Arid West Water Quality Research Project

AQUATIC COMMUNITIES OF EPHEMERAL STREAM ECOSYSTEMS

EXECUTIVE SUMMARY

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The Arid West Water Quality Research Project (AWWQRP or "Project") was established in 1995 as a result of a federal appropriation (Public Law 103-327) and the establishment of an Assistance Agreement between the U.S. Environmental Protection Agency (USEPA) and Pima County Wastewater Management (PCWMD), Tucson, Arizona. The establishment of this Agreement provided a significant opportunity for western water resource stakeholders to (1) work cooperatively to conduct scientific research to recommend appropriate water quality criteria, standards and uses for effluent-dependent and ephemeral waters in the arid and semi-arid regions of the West ("arid West"), and (2) improve the scientific basis for regulating wastewater and stormwater discharges in the arid West. Effluent-dependent waters are created by the discharge of treated effluent into ephemeral streambeds or streams that in the absence of effluent discharge would only flow in response to precipitation.

The current study, *Aquatic Communities of Ephemeral Stream Ecosystems*, examined the aquatic communities found in three arid West watersheds, designated or considered by their respective states as ephemeral[1]. Macroinvertebrate, microinvertebrate, and vertebrate biota were inventoried at numerous sampling sites within each of the three study areas. Sampling sites included tributaries with no upstream source of water; i.e., "ephemeral streams," and ephemeral segments of streams that were intermittent or perennial elsewhere in the watershed, "ephemeral reaches of interrupted streams." The study areas occur in three distinct bioregions, including the high plains of eastern Colorado, the Colorado Plateau of northern New Mexico and the Sonoran Desert of southern Arizona. Sampling occurred in Arizona and New Mexico over an extended part of the receding limb of 2- to 3-year recurrence interval flow events at study areas in both states. In these locations USGS flow gaging stations in the watershed gave an indication of the flow hydrograph at the site. Limited rainfall and lack of streamflow at the Colorado study area precluded sampling a true successional process at that site.

The purpose of this study was to provide data and interpretations that would form the basis for developing an understanding of what biota needs to be protected in ephemeral streams, desert washes, and arroyos of the Southwest. The study organizers suspected at the outset that both the existent animal community and ecological dynamics of these environments were poorly documented, at best, and insufficiently understood from a systems ecology perspective. Hence, developing scientifically valid water quality criteria for an ephemeral aquatic use classification is a challenge.

[1] Only Arizona has a use classification of "ephemeral stream."

The study was organized to provide a first step in developing an improved understanding of ephemeral stream ecology. The objectives of the study were to:

- prepare an aquatic "taxa list" for ephemeral stream communities,
- evaluate flow-duration on succession patterns for aquatic communities of ephemeral streams,
- evaluate applicability of chronic aquatic life criteria to ephemeral streams, and
- evaluate the applicability of chronic toxicity tests to temporary discharges into ephemeral streams.

Before the field sampling, a literature search was conducted to determine communities expected at these three study areas and the best place to establish sampling sites. For the purposes of the study, ephemeral streams were defined as those streams that flow only in direct response to precipitation or snowmelt.

The search revealed that the scientific literature on ephemeral streams is very limited – especially from ephemeral streams in the southwestern U.S. The primary species found in ephemeral waters are highly opportunistic, with good powers of dispersal and are generally aerial colonizers. The duration of flow is extremely important, as well as proximity to permanent waters. Soil conditions are important as they dictate the ability of the watershed to detain runoff and extend the time of flowing water. The phenology (life history strategies) of organisms was important in the opportunistic use of residual pools.

From a more general approach, it was determined that mechanisms most useful for understanding the colonization of ephemeral streams are common to all riverine environments. These would include drift, from either upstream or tributary environments and include both catastrophic and behavioral movements. Aerial sources of individuals, both as aerially dispersing adults and hatched young would be another primary means of colonization. Transport by other animals and man might be important.

Upstream or lateral migration in slow-moving streams or on receding limbs of storm events was determined to be particularly important, both from hydrologically isolated backwaters, disconnected pools, or off-channel ponds that provide opportunity for an extended period of growth and reproduction. Colonization from within sediments seemed possible; however, the ephemeral stream definition, which does not allow for the presence of permanent shallow ground water, seemed to rule out hyporheic organisms. Cryptobiotic life, on the other hand, defined as temporary reduction or cessation of metabolism, growth, and reproduction occurs, is common to ephemeral streams.

Given these assumptions, it was determined that sampling watersheds that included a mix of ephemeral environments would result in the most informative data. The project team looked for watersheds in the three ecoregions that included both small, isolated dry washes and arroyos (ephemeral streams) and larger ephemeral channels with upstream sources of perennial or intermittent water (ephemeral reaches of interrupted streams). This latter physical setting is most similar to the characteristics observed at arid region municipal discharges, where a storm water or effluent stream enters a dry wash that is part of a larger river that may have upstream flow (e.g., Salt River, AZ, Santa Fe River, NM, and other effluent-dependent rivers of the Southwest).

To represent the low desert-Sonoran Desert region, the Santa Cruz River watershed in central Arizona was used, specifically sampling sites upstream of the Rillito River, including one site on Tanque Verde and five sites in the Pantano Wash watershed. In the San Juan Basin, representing high desert ecosystems, sampling sites in the Rio Puerco and Arroyo Chico watersheds were used. For the high plains ecosystems of Colorado, Wyoming and New Mexico, twenty-four sampling sites were examined in the Huefano River watershed; however, because of a lack of precipitation only one site near Walsenburg, Colorado was found to be suitable during the summer storm season.

Sampling occurred between July 29th and August 6th, 2006 at the Arizona study area. Sampling followed three peak discharges of 4,600 to 2,200 cfs with 3.45 and 1.75 years recurrence intervals, as measured at the Pantano Wash USGS stream gaging station. Between August 8th and 14th, 2006 peak discharges at the New Mexico study area were between 1,950 and 2,010 cfs, as recorded by the USGS stream gaging station on the Rio Puerco. These flows had a recurrence interval of 2.3 to 2.45 years. The Colorado study area was sampled at Gordon Arroyo between August 15th and 17th. No stream gaging station was available for that sampling site.

Basic flow and wetted area metrics were taken at each sampling site. Microinvertebrate sampling utilized a standard planktonic tow net. Macroinvertebrates were collected using kick nets, in accord with US EPA Rapid Bioassessment Protocols (Barbour et al. 1999). Vertebrate sampling used seine nets and backpack electrofishing gear. Field QA/QC followed an externally approved work plan. Laboratory identification was to lowest practical taxonomic level, usually class, order and phylum, for microinvertebrates and mostly to genus for aquatic macroinvertebrates.

Among microinvertebrate samples, twenty-one taxa were collected. Most taxa (62%) and most organisms (58%) were likely from terrestrial sources. In many cases, flows transported high sediment loads and active bank erosion was observed – a likely source of terrestrial microorganisms. Truly aquatic microinvertebrates (zooplankton) included Copepoda (40%), Ostracoda (<1%) , and Cladocera (<1%). Nearly all copepods (98%) observed during the study were collected at the Santa Cruz site.

1,658 macroinvertebrate organisms were collected and examined, with 86 taxa collected if terrestrial taxa were excluded. 74 taxa (86%) were insects, with 71 taxa having aerially dispersing life stages. Four fish taxa were collected, including Longfin dace (Ciénega Cr. Only) and fathead minnows (Rio Puerco Watershed). Desiccated specimens of mosquitofish and green sunfish were found in Tanque Verde Wash.

Six amphibian taxa were collected, including tiger salamander, (Gordon Arroyo, Colorado), red-spotted toad and Couch's spadefoot toad (Santa Cruz River and Rio Puerco watersheds) and plains spadefoot toad (Rio Puerco Watershed). An unidentified species of the genus *Bufo* was collected in the Rio Puerco Watershed that probably was a red-spotted toad, and a bullfrog was found at the Santa Cruz River site.

Since most non-crustacean microinvertebrate taxa were probably terrestrial, successional patterns were not strong. However, microcrustaceans were mostly aquatic in origin. Cyclopoid/calanoid copepods were found in the Santa Cruz River. Calanoid copepods did not persist for longer than a day. Cyclopoid copepod densities increased considerably until water dried up. Reproduction presumably occurred while water was present. These organisms probably emerged from, and re-entered to, a cryptobiotic stage as the water disappeared.

Successional patterns were similar for macroinvertebrates in both the ephemeral streams and ephemeral reaches of interrupted streams (upstream source of water). In the ephemeral reaches, 65 of the taxa have aerially dispersing life stages. Others could come from upstream sources, cryptobiotic stages, or transport by other animals. 33 taxa were collected in the first twenty-four hours. Five taxa were collected throughout the entire period of succession: Dryopid beetle (*Postelichus* sp.), midges (Unid. Orthocladiinae), a mayfly (*Callibaetis* sp.), a damselfly (*Coenagrion/Enallagma*) and waterboatmen (Unid. Corixidae).

For the ephemeral streams, 29 of 35 observed taxa have aerially dispersing life stages. It is presumed that others came from cryptobiotic stages or transport by other animals. In this case, four taxa were collected in the first 24 hours and no taxa were collected throughout the entire observed successional period.

Fish were primarily found in ephemeral reaches of interrupted stream, where upstream sources of perennial flow may have been elsewhere in the watershed. Green sunfish and mosquitofish are not native to the Santa Cruz watershed and were found only as desiccated specimens. Longfin dace have a known upstream population in the Ciénega Creek Conservation Area. Fathead minnows are also known to populate upstream reaches of Rio Puerco (near Cuba, NM). Specimens in Cañada Santiago and Arroyo Chico could have swum upstream during receding flows. Similar to the fish, amphibians also did not show a clear successional pattern.

Ephemeral reaches of streams that had upstream sources of water were different from the dry washes, but not greatly different. In these ephemeral waters, 65 of 77 macroinvertebrate

species were aerially dispersing. Five taxa were collected throughout the successional period: Dryopid beetle (*Postelichus* sp.), midges (Unid. Orthocladiinae), a mayfly (*Callibaetis* sp.), a damselfly (*Coenagrion/Enallagma*), and waterboatmen (Unid. Corixidae)

The data were analyzed for regional similarities. Only two taxa were collected at all three study sites: Hydrophilid beetle, *Berosus* sp., and the brine fly family Ephydridae. 25 taxa were collected in both the Santa Cruz River and Rio Puerco watersheds. Nearly all taxa are widespread geographically. Cluster analysis was used to further investigate data trends. Overall, the sampling sites were not very similar, either between study areas or within them. Differences between study areas might reflect the differences in terrestrial biogeography, which is the basis for the distinction of the EPA ecoregions (Omernick and Bailey 1997). The differences between local sampling sites seem to reflect the random pattern of colonization seen in the successional data.

Flow duration varied strongly between the Arizona and New Mexico study areas. Although the Tucson streams diminished to zero discharge in a matter of days to hours, the Rio Puerco streams were still flowing at about a quarter of their flood stage discharge seven days later. This resulted in a larger aquatic habitat over a longer time for the New Mexico system. Strong differences in the soil water retention between the contributing watersheds, for example, clay soils in the New Mexico study area (Craigg and Stone 1983) versus sandy soils in the Arizona study area (Davidson 1973), probably was the determining factor.

With the exception of cyclopoid copepods in Santa Cruz River, microinvertebrates did not vary much between the two study areas. However, macroinvertebrate numbers did tend to diminish as habitat area decreased. Fish and amphibians were not abundant enough to interpret flow duration effects.

There are several implications of this investigation to water quality criteria science. There was no evidence that planktonic microinvertibrate were important members of the ephemeral stream communities and could be considered for removal from consideration when calculating a water quality criterion. Copepoda, on the other hand, should be retained. The aquatic macroinvertebrates seem to be similar to taxa observed in effluent-dependent streams, with the exception of Isopoda and most Amphipoda. It appears benthic crustaceans could also be considered non-residents in ephemeral streams.

Important fish in effluent-dominated or dependent streams are Centrarchidae (sunfish and bass) and were suggested in past studies (AWWQRP 2006) as a replacement for Salmonidae in criteria development. However, this family does not appear to be resident in ephemeral streams and are unable to tolerate the widely varying flows (and lack of flows). In fact, the study demonstrated that fish are rarely found in ephemeral streams, even at flood stage. Cyprinids (minnows) may be the only “resident” fish, but their limited presence (13 fish collected in 12,660 m² seined or electrofished) puts their residency in question. Of the

amphibians, tadpoles were the most important vertebrate group observed in the sampled ephemeral ecosystems and more toxicity data needs to be developed to determine appropriate levels of protection for amphibians.

Clearly, the resident taxa list for ephemeral streams, as developed from this study, differs from the national database. The resident taxa list even differs from the effluent-dominated/dependent stream database (AWWQRP 2006) developed to date. This finding suggests that standards for ephemeral streams would probably be substantially different from national, state, and even site-specific standards for sites with perennial flow. The predominance of terrestrial, aerially dispersive insects in these populations points out that species lists for ephemeral streams need to be reflective of the watershed they drain.

The need for further investigation, over multiple seasons and perhaps a wider geographical area, is indicated by the results of this study. The suggestion of an ecoregional distinction among populations suggests using additional study areas in, perhaps, the Great Basin, Chihuahuan, or Mohave deserts. If long-term study areas and sampling sites are envisioned, more extensive study of the watershed should be undertaken, with specific characterization of watershed complexity, soil and geological character, and hydrology. Life cycle study of resident species should be initiated, including the fate of cryptobiotic species and native fish. Moreover, more toxicity data is needed on species observed in ephemeral streams, particularly data connected to life cycle timing and duration of exposure.