).

ADEQ added one category to institutionally track assessment units that are impaired due to natural conditions (N). Because this list is not recognized by EPA, assessment units in N, also appear in one of the other 5 categories, depending on assessments of other designated uses.

Category 1: Attaining all designated uses.

Assessment units with sufficient data to determine that all designated uses are supported. In these assessment units, at least three samples were collected to represent seasonal differences for all core parameters.

Category 2: Attaining some designated uses, and no use is impaired.

Assessment units with sufficient data to determine that one or more designated use is "attaining" and the remaining designated uses are assessed as "inconclusive." No use is impaired. The specific reasons a designated use is assessed as inconclusive can vary, but in general there are not enough samples to make a decision as to whether the use is "attaining" or "impaired."

Category 3: Insufficient or no data and information to determine if any designated use is attained.

Assessment units with insufficient data to assess any designated use as "attaining" or "impaired." All designated uses are assessed as "inconclusive". By default, this category also includes assessment units with no water quality data available. (Note: An inventory of these waters has not been completed because many ephemeral surface waters in Arizona have not been assigned a name or identification number.)

Category 4: Impaired for one or more designated uses but a TMDL is not necessary

Assessment units with at least one use assessed as "impaired" but development of a TMDL analysis is not needed (at this time), for the following reasons:

Category 4A – Assessment units where TMDLs have been completed and the pollutants covered under those TMDLs. The TMDL is an investigative study of pollutant sources that includes recommendations for pollutant reductions; however, even after recommended improvements have begun, it may take several years to see the effects. Therefore, the assessment unit remains impaired and listed in Category 4A until it is attaining standards again.

Category 4B – Assessment units where alternative pollution control requirements are being used to meet standards, rather than a TMDL. To be placed on 4B, ADEQ must submit to EPA for evaluation and review the following information:

- Statement of the problem causing the impairment, identifying pollutants and their sources;

- Description of the alternative pollution controls being implemented, including the funding mechanism for any associated costs and binding agreements to complete implementation;
- Reasonable time schedule for implementation of controls;
- Projection of when water quality standards will be met;
- Description of and schedule for monitoring, that will show progress with the control strategy; and
- Commitment to revise the control strategy if progress towards meeting water quality standards is not being shown.

Category 4C – Assessment units where the impairment is not caused by a pollutant, but instead by other types of pollution. For example, a designated use may be impaired solely due to lack of adequate flow or stream channelization. In such cases, the specific cause and source of the impairment has been carefully studied, generally through the TMDL process.

On the other hand, although low dissolved oxygen is not a pollutant, under EPA assessment guidance it is listed as the cause of impairment and a TMDL is required when the low dissolved oxygen is caused by the presence of a pollutant (e.g., nutrients or chemical oxygen demand). Similarly, low or high pH is listed as the cause of impairment in Category 5, rather than 4C, when pollutants are thought to be causing or contributing to the impairment. To date ADEQ has not used Category 4C.

Category 5: Impaired for one or more designated uses by a pollutant, and a TMDL needs to be developed or revised.

Assessment units with at least one designated use impaired by a pollutant and a Total Maximum Daily Load analysis needs to be completed. The assessment unit remains on Category 5 until EPA has approved the TMDL or the pollutant is otherwise delisted.

The other uses may be any combination of attaining, inconclusive, and even impaired but not on the 303(d) List (see Category 4 above). For example, as TMDL's are completed those parameters are moved to Category 4A; however, additional parameters may be impairing the assessment unit. In such cases the surface water may appear both in Category 5 and in one or more of the Category 4s.

EPA has added several surface waters to the 303(d) List. Because these waters were listed based on criteria not available to ADEQ (e.g., fish consumption advisories, fewer exceedances or samples than required under Arizona's methods), these waters are kept on or removed from the impaired water list at EPA's discretion.

Sub-category N: The impairment is solely by natural conditions (an Arizona list only).

Assessment units with at least one designated use impaired solely due to natural conditions (no anthropogenic influences). This is a weight of evidence sub-category, developed by ADEQ to track naturally occurring pollutants causing impairments in Arizona. To place an assessment unit on this list, ADEQ must have evidence that anthropogenic activities are not contributing to the impairment.

Multiple Category Listings

Assessment units in Categories 4 and 5 can be in multiple categories as the listings are based on the pollutant causing the impairment. For example, an assessment unit could be impaired by arsenic, copper, selenium, and suspended sediment concentration. Because TMDLs have been completed for arsenic and copper, the assessment unit appears in Category 4A. The stream now

appears to be impaired based on the newly adopted suspended sediment criteria standard, so the assessment unit also appears in Category 5.

New monitoring and laboratory methods allow us to detect much lower concentrations of mercury, so new assessments show that the reach is impaired by mercury. However, the main source of the mercury has developed a plan under its permit obligations to remediate a waste site which should mitigate the mercury contamination. A TMDL for mercury is unnecessary at this time, and the remediation plan allows the assessment unit to be listed in Category 4B for mercury.

Such multiple listings provide credit for taking actions to completing TMDLs and initiate remediation activities, even though other water quality issues have now been shown to exist.

Water Quality Improvements and Delisting Waters

Delists

When a pollutant is removed from Category 5, the pollutant must be officially "delisted" from the federal 303(d) List. A list of assessment units and pollutants being delisted are included in an Appendix E of the assessment report. Removal is generally due to the following:

- Water quality improvements,
- Changes in standards, designated uses, or assessment criteria,
- New data shows that the surface water is not impaired
- New data shows that impairment is solely due to natural conditions (remains impaired), or
- The TMDL has been completed (remains impaired).

Although delisted from the 303(d) List, the surface water may remain "impaired." The surface water is simply moving from Category 5 to Category 4.

Actions Resulting in Water Quality Improvements

When water quality improvements result in an assessment unit being "no longer impaired" by a pollutant, and such improvements can be directly attributed to actions taken within the watershed, Arizona has a success story. ADEQ has started to track these in an appendix to the assessment report.

Such improvements are generally dependent on continuing the water quality improvement action and not allowing new discharges of the pollutant. Decision makers concerned with potential discharges or new activities in the watershed (e.g., grazing actions, permits) need to be aware of the best management practice (BMP), treatment, or other action, along with any TMDL loading requirements.

This list is different than the "Delist" table because it includes only surface waters delisted due to water quality improvements and it accrues pollutants from one assessment to the next.

Public Involvement and EPA Review

Public participation and review are important aspects of developing the integrated assessment and listing report. The public is encouraged to be involved in the process at several stages.

Assessment Methods Development

Public participation is invited and encouraged during the development and revision of Arizona's Impaired Water Identification Rule. Informal public meetings are augmented by information available on ADEQ's website to provide all interested stakeholders many opportunities to discuss assessment issues and potential revisions. Rules are modified only after a formal public review and comment process is complete.

A draft of this Assessment Methods and Technical Support Document is provided for public review and comment during the initial review period for the integrated assessment report. Interested stakeholders are encouraged to comment about both impairment criteria and attainment criteria used during the assessment. Methods will be modified as needed before the final assessment is completed and submitted to EPA.

EPA is included as a stakeholder and provides comments on both the Impaired Water Identification Rule and this Assessment Methods document. Although EPA does not have to approve of ADEQ's assessment and listing methods, it considers the methods when reviewing Arizona's impaired waters lists. Any deficiency in these methods can be cited as a factor in an EPA decision to disapprove of a part of Arizona's 303(d) List.

Surface Water Quality Standards

The public is also encouraged to participate in developing surface water quality standards. Formal meetings and informal focus sessions are scheduled throughout the Triennial Review process. For those who are unable to attend meetings, ADEQ's website provides information about proposed changes.

EPA must grant final approval of any changes to these standards before they are adopted. EPA also encourages public comments and further input by federal resource agencies before giving approval for proposed revisions.

Integrated Assessment Report and Impaired Waters List

Monitoring data and other water quality data are requested from state, federal, and local agencies and other potential monitoring entities who collect, receive, or manage water quality data or information (e.g., NPDES/AZPDES permit holders, WQARF projects, volunteer monitoring groups). ADEQ works with monitoring entities to develop monitoring plans so that data fulfills credible data requirements, and so the data can be uploaded into its water quality database.

A 45-day period initiates the public review of the draft integrated assessment and listing report. Comments from this public review are considered in making the final listing decisions. A summary response to these comments is provided along with the publication of the draft 303(d) List in the Arizona Administrative Register (A.A.R.) for a 45-day Public Notice.

The listing of an assessment unit or pollutant can be appealed pursuant to Title 41, Chapter 6, Article 10 by anyone who submitted comments on the draft list. If a notice of appeal is filed, the listing involved is not included in ADEQ's submission to EPA until the listing is upheld by ADEQ's Director or the appeal is withdrawn.

EPA Approval

After ADEQ's public process and revisions are complete, ADEQ submits the integrated assessment and listing report to EPA Region IX. To be considered complete, the submittal package must include:

- A cover letter;
- A copy of the integrated assessment report and listing report;
- An electronic version of the assessment (preferably using EPA's Assessment Database) and GIS covers linked to the surface water assessments;
- The Notice of Public Information with response to comments published in the Arizona Administrative Register;

EPA also requests other water quality related information or data that was not used for assessments, such as fish tissue data, contaminated sediment data, reports of fish kills, swimming area closures, biocriteria, and habitat data. They may use this additional data to support other listing decisions.

Partial Approval and "Over-filing"

The 303(d) List of impaired waters needing TMDLs (but not the assessment report) is either approved, disapproved, or partially approved/disapproved by EPA within 30 days. If a portion of the list is partially approved or disapproved, EPA proposes changes to the list and initiates another public review and comment period. Proposed revisions to Arizona's 303(d) List are published in the Federal Register. EPA works with ADEQ to attempt to notify all interested parties of this publication. At the end of the comment period, EPA evaluates public comments and compiles the final approved 303(d) List.

In the past, EPA has identified assessment units and pollutants of concern that needed to be added to Arizona's impaired water list to make the list consistent with federal regulations (over-filings). Because the original listings were not made according to Arizona's Impaired Water Identification Rule, they cannot be removed from the list based on Arizona's rule. In subsequent assessments, EPA must decide when these additional impairments are removed from Arizona's 303(d) List. In this respect, these impairments are tracked separately. However, once listed by EPA, ADEQ recognizes these waters as impaired, initiates TMDL according to priorities, and protects them from further pollutant loadings according to Arizona's Antidegradation Rules and permit requirements.

Coordinating with Neighboring Jurisdictions

EPA advises states to coordinate with neighboring jurisdictions to ensure that assessments of surface waters which cross jurisdictional boundaries are reasonably consistent between states, taking into account differences in data availability and applicable standards.

Arizona works with neighboring jurisdictions during several stages of the assessment process, including standards development and assessment methods development. The five states surrounding Arizona and the 21 Tribal nations within Arizona are routinely included in our public review notification. Comments received are evaluated and additional discussion may be initiated. If a conflict cannot be resolved between ADEQ and the other jurisdiction, EPA will be notified.

Arizona has an excellent Border Program that works with Mexico. However, resolution of impaired waters has been a very complex matter, involving high-level actions, and requiring coordination with State Departments of both nations.

Prioritizing and Scheduling TMDLs

Prioritizing the 303(d) List

Prioritization criteria for scheduling TMDL development are established in the Impaired Water Identification Rule (A.A.C. R18-11-606). In general, if a substantial threat to health and safety of humans, aquatic life, or wildlife is noted, the surface water is listed as high priority and ADEQ initiates development of the associated TMDL within two years following EPA's approval of the 303(d) List.

High priority factors:

- Substantial threat to health and safety of humans, aquatic life, or wildlife based on toxicity of the pollutant and magnitude or duration of the exceedance;
- The presence of a Threatened or Endangered species (T&E species) that may be further jeopardized by the water quality pollutant. This is determined by looking at critical habitat, published reasons for decline and vulnerability of the species, and discussions with the AGFD and the U.S. Fish and Wildlife Service;
- Special protection of the water resources, such as classification as a "Outstanding Arizona Water," "wilderness area," "wild and scenic river," or other state or federal designation;
- Delay in the TMDL could jeopardize a timely permit action or ADEQ's ability to gather sufficient credible data to support the TMDL;
- Public interest and support for development of the TMDL;
- The assessment unit has an important recreational and economic significance; or
-

Medium and low priority ranking factors are also identified in the Impaired Water Identification Rule. The rule provides that several low priority factors can take precedence over high priority factors because completing a TMDL at this time would either be inappropriate, premature, or an inefficient use of resources. The low priority factors that trump high priority factors include:

- ADEQ has formally submitted to EPA a proposal to delist the surface water or pollutant based on new data, new standards, or new designated uses.
- Flow conditions inhibit collecting samples during critical conditions or a variety of conditions necessary for modeling;
- The uncertainty of timely coordination with Mexico, another state, or a tribal reservation needed to conduct the TMDL or implement necessary watershed improvements;
- The assessment unit is expected to attain water quality standards due to:
  - Changes in treatment or best management practices;
  - Discharges or activities related to impairment have stopped; or
  - Other controls are in place or scheduled;
- Naturally occurring conditions are the major contributor to the impairment.

It may become necessary to shift priority ranking of an assessment unit due to significant changes in resources to complete TMDLs or as new information is obtained concerning one of the priority factors. Such changes are negotiated with EPA and are made known to the public through the TMDL status page on ADEQ's web site.

SECTION 5 - FURTHER TECHNICAL RATIONALES

Binomial Distribution Method

Impairment Based on the Binomial

How many exceedances must occur before the assessment unit is impaired? EPA has provided specific guidance for working with acute and chronic aquatic and wildlife standards (two or more exceedances in a 3-year period is impaired).

EPA's CALM document (2002) suggests that an exceedance rate greater than 10 percent for conventional parameters, such as dissolved oxygen and pH, indicates impairment of a designated use. ADEQ has extended this approach to Arizona's human health standards that were established to protect for 70-year lifetime exposure periods, since an exceedance rate under 10 percent should not negatively impact human health (with the exception of *E. coli* bacteria and nitrate which are pollutants that can be acutely toxic to humans).

The purpose of the binomial distribution method is to balance the two types of error possible in assessment and listing decisions:

Type I error – Listing an assessment unit that is not impaired (a false positive), and
Type II error – Not listing an assessment unit that is impaired (a false negative)

To reduce listing error, ADEQ adopted a statistical approach to 303(d) listing, using a binomial distribution method and establishing a statistical "confidence level" for assessments. This method is a statistical tool used to test a hypothesis. Using the 10 percent rule from CALM guidance, the null and alternative hypotheses, respectively, become:

H_o: The true exceedance rate (p) is ≤10%; the surface water is not impaired;
H_a: The true exceedance rate (p) is >10%; the surface water is impaired.

The binomial establishes a minimum number of exceedances, and a minimum number of total samples, based on >10 percent exceedance rate at a 90 percent confidence level as acceptable for assessments. The minimum number of exceedances reduces Type I error – listing an assessment unit that is not impaired. Here, Type I error is reduced by establishing a high level of statistical confidence to avoid an unnecessary listing. The minimum number of total samples reduces Type II error – failing to list an assessment unit that is impaired. Type II error is reduced by increasing the sample size so that exceedances are not missed. Establishment of a statistical confidence level reduces both Type 1 and Type II errors.

As shown in the table below, the number of exceedances needed is different based on the raw score or binomial approach. In the raw score approach, exceedances are counted (yes or no exceeded) and a percent exceedance calculated. While the binomial testing approach looks at the probability of exceedance at a chosen confidence level.

ASSESSMENT METHOD	NUMBER OF EXCEEDANCES IN 10 SAMPLES TO GET > 10% EXCEEDANCE RATE
Raw Score	2 of 10 samples
Binomial at 90% Confidence Level	3 of 10 samples

Statistically, the unknown distribution of a pollutant measurement can be transformed to a binomial distribution based on the sample size (n), the measured number of exceedances (x), and the true exceedance probability (p). The BINOMDIST function in Excel (or other spreadsheets) can then calculate the probability that the exceedance rate is greater than 10 percent, and therefore, the probability that the surface water is impaired, for a known number of samples (n) and known number of exceedances (x).

Using another statistical function (CRITBINOM in Excel), a given number of samples and a given confidence level, can be entered, and the minimum number of exceedances needed to determine impairment is calculated. This function was used to create the binomial listing table in the Impaired Water Identification Rule R18-11-605. For example, "=CRITBINOM(10, 0.105, 0.90)" is entered into an Excel spreadsheet to determine the minimum number of exceedances necessary to determine impairment, based on 10 samples, at 10.5 percent or higher exceedance rate, and a confidence level of at least 90 percent. (Notice that 10.5 percent is used in the calculation to numerically represent >10 percent.)

Delisting Based on the Binomial

As described in Section 4, assessment units are no longer impaired if there are sufficient data to show that the assessment unit is no longer impaired. This would require a minimum of 10 samples with no more than two samples exceeding the applicable standard. However, at least some of the samples must have been collected during "critical conditions" and at "critical locations," which are under conditions and at locations where exceedances have occurred in the past, if those conditions still exist.

Other Assessment Methods

Assessments Based on Aquatic and Wildlife Acute Criteria

Arizona's toxic pollutant criteria established to protect the Aquatic and Wildlife designated use require a very different assessment and listing method from the binomial described in the preceding section. The binomial is applied primarily to human health standards, which were developed to protect for lifetime exposure periods, and therefore allows a given percentage of exceedances to occur (10 percent). Toxic pollutant criteria for the Aquatic and Wildlife use, however, were developed to protect for far shorter periods of exposure, due to the shorter lifespan of the aquatic life and wildlife they protect. Studies show that test organisms can tolerate no more than one exceedance of either the acute or chronic aquatic and wildlife criteria over a three-year period. In fact, studies show that even one exceedance can cause damage if the magnitude of exceedance was very high or the affected area was very large (EPA, 1991). Clearly, a statistical approach based on a percentage of exceedances, such as the binomial, is not valid for these standards and would not protect the designated use.

Acute criteria protect against short-term effects of high level pollutant concentrations, which include lethality and immobilization. Acute criteria protect for one-hour exposure periods. Aquatic life may recover from one exceedance of criteria per three-year period; however, recovery is not likely if even

minor exceedances occur more often. A statistical approach, such as the binomial, is not appropriate for this type of standard. Instead, listings must be made based on two or more exceedances in a three-year period, regardless of whether the sample size is small or large.

ADEQ requires that surface waters be placed on the 303(d) List based on two or more exceedances of these criteria. This listing method must be applied regardless of total sample size. Note that although listing based on one large exceedance could potentially be justified, it is ADEQ's policy, and standard practice throughout the country, that listings will be made only if evidence is available to show that the impairment is persistent or recurring. Therefore, two or more exceedances are needed to make a 303(d) listing. This requirement is also consistent with EPA assessment guidance recommendations: CALM (2002), Guidance for 2006 Assessment, Listing and Reporting (2005), and the Technical Support Document for Water Quality-based Toxics Control (1991).

ADEQ does have some flexibility to delay a listing under the weight-of-evidence approach while collecting additional monitoring data when data reliability may be a concern. An example might be samples with exceedances near the laboratory reporting limit and sources of the pollutant were either unknown or unlikely in the watershed.

As required in the TMDL Statute §49-232(C)(4), the criteria for establishing that an assessment unit is no longer impaired cannot be any more stringent than the criteria for adding an assessment unit to the impaired water list. In this case, delisting would require no exceedances during the last three years of monitoring. At least some of the samples must have been collected during "critical conditions" and at "critical locations," which are under conditions and at locations where exceedances have occurred in the past, if those conditions still exist.

Assessments Based on Chronic Aquatic and Wildlife Criteria

"Chronic" conditions for aquatic life are determined by as short as a four-day exposure, as compared to a one-hour exposure for acute criteria. The four-day period was selected by EPA to develop chronic criteria because it was the shortest duration over which chronic effects are sometimes observed. Longer exposures would be even more likely to cause chronic impacts. Chronic exposures can be lethal to aquatic organisms, although the effects are not usually immediate upon exposure. Chronic impacts include disease, behavioral abnormalities, inability to reproduce, reduced growth and survival, physical abnormalities, genetic mutations, and eventual death.

EPA's Technical Support Document (1991) and current assessment guidance documents all indicate that an aquatic community should be able to recover from one chronic exposure every three years, unless there is a long exposure duration. Therefore, ADEQ's assessment method determines impairment at two or more exceedances during the assessment period.

The challenge in establishing assessment methods for these criteria lies in demonstrating that a chronic exposure has occurred. If at least four days of data are available within a seven-day period, ADEQ uses the central tendency of the dataset to determine whether an exceedance has occurred. For standards that vary based on water hardness, ADEQ determines an exceedance based on 50 percent or more samples within a week exceeding standards. For non-hardness dependent standards, in most cases an average is determined, as suggested by EPA guidance. But this type of data is seldom available, and where available, only represents those dates sampled. Can the instantaneous grab samples typically collected be used to represent a 4-day period?

EPA's Guidance for 2006 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the Clean Water Act states that for criteria with multiple day averaging periods (such as chronic criteria), states should develop decision rules for concluding impairment where information indicates a reasonable likelihood that the average was exceeded. For example, if conditions have remained fairly stable over the period of interest (four days), it would be valid to use a grab sample to represent that time period.

ADEQ has developed a method for determining chronic criteria exceedances based on grab samples. This method assumes that stable conditions were occurring at the time unless there is information to the contrary. If sufficient chronic Aquatic and Wildlife criteria have been exceeded to result in the assessment unit being listed as impaired, ADEQ looks at the following information to determine whether 4-day stable conditions were occurring when exceedances occurred:

- Point source discharge records in the reach or immediately upstream;
- Field notes and weather records concerning precipitation and runoff;
- Gaging station records, when available;
- Land uses in the vicinity;
- Records of chemical spills or other unusual events; and
- Historic patterns of pollutant concentrations, when available

If readily available contextual information indicates that the pollutant and stream flow likely remained fairly constant over that four day period, ADEQ will conclude that the grab sample result is valid for chronic Aquatic and Wildlife criteria.

Exceedances of chronic criteria will not be used for listing decisions when unstable conditions were likely, especially in watersheds with precipitation-dependent sources of pollutants (e.g., mine tailings piles). Examples of evidence of unstable conditions include, but are not limited to, samples being collected during:

- A precipitation event with runoff lasting shorter than 4-days;
- The first flush of a precipitation event; or
- A short-lived but high monsoon flow.

However, if the data were collected after several days of high flow, the sample would be assumed representative of the 4-day average conditions.

In a lake, stable conditions will assume to be occurring unless lake "turnover" or other disturbances are documented when the sample was collected. Lake temperature profiles and other field information will be used to look for such disturbances.

In a lake or stream, if one or more point source discharges provide a significant contribution to the receiving water, the facility discharge records are reviewed to determine whether flow and associated pollutant discharges were relatively consistent during the four-day period when the exceedance occurred. Other evidence concerning unstable flow or pollutant discharges can be provided by the facility.

The criteria for establishing that an assessment unit is no longer impaired is no exceedances during the assessment period, and at least some of the samples must have been collected during "critical conditions" and at "critical locations."

Assessments Based on Nitrate and E. coli Criteria

Nitrate (or nitrate/nitrite) and *E. coli* bacteria are two pollutants that may be acutely toxic to humans. Therefore, the Impaired Water Identification Rule established the same assessment criteria as used for acute Aquatic and Wildlife criteria – impaired if two or more exceedances of the single sample maximum criteria occur during the last three years of a monitoring period.

Three issues with *E. coli* bacteria data are being addressed through the weight-of-evidence approach until the Impaired Water Identification Rule can be revised:

- The reliability of "most probable numbers" – Both lab and field bacterial analyses provide an estimation of bacterial density, reported in terms of a Most Probable Number (MPN). For example, using the multiple tube technique, if the result is reported as 240 colony forming units (CFU), there is a 95 percent confidence level that the result is between 100 and 940 CFU (Standard Methods for Examination of Water and Wastewater, 20th Edition). Only two exceedances will result in a listing; therefore, 303(d) listing decisions are not based on results reported relatively near the single sample maximum standards of 235 CFU (for Full Body Contact) or 576 CFU (for Partial Body Contact). Instead, screening values of 300 and 630 CFU, respectively, are used for impairment decisions, so that minimum exceedances must be above these screening values. To be clear, all results above the standard are reported as exceedances in the assessment report; however, a comment is made when the result is below the screening value.

- Bacterial contamination in flood flows – Flood flows in Arizona routinely contain high amounts of bacteria. While high bacterial counts pose a risk to recreational users, flood waters are not typically highly recreated. Although completing and attaining TMDL loads due to such contamination may be difficult, exceedances occurring during flood flows are not exempted under the Impaired Water Identification Rule and must be included when making impairment decisions. However, impairments based on flood related data will only be considered when ten or more samples have been collected and there is a greater than 10 percent exceedances rate.

- Bacterial exceedances sites on very large reservoirs – Exceedances occurring at separate beaches in a large river reservoir, provide a different level of risk to human health than exceedances occurring at the same beach or in the same stretch of river. Bacterial exceedances are counted and assessed per monitoring site at large reservoirs where sites are located several miles apart.

The criteria for establishing that an assessment unit is no longer impaired is the same as for acute Aquatic and Wildlife criteria – no exceedances during the last three years of monitoring, and at least some of the samples must have been collected during "critical conditions" and at "critical locations."

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Assessments Based on Statistically Derived Standards - When two or more exceedances of a statistically-derived standard occur, the surface water is assessed as impaired. These standards, as established in Arizona's Surface Water Quality Standards, establish both a minimum sample size and a statistical calculation. The statistically-derived standards include:

- *E. coli* geometric mean;
- Suspended sediment concentration (SSC) median;
- Nutrient 90th percentile;
- Nutrient annual mean; and
- Total dissolved solids (TDS) flow-weighted annual mean in the Colorado River.

The *E. coli* bacteria geometric mean standard is applied only to locations with a minimum of 4 samples in a 30-day period (e.g., Slide Rock State Park on Oak Creek and Lake Havasu beaches). (Note: Single sample maximum criteria are also applied to *E. coli* – see discussion above.) For assessment purposes, a 30-day period is interpreted as one month. Also, the *E. coli* geometric standard is exempted from the normal 7-day aggregation rule. Therefore, any four consecutive samples collected at a single site in a single month can be used to calculate one geometric mean for the site. If there are multiple geomeans representing different sites in a single month, the worst case site is selected to represent the whole assessment unit.

To determine that an assessment unit is no longer impaired, the minimum data requirements are simply the number of samples necessary to re-calculate the statistical value for comparison to the standard. The assessment unit will be delisted if the standard is not exceeded, and at least some of the samples were collected during "critical conditions" and at "critical locations."

Using the Suspended Sediment Concentration Standard

In 2002, ADEQ adopted a SSC standard to protect Aquatic and Wildlife (A&W) designated uses and concurrently repealed turbidity standards. SSC standards were revised in 2009 creating a different standard for warm and cold waters: 80 mg/L for A&W warmwater and 25 mg/L for A&W coldwater, expressed as a median value of a minimum of four (4) samples collected at least 7 days apart. The standards do not apply to lakes or to ephemeral or effluent-dependent streams.

Since some degree of suspended sediment is natural in streams of the arid west, especially during storm flows, this new standard excludes these precipitation events where large loads of sediment may be naturally flushed downstream. Specifically, any single sample SSC exceedances that occur during or within 48 hours of a local storm event are excluded from the median value determination. The standard is intended to protect fish from chronic, long-term effects of excess suspended sediment.

For assessment purposes, two issues arise: How to determine whether a sample was collected during or within 48 hours of a local storm event? How to determine if two or more exceedances of the median value occurred during the assessment period? These issues are resolved in a three-step assessment process:

> Step 1 –Determine if any single sample exceedance occurred during or within 48 hours of a storm event. There are several ways to check: 1. Obtain nearby USGS gaging records and determine if the sample date falls within 2 days before or after a peak storm flow, 2. Look for

field comments mentioning storm events or "Flood event in progress" or "Significant rain past 48 hours may affect results", and 3. Use NOAA precipitation data to determine if there was a precipitation event starting on or within 2 days before the sampling date.

Step 2 – SSC data within the assessment period are then compiled. Any SSC samples collected during or within 48 hours of storm events are not used in the median calculation. Samples collected at different sites within a 7-day period are aggregated to one sample by selecting the worst-case.

Step 3 – To determine if more than one exceedance occurred, calculate a median value of at least 4 aggregated samples within a 1 or 2-year period. A combination of single year and 2-year medians may be used in assessment, but same samples cannot be used in different median calculations; i.e., samples used to calculate a one-year median cannot be used again to calculate two-year median with the following year's data.

Interpreting Other Water Quality Related Data

To use chemical data to interpret narrative criteria, EPA's CALM document (2002) encourages states to develop implementation procedures, often referred to as translators, to explain how different types of data (e.g., contaminated sediment, fish tissue concentration, bioassessment, physical integrity data, ambient toxicity) are used to make attainment-impairment decisions based on narrative criteria. EPA further encourages that these procedures be made available for review and comment by the public.

Arizona's TMDL statute precludes the use of evidence of narrative standards violation prior to developing and adopting the companion implementation procedures. Similarly, use of numeric data without directly applicable numeric standards is precluded without implementation procedures (e.g., chlorophyll-a, trophic status).

In some instances, screening values or "triggers" are needed to evaluate whether the concentration of a pollutant in fish tissue, sediment, or even the water column is high enough to indicate possible impacts to humans, plants, or animals under narrative standards, where numeric standards are not available. Other than establishing guidance on the use of fish consumption advisories for assessment and listing decisions (Guidance: Use of Fish and Shellfish advisories and Classifications in 303(d) and 305(b) Listing Decisions, EPA, OWOW and OST, October 24, 2000), EPA has left it up to the state to individually establish such standards through a public forum.

Arizona is in the process of developing several procedural documents. As needed, portions of these documents will also be adopted into either the Surface Water Quality Standards or the Impaired Water Identification Rule. The narrative implementation procedures will identify the screening values to be used, the basis of these values, and the actions that should be taken based on exceeding these values to further evaluate potential impacts.

As appropriate screening values and translators have not completed a public review process in Arizona, much of the "other" readily available water quality-related data could not be directly used for this assessment, because there is not a clear link to an adopted numeric water quality criteria. However, such information is used in the weight-of-evidence approach to support listing and delisting decisions.

EPA routinely asks to review such data when it reviews Arizona's 303(d) List of impaired waters, and amends Arizona's list according to federal assessment criteria. EPA has published methods for monitoring and assessing such data as part of its Regional Environmental Monitoring and Assessment Program (REMAP) protocols and procedures; however, it defers to state methods where they have been adopted.

Fish Tissue Data

Some chemical pollutants concentrate in fish and shellfish by accumulating in fatty tissue or selectively binding to muscle tissue. These pollutants may be found at low concentrations in the water column or in bottom sediments, but bioaccumulate in aquatic life and species that prey on aquatic life. The bioaccumulation poses a threat to human health if the organisms are eaten on a regular basis in excess of the federal fish consumption advisory levels. In January 2001, EPA issued a national advisory concerning risks associated with mercury in freshwater fish, especially for women who are pregnant or may become pregnant, nursing mothers, and young children.

Although ADEQ adopted a numeric methylmercury fish tissue standard in 2009 the Impaired Water Identification Rule has not been updated to include assessment procedures, therefore ADEQ will not make impairment decisions based on fish tissue results. EPA historically has overfilled on mercury fish tissue impairments and will continue to do so until the Impaired Water Identification Rule is revised.

The 2016 Assessment report includes fish tissue mercury exceedances for the information purposes only. An exceedance is defined as

> Mean – one standard deviation for a minimum of five fish per species exceeds the standard (0.3 mg/kg).

ADEQ, in association with AGFD, issues a fish consumption advisory based on one or more exceedances of fish tissue mercury for certain fish species.

Swimming Area Closures, Fish Kills, and Drinking Water Advisories

In previous assessments, ADEQ has used issuance of swimming beach closures, documentation of fish kills, or issuance of a drinking water advisory on an assessment unit used for domestic water supply as indications of impairment. These advisories are not, however, issued by ADEQ; therefore, criteria for determining these may vary. Until narrative implementation procedures are developed regarding the issuance of such notices or how to evaluate fish kills and abnormalities, such information is included in the assessment report for informational purposes, but cannot be used as the sole basis in determining impairment.

Bioassessments and Bottom Deposit Criteria

ADEQ's biocriteria standards were developed to protect aquatic life through use of numeric biocriteria that support the narrative biological criteria standard. Indexes of Biological Integrity (IBIs) comprise the numeric biocriteria and were developed for macroinvertebrate samples collected from riffle habitats of perennial, wadeable streams during spring monitoring periods using ADEQ protocols, in predominantly cobble streams. The IBIs are comprised of metric values of the macroinvertebrate community derived from a database of reference condition streams, compiled

into an Index, with the total Index score threshold as a percentage of the reference sites' scores. At this time, the IBIs apply only to wadeable, perennial streams collected during the spring index period and do not apply to macroinvertebrate data collected during other seasons, collected from other habitats such as pools, collected using other methods, or collected in wetland or intermittent stream habitats The narrative and numeric biological criteria (R18-11-108.01) were established in the Surface Water Standards in 2009, and the Implementation Procedures were adopted in 2015.

The bottom deposit standard is intended to prevent excessive sedimentation and siltation in amounts that adversely affect aquatic life. Excessive sediment alters aquatic habitats and suffocates fish eggs and bottom-dwelling organisms. Clean stream bottom substrates are essential for the health of fish and aquatic insect communities. The bottom deposit/sediment criteria are numeric values based on a 100-count pebble count and calculation of the percent fine sediment that is <2mm in size. These numeric criteria are used to interpret the narrative bottom deposits standard that is currently established in the Surface Water Standards. The bottom deposit standard only applies to perennial, wadeable streams at this time. The numeric bottom deposit criteria were established in the Surface Water Standards in 2009 (R18-11-108.02), and the Implementation Procedures were adopted in 2015.

The biocriteria and bottom deposits standards, field and analytical methods, thresholds and implementation procedures are described in the Implementation Procedures documents on the ADEQ webpage at http://www.azdeq.gov/environ/water/standards/index.html . The Implementation procedures also provide guidance on applicability of the standards to various waterbody types and guidance for determining whether an impairment is solely related to natural conditions such as flooding, drought, and travertine or bedrock dominated habitat. Preliminary assessments have shown that habitat measurements must be collected at each site to determine whether the indices of biological integrity are applicable. Some habitats, such as bedrock or travertine dominated substrates, render the data unusable. For example, stream channels composed of bedrock or travertine may be unsuitable for establishing and maintaining a thriving macroinvertebrate community. The habitat can also become impaired due to natural conditions such as scouring of stream bottom habitats due to floods or drought causing the stream to become temporarily dry.

This 2016 Assessment, like the 2012/14 Surface Water Quality Assessment presents biocriteria and bottom deposit standard violations in the watershed assessment reports. However, impairment decisions and 303(d) listing determinations cannot be made until the Impaired Water Identification Rule is updated. Exceedances of narrative water quality standards only go on the planning list not the 303(d) impaired water's list according to A.A.C. R18-11-605(D).

Narrative Nutrient Criteria for Lakes and Reservoirs

ADEQ has a draft narrative nutrient implementation procedures document that would use a matrix of lake measurements to determine whether a lake is receiving excess nutrients and is in violation of the narrative nutrient standard (ADEQ, 2008). If adopted, lake quality data would be compared to a matrix table of values. A combination of elevated values and exceedances of threshold values would be used to determine impairment. The threshold values applied would depend on the lake classification: deep, shallow, igneous, sedimentary, and urban. Lake measurements used to evaluate narrative nutrients include:

- Chlorophyll-a

- Secchi depth
- Blue-green algae (per milliliter and percent of total count)
- Total phosphorus
- Total nitrogen or total Kjeldahl nitrogen
- Dissolved oxygen
- pH
- Fish kills attributed to low dissolved oxygen, high pH, or ammonia toxicity
- Fish kills or other aquatic organism mortality attributed to algal toxicity
- Nuisance algal blooms
- Submerged aquatic vegetation

ADEQ is continuing to refine the matrix and did not use the narrative nutrient criteria in the 2016 Assessment.

Waters with no Applicable Water Quality Standards

It is possible for an assessment unit in Arizona to not have any designated uses assigned to it. Standards do not apply to the following surface waters (unless they are specifically named in the Surface Water Quality Standards):

- A lake constructed outside of a natural water channel (e.g., many urban lakes);
- A hydrologically isolated tributary, not a tributary to a surface water named in the standards (i.e., it drains into Mexico, a neighboring state, or a playa);
- A surface water located on a tribal reservation, in Mexico, or in an adjacent state;
- A manmade conveyance for surface water (e.g., drainage ditches, runoff detention basins, storm water sewers, some canals).

It is also possible to collect water quality data for parameters that do not have standards (e.g., alkalinity, TDS, and radon). As standards are based on designated uses, even commonly used standards may not apply to an assessment unit.

The U.S. Geological Survey collects a significant amount of data that do not have associated water quality standards. Those data are not used for assessments. If no standards could be applied to the data collected, the site is not included in the monitoring data tables. For example, if only TDS, specific conductance, and radon were collected, the monitoring sites are not included in Arizona's assessment because no adopted standards apply. Tracking of such data and monitoring sites is an added resource effort that has little value added at this time. If and when the surface water database can handle input of all relevant water quality information, tracking of these data and sites may be a worthwhile exercise.

CHAPTER 3 – SUMMARY INFORMATION

This chapter provides a summary of assessed surface waters. Progress and comparisons with previous assessments are illustrated in the following chapter. Statewide summary statistics can provide a general sense of the status of water quality in Arizona. The statistics in this chapter exclude surface waters on tribal lands. Also, the statistics include waters that EPA listed as impaired in previous assessments.

ASSESSED WATERS

Overall 55 (97847 acres) lakes and 280 (3180 miles) stream segments were assessed in this report. The following tables show the change in stream miles and lake acres assessed from the 2004 to 2016 assessment. These tables exclude the surface waters assessed in Category 3 (all uses "inconclusive") because by default any water from which no data existed would belong in this category.

Table 3-1. Lake Acres Assessed

Type	2004	2006/8	2010	2012/14	2016
Estimated Waters	289630	295590	295590	295590	295590
Acres Assessed	67340	88672	86234	93821	73497
Units Assessed	51	79	39	39	36
Percent Assessed	23%	30%	29%	32%	25%

Table 3-2. Stream Miles Assessed

Type	2004	2006/8	2010	2012/14	2016
Estimated Waters	90375	90375	90375	90375	90375
Miles Assessed	2227	2806	2538	2208	2275
Units Assessed	172	298	213	193	210
Percent Assessed	2.50%	3.00%	2.80%	2.40%	2.50%

The Total Waters Assessed table (above) indicates that a very low percentage of the state's surface waters are assessed. This is primarily due to the fact that the majority of waters in Arizona are ephemeral (flowing in response only to precipitation events) and not easily sampled. The Total Perennial Waters Assessed table (below) adjusts for this by only looking at perennial lake acres and stream miles. Most ADEQ ambient monitoring is focused on perennial waters (waters that flow year round). Monitoring ephemeral and intermittent waters is limited to special investigations, such as TMDL development. In order increase the waters assessed ADEQ incorporates external data into the assessment. Data from 22 external entities/data sharing partners were used in the 2016 assessment. The largest data contributors are the United States Geological Survey, Army Corp of Engineers, and Pinal Creek Group. Approximately 50% of the data used in the assessment was from external sources.

1. United States Geological Survey
2. Oak Creek Watershed Improvement Council
3. Resolution Copper
4. Various Volunteer Groups
5. Army Corp of Engineers
6. Arizona Game and Fish
7. Slide Rock State Park

8. Upper Gila Watershed Partnership
9. Pinal Creek Group
10. United States Forest Service
11. National Park Service
12. Apache Nitrogen Products
13. Salt River Project
14. ASARCO
15. University of Arizona
16. Sonoran Institute
17. City of Tempe
18. Friends of the Santa Cruz
19. Capstone Mining
20. Sierra Club
21. BHP
22. Friend of the Forest

Table 3-3. Perennial Lake Acres Assessed

Type	2004	2006/8	2010	2012/14	2016
Estimated Waters	168590	174558	174558	174558	174558
Waters Assessed	66264	87773	85192	83588	73408
Percent Assessed	39%	50%	49%	48%	42%

Table 3-4. Perennial Stream Miles Assessed

Type	2004	2006/8	2010	2012/14	2016
Estimated Waters	3530	3530	3530	3530	3530
Waters Assessed	2081	2685	2102	1804	1782
Percent Assessed	59%	76%	60%	51%	50%

Note: Perennial Waters Assessed excludes Category 3 – all uses assessed as "inconclusive"

As shown in the Perennial Waters Assessed table (above), the percent perennial waters assessed fell from 2006/8 to 2016, due to declining monitoring resources.

Another way to look at the effort and effectiveness of monitoring programs is to look at the number of lakes and stream reaches assessed. This is particularly revealing with lakes, as their sizes vary from less than an acre to 27,000 acres. Therefore, monitoring and assessing 20 small, but significant lakes might account for fewer acres than one large reservoir but provides for a larger sampling program in terms of the number of lakes sampled and assessed.

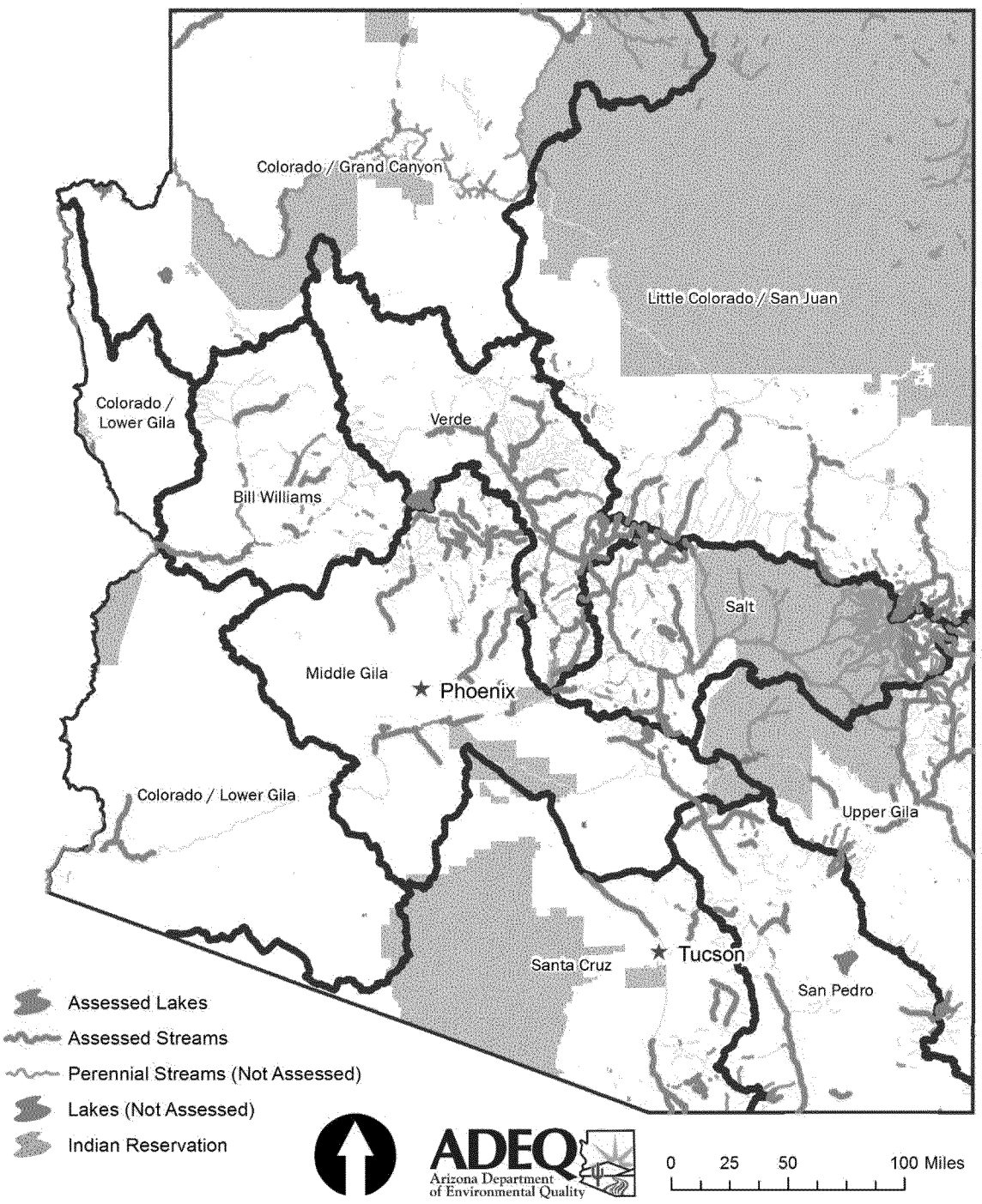

Figure 3-1. Assessed lakes and streams.

ASSESSED WATERS BY CATEGORY

The table below illustrates how the 58 lakes and 284 streams reaches were assessed in 2016. The greatest number of waters were assessed as inconclusive (Category 3) and attaining some uses (Category 2).

Table 3-5. Status of Assessed Waters

Use Support Category	Lakes	Acres	Reaches	Miles
Category 1 (Attaining All Uses)	0	0	20	264
Category 2 (Attaining Some Uses)	3	961	89	1067
Category 3 (Inconclusive)	21	22015	74	692
Category 4 (4A,4A/5,4B/5)(Not Attaining)	12	2732	59	361
Category 5 (Impaired)	21	71950	48	618
Total	57	97658	290	3001

Approximately 1% of the lake acres and 40% of the stream miles assessed are attaining all or some of their uses, as compared to 22 and 28% respectively in the 2012/14 Assessment. Lake acres impaired or not attaining equal approximately 74% of the lake acres assessed. Impaired and not attaining stream miles equal approximately 30% of the stream miles assessed.

DESIGNATED USE SUPPORT

Narrative and numeric criteria were developed to protect the designated uses assigned to a surface water. Designated uses include agriculture, aquatic and wildlife, consumption, and recreation. The largest number of impairments is shown for the aquatic and wildlife designated use within both lakes and streams. The following table summarizes the designated use support by category for lakes and streams.

Table 3-6. Lake Designated Use Support

Support Type (by Units)	Attaining	Inconclusive.	Impaired
Agricultural Irrigation	1	36	4
Agricultural Livestock Watering	1	41	4
Aquatic & Wildlife	0	37	20
Domestic Water Source	0	20	0
Fish Consumption	6	33	16
Body Contact	1	47	9
Support Type (by Acres)	Attaining	Inconclusive	Impaired
Agricultural Irrigation	51	93517	394
Agricultural Livestock Watering	129	95335	1807
Aquatic & Wildlife	0	65172	32487
Domestic Water Source	0	91590	0
Fish Consumption	1823	49860	45927
Body Contact	129	95534	1996

Table 3-7. Stream Designated Use Support

Support Type (by Units)	Attaining	Inconclusive.	Impaired
Agricultural Irrigation	70	65	3

Support Type (by Units)	Attaining	Inconclusive.	Impaired
Agricultural Livestock Watering	113	94	10
Aquatic & Wildlife	33	178	67
Domestic Water Source	18	24	2
Fish Consumption	115	110	8
Body Contact	73	146	64
Support Type (by Miles)	Attaining	Inconclusive.	Impaired
Agricultural Irrigation	970	773	18
Agricultural Livestock Watering	1471	1066	28
Aquatic & Wildlife	441	1917	695
Domestic Water Source	244	332	32
Fish Consumption	1480	1193	127
Body Contact	973	1478	503

FISH CONSUMPTION ADVISORIES

Fish consumption advisories have been issued on 16 lakes and portions of several rivers (see table and map below). The numbers in the table correspond to the labels on the map. These advisories are issued to inform the public about possible adverse health effects and they contain recommendations for how many fish meals (8-ounce portions) can safely be consumed. Advisories may be directed at a specific subset of the population because some people are at greater risk (pregnant women and children). Additional information about fish tissue screening and fish advisories can be obtained by contacting ADEQ at (602) 771-4536 or Arizona Game and Fish Department (AGFD) at (602) 789-3260. Additional information can be obtained from the ADEQ (http://www.azdeq.gov/environ/water/assessment/fish.html) and AGFD (https://www.azgfd.com/fishing/fishconsumption) websites.

Waterbody Pollutant of Concern	Date Issued	Advised Consumption Rates (based on uncooked portion)
Alamo Lake - Mercury	February 2004	Pregnant women and children 16 years of age and younger: No consumption of largemouth bass, black crappie or channel catfish Women of reproductive age: One 8-ounce fish meal per month of largemouth bass, black crappie or channel catfish Adult women past reproductive age and adult men 16 years of age and older: Four 8-ounce fish meals per month of largemouth bass or black crappie. Six 8-ounce fish meals per month of channel catfish
Apache Lake - Mercury	February 2016	Children 12 years of age and younger: Half an ounce per week or 2 ounces per month of largemouth bass Adults: 2.4 ounces per week of largemouth bass
Arivaca Lake - Mercury	1996	Do not consume fish and other aquatic organisms caught from this lake
Bartlett Lake - Mercury	July 2015	Children 12 years of age and younger: Half an ounce per week or 2 ounces per month of largemouth bass or channel catfish Adults: 2.4 ounces per week of largemouth bass or channel catfish
Bartlett Lake - Mercury	February 2016	Children 12 years of age and younger: Half an ounce per week or 2 ounces per month of flathead catfish Adults: 2.4 ounces per week of flathead catfish
Coors Lake - Mercury	February 2004	Pregnant women and children 16 years of age and younger: No consumption of largemouth bass Women of reproductive age: One 8-ounce fish meal per month of largemouth bass Adult women past reproductive age and adult men 16 years of age and older: Four 8-ounce fish meals per month of largemouth bass
Lake Pleasant - Mercury	January 2009	Pregnant women and children 6 years of age and younger: No consumption of largemouth bass Women of reproductive age and children 7 to 15 years of age: One 8-ounce fish meal per month of largemouth bass Adult women past reproductive age and adult men 16 years of age and older: Five 8-ounce fish meals per month of largemouth bass
Lake Pleasant - Mercury	February 2016	Children 12 years of age and younger: Half an ounce per week or 2 ounces per month of striped bass Adults: 2.4 ounces per week of striped bass
Lake Powell - Mercury	October 2012	Pregnant women and children 6 years of age and younger: One 4-ounce meal per month of striped bass Women of reproductive age and children 7 to 15 years of age: Two 8-ounce meals per month of striped bass Adult women past reproductive age and adult men 16 years of age and older: eight 8-ounce fish meals per month of striped bass
Lyman Lake - Mercury	October 2002	Pregnant women and children 6 years of age and younger: No consumption of walleye, largemouth bass or channel catfish Children 7 to 15 years of age: no consumption of walleye or largemouth bass; one 8-ounce fish meal per month of channel catfish Women of reproductive age: One 8-ounce fish meal per month of walleye, largemouth bass or channel catfish Adult women past reproductive age and adult men 16 years of age and older: Three 8-ounce fish meals per month of walleye and large-mouth bass; five 8-ounce fish meals per month of channel catfish
Parker Canyon Lake - Mercury	October 2002	Pregnant women and children 6 years of age and younger: No consumption of largemouth bass, bluegill or pike Children 7 to 15 years of age: no consumption of largemouth bass; one 8-ounce fish meal per month of bluegill or pike Women of reproductive age: One 8-ounce fish meal per month of largemouth bass or bluegill; two 8-ounce fish meals per month of pike Adult women past reproductive age and adult men 16 years of age and older: Three 8-ounce fish meals per month of largemouth bass; five 8-ounce fish meals per month of bluegill; six 8-ounce fish meals per month of pike
Peña Blanca Lake - Mercury	1995	Do not consume fish and other aquatic organisms caught from this lake
Roosevelt Lake - Mercury	January 2009	Pregnant women and children 6 years of age and younger: No consumption of largemouth bass or channel catfish Women of reproductive age and children seven to 15 years of age: One 8-ounce fish meal per month of largemouth bass or channel catfish Adult women past reproductive age and adult men 16 years of age and older: Five 8-ounce fish meals per month of largemouth bass or channel catfish
Tonto Creek (downstream of the north-ern boundary of Hellsgate Wilderness at Bear Flat Campground) - Mercury	July 2011	Do not consume smallmouth bass, green sunfish or black bullhead catfish For common carp in this area: • Pregnant women and children 16 years of age and younger: No consumption • Children 7 to 15 years of age: One 8-ounce fish meal per month • All adults (16 years of age and older): Two 8-ounce fish meals per month
Soldier Lake Soldier Annex Lake and Long Lake - Mercury	July 2003	Do not consume any fish caught from these lakes
Upper and Lower Lake Mary - Mercury	May 2002	Do not consume walleye fish Limit consumption of all other fish species to one 8-ounce fillet per month

Figure 1. Fish Consumption Advisories (2016)

POLLUTANTS CAUSING IMPAIRMENTS

Although nutrients impair the greatest number of lakes, mercury impairs the greatest number of lake acres. Metals impair the largest number of stream reaches and miles followed by Escherichia coli (*E. coli*). The pollutants causing impairments are summarized in the following table.

Biocriteria and bottom deposit data are included in the waterbody data summary tables for informational purposes only and no impairment determinations will be made until the Impaired Water Identification Rule (A.A.C. R 18-11, Article 6) is updated.

Pollutant Stressor Category	# Lakes	Acres	# Reaches	Miles
Nutrients and Related	35	8039	10	150.7
Nitrogen	2	167	0	0
Phosphorus	1	15	0	0
Dissolved Oxygen	11	3458	6	95.1
Ammonia	8	1956	4	55.6
pH	10	2198	(see Metals & related)	
Nutrients	2	230	0	0
Chlorophyll	1	15	0	0
Metals and related	15	72846	103	736
Mercury in fish tissue	15	45802	6	75.6
Selenium	1	27044	17	272.4
Copper	0	0	34	205.7
Zinc	0	0	13	41.9
pH	0	0	11	29.6
Cadmium	0	0	10	39.6
Beryllium	0	0	4	19.1
Lead	0	0	3	35.6
Arsenic	0	0	3	9.8
Boron	0	0	1	5.3
Manganese	0	0	1	1.4
Other	1	13	62	602.5
E. coli	1	13	48	441.5
SSC	0	0	12	149.9
Total residual chlorine	0	0	2	11.1

*Cannot total miles or acres because some waters are impaired by multiple stressors

CHAPTER 4 – ACTION PLAN

Monitoring and assessments are part of a process to identify impaired waters and then reduce discharges of pollutants in the watershed. Surface waters in Appendix B Categories 4 and 5 are impaired for one or more of their designated uses. Impaired waters that require a Total Maximum Daily Load Analysis (TMDL) are in Category 5. Waters that are not attaining a designated use and do not require a TMDL (at this time) are in Category 4. For example, once the TMDL is completed, the surface water is moved from Category 5 to Category 4A. If actions are being implemented so that surface water standards will be met during the next assessment cycle, ADEQ and EPA may agree to place the surface water in Category 4B, rather than Category 5. See the Assessment Methods document for further information.

It is important to recognize that all waters in Category 4 and 5 are protected under Arizona's Antidegradation Rule (Arizona Administrative Code R18-11-107), as a "Tier 1" water. No further degradation by that pollutant is allowed. Potential pollutant loadings must be considered by ADEQ and several federal agencies before permits or certifications are issued (e.g. AZPDES discharge permits, grazing permits).

WATER QUALITY IMPROVEMENT STRATEGIES- A NEW APPROACH

Historically, ADEQ's approach to improving water quality began with developing TMDLs for impaired waters. TMDLs identify sources of pollution, conditions leading the impairment and reductions necessary to attain water quality standards. Pollutant loading can originate from two types of sources: point and nonpoint. Point sources are discrete conveyances of pollutants discharged directly to a surface water, such as wastewater treatment plant outfalls. Nonpoint sources are non-discrete discharges, including stormwater runoff generated by activities such as grazing, agriculture and forestry.

Waste load reductions from point sources can be managed through permitting programs such as AZPDES. However, there are few regulatory actions available to control nonpoint pollution, so load reductions from these sources are primarily voluntary. Nonpoint source pollution may include excessive sediment caused by the denudation of grasslands, the location of roads, bacteria from wildlife and/or recreation, metals from road cuts through ore bodies, and pesticides from historic agricultural practices.

Historically, TMDLs would include a TMDL Implementation Plan (TIP) that identified generic strategies, agencies or groups who potentially would be involved in implementation, a tentative schedule, and how effectiveness of improvements would be determined. Once a TMDL study was complete the ADEQ Water Quality Improvement Grant Program (WQIGP) would then work with interested stakeholders to implement water quality improvement projects. Unfortunately, this approach has proven to be ineffective for reducing nonpoint source pollution.

IN 2013 ADEQ revised our approach by coordinating the TMDL and WQIPG programs with a goal of improving water quality. The focus has shifted from simply completing TMDLs to developing plans that will be implemented. The combined ADEQ Nonpoint Source (NPS) Program considers many different factors when prioritizing nonpoint source activities:

- Human health concerns

- Ecosystem health including ecological risk
- The beneficial uses of water
- Value of the watershed or groundwater basin to the public
- Vulnerability of the surface or ground water to additional environmental degradation
- Implement-ability
- Likelihood of achieving demonstrable environmental results
- Extent of alliance with other federal agencies and states to coordinate resources and actions
- Readiness to proceed.

NPS Program staff meets routinely to discuss Arizona's impaired waters and what management strategies can be applied to them in order to work towards meeting water quality standards. The Impaired Waters Table is the tool that showcases these coordination efforts. Arizona reports on updates to this table annually in its Nonpoint Source Annual Report- http://www.azdeq.gov/environ/water/watershed/download/nonpoint2015.pdf. This tool allows the program to focus efforts on high priority Targeted Watersheds, while keeping track of the potential role that nonpoint source resources may be able to play in other waters throughout the state. Arizona's current Targeted Watersheds and pollutants of concern are:

- San Francisco River/Blue River watershed (Blue River from headwaters to San Francisco River, San Francisco River from Blue River to Limestone Gulch and from Limestone Gulch to the Gila River; *E. coli*)
- Granite Creek watershed (headwaters to Watson Lake; nutrients and *E. coli*)
- Oak Creek watershed (headwaters to Spring Creek and the Spring Creek drainage; *E. coli*)
- San Pedro River watershed (Babocomari Creek to Dragoon Wash; *E. coli*)
- Little Colorado River Headwaters watershed (West Fork LCR to Lyman Lake – four reaches; sediment/turbidity).
- Santa Cruz River watershed (Mexico border to Sapori Wash; *E. coli*)
- Boulder Creek watershed (Wilder Creek to Butte Creek; arsenic, copper, and zinc)
  Impaired Waters List (303(d)-List)

Appendix C contains the 2016 303(d)List of Impaired Waters while Appendix G contains the priority ranking of the 303(d) Listed waters. Waters located in Targeted Watershed are high priority as are those waters that ADEQ anticipates TMDL completion within the next two years.

WATER QUALITY IMPROVEMENT GRANTS

Clean Water Act Section 319(h) funds are used to implement on-the-ground water quality improvement projects that address nonpoint sources of pollution. ADEQ administers these grants through our WQIGP. Projects designed to reduce loadings of pollutants causing impairment are given highest priority. As documented in the table in Appendix F, even before a TMDL can be developed, funds are often distributed to implement projects that will reduce pollutant loadings. Additional information can be obtained from the ADEQ website (http://www.azdeq.gov/environ/water/watershed/index.html#wqig).

DETERMINING WATER QUALITY IMPROVEMENTS

Once a TMDL has been developed, the surface water is removed from the 303(d) list, but usually the water is still impaired and simply moves from the Category 5 to the Category 4A list of not attaining (still impaired) waters. To determine that a water is no longer impaired by a pollutant, ADEQ must conduct additional monitoring. These new data must be collected during critical conditions – those environmental factors (stream flow, season, runoff events, location, runoff events) during which an exceedances of a water quality standard or criterion is most likely to occur based on past exceedances or modeling results. There may also be critical locations or sites where exceedances are most likely to occur. Critical conditions and locations are identified in Appendix D. This list is constantly being revised as new information is analyzed.

The number of samples required to establish that a surface water is no long impaired varies by type of pollutant, but the factors are specified in the Impaired Water Identification Rule (see 2016 Assessment Methods document). The delisting criteria vary depending on the criteria used during the listing. Waters that have been delisted in the 2016 Assessment are contained in Appendix E.

Although assessments are not compliance based actions, once an assessment unit is identified as impaired, there are indirect consequences on dischargers or potential activities in the drainage area. For example, any entity seeking a permit for a new discharge or renewing an existing permitted discharge under the National (or Arizona) Pollutant Discharge Elimination System (NPDES/AZPDES) Program must demonstrate that it will not increase loadings for the parameter identified as causing the impairment. During the permit review cycle, additional monitoring may be required for the pollutant of concern. If discharge monitoring data or ambient in-stream monitoring data is available from a permitted facility, it may be used to model the discharge load during the TMDL. Such data can be used to accurately quantify the contribution from waste loads. After the TMDL is completed, ADEQ may renegotiate the permit discharge levels if the TMDL indicates that a waste load reduction is necessary. Discharge monitoring and ambient in-stream monitoring is invaluable in developing realistic discharge limitations.

Another example is that federally approved actions, such as grazing permits, may also be restricted when a stream is listed as impaired, if those actions would contribute pollutant loadings. ADEQ actively coordinates with the U.S. Forest Service and the Bureau of Land Management to identify strategies that would minimize load reductions especially to impaired waters.

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