

Revising the Impaired Water Identification Rule



Clean Water Act Requirements



- CWA §305(b) requires assessment of all surface waters every two years using “all readily available data”
- CWA §303(d) requires list of impaired waters every two years



EPA Oversight

- Assessment and list of impaired waters submitted to EPA Region IX as an Integrated Report
- EPA has maintained authority to approve or disapprove 303(d) list (CFR §130.7)

Attaining Assessments

- Set of core parameters
 - What pollutants we expect to find in Arizona
 - What parameters are indicators of stream health
- We need at least 3 samples seasonally distributed to call something “attaining all uses,” provided **no exceedances are found**

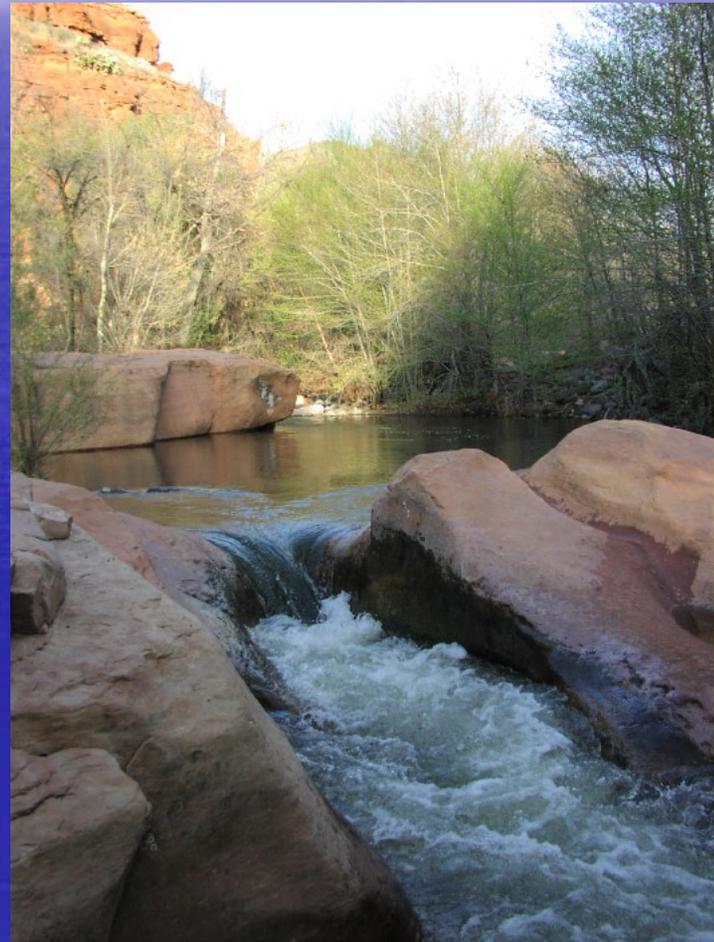
If everything is meeting standards, we do not pick up the Impaired Waters Rule (provided no problems in previous assessment)

Impaired Assessments

- Statute adopted in 2000 required that we establish in rule:
 - Credible data requirements for listing
 - Minimum sample size requirements for listing
 - 303(d) listing and delisting methods
- Impaired Water Identification Rule was adopted in 2002

Methods to determine impairment

- **Statistical method - Binomial Approach**
 - >10% exceedance rate at given confidence level (90%)
- **Method for “acutely toxic” parameters**
 - >1 exceedance in 3 years
- **Method for statistically-based standards**
 - >1 exceedance after statistical calculation is applied



Determination of Impairment

It is ADEQ's responsibility to:

- Determine whether ANY PORTION of a reach or lake is impaired, and
- Determine whether it is impaired AT ANY TIME (provided the problem is persistent or recurring).



Determination of Impairment

- If at one site on a 10 mile stream reach, we find repeated WQ violations...
 - Does this constitute impairment? Yes.
 - The TMDL study will confirm the source and delineate the extent of the impairment.
- If a stream reach is attaining its uses during most of the year, but repeatedly violates standards during times of heavy recreational use...
 - Does this constitute impairment? Yes.
 - TMDL study and implementation plan will address these critical conditions.

The Binomial Approach

The **binomial approach** is applied to:

- **Human health criteria** to protect for recreation and consumption;
- **Conventional standards** (e.g., dissolved oxygen) to protect Aquatic and Wildlife use; and
- Standards to protect **agricultural uses**.

The Binomial Approach

- EPA assessment guidance -- impaired if $>10\%$ of samples exceed standards.
 - 1 of 10 samples is 10% - not impaired
 - 2 of 10 samples is $>10\%$ - impaired
- EPA guidance also suggests that a statistical approach should be used to reduce listing error
 - Placing a water on the list that is not truly impaired
 - Not placing a water on the list that is truly impaired
- The binomial
 - Use the statistics of a binomial distribution curve to determine the number of samples and exceedances at an acceptable confidence level.
 - By establishing a confidence level, we correct for potential sampling error.
 - For example, at a 95% confidence level, $>10\%$ exceedances becomes 3 of 10 samples - impaired

The Binomial Approach: Show us the Statistics

- Our binomial was modeled after the binomial developed by **Florida's Dept of Environmental Protection**.
- Florida State University (FSU) Dept of Statistics provided the statistical basis for listing and delisting criteria. Their report's conclusions were:
 - for 95% confidence that the *true exceedance rate* is >10%:
 - a. The minimum number of samples is 10.
 - b. The minimum number exceedances is 3.

The Binomial Approach Minimum Sample Size

- ADEQ can justify using 10 instead of 20 samples because:
 - Data must meet credible data requirements.
 - IWIR has a provision to not list if exceedance is due to temporary conditions (such as a spill)
 - Other provisions in IWIR, statute, and surface water standards allow ADEQ to not list if impairment due to natural conditions, other actions will result in standards being met, etc.

Revising the Binomial

- ADEQ proposes reducing min. sample size from 20 to 10, and min. # exceedances from 5 to 3
- So, the listing minimum becomes 3 of 10 exceedances
 - But, we will go ahead and make a listing if sufficient exceedances have already occurred (3 of 3, 3 of 9)
 - Exceedances must have occurred during at least 3 monitoring events.

Revising the Binomial

- The probability a $>10\%$ exceedance rate, when you have 3 exceedances in 3-9 samples?
 - Between 99 – 100% probability!!!
(using the BINOMDIST function in Excel)
- Why is the 10 sample minimum important?
 - Once we get an exceedance, we need to get at least 10 samples to make a call
 - If we made the min. sample size 3, we could call 2 of 3 exceedances attaining

Revising the Binomial

- We can choose to delay making a listing until at least 10 samples were collected using the weight-of-evidence approach. Considerations would include:
 - Probable anthropogenic sources in watershed
 - Associated pollutants exceeding standards
 - Extent of exceedances (upstream or downstream too)
 - Magnitude of exceedances
 - Diurnal variability
 - More direct measurement of impacts available

Revising the Binomial

- ADEQ also proposes to raise the confidence level from 90% confidence to 95% confidence.
 - This would conform to the confidence level recommended in the FSU report and statistically increase the reliability of assessments.
 - The change would require more samples exceed standards before a listing is made.
 - This change would also increase minimum sample size to support delistings (once impaired).

Revising the Binomial Impaired

EXISTING

Impaired

- Impaired if $>10\%$ at a 90% confidence level,
- Minimum of 5 exceedances over 3 sampling events,
- Minimum of 20 total samples.

PROPOSED

Impaired

- Impaired if $>10\%$ at a 95% confidence level,
- Minimum 3 exceedances over 3 sampling events,
- Minimum of 10 samples, unless sufficient exceedances have already occurred (3 exceedances).

Revising the Binomial Attaining

EXISTING

Attaining

- Attaining if $<$ or $=10\%$ at an 80% confidence level,
- Minimum of 3 sampling events,
- Seasonal distribution

In other words, **less than it takes to get on the Planning List**

PROPOSED

Attaining

- Attaining if $<$ or $=10\%$ at an 85% confidence level,
- Minimum of 3 sampling events,
- Seasonal distribution.

Also less than it takes to get on the Planning List, **HOWEVER, we have removed the Planning List from rule**

Revising the Binomial

- Impaired
if $>10\%$ exceedance rate, at
95% confidence level
- Attaining
if $< \text{or} = 10\%$ exceedance rate,
at 85% confidence level
- Inconclusive
is everything in between



Revising the Binomial Approach Delisting

EXISTING

Delisting

- Attaining if $<$ or $=10\%$ at an 80% confidence level,
- Minimum of 3 sampling events,
- Seasonal distribution
- Samples must account for critical conditions.

(same as attaining – less than it takes to get on the Planning List)

PROPOSED

Delisting

- Based on $\leq 10\%$ at 95% confidence level with reverse hypothesis. Attaining if 0 exceed in 27 samples minimum. (Table 4)
- Samples must account for critical conditions.
- If documented improvements, use attainment based on the $\leq 10\%$ at 85% confidence level.

Revising the Binomial

How do we account for "unique conditions?"

- **Assessments are not water quality studies.** Assessments are based on a number of water quality exceedances, modified by the weight of evidence approach and exceptions specified in the IWIR.
 - The binomial is simply a statistical method to **account for a margin of error.**
 - If studies have been completed, the **weight-of-evidence approach, "natural background condition,"** and other exceptions in the IWIR provide the opportunity to not list.
 - **The TMDL investigation** should address unique Arizona conditions.
 - Surface water quality **standards** are modified as we learn more about Arizona's unique conditions.

Revising the Binomial

Avoiding Unnecessary Listings

- The assessment process has been modified to ensure that a listing is merited, while also being protective of the natural resources.
 - Credible data requirements (IWIR 602);
 - Binomial corrects for potential sampling error (IWIR new 604C);
 - Weight-of-evidence (IWIR new 604E);
 - Probable anthropogenic sources in watershed
 - Associated pollutants exceeding standards
 - Extent of exceedances (upstream or downstream too)
 - Magnitude of exceedances
 - Diurnal variability
 - More direct measurement of impacts available
 - Specific exempted conditions (IWIR new 604F);
 - Extensive public review process for the 303(d) List; and
 - The regulated community is encouraged to provide monitoring data from surface waters receiving discharges.
 - Water quality data, and
 - Flow data.

Planning List

Concern when current IWIR was adopted - waters removed from the 1998 303(d) List would be lost. Planning List would track them. Also could serve as a "warning" that a water may be listed soon.

- However, we now track all waters assessed within the five categories: Attaining all uses, Attaining some uses, Inconclusive, Impaired, Not attaining
- This is a much more complete list than what is specified in rule. Almost all waters are scheduled for further monitoring:
 1. Impaired waters
 2. Fixed station sites
 3. Waters with exceedances
 4. TMDL effectiveness monitoring
 5. Waters missing core parameters or sampling events
 6. Waters attaining all uses
 7. Waters lacking any data

Planning List

ADEQ proposes to **remove all material related to the Planning List from the IWIR**

- Planning List is not directly related to identification of impaired waters – it is a tool that we use to prioritize monitoring
- Removal would simplify rule and focus it solely on impaired water identification
- We will **not change our surface water tracking methods**
 - All waters monitored will be tracked through the years in the Integrated Report

Escherichia coli: Listing Criteria

Issues to resolve:

- Is the **>1 exceedance in 3 years** for **single sample max** appropriate with all types of datasets?
- *E. coli* analysis results in a **"most probable number;"** therefore, should listing criteria account for this wide margin of error?
- When applying the **geometric mean standard**, what is the **appropriate time interval** (e.g., 30-day, annual swimming season, annual, all data)?
- How should a **"greater than" value** be handled within a geometric mean calculation?

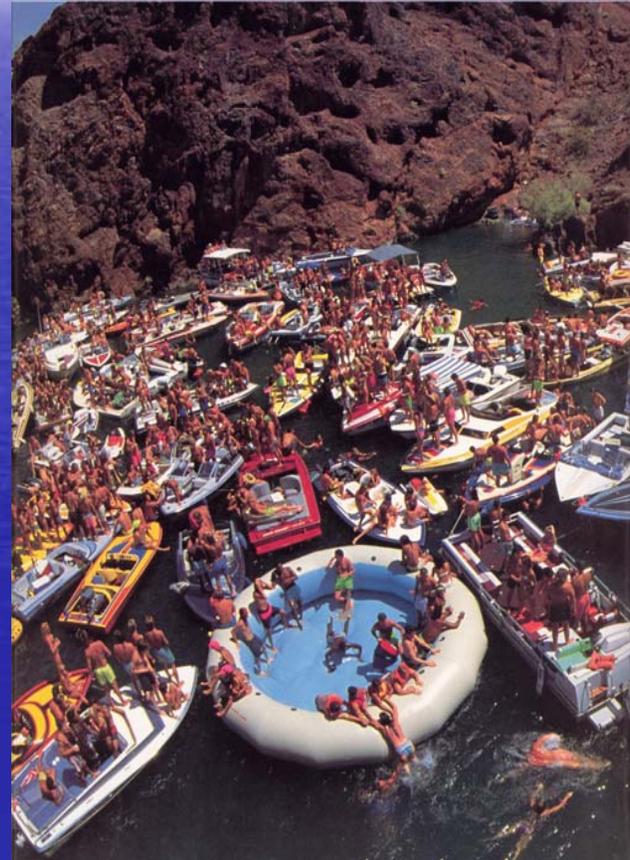
Escherichia coli: Single Sample Max

Do we always need to make a listing based on:

>1 exceedance in 3 years?

Should we look at these exceedances differently?

- 2 exceed in 4 samples
- 2 exceed in 400 samples
- Exceedances at separate sites
- Sporadic exceedances



Escherichia coli: Single Sample Max

- EPA Guidance

Implementation Guidance for Ambient Water Quality Criteria for Bacteria –
Draft November 2003

- Where swimming and water recreation is likely, **monitoring should occur on a weekly basis.**
- Waters not likely to be used for recreation can be **monitored less often.**
- If only a few samples, **no samples** should exceed the single sample maximum.
- Where sufficient samples, **inferential statistics (e.g., binomial)** should be used to provide the most certainty in attainment decisions.

Escherichia coli: Single Sample Max

- **Proposal for larger datasets:**
 - Larger datasets = approximately 1 sample per week during the swimming season.
 - **Use modified binomial approach.**
 - Impaired if >10% of sampling events exceed at 95% confidence level during at least 1 year.
 - Attaining if 10% or fewer sampling events exceed.
 - Samples within 7 days are combined (sampling event).
 - **Assess based on exceedances per site per year.**

Note: In 2004, large datasets occurred at: Slide Rock State Park, Lake Havasu, Lake Powell, and the Salt River tubing area. Sites monitored weekly generally have about 50 samples per site per year.

Escherichia coli: Single Sample Max

- **Proposal for smaller datasets:**
 - Small dataset (all other datasets)
 - **Use the existing assessment criteria**
 - Impaired if:
 - >1 sample exceedance in 3-year monitoring period. Minimum of 2 sampling events.
 - Attaining if:
 - 0 exceedances of standards in the last 3 years of monitoring.
 - Minimum of 3 sampling events.
 - Samples taken within a 7-day period are combined.

The majority of data will be handled this way.

Escherichia coli

Most Probable Number

- Working with a Most Probable Number
 - With bacterial samples, when the result is reported as 240 CFU, the result is between 100 to 940 CFU at a 95% confidence level.

Recommendation:

- Use a screening value to account for this large margin of error in the results.

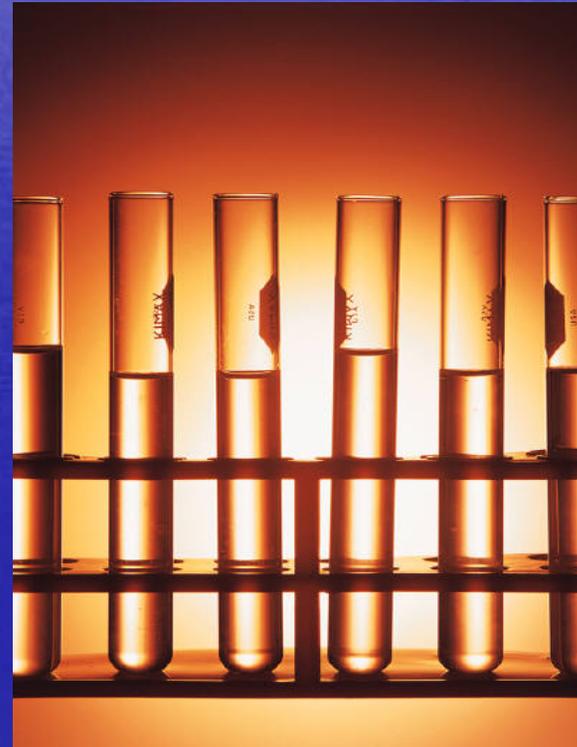
	Full Body Contact	Partial Body Contact
Standard	235 CFU	576 CFU
Screening Value	300 CFU	750 CFU

Screening value is 1.3 times the standard or 30% higher.

Escherichia coli

Most Probable Number

- Proposal:
 - When applying single sample maximum standard, listings will be based on exceedances of the screening value.
 - If exceeding the standard, but not the screening value, assess as inconclusive.
 - The screening value will only be used in listing decisions. To determine attainment or delisting, we will use the standard.



Escherichia coli: Geometric Mean

- What time interval should be applied to the *E. coli* geometric mean standard when assessing water quality?
 - New surface water standards require a minimum of four samples but does not set a time period.
 - The Impaired Water Identification Rule references a 30-day period (old surface water quality standard, subsequently replaced).
 - What is a valid time period? 30 days? Swimming season (May – Sept)? Five years of data?

Escherichia coli: Geometric Mean

- **EPA Guidance**

Consolidated Assessment and Listing Methods (CALM) (2002)

- Geometric mean should be based on 5 samples or more, equally spaced over a 30-day period.
- Impaired if geometric mean is exceeded during recreational season.

Note that impairment is based on 1 exceedance of a geometric mean, rather than >1 exceedances.

Escherichia coli: Geometric Mean

- **EPA Guidance**

Implementation Guidance for Ambient Water Quality Criteria for Bacteria – Draft November 2003

- Monitor primary swimming areas at least once a week during the swimming season
- Geometric means may be calculated for specified periods of time (e.g., monthly, seasonal, or annual geometric mean).
- Where insufficient samples to calculate a geometric mean, use the single sample maximum to assess.

Escherichia coli: Geometric Mean

- Recommendations:
 - Assessments will be based on either exceedances of a single sample maximum or a geometric mean (this is nothing new).
 - If assessed as impaired due to exceedances of single sample maximum standards, geometric means will not be calculated.
 - Calculate the geometric mean in two ways:
 - If least 4 samples in a calendar month, **calculate a monthly geometric mean.**
 - If insufficient samples to calculate a monthly geometric mean, but at least 4 samples in a calendar year, **calculate an annual geometric mean.**

Impaired if either geometric mean calculation exceeds the standard one or more times.

Escherichia coli: Data Interpretation

- Example: Data Interpretation for Geometric Mean Calculations

Geometric mean does not exceed standard of 126 CFU

Single sample maximum is much more likely to be reason for listing. Note in this example, geometric mean is not exceeded although 4 of 5 samples exceeded 126.

Escherichia coli Results

Lab Result	Lab Note	Result Used In Calculation
132		132
2	K	1
220		220
159		159
2419	L	3628.5

Lab notes: L = greater than, K = less than

Geometric mean = 101

Escherichia coli: Summary

- **Proposal Summary**
 - Screening values for single sample maximum
 - **Impaired based on exceedances of screening values**
 - Full Body Contact = 300 CFU
 - Partial Body Contact = 750 CFU

Escherichia coli: Summary

- **Proposal Summary**

- Single Sample Maximum assessments will vary based on:

- If a large reservoir and **distant sites, assess based on exceedances/site.**
 - **If small dataset – Use existing assessment criteria**
 - Impaired if >1 sample exceeds screening value in 3 years.
 - Minimum of 2 sampling events exceed.
 - **If large dataset (1 sample per week during swimming season) use binomial approach.**
 - Impaired if >10% samples exceed screening value with a 95% confidence level.
 - Minimum of 3 sampling events exceed.

Escherichia coli: Summary

- **Proposal Summary**

- Geometric means

- Assess if not already impaired based on single sample maximum
 - Impaired based on **one exceedance of a geometric mean**.
 - Calculate **monthly geometric mean** if at least 4 samples/month.
 - Calculate **annual geometric mean**, if insufficient samples to calculate monthly geometric mean, but at least 4 samples in a calendar year.
 - If analytical result is reported as "greater than" or "Too Numerous To Count," **multiply result by 1.5** to determine geometric mean.

Chronic Aquatic and Wildlife Criteria

Chronic A&W criteria are developed for a particular pollutant based on all available information concerning toxicity to, and bioaccumulation by, aquatic organisms.

Chronic criteria are established for to **protect aquatic life during a 96-hour exposure period.**



Chronic Aquatic and Wildlife Criteria

EPA Technical Support Document (1991)

(Guidance for point source dischargers of toxic pollutants.)

- Excursions can occur **no more often than once in 3-years**. An ecosystem should be able to recover that often from a marginal criterion excursion.
 - Recovery periods may be longer than 3 years if:
 - Multiple minor excursions (frequency),
 - A single major excursion (magnitude),
 - Affected area is large (extent), or
 - Persistent pollutant (duration).

Chronic Aquatic and Wildlife Criteria

EPA 2004 Assessment Guidance

- Guidance and instructions to states on how to do assessments and what to submit.
- Impaired if **acute or chronic A&W criteria for toxics are exceeded more than once in a 3-year period.**

EPA CALM Guidance – 2002 (assessment guidance for states)

- Evaluate criteria based on **grab or composite samples**

Chronic Aquatic and Wildlife Criteria

- Our original proposal:
 - Modified binomial approach (>10% exceedance at 95% confidence level),
 - Frequency of exceedances,
 - Plus specific supporting evidence:
 - Magnitude of exceedances,
 - Duration of exceedances, and
 - Extent of the contamination area.

Chronic Aquatic and Wildlife Criteria Reconsidering the Binomial

- However:
 - A 10% binomial really has **no applicability to chronic criteria**
 - Aquatic life cannot tolerate exceedances 10% of the time, only one 4-day period
 - If we use a statistical approach, it must be based on **>1 exceedance of a 4-day period over 3 yrs.**
 - Or, **>1 exceedance of 274 4-day periods in 3 yrs.**
 - 1 of 274 = 0.36%
 - Using the binomial, we would need to calculate **>0.36% samples exceed at 95% confidence level**

Chronic Aquatic and Wildlife Criteria Reconsidering the Binomial

This comes out to:

- 2 to 215 samples – impaired if 2 or more exceed
- 216 to 361 samples – impaired if 3 or more exceed

Basically, we're back where we started:

>1 exceedance = impaired

Chronic Aquatic and Wildlife Criteria New Proposal

We developed the following proposal:

To be adequately resource protective, we must use a grab sample to evaluate chronic criteria, unless evidence is available to show that chronic conditions were not occurring.

Therefore, we propose to incorporate the following concepts in rule:

- Provisions for exemptions of exceedances, and
- Incorporation of the weight-of-evidence approach for "marginal calls."

Chronic Aquatic and Wildlife Criteria New Proposal

- Exceedances will be excluded if:
 - Documentation is provided that the flow conditions under which the exceedances occurred lasted less than 4 days
 - Gage station data, flow records, discharge records could be used.
 - Important: this does not necessarily exclude storm flow exceedances. If high flow was consistent for 4 days, exceedance cannot be excluded.
- Proposal: include in “Exceptions” section
(Note also: If four consecutive days of samples are available, we will calculate a mean or median and compare that value to the standard)

Chronic Aquatic and Wildlife Criteria New Proposal

For “marginal” calls, the weight-of-evidence approach will be used:

- We would consider to be “marginal:”
 - Only two exceedances
 - Exceedances only during storm flows
 - Diurnal variability

Chronic Aquatic and Wildlife Criteria New Proposal

- For these marginal cases, additional evidence would be needed to list:
 - Probable anthropogenic sources in watershed
 - Associated pollutants exceeding standards
 - Extent of exceedances (upstream or downstream too)
 - Magnitude of exceedances
 - Diurnal variability
 - More direct measurement of impacts available

If there is supporting evidence, then we will list. If there is not supporting evidence, then we will make the case to not list and target more monitoring.

- Proposal: Clarify these concepts in the weight-of-evidence approach

Statistically Derived Criteria

- **Nutrient Annual Mean**
 - Minimum of 2 samples per month and 3 months during a 12 month period. (Data only available if special investigation)
- **Nutrient 90th Percentile**
 - Requires at least 10 samples, taken at least 10 days apart, within 12 months. (Data only available if special investigation)
- **Flow-weighted average annual salinity in Colorado River**
 - Minimum sample size not established.
- ***E. coli* geometric mean**
 - Minimum of 4 samples per month for a monthly geomean,
 - Minimum of 4 samples within a 12 month period if annual geomean.

Statistically Derived Criteria

Propose changing listing requirement from >1 exceedance to one or more exceedance for these statistically-based standards.

- In most cases, a significant amount of data is needed to calculate one exceedance. **Minimum sample size requirements established within the standard.**
- Such statistics smooth out results so that a couple of exceedances are not over-emphasized. If you have exceedance of a mean or percentile, you have **shown that the problem is persistent** without need for " >1 ."
- As seen by talking with other states about applying a geometric mean for bacteria data, this is **consistent with standard methods used by other states.**

Statistically Derived Criteria

Existing

- Impaired if >1 exceedance.
- Attaining if 0 exceedances criteria.
- Delist if 0 exceedances in monitoring period, with seasonal distribution.
 - Sampling must account for critical conditions.

Proposal:

- Impaired if 1 or more exceedance.
- Attaining if 0 exceedances of criteria. (No change)
- Delist 0 exceed in monitoring period, with seasonal distribution. (No change)
 - Sampling must account for critical conditions.



www.azdeq.gov/environ/water/assessment/index.html