

August 1, 2006

Senator Lincoln Chafee, Chairman
Subcommittee on Fisheries, Wildlife and Water
Senate Committee on Environment and Public Works

Senator Hillary Rodham Clinton, Ranking Member
Subcommittee on Fisheries, Wildlife and Water
Senate Committee on Environment and Public Works

Dear Senators Chafee and Clinton,

We are submitting this letter for the record of your hearing on August 1, 2006 regarding the scope of the Clean Water Act following the recent Supreme Court ruling in the *Rapanos* and *Carabell* cases. Although the specific question at issue in these cases was the relationship of upstream wetlands to downstream waters, the opinion also addressed tributary streams that are not traditionally considered “navigable in fact waters.” Because there is no scientific distinction between navigable and non-navigable waters, we wanted to take this opportunity to reiterate the critical role of small, headwater tributaries to the chemical, physical and biological integrity of downstream waters.

The undersigned are professional aquatic scientists from an array of institutions with broad knowledge and expertise in stream ecosystems including their physical structure, chemistry, and biology. The scientists who have signed this letter include members of the National Academy of Sciences and its scientific Boards, individuals who have been or who are President of national scientific organizations, and leading researchers on the ecology, water quality, and biota of streams and rivers.

Headwater streams provide essential goods and services; their elimination from Clean Water Act jurisdiction would have an adverse impact on downstream ecosystems. Rivers are networks, and their downstream navigable portions are inextricably linked to small headwaters just as fine roots are an essential part of the root structure of a tree or our own circulatory system is dependent on the function of healthy capillaries. The small ephemeral or intermittent stream is not isolated from the mighty river. Small tributary streams have a significant nexus with downstream waters as polluting and filling these headwaters directly affects the integrity of larger streams and rivers.

Scientific research on rivers and streams over the past several decades has been founded on the concept of the longitudinal connectivity of river networks, i.e. that ecological processes in large rivers reflect what is occurring in their headwaters as well as in adjacent floodplains, tributaries, and even downstream ecosystems (e.g. Hynes 1975, Vannote et al. 1980, Minshall et al. 1985, Junk et al. 1989, Ward 1989, Pringle 1997, Fausch et al. 2002). **Considering navigable rivers to be isolated from their ephemeral and intermittent headwaters stands in direct contradiction to long standing and robust scientific evidence**

In the following five points, we discuss the scientific basis for the statement that removing ephemeral, intermittent and other small headwater streams from Clean Water Act jurisdiction will adversely impact our Nation's waters and make it less likely that we can achieve the goal of the Clean Water Act, which is "to restore and maintain the chemical, physical and biological integrity of the Nation's waters."

1. A large fraction of the channels in a stream network do not flow year round. Because of limitations of current databases, the total length of small streams is seriously underestimated in the U.S.

Calculations of intermittent and ephemeral streams underestimate the actual length of channel impacted because small streams are not adequately captured in our national hydrography databases. These databases are derived from maps drawn at a scale of 1:100,000 (<http://nhd.usgs.gov>). Even maps drawn to a scale of 1:24,000 underestimate the true extent of small streams. For example, 1:24,000 scale maps identify only 21% of the stream channel length in the 728 km² Chattooga River basin in North Carolina (Hansen 2001) and 49% of the stream channels supporting salamanders in a Georgia watershed (M. Elliott, University of Georgia, personal communication). This shortcoming of nationwide databases was recognized in a recent report on the state of the Nation's ecosystems, which noted that data on miles of small streams were not available for the nation (Heinz Center 2002). Even the streams indicated on topographic maps do not represent the true extent of streams in the landscape. Headwater streams shown on a map meet no clearly defined statistical characteristic of the extent of streamflow (Leopold 1994). The terms ephemeral, intermittent and perennial apply to a continuum of flow persistence. Intermittent streams can flow year round in very wet years. In river networks with glacial and alluvial sediments, streams without visible surface flow often remain flowing within their bed throughout the year, continuing geochemical processes and supporting a diverse array of often unique biota. Aquatic insect assemblages and salamander larvae requiring 9 - 18 months of flow can be found in many channels represented as intermittent streams on a topographic map (Meyer and Wallace 2001).

Available estimates show that a sizable fraction of channel length in a river network is in ephemeral, intermittent and headwaters streams, even though these represent underestimates of the true extent of these ecosystems. In arid states such as Arizona, 96% of stream miles have been classified as ephemeral or intermittent (Chapter 2, Table 3 in <http://www.adeq.state.az.us/enviro/water/assess/305/index.html>). In one Arizona county where more extensive mapping has been done, 99% of stream miles have been classed as ephemeral or intermittent (J. Fonseca, Pima County Flood Control District, Tucson AZ, personal communication). Analysis of a 1:24,000 USGS digital line graph coverage of Utah's streams shows that 89% of the state's stream length is in intermittent and ephemeral channels (R. Hilderbrand, U. of Maryland, personal communication). Estimates based on 1:100,000 maps for Colorado classify 71% of stream miles as intermittent (L. Poff, Colorado State University, personal communication). Existing databases for Kansas list as intermittent 82% of stream miles in the state (Chou et al.

1999). In the arid and semi-arid West, even large rivers such as the Rio Grande do not flow continuously.

Intermittent streams are also significant in states that receive more rainfall. In Hawaii, headwater streams may flow continuously, but their lower reaches are intermittent and serve as barriers to invasion of exotic species; these have been called "interrupted streams" (Polhemus et al. 1992). In Alabama, 80% of stream miles in the National Forests are considered intermittent because they go dry during late summer or autumn, particularly during drought years (S. Chubb, U.S. Forest Service, personal communication). In western Kentucky, 75% of the second order streams flow only in February through May, but all have a resident community of chironomids and capniid stoneflies (D. White, Murray State University, personal communication). Intermittent streams in Michigan comprise 48% of the length of stream channels in the state (R. Cifaldi and J.D. Allan, University of Michigan, personal communication).

These examples illustrate the extent of intermittent channels in river networks throughout the Nation. Eliminating this large a fraction of stream networks from the protections offered by the Clean Water Act will profoundly alter the physical, chemical and biotic integrity of that network. Protection of the public good provided by our surface water resources requires protection of all elements of the river network including ephemeral, intermittent, and headwater streams.

2. Human activities in the watershed have resulted in significant loss of small streams.

Groundwater withdrawal for irrigation or other human uses and interception of recharge by impervious surfaces has resulted in significant lowering of the water table, which affects headwater streams by making perennial streams intermittent (Postel 1999). Channels without water can extend far downstream; for example, a channel of the Santa Cruz River near Tucson, Arizona, was dry for several decades because of groundwater pumping (Grimm et al. 1997), and water withdrawals from riverine aquifers have dewatered reaches of the Arkansas River (Ferrington 1993). Reaches of the Rio Grande no longer have water because of water withdrawal for human uses. As more of the landscape is covered with impervious surface, groundwater recharge is reduced, leading to lower baseflows which can lead to intermittent flow (Paul and Meyer 2001). In contrast, some intermittent streams have become perennial because of the continuous addition of effluent from municipal wastewater treatment plants (Paul and Meyer 2001).

The length of headwater streams in the landscape has been significantly reduced because of piping and filling activities done in the name of agriculture, mining, and development. For example, suburban development around Rock Creek in Maryland reduced the drainage density (m stream channel / m² watershed area) by 58% (Leopold 1994); drainage density of urban and suburban watersheds in the Chattahoochee River basin near Atlanta is one third less than drainage density in watersheds in this basin that are covered in forest and pasture (Meyer and Wallace 2001). At least 1450 km of streams were eliminated in the Southern Appalachians from 1986 - 1998 because of mountaintop

removal valley-fill coal mining practices (U.S. Fish and Wildlife Service 1998). Untold miles of streams in the midwestern U.S. have been converted into drainage ditches that route water quickly out of the watershed. Because of their simplified channel structure, they no longer provide the ecological services of unchannelized headwater streams (Brookes 1994). Recognizing the value of headwater systems and their vulnerability to human disturbance, an international group of scientists meets regularly to present recent research and to design more protective management practices (e.g. Haigh et al. 1998). The loss of headwater streams has profoundly altered the structure and function of stream networks (Meyer and Wallace 2001). Elimination of small tributaries from Clean Water Act jurisdiction would lead to further loss and degradation of these systems to the detriment of the physical, chemical and biotic integrity of ecosystems downstream.

3. Ephemeral, intermittent and small headwater streams contribute to the physical integrity of the river network.

Small streams provide hydrologic retention capacity (i.e., the ability to hold and store water). Their contribution is apparent because when these small streams have been eliminated as a result of human activity, frequency and intensity of flooding increases downstream, and base flows are lower (e.g., Dunne and Leopold 1978). The increased frequency and intensity of flooding associated with replacement of small streams with impervious surfaces increases bank erosion, channel widening and incision, and other changes in channel form (Arnold et al. 1982). In San Diego, California, extensive channel erosion contributed two-thirds of the in-stream sediment load and resulted in loss of valuable urban land (Trimble 1997). An increase in flood frequency and magnitude negatively impacts the stream biota, particularly when this is combined with increasing sediment transport (e.g., Waters 1995). The loss of hydrologic retention provided by small streams in agricultural catchments has resulted in increased transport of excess nutrients to downstream ecosystems (Steinman and Rosen 2000).

Small streams also contribute to the physical integrity of downstream ecosystems by retaining sediments. Sediment eroded from hillslopes during storms is stored in these small channels and released over a longer period of time to downstream ecosystems. If sediment retention is reduced in headwater channels, downstream sediment transport during storms will increase. Sediment accumulation in larger streams and rivers can affect fish feeding and spawning, aquatic insect communities, and overall stream productivity (Lemly 1982, Newcombe and McDonald 1991, Lenat and Crawford 1994, Waters 1995, Newcombe and Jensen 1996).

Organic debris dams are a prominent feature of headwater streams (e.g., Bilby and Likens 1980). They provide sediment retention, important habitat structure, and sites for critical metabolic activity (e.g., Steinhart et al. 2000). These functions are eliminated when headwaters are channelized, piped, or filled, which is more likely to occur if headwaters are removed from Clean Water Act jurisdiction.

Evidence for the importance of headwater streams in maintaining the physical integrity of downstream ecosystems can be seen by observing the consequences of their loss from the

network. Filling of stream valleys by mountaintop removal valley-fill coal mining has resulted in a greater proportion of fine particles in stream sediments and an altered flow and temperature regime downstream of the filled valleys (Wiley et al. 2001). Substrate particle size, water temperature, and flow regime are physical parameters with significant impact on the biota of a stream (Allan 1995). The value of the thermal refuge provided by very small streams is detailed under point 5 (below).

4. Ephemeral, intermittent and headwater tributaries are essential to the maintenance of the chemical integrity of navigable rivers.

The basic chemical composition of unpolluted streams draining a landscape is largely established in headwater streams (Gibbs 1970, Likens 1999, Johnson et al. 2000). These are the channels of the drainage network in closest contact with the soil and are the sites of extensive chemical and biological activity that influences water quality downstream.

Recent scientific research has demonstrated that small streams in the network are the sites of the most active uptake, transformation, and retention of nutrients (Alexander et al. 2000, Peterson et al. 2001). These streams are shallow, and water spends a longer time in contact with biologically and chemically reactive substrates in small, shallow channels. Once a chemical element enters a stream, the distance it travels downstream before being removed from the water column increases with increasing discharge as stream size increases (Peterson et al. 2001, Hall et al. 2001); hence destruction of small streams in the network results in increased downstream transport of nutrients. When headwater streams are eliminated, floodwaters are delivered more rapidly, and more of the nutrients being applied to farm fields or lawns are delivered to receiving systems downstream. Downstream waterways such as navigable rivers, lakes, estuaries, and coastal waters, may be sensitive to the resulting high nutrient concentrations with eutrophication as a likely consequence of loss of the nutrient retention capacity afforded by headwater streams. Nuisance algal blooms, deoxygenation of the water column, and fish kills are undesirable features of eutrophication. As an example of the ability of headwater streams to retain nutrients, recent studies have shown that 64% of the inorganic nitrogen entering a stream is retained or transformed in the headwaters (Peterson et al. 2001). Biofilms in small headwater channels are also sites of active uptake of inorganic (e.g., heavy metals) and organic (e.g., PCBs) pollutants (Schorer and Symader 1998). The chemical and biological transformations that occur in headwater streams (e.g., denitrification, microbial uptake, excretion of organic nitrogen) reduce the biological availability of nutrients exported downstream.

Small streams serve as buffers for larger rivers, reducing the amount of non-point source nutrients entering navigable rivers. Nutrients and contaminants enter streams from non-point sources primarily during storms, and it is during storms when ephemeral and intermittent streams are most likely to contain water. Hence the nutrient removal capacity of these small streams is engaged at the time when most nutrients are entering the stream network from non-point sources. Federal, state, and local programs are spending considerable sums of money implementing best management practices to reduce non-point source inputs of nutrients because these are a major threat to water

quality (Wang et al. 2002). Eliminating protection for intermittent and ephemeral streams negates the efforts at non-point source nutrient reduction being done in support of the Clean Water Act.

5. Ephemeral, intermittent and headwater tributaries contribute to the biotic integrity of river networks by supplying food resources to downstream and riparian ecosystems and providing thermal refuges, spawning areas, nursery areas, and critical habitats for unique and economically valuable species (see Figure 1).

a. Small streams supply food resources to riparian and downstream ecosystems.

Headwater streams are sites for physical and biological processing of inputs of organic matter from the watershed such as falling leaves (e.g., Wallace et al. 1997) and a source of energy for downstream reaches (Kaplan et al. 1980, Gomi et al. 2002, Piccolo and Wipfli 2002). The dissolved organic matter and fine particles exported from headwaters are important food resources for ecosystems downstream (Vannote et al. 1980, Piccolo and Wipfli 2002, Wipfli and Gregovich 2002). An example of the significance of this subsidy comes from fishless headwater streams in Alaska, where enough prey and detritus is exported from headwater streams to support 100 - 2000 young-of-the-year salmonids in each kilometer of salmon-bearing streams (Wipfli and Gregovich 2002). Degradation of small streams in the network is likely to result in reduced inputs of food resources for downstream ecosystems.

Invertebrate inhabitants of headwater streams are sources of food to fish, water shrews, and salamanders within the headwater reach. Additionally, emerging aerial adults of aquatic insects are often used as food by terrestrial species such as spiders, birds, and bats; they represent an important reciprocal link between streams and terrestrial biota (Fisher 1991, Gray 1993, Murakami and Nakano 2001, Nakano and Murakami 2001, Sanzone 2001, Sanzone et al. 2003). Fisher (1991) reported that flycatchers used a large portion of the insect biomass emerging from Sycamore Creek, Arizona. Insectivorous birds inhabiting the riparian zone of a prairie stream in Kansas required 57 – 87% of the daily emergence of adult aquatic insects from the adjacent stream (Gray 1993). Insects from intermittent streams may serve as an important food resource for bats (Seidman and Zabel 2001). Reciprocal subsidies between stream and terrestrial habitats are important for maintaining animal assemblages across landscapes (Nakano and Murakami 2001).

b. Small streams provide a thermal refuge at critical life history stages or during critical times of the year.

Small, spring-fed headwater streams can serve as thermal refuges for fishes, providing a refuge from freezing for stream fishes during winter (e.g., Power et al. 1999) and cool refuges for young-of-the-year during summer (e.g., Curry et al. 1997). Small streams serve as a thermal refuge for species that spend most of their lives in larger systems. The Arkansas darter, *Etheostoma cragini*, a federal candidate darter species, uses small first order streams as a summer time refuge from heat and drought in the Ozarks (Radwell 2001). Arkansas darter populations are also found in intermittent streams in Colorado,

where their persistence depends upon deep pools fed by cool groundwater and temporarily isolated from other pools by dry stream channel (Labbe and Fausch 2000). Brook trout (*Salvelinus fontinalis*) in the Ford River in Michigan retreat to cooler headwaters in summer (Hayes et al. 1998). Young-of-the-year brook trout that were spawned in a Wisconsin lake also migrated into small, groundwater-fed inlet streams and spent the summer there, where stream temperatures, sustained by groundwater, were consistently cooler than in the littoral zone of the lake during summer (Curry et al. 1997). Groundwater is often warmer than stream water during winter, so small spring-fed streams provide a refuge from freezing for stream fishes (Power et al. 1999). Given the climatic extremes of continental North America, access to thermal refuges such as those provided by small spring-fed streams is an important aspect of survival for stream fishes (Power et al. 1999).

c. Small streams serve as vital spawning habitats.

Small headwater streams provide essential breeding habitat for numerous species, many of which live in larger streams during most of the year. The trispot darter (*Etheostoma trisella*) spends most months in large perennial streams, but it moves upstream to spawn and attaches its eggs to submerged blades of grass in tiny rivulets that flow from ephemeral ponds in fields (Ryon 1986). The slackwater darter (*Etheostoma boschungii*) breeds in tiny streams, many of which are now small ditches flowing through pastures (Mettee et al. 1996). Trout production in a California stream was dependent on intermittent streams: over a 4 year period, 39 – 47% of all rainbow trout recruits in Sagehen Creek, California, came from an intermittent tributary that flowed only 4 months each year (Erman and Hawthorne 1976). Migratory cyprinid fishes were found spawning in intermittent tributaries of the Sacramento River (<http://www.ecst.csuchico.edu/~loggins/cyprin.html>). Recent research in West Virginia has demonstrated that, although adult brook trout were found in streams throughout the watershed, over 80% of brook trout reproduction occurred in headwater streams and intermittent seeps (Lamothe 2002). Degradation of those habitats would impact the viability of the brook trout population in the entire watershed.

d. Small streams serve as nursery habitat for juvenile fishes.

Intermittent streams provide rearing habitat for juvenile chinook salmon (Murray and Rosenau 1989, Richards et al. 1992, Scrivener et al. 1994). Juvenile coho salmon and steelhead also use intermittent streams as winter refugia (Peterson and Reid 1984). Small headwater streams serve as vital nursery areas for brook trout in a Michigan stream; the scientists conducting this study recognized “the importance of headwater streams as fish habitat and the need to maintain the integrity of these systems as a connector between the mainstem and their watersheds” (Hayes et al. 1998, p.184).

e. Small streams provide critical habitat for unique and threatened species.

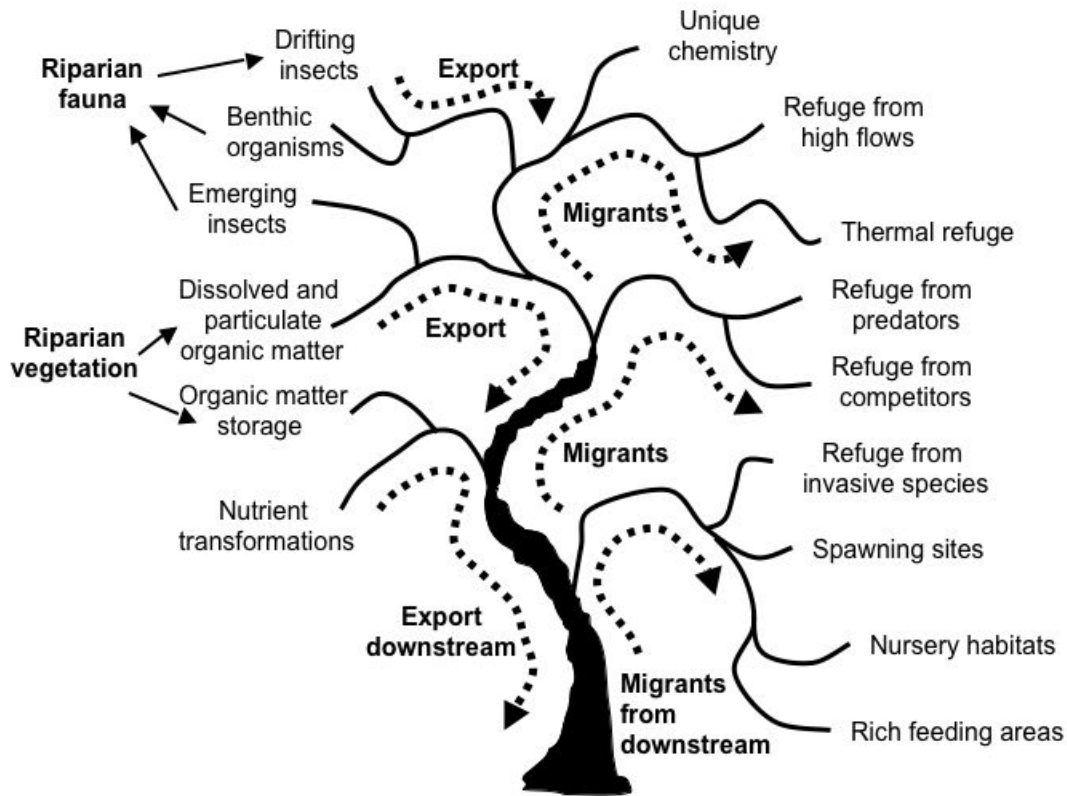
Headwater streams provide unique habitats for numerous species. Their degradation and elimination from the network increases extinction vulnerability for aquatic invertebrate,

amphibian, and fish species (e.g., Morse et al. 1993, Meyer and Wallace 2001). Ephemeral and intermittent streams can support a diverse and sometimes unique community of aquatic organisms. For example, in western Oregon, the number of invertebrate taxa in intermittent streams exceeded that of permanent headwaters, and several undescribed species were associated with intermittent streams (Dieterich and Anderson 2000). Up to 60% of the taxa in intermittent Kansas streams were species with adaptations for intermittent flow that can be considered specialists for this type of stream (Chou et al. 1999). Candidates for threatened and endangered caddisflies in California are found in small spring streams (Erman and Nagano 1992). The proportion of federally at risk species is often high in headwater streams. For example, in the National Forests of Alabama, 70 of the 113 “at risk” aquatic species are primarily headwater stream or spring residents. These “at risk” taxa include crayfish, mussels, snails, amphibians, and fish (S. Chubb, U. S. Forest Service, Alabama, personal communication). The threatened Louisiana pearlshell mussel, *Margaritifera hembeli*, occurs only in small headwater streams with shallow gravel riffles (Johnson and Brown 2000, Bolden and Brown 2002). Some terrestrial species are also dependent on high quality headwater streams. For example, the Louisiana Waterthrush (*Seiurus motacilla*) shows a strong habitat preference for unpolluted headwater streams (Prosser and Brooks 1998).

In karst regions, small streams contribute to the recharge of subterranean phreatic and cave aquifers that harbor unique species. For example, small streams in the Ozarks enter caves that harbor threatened and endangered species of cave fishes, crayfishes, amphipods and other organisms. The water quality and quantity in these small streams is important to the continued existence of the subterranean fauna (Elliot 2000).

Ephemeral and intermittent streams provide vital habitat for amphibians, many of which are state and/or federally threatened and endangered, such as Chiricahua leopard frog, lowland leopard frog, California red-legged frog, and Arroyo toads. The Pacific tree frog and black salamander rely on intermittent streams during part of their life cycle (Reid and Ziemer 1994). Many amphibian species are most abundant in intermittent streams, perhaps because they offer freedom from predators (Reid and Ziemer 1994). In the Mattole watershed in California, Pacific giant salamander (*Dicamptodon tenebrosus*) and black salamander (*Aneides flavipunctatus*) are more abundant along intermittent streams (Welch et al. in review). A native amphibian of the Mojave Desert, the red-spotted toad (*Bufo punctatus*) is dependent on the ephemeral nature of water in small spring-fed streams (Bradford et al. in press). Over half (16 of 29) amphibian genera in the Southeast have species that live in small streams, seeps, bogs or swamps (Dodd 1997). Many stream salamanders require headwater seeps and small streams in forested habitats to maintain viable populations (Petranka 1998). Plethodontid salamanders are extremely diverse in Appalachia, and their lungless condition appears to be an adaptation for small headwater streams, which are their principal larval habitat, where they spend from a few months to five years (Beachy and Bruce 1992). Riparian ecosystems adjacent to small headwater streams are sensitive to stream degradation, and these ecosystems can be sites of high biodiversity in watersheds; e.g., six amphibian species use them as habitat in Douglas fir forests in western Washington (Wilkins and Peterson 2000).

Figure 1. Factors that contribute to the biological importance of headwater streams in river networks. Attributes on the right benefit species unique to headwaters and also make headwaters essential seasonal habitats for migrants from downstream. On the left are biological contributions of headwater ecosystems to riparian and downstream ecosystems (Meyer, J.L., D.L. Strayer, J.B. Wallace, et al. 2007).



Headwater streams also provide habitat for several endangered fish species in the southeastern U.S. Etnier (1997) identified sixteen fish taxa occurring in first and second order southeastern streams, a quarter of which are jeopardized because of non-point source pollution or extremely limited range. The imperilment of fishes in the western US has been related to the degradation and loss of intermittent streams (Moyle and Nichols 1973, Moyle and Williams 1990). Five native fish species were found using intermittent streams in the Sacramento River basin: Sacramento squawfish (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), speckled dace (*Rhinichthys osculus*) and Sacramento sucker (*Catostomus occidentalis*) (<http://www.ecst.csuchico.edu/~loggins/cyprin.html>).

Just as estimates of the extent of ephemeral, intermittent and small headwater streams in the U.S. are likely underestimates of true extent, so are estimates of headwater species at risk a likely underestimate (Burkhead and Jelks 2000). Estimates of the numbers of threatened and endangered invertebrate species are very conservative because of insufficient knowledge of the fauna, inadequate numbers of practicing taxonomists able

to identify new species, and absence of recent comprehensive surveys (Morse et al. 1997, Burkhead and Jelks 2000, Strayer 2000). It is likely that there are many new species and unrecognized ecological relationships in small streams, especially those tightly linked with groundwater (Strayer 2000). These are the very ecosystems that are threatened by any reduction in Clean Water Act jurisdiction.

In conclusion, ephemeral, intermittent, and small headwater streams are an integral part of a river network; they are not isolated from the larger navigable channels in the network, but rather are significantly interrelated. They provide ecological goods and services of value to society. Although they may not have a direct hydrologic connection to a navigable river during all months of the year, they have a direct impact on the physical, chemical, and biotic integrity of navigable rivers. To summarize the main points of this discussion, which we have supported by over 85 references to the scientific literature, ephemeral, intermittent and small headwater streams:

- are the most extensive but poorest quantified stream types;
- are being profoundly altered by human activities;
- impact the physical integrity of larger rivers because they alter rates of runoff and retain sediments;
- impact downstream chemical integrity by their capacity for nutrient and contaminant uptake, retention and transformation;
- impact biological integrity of the stream network by providing food resources, thermal refuges, spawning sites, nursery areas for juveniles, and habitat for unique biota.

On the basis of decades of scientific research, we conclude that ephemeral, intermittent, and small headwater streams CANNOT be considered isolated or unrelated to the chemical, physical and biological integrity of navigable waterways. If our nation hopes to achieve the goals of the Clean Water Act, ephemeral, intermittent and small headwater streams should remain under its jurisdiction.

Sincerely,

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