STATE OF ARIZONA

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April 5, 2002

Ms. Jacqueline E. Schafer, Director
Arizona Department of Water Quality
3033 North Central Avenue
Phoenix, AZ 85012

Re: Revisions to State Water Quality Standards, A.A.C. Title 18, Chapter 11, Article 1, adopted January 16, 2002.

Dear Ms. Schafer:

We have reviewed the above-referenced Rule and have determined pursuant to 40 C.P.R. §131.6(e), that it was duly adopted in accordance with state law.

Yours very truly,

Janet Napolitano
Attorney General

REQUEST FOR ATTORNEY GENERAL'S APPROVAL/SIGNATURE

(This cover sheet should accompany all packages requesting the Attorney General's signature or approval. Note: Urgent items should be printed on lime green paper; routine items on white paper.)

AG/ADM RECEIVED MAR 25 2002

To: Janet Napolitano
Attorney General
thru
Dennis Burke
Chief Deputy Attorney General

From: Name: Steven J. Burr
Section: PAD/EES
Phone: (602) 207-4251 (ADEQ)
Date: March 25, 2002

RESPONSE NEEDED BY: March 26, 2002

RECEIVED APR - 9 2002 AZ DEPT. OF ENVIRONMENTAL QUALITY WATER QUALITY DIVISION

RECEIVED APR 09 2002 ADEQ Office of Special Counsel

ACTION
- X Letter for Signature
- X Material for Approval
- X Response to Request by Steven J. Burr
- ☐ Other

SUBJECT/DESCRIPTION OF PACKAGE BEING SUBMITTED:
Certification under 40 C.F.R. § 131.6(e) that revised state water quality standards were duly adopted pursuant to state law. A draft letter of certification is attached.

BRIEF SYNOPSIS

Section 303 of the Clean Water Act, 33 U.S.C. § 1313, requires the states to adopt surface water quality standards that consist of the designated uses for navigable waters within the state and water quality criteria based on those uses. Under section 303(c) of the Act, the states must conduct triennial reviews of their water quality standards and submit any necessary revisions to EPA for approval. Section 131.6(e) of 40 C.F.R. requires the state submission to include certification "by the State Attorney General or other appropriate legal authority within the state that the water quality standards were duly adopted pursuant to state law.

ADEQ is the state agency for all purposes of the Clean Water Act under A.R.S. § 49-202(A) and is therefore responsible for conducting this triennial review. ADEQ published proposed revisions to the state water quality standards in the state administrative register in accordance with A.R.S. § 49-1022 on May 4, 2001, 7 Ariz. Admin. Register 1819. Pursuant to A.R.S. § 41-1024(E), ADEQ submitted a final rule package consisting of the preamble; the exact wording of the rule; the concise explanatory statement; and the economic, small business and consumer impact statement to the Governor's Regulatory Review Council on January 16, 2002. The council approved the rule by consent at its regular meeting on February 5, 2002. The revisions have been duly adopted pursuant to state law.

The state's triennial review is approximately one year overdue. Karen Smith, the Director of the ADEQ Water Quality Division, is scheduled to meet with Alexis Strauss, the Director of the EPA Region 9 Water Division on March 26, 2002, and would very much like to submit the water quality standard revisions to her at that time.

APPROVED:		DATE:
Nancy Jamison	Section Chief	3-25-02
Paul Bullis	Division Chief	3-25-02
Dennis Burke	Chief Deputy Atty. Gen.	3/25/02
Janet Napolitano	Attorney General	4-5-02

RequestForAGApproval.wpd

(See Part 1 of this issue of the Register for the Preamble of this Notice of Final Rulemaking.)

TITLE 18. ENVIRONMENTAL QUALITY

CHAPTER 11. DEPARTMENT OF ENVIRONMENTAL QUALITY WATER QUALITY STANDARDS

ARTICLE 1. WATER QUALITY STANDARDS FOR SURFACE WATERS

Section
R18-11-101. Definitions
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R18-11-106. Net Ecological Benefit
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R18-11-108. Narrative Water Quality Standards
R18-11-109. Numeric Water Quality Standards
R18-11-110. Salinity ~~of~~ Standards for the Colorado River
R18-11-111. Analytical Methods
R18-11-112. Unique Waters
R18-11-113. ~~Effluent-dependent~~ Effluent-dependent Waters
R18-11-114. Mixing Zones
R18-11-115. ~~Nutrient Waivers~~ Repealed
R18-11-118. Dams and Flood Control Structures
R18-11-120. Enforcement
R18-11-121. Schedules of Compliance
R18-11-122. Variances
R18-11-123. Prohibition Against Discharge~~; Sabino Creek~~
Appendix A.Numeric Water Quality Criteria
Appendix B.List of Surface Waters and Designated Uses

ARTICLE 1. WATER QUALITY STANDARDS FOR SURFACE WATERS

R18-11-101. Definitions

The terms of this Article ~~shall~~ have the following meanings:

1. "Acute toxicity" means toxicity involving a stimulus severe enough to ~~rapidly~~ induce a response rapidly. In aquatic toxicity tests, an effect observed in 96 hours or less is considered acute.
2. "AgI" means agricultural irrigation.
3. "AgL" means agricultural livestock watering.
4. "Agricultural irrigation" means the use of a surface water for the irrigation of crops.
5. "Agricultural livestock watering" means the use of a surface water as a supply of water for consumption by livestock.
6. "Annual mean" means the arithmetic mean of monthly values determined over a consecutive 12-month period, provided that monthly values are determined for at least ~~3~~ three months. The monthly value is the arithmetic mean of all values determined in a calendar month.
7. "Aquatic and wildlife (cold water ~~fishery~~)" means the use of a surface water by animals, plants, or other cold-water organisms~~, including salmonids~~, generally occurring at elevations greater than 5000 feet, for habitation, growth, or propagation.
8. "Aquatic and wildlife (~~effluent-dependent~~ effluent-dependent water)" means the use of an ~~effluent-dependent~~ effluent-dependent water by animals, plants, or other organisms for habitation, growth, or propagation.
9. "Aquatic and wildlife (ephemeral)" means the use of an ephemeral water by animals, plants, or other organisms, excluding fish, for habitation, growth, or propagation.
10. "Aquatic and wildlife (warm water ~~fishery~~)" means the use of a surface water by animals, plants, or other warm-water organisms~~, excluding salmonids~~, generally occurring at elevations less than 5000 feet, for habitation, growth, or propagation.
11. "A&Wc" means aquatic and wildlife (cold water ~~fishery~~).
12. "A&We" means aquatic and wildlife (ephemeral).
13. "A&Wedw" means aquatic and wildlife (~~effluent-dependent~~ effluent-dependent water).
14. "A&Ww" means aquatic and wildlife (warm water ~~fishery~~).

15. "Clean Water Act" means the Federal Water Pollution Control Act~~, as amended by the Water Quality Act of 1987~~ [33 U.S.C. §§ 1251 to 1387].
16. "Criteria" means elements of water quality standards that are expressed as pollutant concentrations, levels, or narrative statements representing a water quality that supports a designated use.
17. "Designated use" means a use specified in Appendix B of this Article for a surface water.
18. "Domestic water source" means the use of a surface water as a potable water supply. Coagulation, sedimentation, filtration, disinfection, or other treatments may be necessary to yield a finished water suitable for human consumption.
19. "DWS" means domestic water source.
20. "EDW" means ~~effluent-dependent~~ effluent-dependent water.
21. ~~"Effluent-dependent~~ Effluent-dependent water" means a surface water that consists ~~primarily~~ of discharges of treated wastewater~~ which has been~~ that is classified as an ~~effluent-dependent~~ effluent-dependent water by the Director under R18-11-113. An effluent-dependent water is a surface water that, without the discharge of treated wastewater, would be an ephemeral water.
22. "Ephemeral water" means a surface water that has a channel that is at all times above the water table, and that flows only in direct response to precipitation~~, and that does not support a self-sustaining fish population)~~.
23. "Existing use" means a use of a surface water that~~ has actually occurred~~ occurs in a surface water ~~on or after November 28, 1975~~ or a use that the existing water quality of a surface water will allow.
24. "FBC" means ~~full body~~ full-body contact.
25. "FC" means fish consumption.
26. "Fish consumption" means the use of a surface water by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, turtles, crayfish, and frogs.
27. "~~Full body~~ Full-body contact" means the use of a surface water~~ which~~ for swimming or other recreational activity that causes the human body to come into direct contact with the water to the point of complete submergence. The use is such that ingestion of the water is likely ~~to occur~~ and ~~certain~~ sensitive body organs, such as the eyes, ears, or nose, may be exposed to direct contact with the water.
28. "Geometric mean" mean the nth root of the product of n items or values. The geometric mean is calculated using the following formula:

$$G.M._Y = \sqrt[n]{(Y_1)(Y_2)(Y_3)...(Y_n)}$$

29. "Hardness" means the sum of the calcium and magnesium concentrations, expressed as calcium carbonate ($CaCO_3$) in milligrams per liter.
30. "Intermittent surface water" means a surface water that flows continuously for 30 days or more at times of the year when the surface water receives water from a spring or from another source such as melting snow.

~~30.~~31. "Mixing zone" means a prescribed area or volume of a surface water that is contiguous to a point source discharge where initial dilution of the discharge takes place.

~~31.~~32. "National Pollutant Discharge Elimination System" means the point source discharge permit program established by § 402 of the Clean Water Act [33 U.S.C. § 1342].

~~32.~~33. "Ninetieth percentile" means the value which may not be exceeded by more than 10% of the observations in a consecutive 12 month period. A minimum of 10 samples, each taken at least 10 days apart, are required to determine a ninetieth percentile.

~~33.~~34. "NNS" means no numeric standard.

~~34.~~35. "Oil" means petroleum in any form, including but not limited to crude oil, gasoline, fuel oil, diesel oil, lubricating oil, or sludge.

~~35.~~36. "~~Partial body~~ Partial-body contact" means the recreational use of a surface water~~ which~~ that may cause the human body to come into direct contact with the water, but normally not to the point of complete submergence (for example, wading or boating). The use is such that ingestion of the water is not likely ~~to occur, nor will~~ and sensitive body organs, such as the eyes, ears, or nose, will not normally be exposed to direct contact with the water.

~~36.~~37. "PBC" means ~~partial body~~ partial-body contact.

38. "Perennial surface water" means a surface water that flows continuously throughout the year.
39. "Pollutant" means fluids, contaminants, toxic wastes, toxic pollutants, dredged spoil, solid waste, substances and chemicals, pesticides, herbicides, fertilizers and other agricultural chemicals, incinerator residue, sewage, garbage, sewage sludge, munitions, petroleum products, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and mining, industrial, municipal, and agricultural wastes or any other liquid, solid, gaseous, or hazardous substance.

~~37.~~40. "Practical quantitation limit" means the lowest level of quantitative measurement that can be reliably achieved during routine laboratory operations.

~~38.~~41. "Recreational uses" means the ~~full body~~ full-body contact and ~~partial body~~ partial-body contact designated uses.

~~39.~~42. "Regional Administrator" means the Regional Administrator of Region ~~9~~ IX of the U.S. Environmental Protection Agency.

~~40.~~43. "Surface water" means a water of the United States and includes the following:

a. ~~All waters which are~~ A water that is currently used, ~~were~~ was used in the past, or may be susceptible to use in interstate or foreign commerce;

b. ~~All~~ An interstate ~~waters~~ water, including an interstate ~~wetlands~~ wetland;

c. All other waters, such as an intrastate ~~lakes, reservoirs, natural ponds, rivers, streams (including intermittent and ephemeral streams), creeks, washes, draws, mudflats, sandflats, wetlands, sloughs, backwaters, prairie potholes, wet meadows, or playa lakes,~~ lake, reservoir, natural pond, river, stream (including an intermittent or ephemeral stream), creek, wash, draw, mudflat, sandflat, wetland, slough, backwater, prairie pothole, wet meadow, or playa lake, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce, including any such ~~waters~~ water:

i. ~~Which are~~ That is or could be used by interstate or foreign travelers for recreational or other purposes;

ii. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

iii. ~~Which are~~ That is used or could be used for industrial purposes by industries in interstate or foreign commerce;

d. ~~All impoundments of waters otherwise defined as surface waters under this definition~~ An impoundment of a surface water as defined by this definition;

e. ~~Tributaries of surface waters identified in paragraphs~~ A tributary of a surface water identified in subsections (a) through (d) of this definition; and

f. ~~Wetlands adjacent to surface waters identified in paragraphs~~ A wetland adjacent to a surface water identified in subsections (a) through (e) of this definition.

~~41.~~44. "Total nitrogen" means the sum of the concentrations of ammonia (NH_3), ammonium ion (NH_4+), nitrite (NO_2), and nitrate (NO_3), and dissolved and particulate organic nitrogen expressed as elemental nitrogen.

~~42.~~45. "Total phosphorus" means all of the phosphorus present in ~~the~~ a sample, regardless of form, as measured by a persulfate digestion procedure.

~~43.~~46. "Toxic" means ~~those pollutants~~ a pollutant, or combination of pollutants, which after discharge and upon exposure, ingestion, inhalation, or assimilation into ~~any~~ an organism, either directly from the environment or indirectly by ingestion through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in ~~such organisms~~ the organism or ~~their~~ its offspring.

~~44.~~47. "Unique water" means a surface water ~~which~~ that ~~has been~~ is classified as an outstanding state resource water by the Director under R18-11-112.

~~45.~~48. "Use attainability analysis" means a structured scientific assessment of the factors affecting the attainment of a designated use ~~which may include,~~ including physical, chemical, biological, and economic factors.

~~46.~~49. ~~"Wetlands"~~ "Wetland" means ~~those are as~~ an area that ~~are~~ is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances ~~do~~ does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. ~~Wetlands include swamps, marshes, bogs, cienegas, tinajas,~~ A wetland includes a swamp, marsh, bog, cienega, tinaja, and similar areas.

~~47.~~50. "Zone of passage" means a continuous water route of volume, cross-sectional area, and quality necessary to allow passage of free-swimming or drifting organisms with no acutely toxic effect produced on the organisms.

R18-11-102. Applicability

A. The water quality standards prescribed in this Article apply to ~~all~~ surface waters.

B. The water quality standards prescribed in this Article do not apply to the following:

1. ~~Waste treatment systems~~ A waste treatment system, including ~~impoundments, ponds, lagoons, and constructed wetlands that are a part of such waste treatment systems~~ an impoundment, pond, lagoon, or constructed wetland that is a part of the waste treatment system.

2. ~~Man-made surface impoundments~~ A man-made surface impoundment and associated ditches and conveyances used in the extraction, beneficiation, ~~and~~ or processing of metallic ores, including ~~pits, pregnant leach solution ponds, raffinate ponds, tailing impoundments, decant ponds, ponds and sumps in mine pits associated with dewatering activity, ponds holding water that has come into contact with process or product and that is being held for recycling, spill or upset catchment ponds, or ponds used for on-site remediation that are not surface waters or are located in areas that once were surface waters but no longer remain surface waters because they have been legally converted~~ a pit, pregnant leach solution pond, raffinate pond, tailing impoundment, decant pond, pond or a sump in a mine pit associated with dewatering activity, pond holding water that has come into contact with a process or product and that is being held for recycling, spill or upset catchment pond, or pond used for onsite remediation, that is not a surface water or is located in an area that once was a surface water but no longer remains a surface water because it has been and remains legally converted.

R18-11-104. Designated ~~uses~~ Uses

A. The Director shall adopt or remove a designated ~~uses and subcategories of designated uses~~ use or subcategory of a designated use by rule.

B. Designated uses of a surface water may include ~~full-body~~ full-body contact, ~~partial-body~~ partial-body contact, domestic water source, fish consumption, aquatic and wildlife (cold water ~~fishery~~), aquatic and wildlife (warm water ~~fishery~~), aquatic and wildlife (ephemeral), aquatic and wildlife (~~effluent-dependent~~ effluent-dependent water), agricultural irrigation, and agricultural livestock watering. The designated uses for specific surface waters are listed in Appendix B of this Article.

C. Numeric water quality criteria to maintain and protect water quality for the designated uses are prescribed in Appendix A, R18-11-109, R18-11-110, and R18-11-112. Narrative water quality standards to protect all surface waters are prescribed in R18-11-108.

D. If a surface water has more than ~~1~~ one designated use listed in Appendix B, ~~then~~ the most stringent water quality criterion applies.

E. The Director shall revise the designated uses of a surface water if water quality improvements result in a level of water quality ~~which~~ that permits a use that is not currently listed as a designated use in Appendix B.

F. In designating uses of a surface water and in establishing water quality criteria to protect ~~those~~ the designated uses, the Director shall take into consideration the applicable water quality standards for downstream surface waters and shall ensure that the water quality standards that are established for an upstream surface water also provide for the attainment and maintenance of the water quality standards of downstream surface waters.

G. A use attainability analysis shall be conducted prior to removal of a designated use or adoption of a subcategory of a designated use that requires less stringent water quality criteria.

H. The Director may remove a designated use or adopt a subcategory of a designated use that requires less stringent water quality criteria, provided the designated use is not an existing use and it is demonstrated through a use attainability analysis that attaining the designated use ~~in~~ is not feasible for any of the following reasons:

1. ~~Naturally-occurring pollutant concentrations prevent~~ A naturally-occurring pollutant concentration prevents the attainment of the use;
2. ~~Natural, ephemeral, intermittent, or low-flow conditions or water levels prevent~~ A natural, ephemeral, intermittent, or low-flow condition or water level prevents the attainment of the use;
3. ~~Human-caused conditions or sources of pollution prevent~~ A human-caused condition or source of pollution prevents the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;
4. ~~Dams, diversions, or other types of hydrologic modifications preclude~~ A dam, diversion, or other type of hydrologic modification precludes the attainment of the use, and it is not feasible to restore the surface water to its original condition or to operate ~~such~~ the modification in a way that would result in attainment of the use;
5. ~~Physical conditions~~ A physical condition related to the natural features of the surface water, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, ~~preclude~~ precludes attainment of an aquatic life designated ~~uses~~ use; or
6. Controls more stringent than those required by § 301 (b) and § 306 of the Clean Water Act [33 U.S.C. § 1311 and § 1316] are necessary to attain the use and implementation of ~~such~~ the controls would result in substantial and widespread economic and social impact.

R18-11-105. ~~Tributaries, Designated Uses~~ Tributaries; Designated Uses

The following water quality standards apply to a surface water that is not listed in Appendix B but that is a tributary to a listed surface water.

1. ~~For an unlisted tributary that is an ephemeral water, the~~ The aquatic and wildlife (ephemeral) and ~~partial-body~~ partial-body contact standards apply to an unlisted tributary that is an ephemeral water.
2. ~~For an unlisted tributary that is an effluent-dependent water, the aquatic and wildlife (effluent-dependent water) and partial-body contact standards apply.~~
3. ~~For an unlisted tributary that is not an ephemeral water or an effluent-dependent water and which has salmonids present, the aquatic and wildlife (cold water fishery) and fish consumption standards apply as well as the water quality standards that have been established for the nearest downstream surface water listed in Appendix B that is not an ephemeral water or an effluent-dependent water.~~ The aquatic and wildlife (cold water), full-body contact, and fish consumption standards apply to an unlisted tributary that is a perennial or intermittent surface water and is above 5000 feet in elevation.
4. ~~For an unlisted tributary that is not an ephemeral water or an effluent-dependent water and which does not have salmonids present, the aquatic and wildlife (warm water fishery) and fish consumption standards apply as well as the water quality standards which have been established for the nearest downstream surface water listed in Appendix B that is not an ephemeral water or effluent-dependent water.~~ The aquatic and wildlife (warm water), full-body contact, and fish consumption standards apply to an unlisted tributary that is a perennial or intermittent surface water and is below 5000 feet in elevation.

R18-11-106. Net Ecological Benefit

A. The Director may, by rule, modify a water quality standard on the ground that there is a net ecological benefit associated with the discharge of effluent to support or create a riparian and aquatic habitat in an area where ~~such~~ water resources are limited. The Director may modify a water quality standard for a pollutant if it is demonstrated that:
   1. The discharge of effluent creates or supports an ecologically valuable aquatic, wetland, or riparian ecosystem in an area where ~~such~~ these resources are limited~~.~~ ;
   2. The ecological benefits associated with the discharge of effluent under a modified water quality standard exceed the environmental costs associated with the elimination of the discharge of effluent~~.~~ ;
   3. The cost of treatment to achieve compliance with a water quality standard is so high that it is more cost effective to eliminate the discharge of effluent to the surface water. The discharger shall demonstrate that it is feasible to eliminate the discharge of effluent ~~which~~ that creates or supports the ecologically valuable aquatic, wetland, or riparian ecosystem and that a plan to eliminate the discharge is under active consideration ~~.~~ ;
   4. The discharge of effluent to the surface water will not cause or contribute to a violation of a water quality standard that has been established for a downstream surface water ~~.~~ ;
   5. All practicable point source discharge control programs, including local pretreatment, waste minimization, and source reduction programs are implemented; and
   6. The discharge of effluent does not produce or contribute to the concentration of a pollutant in the tissues of aquatic organisms or wildlife that is likely to be harmful to humans or wildlife through food chain concentration.

B. The Director shall not modify a water quality criterion for a pollutant to be less stringent than a technology-based effluent limitation ~~which~~ that applies to the discharge of that effluent. The discharge of effluent ~~which creates or supports and ecologically valuable aquatic, riparian, or wetland ecosystem~~ shall, at a minimum, comply with applicable technology-based effluent limitations.

R18-11-107. Antidegradation

A. The ~~Department~~ Director shall determine whether there is ~~any~~ degradation of water quality in a surface water on a ~~pollutant by pollutant~~ pollutant-by-pollutant basis.

B. Tier 1: The level of water quality necessary to protect existing uses shall be maintained and protected. No degradation of existing water quality is permitted in a surface water where the existing water quality does not meet the applicable water quality standard.

C. Tier 2: Where existing water quality in a surface water is better than the applicable water quality standard, the existing water quality shall be maintained and protected. The Director may allow limited degradation of existing water quality in the surface water, provided that the Department ~~has held~~ holds a public hearing on whether degradation should be allowed ~~pursuant to~~ under the general public hearing procedures prescribed at R18-1-401 and R18-1-402 and the Director makes all of the following findings:
   1. The level of water quality necessary to protect existing uses is fully protected. Water quality shall not be lowered to a level that does not comply with applicable water quality standards.
   2. The highest statutory and regulatory requirements for ~~all~~ new and existing point sources ~~as set forth in the Clean Water Act~~ are achieved.
   3. All cost-effective and reasonable best management practices for nonpoint source pollution control are implemented.
   4. Allowing lower water quality is necessary to accommodate important economic or social development in the area ~~in which~~ where the surface water is located.

D. Tier 3: Existing water quality shall be maintained and protected in a surface water that is classified as a unique water ~~or that the Director has proposed for classification as a unique water pursuant to~~ under R18-11-112. The Director shall not allow limited degradation of a unique water ~~pursuant to~~ under subsection (C) ~~of this Section~~.

E. The Department shall implement this Section in a manner consistent with § 316 of the Clean Water Act [33 U.S.C. § 1326] ~~where~~ if a potential water quality impairment associated with a thermal discharge is involved.

R18-11-108. Narrative Water Quality Standards

A. A surface water shall be free from pollutants in amounts or combinations that:
   1. Settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life ~~or that impair recreational uses~~;
   2. Cause objectionable odor in the area in which the surface water is located;
   3. Cause off-taste or odor in drinking water;
   4. Cause off-flavor in aquatic organisms ~~or waterfowl~~;
   5. Are toxic to humans, animals, plants, or other organisms;
   6. Cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth, or propagation of other aquatic life or that impair recreational uses;
   7. Cause or contribute to a violation of an aquifer water quality standard prescribed in R18-11-405 or R18-11-406; or
   8. Change the color of the surface water from natural background levels of color.

B. A surface water shall be free from oil, grease, and other pollutants that float as debris, foam, or scum; or that cause a film or iridescent appearance on the surface of the water; or that cause a deposit on a shoreline, bank, or aquatic vegetation. The discharge of lubricating oil or gasoline associated with the normal operation of a recreational ~~water craft shall not be considered~~ watercraft is not a violation of this narrative standard.

C. A discharge of suspended solids to a surface water shall not be in quantities or concentrations that either interfere with the treatment processes at the nearest downstream potable water treatment plant or substantially increase the cost of handling solids produced at the nearest downstream potable water treatment plant.

R18-11-109. Numeric Water Quality Standards

~~A. The water quality standards prescribed in this Section and in Appendix A apply to surface waters listed in Appendix B and their tributaries. Additional numeric water quality standards for unique waters are prescribed in R18-11-112.~~

~~B. The following water quality standards for fecal coliform, expressed in colony forming units per 100 milliliters of water (cfu/100 ml), shall not be exceeded:~~

~~1. **Fecal Coliform**~~	~~**DWS, PBC, A&W1, AgI, AgL**~~
~~30-day geometric mean (5 sample minimum)~~	~~1000~~
~~10% if samples for a 30-day period~~	~~2000~~
~~Single sample maximum~~	~~4000~~
~~2. **Fecal Coliform in effluent-dependent waters**~~	~~**All designated areas**~~
~~30-day geometric mean (5 sample minimum)~~	~~200~~
~~10% if samples for a 30-day period~~	~~400~~
~~Single sample maximum~~	~~800~~

~~C.~~A. The following water quality standards for *Escherichia coli (E. coli)*, expressed in colony forming units per 100 milliliters of water (cfu / 100 ml), shall not be exceeded:

E. coli	FBC	PBC
~~30-day geometric mean (5 sample minimum)~~	~~130~~	
Geometric mean (four-sample minimum)	126	126
Single sample maximum	~~580~~ 235	576

~~D.~~B. The following water quality standards for pH, expressed in standard units, shall not be violated:

pH	DWS	FBC, PBC, A&W~~2~~1	AgI	AgL
Maximum	9.0	9.0	9.0	9.0
Minimum	5.0	6.5	4.5	6.5
Maximum change due to discharge	NNS	0.5	NNS	NNS

~~E.~~C. The following maximum allowable increase in ambient water temperature, expressed in degrees Celsius, shall not be exceeded:

Temperature	A&Ww, A&Wedw	A&Wc
Maximum increase due to a thermal discharge~~3,4~~2,3	3.0	1.0

~~F. The following water quality standards for turbidity, expressed as a maximum concentration in nephelometric turbidity units (NTU), shall not be exceeded:~~

~~Turbidity~~	~~A&Ww, A&Wedw~~	~~A&Wc~~
~~Rivers, streams~~		

~~and other flowing waters~~	~~50~~	~~10~~
~~Lakes, reservoirs, tanks and ponds~~	~~25~~	~~10~~

D. The following water quality standard for suspended sediment concentration, expressed as a geometric mean (four-sample minimum) shall not be exceeded. The standard applies to a surface water that is at or near base flow and does not apply to a surface water during or soon after a precipitation event:

A&Wc, A&Ww
80 mg / L

~~G.~~E. The following are the water quality standards for dissolved oxygen, expressed in milligrams per liter (mg/L). The dissolved oxygen concentration in a surface water shall not fall below the following minimum concentrations:

1. **Dissolved oxygen**	**A&Ww**	**A&Wc**
Single sample minimum~~5~~4	6.0	7.0

2. **Dissolved oxygen in ~~effluent dependent~~ effluent-dependent waters**

(single sample minimum):	**A&W edw**
~~3~~ Three hours after sunrise to sunset	3.0
Sunset to ~~3~~ three hours after sunrise	1.0

3. ~~If the dissolved oxygen (mg/L) of a surface water is less than the water quality standard for dissolved oxygen, but the percent saturation of oxygen is equal to or greater than 90%, then the surface water shall be deemed to be in compliance with the water quality standard for dissolved oxygen.~~ A surface water is in compliance with the water quality standard for dissolved oxygen if the percent saturation of dissolved oxygen is equal to or greater than 90%.

~~H.~~F. The following water quality standards for total phosphorus and total nitrogen, expressed in milligrams per liter (mg/L), shall not be exceeded:

		Annual mean	**90th percentile**	**Single Sample Maximum**
1.	Verde River and its tributaries from headwaters to Bartlett Lake:			
	Total phosphorus	0.10	0.30	1.00
	Total nitrogen	1.00	1.50	3.00
2.	Black River, Tonto Creek, and their tributaries that are not located on tribal lands:			
	Total phosphorus	0.10	0.20	0.80
	Total nitrogen	0.50	1.00	2.00
3.	Salt River and its tributaries~~, except Pinal Creek, above Theodore Roosevelt Lake~~ that are not located on tribal lands but not Pinal Creek above Theodore Roosevelt Lake:			
	Total phosphorus	0.12	0.30	1.00
	Total nitrogen	0.60	1.20	2.00
4.	Theodore Roosevelt, Apache, Canyon, and Saguaro Lakes:			
	Total phosphorus	0.03~~a~~5	NNS	0.60~~b~~6
	Total nitrogen	0.30~~a~~5	NNS	1.00~~b~~6
5.	Salt River below Stewart Mountain Dam to confluence with the Verde River:			
	Total phosphorus	0.05	NNS	0.20
	Total nitrogen	0.60	NNS	3.00
6.	Little Colorado River and its tributaries above River Reservoir in Greer, South Fork of Little Colorado River above South Fork Campground, Water Canyon Creek above Apache-Sitgreaves National Forest boundary:			
	Total phosphorus	0.08	0.10	0.75
	Total nitrogen	0.60	0.75	1.10
7.	Little Colorado River at the crossing of Apache County Road No. 124:			

Total phosphorus	NNS	NNS	0.75
Total nitrogen	NNS	NNS	1.80

8. Little Colorado River above Lyman Lake to above the Amity Ditch diversion near crossing of Arizona Highway 273 (applies only when in-stream turbidity is less than 50 NTU):

Total phosphorus	0.20	0.30	0.75
Total nitrogen	0.70	1.20	1.50

9. Colorado River, at Northern International Boundary near Morelos Dam:

Total phosphorus	NNS	0.33	NNS
Total nitrogen	NNS	2.50	NNS

10. San Pedro River, from Curtis to Benson:

Total phosphorus	NNS	NNS	NNS
Total nitrate as N	NNS	NNS	10.00

11. The discharge of wastewater to Show Low Creek and tributaries upstream of and including Fools Hollow Lake shall not exceed 0.16 mg/L total phosphates as P.
12. The discharge of wastewater to the San Francisco River and tributaries upstream of Luna Lake Dam shall not exceed 1.0 mg/L total phosphates as P.

~~I.~~G. The following water quality standards for radiochemicals shall not be exceeded in surface waters with the domestic water source designated use:

~~1. In all surface waters, the concentration of radio chemicals shall not exceed the limits established by the Arizona Radiation Regulatory Agency in 12 A.A.C. 1, Article 4, Appendix A, Table II, Column 2 (effective June 30, 1977 and no future amendments), which is incorporated by reference and on file with the Office of the Secretary of State and with the Department.~~

~~2. In surface waters that are designated as domestic water sources, the following water quality standards for radiochemicals shall not be exceeded:~~

~~a.~~1. The concentration of gross alpha particle activity, including radium-226, but excluding radon and uranium, shall not exceed 15 picocuries per liter of water.

~~b.~~2. The concentration of combined radium-226 and radium-228 shall not exceed ~~5~~ five picocuries per liter of water.

~~c.~~3. The concentration of strontium-90 shall not exceed 8 eight picocuries per liter of water.

~~d.~~4. The concentration of tritium shall not exceed 20,000 picocuries per liter of water.

~~e.~~5. The average annual concentration of beta particle activity and photon emitters from ~~man-made~~ manmade radionuclides shall not produce an annual dose equivalent to the total body or any internal organ greater than ~~4~~ four millirems per year.

Footnotes:

~~1~~ ~~Includes A&Wc, A&Ww, and A&We~~

~~2~~1 Includes A&Wc, A&Ww, A&Wedw, and A&We.

~~3~~2 Does not apply to Cholla Lake.

~~4~~3 Does not apply to a wastewater treatment plant discharge to a dry watercourse that creates an ~~effluent-dependent~~ effluent-dependent water or to a stormwater discharge.

~~5~~4 The dissolved oxygen water quality standard for a lake shall apply below the surface but not at a depth greater than ~~1~~ one meter.

~~a~~5 Means the annual mean of representative composite samples taken from the surface and at ~~2 and 5~~ two and five meter depths.

~~b~~6 Means the maximum for any set of representative composite samples taken from the surface and at ~~2 and 5~~ two and five meter depths.

R18-11-110. Salinity ~~of~~ Standards for the Colorado River

A. The flow-weighted average annual salinity in the lower main stem of the Colorado River shall be maintained at or below the following concentrations:

Location	Total Dissolved Solids
Below Hoover Dam	723 mg/L
Below Parker Dam	747 mg/L
At Imperial Dam	879 mg/L

B. To preserve the basin-wide approach to salinity control developed by the Colorado River Basin states and to ensure compliance with the numeric criteria for salinity in subsection (A), the Department adopts the plan of implementation contained in the "1999 Review, Water Quality Standards for Salinity, Colorado River System," Colorado River Basin Salinity

Control Forum, 106 West 500 South, Suite 101, Bountiful, Utah 84010-6232 (June, 1999), which is incorporated by reference and on file with the Office of the Secretary of State and the Department. This incorporation by reference contains no future editions or amendments.

R18-11-111 Analytical Methods

A. A person conducting an analysis of a sample taken to determine compliance with a water quality standard shall use an approved analytical method prescribed in 9 A.A.C. 14, Article 6, or an alternative analytical method that is approved by the Director of the Arizona Department of Health Services under ~~R9-14-607(B)~~ R9-16-610(B).

B. A test result from a sample taken to determine compliance with a water quality standard is valid only if the sample ~~has been~~ is analyzed by a laboratory that is licensed by the Arizona Department of Health Services for the analysis performed.

R18-11-112. Unique Waters

A The Director shall ~~use rulemaking to~~ classify a surface water as a unique water by rule. The Director shall consider nominations to classify a surface water as a unique water during the triennial review of water quality standards for surface waters.

B. The Director may adopt, by rule, site-specific water quality standards to maintain and protect existing water quality in a unique water.

C. Any person may nominate a surface water for classification as a unique water by filing a ~~petition for rule adoption~~ nomination with the Department. ~~A petition for rule adoption~~ The nomination to classify a surface water as a unique water shall include:

1. A map and a description of the surface water;
2. A written statement in support of the nomination, including specific reference to the applicable criteria for unique ~~waters~~ water classification ~~as~~ prescribed in subsection (D) ~~of this Section~~;
3. Supporting evidence demonstrating that ~~1 or more of~~ the applicable unique ~~waters~~ water criteria prescribed in subsection (D) ~~of this Section has been~~ are met; and
4. Available water quality data relevant to establishing the baseline water quality of the proposed unique water.

D. The Director may classify a surface water as a unique water upon finding that the surface water is an outstanding state resource water based upon ~~1 of~~ the following criteria:

1. The surface water is a perennial water;
2. The surface water is in a free-flowing condition. For purposes of this subsection, "in a free-flowing condition" means that a surface water does not have an impoundment, diversion, channelization, rip-rapping or other bank armor, or another hydrological modification within the reach nominated for unique water classification;
3. The surface water has good water quality. For purposes of this subsection, "good water quality" means that the surface water has water quality that meets or exceeds applicable surface water quality standards. A surface water that is listed as impaired under § 303(d) of the Clean Water Act [33 U.S.C. § 1313] is ineligible for unique waters classification; and
4. The surface water meets one or both of the following conditions:
   ~~1.~~a. The surface water is of exceptional recreational or ecological significance because of its unique attributes, including but not limited to, attributes related to the geology, flora, fauna, water quality, aesthetic values, or the wilderness characteristics of the surface water.
   ~~2.~~b. Threatened or endangered species are known to be associated with the surface water and the existing water quality is essential to the maintenance and propagation of a threatened or endangered species or the surface water provides critical habitat for a threatened or endangered species. Endangered or threatened species are identified ~~on the following lists which are hereby incorporated by reference and on file with the Office of the Secretary of State and the Department:~~ in Endangered and Threatened Wildlife and Plants, 50 CFR § 17.11 and § 17.12 (revised as of October 1, 2000) which is incorporated by reference and on file with the Department and the Office of the Secretary of State. This incorporation by reference contains no future editions or amendments.
   ~~a. Endangered and Threatened Wildlife and Plants, 50 CFR § 17.11 and 17.12 (revised as of October 1, 1994);~~
   ~~b. "Threatened Native Wildlife of Arizona," Arizona Game and Fish Department (July 21, 1988);~~
   ~~c. List of highly safeguarded protected native plants in 3 A.A.C. 4, Article 6, Appendix A(A) (December 20, 1994);~~
   ~~d. Federally Listed Threatened and Endangered Species of Arizona," U.S. Fish & Wildlife Service (June 6, 1995).~~

E. The following surface waters are classified as unique waters:

1. The West Fork of the Little Colorado River, above Government Springs;
2. Oak Creek, including the West Fork of Oak Creek;
3. Peeples Canyon Creek, tributary to the Santa Maria River;
4. Burro Creek, above its confluence with Boulder Creek;
5. Francis Creek, in Mohave and Yavapai counties;
6. Bonita Creek, tributary to the upper Gila River;
7. Cienega Creek, from ~~I-10 bridge to Del Lago Dam~~ confluence with Gardner Canyon and Spring Water Canyon at R18E T17S to USGS gaging station at 32°02'09" / 110°40'34", in Pima County;

8. Aravaipa Creek, from its confluence ~~of~~ with Stowe Gulch to the downstream boundary of Aravaipa Canyon Wilderness Area;
9. Cave Creek and the South Fork of Cave Creek (Chircahua Mountains), from the headwaters to the Coronado National Forest boundary; ~~and~~
10. Buehman Canyon Creek, from its headwaters (Lat. 32°24'55.5" N, Long. 110°39'43.5"W) to approximately 9.8 miles downstream (Lat. 32°24'31.5" N, Long. 10°32'08" W);
11. Lee Valley Creek, from its headwaters to Lee Valley Reservoir;
12. Bear Wallow Creek, from its headwaters to the boundary of the San Carlos Indian Reservation;
13. North Fork of Bear Wallow Creek, from its headwaters to Bear Wallow Creek;
14. South Fork of Bear Wallow Creek, from its headwaters to Bear Wallow Creek;
15. Snake Creek, from its headwaters to its confluence with Black River;
17. Hay Creek, from its headwaters to its confluence with the West Fork of the Black River;
18. Stinky Creek, from the Fort Apache Indian Reservation boundary to its confluence with the West Fork of the Black River; and
19. KP Creek, from its headwaters to its confluence with the Blue River.

F. The Department shall hold at least one public meeting in the local area of a nominated unique water to solicit public comment on the nomination.

G. The Director may consider the following factors when making a decision whether to classify a nominated surface water as a unique water:
1. Whether there is the ability to manage the unique water and its watershed to maintain and protect existing water quality;
2. The social and economic impact of Tier 3 antidegradation protection;
3. The public comments in support or opposition to a unique waters classification;
4. The support or opposition of federal and state land management and natural resources agencies to a nomination;
5. Agency resource constraints;
6. The timing of the unique water nomination relative to the triennial review of surface water quality standards;
7. The consistency of a unique water classification with applicable water quality management plans (for example, § 208 water quality management plans); and
8. Whether the nominated surface water is located within a national or state park, national monument, national recreation area, wilderness area, riparian conservation area, area of critical environmental concern, or it has another special use designation (for example, Wild and Scenic River designation).

~~F.~~H. The following water quality standards apply to the listed unique waters. Water quality standards prescribed in this subsection supplement the water quality standards prescribed ~~pursuant to R18-11-109~~ by this Article.

1. The West Fork of the Little Colorado River, above Government Springs:

Parameter	Standard
pH (standard units)	No change due to discharge
Temperature	No increase due to discharge
Dissolved oxygen	No decrease due to discharge
Total dissolved solids	No increase due to discharge
Chromium (as Cr)(D)	10 µg/L

2. Oak Creek, including the West Fork of Oak Creek:

Parameter	Standard
pH (standard units)	No change due to discharge
Nitrogen (T)	1.00 mg / L (annual mean)
	1.50 mg / L (90th percentile)
	2.50 mg / L (single sample max.)
Phosphorus (T)	0.10 mg/L (annual mean)
	0.25 mg/L (90th percentile)
	0.30 mg/ L (single sample max.)
Chromium (as Cr) (D)	5 µg/L
Turbidity change due to discharge	3 ~~NTU~~ NTUs

3. Peeples Canyon Creek, tributary to the Santa Maria River:

Parameter	Standard
Temperature	No increase due to discharge
Dissolved oxygen	No decrease due to discharge
Turbidity change due to discharge	5 ~~NTU~~ NTUs
Arsenic (T)	20 µg/L
Manganese (T)	500 µg/L

4. Burro Creek, above its confluence with Boulder Creek:

Parameter	**Standard**
Manganese (T)	500 µg/L

5. Francis Creek, in Mohave and Yavapai counties:

Parameter	**Standard**
Manganese (T)	500 µg/L

6. Cienega Creek, from ~~I-10 bridge~~ its confluence with Gardner Canyon and Spring Water Canyon at R18E T17S to Del Lago Dam, in Pima County:

Parameter	**Standard**
pH	No change due to discharge
Temperature	No increase due to discharge
Dissolved oxygen	No decrease due to discharge
Total dissolved solids	No increase due to discharge
Turbidity	10 ~~NTU~~ NTUs

7. Bonita Creek, tributary to the Upper Gila River:

Parameter	**Standard**
pH	No change due to discharge
Temperature	No increase due to discharge
Dissolved oxygen	No decrease due to discharge
Total dissolved solids	No increase due to discharge
Turbidity	15 ~~NTU~~ NTUs

Abbreviations:
~~(D)~~ "(D)" means dissolved fraction
~~(T)~~ "(T)" means total recoverable
~~NTU~~ "NTUs" means nephelometric turbidity ~~unit~~ units
~~mg/L~~ "mg/L" means milligrams per liter
~~ug/L~~ "µg/L" means micrograms per liter

R18-11-113. ~~Effluent-dependent~~ Effluent-dependent Waters

A. The Director shall ~~use rulemaking to~~ classify a surface water as an ~~effluent-dependent~~ effluent-dependent water by rule.

B. The Director may adopt, by rule, site-specific water quality standards for an ~~effluent-dependent~~ effluent-dependent water.

C. Any person may submit a petition for rule adoption requesting that the Director classify a surface water as an ~~effluent-dependent~~ effluent-dependent water. The petition for rule adoption shall include:
1. A map and a description of the surface water~~.~~ ,
2. Information that demonstrates that the surface water consists ~~primarily~~ of discharges of treated wastewater~~.~~ , and
3. Information that demonstrates that the receiving water is an ephemeral water in the absence of the discharge of treated wastewater.

D. The following surface waters are classified as ~~effluent-dependent~~ effluent-dependent waters:
1. In the Colorado River Main Stem Basin:
   a. Bright Angel Wash from the South Rim Grand Canyon WWTP outfall to its confluence with Coconino Wash~~:~~ ,
   b. Cataract Creek from the Williams WWTP outfall to ~~1~~ one kilometer downstream from the outfall~~.~~ ,
   c. Holy Moses Wash from the Kingman WWTP outfall to ~~3~~ three kilometers downstream from the outfall~~.~~ , and
   d. Transept Canyon from the North Rim Grand Canyon WWTP outfall to ~~1~~ one kilometer downstream from the outfall.
2. In the Little Colorado River Basin:
   a. Dry Lake. ,
   b. Lake Humphreys. ,
   c. Lower Walnut Canyon Lake. ,
   d. Ned Lake. ,
   e. Pintail Lake. ,
   f. Telephone Lake. ,
   g. Rio de Flag from the City of Flagstaff WWTP outfall to its confluence with San Francisco Wash. , and
   h. Whale Lake.
3. In the Middle Gila River Basin:
   a. Unnamed wash from the Town of Prescott Valley WWTP outfall to ~~the~~ its confluence with the Agua Fria River, and the Agua Fria River below ~~the~~ its confluence with the unnamed wash receiving treated wastewater from the Prescott Valley WWTP to State Route 169. ;
   b. Agua Fria river from the El Mirage WWTP outfall to ~~2~~ two kilometers downstream from the outfall. ;
   c. Gila River from the Florence WWTP outfall to Felix Road. ,
   d. Gila River from its confluence with the Salt River to Gillespie Dam. ;

e. Queen Creek from ~~Superior Mining Division discharge~~ the Town of Superior WWTP outfall to its confluence with Potts Canyon. ;
f. Unnamed wash from the Gila Bend WWTP outfall to its confluence with the Gila River. ;
g. Unnamed wash from the Luke AFB WWTP outfall to ~~the~~ its confluence with the Agua Fria River. ; and
h. Unnamed wash from the Queen Valley WWTP outfall to its confluence with Queen Creek.

4. In the Rios de Mexico Basin:
   a. Mule Gulch, from the Bisbee WWTP outfall to ~~confluence with Whitewater Draw.~~ the Highway 80 bridge, and
   b. Unnamed wash from the Bisbee-Douglas International Airport WWTP outfall to Whitewater Draw.
5. In the Salt River Basin:
   a. Unnamed wash from the Globe WWTP outfall to its confluence with Pinal Creek and Pinal Creek from its confluence ~~of~~ with the unnamed wash ~~and Pinal Creek~~ to Radium. , and
   b. Salt River from the 23rd Avenue WWTP outfall to its confluence with the Gila River.
6. In the San Pedro River Basin:
   a. Unnamed wash from the Mt. Lemmon WWTP outfall to 0.25 kilometers downstream, and
   b. Walnut Gulch from the Tombstone WWTP outfall to its confluence with Tombstone Gulch.
7. In the Santa Cruz Basin:
   a. Santa Cruz River from the Nogales International WWTP outfall to Tubac Bridge. ,
   b. Santa Cruz River from the Roger Road WWTP outfall to Baumgartner Road crossing. ,
   c. Unnamed wash from the Oracle WWTP outfall to ~~5~~ five kilometers downstream. , and
   d. Sonoita Creek from the Town of Patagonia WWTP outfall to 750 feet downstream.
8. In the Upper Gila River Basin:
   a. Bennett Wash from the Arizona Department of Corrections-Safford WWTP outfall to the Gila River. and
   b. Unnamed wash from the Arizona Department of Corrections-Globe WWTP outfall to the boundary of the San Carlos Indian Reservation.
9. In the Verde River Basin:
   a. American Gulch from the Northern Gila County Sanitary District WWTP outfall to the East Verde River. ,
   b. Bitter Creek from the Jerome WWTP outfall to 2.5 kilometers downstream from the outfall. , and
   c. Jacks Canyon Wash from the Big Park WWTP outfall to its confluence with Dry Beaver Creek.
10. In the Willcox Playa Basin: Lake Cochise

E. The NPDES permit issuing authority shall use the water quality standards that apply to an ~~effluent-dependent~~ effluent-dependent water to derive discharge limitations for a point source discharge from a wastewater treatment plant to an ephemeral water ~~which~~ that changes that ephemeral water into an ~~effluent-dependent~~ effluent-dependent water.

F. The site-specific standard of 36 µg / L for dissolved copper for the aquatic and wildlife (effluent-dependent water) designated use applies to the Rio de Flag from the City of Flagstaff WWTP outfall to its confluence with the San Francisco Wash.

R18-11-114. Mixing Zones

A. The Director may~~, by order,~~ establish a mixing zone ~~in~~ for a point source discharge to a surface water as a condition of a NPDES permit. Mixing zones are prohibited in ephemeral waters or where there is no water for dilution.

B. The owner or operator of a point source seeking the establishment of a mixing zone shall submit a mixing zone application to the Department on a standard form that is available from the Department. The application shall include:
   1. Identification of the pollutant for which the mixing zone is requested;
   2. A proposed outfall design;
   3. A definition of the boundary of the proposed mixing zone. For purposes of this subsection, the boundary of a mixing zone means the location where the concentration of treated wastewater across a transect of the surface water differs by less than 5%; and
   4. A complete and detailed description of the existing physical, biological, and chemical conditions of the receiving water and ~~of~~ the predicted impact ~~on such conditions from~~ of the proposed mixing zone on those conditions.
   ~~5. Information which demonstrates that there will be no acute toxicity in the proposed mixing zone.~~

C. The Department shall review the application for a mixing zone to determine whether the application is complete. If the application is incomplete, the Department shall identify in writing the additional information that must be submitted to the Department ~~before the Department can take administrative action on the application for a mixing zone~~ to complete the mixing zone application.

~~D. When the application for a mixing zone is complete, the Department shall make a preliminary determination of whether to establish the mixing zone. The Department shall give public notice and provide an opportunity for a public hearing on whether to establish a mixing zone pursuant to the administrative procedures prescribed in R18-1-401 and R18-1-402.~~

~~E. In making the determination of whether to grant or deny the request for the establishment of a mixing zone, the Director shall consider the following factors: sediment deposition; bioaccumulation; bioconcentration; predicted exposure of biota and the likelihood that resident biota will be adversely affected; whether there will be acute toxicity in the mixing zone; the known or predicted safe exposure levels for the pollutant of concern; the likelihood of adverse human health effects;~~

~~the size of the mixing zone; location of the mixing zone relative to biologically sensitive areas in the surface water; concentration gradient within the mixing zone, the physical habitat, the potential for attraction of aquatic life to the mixing zone, and the cumulative impacts of other mixing zones and other discharges to the surface water.~~

D. The Director shall consider the following factors when deciding whether to grant or deny a request for a mixing zone:
1. The assimilative capacity of the receiving water;
2. The likelihood of adverse human health effects;
3. The location of drinking water plant intakes and public swimming areas;
4. The predicted exposure of biota and the likelihood that resident biota will be adversely affected;
5. Bioaccumulation and bioconcentration;
6. Whether there will be acute toxicity in the mixing zone, and, if so, the size of the area of acute toxicity;
7. The known or predicted safe exposure levels for the pollutant of concern;
8. The size of the mixing zone;
9. The location of the mixing zone relative to biologically sensitive areas in the surface water;
10. The concentration gradient of the pollutant within the mixing zone;
11. Sediment deposition;
12. The potential for attracting aquatic life to the mixing zone; and
13. The cumulative impacts of other mixing zones and other discharges to the surface water.

~~F.~~E. The Director shall deny the request to establish a mixing zone if water quality standards outside the boundaries of the proposed mixing zone will be violated ~~or if concentrations of pollutants within the proposed mixing zone will cause acute toxicity to aquatic life. Denials of applications~~ The denial of a request for a mixing zone shall be in writing and shall state the ~~reasons~~ reason for the denial. If the Director determines that a mixing zone should be established, ~~he shall issue an order to~~ the Director shall establish ~~a~~ the mixing zone as a condition of a NPDES permit. The Director may include mixing zone conditions in the ~~order~~ NPDES permit that the Director deems necessary to protect human health and the designated uses of the surface water. ~~A copy of the Director's decision and order shall be sent by certified mail to the applicant.~~

~~G.~~F. Any person who is adversely affected by ~~an order of the Director pertaining to~~ the Director's decision to grant or deny a request for a mixing zone may appeal the ~~director's~~ decision to an administrative law judge ~~pursuant to~~ under A.R.S. § 49-321 and A.R.S. § 41-1092 et seq.

~~H.~~G. The Department shall reevaluate a mixing zone upon issuance, reissuance, or modification of the National Pollutant Discharge Elimination System permit for the point source or a modification of the outfall structure.

~~I.~~H. The length of ~~the~~ a mixing zone shall not exceed 500 meters in ~~flowing streams~~ a stream. The total horizontal area allocated to all mixing zones on a lake shall not exceed 10% of the surface area of the lake. Adjacent mixing zones in a lake shall be no closer than the greatest horizontal dimension of any ~~of the~~ individual mixing ~~zones~~ zone.

~~J.~~I. A mixing zone shall provide for a zone of passage of not less than 50% of the cross-sectional area of a river or stream.

~~K.~~J. The discharge outfall shall be designed to maximize initial dilution of the treated wastewater in a surface water.

K. A mixing zone is prohibited for the following persistent, bioaccumulative pollutants:
1. Chlordane,
2. DDT and its metabolites (DDD and DDE),
3. Dieldrin,
4. Dioxin,
5. Endrin,
6. Endrin aldehyde,
7. Heptachlor,
8. Heptachlor epoxide,
9. Lindane,
10. Mercury,
11. PCBs, and
12. Toxaphene.

R18-11-115. ~~Nutrient Waivers~~ Repealed

~~A. The Department may waive the water quality standards for total phosphorus or total nitrogen on a discharger specific basis for a discharge to an ephemeral water which is tributary to a surface water for which water quality standards for total nitrogen or total phosphorus are prescribed in R18-11-109(H).~~

~~B. A discharger who seeks a nutrient waiver shall submit an application to the Department on a standard form that is available from the Department. The application shall include:~~
~~1. Identification of the applicant;~~
~~2. Information on the discharging facility, including:~~
~~a. Date the facility was placed in service;~~
~~b. Location of the facility;~~
~~c. Location of the discharge point;~~
~~d. Wastewater treatment method; and~~

~~c. Discharge flow.~~

~~3. Information on the receiving surface water, including:~~

~~a. Name of the receiving water;~~

~~b. Distance in river miles to the nearest downstream surface water; and~~

~~c. Distance from the point of discharge to the point where the flow goes subsurface during an average dry season.~~

~~4. Information which demonstrates that the nearest downstream surface water is free from pollutants in amounts or combinations which cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth, or propagation of other aquatic life or that impair recreational uses.~~

~~5. Water quality data, including:~~

~~a. Monthly average, 90th percentile, and single sample maximum concentrations of total phosphorus and total nitrogen as measured at the point of discharge.~~

~~b. Monthly average, 90th percentile, and single sample maximum concentrations of total phosphorus and total nitrogen as measured at a downstream control point established by the Department; and~~

~~c. Discharge flow at the time of sampling.~~

~~C. The Department shall review the application for completeness and shall notify the applicant in writing whether the application is complete or whether additional information needs to be submitted to the Department.~~

~~D. Once an application for a nutrient waiver is complete, the Department shall make a preliminary determination of whether to grant or deny the nutrient waiver. The Department shall issue public notice and provide an opportunity for a public hearing on whether the request for a nutrient waiver should be granted pursuant to procedures prescribed in A.A.C. R18-1-401 and R18-1-402.~~

~~E. The Director may, by order, grant a nutrient waiver provided the discharge will not cause a violation of a water quality standard for total phosphorus or total nitrogen in any downstream surface water or cause a violation of narrative standards prescribed in R18-11-108. A copy of the Director's decision and order shall be sent by certified mail to the applicant.~~

~~F. Any person who is adversely affected by an order granting or denying a nutrient waiver may appeal the decision to an administrative law judge pursuant to A.R.S. § 49-321.~~

~~G. A nutrient waiver expires after a fixed term not to exceed 5 years. The Department shall reevaluate a nutrient waiver upon issuance, reissuance, or modification of the National Pollutant Discharge Elimination System permit for the point source.~~

R18-11-118. Dams and Flood Control Structures

A. Increases in turbidity that result from the routine physical or mechanical maintenance of ~~dams and flood control structures~~ a dam or flood control structure are not violations of this Article.

~~B. Nothing in this Article shall be construed to require a person who operates a dam or flood control structure to operate the structure to cure or mitigate an exceedance of a water quality standard caused by another person.~~

~~C.~~B. Nothing in this Article shall be construed to require the ~~releases of water from dams~~ release of water from a dam or a flood control structure.

R18-11-120. Enforcement

A. Any person who causes a violation of a water quality standard or any provision of this Article is subject to the enforcement provisions ~~prescribed~~ in A.R.S. Title 49, Chapter 2, Article 4.

B. The Department may establish a numeric water quality standard at a concentration that is below the practical quantitation limit. In such cases, the water quality standard is enforceable at the practical quantitation limit.

C. The Department shall determine compliance with acute aquatic and wildlife criteria from the analytical result of a grab sample. Compliance with chronic aquatic and wildlife criteria shall be determined from the ~~arithmetic~~ geometric mean of the analytical results of ~~grab samples collected over a period of 4 consecutive days at a minimum rate of 1 grab sample per day~~ the last four samples taken at least 24 hours apart.

D. A person is not subject to penalties for violation of a water quality standard provided that the person is in compliance with the provisions of a compliance schedule issued ~~pursuant to~~ under R18-11-121.

R18-11-121. Schedules of Compliance

A. A schedule to bring an existing point source into compliance with a new or revised water quality standard may be established in a National Pollutant Discharge Elimination System permit for ~~the~~ an existing point source. A compliance schedule for an existing point source, other than a storm water discharge, shall require compliance with a discharge limitation based upon a new or revised water quality standard no later than ~~3~~ three years after the effective date of the National Pollutant Discharge Elimination System permit. ~~In order for~~ For a schedule of compliance to be granted, the owner or operator of the existing point source shall demonstrate that all requirements under § 301(b) and § 306 of the Clean Water Act [33 U.S.C. § 1311(b) and § 1316] have been achieved and that the point source cannot comply with a discharge limitation based upon the new or revised water quality standard through the application of existing water pollution control technology, operational changes, or source reduction.

B. A schedule of compliance ~~shall not~~ may be established in a National Pollutant Discharge Elimination System permit for a new point source. The first National Pollutant Discharge Elimination System permit issued to a new point source may contain a schedule of compliance only when necessary to allow a reasonable opportunity to attain compliance with a new

or revised water quality standard that becomes effective after commencement of construction but less than three years before commencement of the discharge. For purposes of this subsection, ~~a new point source means a point source, the construction of which commences after the effective date of a water quality standard. Commencement~~ commencement of construction means that the owner or operator of the point source has obtained the federal, state, and local approvals or permits necessary to begin physical construction of the point source and either:

1. Onsite physical construction ~~program~~ has begun; or
2. The owner or operator has entered into a contract for physical construction of the point source and the contract cannot be cancelled or modified without substantial loss. For purposes of this subsection, "substantial loss" means in excess of 10% of the total cost incurred for physical construction.

C. A schedule of compliance may be established in a National Pollutant Discharge Elimination System permit for a recommencing point source discharge. The first National Pollutant Discharge Elimination System permit issued to a recommencing point source discharge may contain a schedule of compliance only when necessary to allow a reasonable opportunity to attain compliance with a new or revised water quality standard that becomes effective less than three years before recommencement of discharge.

~~C.~~D. A schedule to bring a point source discharge of storm water into compliance with a water quality standard may be established in a National Pollutant Discharge Elimination System permit. A compliance schedule for a storm water discharge shall require implementation of all reasonable and cost-effective best management practices to control the discharge of pollutants in storm water.

R18-11-122. Variances

A. The Director may grant a variance from a water quality standard for a point source discharge ~~provided~~ if the discharger demonstrates that treatment more advanced than that required to comply with technology-based effluent limitations is necessary to comply with the water quality standard and:
   1. It is not technically feasible to achieve compliance within the next ~~5~~ five years~~; or~~.
   2. The cost of the treatment would result in substantial and widespread economic and social impact~~;~~, or
   3. Human-caused conditions or sources of pollution prevent attainment of the water quality standard and cannot be remedied within the next five years.

B. A variance may be granted only on a pollutant-specific basis. A point source discharge is required to comply with all other applicable water quality standards for which a variance is not granted.

C. A variance applies only to a specific point source discharge. The granting of a variance does not modify a water quality standard. Other point source dischargers to the surface water shall comply with applicable water quality standards, including any water quality standard for which a variance has been granted for a specific point source discharge.

D. A variance is for a fixed term not to exceed ~~5~~ five years. Upon expiration of a variance, a point source discharger shall either comply with the water quality standard or apply for renewal of the variance. ~~In order for a variance to be renewed~~ To renew a variance, the applicant shall demonstrate reasonable progress towards compliance with the water quality standard during the term of the variance.

E. The Department shall reevaluate a variance upon the issuance, reissuance, or modification of the National Pollutant Discharge Elimination System permit for the point source discharge.

F. A person who seeks a variance from a water quality standard shall submit a ~~letter~~ a written request for a variance to the Department ~~requesting a variance~~. A request for a variance shall include the following information:
   1. Identification of the specific pollutant and water quality standard for which a variance is sought;
   2. Identification of the receiving surface water;
   3. For an existing point source discharge, a detailed description of the existing discharge control technologies that are used to achieve compliance with applicable water quality standards. For a new point source discharge, a detailed description of the proposed discharge control technologies that will be used to achieve compliance with applicable water quality standards;
   4. Documentation that the existing or proposed discharge control technologies will comply with applicable technology-based effluent limitations and that more advanced treatment technology is necessary to achieve compliance with the water quality standard for which a variance is sought;
   5. A detailed discussion of the reasons why compliance with the water quality standard cannot be achieved;
   6. A detailed discussion of the discharge control technologies that are available for achieving compliance with the water quality standard for which a variance is sought;
   7. Documentation of ~~1 or both~~ one of the following:
      a. That it is not technically feasible to install and operate any of the available discharge control technologies to achieve compliance with the water quality standard for which a variance is sought~~; or~~.
      b. That installation and operation of each of the available discharge technologies to achieve compliance with the water quality standard would result in substantial and widespread economic and social impact~~;~~, or
      c. That human-caused conditions or sources of pollution prevent the attainment of the water quality standard for which the variance is sought and it is not possible to remedy the conditions or sources of pollution within the next five years.

8. Documentation that the point source discharger has reduced, to the maximum extent practicable, the discharge of the pollutant for which a variance is sought through implementation of a local pretreatment, source reduction, or waste minimization program~~;~~, and
9. A detailed description of proposed interim discharge limitations ~~which~~ that represent the highest level of treatment achievable by the point source ~~discharge~~ discharger during the term of the variance. Interim discharge limitations shall not be less stringent than technology-based effluent limitations.

G. In making a decision on whether to grant or deny the request for a variance, the Director shall consider the following factors: ~~bioaccumulation, bioconcentration, predicted exposure of biota and the likelihood that resident biota will be adversely affected, the known or predicted safe exposure levels for the pollutant of concern, and the likelihood of adverse human health effects~~.
   1. Bioaccumulation and bioconcentration,
   2. The predicted exposure of biota and the likelihood that resident biota will be adversely affected,
   3. The known or predicted safe exposure levels for the pollutant of concern, and
   4. The likelihood of adverse human health effects.

H. The Department shall issue a public notice and shall provide an opportunity for a public hearing on whether the request for a variance should be granted or denied ~~pursuant to~~ under procedures prescribed in ~~A.A.C.~~ R18-1-401 and R18-1-402.

I. Any person who is adversely affected by a decision of the Director to grant or deny a variance may appeal the decision to an administrative law judge ~~pursuant to~~ under A.R.S. § 49-321 and A.R.S. § 41-1092 et seq.

J. The Department shall not grant a variance for a point source discharge to a unique water listed in R18-11-112.

K. A variance is subject to review and approval by the Regional Administrator of the U.S. Environmental Protection Agency.

R18-11-123. Prohibition Against Discharge~~; Sabino Creek~~

A. The discharge of treated wastewater to Sabino Creek is prohibited.

B. The discharge of human body wastes and the wastes from toilets and other receptacles intended to receive or retain those wastes on a vessel to Lake Powell is prohibited.

Appendix A: Numeric Water Quality Criteria
Table 1. Human Health and Agricultural Designated ~~Use Numeric Water Quality Criteria~~ Uses

PARAMETER	CAS[1] NUMBER	DWS[2] (µg/L)	FC[2] (µg/L)	FBC[2] (µg/L)	PBC[2] (µg/L)	AgI[2] (µg/L)	AgL[2] (µg/L)
Acenaphthene	83-32-9	420	~~2600~~ 2670	~~8400~~ 84,000	~~8400~~ 84,000	NNS	NNS
Acenaphthylene	208-96-8	NNS	NNS	NNS	NNS	NNS	NNS
Acrolein	107-02-8	~~110~~ 3.5	~~750~~ 25	~~2200~~ 700	~~2200~~ 700	NNS	NNS
Acrylonitrile	107-13-1	~~0.06~~ 0.07	~~0.64~~ 0.7	3	~~NNS~~ 56,000	NNS	NNS
Alachlor	15972-60-8	2	NNS	~~1400~~ 14,000	~~1400~~ 14,000	NNS	NNS
Aldrin	309-00-2	0.002	~~0.0003~~ 0.0001	0.08	~~4.2~~ 42	~~k~~ p	~~k~~ p
Ammonia	7664-41-7	NNS	NNS	NNS	NNS	NNS	NNS
Anthracene	120-12-7	2100	~~6300~~ 1000	~~42000~~ 420,000	~~42000~~ 420,000	NNS	NNS
Antimony (as Sb)	7440-36-0	6 T	~~140~~ T 4,300 T	~~56~~ 560 T	~~56~~ 560 T	NNS	NNS
Arsenic (as As)	7440-38-2	50 T	1450 T	50 T	~~50~~ 420 T	2000 T	200 T
Asbestos	1332-21-4	a	NNS	NNS	NNS	NNS	NNS
Atrazine	1912-24-9	3	NNS	~~4900~~ 49,000	~~4900~~ 49,000	NNS	NNS
Barium (as Ba)	7440-39-3	2000 T	NNS	~~9800 D~~ 98,000	~~9800 D~~ 98,000	NNS	NNS
Benzene	71-43-2	5	~~120~~ 140	~~48~~ 93	~~NNS~~ 93	NNS	NNS
Benzidine	92-87-5	0.0002	~~0.002~~ 0.001	~~0.006~~ 0.01	~~420~~ 4,200	0.01	0.01
Benz (a) anthracene	56-55-3	~~0.003~~ NNS	~~0.00008~~ NNS	~~0.12~~ NNS	NNS	NNS	NNS
Benzo (a) pyrene	50-32-8	0.2	~~0.002~~ 0.05	0.2	~~NNS~~ 0.2	NNS	NNS
Benzo (ghi) perylene	191-24-2	NNS	NNS	NNS	NNS	NNS	NNS
Benzo (k) fluoranthene	207-08-9	~~0.003~~ NNS	~~0.00001~~ NNS	~~0.12~~ NNS	NNS	NNS	NNS
3,4-Benzofluoranthene	205-99-2	~~0.003~~ NNS	~~0.00004~~ NNS	~~0.12~~ NNS	NNS	NNS	NNS
Beryllium (as Be)	7440-41-7	4 T	~~0.21~~ 1,130 T	~~4~~ 2,800 T	~~700~~ 2,800 T	NNS	NNS
Bis (2-chloroethoxy) methane	111-91-1	NNS	NNS	NNS	NNS	NNS	NNS
Bis (2-chloroethyl) ether	111-44-4	0.03	1.4	1.3	~~NNS~~ 1.3	NNS	NNS
Bis (2-chloroisopropyl) ether	108-60-1	280	~~15000~~ 174,400	~~5600~~ 56,000	~~5600~~ 56,000	NNS	NNS
Boron (as B)	7440-42-8	630	NNS	~~12600~~ 126,000	~~12600~~ 126,000	1000 T	NNS
Bromodichloromethane	75-27-4	TTHM	~~22~~ 46	~~100~~ TTHM	~~2800~~ 28,000	NNS	NNS
p-Bromodiphenyl ether	101-55-3	NNS	NNS	NNS	NNS	NNS	NNS
Bromoform[e]	75-25-2	TTHM	~~80~~ 360	180	~~2,800~~ 28,000	NNS	NNS
Bromomethane	74-83-9	9.8	~~7500~~ 4020	~~200~~ 2000	~~200~~ 2000	NNS	NNS
Butyl benzyl phthalate	85-68-7	1400	~~5000~~ 5200	~~28000~~ 280,000	~~28000~~ 280,000	NNS	NNS
Cadmium (as Cd)	7440-43-9	5 T	~~41~~ T 84 T	~~70~~ 700 T	~~70~~ 700 T	50 T	50 T
Carbofuran	1563-66-2	40	NNS	~~700~~ 7,000	~~700~~ 7,000	NNS	NNS
Carbon tetrachloride	56-23-5	5	~~5.5~~ 4	11	~~98~~ 980	NNS	NNS

Chlordane	57-74-9	2	~~0.001~~ 0.002	~~2~~ 4	~~8.4~~ 700	NNS	NNS
Chlorine (total residual)	7782-50-5	~~NNS~~ 700	NNS	~~14000~~ 140,000	~~14000~~ 140,000	NNS	NNS
Chlorobenzene	108-90-7	100	~~500~~ 20,900	~~2800~~ 28,000	~~2800~~ 28,000	NNS	NNS
p-Chloro-m-cresol	59-50-7	NNS	NNS	NNS	NNS	NNS	NNS
2-Chloroethyl vinyl ether	110-75-8	NNS	NNS	NNS	NNS	NNS	NNS
Chloroform[e]	67-66-3	TTHM	~~590~~ 470	230	~~1400~~ 14,000	NNS	NNS
Chloromethane	74-87-3	NNS	NNS	NNS	NNS	NNS	NNS
Chloronapthalene beta	91-58-7	560	~~13000~~ 4,300	~~11000~~ 112,000	~~11000~~ 112,000	NNS	NNS
2-Chlorophenol	95-57-8	35	~~2100~~ 400	~~700~~ 7,000	~~700~~ 7,000	NNS	NNS
4-Chlorophenyl phenyl ether	7005-72-3	NNS	NNS	NNS	NNS	NNS	NNS
Chromium (as Cr III)	16065-83-1	~~NNS~~ 10,500 T	~~67000 T~~ 1,010,000 T	~~140000 T~~ 2,100,000 T	~~140000 T~~ 2,100,000 T	NNS	NNS
Chromium (as Cr VI)	18540-29-9	~~NNS~~ 21 T	~~3400~~ 2,000T	~~700~~ 4,200 T	~~700~~ 4,200 T	NNS	NNS
Chromium (Total as Cr)	7440-47-3	100 T	NNS	~~NNS~~ 100 T	~~NNS~~ 100 T	1000 T	1000 T
Chrysene	218-01-9	~~0.003~~ NNS	~~.0001~~ NNS	~~0.12~~ NNS	NNS	NNS	NNS
Copper (as Cu)	7440-50-8	~~1000 D~~ 1,300 T	NNS	~~5200 D~~ 1,300 T	~~5200 D~~ 1,300 T	5000 T	500 T
Cyanide	57-12-5	200 T	~~210000 T~~ 215,000 T	~~2800 T~~ 28,000 T	~~2800 T~~ 28,000 T	NNS	200 T
Dalapon	75-99-0	200	161,500	42,000	42,000	NNS	NNS
Dibenz (ah) anthracene	53-70-3	~~0.003~~ NNS	~~0.00003~~ NNS	~~0.12~~ NNS	NNS	NNS	NNS
Dibromochloromethane	124-48-1	TTHM	~~12~~ 34	~~17~~ TTHM	~~2,800~~ 28,000	NNS	NNS
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.2	NNS	~~NNS~~ 2,800	~~NNS~~ 2,800	NNS	NNS
1,2-Dibromoethane (EDB)	106-93-4	0.05	NNS	~~1.6~~ 0.05	~~NNS~~ 0.05	NNS	NNS
Dibutyl phthalate	84-74-2	700	~~2300~~ 12,100	~~14000~~ 140,000	~~14000~~ 140,000	NNS	NNS
1,2-Dichlorobenzene	95-50-1	600	2800	~~13000~~ 126,000	~~13000~~ 126,000	NNS	NNS
1,3-Dichlorobenzene	541-73-1	~~94~~ NNS	~~2000~~ NNS	~~1880~~ NNS	~~1880~~ NNS	NNS	NNS
1,4-Dichlorobenzene	106-46-7	75	~~1200~~ 77,500	~~1880~~ 560,000	~~1880~~ 560,000	NNS	NNS
3,3'-Dichlorobenzidine	91-94-1	0.08	~~0.09~~ 0.08	3.1	~~NNS~~ 3.1	NNS	NNS
p,p'-Dichlorodiphenyldichloroethane (DDD)	72-54-8	0.15	~~0.0009~~ 0.001	5.8	~~NNS~~ 5.8	0.001	0.001
p,p'-Dichlorodiphenyldichloroethylene (DDE)	72-55-9	0.1	~~0.0006~~ 0.001	4.1	~~NNS~~ 4.1	0.001	0.001
p,p'-Dichlorodiphenyltrichloroethane (DDT)	50-29-3	0.1	~~0.0005~~ 0.0006	4.1	~~70~~ 700	0.001	0.001
1,1-Dichloroethane	75-34-3	NNS	NNS	NNS	NNS	NNS	NNS
1,2-Dichloroethane	107-06-2	5	~~120~~ 100	15	~~NNS~~ 280,000	NNS	NNS
1,1-Dichloroethylene	75-35-4	7	~~4.5~~ 320	~~7~~ 230	~~1300~~ 12,600	NNS	NNS
1,2-cis-Dichloroethylene	156-59-2	70	NNS	~~NNS~~ 70	~~NNS~~ 70	NNS	NNS

GOVERNOR'S REGULATORY REVIEW COUNCIL
(G. R. R. C.)
CERTIFICATE OF APPROVAL OF FINAL RULES

1. Agency Name: DEPARTMENT OF ENVIRONMENTAL QUALITY (AR-02-0110)

2. Chapter Heading: Department of Environmental Quality – Water Quality Standards

3. Code Citation for the Chapter: 18 A.A.C. 11

4. The Subchapters, if applicable; the Articles; the Parts, if applicable, and the Sections involved in the rulemaking, listed in alphabetical and numerical order:

Subchapters, Articles, Parts and Sections (in alphabetical and numerical order)	Action: (preferred, not required)
R18-11-101, R18-11-102, R18-11-104 through R18-11-114, R18-11-118, R18-11-120 through R18-11-123, Appendix A, and Appendix B	Amend
R18-11-115	Repeal

5. The rules contained in this package are approved as final rules.

6. Jeanne Hann 2/7/2002

Signature of Jeanne Hann
GRRC Administrator

Date of Signing

Jeanne Hann
Typed Name of Jeanne Hann
GRRC Administrator

Attachment F
Public Participation Documentation

Arizona Administrative Register

A Weekly Publication of the Secretary of State's Office

Volume 7, Issue 18 May 4, 2001

JUL 2001
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Administrative
Hearings

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Due to the size of this week's Register, this issue is printed in two parts. Part 1 of this issue contains pages 1806 through 1910. The remaining portion of the Register (pages 1915 through 2033) can be found in Part 2.

Part 1 of 2

Chan Martinez
Director
Public Services Department

BETSEY BAYLESS
Secretary of State

Lupe Baysinger
Editor
Arizona Administrative Register

The proposed revisions to the rules may affect political subdivisions of Arizona that operate wastewater treatment plants that discharge to surface waters regulated by surface water quality standards. In particular, the adoption of stringent water quality criteria to control chronic ammonia toxicity in surface waters with the A&Wc and A&Ww designated uses may result in new water quality-based discharge limitations in NPDES permits for wastewater treatment plants that discharge to perennial streams with these designated uses. Wastewater treatment plants and other point source dischargers may be required to upgrade treatment to control ammonia toxicity in discharges to surface waters. ADEQ received no comments on preliminary draft ammonia standards and cannot predict the extent of the economic impact to political subdivisions from the proposed rule change (if any).

Similarly, the repeal of the nutrient waiver rule may affect approximately 10 operators who currently operate wastewater treatment plants under nutrient waivers. Again, the proposed revision may require these wastewater treatment plants to upgrade wastewater treatment processes to control the discharge of nutrients to surface waters. If the nutrient waiver rule is repealed, ADEQ may establish schedules of compliance to provide time for the wastewater treatment plants to come into compliance with applicable nutrient standards. In the alternative, operators of the affected wastewater treatment plants may apply for a variance.

The proposed revisions to the surface water quality standards are expected to have no impact on private and public employment.

The proposal to classify 10 surface waters as unique waters may affect some persons (e.g., ranchers who have grazing allotments in the watersheds where the proposed unique waters are located). In general, the proposed unique waters are located in remote areas of the state, in National Forests, or in wilderness areas. A unique waters classification may result in changes in forest management plans for the Apache Sitgreaves National Forest and new requirements for best management practices. Unique waters classifications may affect the uses of public lands within the proposed unique waters watersheds such as grazing, timber harvesting, and mining activity. ADEQ is interested in receiving comments from persons who have economic interests who may be affected by the proposed unique waters classifications.

The proposed revisions to the surface water quality standards rules are anticipated to have little or no economic impact on other state agencies, other than ADEQ. The revisions to the rules are expected to have no effect on state revenues.

9. The name and address of agency personnel with whom persons may communicate regarding the economic, small business, and consumer impact statement:

Name:	Mr. Steven Pawlowski
Address:	Arizona Department of Environmental Quality 3033 North Central Avenue Phoenix, Arizona 85012-2809
Telephone:	(602) 207-4219
Fax:	(602) 207-4528
E-mail:	sep@ev.state.az.us

10. The date, time and place of public meetings to discuss the proposed rules:

Date:	**June 6, 2001**
Time:	7:00 p.m.
Location:	Arizona Department of Environmental Quality Room 1709 3033 North Central Avenue Phoenix, Arizona
Date:	**June 12, 2001**
Time:	7:00 p.m. to 10:00 p.m.
Location:	Arizona Corporation Commission Hearing Room 222 Arizona State Office Complex 400 West Congress Street Tucson, Arizona

Date:	**June 14, 2001**
Time:	7:00 p.m. to 10:00 p.m.
Location:	City of Flagstaff City Council Chambers 211 West Aspen Avenue Flagstaff, Arizona

Date:	**June 26, 2001**
Time:	7:00 p.m. to 10:00 p.m.
Location:	Gila County Board of Supervisors Meeting Room 1400 East Ash Street Globe, Arizona

Date:	**June 27, 2001**
Time:	7:00 p.m. to 10:00 p.m.
Location:	Town of Springerville City Hall 418 Main Street Springerville, Arizona

The public comment period on the proposed rules will close on July 20, 2001. Written comments may be submitted by letter or e-mail to Mr. Steve Pawlowski at the address stated in paragraphs #4 and #9 of this preamble. Written comment letters must be postmarked by July 20, 2001.

11. Any other matters prescribed by statute that are applicable to the specific agency or to any specific rule or class of rules:

Not applicable

12. Incorporations by reference and their location in the rules:

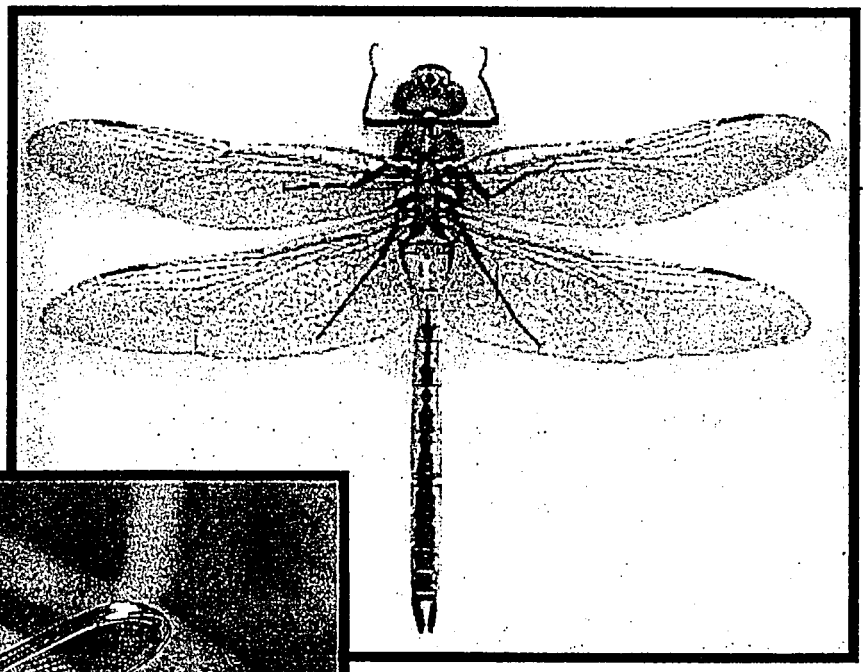
In R18-11-110(B) ADEQ incorporates by reference the "1999 Review, Water Quality Standards for Salinity, Colorado River System," Colorado River Basin Salinity Control Forum (June, 1999).

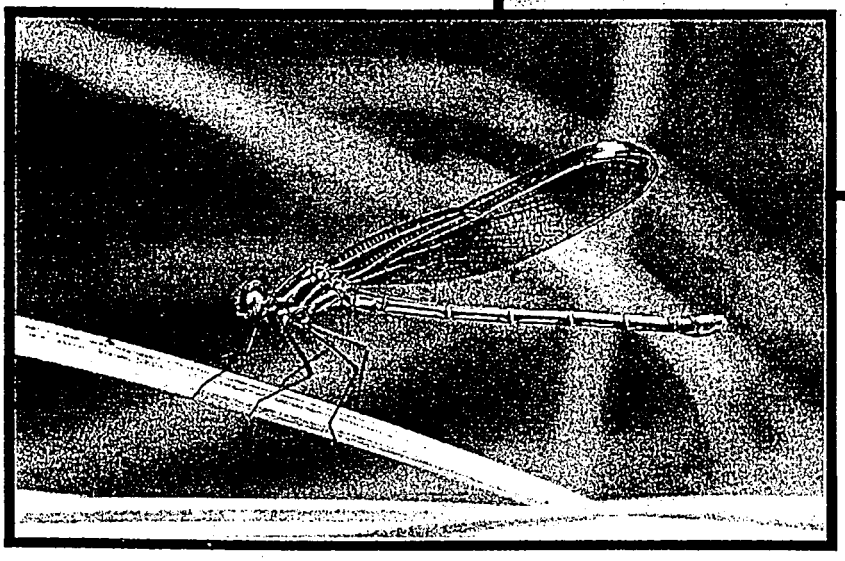
13. The full text of the rules can be found in Part 2 of 2 (page 1916):

Attachment G

Macroinvertebrate Community Distribution Among Reference Sites in Arizona

Macroinvertebrate Community Distribution Among Reference Sites in Arizona





Open File Report 00-05
Biocriteria Program
Arizona Department of Environmental Quality
October 2000

MACROINVERTEBRATE COMMUNITY DISTRIBUTION AMONG REFERENCE SITES IN ARIZONA

DRAFT REPORT

Patti Spindler, Aquatic Ecologist
Biocriteria Program
Hydrologic Support and Assessment Section
Water Quality Division
Arizona Department of Environmental Quality

October 2000

Acknowledgments

Acknowledgments go to dedicated field hands, support and technical staff, supportive managers and report reviewers. The success of the reference site sampling program was only possible with the hard physical labor of Richard Meyerhoff, Kyle Palmer, Sam Rector and Lucia Machado. Without their help, samples from sometimes nearly inaccessible reference sites would not have been collected. Special thanks to Kyle Palmer for being my partner in all aspects of the program, from sampling and shipping samples to calculating metrics to training other staff. Thanks to Forrest Woodwick and Richard Meyerhoff for initiating the program in 1991. Thanks to ADEQ managers Richard Meyerhoff, Wayne Hood III, Steve Pawlowski and Troy Day for continuing financial support and assistance to the biocriteria program. The analyses in this report are much improved thanks to Lin Lawson, who assisted me with learning SAS and Primer software and performing discriminant function analysis. Special thanks to Robert Wisseman for taxonomic advice and consistent taxonomy over the course of several years, without which these analyses would not be possible.

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EXECUTIVE SUMMARY

ADEQ is developing a bioassessment method for assessing the biological integrity of perennial, wadeable streams in Arizona. According to the USEPA's Rapid Bioassessment Protocols, the first step is to develop regional reference conditions which are necessary for developing the bioassessment tool and are also required as a reference by which to compare all future samples.

Ecoregions, a classification system for land areas based on soils, land use, topography, and vegetation have been successfully used to develop regional reference conditions for stream biological assemblages of eastern states. ADEQ's previous report entitled "Using ecoregions for explaining macroinvertebrate community distribution among reference sites in Arizona, 1992" found that the ecoregion model did not accurately predict the macroinvertebrate community distribution in Arizona based on one year's data. This study re-examines the ecoregion concept with additional data from 1993 and 1994 and proposes an alternate classification system to describe the natural patterns in the macroinvertebrate community statewide based on 89 sites, 240 samples, and 329 taxa collected over three years across the state of Arizona. Three multi-variate analyses were performed to create this alternate classification system; detrended correspondence analysis, cluster analysis and discriminant function analysis (DFA). The new classification system is based on an elevation model and consists of two broad macroinvertebrate regions and community types: 1) a warm water community located at approximately <5000' and a cold water community located at >5000'. All small to medium sized, wadeable, perennial streams located in these regions are predicted to have the same general macro-invertebrate community type. The warm water community is uniquely adapted to droughts and floods of the arid desert landscape and consists of a resilient community which is a taxonomically poorer community than the cold water community. The cold water community is taxonomically richer and resembles Rocky Mountain streams of other western states.

This customized regional reference approach forms the foundation from which to develop bioassessments, assessments of the biological integrity of any given perennial stream site. ADEQ will follow the Rapid Bioassessment Protocol approach to developing multi-metric Indexes of Biological Integrity (IBI's) for each of the two reference regions. Bioassessments will then be performed using these two IBI's for perennial, wadeable streams in Arizona.

INTRODUCTION

Development of biocriteria and use of bioassessments within the states has only begun within the past decade as USEPA methods for assessing biological integrity have become available. The US Environmental Protection Agency's initial Rapid Bioassessment Protocols (Plafkin et al.1989) and the 1999 Revised Rapid Bioassessment Protocols (Barbour et al. 1999) have been instrumental in helping states to initiate this bioassessment work. The Rapid Bioassessment Protocols (RBP) manual has outlined the concept of bioassessment and regional reference conditions and described a habitat assessment method and sample collection and analysis techniques for periphyton, benthic macroinvertebrates, and fish. Unlike previous approaches, such as the use of indicator taxa to assess the condition of the macroinvertebrate community (Hilsenhoff, 1988), the RBP presented several metrics (structural, functional and tolerance numeric characteristics of the community) which is combined into a final bioassessment score. This final score is then compared to the composite reference condition for that region to assess the biological integrity of that stream ecosystem.

In Arizona many studies of aquatic communities have been conducted. Several studies have described the benthic macroinvertebrate community present in streams (Blinn and Sanderson, 1989; Bruns and Minckley, 1980; and Gray, 1981), the successional and colonization patterns following floods (Fisher et al. 1982), and the composition of the hyporheic community (Boulton, et al. 1992). Mangum (1990) developed a benthic macroinvertebrate assessment method for the U.S. Forest Service for use in the western United States and this method was applied in the Upper Verde River by Ellsworth (1994). However, no studies developing the RBP regional reference condition for Arizona have been conducted in Arizona. This study presents a customized RBP regional reference approach for application of bioassessments to perennial, wadeable streams in Arizona.

METHODS

Sampling Sites

ADEQ is developing the regional reference site approach (Barbour et al. 1999) for classifying macroinvertebrate communities and developing biocriteria. A total of 116 potential reference sites were sampled during the three year period to represent the best available small to medium sized perennial streams in all major river basins, mountain ranges, and ecoregions in Arizona. Reference sites were initially selected by: 1)Identifying accessible, perennial, reference stream reaches on maps, 2) surveying environmental professionals and the literature for candidate reference streams, 3) identifying human disturbances to avoid in watersheds of potential sites (bridges, impoundments, channel alterations, point and non-point discharges), 4) conducting field reconnaissance to assure that water chemistry meets standards, 5) ensuring that habitat and riparian conditions meet minimum reference conditions using the RBP visual-based habitat protocol (habitat score >100), and 6) estimating condition of the macroinvertebrate community using the modified Family Hilsenhoff Biotic Index. After the initial site visits, many sites were found to be inadequate as reference sites due to intermittence, local impacts, waterbody type, or poor habitat (RBP habitat score < 100 or bedrock or travertine dominated). The number of reference sites was shortened to 89 sites and 240 samples which were collected during the period of 1992-1994 for this analysis (Figure 1, Appendix A).

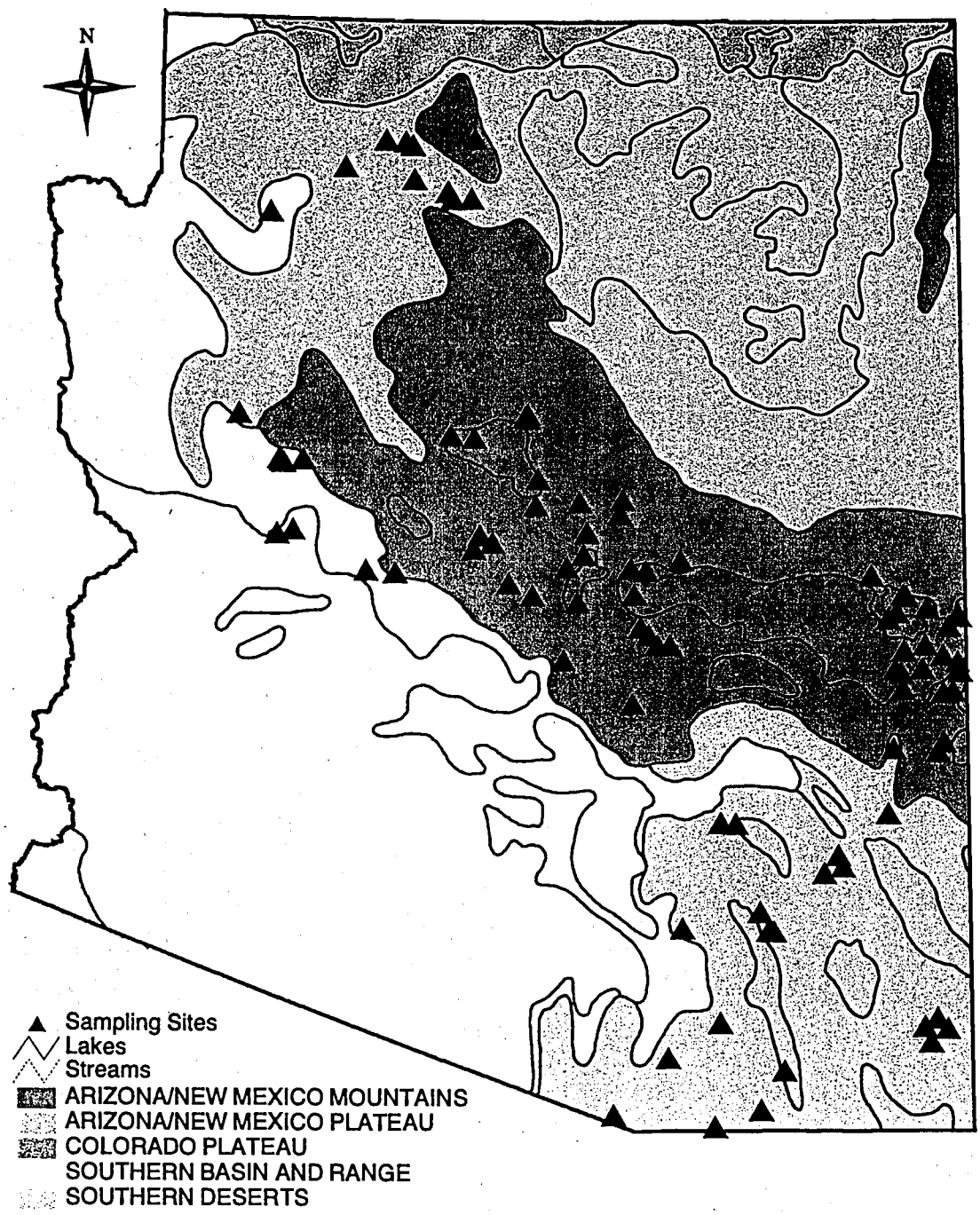

Figure 1. Eighty-nine reference sites located in best available, small to medium sized perennial, wadable streams among ecoregions of Arizona, sampled 1992-94.

Sampling Methods

ADEQ collected macroinvertebrates, water samples, and habitat data at reference sites during the spring index period, April through June depending on altitude, in 1992, 1993 and 1994. The macroinvertebrate sampling method consisted of a 3-minute timed kick sample with a D-frame kick net in riffles. Water samples were analyzed for inorganic, nutrient, and metal parameters. Field notes and a Rapid Bioassessment Protocol (Plafkin et al, 1989) visual-based habitat assessment were made for each sample. Sampling methods are described in the Draft ADEQ Biological Sampling Protocols (Meyerhoff and Spindler, 1994).

Data preparation

The lowest accurate level of taxonomic identification of samples was used to ensure good data quality. Where uncertain genus level identifications could be made, these data were reported at the family level instead to ensure accuracy. This resulted in 329 total taxa discovered during the three year period. There were 111 Chironomidae taxa which were lumped to the family level to reduce variability prior to multi-variate analyses. Natural log transformations were performed prior to multi-variate analyses. Raw, untransformed data, not including midge genera, were used to calculate metrics. A list of taxa found in all 240 samples is included in Appendix B.

Multi-variate Analyses

Community patterns among the reference sites were described using three multi-variate methods. A cluster analysis using Ward's linkage method and Pearson's distance metric was performed to develop an initial classification (SYSTAT software; Wilkinson and Hill, 1994). A second ordination method, discriminant function analysis, using SYSTAT software, was used to confirm the site groupings from the cluster analysis and identify the most important environmental variables responsible for the sample distributions. The third method, Detrended Correspondence Analysis (DCA; Hill, 1979) was used to visually show site groupings, ecoregion groupings of sites, and the elevation gradient among sites.

Environmental variable selection

Many new variables were included in this analysis which were not included in the 1992 study (Spindler, 1996). The variables of geology type, upland vegetation type, and soil class were extracted from databases in ArcView map layers. Simplified geology types were estimated based on alluvium, sedimentary, metamorphic, granitoid, and volcanic rock types. The Rosgen stream classification (Rosgen, 1996) was estimated from the New Mexico regional curve, gradients of streams at sampling locations, and field estimated width/depth ratios. Riparian vegetation categories were developed based on Brown's community distribution of deciduous riparian trees in central Arizona (Brown, 1994). Watershed areas, site gradients, and basin relief ratios were calculated from USGS topographic maps with a planimeter and map wheel. Stream width, velocity, and discharge were calculated from field measurements. The initial 59 environmental variables are listed in Table 1. Pearson correlations on all variables were performed to remove auto-correlated variables and find the most important variables which explain the macro-invertebrate community distribution. The resulting 14 selected variables for inclusion in the multiple regression and discriminant function analyses included:

1. Average discharge
2. Basin relief ratio
3. Ecoregion
4. Elevation
5. Gradient at the site
6. Pool/Riffle ratio
7. Riparian association
8. Rosgen stream type
9. Simplified geology type
10. Stream size class
11. Stream velocity
12. Total alkalinity
13. Total Habitat Score
14. Watershed area

Table 1. Fifty-nine habitat, physical, and chemical parameters from Arizona reference sites for correlation analysis.

Physico-chemical	Physical	RBP Habitat Assessment Variables
Temperature	Ecoregion	Riffle Substrate
Dissolved Oxygen	Geology type (detailed)	Riffle Embeddedness
% Saturation	Geology type (simple)	Pool Substrate
Field & Lab Conductance	Soil Temperature Classification	Velocity/Depth Ratio
Field and Lab pH	Upland Vegetation type	Shade condition
Field and Lab TDS	Riparian Classification	Channel Shape
TSS	Pool/Riffle Ratio (actual #)	Pool/Riffle Ratio category
Field and Lab Turbidity	Stream Width	Lower Bank Channel Capacity
EDTA Hardness	Stream Size Category	Upper Bank Stability
Cations: Ca, Mg, Na, K	Average Velocity	Grazing Impacts
Anions: CO3, HCO3, SO4, Cl, F	Average Discharge	Stream-side Cover
Alkalinity, Total and Phenolthalein	Watershed Area	Riparian Width
Nutrients: TKN, NO3, TP	Elevation	Sum of Habitat Scores: 1-4, 5-8, 9-12
	Gradient at Site	Total Habitat Score
	Basin Relief Ratio	
	Rosgen Stream Type (estimated)	

Six community metrics (parameters which measure a component of the structure or function of the macroinvertebrate community) were calculated and box and whisker plots were created to characterize the two community types found in the multi-variate analysis.

Box and whisker plots also are used to compare the ecoregion and macroinvertebrate regions models as tools for classifying macroinvertebrate communities. The box indicates the median, 25th and 75th percentiles of the range of values. The whiskers show the range of values 1.5 times the spread of the box. Asterisks and dots indicate outlier values. The notch in each box defines the 95% confidence interval by which to test for significant differences.

ArcView3 maps were used for a visual comparison of the ecoregion map layer with the macroinvertebrate classification. This was done by overlaying the two groups of sites onto a map of ecoregions of the state. A final map of simplified elevation contours was created to show simplified regions of streams with similar macroinvertebrate community structure.

Multi-variate Analysis of Ecoregions

The relationship between macroinvertebrate distribution at Arizona reference sites and ecoregions was examined with detrended correspondence analysis (DCA) scatter plots of macroinvertebrate taxonomic data from reference sites in 1994. DCA is a multi-variate technique which summarizes community patterns from large amounts of species data and produces a species-space scatter-plot in which similar samples are close together and dissimilar ones far apart. The multi-dimensional species space is projected onto a space of fewer dimensions which allows an examination of the structure of the points along the two shown dimensions. The axes of the species-space scatter-plot consist of two species axes which are unlike the axes of normal two-dimensional data. Natural groupings of similar sites can be determined from these species-space scatter plots. Multiple regressions of environmental variables on the DCA axes scores are then conducted to assess which environmental gradients relate to the community structure.

Associations between the natural distribution of the 1994 macroinvertebrate abundance data and ecoregions was analyzed using DCA scatter plots. The natural distribution of sample points in Figure 2 indicate that there are two broad groups within the 1994 macroinvertebrate data set. Sample points are represented by ecoregion labels in Figure 3 to compare how well ecoregions grouped the macro-invertebrate communities with the natural distribution. Sites within the Southern Basin and Range ecoregion group together on the left, however sites within the Southern Deserts and Arizona-New Mexico Mountains ecoregions are spread out along the x and y-axes, displaying no particular grouping structure. Ecoregions did not classify the samples well, as the ecoregion labels did not form well-defined clusters.

A multiple regression was performed to test which environmental parameter, other than ecoregions, best predicts the grouping structure in Figure 2. The multiple regression was conducted with 14 environ-mental variables and the DCA axis1 and axis 2 scores. Elevation ($r=0.62$; $p<0.01$) and total alkalinity ($r=-0.35$; $p<0.01$) were the significant variables explaining the distribution of sites along axis 1, accounting for 38% and 12% of the variance, respectively. There were no significant variables accounting for the distribution of sites along the y-axis. Since elevation was the most significant parameter, elevations were used to represent sample points in Figure 4. Elevations are different between each of the two natural groups with a range of approximately 2000'-5000' in one group and a range of 5000'-9000' in the other group.

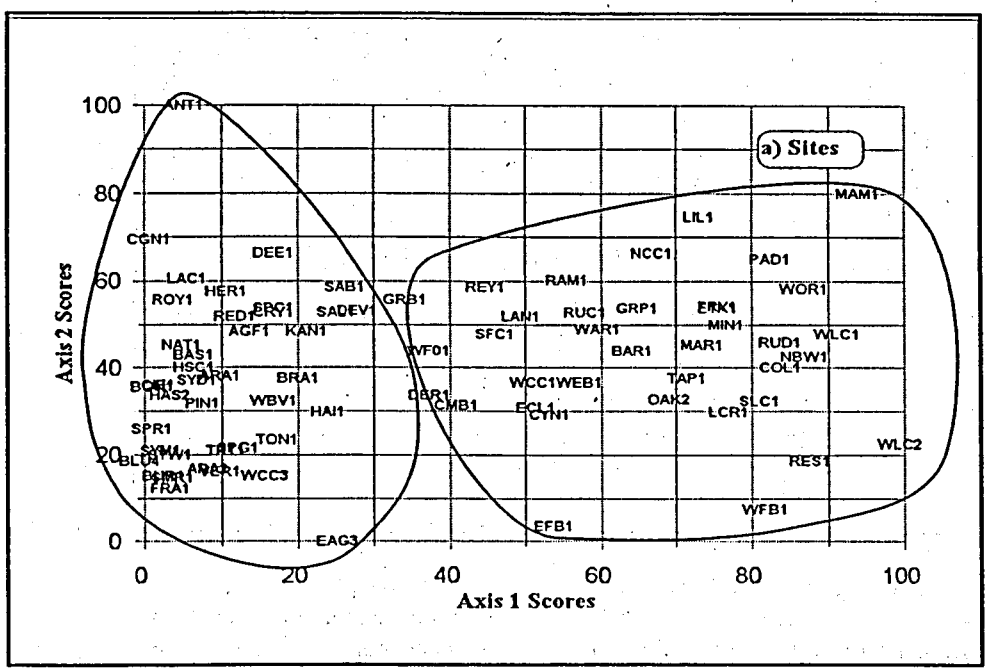

Figure 2. The natural groups found among sample sites in a detrended correspondence analysis scatter plot of macroinvertebrate abundance data from 1994.

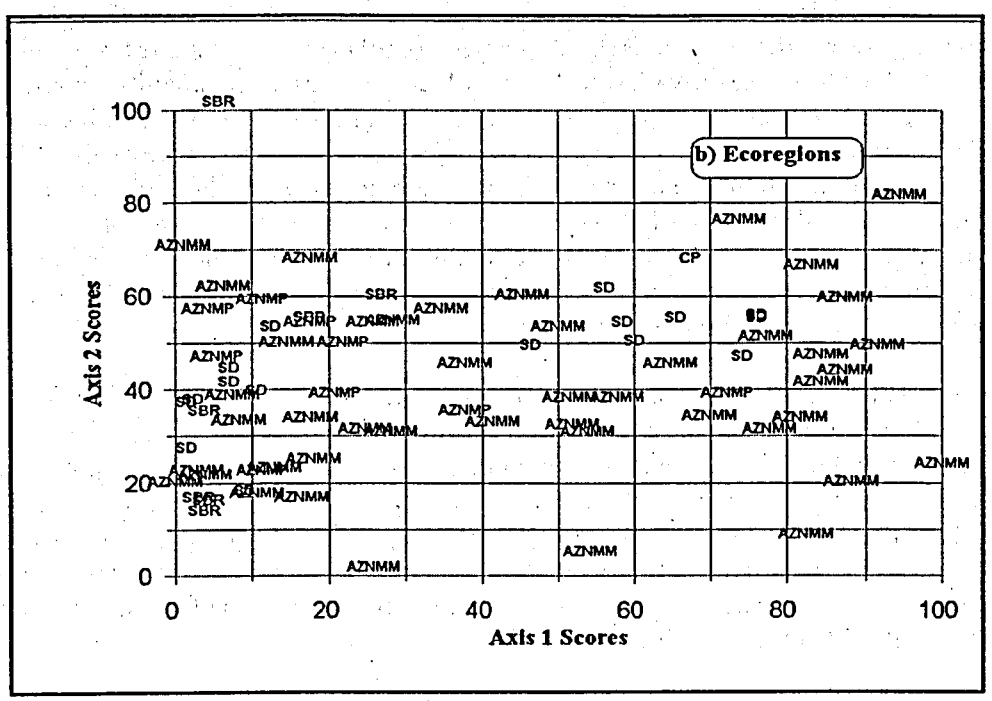

Figure 3. A comparison of the ecoregions classification and the natural groups among sample sites in a detrended correspondence analysis scatter plot of macroinvertebrate abundance data from 1994.

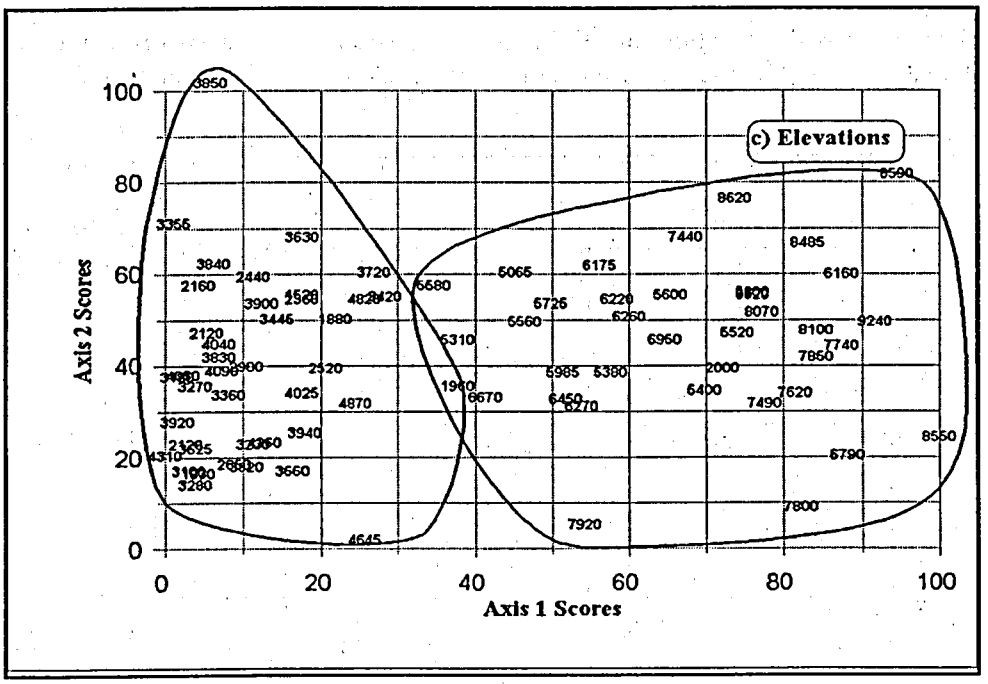

Figure 4. Two natural groups of reference sites in Arizona with sample points represented by elevations in a DCA scatter plot using 1994 macroinvertebrate community data. Two sites have marginal warm water communities due to a cold water source; Reynolds Creek (5065') and Deer Creek (1960'). Tapeats Creek (2000'), a tributary of the Colorado River, is an unique cold water stream fed by a large spring but is found at a low elevation.

Cluster and Discriminant Function Analyses

The ecoregion classification model was inadequate for explaining macroinvertebrate community distribution across Arizona and an exploratory DCA indicated the potential for two broad groups to classify reference samples. Additional multi-variate analyses on the 1992, 1993, and 1994 data sets were then conducted to explore initial patterns identified by the DCA and to develop an alternate classification system. A cluster analysis was performed to initially classify the samples for each year's data set. Then a discriminant function analysis (DFA) was conducted to test the accuracy of the initial classification, reclassify samples, and identify the linear combination of environmental variables which best predicted group membership of samples.

The 1992 riffle dataset (natural log transformed) contained 81 reference samples. The 1992 cluster analysis on macroinvertebrate taxa placed the 81samples into two broad groups, as indicated in Figure 5. A discriminant function analysis (DFA) was performed on the groups identified in the cluster analysis and the fourteen selected environmental variables using a stepwise backward regression. Three environmental variables explaining the site distribution were identified: elevation, discharge, and basin relief. Five complete regressions were run using the three identified environmental variables to reclassify seven sites. The first canonical variable, which is the linear combination of the environmental variables that best discriminates among the groups, accounted for 86% of the dispersion among the samples. The final group membership for all 1992 samples is recorded in Appendix A.

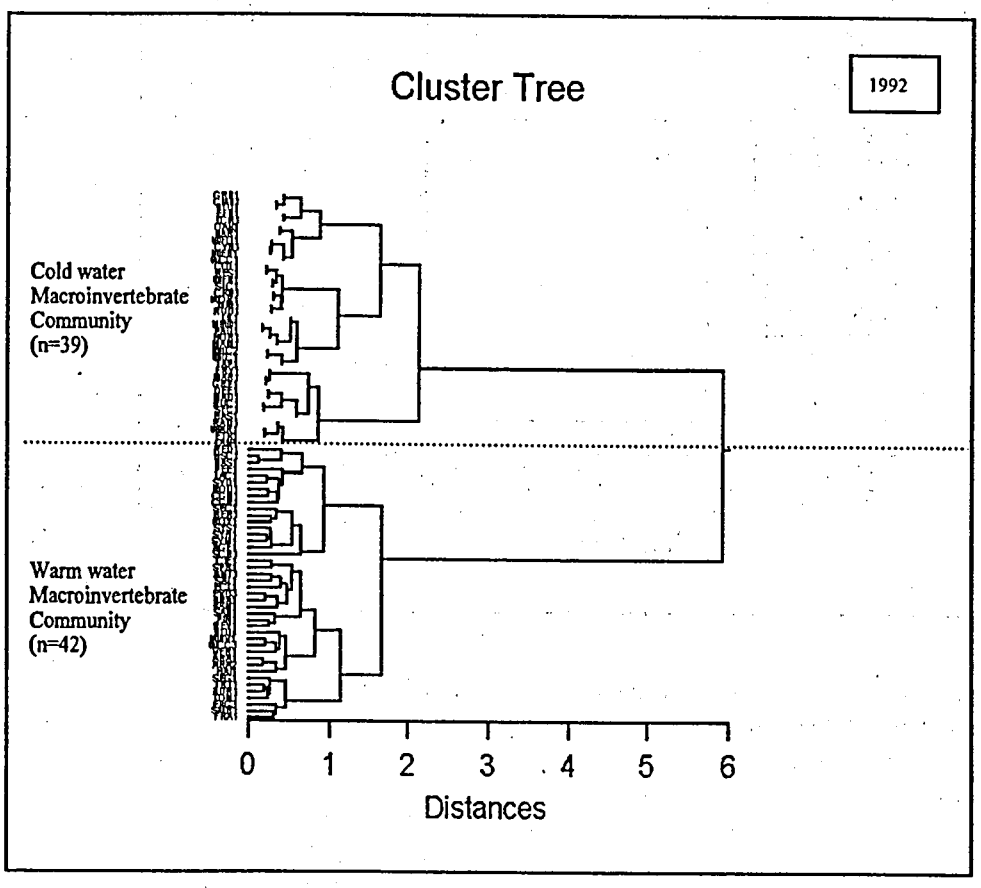

Figure 5. Two natural groups among Arizona reference sites as determined by a cluster analysis dendrogram, based upon macroinvertebrate abundance data from 1992.

The 1993 riffle dataset (natural log transformed) contained 81 reference sites. The 1993 cluster analysis on macroinvertebrate taxa placed the 81samples into two broad groups, as indicated in Figure 6. A DFA was performed on the two groups identified in the cluster analysis and the fourteen selected environmental variables using a stepwise backward regression. Three variables which explained the site distribution were identified: elevation, total alkalinity, and Rosgen stream type. Three complete regressions were run using the three identified environmental variables to reclassify seven sites. The first canonical variable accounted for 90% of the dispersion among the samples. The final group membership for all 1993 samples is recorded in Appendix A.

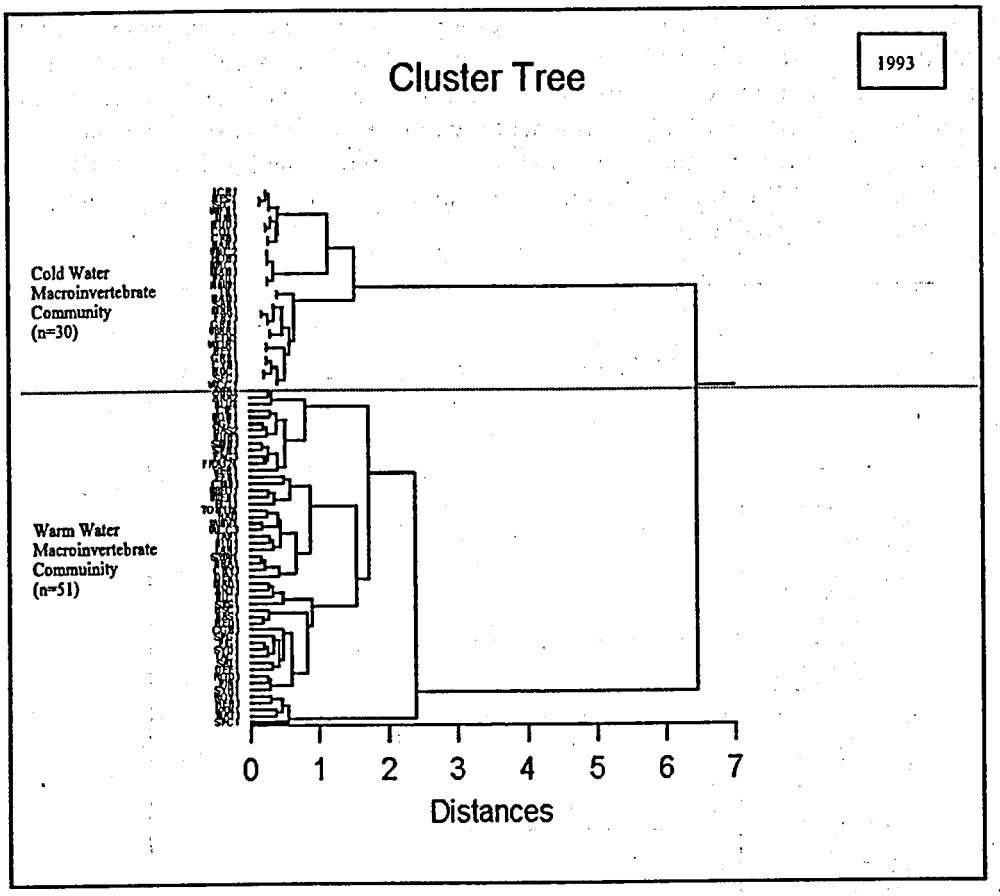

Figure 6. Two natural groups among Arizona reference sites as determined by a cluster analysis dendrogram, based upon macroinvertebrate abundance data from 1993.

The 1994 riffle data set (natural log transformed) contained 78 reference sites. The 1994 cluster analysis on macroinvertebrate taxa placed the 78 samples into two broad groups, as indicated in Figure 7. A DFA was performed on the groups from the cluster analysis and the fourteen selected environmental variables using a stepwise backward regression. Three environmental variables explaining the site distribution were identified: elevation, site gradient, and pool-riffle ratio. Two complete regressions were run using the three identified environmental variables to reclassify four sites. The first canonical variable accounted for 87% of the dispersion among the samples. The final group membership for all 1994 samples is shown in Appendix A.

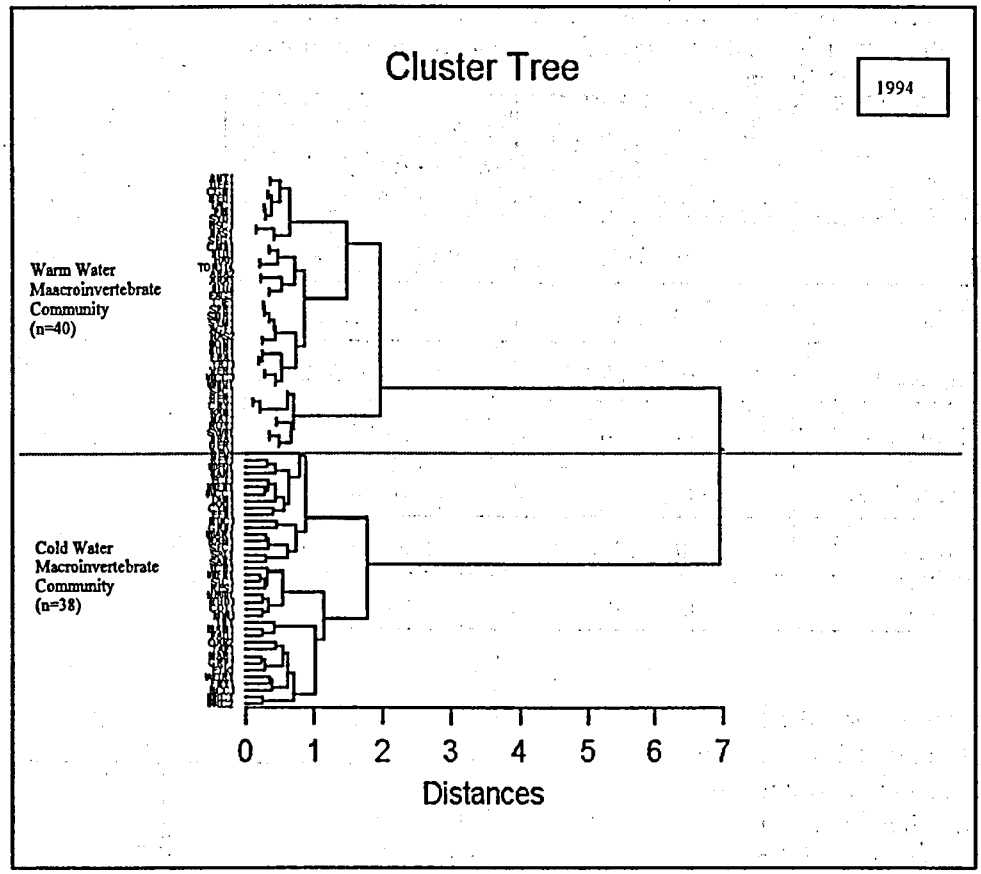

Figure 7. Two natural groups among Arizona reference sites as determined by a cluster analysis dendrogram, based upon macroinvertebrate abundance data from 1994.

The cluster and DFA for 1992, 1993, and 1994 found two community types in the macroinvertebrate data. Most sites which were sampled for 2 or more years were consistently placed into the same community group in each analysis. A few sample sites were borderline between the two groups. Sample sites were placed in whichever group they more often appeared.

Environmental Characteristics of the new Classification System

The two macroinvertebrate groups resulting from the cluster and DFA can be characterized by the environmental variables which were identified by the DFA for each year's analysis. Ranges of values for the seven selected environmental variables identified in the DFA are shown in Table 2.

Table 2. Ranges of values for seven environmental variables selected by DFA which describe the distribution of the two macroinvertebrate community groups in Arizona, based on 1992-94 data.

Parameter	Macroinvertebrate Group 1	Macroinvertebrate Group 2 (outlier)
Elevation (ft)	1500-5165	(2000) 5310-9240
Discharge (cfs)	0.1-33.0	0.0-126.7
Basin Relief Ratio	0.011-0.282	0.014-0.618
Total Alkalinity (mg/L)	20.8-318.0	9.3-197.0
Rosgen Stream Type	1 - 6 (Aa - F)	1 - 6 (Aa - F)
Gradient at the site	0.003-0.246	0.004-0.216
Pool/Riffle ratio	0.0-34.4	0.2-33.0

Elevation was consistently identified each year as the most important variable explaining the two community groups. The elevations between the two macro-invertebrate groups were significantly different, as indicated by the box-and-whisker plot in Figure 8. Each macroinvertebrate group is characterized by a range of elevation as follows: 1) a high elevation cold water macroinvertebrate community found at elevations ranging from 5310' to 9240' (with an outlier at 2000') and 2) a low elevation warm water macroinvertebrate community found at elevations ranging from 1500' to 5165'.

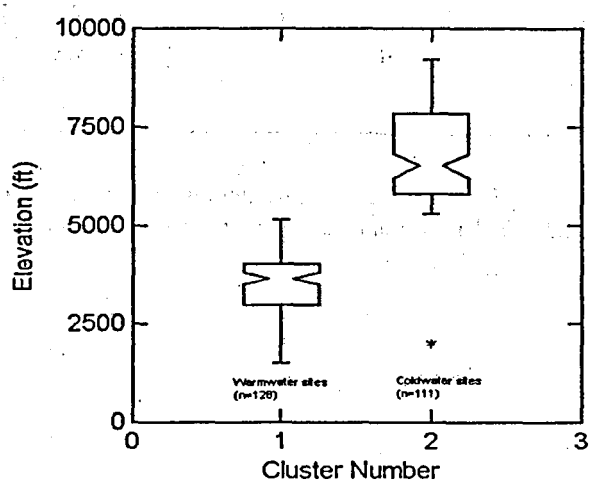

Figure 8. Regional elevation differences between Arizona macroinvertebrate groups, 1992-94.

Geographic Model of Macroinvertebrate Regions

An alternate classification model to ecoregions can be constructed using the environmental variables from Table 2. Since elevation, a variable which reflects multiple other variables such as climate and vegetation type, is the most important variable explaining the distribution of reference communities, a geographic model based on elevation can be constructed. Figure 9 displays "macroinvertebrate regions" which were constructed using the 1500 m (approximately 5000') topographic contour line. This elevation model can be used to predict which macroinvertebrate community type might be present in any given perennial stream in the state. Streams on tribal lands may be an exception to this model, because of high plains streams with little perennial water, but we have no data yet to make any determination.

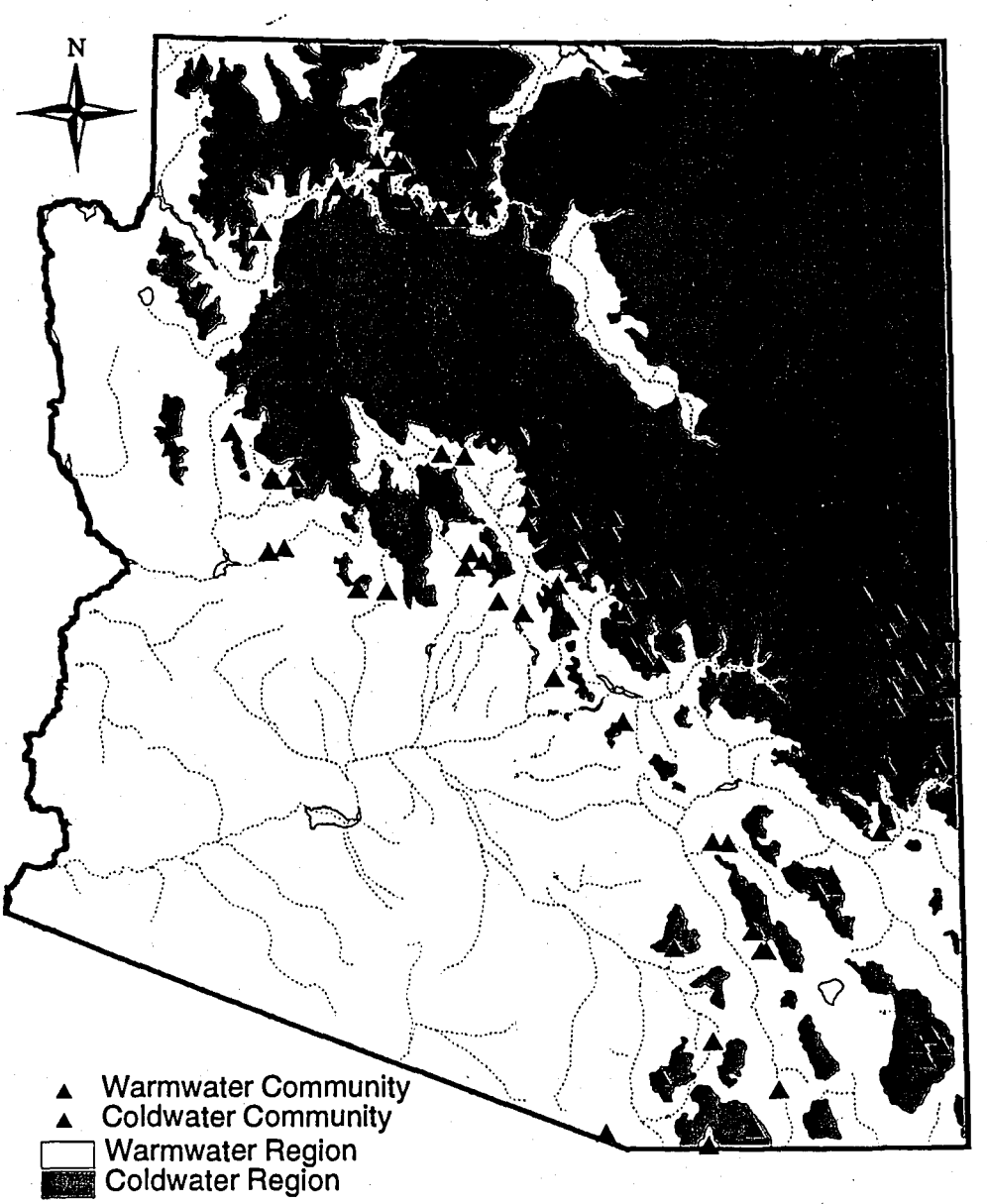

Figure 9. Macroinvertebrate regions map of Arizona, showing regions containing warm water and cold water macroinvertebrate communities.

Community Characteristics of Each Macroinvertebrate Region

Unique characteristics of each macroinvertebrate community, called metrics, describe the structure and function of the macroinvertebrate community for each region. A comparison of community characteristics of the two macroinvertebrate communities is displayed in Table 3 and in Figure 10 using box-and-whisker plots of six metrics. The warm water macroinvertebrate community contains fewer taxa of pollution sensitive mayflies and caddisflies, has fewer taxa overall, contains fewer scraper taxa, almost non-existent shredder abundance, and greater composition by the most dominant taxon. The cold water macroinvertebrate community is richer in pollution sensitive mayflies and caddisflies, has greater overall taxa richness, more abundant shredders, contains more scraper taxa and reduced composition by the most dominant taxon. The most significant differences between communities of warm and cold water streams were in the percent shredders and the scraper taxa richness metric; both were greater in the cold water community.

Table 3. Ranges of values for six metrics of the two macroinvertebrate communities of Arizona for samples collected during 1992, 1993 and 1994. The mean metric value is in parentheses.

Metric	Metric ranges and mean values for the warm water macroinvertebrate community	Metric ranges and mean values for the cold water macroinvertebrate community
Mayfly Taxa Richness	0-10 (4)	0-10 (5)
Caddisfly Taxa Richness	0-14 (5)	0-15 (6)
Total Taxa Richness	12-53 (34)	17-55 (37)
Scraper Taxa Richness	0-11 (4)	1-15 (7)
Percent Dominant Taxon	13-79 (35)	11-84 (33)
Percent Shredders	0-21 (0)	0-44 (7)

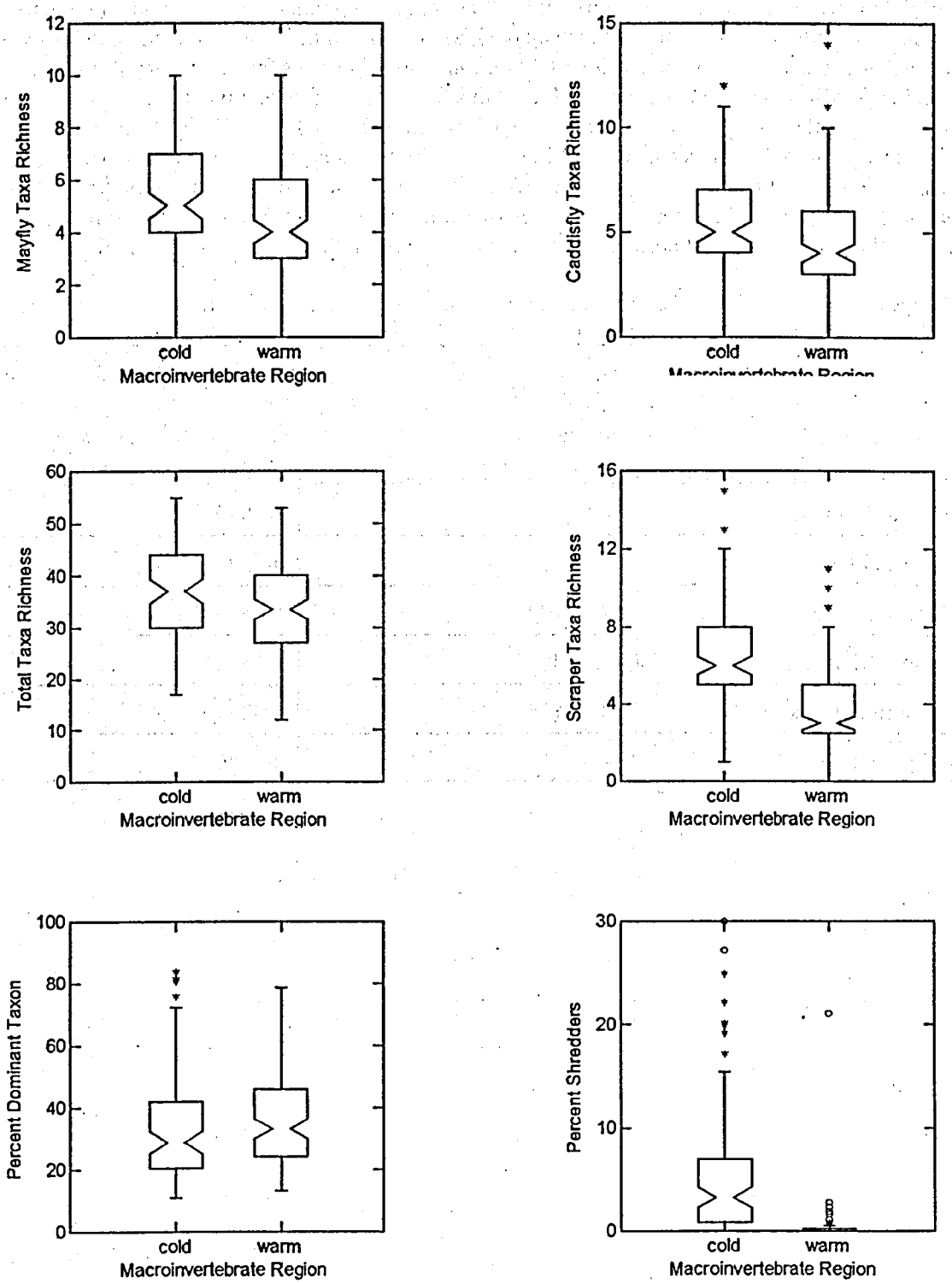

Figure 10. Box and whisker plots of different macroinvertebrate reference community characteristics between macroinvertebrate regions, based on 1992-94 abundance data in Arizona.

DISCUSSION

In order for accurate bioassessments to be made for all wadeable, perennial streams in Arizona, it is important that regional reference conditions be defined. Regional reference conditions consist of measurements from a population of best available reference sites within a relatively homogeneous region and habitat type. "The reference condition establishes the basis for making comparisons and for detecting use impairment; it should be applicable to an individual waterbody, such as a stream segment, but also to similar waterbodies on a regional scale" (Gibson et al. 1996). The popular "ecoregion" approach developed by Omernik (1987) was based on the assumption that waterbodies reflect the lands they drain and that similar lands should produce similar waterbodies. Omernik's ecoregion model classifies land areas based upon soils, land use, topography and vegetation. The naturally occurring biotic assemblages would be expected to differ among ecoregions but be relatively similar within a given ecoregion. The ecoregion model has accurately classified stream biological assemblages of eastern states such as Arkansas, Ohio, and Minnesota which have large homogeneous landforms (Hughes and Larsen, 1988).

Arizona's topography and hydrology is variable even in the desert regions, where "sky-island" mountains are present (Heald, 1951). There are five ecoregions in the state of Arizona as shown in Figure 1: Southern Basin and Range, Southern Deserts, Arizona-New Mexico Mountains, Arizona-New Mexico Plateau, and the Colorado Plateau. Sky islands are prevalent in the Southern Deserts ecoregion, in which all the life zones from desert to spruce-fir forest may lie in close proximity to one another. The Arizona-New Mexico Mountains ecoregion also contains a mixture of topography and vegetation in landforms of high desert to foothills of the Mogollon Rim to some of the highest mountain peaks in the White Mountains of Arizona. We have hypothesized that the ecoregion concept is not the appropriate model for classifying benthic macroinvertebrate communities in Arizona because of variable topography and stream types within ecoregions of the state.

We re-examined the ecoregion model with 1993 and 1994 reference site data sets, as it was done in the previous report on the 1992 dataset (Spindler, 1996). The DCA scatter plots of the macroinvertebrate communities again showed that they do not group well by ecoregions. The multiple regression analysis of 14 environmental variables on the DCA axes scores indicated that elevation and total alkalinity were the most important variables explaining the community distribution along the x-axis. These findings are consistent with those of our previous report (Spindler, 1996). We have concluded that the ecoregion model is inappropriate for properly classifying macroinvertebrate communities in Arizona.

We performed three multi-variate analyses to develop an alternate model for classifying macroinvertebrate communities. The DCA scatter plots indicated that there were basically two macroinvertebrate groups in the data, identified as warm water and cold water communities. A cluster analysis for each year of data also described two broad groups, having some mis-classified sites which were properly reclassified by DFA. The resulting warm water group of reference sites contained 50 sites from 9 surface water basins and 4 ecoregions statewide. The coldwater macroinvertebrate group of reference sites contained 39 sites from 8 surface water basins and 4 ecoregions statewide. No warm water reference sites were located in the Little Colorado Basin. More research is needed to determine whether there are any potential warm water reference sites in the Little Colorado River Basin. There are no cold water reference sites in the Middle Gila or Bill Williams basins. We concluded that a classification model consisting of two broad groups best describes the macroinvertebrate community distribution in Arizona.

An elevation model was determined to best classify macroinvertebrate communities, since elevation was consistently found by DCA, multiple regression and DFA to be the most important environmental variable explaining the macroinvertebrate distribution. We recognize that elevation is correlated with many other

environmental variables, such as water temperature, canopy density, stream gradient, conductivity and in-stream habitat, and is considered a surrogate measure for these combined variables. The elevations for the two community types were: 1) warm water macroinvertebrate community located at 1500-5165' and 2) cold water macroinvertebrate community located at 5310-9240'. The warm water communities have low elevations, desert to foothills topography, high alkalinity, and low flows. The cold water sites of Group 2 have higher elevations, mountain topography, low alkalinity and greater flows.

This elevation model can predict macroinvertebrate community membership for any given perennial stream site in Arizona. The elevation of approximately 5000' on topographic maps or the 5000' contour line in an arcview cover can be used to identify which community type applies to a new site. New sites can easily be classified based on topographic map elevations as shown in Figure 7. The two areas of the map are named "warm water macroinvertebrate region" and "cold water macroinvertebrate region". These two community types, "warm water" and "cold water" macroinvertebrate communities correspond with the Aquatic and Wildlife Use Classifications of Aquatic & Wildlife warm and Aquatic & Wildlife cold which currently exist in our Surface Water Quality Standards (A.A.C. R18-11-101, 104 and Appendix A).

Each macroinvertebrate community is markedly different as indicated by six community metrics. The warm water macroinvertebrate community is characterized by less mayfly, caddisfly, scraper, and total taxa richness, much reduced percent composition by shredders and a greater percentage composition by the most dominant taxon. The cold water macroinvertebrate community is characterized by greater mayfly, caddisfly, scraper, and total taxa richness, a much greater percent composition by shredders, and a reduced composition by the most dominant taxon.

The cold water community is richer in pollution sensitive mayflies and caddisflies and functionally has more scraper taxa and greater numbers of shredders. The warm water community contains fewer taxa of pollution sensitive mayflies and caddisflies and fewer taxa overall and functionally contains fewer scraper taxa and minimal shredders. Warm water communities are unique because they develop rapidly, generally do not have dormant stages, and are adapted to drought and flooding by behavioral avoidance in response to the arid environment (Gray, 1981). Mayfly, caddisfly and stonefly taxa of Arizona's cold water streams resemble taxa found in temperate region streams such as those of the Rocky Mountains (Wisseman, pers. comm.). These characteristics lead us to conclude that the taxa found in desert streams are much different than those in mountain streams in Arizona and that a minimum of two broad macroinvertebrate community types exist in the state.

This research document has identified appropriate reference regions and macroinvertebrate communities, which is the first step in developing a bioassessment tool. The bioassessment tool consists of IBI's for each macroinvertebrate type or region in the state. The development of IBI's involves a process of identifying metrics which best discriminate between reference and impacted samples, selecting from the metric categories of richness, composition, tolerance and trophic function, and selecting a scoring system with associated narrative categories, such as fair or good.

ADEQ is in the process of developing Indexes of Biological Integrity for warm water and cold water reference regions (or the A&Wwarm and A&Wcold designated uses) following guidance in the new Rapid Bioassessment Protocols (Barbour et al. 1999). These IBI's can only be used for perennial wadable streams and are not applicable to intermittent, ephemeral, or effluent dependent waterbodies or lakes. These multi-metric IBI's form the bioassessment tool by which to evaluate the health of the aquatic community. Methods for collecting, analyzing, and calculating IBI's for macroinvertebrate samples will be presented in a quality assurance program plan in the near future. Methods for applying the bioassessments for various purposes such as for water quality assessments (305b) will be presented in an implementation guidance document by 2001.

LITERATURE CITED

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APPENDIX A:

ADEQ Biocriteria Program Reference Site List

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	STREAM NAME	DESCRIPTION	LATITUDE	LONGITUDE	BASIN	COUNTY
AGF1	AGUA FRIA RIVER	BELOW GAGING STATION	341851	1120339	Middle Gila	YAVAPAI
ANT1	ANTELOPE CREEK	ABV ROAD CROSSING NR STANTON	341146	1124252	Middle Gila	YAVAPAI
ARA1	ARAVAIPA CANYON CREEK	AT PARSONS CANYON (EAST END)	325413	1102740	San Pedro	PINAL
ARA2	ARAVAIPA CANYON CREEK	AT HELLS HALF ACRE CANYON (WEST END)	325439	1103259	San Pedro	PINAL
BAR1	BARBERSHOP CANYON CREEK	BELOW MERRITT DRAW CONFLUENCE	342940	1110955	Little Colorado	COCONINO
BAS1	BASS CANYON	ABOVE DOUBLE R CANYON CONFLUENCE	322107	1101406	San Pedro	COCHISE
BLU1	BLUE RIVER	BELOW JACKSON BOX (UPPER)	334104	1090457	Upper Gila	GREENLEE
BLU4	BLUE RIVER	ABOVE FRITZ RANCH (LOWER)	331936	1091123	Upper Gila	GREENLEE
BON1	BONITA CREEK	ABOVE CONFLUENCE WITH GILA RIVER	325723	1093152	Upper Gila	GRAHAM
BRA1	BRIGHT ANGEL CREEK	BELOW PHANTOM RANCH	360609	1120543	Colorado River	COCONINO
BUR1	BURRO CREEK	ABOVE CONF WITH FRANCIS CREEK	344438	1131423	Bill Williams	YAVAPAI
CGN1	CAMPAIGN CREEK	AT SUPERSTITION WILDERNESS BOUNDARY	333127	1110512	Salt River	MARICOPA
CGR1	CONGER CREEK	BELOW CONGER SPRING	344531	1130710	Bill Williams	YAVAPAI
CIE1	CIENEGA CREEK	ABOVE THE NARROWS	315305	1103315	Santa Cruz	PIMA
CKN1	CONKLIN CREEK	ABOVE FOREST SERVICE ROAD #25	334055	1092637	Salt River	GREENLEE
CMB1	CAMPBELL BLUE CREEK	ABOVE CONFLUENCE WITH K E CANYON	334420	1090548	Upper Gila	GREENLEE
COL1	COLEMAN CREEK	BELOW TURKEY CREEK CONFLUENCE	334617	1091112	Upper Gila	GREENLEE
CRY1	CRYSTAL CREEK	ABOVE COLORADO RIVER CONFLUENCE	360808	1121436	Colorado River	COCONINO
CYN1	CANYON CREEK	ABOVE VALENTINE CANYON	341530	1104742	Salt River	GILA
DEE1	DEER CREEK	AT MAZATZAL WILDERNESS BOUNDARY	340236	1112514	Salt River	GILA
DER1	DEER CREEK	ABOVE CONFLUENCE WITH COLORADO RIVER	362322	1123028	Colorado River	COCONINO
DEV1	DEVILS CHASM	ABOVE CONFLUENCE WITH CHERRY CREEK	334923	1105137	Salt River	GILA
EAG3	EAGLE CREEK	BELOW GAGING STATION	331740	1092939	Upper Gila	GREENLEE
ECL1	EAST CLEAR CREEK	ABOVE CONFLUENCE WITH YEAGER CANYON	343360	1110849	Little Colorado	COCONINO
EFB1	EAST FORK BLACK RIVER	ABOVE DIAMOND ROCK CAMPGROUND	334920	1091747	Salt River	APACHE
ETK1	EAST TURKEY CREEK	ABOVE FOREST ROAD 42	315431	1091509	Upper Gila	COCHISE
EVD3	EAST VERDE RIVER	ABOVE BRUSHY CANYON CONFLUENCE	341712	1112305	Verde River	GILA
FRA1	FRANCIS CREEK	ABOVE BURRO CREEK CONFLUENCE	344443	1131457	Bill Williams	YAVAPAI
FRY1	FRYE CANYON CREEK	AT FIRST CROSSING OF FS TRAIL #36	324437	1095019	Upper Gila	GRAHAM
GRB1	GRANT CREEK	ABOVE BLUE RIVER CONFLUENCE	333442	1091117	Upper Gila	GRAHAM
GRP1	GRANT CREEK	1 MILE BELOW POST CREEK CONFLUENCE	323907	1095528	Willcox Playa	GREENLEE
HAI1	HAIGLER CREEK	1.4 MILES BELOW ALDERWOOD RECREATION SIT	341214	1110029	Salt River	GILA
HAS2	HASSAYAMPA RIVER	BELOW COTTONWOOD CREEK CONFLUENCE	341113	1123222	Middle Gila	YAVAPAI
HER1	HERMIT CREEK	ABOVE COLORADO RIVER CONFLUENCE	360556	1121232	Colorado River	COCONINO
HOR1	HORTON CREEK	ABOVE FOREST SERVICE ROAD #26	334206	1091857	Salt River	GREENLEE

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	STREAM NAME	DESCRIPTION	LATITUDE	LONGITUDE	BASIN	COUNTY
HSC1	HOT SPRINGS CANYON	BELOW WILDCAT CANYON CONFLUENCE	322115	1101602	San Pedro	COCHISE
KAN1	KANAB CREEK	ABOVE COLORADO RIVER CONFLUENCE	362340	1123755	Colorado River	MOHAVE
LAC1	LITTLE ASH CREEK	NEAR ESTLER PEAK	342302	1120131	Middle Gila	YAVAPAI
LAN1	LANPHIER CANYON	ABOVE FOREST SERVICE TRAIL #51 CROSSING	333511	1090745	Upper Gila	GREENLEE
LCR1	LITTLE COLORADO RIVER	ABV S. FK LITTLE COLORADO RIVER CONFLUENC	340440	1092534	Little Colorado	APACHE
LIL1	LILY CREEK	BELOW FORK; BELOW FOREST ROAD #275	335838	1090533	Little Colorado	APACHE
MAD1	MADERA CANYON CREEK	1 MILE BELOW SPRUNG SPRING	314217	1105159	Santa Cruz	SANTA CRUZ
MAM1	MAMIE CREEK	BELOW FOREST SERVICE ROAD #275	335802	1090455	Little Colorado	APACHE
MAR1	MARIJILDA CREEK	ABOVE TRAIL #308 CROSSING	324102	1094843	Upper Gila	GRAHAM
MIN1	MINERAL CREEK	ABOVE FOREST SERVICE ROAD #404	341048	1093706	Little Colorado	APACHE
NAT1	NATIONAL CREEK	ABOVE COLORADO RIVER CONFLUENCE	361518	1125308	Colorado River	CONONINO
NBW1	NORTH FORK BEAR WALLOW CREEK	ABOVE S. FK BEAR WALLOW CRK CONFLUENCE	333547	1092559	Salt River	GREENLEE
NCC1	NORTH CANYON CREEK	BELOW NORTH CANYON SPRING	362430	1120441	Colorado River	COCONINO
OAK2	OAK CREEK	BELOW CAVE SPRING CAMPGROUND	345935	1114411	Verde River	COCONINO
PAD1	PADDY CREEK	APPX 1.2 MILES ABV NUTRIOSO CRK CONFLUENC	335505	1090903	Little Colorado	APACHE
PEE1	PEOPLES CANYON CREEK	BELOW SOUTH PEOPLES SPRING	342234	1131613	Bill Williams	YAVAPAI
PIG1	PIGEON CREEK	ABOVE BEAR CREEK CONFLUENCE	331635	1091339	Upper Gila	GREENLEE
PIN1	PINE CREEK	ABOVE EAST VERDE RIVER CONNFLUENCE	341327	1112916	Verde River	GILA
RAM1	RAMSEY CANYON	ABOVE THE NATURE CONSERVANCY BUILDINGS	312614	1101907	San Pedro	COCHISE
RED1	REDFIELD CANYON	BELOW SYCAMORE CANYON CONFLUENCE	322709	1101855	San Pedro	GRAHAM
RES1	RESERVATION CREEK	ABOVE BLACK RIVER CONFLUENCE	334157	1092836	Salt River	APACHE
REY1	REYNOLDS CREEK	BELOW MCFADDEN CREEK CONFLUENCE	335233	1105917	Salt River	GILA
ROU1	ROUNDTREE CREEK	THREE MILES ABV TANGLE CRK CONFLUENCE	340821	1115047	Verde River	YAVAPAI
ROY1	ROYAL ARCH CREEK	ABOVE COLORADO RIVER CONFLUENCE	361151	1122701	Colorado River	COCONINO
RUC1	RUCKER CANYON CREEK	ABOVE BEAR CANYON CONFLUENCE	314707	1091734	Rios de Mexico	COCHISE
RUD1	RUDD CREEK	ABOVE BENTON CREEK CONFLUENCE	340040	1091652	Little Colorado	APACHE
SAB1	SABINO CANYON CREEK	ABOVE E. FK SABINO CANYON CONFLUENCE	322204	1104651	Santa Cruz	PIMA
SAL1	SALOME CREEK	BELOW LITTLE TURKEY CREEK CONFLUENCE	335446	1110223	Salt River	GILA
SCR1	SANTA CRUZ RIVER	BELOW USGS GAGING STATION @ LOCHIEL	312058	1103525	Santa Cruz	SANTA CRUZ
SFC1	SOUTH FORK CAVE CREEK	ABOVE SOUTH FORK CAMPGROUND	315114	1091133	Upper Gila	COCHISE
SLC1	SOUTH FORK LITTLE COLORADO RIVER	ABOVE SOUTH FORK CAMPGROUND	340415	1092435	Little Colorado	APACHE
SMR1	SANTA MARIA RIVER	ABV HWY 93 AND SANTA MARIA RANCH	342401	1131024	Bill Williams	YAVAPAI
SPC1	SPRING CANYON CREEK	ABOVE COLORADO RIVER CONFLUENCE	360108	1132110	Colorado River	MOHAVE
SPG1	SPRING CREEK	ABOVE BRYANT CANYON CONFLUENCE	340451	1110433	Salt River	GILA
SPR1	SAN PEDRO RIVER	BELOW GRAVEYARD GULCH CONFLUENCE	313814	1101030	San Pedro	COCHISE

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	STREAM NAME	DESCRIPTION	LATITUDE	LONGITUDE	BASIN	COUNTY
SYD1	SYCAMORE CREEK	NR DUGAS, ABV SYCAMORE RANGER STN	342051	1115703	Middle Gila	YAVAPAI
SYH1	SYCAMORE CREEK	TRIBUTARY TO HORSESHOE RESERVOIR	340447	1114204	Verde River	YAVAPAI
SYM1	SYCAMORE CREEK	IN MAZATZAL MTNS, ABV MESQUITE WASH CONF	334417	1113055	Verde River	MARICOPA
SYS1	SYCAMORE CANYON	ENTERS SONORA, MEXICO, ABV PENASCO CYN	312439	1111145	Rios de Mexico	SANTA CRUZ
SYW1	SYCAMORE CREEK	IN WILDERNESS AREA, NR SUMMERS SPRINGS	345256	1120359	Verde River	YAVAPAI
TAP1	TAPEATS CREEK	ABOVE COLORADO RIVER CONFLUENCE	362216	1122751	Colorado River	COCONINO
TON114	TONTO CREEK	BLW HAIGLER CR. CONFLUENCE @ HELLSGATE	341255	1110557	Salt River	GILA
TRT1	TROUT CREEK	ABOVE DIVIDE CANYON CONFLUENCE	345914	1133115	Bill Williams	MOHAVE
VER1	VERDE RIVER	ABOVE PERKINSVILLE CROSSING	345337	1121241	Verde River	YAVAPAI
WAR1	WARD CANYON	ABOVE SAULSBURY CANYON CONFLUENCE	315154	1091945	Willcox Playa	COCHISE
WBV1	WET BEAVER CREEK	ABOVE USGS GAGE	344024	1114006	Verde River	YAVAPAI
WCC1	WEST CLEAR CREEK	AT MAXWELL TRAIL, UPPER	343313	1112428	Verde River	COCONINO
WCC3	WEST CLEAR CREEK	ABOVE BULL PEN RANCH	343219	1114101	Verde River	YAVAPAI
WEB1	WEBBER CREEK	BELOW GERONIMO BOY SCOUT CAMP	342358	1112151	Verde River	GILA
WFB1	WEST FORK BLACK RIVER	ABOVE WEST FORK CAMPGROUND	334739	1092522	Salt River	APACHE
WFO1	WEST FORK OAK CREEK	ABOVE FOURTH TRAIL CROSSING	345947	1114444	Verde River	COCONINO
WLC1	WEST FORK LITTLE COLORADO RIVER	ABOVE MOUNT BALDY WILDERNESS BOUNDARY	335722	1093106	Little Colorado	APACHE
WLC2	WEST FORK LITTLE COLORADO RIVER	ABOVE GOVERNMENT SPRINGS	335921	1092753	Little Colorado	APACHE
WOR1	WORKMAN CREEK	BELOW WORKMAN CREEK FALLS	334926	1105619	Salt River	GILA

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	ECOREGION	W.AREA (SQMI)	ELEVATION	1992 CLUSTER GROUP	1993 CLUSTER GROUP	1994 CLUSTER GROUP	FINAL CLUSTER GROUP	COMMENTS
AGF1	AZNMM	462	3445	warm	warm	warm	warm	
ANT1	SBR	5	3850	warm	warm	warm	warm	
ARA1	SD	400	2980	warm	warm	warm	warm	
ARA2	SD	493	2650	warm	warm	warm	warm	
BAR1	AZNMM	8	6950	cold	cold	cold	cold	
BAS1	SD	34	4040	warm	warm	warm	warm	
BLU1	AZNMM	115	6110	cold	cold	cold	cold	
BLU4	AZNMM	490	4310	warm	warm	warm	warm	
BON1	SD		3180	-	warm	warm	warm	
BRA1	AZNMP	303	2520	warm	warm	warm	warm	
BUR1	SBR	169	3100	warm	warm	warm	warm	
CGN1	AZNMM	10	3355	warm	-	warm	warm	
CGR1	SBR	15	4360	warm	warm	-	warm	
CIE1	SD	199	4050	warm	warm	warm	warm	
CKN1	AZNMM	7	7200	cold	cold	-	cold	
CMB1	AZNMM	47	6670	cold	cold	cold	cold	
COL1	AZNMM	9	7850	cold	cold	cold	cold	
CRY1	AZNMP	35	2360	-	warm	warm	warm	
CYN1	AZNMM	29	6270	cold	warm	cold	cold	May not be reference, investigate.
DEE1	AZNMM	8	3630	warm	warm	warm	warm	
DER1	AZNMP		1960	-	-	warm	warm	
DEV1	AZNMM	3	3420	-	warm	warm	warm	
EAG3	AZNMM	380	4645	warm	warm	warm	warm	
ECL1	AZNMM	104	6450	cold	warm	cold	cold	May not be reference, investigate.
EFB1	AZNMM	102	7920	cold	cold	cold	cold	
ETK1	SD	2	6520	cold	cold	cold	cold	
EVD3	AZNMM	152	4280	warm	-	-	warm	
FRA1	SBR		3120	warm	warm	warm	warm	
FRY1	SD	3	5800	cold	cold	cold	cold	
GRB1	AZNMM	19	5580	warm	cold	cold	cold	May not be reference, investigate.
GRP1	SD	10	5600	cold	cold	cold	cold	
HAI1	AZNMM	35	4870	warm	warm	cold	warm	Marginal warm/coldwater community.
HAS2	SBR	303	3270	-	warm	warm	warm	
HER1	AZNMP		2400	warm	warm	warm	warm	
HOR1	AZNMM	4	7995	cold	cold	-	cold	

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	ECOREGION	W.AREA (SQMI)	ELEVATION	1992 CLUSTER GROUP	1993 CLUSTER GROUP	1994 CLUSTER GROUP	FINAL CLUSTER GROUP	COMMENTS
HSC1	SD	95	3830	warm	warm	warm	warm	
KAN1	AZNMP	2312	1880	warm	warm	warm	warm	
LAC1	AZNMM	44	3840	warm	warm	warm	warm	
LAN1	AZNMM	10	5725	cold	warm	cold	cold	Marginal coldwater community.
LCR1	AZNMM	68	7490	cold	cold	cold	cold	
LIL1	AZNMM	1	8620	cold	cold	cold	cold	
MAD1	SD	1	6060	cold	cold	cold	cold	
MAM1	AZNMM	2	8590	cold	cold	cold	cold	
MAR1	SD	5	5520	cold	cold	cold	cold	
MIN1	AZNMM	6	8070	cold	cold	cold	cold	
NAT1	AZNMP	153	2120	-	warm	warm	warm	
NBW1	AZNMM	6	7740	cold	cold	cold	cold	
NCC1	CP	11	7440	-	-	cold	cold	
OAK2	AZNMM	91	5400	warm	-	cold	cold	May not be reference, investigate.
PAD1	AZNMM	4	8485	cold	cold	cold	cold	
PEE1	SBR	6	2440	warm	-	-	warm	
PIG1	AZNMM	55	4300	-	warm	-	warm	
PIN1	AZNMM	46	3360	warm	warm	warm	warm	
RAM1	SD	3	6175	cold	cold	cold	cold	
RED1	SD	37	3900	warm	warm	warm	warm	
RES1	AZNMM	23	6790	cold	cold	cold	cold	
REY1	AZNMM	14	5065	warm	warm	warm	warm	
ROU1	AZNMM	10	3300	warm	warm	-	warm	
ROY1	AZNMP	15	2160	warm	warm	warm	warm	
RUC1	SD	7	6220	cold	cold	cold	cold	
RUD1	AZNMM	5	8100	cold	cold	cold	cold	
SAB1	SBR	18	3720	warm	warm	warm	warm	
SAL1	AZNMM	19	4820	warm	warm	cold	warm	May not be reference, investigate.
SCR1	SD	98	4630	warm	-	-	warm	
SFC1	SD	11	5520	cold	cold	cold	cold	
SLC1	AZNMM	23	7620	cold	cold	cold	cold	
SMR1	SBR	770	1830	warm	warm	warm	warm	
SPC1	SBR	22	1520	warm	warm	warm	warm	
SPG1	AZNMM	88	4260	warm	warm	warm	warm	
SPR1	SD	1234	3920	warm	warm	warm	warm	

APPENDIX A: ADEQ Biocriteria Program Reference Site list, 1992-94

SITEID	ECOREGION	W.AREA (SQMI)	ELEVATION	1992 CLUSTER GROUP	1993 CLUSTER GROUP	1994 CLUSTER GROUP	FINAL CLUSTER GROUP	COMMENTS
SYD1	AZNMM	36	4090	warm	warm	warm	warm	
SYH1	AZNMM	32	2080	warm	warm	-	warm	
SYM1	AZNMM	106	2060	warm	warm	warm	warm	
SYS1	SD	11	3790	warm	warm	warm	warm	
SYW1	AZNMM	471	3625	-	warm	warm	warm	
TAP1	AZNMP	470	2000	cold	warm	cold	cold	Stream has coldwater source and comm
TON114	AZNMM		3940	warm	warm	warm	warm	
TRT1	AZNMP	514	3230	warm	-	warm	warm	
VER1	AZNMM	2930	3820	warm	warm	warm	warm	
WAR1	SD	3	6260	cold	cold	cold	cold	
WBV1	AZNMM	107	4025	warm	warm	warm	warm	
WCC1	AZNMM	143	5985	cold	cold	cold	cold	
WCC3	AZNMM	242	3660	warm	warm	warm	warm	
WEB1	AZNMM	11	5380	warm	warm	cold	cold	Site may not be reference; investigate.
WFB1	AZNMM	35	7800	cold	cold	cold	cold	
WFO1	AZNMM	43	5310	warm	warm	cold	cold	Site may not be reference; investigate.
WLC1	AZNMM	6	9240	cold	cold	cold	cold	
WLC2	AZNMM	11	8550	cold	cold	cold	cold	
WOR1	AZNMM	3	6160	cold	cold	cold	cold	

APPENDIX B:

ADEQ Macroinvertebrate Taxa List

APPENDIX B: ADEQ Biocriteria Program Macroinvertebrate Taxa List for Arizona Reference Sites, 1992-94.

ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Coleoptera	Hydrophilidae	Berosus	BEROSUS	PR	8
Coleoptera	Elmidae	Cleptelmis	CLEPTEL	SC	6
Coleoptera	Unknown	Coleoptera	COLEOPU	UN	11
Coleoptera	Elmidae	Cylloepus	CYLLOEP	SC	5
Coleoptera	Dryopidae	Dryopidae	DRYOPID	SH	5
Coleoptera	Elmidae	Dubiraphia	DUBIRPH	SC	8
Coleoptera	Dytiscidae	Dytiscidae	DYTISCD	PR	7
Coleoptera	Elmidae	Elmidae	ELMIDUN	SC	4
Coleoptera	Scirtidae	Elodes	ELODESS	OM	11
Coleoptera	Dryopidae	Helichus	HELICHS	SH	5
Coleoptera	Elmidae	Heterelmis	HETRLMN	SC	4
Coleoptera	Elmidae	Heterlimnius	HTLNIUS	SC	3
Coleoptera	Hydrophilidae	Hydrophilidae	HYDPHIL	PR	7
Coleoptera	Hydroscaphidae	Hydroscapha	HYDSCAP	SC	11
Coleoptera	Lutrochidae	Lutrochus	LUTROCH	CG	11
Coleoptera	Elmidae	Macrelmis	MACRELM	SC	4
Coleoptera	Elmidae	Microcylloepus	MICYLEP	SC	7
Coleoptera	Elmidae	Narpus	NARPUSS	SC	4
Coleoptera	Elmidae	Neocylloepus	NEOCYLL	SC	4
Coleoptera	Elmidae	Neoelmis	NEOELMS	SC	4
Coleoptera	Noteridae	Noteridae	NOTERID	PR	11
Coleoptera	Elmidae	Optioservus	OPTIOSR	SC	5
Coleoptera	Dryopidae	Postelichus	POSTELS	SH	5
Coleoptera	Psephenidae	Psephenus	PSEPHEN	SC	7

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

APPENDIX B: ADEQ Biocriteria Program Macroinvertebrate Taxa List for Arizona Reference Sites, 1992-94.

ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Coleoptera	Scirtidae	Scirtidae	SCIRTID	OM	11
Coleoptera	Elmidae	Xenelmis	XENELMS	SC	4
Coleoptera	Elmidae	Zaitzevia	ZAITZEV	SC	6
Diptera	Chironomidae	Ablabesmyia	ABLABES	CG	8
Diptera	Chironomidae	Acamptocladius	ACAMPTO	CG	6
Diptera	Blephariceridae	Agathon arizonicus	AGATHAZ	SC	3
Diptera	Chironomidae	Alotanypus	ALOTANY	PR	6
Diptera	Chironomidae	Antillocladius	ANTILLO	UN	11
Diptera	Tipulidae	Antocha	ANTOCHA	CG	6
Diptera	Chironomidae	Apedilum	APEDILU	CG	11
Diptera	Athericidae	Atherix	ATHERIX	PR	7
Diptera	Chironomidae	Boreochlus	BOREOCH	CG	6
Diptera	Chironomidae	Boreoheptagyia	BOREOHP	CG	6
Diptera	Chironomidae	Brillia	BRILLIA	SH	5
Diptera	Chironomidae	Brundiniella	BRUNDIN	PR	6
Diptera	Chironomidae	Bryophaenocladius	BRYOPHN	UN	6
Diptera	Chironomidae	Camptocladius	CAMPTCL	UN	6
Diptera	Chironomidae	Cardiocladius	CARDIOC	PR	5
Diptera	Cecidomyiidae	Cecidomyiidae	CECIDMY	UN	11
Diptera	Ceratopogonidae	Ceratopogoninae	CERTPGN	PR	7
Diptera	Chironomidae	Chaetocladius	CHAETOC	CG	6
Diptera	Empididae	Chelifera	CHELIFR	PR	6
Diptera	Chironomidae	Chironomidae	CHIROND	UN	6
Diptera	Chironomidae	Chironominae	CHIRNMN	CG	6

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

APPENDIX B: ADEQ Biocriteria Program Macroinvertebrate Taxa List for Arizona Reference Sites, 1992-94.

ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Diptera	Chironomidae	Chironomini	CHIRMIN	CG	6
Diptera	Chironomidae	Chironomus	CHIRNMS	CG	10
Diptera	Chironomidae	Cladopelma	CLADPEL	CG	9
Diptera	Chironomidae	Cladotanytarsus	CLADTNY	CG	7
Diptera	Empididae	Clinocera	CLINOCR	PR	6
Diptera	Chironomidae	Constempellina	CONSTMP	CG	4
Diptera	Chironomidae	Corynoneura	CORYNON	CG	7
Diptera	Chironomidae	Cricotopus (Nostococladius)	CRICNOS	MH	3
Diptera	Chironomidae	Cryptochironomus	CRYPCHR	PR	8
Diptera	Tipulidae	Cryptolabis	CRYPTOL	UN	4
Diptera	Chironomidae	Cryptotendipes	CRYPTND	UN	6
Diptera	Chironomidae	Demicryptochironomus	DEMCRYP	CG	8
Diptera	Chironomidae	Diamesa	DIAMESA	CG	5
Diptera	Chironomidae	Diamesinae	DIAMESN	CG	2
Diptera	Tipulidae	Dicranota	DICRANO	PR	6
Diptera	Chironomidae	Dicrotendipes	DICRTND	CG	8
Diptera	Dixidae	Dixa	DIXAAAA	CG	3
Diptera	Dixidae	Dixella	DIXELLA	CG	8
Diptera	Chironomidae	Djalmabatista	DJALMAB	PR	3
Diptera	Dolichopodidae	Dolichopodidae	DOLICHP	PR	6
Diptera	Empididae	Empididae	EMPIDID	PR	5
Diptera	Chironomidae	Endotribelas	ENDOTRB	UN	11
Diptera	Ephydridae	Ephydridae	EPHYDRI	CG	9
Diptera	Tipulidae	Erioptera	ERIOPTE	CG	4

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

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Diptera	Chironomidae	Eukiefferiella	EUKIELL	OM	8
Diptera	Chironomidae	Eukiefferiella/Thienemanniella	EUKTHIE	OM	6
Diptera	Chironomidae	Euryhapsis	EURYHAP	UN	6
Diptera	Ceratopogonidae	Forcipomyiinae	FORCIPO	PR	7
Diptera	Chironomidae	Glyptotendipes	GLYPTOT	CG	10
Diptera	Chironomidae	Goeldichironomus	GOELDCH	CG	8
Diptera	Tipulidae	Gonomyia	GONOMYI	UN	4
Diptera	Chironomidae	Heleniella	HELENIE	UN	6
Diptera	Empididae	Hemerodromia	HEMEROD	PR	6
Diptera	Tipulidae	Hesperoconopa	HESPCON	UN	1
Diptera	Chironomidae	Heterotrissocladius	HETRISS	CG	0
Diptera	Tipulidae	Hexatoma	HEXATOM	PR	5
Diptera	Tipulidae	Holorusia	HOLORUS	SH	5
Diptera	Chironomidae	Hydrobaenus	HYDBAEN	OM	8
Diptera	Chironomidae	Krenopelopia	KRENPEL	PR	6
Diptera	Chironomidae	Krenosmittia	KRENSMT	CG	1
Diptera	Chironomidae	Labrundinia	LABRUND	PR	7
Diptera	Chironomidae	Larsia	LARSIAA	PR	6
Diptera	Chironomidae	Lauterborniella	LAUTERB	CG	6
Diptera	Muscidae	Limnophora	LIMPHOR	PR	8
Diptera	Chironomidae	Limnophyhes	LIMPHYH	CG	8
Diptera	Tipulidae	Limonia	LIMONIA	MH	7
Diptera	Chironomidae	Lopescladius	LOPESCL	CG	6
Diptera	Chironomidae	Macropelopini	MACPELO	PR	6

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Diptera	Psychodidae	Maruina	MARUINA	SC	5
Diptera	Dixidae	Meringodixa	MERINGO	CG	2
Diptera	Chironomidae	Mesosmittia	MESMITT	UN	11
Diptera	Chironomidae	Metriocnemus	METRIOC	CG	6
Diptera	Chironomidae	Micropsectra	MICROPS	CG	7
Diptera	Chironomidae	Microtendipes	MICRTEN	CG	6
Diptera	Tipulidae	Molophilus	MOLOPHL	UN	4
Diptera	Muscidae	Muscidae	MUSCIDA	PR	8
Diptera	Mycetophilidae	Mycetophilidae	MYCETOP	UN	11
Diptera	Chironomidae	Nanocladius	NANCLDS	CG	3
Diptera	Chironomidae	Nilotanypus	NILOTAN	PR	6
Diptera	Chironomidae	Nilothauma	NILOTHA	UN	2
Diptera	Chironomidae	nr. Chernovskiia	NRCHERN	UN	6
Diptera	Chironomidae	nr. Hyporhygma	HYPHYGM	MH	6
Diptera	Chironomidae	nr. Mesocricotopus	NRMESCR	CG	6
Diptera	Chironomidae	Odontomesa	ODONTOM	CG	4
Diptera	Empididae	Oreogeton	OREOGET	PR	1
Diptera	Chironomidae	Orthocladiinae	ORTHCLU	CG	5
Diptera	Chironomidae	Orthocladius (Symposiocladius)	ORTHCLS	SH	5
Diptera	Chironomidae	Orthocladius complex	ORTHCL1	CG	6
Diptera	Chironomidae	Pagastia	PAGASTI	CG	1
Diptera	Chironomidae	Parachaetocladius	PRCHAET	CG	2
Diptera	Chironomidae	Parachironomus	PRCHIRN	PR	10
Diptera	Chironomidae	Paracladopelma	PRCLADP	UN	7

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

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ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Diptera	Tipulidae	Paradelphomyia	PARADEL	UN	4
Diptera	Chironomidae	Parakiefferiella	PRKIEFF	CG	4
Diptera	Chironomidae	Paralauterborniella	PRLAUTR	CG	8
Diptera	Chironomidae	Paramerina	PRMERIN	PR	6
Diptera	Chironomidae	Parametriocnemus	PRMETRI	CG	5
Diptera	Chironomidae	Paraphaenocladius	PRPHAEN	CG	4
Diptera	Chironomidae	Paratanytarsus	PRTANYT	UN	6
Diptera	Chironomidae	Paratendipes	PRTENDP	CG	8
Diptera	Chironomidae	Parochlus	PAROCHL	UN	6
Diptera	Tipulidae	Pedicia	PEDICIA	PR	6
Diptera	Chironomidae	Pentaneura	PENTANN	PR	6
Diptera	Chironomidae	Pentaneurini	PENTINI	PR	6
Diptera	Psychodidae	Pericoma	PERICOM	CG	5
Diptera	Chironomidae	Phaenopsectra	PHAENOP	SC	7
Diptera	Chironomidae	Polypedilum	POLYPED	OM	6
Diptera	Chironomidae	Potthastia gaedii group	POTTGAE	CG	2
Diptera	Chironomidae	Potthastia longimanus group	POTTLON	CG	2
Diptera	Chironomidae	Procladius	PROCLAD	PR	9
Diptera	Chironomidae	Prodiamesa	PRODIAM	CG	3
Diptera	Chironomidae	Psectrocladius	PSECTRO	CG	8
Diptera	Chironomidae	Pseudochironomus	PSDCHIR	CG	5
Diptera	Chironomidae	Pseudodiamesa	PSDDIAM	CG	6
Diptera	Chironomidae	Pseudorthocladius	PSDORTH	CG	0
Diptera	Chironomidae	Pseudosmittia	PSDSMIT	UN	6

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Diptera	Chironomidae	Psilometriocnemus	PSDMETR	CG	6
Diptera	Psychodidae	Psychoda	PSYCHDA	CG	10
Diptera	Psychodidae	Psychodidae	PSYCHOD	CG	5
Diptera	Ptychopteridae	Ptychoptera	PTYCHOP	CG	7
Diptera	Tipulidae	Rhabdomastix	PHABDOM	UN	2
Diptera	Chironomidae	Rheocricotopus	RHEOCRC	OM	6
Diptera	Chironomidae	Rheopelopia	RHEOPEL	PR	4
Diptera	Chironomidae	Rheotanytarsus	RHEOTAN	CF	6
Diptera	Chironomidae	Robackia	ROBACKI	CG	6
Diptera	Chironomidae	Saetheria	SAETHER	CG	4
Diptera	Sciaridae	Sciaridae	SCIARID	UN	11
Diptera	Sciomyzidae	Sciomyzidae	SCIOMYZ	PR	11
Diptera	Simuliidae	Simuliidae	SIMULII	CF	6
Diptera	Chironomidae	Smittia	SMITTIA	CG	6
Diptera	Chironomidae	Stelechomyia	STELECH	UN	11
Diptera	Chironomidae	Stempellina	STEMPIN	CG	2
Diptera	Chironomidae	Stempellinella	STEMPEL	UN	4
Diptera	Chironomidae	Stenochironomus	STENOCH	CG	5
Diptera	Chironomidae	Stictochironomus	STICTOC	CG	9
Diptera	Chironomidae	Stilocladius	STILOCL	UN	6
Diptera	Stratiomyiidae	Stratiomyiidae	STRATIO	CG	8
Diptera	Chironomidae	Sublettia	SUBLETT	UN	4
Diptera	Chironomidae	Symbiocladius	SYMBCLD	PA	6
Diptera	Chironomidae	Synorthocladius	SYNORTH	CG	2

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Diptera	Syrphidae	Syrphidae	SYRPHID	CG	10
Diptera	Tabanidae	Tabanidae	TABANID	PR	7
Diptera	Tanyderidae	Tanyderidae	TANYDER	UN	1
Diptera	Chironomidae	Tanypodinae	TANYPDN	PR	7
Diptera	Chironomidae	Tanypus	TANYPUS	PR	10
Diptera	Chironomidae	Tanytarsini	TANTINI	UN	6
Diptera	Chironomidae	Tanytarsus	TANYTAR	CF	6
Diptera	Thaumaleidae	Thaumaleidae	THAUMAL	UN	11
Diptera	Chironomidae	Thienemanniella	THIENEL	CG	6
Diptera	Chironomidae	Thienemannimyia group	THIENMY	PR	6
Diptera	Tipulidae	Tipula	TIPULAA	OM	6
Diptera	Tipulidae	Tipulidae	TIPULID	UN	4
Diptera	Chironomidae	Tvetenia	TVETENI	CG	5
Diptera	Chironomidae	Xestochironomus	XESTCHR	XY	11
Diptera	Chironomidae	Zavrelimyia	ZAVRLMY	PR	8
Ephemeroptera	Baetidae	Acentrella	ACENTRL	CG	6
Ephemeroptera	Ameletidae	Ameletus	AMELETS	CG	3
Ephemeroptera	Baetidae	Baetidae	BAETIDE	CG	4
Ephemeroptera	Baetidae	Baetis	BAETISS	CG	5
Ephemeroptera	Baetidae	Baetis bicaudatus	BAETBIC	CG	4
Ephemeroptera	Baetidae	Baetis tricaudatus	BAETTRI	CG	4
Ephemeroptera	Baetidae	Baetodes	BAETODS	SC	4
Ephemeroptera	Caenidae	Caenis	CAENISS	CG	7
Ephemeroptera	Baetidae	Callibaetis	CALLIBT	CG	9

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Ephemeroptera	Baetidae	Centroptilum	CENTROP	CG	6
Ephemeroptera	Leptophlebiidae	Choroterpes	CHOROTR	CG	7
Ephemeroptera	Heptageniidae	Cinygmula	CINYGML	SC	4
Ephemeroptera	Baetidae	Diphetor	DIPHETR	CG	5
Ephemeroptera	Ephemerellidae	Drunella coloradensis/flavilinea	DRUNCFL	CG	2
Ephemeroptera	Ephemerellidae	Drunella doddsi	DRUNDOD	CG	1
Ephemeroptera	Ephemerellidae	Drunella grandis	DRUNGRD	CG	2
Ephemeroptera	Heptageniidae	Epeorus	EPEORUS	SC	1
Ephemeroptera	Heptageniidae	Epeorus grandis	EPEORGR	SC	0
Ephemeroptera	Ephemerellidae	Ephemerella	EPHEMER	CG	3
Ephemeroptera	Ephemerellidae	Ephemerella inermis/infrequens	EPHEMIN	CG	3
Ephemeroptera	Ephemerellidae	Ephemerellidae	EPHEMLD	CG	1
Ephemeroptera	Heptageniidae	Heptagenia/Nixe	HEPTAGN	SC	4
Ephemeroptera	Heptageniidae	Heptageniidae	HEPGNID	SC	4
Ephemeroptera	Isonychiidae	Isonychia	ISONYCH	CF	4
Ephemeroptera	Tricorythidae	Leptohyphes	LEPTHYP	CG	7
Ephemeroptera	Leptophlebiidae	Leptophlebia	LEPTOPH	CG	7
Ephemeroptera	Leptophlebiidae	Leptophlebiidae	LEPTOPE	CG	6
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	PARALEP	CG	4
Ephemeroptera	Heptageniidae	Rhithrogena	RHITHRG	SC	2
Ephemeroptera	Ephemerellidae	Serratella micheneri	SERRATL	CG	2
Ephemeroptera	Ephemerellidae	Serratella tibialis	SERRTIB	CG	2
Ephemeroptera	Siphlonuridae	Siphlonuridae	SIPHLND	CG	7
Ephemeroptera	Siphlonuridae	Siphlonurus	SIPHLON	OM	7

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Ephemeroptera	Heptageniidae	Stenonema	STENONM	SC	6
Ephemeroptera	Leptophlebiidae	Thraulodes	THRAULO	CG	6
Ephemeroptera	Leptophlebiidae	Traverella	TRAVERL	CF	6
Ephemeroptera	Tricorythidae	Tricorythidae	TRICORD	CG	7
Ephemeroptera	Tricorythidae	Tricorythodes	TRICORY	CG	7
Hemiptera	Belostomatidae	Abedus	ABEDUSS	PR	8
Hemiptera	Naucoridae	Ambrysus	AMBRYSU	PR	7
Hemiptera	Corixidae	Corixidae	CORIXID	PR	8
Hemiptera	Hebridae	Hebrus	HEBRUSS	PR	11
Hemiptera	Notonectidae	Notonecta	NOTONEC	PR	7
Hemiptera	Nepidae	Ranatra	RANATRA	PR	11
Lepidoptera	Pyralidae	Petrophila	PETROPH	SC	6
Megaloptera	Corydalidae	Corydalus cornutus	CORYCOR	PR	6
Megaloptera	Corydalidae	Neohermes filicornis	NEOHERM	PR	4
Miscellaneous taxa		Acari	ACARIII	PA	5
Miscellaneous taxa		Cladocera	CLADOCR	CF	8
Miscellaneous taxa		Copepoda	COPEPOD	CG	8
Miscellaneous taxa	Corbiculidae	Corbicula	CORBICU	CF	8
Miscellaneous taxa	Ancylidae	Ferrissia	FERRISS	SC	6
Miscellaneous taxa	Gammaridae	Gammaridae	GAMMARD	CG	6
Miscellaneous taxa	Gammaridae	Gammarus	GAMMARS	CG	6
Miscellaneous taxa	Glossiphoniidae	Helobdella stagnalis	HELOBST	PR	9
Miscellaneous taxa		Hirudinea	HIRUDIN	PR	10
Miscellaneous taxa	Hyalellidae	Hyalella azteca	HYALAZT	CG	8

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Miscellaneous taxa		Hydra	HYDRAAA	PR	5
Miscellaneous taxa	Hydrobiidae	Hydrobiidae	HYDROBI	SC	8
Miscellaneous taxa		Isopoda	ISOPODA	CG	8
Miscellaneous taxa	Lymnaeidae	Lymnaeidae	LYMNAEI	CG	8
Miscellaneous taxa		Nematoda	NEMATOM	UN	5
Miscellaneous taxa		Nematomorpha	NEMAMOR	PA	11
Miscellaneous taxa		Oligochaeta	OLIGOCH	CG	8
Miscellaneous taxa	Astacidae	Orconectes	ORCONEC	OM	6
Miscellaneous taxa		Ostracoda	OSTRACD	CG	8
Miscellaneous taxa	Physidae	Physella	PHYSELL	CG	8
Miscellaneous taxa	Planorbidae	Planorbidae	PLANORB	SC	8
Miscellaneous taxa		Porifera	PORIFER	CF	11
Miscellaneous taxa	Sphaeriidae	Sphaeriidae	SPHAERD	CG	8
Miscellaneous taxa		Turbellaria	TURBELL	UN	4
Miscellaneous taxa	Valvatidae	Valvata	VALVATA	SC	8
Odonata	Aeshnidae	Aeshnidae	AESHNID	PR	5
Odonata	Aeshnidae	Anax	ANAXXXX	PR	8
Odonata	Lestidae	Archilestes	ARCHILE	PR	9
Odonata	Coenagrionidae	Argia	ARGIAAA	PR	7
Odonata	Libellulidae	Brechmorhoga	BRECHMR	PR	9
Odonata	Calopterygidae	Calopterygidae	CALOPTR	PR	5
Odonata	Coenagrionidae	Coenagrionidae	COENAGR	PR	9
Odonata	Cordulegastridae	Cordulegaster	CORDULG	PR	3
Odonata	Coenagrionidae	Enallagma / Ischnura	ENALLAG	PR	9

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Odonata	Gomphidae	Erpetogomphus	ERPETOG	PR	5
Odonata	Gomphidae	Gomphidae	GOMPHID	PR	4
Odonata	Calopterygidae	Hetaerina	HETAERN	PR	6
Odonata	Lestidae	Lestes	LESTESS	PR	9
Odonata	Lestidae	Lestidae	LESTIDE	PR	9
Odonata	Libellulidae	Libellulidae	LIBELLU	PR	9
Odonata	Corduliidae	Macromia	MACROMI	PR	2
Odonata	Gomphidae	Ophiogomphus	OPHIOGO	PR	4
Odonata	Aeshnidae	Oplonaeschna	OPLONAE	PR	5
Odonata	Libellulidae	Paltothemis	PALTOTH	PR	9
Odonata	Gomphidae	Progomphus	PROGOMP	PR	4
Plecoptera	Nemouridae	Amphinemura	AMPHINM	SH	4
Plecoptera	Capniidae	Capniidae	CAPNIID	SH	3
Plecoptera	Chloroperlidae	Chloroperlidae	CHLRPER	PR	3
Plecoptera	Perlidae	Claassenia sabulosa	CLAASAB	PR	4
Plecoptera	Perlodidae	Cultus	CULTUSS	PR	2
Plecoptera	Perlodidae	Diura	DIURAAA	PR	2
Plecoptera	Perlidae	Doroneuria	DORONRI	PR	2
Plecoptera	Perlidae	Hesperoperla pacifica	HESPACF	PR	4
Plecoptera	Perlodidae	Isoperla	ISOPERL	PR	4
Plecoptera	Nemouridae	Nemouridae	NEMOURD	SH	3
Plecoptera	Perlidae	Perlidae	PERLIDA	PR	4
Plecoptera	Perlodidae	Perlodidae	PERLODD	PR	2
Plecoptera	Perlodidae	Skwala	SKWALAA	PR	4

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Plecoptera	Chloroperlidae	Sweltsa	SWELTSA	PR	3
Plecoptera	Taeniopterygidae	Taeniopterygidae	TAENIOP	SH	2
Plecoptera	Nemouridae	Zapada	ZAPADAA	SH	2
Plecoptera	Nemouridae	Zapada cinctipes	ZAPCINC	SH	4
Plecoptera	Nemouridae	Zapada columbiana	ZAPCOLM	SH	1
Plecoptera	Nemouridae	Zapada frigida	ZAPFRIG	SH	2
Plecoptera	Nemouridae	Zapada Oregonensis Group	ZAPOREG	SH	2
Trichoptera	Glossosomatidae	Agapetus	AGAPETS	SC	4
Trichoptera	Hydroptilidae	Alisotrichia	ALISOTR	UN	11
Trichoptera	Limnephilidae	Apatania	APATANI	SC	2
Trichoptera	Hydrobiosidae	Atopsyche	ATPSYCH	PR	11
Trichoptera	Brachycentridae	Brachycentrus	BRACHYC	SC	4
Trichoptera	Brachycentridae	Brachycentrus americanus	BRACHAM	SC	4
Trichoptera	Brachycentridae	Brachycentrus occidentalis	BRACHOC	SC	4
Trichoptera	Hydropsychidae	Cheumatopsyche	CHEUMAT	CF	8
Trichoptera	Philopotamidae	Chimarra	CHIMARR	CF	5
Trichoptera	Glossosomatidae	Culoptila	CULOPTL	SC	6
Trichoptera	Limnephilidae	Dicosmoecinae	DICOSMO	UN	3
Trichoptera	Glossosomatidae	Glossosoma	GLOSSOS	SC	4
Trichoptera	Sericostomatidae	Gumaga	GUMAGAA	SH	8
Trichoptera	Helicopsychidae	Helicopsyche	HELICOP	SC	7
Trichoptera	Limnephilidae	Hesperophylax	HESPERO	OM	7
Trichoptera	Hydropsychidae	Hydropsyche	HYDROPS	CF	7
Trichoptera	Hydropsychidae	Hydropsychidae	HYDRPSD	CF	11
Trichoptera	Hydroptilidae	Hydroptila	HYDTILA	PH	7

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

APPENDIX B: ADEQ Biocriteria Program Macroinvertebrate Taxa List for Arizona Reference Sites, 1992-94.

ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Trichoptera	Hydroptilidae	Hydroptilidae	HYDTILD	PH	6
Trichoptera	Hydroptilidae	Hydroptilidae-unknown	HYDTILU	PH	11
Trichoptera	Hydroptilidae	Ithytrichia	ITHYTRI	SC	8
Trichoptera	Lepidostomatidae	Lepidostoma	LEPINST	SH	4
Trichoptera	Lepidostomatidae	Lepidostoma acarolum	LEPACAR	SH	4
Trichoptera	Lepidostomatidae	Lepidostoma-sand case	LEPSAND	SH	4
Trichoptera	Lepidostomatidae	Lepidostoma-turret case	LEPTURR	SH	4
Trichoptera	Leptoceridae	Leptoceridae	LEPTOCR	OM	4
Trichoptera	Hydropsychidae	Leptonema	LEPTONM	CF	4
Trichoptera	Hydroptilidae	Leucotrichia	LEUCOTR	SC	7
Trichoptera	Hydroptilidae	Leucotrichinae	LEUCOTU	SC	7
Trichoptera	Limnephilidae	Limnephilidae	LIMNEPH	UN	4
Trichoptera	Limnephilidae	Limnephilus	LIMPHIL	SH	6
Trichoptera	Odontoceridae	Marilia	MARILIA	OM	0
Trichoptera	Hydroptilidae	Mayatrichia	MAYATRI	SC	7
Trichoptera	Brachycentridae	Micrasema	MICRASM	MH	4
Trichoptera	Leptoceridae	Mystacides	MYSTACD	OM	5
Trichoptera	Leptoceridae	Nectopsyche	NECTOCR	OM	7
Trichoptera	Hydroptilidae	Neotrichia	NEOTRIC	SC	7
Trichoptera	Hydroptilidae	Ochrotrichia	OCHROTR	PH	6
Trichoptera	Odontoceridae	Odontoceridae	ODONTCR	OM	0
Trichoptera	Leptoceridae	Oecetis	OECETIS	OM	8
Trichoptera	Uenoidae	Oligophlebodes	OLIGPHL	SC	1
Trichoptera	Limnephilidae	Onocosmoecus unicolor	ONOCOSM	OM	4
Trichoptera	Hydroptilidae	Oxyethira	OXYETHR	PH	8

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

APPENDIX B: ADEQ Biocriteria Program Macroinvertebrate Taxa List for Arizona Reference Sites, 1992-94.

ORDER	FAMILY	FINAL IDENTIFICATION (Genus with or w/o species)	ADEQ TAXA CODE	FUNCTIONAL FEEDING GROUP	TOLERANCE VALUE
Trichoptera	Calamoceratidae	Phylloicus	PHYLLOI	SH	3
Trichoptera	Polycentropodidae	Polycentropus	POLYCEN	PR	6
Trichoptera	Polycentropodidae	Polyplectropus	POLYPLE	PR	6
Trichoptera	Glossosomatidae	Protoptila	PROTOPT	SC	6
Trichoptera	Limnephilidae	Psychoglypha	PSYCHOG	OM	1
Trichoptera	Psychomyiidae	Psychomyia	PSYCHMY	SC	4
Trichoptera	Rhyacophilidae	Rhyacophila	RHYCOPH	PR	2
Trichoptera	Rhyacophilidae	Rhyacophila Angelita Group	RHYANGL	PR	4
Trichoptera	Rhyacophilidae	Rhyacophila Coloradensis Group	RHYCOLR	PR	5
Trichoptera	Rhyacophilidae	Rhyacophila Rotunda Group	RHYROTD	PR	0
Trichoptera	Hydropsychidae	Smicridea	SMICRID	CF	11
Trichoptera	Psychomyiidae	Tinodes	TINODES	SC	3
Trichoptera	Philopotamidae	Wormaldia	WORMALD	CF	4
Trichoptera	Hydroptilidae	Zumatrichia	ZUMATRI	PH	7

Functional Feeding Group and Tolerance Values from: Aquatic Biology Associates. 1995. Benthic Invertebrate Taxa Coding List. Corvallis, OR.

Use Attainability Analysis
Queen Creek

Background

On October 18, 1999, the BHP Copper Company petitioned the Arizona Department of Environmental Quality (ADEQ) to change the designated use of a segment of Queen Creek in the Middle Gila River Basin. The segment of Queen Creek that was the subject of the petition was from the Superior Mining Division discharge to the Town of Superior Wastewater Treatment Plant. BHP Copper requested that this segment of Queen Creek be changed from effluent-dependent water (EDW) to ephemeral water. With this change, Queen Creek would be designated as an ephemeral water from its headwaters to the Town of Superior WWTP discharge outfall.

BHP Copper stated in its request that it believed that the segment of Queen Creek upstream of the Town of Superior WWTP discharge was inappropriately classified as an EDW and that it should have been designated as an ephemeral water. BHP Copper submitted evidence that the segment in question met the definition of an ephemeral water as defined by Arizona's surface water quality standard rules. At the time the petition was submitted to ADEQ, R18-11-101(22) defined "ephemeral water" as a surface water that has a channel that is at all times above the water table, that flows only in direct response to precipitation, and that does not support a self-sustaining fish population.

BHP Copper submitted a water table contour map for the shallow and deep aquifer near Superior, Arizona demonstrating that the water table is, at all times, below the channel of the segment of Queen Creek that is the subject of the petition [See Attachment 1]. BHP Copper also submitted an excerpt from a Site Characterization Report for BHP Copper Superior Operations characterizing the hydrogeology of Queen Creek. Queen Creek was described as follows:

> "Historically, surface flow in Queen Creek was perennial, and was an integral source of water and sediment to the East Salt River Valley Basin. Surface flow disappeared in the late 1940s, and flow in Queen Creek presently occurs only in response to recharge events. Although surface flow is ephemeral, the Queen Creek drainage continues to provide a groundwater flow path between the mountainous region and the East Salt River Valley Basin."

Finally, BHP Copper submitted a copy of the Annual Bioassessment Report for Queen Creek, Arizona, 1999. The bioassessment report characterizes Queen Creek as an ephemeral water and includes a description from Graf, et. al (1991) describing Queen Creek as having a channel that is normally dry [See Attachment 2].

Revisions to the Designated Uses of Queen Creek

Four segments of Queen Creek are listed in Appendix B of the surface water quality standards rules as codified in Title 18, Chapter 11, Article 1, Appendix B (effective April 24, 1996). The four segments of Queen Creek are:

Segment	Location	Designated Uses
Queen Creek	Headwaters to the Superior Mining Division outfall	A&Ww, PBC, DWS, FC, AgL
Queen Creek	Superior Mining Division to discharge outfall to confluence with Potts Canyon	A&Wedw, PBC
Queen Creek	Potts Canyon to El Camino Viejo Road	A&Ww, FBC, FC, AgL
Queen Creek	Below El Camino Viejo Road	A&We, PBC, AgL

In the 2002 triennial review, ADEQ revised the designated uses of Queen Creek as follows:

Segment	Location	Designated Uses
Queen Creek	Headwaters to the Town of Superior WWTP outfall	A&We, PBC, AgL
Queen Creek	Town of Superior WWTP outfall to confluence with Potts Canyon	A&Wedw, PBC
Queen Creek	Potts Canyon to Queen Valley golf course	A&Ww, FBC, FC, AgL
Queen Creek	Below Queen Valley golf course	A&We, PBC

The revisions to the designated uses of Queen Creek are to the segment of Queen Creek from its headwaters to the Town of Superior WWTP outfall. ADEQ determined that Queen Creek, from its headwaters to the Town of Superior WWTP outfall, is an ephemeral water and ADEQ revised the designated uses of the segment accordingly. ADEQ removed the aquatic and wildlife (warm water) (A&Ww), domestic water source (DWS), and fish consumption (FC) designated uses from the segment of Queen Creek and established the aquatic and wildlife (ephemeral) to replace

the A&Ww.designated use. The DWS designated use was removed from the segment because of new information received by ADEQ indicating that groundwater was the source of drinking water for the Town of Superior, not Queen Creek [See Attachment 3]. The fish consumption

Grounds for Use Attainability Analysis

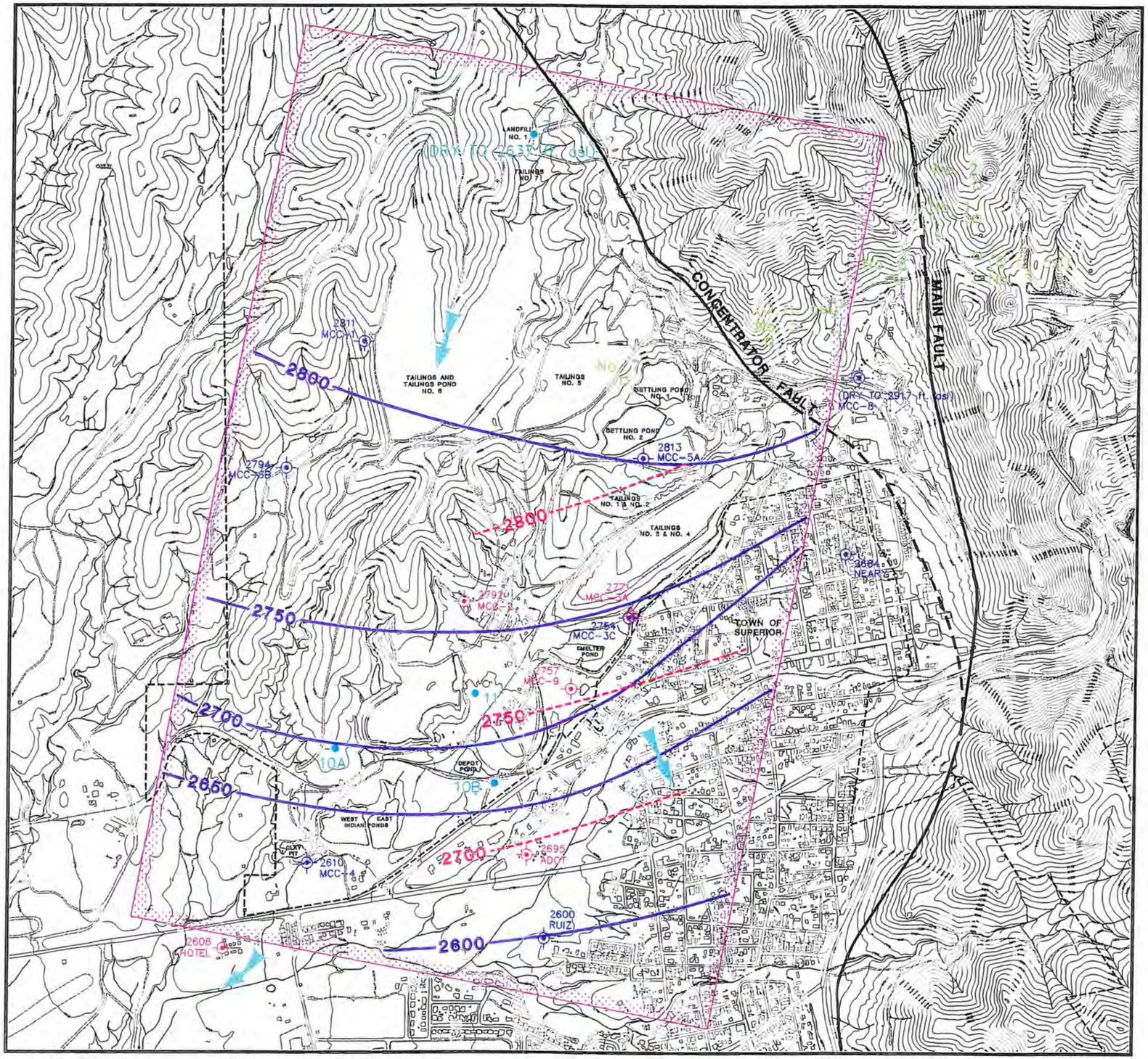
The A&Ww and FC designated uses are not attainable in Queen Creek because natural, ephemeral, or low flow conditions or water levels prevent attainment of both designated uses [*See* 40 CFR §131.10(g)(2)].

Supporting Documentation

ADEQ's determination that the headwaters of Queen Creek to the Town of Superior WWTP discharge outfall is an ephemeral water is supported by the documentation submitted by BHP Copper and corroborated by independent evaluations of the Queen Creek drainage basin. Please find attached a field trip guide book entitled "Fluvial Processes of the Queen Creek Drainage Basin,"developed for a class in fluvial processes in the Department of Geology at Arizona State University [Attachment 3]. The guidebook is an informal collection of papers on the Queen Creek drainage system. Several papers in the guide book include detailed descriptions of Queen Creek and its geology, soils, climate, vegetation, and cultural history. The papers uniformly describe Queen Creek as an ephemeral water. The following citations support the establishment of the A&We designated use:

> Queen Creek is typical of Arizona's desert streams. Its hydrologic cycle is characterized by flows produced in the upland areas of a normally dry wash. This runoff passes from bedrock to alluvium where infiltration becomes an addition to the ground water reservoir.... The streamflow consists almost entirely of storm water of the quick, flashy type common to the deserts of the Southwest. [p. 1]
>
> Queen Creek originates in the Superstition Mountains east of Phoenix at an elevation of 1430 m. The stream channel runs south to U.S. Route 60 then shifts to a more westerly direction toward Superior where it continues west parallel to the highway. Flow in this upper region of the creek is ephemeral; water is usually only present during and soon after a flood [p. 3-1].
>
> Queen Creek is an ephemeral creek. The annual precipitation rarely exceeds 20 inches. During the summer, intensive thunderstorms of short duration occur in the upper reach of the Queen Creek watershed. Depending on the location of the storm, tributaries can contribute to flash flooding in Queen Creek [Chapter 7, p. 2].

Attachment 1
Water Table Contour Map



0 600 1200
APPROXIMATE SCALE IN FEET

EXPLANATION

- APPROXIMATE PROPERTY BOUNDARY
- MODEL DOMAIN
- 2752 MCC-3C — WELL LOCATION; WATER LEVEL (feet, asl); MONITORING WELL – DEEP
- 2792 MCC-2 — WELL LOCATION; WATER LEVEL (feet, asl); MONITORING WELL – SHALLOW
- 10A — EXPLORATORY BOREHOLE
- 2800 — WATER TABLE CONTOUR – DEEP (feet, asl) (CONTOUR INTERVAL = 50 FEET)
- 2800 — WATER TABLE CONTOUR – SHALLOW (feet, asl) (CONTOUR INTERVAL = 50 FEET)
- EXISTING FAULT (DASHED WHERE INFERRED)
- MINE SHAFT LOCATIONS
- GROUNDWATER FLOW DIRECTION

BHP
BHP Copper *Superior Operations*

WEST PLANT SITE
WATER TABLE CONTOUR MAP FOR THE SHALLOW AND DEEP AQUIFER
SUPERIOR, ARIZONA

DRAWN JC	DATE	REV.	
DESIGNED JW	7-15-99	A	Figure I.5
CHECKED			
CHECKED			

BROWN AND CALDWELL
Phoenix, Arizona

BASEMAP SOURCE: COOPER AERIAL SURVEY (1992)
MODIFIED USING SURVEY INFORMATION (1997)
CONTOUR INTERVAL: 25 FEET

P:\Cad\ES\BHP-SUP\3800\F3800112.dwg (1=1) 07-15-99 BSimmons

Attachment 2
Annual Bioassessment Report for Queen Creek, Arizona 1999

BHP

Superior Operations
BHP Copper

AZ DEPT OF ENVIRONMENTTAL QUALITY
OCT 20 1999
WATER QUALITY DIVISION

October 18, 1999

Mr. Steven Pawlowski
Arizona Department of Environmental Quality
Water Quality Standards Coordinator
3033 North Central Avenue
Phoenix, Arizona 85102

Dear Mr. Pawlowski:

The purpose of this letter is to petition the Arizona Department of Environmental Quality (ADEQ) to change the designated use of a segment of Queen Creek in the Middle Gila River Basin, Pinal County. BHP Copper requests that the segment of Queen Creek from the Superior Mining Division discharge point downstream to the Town of Superior Wastewater Treatment Plant (WWTP) discharge to Queen Creek be changed from effluent dominated water (EDW) to ephemeral water. Currently, upstream of the Superior Mining Division, the creek is classified as ephemeral. With this change in classification, Queen Creek would be designated as an ephemeral water from its headwaters to the Superior WWTP discharge.

Because of the reasons provided below, BHP believes that this segment of the creek was inappropriately designated as an EDW and that it should have been designated as an ephemeral water. ADEQ's water quality standards at R18-11-101, No. 21, define effluent dominated as "a surface water that consists primarily of discharges of treated wastewater."

This segment should not be classified as an EDW because discharges from the Superior Mining Division only occur intermittently between December and March and generally occur for less than 30 days at one time. During the remainder of the time, the creek either lacks any surface flow or only flows in direct response to precipitation.

At R18-11-101, No. 22, an ephemeral water is defined as "a surface water that has a channel that is at all times above the water table, that flows only in direct response to precipitation, and that does not support a self-sustaining fish population." The following information is provided to demonstrate that this segment meets the definition of an ephemeral water.

1. Channel is at all times above the water table and flows only in direct response to precipitation.

BHP Copper Inc. P.O. Box 37 Superior Arizona 85273-0037
Telephone (520) 689-2444 Facsimile (602) 229-4323
BHP Copper is a Business Group of The Broken Hill Proprietary Company Limited

In June, 1999, Brown and Caldwell, Phoenix, AZ, completed a *Site Characterization Report* for BHP Copper Superior Operations, which included surface water and ground water characterization along parts of this segment of Queen Creek. This report has been submitted to the ADEQ APP Mining Unit in support of the Superior Operations APP Application. The groundwater characterization data is described in Table 2-2. Figure 1.5 (attached) of the report shows that the Queen Creek channel is at all times above the water table. Of the monitoring wells on Figure 1.5, *ADOT* and *Hotel* are adjacent to the Queen Creek channel and the depth to water in these wells is 15 feet and 32 feet, respectively. On page 2-6, Section 2.5.1, the hydrogeology of Queen Creek is described, as follows:

> "Historically, surface flow in Queen Creek was perennial, and was an integral source of water and sediment to the East Salt River Valley Basin. Surface flow disappeared in the late 1940s, and flow in Queen Creek presently occurs only in response to recharge events. Although surface flow is ephemeral, the Queen Creek drainage continues to provide a groundwater flow path between the mountainous region and the East Salt River Valley Basin."

2. Does not support a self-sustaining fish population.

As a requirement of its NPDES Permit, from 1994 to 1999 the Superior Mining Division has conducted an annual bioassessment of Queen Creek immediately upstream and downstream of the Division's discharge point. In some years, a few (<10) adult green sunfish, *Lepomis cyanellus*, were present in a single, small pool immediately downstream of the discharge point. No young green sunfish were found. During the 1999 bioassessment, no adult or young sunfish were found (Attachment A). The absence of young sunfish in all years and the absence of any fish in 1999 demonstrates that this segment of Queen Creek does not support a self-sustaining fish population.

For additional information on the physical, hydrological, and biological characteristics of Queen Creek immediately upstream and downstream of the Division's discharge point, including long-term trends from 1994 to 1999, please refer to Attachment A, *Annual Bioassessment Report for Queen Creek, Arizona, 1999*.

Thank you for your consideration of this request. If you have any questions or need additional information, please contact me.

Sincerely,

Bill Gray
Environmental Project Manager
(602) 229-4306 Fax: (602) 229-4281

cc: E. Bingham
B. Parkhurst
Attachments

ATTACHMENT A

ANNUAL BIOASSESSMENT REPORT FOR QUEEN CREEK, ARIZONA 1999

ANNUAL BIOASSESSMENT REPORT FOR QUEEN CREEK, ARIZONA 1999

Prepared for

Mr. Bill Gray
Environmental Coordinator
Superior Mining Division
BHP, Inc.
7400 North Oracle Road
Suite 200
Tucson, AZ 85704

Prepared by

The Cadmus Group, Inc.
309 South Fourth Street
Suite 202
Laramie, Wyoming 82070

September 21, 1999

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EXECUTIVE SUMMARY

BHP Copper's Superior Mining Division (SMD) is required to conduct an annual receiving water bioassessment of Queen Creek pursuant to its NPDES discharge permit. Queen Creek's natural flows are ephemeral, but it periodically receives treated effluent from SMD intermittently during December through March. The Cadmus Group, Inc., visited Queen Creek on May 5, 1999, conducting the sixth bioassessment since 1994. QCAMP1 and 2 sampling sites remained in the same location as 1998 to correspond with the ambient water quality monitoring sites, though the entire creek was almost completely dry. QCAMP1 begins downstream at the SMD discharge pipe and proceeds 100 m upstream to Mary Drive; it contained one 10 m pool. QCAMP2 extends for 100 m downstream of the SMD discharge pipe. Water was present in a few pools at QCAMP2, downstream of the point of past effluent discharge. Riparian and aquatic habitat assessments were conducted at both sites, with benthic macroinvertebrate and periphyton samples collected from the pools present. No water quality data other than that collected on site was available, as SMD was not discharging on May 5 when the bioassessment was done.

The riparian plant community was similar at both sites, consisting of deciduous trees and shrubs and remained relatively unchanged from 1998. Saltcedar (*Tamarix pentandra*) continues to dominate both segments of Queen Creek. Litter from the saltcedar was the dominant organic material in the creek. Channel banks were comprised of large-sized materials, such as boulders and cobbles, with an equal amount of gravel at QCAMP2.

Poor aquatic habitat was present at both sites, and that confined to small, stagnant pools. Only three benthic macroinvertebrate taxa were collected at QCAMP1. Dipterans, *Aedes* and *Microtendipes*, were the most abundant taxa collected, followed by Coleopterans (beetles). At QCAMP2, nine taxa were identified, heavily dominated by the Dipterans, again *Aedes* and *Microtendipes*. A few beetles, and four mayflies were also present.

For periphyton, twelve taxa were identified at QCAMP1 and ten taxa at QCAMP2. Representatives of three phyla were identified at both sites. The density of periphyton (number of organisms/mm^2) was 3020 at QCAMP1 and 4699 at QCAMP2. Bacillariophyta (diatoms) took

second place to green algae at both sites this year. Three species of Cyanophyta appeared in significant density at QCAMP1 and one species at QCAMP2.

Trends in habitat quality and the benthic macroinvertebrate and periphyton communities from 1994 to 1999 were evaluated. This evaluation indicates that habitat quality score, number of taxa and abundance of benthic macroinvertebrates, and periphyton diversity appear to be all primarily determined by the presence or absence and quantity of water, especially in pools, at the two sampling sites. If some flowing water was present, then the number of taxa and abundance of benthic macroinvertebrates, as well as periphyton diversity, were relatively high. Obviously, when little or no surface water was present, such as in 1999, then benthic macroinvertebrates and periphyton were virtually absent.

Previous bioassessments suggested that the lack of perennial surface flows, not water quality, was the primary limiting factor for the aquatic community in Queen Creek near the discharge for the SMD facility. This conclusion was based on the fact that Queen Creek, as it passes through the town of Superior, is usually dry. Water flow only occurs in the creek after significant rainfalls, or downstream of QCAMP2 when SMD discharges. Because the SMD discharge is intermittent and primarily occurs during wet weather periods, only a few pools have water. Metals do not appear to be limiting aquatic life in Queen Creek according to past measurements.

INTRODUCTION

As part of its National Pollutant Discharge Elimination System (NPDES) permit number AZ0020389, BHP Copper's Superior Mining Division (SMD) is required to conduct an annual receiving water bioassessment of Queen Creek. BHP contracted The Cadmus Group, Inc. to conduct the bioassessment. According to the provisions of the permit, Cadmus visited Queen Creek on May 5, 1999, consistent with previous bioassessments, to assess physical habitat and collect benthic macroinvertebrate and periphyton samples. The bioassessment's objectives were:

- to evaluate the physical in-stream habitat and associated riparian community for Queen Creek at two sites, above and below the discharge point;
- to evaluate benthic macroinvertebrate and periphyton communities, indicators of Queen Creek's biotic condition; and
- to provide physical and biological data sufficient to evaluate trends in the biotic integrity of Queen Creek.

STUDY AREA

Queen Creek is part of the Gila River watershed in the Southern Basin and Range ecoregion of Arizona. It flows southwest from the Superstition Mountains to the Gila River. Superior, Arizona lies at the base of the mountains where Queen Creek exits a canyon. In Superior, Queen Creek flows at an elevation of approximately 2650 feet amsl. Graf et al. (1991) provides the following description of the Queen Creek drainage basin:

> "The Queen Creek watershed drains a portion of the semiarid, metalliferous Superstition Mountains, as part of the transition zone between the Colorado Plateau and the Basin and Range geomorphic provinces. Elevations range from 4800 feet in the headwater region to about 1800 feet in the downstream region. Although the channel is normally dry, highly variable flows are common. The upper channel moves through tertiary dactite rocks. Surrounding soils are mostly Ustollic Haplargids and Lithic Torriorthent, an association of well-drained, deep, gravelly and moderate fine to fine reddish soils, intermingled by volcanic outcrops. Recent alluvium along streams includes various textures and is calcium rich. Geologically, the channel flows through tertiary dactite rocks while much of the basin drains through a variety of aged limestones, quartzite, diabase, and Pinal schist formations."

BHP Copper's SMD is located in the town of Superior, in Pinal County, Arizona. Discharge is permitted into an unnamed wash that flows into nearby Queen Creek. The discharge is comprised of treated intermittent/seasonal mine drainage and storm water runoff. The discharge permit for this facility identifies two ambient water quality monitoring sites, used as the bioassessment sites (Appendix A). Because of the lack of flowing water during the first two bioassessments, the Queen Creek bioassessment sites were moved upstream of the ambient monitoring sites to areas with large pools. The sites for the assessments from 1994-1997 were located and designated as:

- QCAMP1 - Queen Creek immediately upstream of the Mary Drive creek crossing, approximately 400 feet upstream of the confluence of the unnamed wash that carries SMD's discharge to Queen Creek.
- QCAMP2 - Queen Creek approximately 185 feet downstream of the unnamed wash confluence with the creek.

Since the segment of creek downstream of Mary Drive continued to seem more comparable to QCAMP2, and thus a better reference site, QCAMP1 was kept in the same location as in 1998. QCAMP1 1999 begins downstream at the SMD discharge pipe and proceeds 100 m upstream to Mary Drive. More pools of water were present at QCAMP2, also maintained at immediately below the point of former effluent discharge.

MATERIALS AND METHODS

The annual bioassessment for Queen Creek was conducted on May 5, 1999. A physical habitat assessment was completed using the habitat assessment methods outlined in the Arizona Department of Environmental Quality's (ADEQ) guidance (Meyerhoff and Spindler, 1994) and using the 1999 Field Data Sheets. Channel morphology and substrate composition evaluations, riparian assessments, as well as benthic macroinvertebrate and periphyton sampling, were performed according to the guidance. Some water quality data were also collected on site.

Benthic macroinvertebrate and periphyton samples were collected by Cadmus personnel from the pools present, and a microhabitat sample was collected for QCAMP2, according to the protocols outlined in ADEQ's guidelines (Meyerhoff and Spindler, 1994). Benthic macroinvertebrate and microhabitat samples were sorted and identified in their entirety. Periphyton samples were subsampled according to the methods identified in the 1994 bioassessment (Cadmus, 1995). All biological samples were identified to the lowest possible taxon.

No water quality samples for metals analyses were collected by Superior Mine personnel as the mine was not discharging into the creek. Water temperature, dissolved oxygen, pH and conductivity were measured in the field. Methods used to collect physical, chemical, and biological samples during the bioassessment are described in the 1994 bioassessment (Cadmus, 1995).

RESULTS AND DISCUSSION

Physical Habitat Assessment and Riparian Community Characterization

A map of sample site locations is presented in Appendix A. Flow at QCAMP1, originating entirely from groundwater, was estimated to be 0.002 cfs, or barely detectable. One pool, approximately 10 m long, was present. A similar, barely perceptible flow of 0.002 cfs was present in the 75 m of intermittent pools at QCAMP2.

The riparian plant communities at both sites were relatively unchanged from the 1998 bioassessment. At QCAMP1, the riparian plant community consisted of shrubs intermixed with grasses closest to the road, while upstream of Mary Drive, larger shrubs and trees created a canopy over the dry stream bed (Table 1). Saltcedar (*Tamarix pentandra*) in all three age classes, mature Fremont cottonwoods and sapling willows (*Salix spp.*) dominated.

Table 1. Riparian assessment for Queen Creek, Superior, Arizona, May 5, 1999.

Parameter	QCAMP1	QCAMP2
Taxa Identification		
a. Upland plant association	mesquite	mesquite, saltcedar, oak
b. Primary riparian association	saltcedar	saltcedar
c. Other riparian species noted	Fremont cottonwood, Gooding willow	Fremont cottonwood, mesquite
d. Plant specimens collected (Y/N)	N	N
Riparian Quality		
a. Percent of stream shaded	3.5%	4.5%
b. Percent plant cover on soil		
1. Overall cover	70%	85%
2. Trees	15%	17%
3. Shrubs	15%	17%
4. Grasses/forbs	70%	66%
c. Aquatic plants (Y/N)	Y	Y
1. Algae	26-50%	1-25%
2. Floating algae	common, green	common, green
3. Algal slime	rare	rare
4. Aquatic and semi-aquatic vascular plants	<1%	<1%
d. Regeneration potential (% composition within each species)		
Saltcedar (% Mature trees/% Saplings/% Seedlings)	50/50/0	50/50/0
Cottonwood (% Mature trees/% Saplings/% Seedlings)	100/0/0	100/0/0
Willow (% Mature trees/% Saplings/% Seedlings)	100/0/0	0/0/0

Table 2. Sediment and substrate features for Queen Creek, Superior, Arizona, May 5, 1999.

Parameter	QCAMP1	QCAMP2
Creek Bed Composition (%)		
Bedrock	9	0
Boulder (>256mm)	23	10
Cobble (>64mm)	26	8
Gravel (>2mm)	34	67
Sand and Silt (>0.5mm)	0	15
Organic Soil (<0.063mm)	0	0
Channel Bank Composition (%)		
Bedrock	0	0
Boulders	20	30
Cobbles	20	30
Gravel	20	20
Sand/Silt	20	10
Organic soil	20	10
Channel Undercutting (%)		
Cut	10	1
Uncut	90	99
Bank Type (%)		
Cut	50	0
Uncut	50	100
Inner Channel Width (feet)	26.25	16.4
Scour Channel Width (100 yr.)	39.37	32.8
Comments on Bank Stability	Stable	Stable
Description of Flowing Side Drainages, Springs, Other Sources	No flow, water present only for one 10 m pool	No flow, water present only for 75 m

At QCAMP2, the riparian community was denser, with larger deciduous trees and shrubs providing canopy cover, but many mature cottonwood trees appeared to be dead. Saltcedar dominated as mature and sapling plants, interspersed with mature Fremont cottonwoods and mesquite (*Prosopis glandulosa*). Other shrubs and grasses composed the under story. The riparian plant community provided shaded to partly-shaded conditions for the stream bed.

Filamentous algae covered up to 50% of the stream bed at QCAMP1, and no aquatic or semi-aquatic macrophytes were present. QCAMP2 also had no aquatic or semi-aquatic macrophytes, but less filamentous algae (Table 1).

The creek bed throughout was comprised of boulders, cobble and gravel, with some sand and silt present (Table 2). A predominance of boulders and cobbles created a stable bank, minimizing channel undercutting at both sites — though some was noted at QCAMP1. Also, about half of the QCAMP1 site displayed some vertical channel cutting.

The overall habitat quality at both sites scored as 60 and 62 for QCAMP1 and 2, respectively, in the "marginal" category (Meyerhoff and Spindler, 1993). This reflects the absence of any real flow, despite a good diversity of habitat, good riparian conditions, as well as good pool substrates and shade conditions (Table 3).

Water Quality

Water quality measurements for the field and ambient samples appear in Table 4. Dissolved oxygen was 1.8 mg/L at 15°C at QCAMP2 and 2.8 mg/L at 23°C at QCAMP1. pH was approximately 7.2 and 7.1, respectively. Conductivity was 512 μS/cm and 354 μS/cm, respectively.

Table 3. Habitat assessment scores for Queen Creek in Superior, Arizona, May 5, 1999.

Habitat Scoring Parameter	QCAMP1 Score	QCAMP2 Score
Riffle substrate/in stream cover	0	0
Embeddedness	0	0
Pool substrate	18	13
Velocity/depth	0	0
Shade conditions	9	9
Channel shape (wetted width)	2	3
Pool/riffle ratio	0	0
Lower bank channel capacity	3	10
Upper bank stability	6	8
Grazing impacts	7	7
Stream side cover	9	9
Width of riparian vegetative zone	3	3
Total score	60	62

Wildlife

At QCAMP2, doves and songbirds were observed. Signs of horses appeared throughout the area, as well as the discarded corpse of a domestic dog. Quail, doves and rabbits were observed at QCAMP1.

Table 4. Water quality features for Queen Creek in Pinal County, Arizona, May 5, 1999.

Parameter	QCAMP1	QCAMP2
Water Temperature (°C)	23°	15°
Dissolved Oxygen (mg/L)	2.8	1.8
Conductivity	354	512
Flow (estimated) (cfs)	0.002	0.002

Fish

No fish were observed in the pools at either QCAMP1 or 2; green sunfish had been observed in some previous bioassessments.

Benthic Macroinvertebrates

Only pools were available for sampling at both sites. Summary statistics for benthic macroinvertebrates collected during the bioassessment are presented in Table 5, and a complete record is presented in Appendix B, Table B-1. Three taxa were collected at QCAMP1 and nine at QCAMP2. Diversity and evenness indices for QCAMP1 were 0.37 and 0.78, respectively. QCAMP2 showed indices of 0.43 and 0.45, respectively. Dipterans, primarily *Aedes* at QCAMP1 and

Table 5. Summary statistics and metrics for benthic macroinvertebrates collected in Queen Creek during the annual bioassessment, May 5, 1999.

Parameter	QCAMP1	QCAMP2
Number of Taxa	3	9
Total Abundance	59	1188
Brillouin's diversity	0.37	0.43
Evenness	0.78	0.45
Hilsenhoff Biotic Index	7.22	6.5

Microtendipes at QCAMP2, were predominant, accounting for 89.8 and 96.9 percent of the total macroinvertebrates, respectively. Warmwater Index scores were not calculated for Queen Creek, as the index draws only from riffle data and the low flows precluded the presence of riffles.

Periphyton

Summary statistics for periphyton collected during the bioassessment are presented in Table 6 and a complete record of periphyton collected is presented in Appendix B, Table B-2. Twelve taxa were collected at QCAMP1 and ten at QCAMP2, representing three distinct phyla, Bacillariophyta (diatoms), Chlorophyta (green algae), and Cyanophyta (blue-green). However, Chlorophyta was found as only one species, *Mougeotia sp.*, which differed from the one species of Chlorophyta identified in 1998. Periphyton densities were 3020 and 4699 organisms/mm^2 at QCAMP1 and 2, respectively. Diversity and evenness were 0.77 and 0.71, respectively at QCAMP1 and 0.70 for both at QCAMP2.

Table 6. Summary statistics and metrics for periphyton collected in Queen Creek during the annual bioassessment, May 5, 1999.

Parameter	QCAMP1	QCAMP2
Number of Taxa	12	10
Number of organisms/mm^2	3020	4699
Brillouin's diversity	0.77	0.70
Evenness	0.71	0.70

Green algae dominated at both sites, with 44.9 and 52.4 percent of the periphyton composition, all *Mougeotia sp.*, followed by diatoms at 31.9 and 41.7 percent, with eight varying taxa at each site. Cyanophyta, the third most dominant phyla at both sites, represented 23.2 and 5.9 percent of the taxa collected. QCAMP1 displayed three Cyanophyta taxa, but QCAMP2 showed only one of those three, *Apahnizomenon flos-aquae*.

LONG-TERM TRENDS IN THE BIOLOGICAL COMMUNITY OF QUEEN CREEK

Trends in habitat quality and the benthic macroinvertebrate and periphyton communities from 1994 to 1999 were evaluated (Figures 1-8). In general, habitat quality score, number of taxa and abundance of benthic macroinvertebrates, and periphyton diversity appeared to be primarily determined by the presence or absence and quantity of water, especially in pools, at the two sampling sites. If some flowing water was present at a site, then the number of taxa and abundance of benthic macroinvertebrates, as well as periphyton diversity, were relatively high. Obviously, when little or no surface flow was present, such as in 1999, then benthic macroinvertebrates and periphyton were virtually absent. Habitat quality was also primarily determined by the presence or absence of flowing

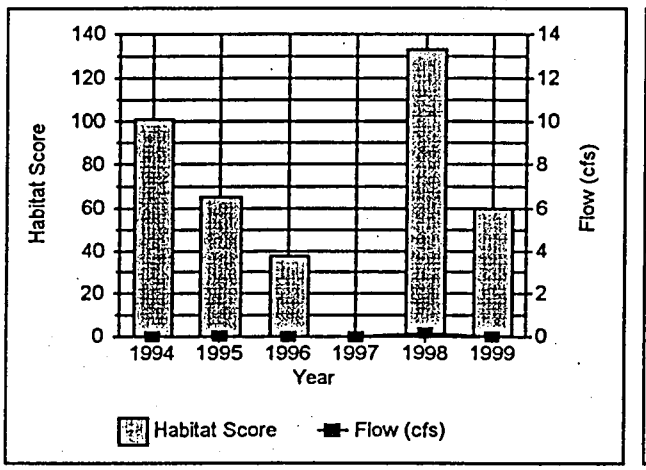

Figure 1. Habitat quality scores and stream flows at Queen Creek station QCAMP1, 1994-1999.

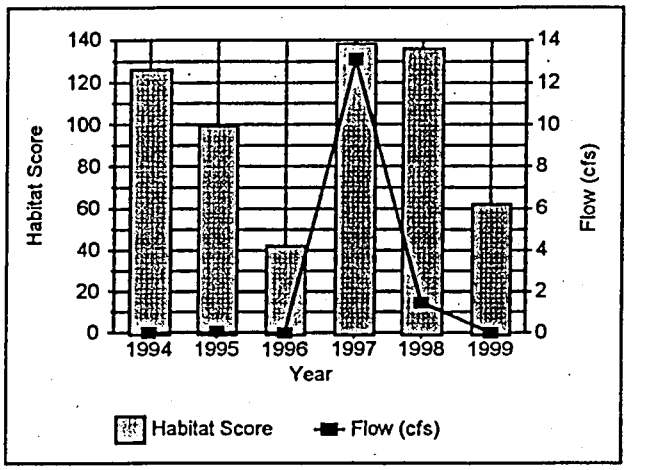

Figure 2. Habitat quality scores and stream flows at Queen Creek station QCAMP2, 1994-1999.

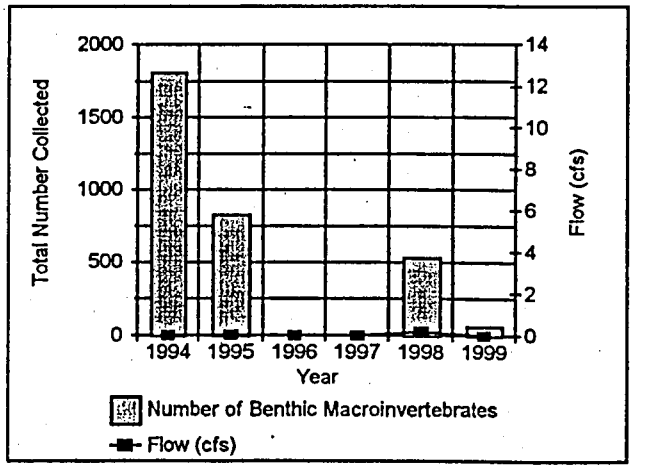

Figure 3. Comparison of flow and the total number of benthic macroinvertebrates collected at Queen Creek station QCAMP1, 1994-1999.

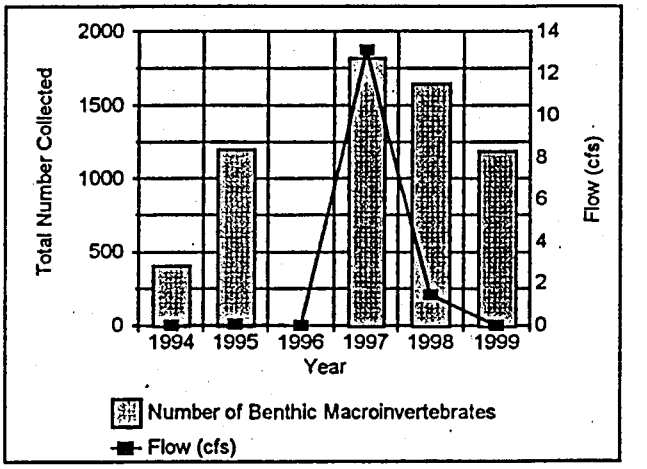

Figure 4. Comparison of flow and the total number of benthic macroinvertebrates collected at Queen Creek station QCAMP2, 1994-1999.

water. At both QCAMP1 and 2 during 1999, habitat quality dropped in the absence of adequate water flow.

Previous bioassessments had suggested that the lack of permanent surface flow, not water quality, was the primary limiting factor for the aquatic community in Queen Creek near the discharge for the SMD facility. This conclusion was based on the fact that Queen Creek, as it passes through the town of Superior, is ephemeral. Water flow only occurs in the creek after significant rainfalls, or after an unusual rainy season as in 1998, or downstream of QCAMP2 when SMD discharges. Because the SMD discharge has ceased, only a few small pools had permanent water. Metals do not appear to be limiting aquatic life in Queen Creek; historically all concentrations of total recoverable and dissolved

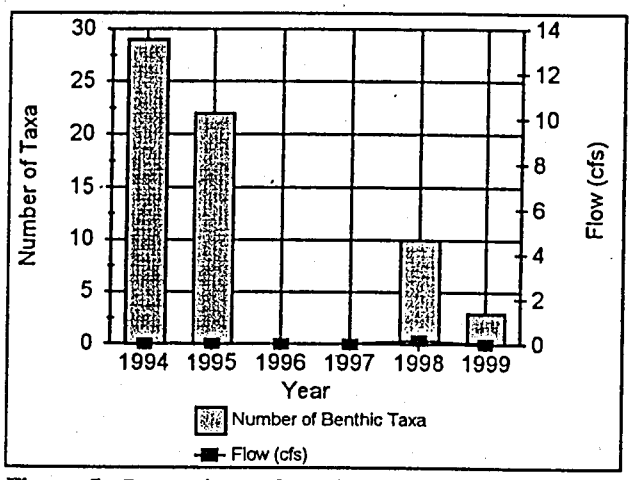

Figure 5. Comparison of number of benthic macroinvertebrate taxa and flow at Queen Creek station QCAMP1, 1994-1999.

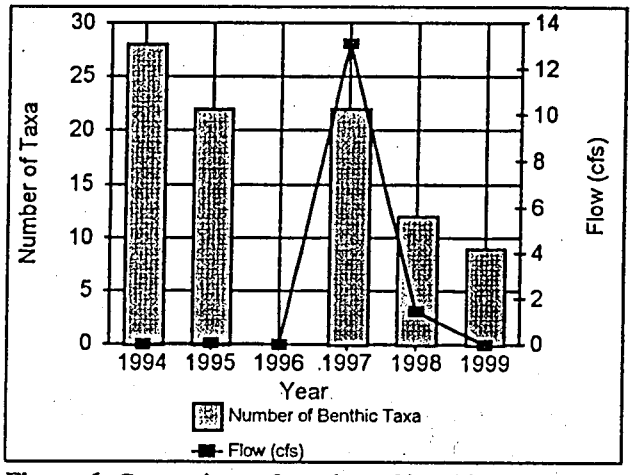

Figure 6. Comparison of number of benthic macroinvertebrate taxa and flow at Queen Creek station QCAMP2, 1994-1999.

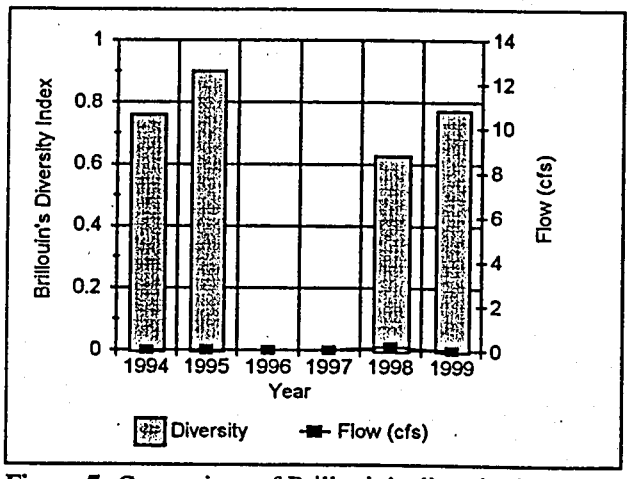

Figure 7. Comparison of Brillouin's diversity index for periphyton and flow at Queen Creek station QCAMP1, 1994-1999.

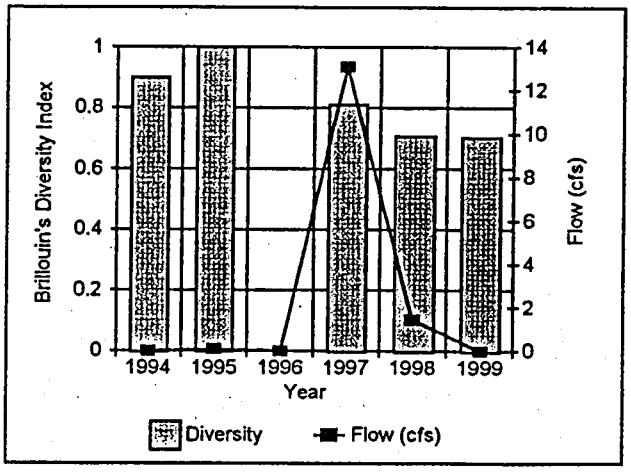

Figure 8. Comparison of Brillouin's diversity index for periphyton and flow at Queen Creek station QCAMP2, 1994-1999.

metals, except copper and arsenic, were less than detectable in the past. At the typically high hardness levels, these concentrations are less than chronic water quality standards and would have negligible toxicity.

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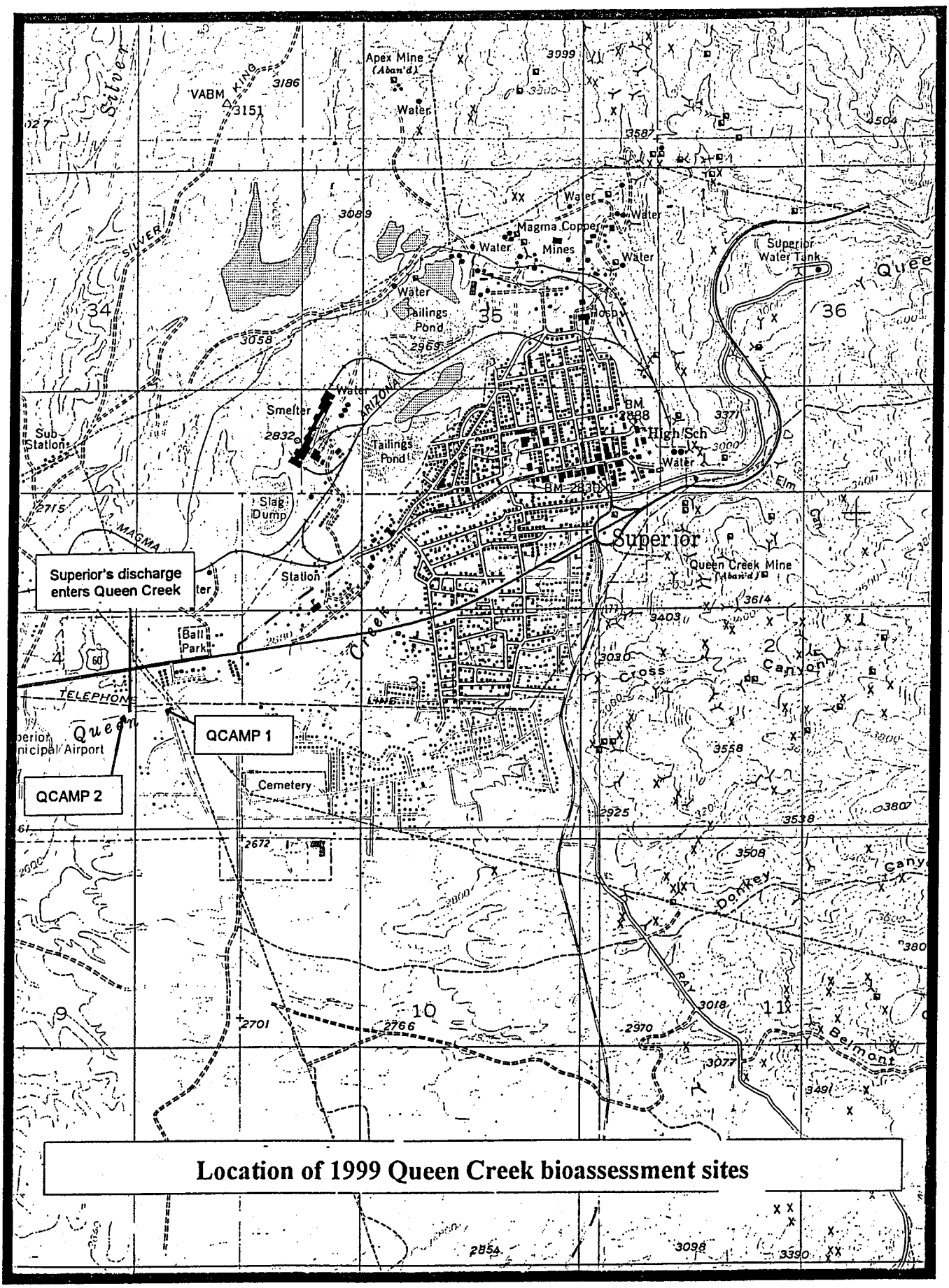
APPENDIX A

Map of Queen Creek Bioassessment Site Locations
May 5, 1999



Location of 1999 Queen Creek bioassessment sites

APPENDIX B

Complete Benthic Macroinvertebrate and Periphyton Data
Collected During the Bioassessment of Queen Creek
May 5, 1999

Table B-1. Hilsenhoff Biotic Index scores, functional groups and tolerances for benthic macroinvertebrates collected in Queen Creek, Pinal County, Arizona, May 5, 1999.

TAXON	FUNCTIONAL GROUP	TOLERANCE VALUE	QCAMP1 # INDIVIDUALS POOL	QCAMP1 HBI	QCAMP2 # INDIVIDUALS Pool	QCAMP2 # INDIVIDUALS Microhabitat	QCAMP2 HBI
Order Coleoptera (beetles)							
Dytiscidae	PR	7					
Agabus sp.	PR	7			8	1	0.0530303
Laccophilus sp.	PR	7			8		0.047138
Stictotarsus sp.	PR	7	6	0.7118644	12		0.0707071
Staphylinidae	UN	11					
Stenus sp.	UN	11			4		0.037037
Order Diptera (flies, mosquitos, midges)							
Ceratopogonidae	PR	7			1		0.0058923
Chironomidae	PR, CF, SH, SC	6					
Heterotrissocladius sp.	CG	0			54	1	0
Microtendipes sp.	CG	6	20	2.0338983	646	12	3.3232323
Culicidae							
Aedes sp.		8	33	4.4745763	432	5	2.9427609
Order Ephemeroptera (Mayflies)							
Baetidae							
Baetis sp.	CG	5			4		0.016835
SH-Shredders, FT-Filterers, CG-Collector-Gatherers, CF-Collector-Filterers, SC-Scrapers, PR-Predators							
Total Number of Organisms			59			1188	
Taxa Richness			3			9	
HBI, Value			7.22			6.49	
Brillouin's diversity			0.3722			0.4275	
Evenness			0.7801			0.448	
% of total as ephemeroptera						0.34%	
% of total as odonates							
% of total as hemipterans							
% of total as megalopterans							
% of total as tricoptera							
% of total as coleopterans			10.17%			2.78%	
% of total as dipterans			89.83%			96.89%	
% of total as gastropoda							

Table B-2. Periphyton data collected during the May 5, 1999 bioassessment of Queen Creek, Pinal County, Arizona.

Site Identification	*QCAMP1*	*QCAMP2*
Date	*05/05/98*	*05/05/98*
Habitat	*pool*	*pool*
Taxon		
BACILLARIOPHYTA		
Pennales		
Amphora ovalis var ovalis	*14775*	*141070*
Cocconeis placentula var placentula		*70535*
Fragilaria crotonensis var crotonenesis	*59098*	
Navicula sp.	*73873*	*211606*
Nitzschia palea var palea	*132971*	*775887*
Pinnularia brevicostata var brevicostata	*88648*	*352676*
Rhopalodia parallela var. parallela	*635308*	*141070*
Surirella guatemalensis		*141070*
Surirella saxonica	*29549*	
Synedra ulna var ulna	*147746*	*564282*
CHLOROPHYTA (Green algae)		
Mougeotia sp.	*1661608*	*3014876*
CYANOPHYTA		
Anabaena sp.	*171300*	
Apahnizomenon flos-aquae	*342600*	*342600*
Aphanocapsa delicatissima	*342600*	
Total Density (Cells/sample)	*3700076*	*5755672*
Surface Area sampled (sq. mm)	*1225*	*1225*
Density (Cells/sq. mm)	*3020*	*4699*
Total Number of Taxa	*12*	*10*
% of total as bacillariophyta	*31.94%*	*41.67%*
% of total as chrysophyta	*0.00%*	*0.00%*
% of total as chlorophyta	*44.91%*	*52.38%*
% of total as euglenophyta	*0.00%*	*0.00%*
% of total as cyanophyta	*23.15%*	*5.95%*
% of total as cryptophyta	*0.00%*	*0.00%*
% of total as pyhrrophyta	*0.00%*	*0.00%*
	100.0%	*100.0%*

Attachment 3
Fluvial Processes of the Queen Creek Basin

CHAPTER 1

REGIONAL INTRODUCTION

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Introduction

Queen Creek is typical of Arizona's desert streams. It's hydrologic cycle is characterized by flows produced in the upland areas of a normally dry wash. This runoff passes from bedrock to alluvium where infiltration becomes an addition to the ground water reservoir. Pumping brings this ground water to the surface for irrigation, where it is transpired or evaporated, and the cycle completed (Babcock and Cushing, 1942).

Queen Creek begins in the Pinal Mountains, four miles northeast of the town of Superior at an altitude of 1364 m. (4500 ft.), heading west through Superior, past Picketpost Mountain, and enters an outwash plain at Black Point about three miles north of Florence Junction. Then heading southwesterly toward Chandler, it passes through the desert and spreads out over the lowlands. The drainage area is approximately 572 sq. km. (221 sq.mi.)

The streamflow consists almost entirely of storm water of the quick, flashy type common to the deserts of the Southwest. Formerly the floodwaters spread over the floor of the desert and did no harm. With the advent of irrigated farming in the lower reaches, it's potential for flood damage became serious. In November of 1960, the U.S. Army Corps of Engineers completed Whitlow Ranch Dam as a flood control improvement for the community of Queen Valley and the downstream inhabitants (Szaro and DeBano, 1985).

Geology

Queen Creek begins in the Transition Zone, a narrow strip across central Arizona, and quickly flows into the Basin and Range Province of the southern Arizona (fig. 1.1). Typical features of this area are rugged, linear mountain ranges separated by broad flat valleys. The mountains, composed of various rock types representing many geologic ages, are deformed by uplift along major fault planes. The valleys are underlain of alluvial debris eroded in the mountains and transported to the lowlands by running water and gravity.

The stratigraphic record includes rocks of Precambrian age. Early Precambrian rocks are mostly schists and gneiss known as Pinal schists. Late Precambrian rocks include limestones, mudstones, orthoquatzites, and conglomerates of the Apache group.

Paleozoic deposits are composed of marine limestones and reworked detrital sediments of shelf seas that extended northward from a Sonoran geosyncline . Sediments of Triassic and Jurassic age are absent and those of Cretaceous age are predominantly continental. Cenozoic deposits are entirely continental and of valley fill type (Darton, 1922).

The Pinal Mountains are made up of Precambrian schists, Troy quartzite, Martin and Tornado limestones, with a thick flow of dacite forming the Apache Leap. Some thick sills of diabase are intruded in the quartzite and there are intrusive dikes or stocks of quartz diorite porphyry. At Superior there is a fault striking a little west of north. This fault is believed to be younger than the dacite (Tertiary) and probably causes the steep west front of the mesa known as Apache Leap (Darton, 1922).

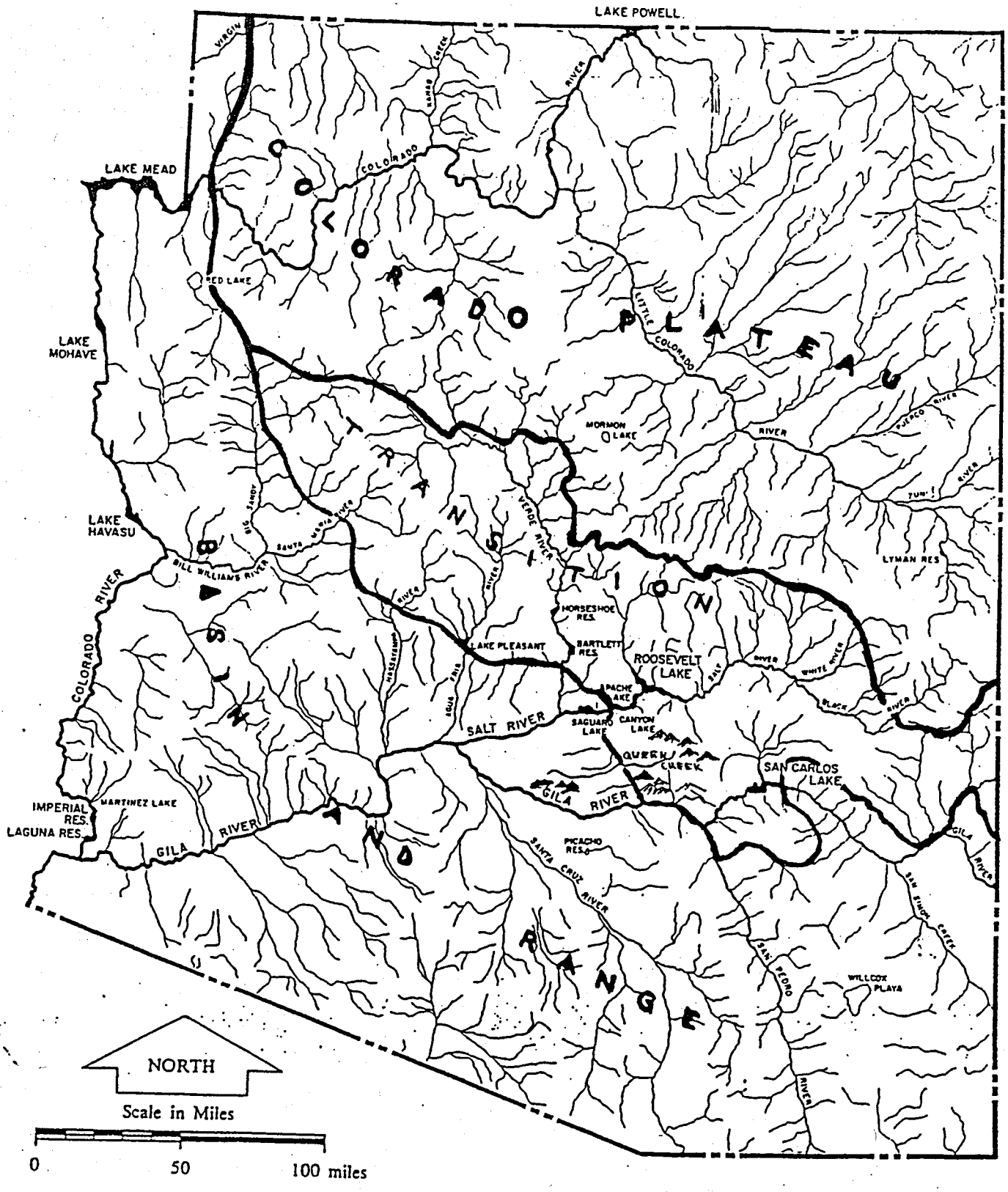

LAKE POWELL
LAKE MEAD
LAKE MOHAVE
LAKE HAVASU
COLORADO RIVER
COLORADO PLATEAU
TRANSITION ZONE
SONORA DESERT
BASIN AND RANGE
MORMON LAKE
LYMAN RES
HORSESHOE RES.
BARTLETT RES.
ROOSEVELT LAKE
LAKE PLEASANT
PACHE LAKE
SAGUARO LAKE
CANYON LAKE
QUEEN CREEK
SAN CARLOS LAKE
SALT RIVER
GILA RIVER
IMPERIAL RES.
LAGUNA RES.
MARTINEZ LAKE
PICACHO RES.
WILLCOX PLAYA
NORTH
Scale in Miles
0
50
100 miles

Fig. 1.1

As Queen Creek leaves Superior, it passes Picketpost Mountain about four miles southwest of Superior. This area is underlain by Pinal schist. Directly south of Picketpost Mountain is a mile wide belt of steeply eastward dipping sedimentary rocks of the Apache group. Both schist and sedimentary rock have been intruded by diabase. Much of this area is covered by a widespread dacitic ash-flow sheet of mid-Tertiary age. The valley of Queen Creek at this point is filled with alluvial gravel of Tertiary and Quaternary age.

The rocks capping Picketpost Mountain bear a marked resemblance to the dacite on Apache Leap, but are distinctly younger. Picketpost Mountain includes diverse kinds of lavas and tufts erupted from numerous volcanoes at different times. The top of the mountain, classified as the Heliograph Formation, is quartz latite (Crosswhite, 1984).

About a mile west of Black Point, Queen Creek passes from mountains to an alluvial slope of the desert plain. Near the mountains, it's present flood plain is entrenched below the surface of it's old alluvial fan. This fan coalesces with those of neighboring washes to form a piedmont plain. For several miles west, the piedmont plain is underlain by rock that is only partially buried beneath relatively shallow alluvial fill. Farther west, the presence of a buried fault scarp and thicker alluvial deposits are suggested (Babcock and Cushing, 1942). The piedmont and terrace deposits are similar in lithology and are grouped together as old alluvium.

Recent stream deposits of gravel, sand, and silt cover the older alluvium in the present flood plain. The flash floods carry a heavy bedload, but this is quickly dropped as the stream gradient decreases westward. As a result, a flood plain with many shifting and interlacing channels has been produced (Babcock and Cushing, 1942).

Climate

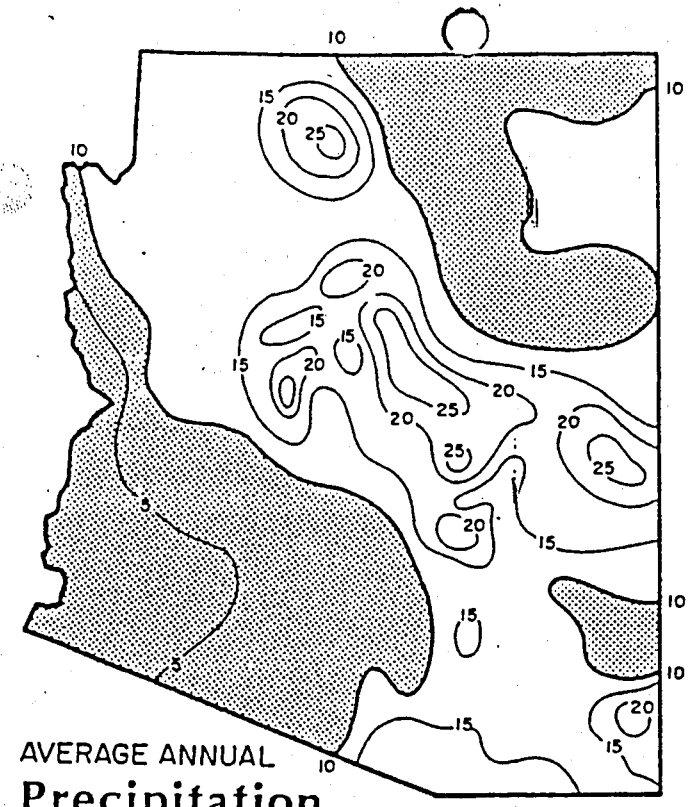
Queen Creek lies in an arid to climate zone, characterized by limited precipitation. Precipitation patterns are bimodal, with summer thunderstorms and winter showers. Precipitation totals range from less than twenty inches a year in Superior to seven inches a year at Chandler (fig. 1.2).

The greatest amounts of precipitation normally fall in the summer when the state is subjected to frequent invasions of moist tropical air from the Gulf of Mexico. Thunderstorms develop almost every afternoon from early July until the end of August. Most storms are centered over the mountains, then spread out into the surrounding canyons and valleys producing light to moderate showers.

A second season of moderately heavy precipitation occurs in winter. At this time of year, middle latitude cyclones advance across Arizona from the Pacific Ocean producing widespread gentle showers. A small part of the winter precipitation falls as snow in the mountains, but this normally melts as soon as it hits the ground. These winter showers are lighter in intensity than the summer storms, but last much longer.

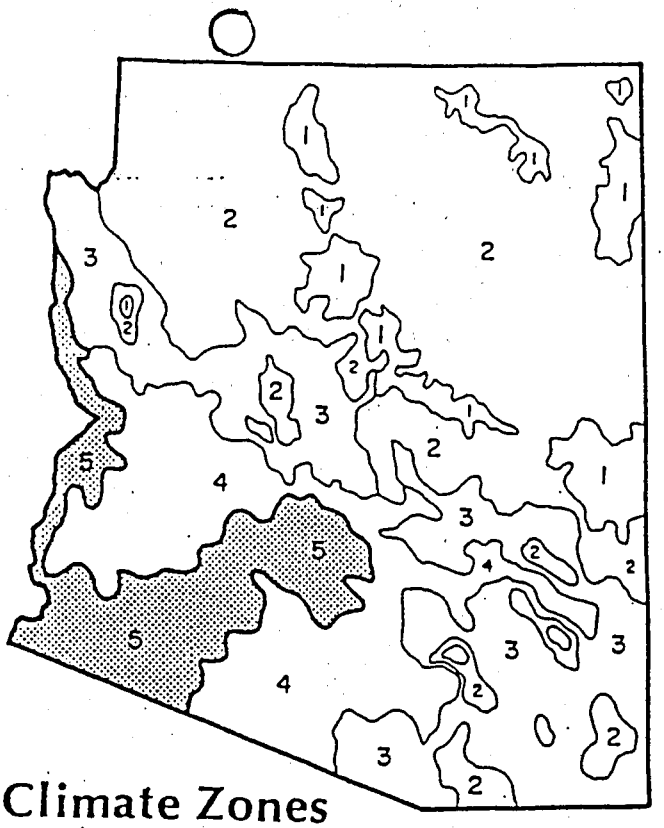
Temperatures in the Queen Creek area are hot during the summer. At the higher elevations, the temperature can vary from the seventies in the early mornings, to the middle nineties in the afternoon. Temperatures in the lower elevations are well above one hundred degrees during the day.

Winters are mild at the higher elevations, with temperatures rarely falling below freezing at night, and usually rising into the sixties during the day. Early morning temperatures are considerably higher than those recorded at



AVERAGE ANNUAL
Precipitation

Average annual precipitation shown in inches per year.
Shaded area – less than 10 inches annually.

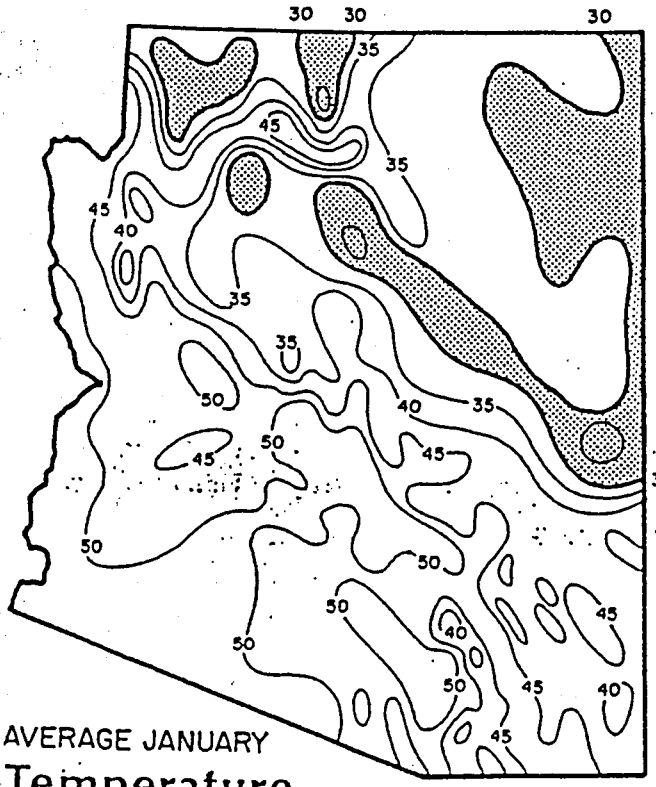


Climate Zones

Legend

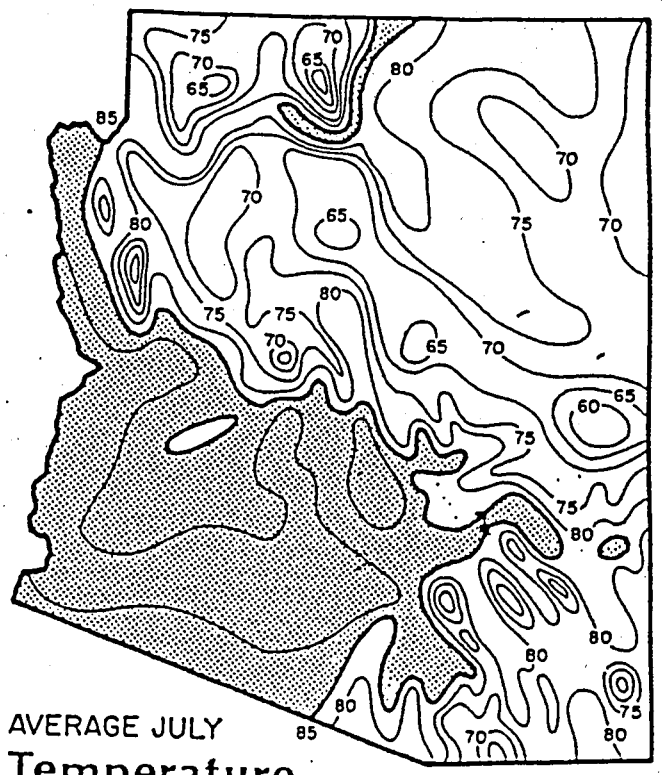
1 - HIGHLANDS snow forest
2 - OTHER HIGHLANDS
3 - HIGH DESERT
4 - INTERMEDIATE DESERT
5 - LOW DESERT

Shaded area -(low desert)- averages 10 days per year or less with temperatures below 32° fahrenheit.



AVERAGE JANUARY
Temperature

Shaded area – average temperature 30° or less.



AVERAGE JULY
Temperature

Shaded area – average temperature 85° or more.

Temperatures shown in degrees fahrenheit

Fig. 1.2

lower elevations to the west, because the coldest air tends to drain off the mountains at night and settle on the desert floor (Green and Seller, 1964).

Except for summer, the lower elevations are characterized by warm days, cool nights, and a diurnal temperature variation of better than thirty degrees. Readings of ninety degrees or greater have been recorded in all months except January. Winter nights are cool, the minimum temperature falling to freezing or lower about thirty days of the year between the last week of November and the third week in February (Green and Sellers, 1964).

Vegetation

Queen Creek's vegetation ranges from Interior Chaparral in the Pinal Mountains to Arizona Upland and Lower Colorado River Valley subdivisions of Sonoran Desertscrub. In and along the drainages within the Sonoran Desert lie the Sonoran Riparian Scrubland.

Interior Chaparral vegetation type is composed of shrubs that have dense, compact crowns, and small evergreen sclerophyllous leaves. Shrub Live Oak (Quercus turbinella) is the most widespread chaparral species, commonly associated with shrubs such as Birchleaf Mountain-mahogany (Ceanothus betuloides), Skunkbush Sumac (Rhus trilobata), silktassels (Garrya wrightii, G. flavescens), and Desert Ceanothus (C. greggii). Manzanitas (Arctostaphylos pungens, A. Pringlei) are a frequent associates at higher elevations.

There is integration of Interior Chaparral with Madrean Evergreen Woodland in the higher, wetter chaparral reaches. Chaparral gradually gives way upslope to taller evergreen oaks (Q. emoryi, Q. arizonica), Junipers (Juniperus deppeana, J. monosperma), Pinyon (Pinus edulis), and Pondersosa Pine (P.

ponderosa) (Brown, 1982).

The Arizona Upland vegetation type occupies the majority of the Queen Creek area. Within the Arizona Upland subdivision, two series occupy the valley slopes and upper areas surrounding Queen Creek. First is the Palo Verde-Cacti-Mixed Scrub series, dominated by Palo Verde (Cercidium spp.) and Saguaro (Carnegiea gigantea). This community is best developed away from the valley floors on bajadas and mountain sides. This ecotone and Creosote-White Bursage series is a common feature along the margins of the valleys of this region (Brown, 1982). The second series is the Jojoba (Simmondsia chinensis)-Mixed Scrub series. This series is best developed at the desert's upper limits and in transition areas between Sonoran Desertscrub and Interior Chaparral.

The lowest elevations of Queen Creek is in the Lower Colorado River Valley subdivision. Two series, Creosote-White Bursage and Saltbush, occur along Queen Creek. Creosotebush (Larrea tridentata) and White Bursage (Ambrosia dumosa), compose the most widespread and important community of the Lower Colorado River Valley subdivision. Both species normally decrease in importance upslope on the bajadas (fig. 1.3). White Bursage barely extends above the broad valley floors, whereas Creosotebush holds a position on the upper most bajada and into the mountains (Brown, 1982). Saltbush series is a community of gently sloping land and valleys. Saltbush (Atriplex spp.), Lycium spp., and Mesquites (Prosopis spp.) are common associates.

In and along drainages within the Sonoran Desert, area scrublands too dense to be considered desertscrub are classified Sonoran Riparian Scrubland, where the actual stream channel dominants are distinctly riparian species (Brown, 1982). Seepwillow (Baccharis glutinosa) is abundant nearest water, with Desert Broom (B. sarothroides) and Mule Fat (B. viminea) in drier areas in the desert

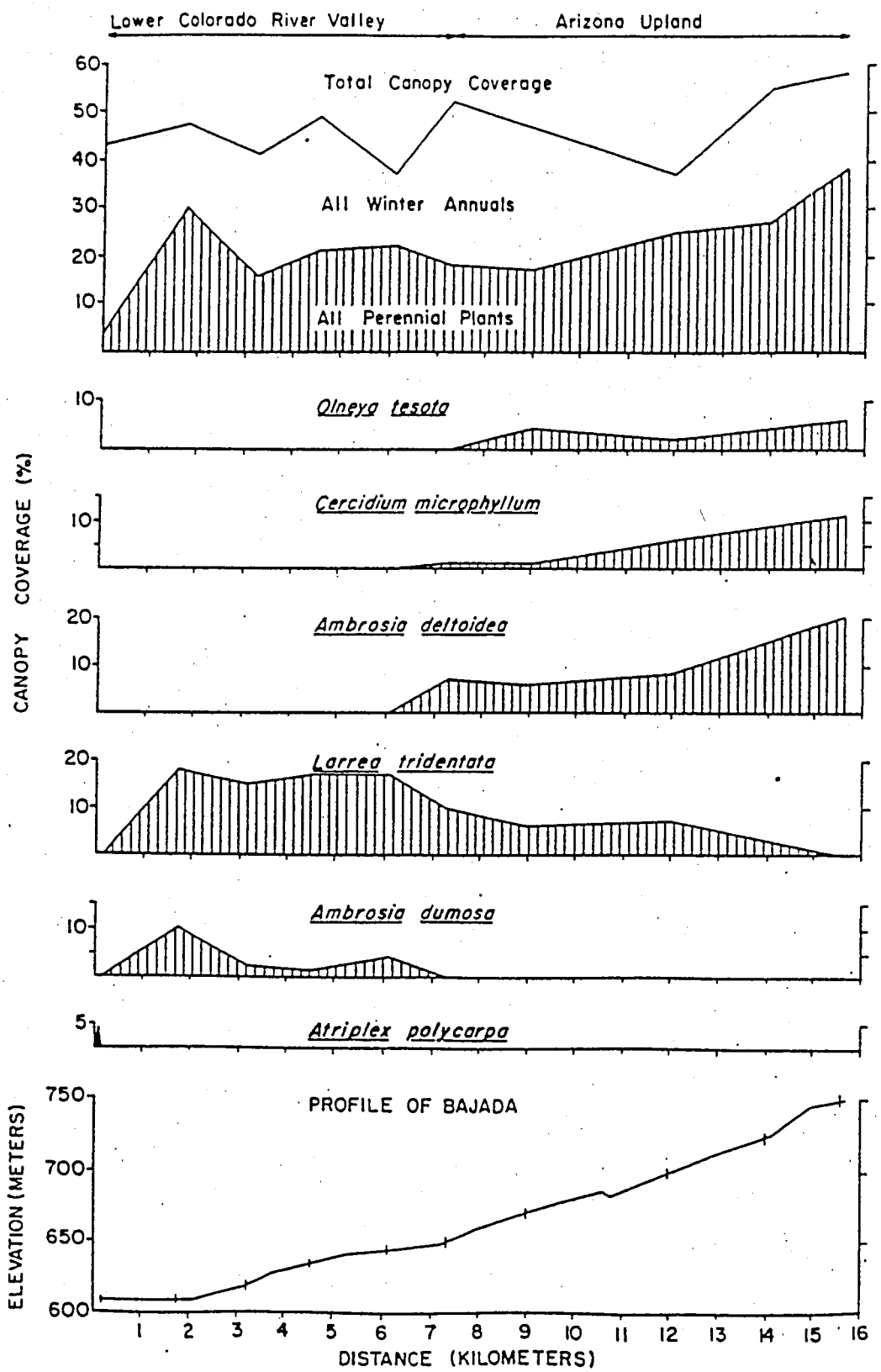


Fig. 1.3 Profile of Bajada (Sonoran Desert)

washes. Arrow-weeds (Pluchea sericea, P. camphorata, P. purpurascens) and Burro-brush (Hymenoclea spp.) may dominate on sandy soils. The deciduous Desertwillow (Chilopsis linearis) is a common tree component, as is the increasingly prevalent deciduous Saltcedar (Tammarix spp.).

Soils

Queen Creek's higher elevation soils are classified as Lithic Torriorthents, Lithic Paleoargids, and Lithic Haplustolls (SCS, 1971). These soils are shallow, cobbly and gravelly, on steep slopes, with more than half of this association being rock outcrop. These soils have low available water capacity and moderate permeability. Runoff is medium to rapid and the hazard of erosion slight. Factors limiting the potential of these areas for community uses are steep slopes, shallow depth to bedrock, and rock fragments on the surface (Hendricks,1985).

From the Superior to Pickestpost Mountain, the soils are classified as Usotllic Haplargids and Lithic Torriorthents (SCS,1971) . This association consists of well drained soils formed on low mountains and piedmonts. These deep, gravelly, moderately fine to fine reddish soils with dark colored surfaces, are typically found on slopes between five and thirty percent. They have good water holding capacity and moderately slow permeability. Also included are soils of recent alluvium along small streams with limy, medium textures on short eroded slopes (Hendricks, 1985).

Rock outcrop dominant Ustollic Haplargids and Lithic Torriorthents characterize the Picketpost Mountain area (SCS, 1971). These soils are shallow, cobbly soils dominated by volcanic rock outcrops. Small areas of

sedimentary rock are included. Under good management these soils have good potential for production of livestock and wildlife forage (Hendricks, 1985).

The remainder of Queen Creek's soils are Typic Haplargids and Typic Torrifluvents (SCS, 1971; SCS, 1974). The Typic Haplargids are deep, moderately fine and fine textured, gravelly, nearly level to gently sloping soils on valley plains. Part of this group is well suited for growing arid adapted crops where irrigation water is available. Factors limiting the potential of these soils are the moderately slow permeability, with high to moderate shrink-swell characteristics (Hendricks, 1985).

The Typic Torrifluvent consists of well drained, deep, stratified, coarse to fine textured, nearly level to gently sloping soils on flood plains and lower alluvial fans. These soils are subject to seasonal, brief flooding unless protected. Runoff is slow and the hazard of erosion is usually slight, except along entrenched streams where soils are subject to bank cutting, piping, and gullying. These soils constitute the majority of irrigated croplands in Arizona. Flooding potential is the major limitation (Hendricks, 1985).

Human Influence

Human history of this area began well before the Christian era. Emigrated to Arizona from Mexico, the Hohokam brought a well established culture with them (fig. 1.4). The most remarkable accomplishment of the Hohokam, and one that left its mark on succeeding centuries of local culture, was the engineering and construction of irrigation canal systems.

About 1400 A.D. the Hohokams disappeared. Archaeologists have not yet

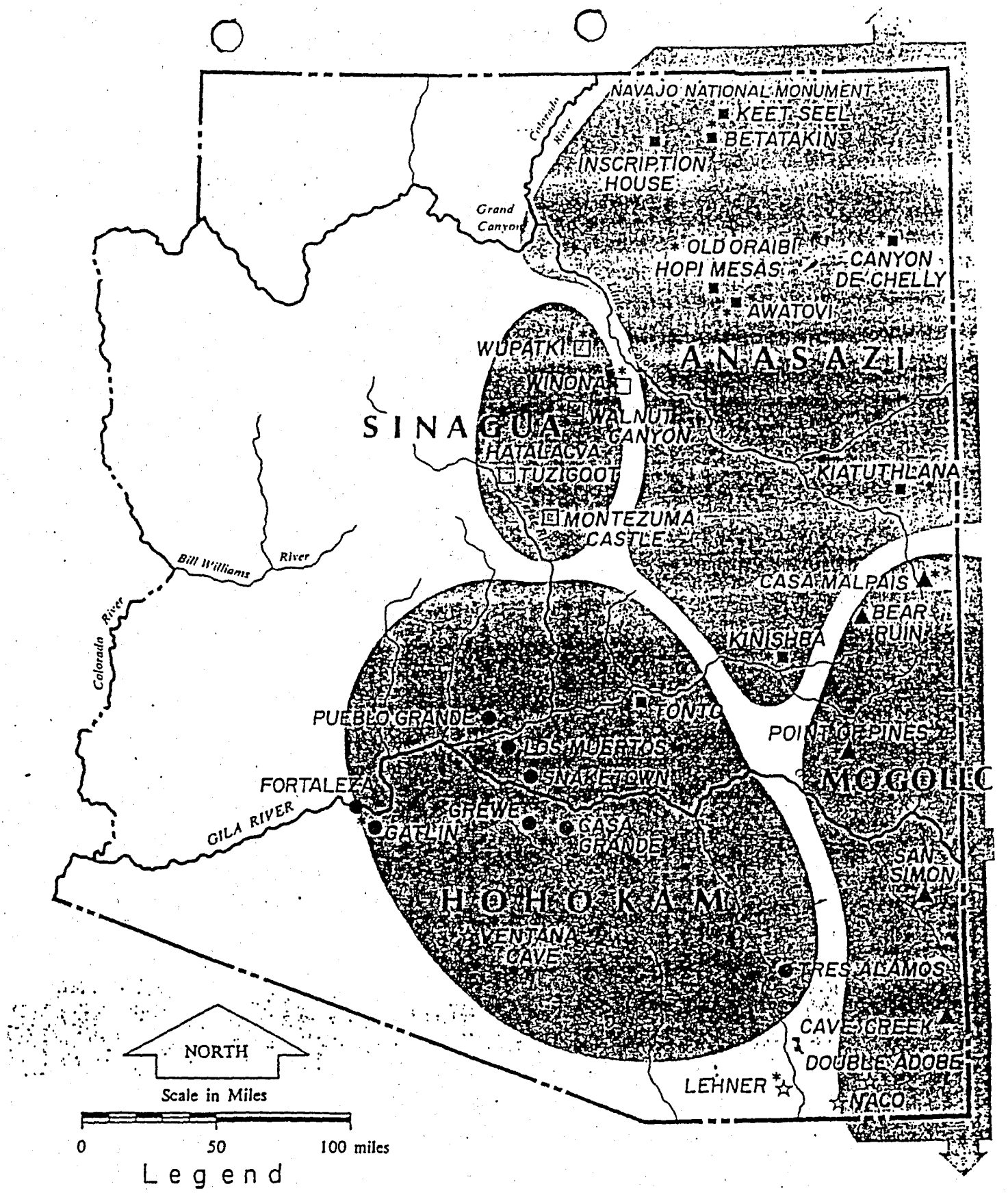

NAVAJO NATIONAL MONUMENT
KEET SEEL
BETATAKIN
INSCRIPTION HOUSE
Grand Canyon
Colorado River
OLD ORAIBI
HOPI MESAS
CANYON DE CHELLY
AWATOVI
WUPATKI
WINONA
ANASAZI
SINAGUA
WALNUT CANYON
HATALACVA
TUZIGOOT
KIATUTHLANA
MONTEZUMA CASTLE
Bill Williams River
Colorado River
CASA MALPAIS
BEAR RUIN
KINISHBA
PUEBLO GRANDE
TONTO
POINTE PINES
LOS MUERTOS
SNAKETOWN
MOGOLLON
FORTALEZA
GILA RIVER
GREWE
GATLIN
CASA GRANDE
SAN SIMON
HOHOKAM
VENTANA CAVE
TRES ALAMOS
CAVE CREEK
DOUBLE ADOBE
LEHNER
NACO
NORTH
Scale in Miles
0
50
100 miles
Legend
Principal Archaeological Sites
ANASAZI
HOHOKAM
MOGOLLON
SINAGUA
EARLY MAN SITES
PREHISTORIC CIVILIZATION
* SITE LISTED ON THE NATIONAL REGISTER OF HISTORIC PLACES

Fig. 1.4

established what took place in the years between the disappearance of the Hohokam and the discovery of the Pima Indians by Spanish explorers about 1530. The first Spanish explorer who left a moderately accurate record of his travels was Jesuit missionary Father Eusebio Francisco Kino, who had been trained as a mathematician and cartographer (Walker and Bufkin, 1979). The mission period, extending from 1687 to 1781, which colonized northern Sonora and southern Arizona, failed to exert lasting effect upon the Indians of the area.

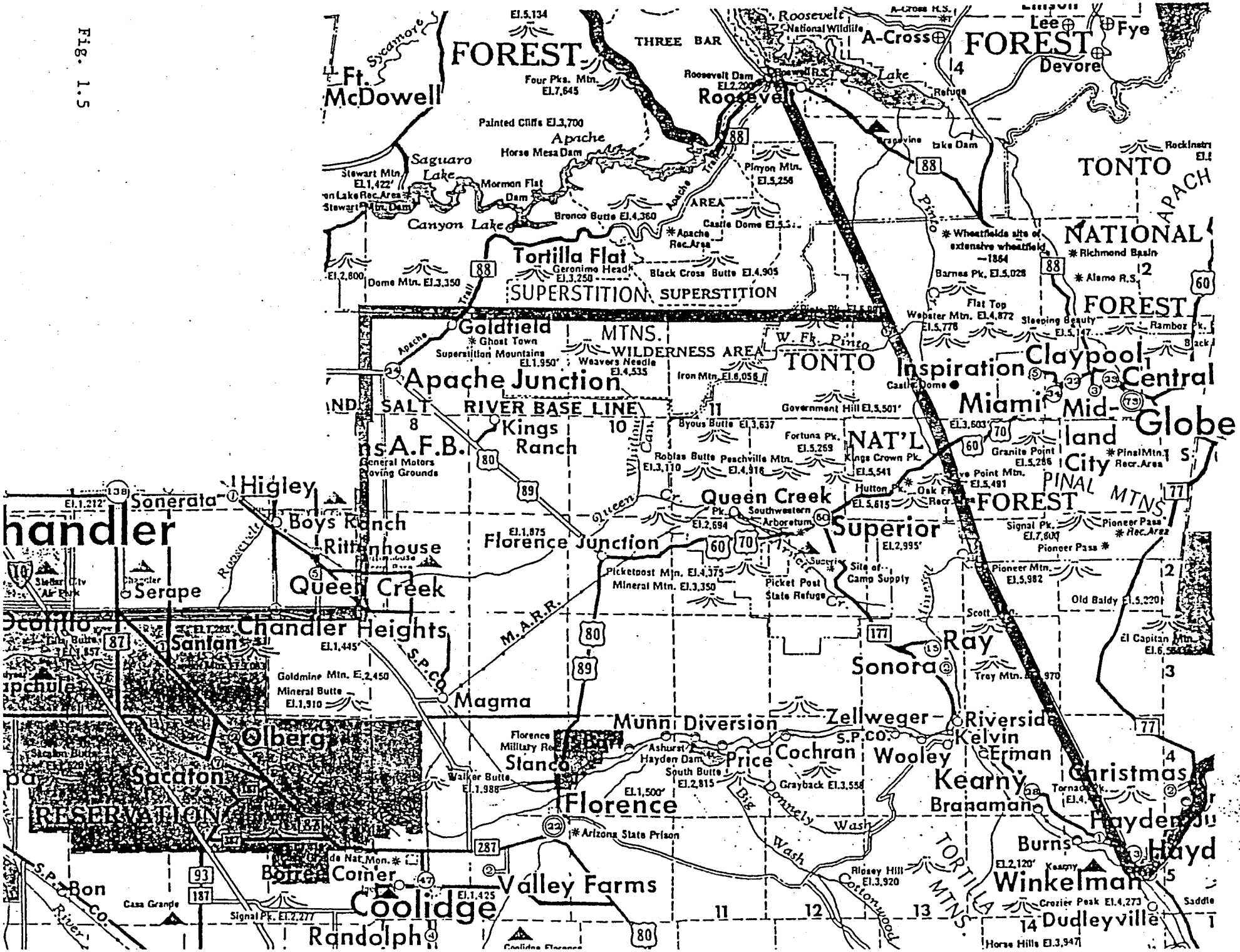
By 1824, American trappers explored along the Gila River. They found the mission communities largely deserted. The Pimas were hospitable and the mountain men enjoyed the tolerance of the Apaches, who were fighting against Spanish and Mexican miners.

In 1846, Col. Stephen Kearney, guided by Kit Carson, led an expedition from Santa Fe to California following the Gila River Route. Kearney had with him Lt. William H. Emory of the Corps of Topographical Engineers, whose map of the route was the first accurate map of the Gila Trail. In a few years the Gila Trail carried thousands of gold seekers.

Discovery in 1875 of Arizona's largest silver mine, the Silver King, first attracted attention to the Superior area. The Magma mine, formerly the Silver Queen, was organized in 1910 by William Boyce Thompson (Pinal Planning and Zoning Commission, 1962). This area has experienced the typical boom-bust economic cycle commonly associated with mining in the West.

Queen Creek today flows through northern Pinal and eastern Maricopa county (fig 1.5). It has been diverted from it's original path to the south, onto the Gila River Indian Reservation, just west of the San Tan Mountains. This lower area is irrigated and is used to grow row crops, hay crops, citrus, grape, and

Fig. 1.5


FOREST
THREE BAR
Roosevelt
National Wildlife
A-Cross
Lee
Fye
Devore
Ft. McDowell
Sycamore
Four Pks. Mtn. El.7,645
Roosevelt Dam
Roosevelt
Lake
Painted Cliffs El.3,700
Apache
Horse Mesa Dam
Saguaro Lake
Stewart Mtn. El.1,422'
Mormon Flat Dam
Canyon Lake
Bronco Butte El.4,360
Apache Trail
Pinyon Mtn. El.5,256
AREA
Castle Dome El.5,
Apache Rec.Area
Tortilla Flat
Geronimo Head El.3,250
Black Cross Butte El.4,905
Dome Mtn. El.3,350
SUPERSTITION
SUPERSTITION
MTNS.
WILDERNESS AREA
Goldfield
Ghost Town
Superstition Mountains
Weavers Needle El.4,535
Iron Mtn. El.6,056
Apache Junction
SALT
RIVER BASE LINE
Kings Ranch
General Motors Proving Grounds
Higley
Sonerata
Boys Ranch
Rittenhouse
Queen Creek
Serape
Chandler Heights
Santan
Goldmine Mtn. El.2,450
Mineral Butte El.1,910
Magma
Olberg
Sacaton
RESERVATION
Florence Junction
Picketpost Mtn. El.4,375
Mineral Mtn. El.3,350
Picket Post State Refuge
Queen Creek
Southwestern Arboretum
Superior
Site of Camp Supply
Inspiration
Castle Dome
Miami
Claypool
Central
Mid-land City
Globe
Government Hill El.5,501'
Byous Butte El.3,637
Roblas Butte El.3,110
Peachville Mtn. El.4,916
Fortuna Pk. El.5,269
Kings Crown Pk. El.5,541
Hutton Pk. El.5,615
Oak Flat Rec. Area
Five Point Mtn. El.5,491
Granite Point El.5,286
Pinal Mtn. Rec. Area
PINAL MTNS
Signal Pk. El.7,807
Pioneer Pass
Pioneer Mtn. El.5,982
Old Baldy El.5,220
El Capitan Mtn.
Ray
Sonora
Munn Diversion
Zellweger
Riverside
Kelvin
Erman
Wooley
Cochran
Price
Hayden Dam
South Butte El.2,815
Grayback El.3,558
Kearny
Branaman
Christmas
Hayden
Florence
Arizona State Prison
Stanco
Walker Butte El.1,988
Big Wash
Donnelly Wash
Cottonwood
Burns
Winkelman
Dudleyville
Rosey Hill El.3,920
Crozier Peak El.4,273
Horse Hills El.3,947
Valley Farms
Coolidge
Randolph
Bon
Casa Grande
Signal Pk. El.2,277
Borrego Corner
Coolidge Florence
Chandler
Scottsdale
Tonto
National
Forest
Wheatfields site of extensive wheatfield —1864
Richmond Basin
Alamo R.S.
Barnes Pk. El.5,028
Flat Top
Webster Mtn. El.4,872
Sleeping Beauty
Ramboz Pk.
Black Pk.
Pinto
W. Fk. Pinto
Queen Cr.
Roosevelt
Apache Junction
Superior
Florence
Coolidge
Winkelman
Dudleyville
Kearny
Hayden
Christmas
Ray
Sonora
Riverside
Kelvin
Erman
Wooley
Cochran
Price
Munn Diversion
Zellweger
Florence
Stanco
Magma
Olberg
Sacaton
Chandler Heights
Queen Creek
Florence Junction
Superior
Inspiration
Claypool
Miami
Globe
Mid-land City

most importantly cotton. Some mining of copper and perlite in the upper reaches is still going on, while sand and gravel is excavated in the alluvial sections after it leaves the mountains. This lower section is under increasing urban pressure as the greater Phoenix metropolitan area searches for new lands to develop housing, commercial, and recreational opportunities.

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CHAPTER 3

SUPERIOR

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INTRODUCTION

The first stop along is in the town of Superior where Queen Creek emerges from its canyon before passing through the town and continuing west. Queen Creek originates in the Superstition Mountains east of Phoenix at an elevation of 1430 m. The stream channel runs south to U.S. Route 60 then shifts to a more westerly direction toward Superior where it continues west parallel to the highway. Flow in this upper region of the creek is ephemeral; water is usually only present during and soon after a flood.

This chapter outlines the history of the town of Superior, the major geological features of the upper Queen Creek basin, and discusses the channel geomorphology of the creek as it enters town.

HISTORY OF SUPERIOR

As with much of the west in general, and Arizona in particular, the history of Superior is a story of prospecting and mining. Before the establishment of a town at the site of

Superior, the first non-Indians in this area were soldiers who established a military post to keep a lookout for Apaches and to provide protection for travellers passing between Globe and Pinal Camp on a road known as Stoneman Grade (which evolved into present-day Route 60). In 1871 a soldier named Sullivan first discovered a heavy black rock later identified as silver ore near Stoneman Grade. Sullivan later disappeared without revealing the exact location of his discovery, so four years passed before these silver deposits were rediscovered. While searching for a lost mule four men located the exposed silver deposits near Queen Creek and five days later, Charles Mason located the Irene Mine and Hub lode claims and organized the Silver Queen Mine. By 1880 there were at least four milling operations which proccessed materials from Silver Queen as well as the Gem and Hastings group gold mines. The townsite was at this time known as Hastings, after the San Francisco clothing merchant who owned the Hastings 20-stamp pan amalgamation mill. However, despite the promising start, these mills shut down in 1882 as nearly all the prospectors were drawn to the nearby town of Pinal and what was considered one of the richest silver claims ever in the Silver King mine. Despite early optimism, Silver King's glory was short-lived. Silver prices dropped precipitously when the Sherman Silver Purchase Act, which had sought to stabilize the economy through the issuance of silver coins and notes, was repealed in an effort spearheaded by eastern United States interests who feared the rapid economic ascendancy of western states. Many

miners left Silver King, and some returned to the Superior area where mining efforts had been expanded beyond the pursuit of silver and gold; discovery of rich copper deposits insulateded Superior from the economic disaster that befell Silver King. One such individual moving to this area was George Lobb, who, in 1897 along with a few others took over the Gem and Hastings claims, renamed them the Golden Eagle group, and got a lease from the Silver Queen Mining Company. The following year Lobb leased and bonded his Golden Eagle claim to the Lake Superior and Arizona Mining Company, which he and his co-workers later purchased. Lobb established the first post office, layed out streets, and changed the town's name to Superior after the mining company. Later, when writing about Superior during its early days, Lobb wrote:

> "In 1902 the country was still beautiful near Queen Creek down to Pinal and beyond, with large trees, running water all the year round, grass, clover, Indian wheat, and more (Garrido 1982)."

However, the growing success of the mining in Superior required local processing of the ores which could no longer be done at Silver King, so wood boilers were built to provide steam power. As a result, by 1906 most of the trees in the area had been removed, including much of the riparian vegetation along Queen Creek from Superior to Pinal. Differences in extent of riparian vegetation between 1920 and the present are clearly seen in figure 2.

Mining remained a lucrative business through the first

decade of the twentieth century, and likewise the town of Superior was transformed from a small tent town (fig. 3) to a more prosperous and permanent settlement. In 1910 a group of investors headed by Col. W. Boyce Thompson acquired the Queen Copper Mine (formerly Silver Queen) for $130,000 and reorganized it as the Magma Copper Mining Company in May of that year. Subsequently the history of the town has largely been dictated by the economic success of the Magma Copper company. Mining efforts were progressively expanded and modernized, but ultimately Superior met the same fate as most Arizona minining towns. The first talks of mine closure began in the mid 1960's when copper prices began to drop and the town's economy swooned after an eight-month miner's strike. The town's economy was given its first real blow in 1972 when Magma's antiquated smelter was abandoned and materials were sent to a newer more cost-effective facility in San Manuel for processing (Garrido 1982). However, a recovery period followed and in September 1976 the town became officially incorporated with a population of 5600 (Arizona Dept. of Commerce Report 1976). After a long period of financial loss, Magma Copper Company put the mine on standby status and laid off 1250 employees in August, 1982. Water continued to be pumped from the mines and the ventilation system remained in operation until February 1986 when Magma permanently closed down the mine when depressed copper prices failed to recover. Only twenty nine employees were kept on (Walenga 1986). The mine closing has had a major effect on the town, and subsequent to the 1982 layoff, many

local businesses closed down and the town's population dropped from approximately 5000 to its present 4300 (Arizona Department of Commerce Report 1987). Currently, the town is trying to improve its trade and service sectors in an effort to attract out-of-town tourist dollars although it is as yet unclear if Superior can survive economically without the mining industry.

REGIONAL GEOLOGY

Upstream of Superior, Queen Creek traverses through a first wide then considerably narrower canyon which cuts through the Superstition-Superior volcanic field. The highly visible rock type in the upper watershed is Apache Leap tuff, as is represented by Apache Leap itself, the impressive west-facing cliff just 2 km east of town, along with the eroded columnar deposits of welded tuff in the Queen Creek canyon. This tuff originated from volcanic eruptions during the Miocene. A series of three eruptions occurred within a relatively short interval permitting the formation of a single cooling unit to make up Apache Leap, which has a mean rock thickness of 150 m and a maximum thickness of 600 m (Suneson 1976). Underlying this volcanic rock are older sedimentary rocks predominated by the Whitetail conglomerate. The town of Superior sits on the edge of these volcanic deposits and both tuff and earlier sedimentary formations are evident. But while above ground geology appears to be dominated by tertiary volcanism and earlier sedimentation processes, subsurface geological characteristics have been

strongly influenced by the Laramide orogeny, an uplifting event which occurred throughout the state, but had its largest effects in the southern part of Arizona during the late Cretaceous (75-80 mya; Nations and Stump 1981). Eruption of intermediate to silicic rocks was followed by an intense compression which caused folding and thrust faulting. This episode was accompanied by fluids which resulted in the mineralization of most of Arizona's copper deposits. In the Superior area, these fluids became localized along folds and faults produced during the orogeny. Further east in the Globe-Miami area, copper ores were deposited in the upper levels of the intrusions and are known as porphyry copper deposits, and due to their closeness to the surface, can be mined by a less expensive strip-mining process rather than the more costly approach of drilling down to copper-rich subterranian seams, as has been done in Superior (Nations and Stump 1981).

CHANNEL GEOMORPHOLOGY

Queen Creek runs through a bedrock channel overlayed with large boulders as the stream emerges from Queen Creek Canyon. Brief stretches of exposed bedrock (Whitetail conglomerate can be seen from the Ray Road bridge) are interspersed between longer stretches in which the bedrock is covered with substrate ranging from a few small patches of sand to extremely large boulders (boulders of 2 - 3 m diameter are not uncommon). Such substrate cover can be seen by walking up the service road on the south

side of the creek. This road follows the canyon for roughly 1 km passing by the remains of an old silver mine on the north bank before turning north toward a gravel pit. (The buildings accompanying this mine which no longer remain are seen in fig. 2) The geomorphology of the channel reflects forces of flash floods and the resistance posed by the underlying bedrock. Over a distance of approximately 3.5 km, the stream drops from its initial elevation of 1430 to 850 m (i.e. a gradient of approximately 170 m km-1). This steep gradient coupled with rapid runoff from summer storm events characteristic of arid land deserts (Fisher 1986) produce high discharge flood events which are able to entrain and transport all but the largest boulders. However, after removal of the smaller particles, channel erosion by such discharges has been relatively slow, and subsequently change in channel shape has also apparently occurred at a slow pace due to the resistance provided by the underlying bedrock. Benches lateral to the stream at the bridge appear to be well established and support vegetation such as Opuntia that suggest that these terraces are not heavily or regularly inundated. The original foundation of the stone building on the north side of the bridge along with some of the accompanying reinforcement walls were built during the 1920's further suggesting that over the last 60 years there has been little lateral movement of the channel. Bedrock channels are typically narrower than those with less cohesive bank material (Leopold et al. 1964) and such channels tend to become narrower and deeper rather than

developing a wide, shallow form due to erosional constraints imposed by the bedrock. As Queen Creek moves west through Superior, the gradient decreases rapidly, and with this decrease in slope, there should be a proportional decrease in stream power (Leopold et al. 1964), which in turn should be reflected by changes in channel form and substrate size.

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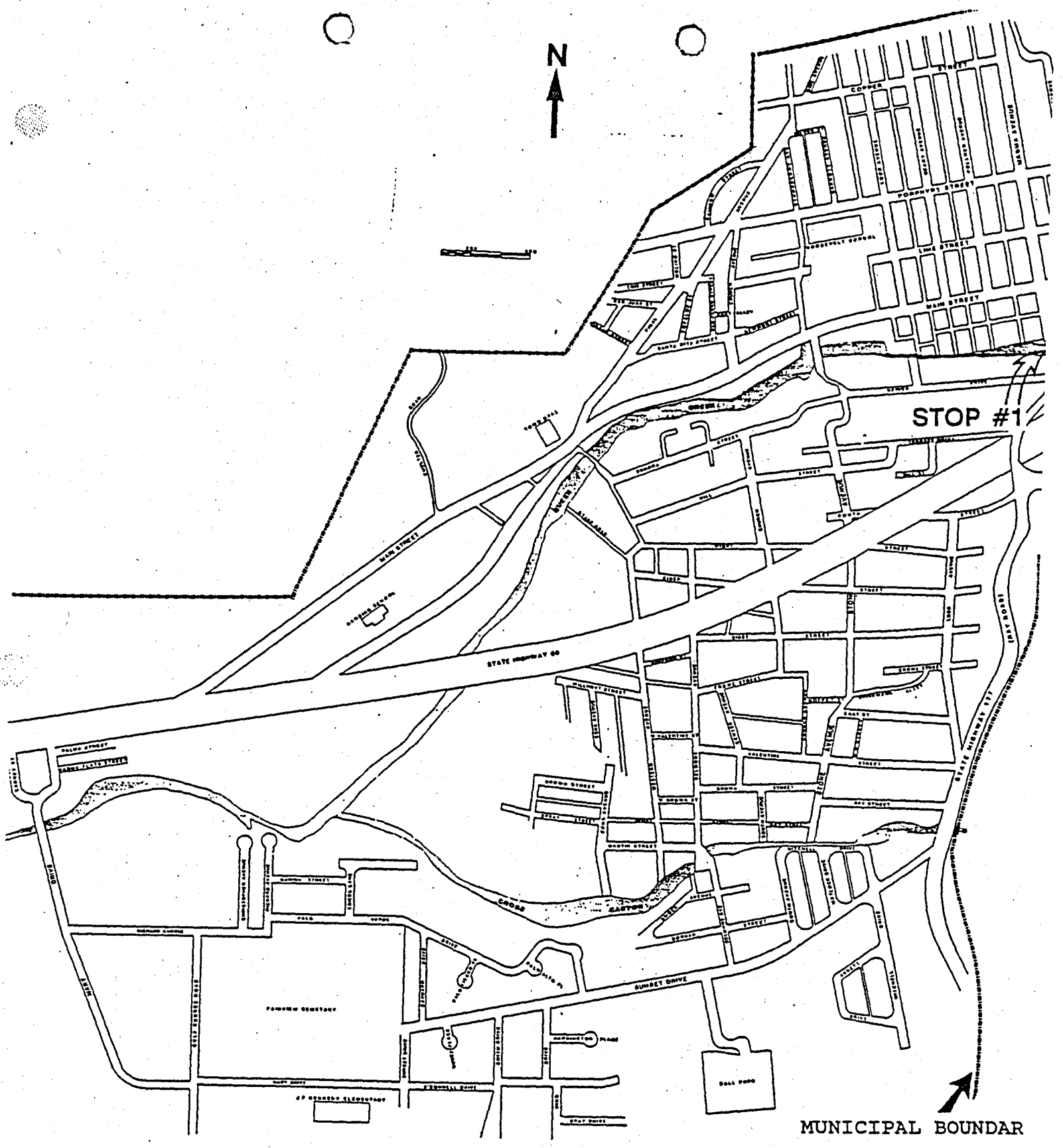

Figure 1. Site map of Superior, Arizona.