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# ASSESSING NONPOINT SOURCES OF TOXICITY PART II: USING BIOMONITORING TECHNIQUES

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*"What happens outside the parks dramatically affects what happens inside them" (Kerwin 1991).*

The message in this article about encroachment on our National Parks by an "array of executioners: builders, commercial developers, recreation lovers, ranchers, miners, and thirsty, smoggy cities" (Kerwin 1991), is a common concern in all fields of resource management. Nowhere is this more obvious than in the field of water quality assessment. The complex problem of protecting water quality that is facing our Nation today is especially felt in our National Parks where the goals are to maintain pristine conditions and the highest standards. As a result, most people visiting parks believe that they have entered an isolated, uncontaminated "biosphere." Unfortunately, this is not the case. What happens to water before it enters parks controls the quality of water within; parks are dependent upon this water regardless of where it comes from or its condition. The most insidious threat is from nonpoint source pollution (i.e. pollution neither enclosed in a pipe or conveyance nor subject to federal or state effluent limitations).

How to confront these nonpoint source issues seems to be the "$64,000 question." The scientific complexity of the watershed, surface and subsurface geology and the sociopolitical complexity of land use surrounding parks make the protection of water quality a formidable task. It is even more difficult to address the interaction of individual pollutants with the physical characteristics (i.e., pH, dissolved oxygen) of natural waters. In an effort to address these complex concerns, we have developed and initiated various pilot biomonitoring (see previous article in *Park Science*) programs in five National Parks, each with differing nonpoint source water quality problems (Table 1).

Table 1. Locations where nonpoint, biomonitoring, pilot programs were conducted.

| | |
|---|---|
| **I. ST. CROIX NATIONAL SCENIC RIVERWAY (SACN)** | |
| **SITE:** | The Namekagon River, a tributary to the St. Croix River, Hayward, Wisconsin. |
| **ISSUE:** | Nonpoint sources from extensive commercial cranberry marshes. |
| **QUESTION:** | Are pesticides and/or nutrients entering the Namekagon River? |
| **II. RICHMOND NATIONAL BATTLEFIELD PARK (RICH)** | |
| **SITE:** | The Fort Darling Unit near Richmond, Virginia. |
| **ISSUE:** | Nonpoint source from a landfill contained within the park. |
| **QUESTION:** | Are leachates from the landfill, which have severely discolored the sediments of an unnamed creek within the park, toxic to aquatic species? |
| **III. EVERGLADES NATIONAL PARK (EVER)** | |
| **SITE:** | Southern Florida. |
| **ISSUE:** | Nonpoint sources from encroaching agriculture and urbanization. |
| **QUESTION:** | Two problems currently being addressed are: (1) the high concentrations of mercury identified in both the bass and the endangered Florida Panther within the park (Simons 1991; Loftus 1990), and (2) the rapid die-off rate of the park's native vegetation (Robblee and DiDomenico 1991). How can the park incorporate biomonitoring to address these problems? |
| **IV. UPPER DELAWARE SCENIC AND RECREATIONAL RIVER (UPDE)** | |
| **SITE:** | Narrowsburg, New York. |
| **ISSUE:** | Nonpoint source from a nearby Superfund landfill. |
| **QUESTION:** | Are leachates from the landfill, which have been discoloring the river sediments, toxic to aquatic species? |
| **V. WILSON'S CREEK NATIONAL BATTLEFIELD (WICR)** | |
| **SITE:** | Near Springfield, Missouri. |
| **ISSUE:** | Nonpoint sources from increasing nearby urbanization. |
| **QUESTION:** | Is the rapid urbanization of Springfield affecting the quality of water in Wilson's Creek within the park? |

It is obvious that the issues and questions affecting these parks (Table 1) present scientists and managers with various challenges for designing early-warning programs to detect, test, collect, analyze, and present the evidence for nonpoint source pollution. The question is, how does *biomonitoring* assist in assessing nonpoint source pollution problems? Biomonitoring assists in doing this by: (1) helping to maintain objectivity when addressing water quality, (2) targeting and/or prioritizing suspected problems, (3) aiding in identifying and prioritizing future sampling sites, (4) identifying certain toxicants (when used in conjunction with chemical analysis) at a particular sampling location, and (5) helping to cost effectively discover and understand the causes of water quality impairments.

Biomonitoring is an objective way to address water quality issues. This was the case with the Namekagon River, St. Croix National Scenic Riverway (SACN), and an unnamed creek within the Ft. Darling Unit of the Richmond National Battlefield Park (RICH). At the Namekagon River, the test water looked "healthy" (clear, with vegetation and insect activity) but biomonitoring, using daphnids and fathead minnows, indicated that water quality problems existed. First, there were significant decreases in the reproduction of daphnids in waters coming from two of the three cranberry marshes (Sites 3 and 5, Fig.1). Second, at site 5, only 50% of the larval fathead minnows survived the 96-hr *in situ* exposure compared to 100% that survived at site 6, a site which receives substantial dilution from a larger unimpacted tributary--Potato Creek. In contrast, at the Neimitz marsh (Sites 7, 8, and 9), daphnids reproduced better than average and the minnows survived at an average of 87% giving no evidence of impact from the cranberry marshes located there. Data gathered from these biomonitoring studies, therefore, suggest that further investigation of sites 3 and 5 are warranted.

Additionally, biomonitoring assessment of an unsightly creek in the Ft. Darling Unit (RICH), also gave an objective indication of water quality. Here, unlike the Namekagon studies where all the water samples looked "healthy," extreme turbidity and an intense rust color from leachates seeping into the creek from a nearby landfill obviously suggested impaired conditions. Biomonitoring indicated that substances in the leachates, contrary to previous assumption, were not toxic to the daphnids, amphipods, or minnows in the initial tests or in chronic toxicity tests with daphnids in later studies (Fig.2). Because of the results obtained from these biomonitoring studies, we were able to conclude that the absence of aquatic life in the creek was probably due to thick soft sediment-oxides and not, as first believed, from toxic chemicals coming from the landfill.

In addition to objectivity, biomonitoring can target and/or prioritize already suspected problem areas in parks. For instance, information gained in an Everglades National Park (EVER) study, using daphnids, minnows, and feeding rates of amphipods, suggested that specific canals were impaired and should be selected for further in-depth studies. By ranking the three test endpoints (eating rate of amphipods, growth rate of larval Fathead Minnows, and reproduction rate of *Ceriodaphnia dubia*) and subdividing the ranks into good, fair, and poor (Fig.3), an association between endpoint ranks and water quality was made 74% of the time. This lead to prioritization of suspected problems and reevaluation of chosen controls. Pineglades Lake, for example (Site 1, Fig.3) because of its central location, isolation from direct surfacewater (canals) or groundwater, and history of good water-quality was initially considered as a control site for the studies; however, it ranked lower than expected. Thus, based on higher ranking, other lakes and canals in the park were targeted as more appropriate controls for future studies. Endpoint ranking also uncovered severely impacted water in need of high, immediate, prioritizing. Exposure to waters from canal sites L-28Tm and S-12C, endpoint ranked "poor," caused spinal deformation in a few of the larval fathead minnows tested--a condition seen only in severely impacted waters.

Using known test data, biomonitoring can aid in identifying and prioritizing toxic sampling sites for future biomonitoring studies. Eight samples of leachates entering the Upper Delaware Scenic and Recreational River (UPDE) from a nearby Superfund landfill were shipped to a cooperating laboratory. Toxicity was detected in five, three, and two samples using daphnids, larval fathead minnows, and amphipods and grass seeds respectively. However, a question arose about many more seeps located upstream and downstream from the landfill that were not tested due to limitations of laboratory space, time and money.

The question was, could we conduct biomonitoring tests and use the information to prioritize the leachate areas based on toxicity? Thus, a second series of tests were conducted on site with the daphnids; results indicated that *all* the leachates, except at field reference site C1 (surfacing upstream from the landfill at the river's edge), were acutely or chronically toxic to the daphnids (Fig.4). Among the toxic sites identified were A.S., a spring with substantial flow, and C2, the most toxic seep where 92% of the daphnids died within 12 hours. Another sample collected from C2 was shipped to a cooperating laboratory where its toxicity to fish and grass seeds was identified. Additional chemical analysis of the C2 leachate detected the presence of acetone, methylene chloride, and ammonia. Another important toxic site identified was C9, which, because of its "healthy" color, was previously believed to be downstream from the leachate influence. Findings therefore indicated that: (1) data from the on site daphnid studies were useful in prioritizing the locations of leachates for more in-depth analysis, (2) assessments of toxicity should be made with a variety of test organisms, in this case daphnids, minnows, amphipods, and grass seeds for a complete confirmation and understanding of the biological impact, and (3) without toxicity testing, a full comprehension of the toxicity of all the leachate sites would not have been identified including C9, which at first appeared to be unimpacted.

The use of living organisms can be used in conjunction with chemical analyses to identify certain toxicants affecting the quality of water at a particular sampling location. Earlier biomonitoring investigations of tributaries, springs, and segments of the Wilson's Creek watershed, conducted during two different seasons within two years, at Wilson's Creek National Battlefield (Nimmo et al., 1992), suggested that water collected from site 6, above the park, was toxic to daphnids each time tests were conducted (Fig.5). Next, biomonitoring plus Toxicity Identification Evaluation (TIE) procedures were planned. These procedures join biomonitoring with laboratory tests to identify the physical and chemical characteristics of the substances believed to be toxic. Eventually, after biomonitoring and TIEs were conducted, the appropriate analytical techniques were chosen to verify the toxicant or toxicants responsible for the toxicity. The data gained from site 6 indicated that when metals (copper, nickel, and zinc) were present at specific concentrations--the result was toxicity (Fig.5).

We believe biomonitoring to be a cost-effective approach for discovering and understanding the causes of water quality impairments. The data gathered at both RICH and UPDE were multi-year research efforts designed to develop and test procedures under field conditions. After the procedures were established and used in SACN, EVER, and WICR, we approximated the average cost of each of the studies (12 sampling sites tested over 7 sampling days) to be only $3,000 for 3 weeks of effort. This is a modest amount compared to only one priority pollutant (chemical by chemical) analysis (one sampling site tested one time, including both organic and inorganic compounds) which can cost between $1,500 and $2,000.

Water and its accompanying aquatic communities are critical to all forms of life. We believe the data gathered from our pilot programs indicate that biomonitoring can directly assess the health of aquatic and terrestrial life. Biomonitoring is needed to ensure these aquatic resources for various interests if only for the aesthetic value of a spectacular waterfall. Increasing human populations and expanding land-use needs require society to research and develop new ways of understanding and detecting the subtle or perhaps not-so-subtle changes in water quality in our park's from *outside* sources. Biomonitoring, because it has proven to be an objective way to target and prioritize suspected and known problem areas, in conjunction with TIE to identify specific toxicants, is worth pursuing as a valuable, cost effective component of monitoring programs in our National Parks.

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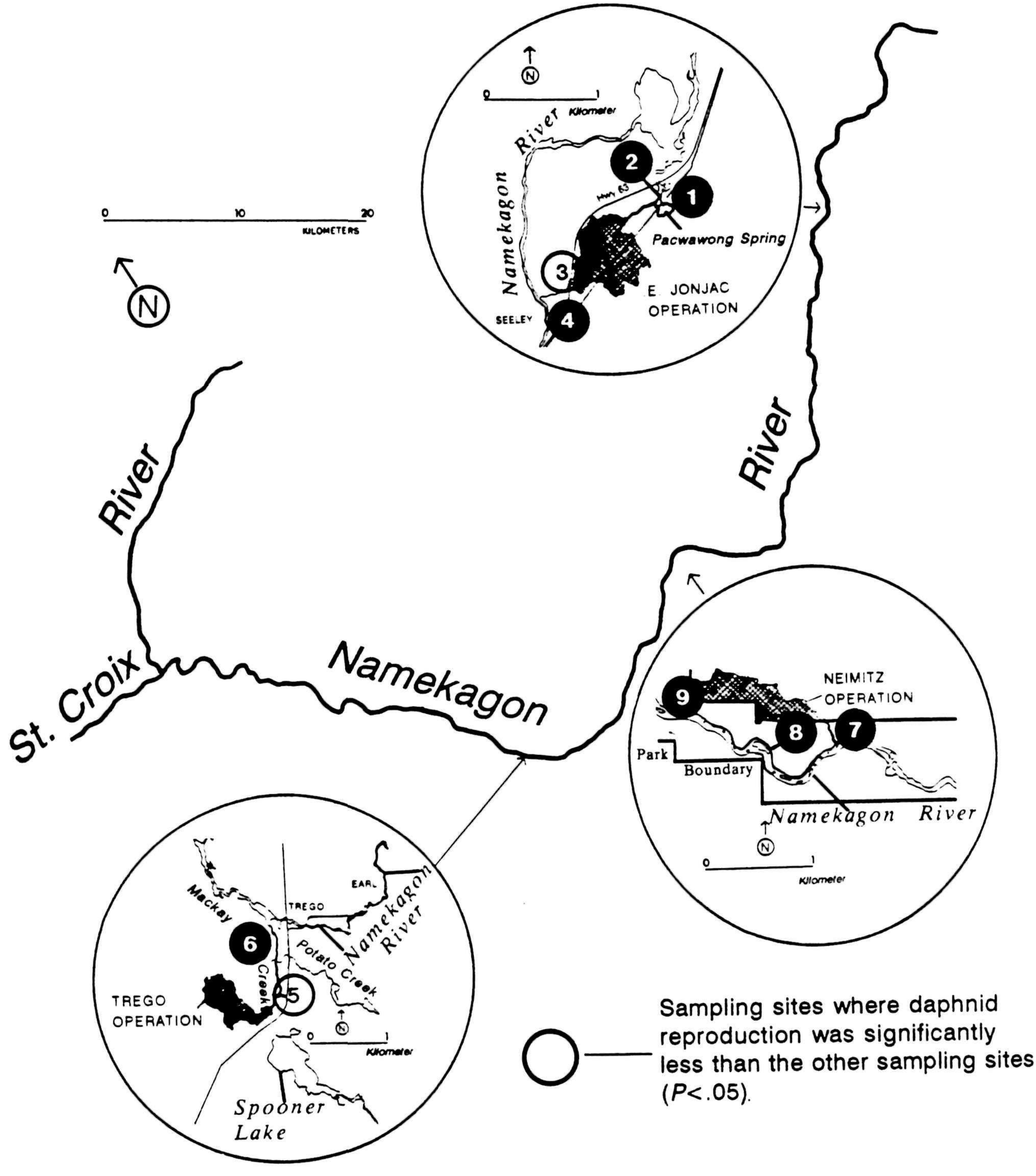
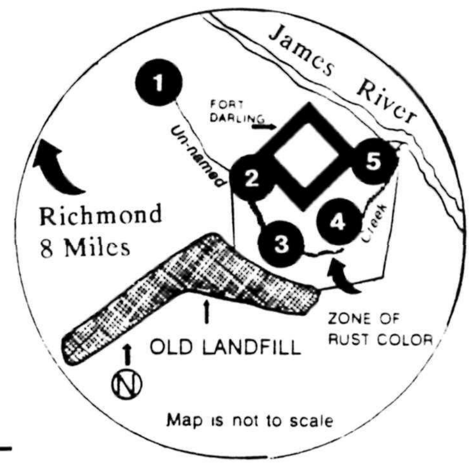



Figure 1. Locations of cranberry marshes and biomonitoring sites along the Namekagon River, St. Croix National Scenic Riverway, Wisconsin. Sites 1, 2, 6 and 7 are reference sites which were either above the influence of the cranberry operations or, as with site 6, greatly diluted by another tributary.

## Percent Survival

| | Location | *Ceriodaphnia** | F.H. Minnows** | Amphipods*** |
|---|---|---|---|---|
| 1 | Control site upstream from landfill | 100 | 70 | 90 |
| 2 | Below initial visible leachate (rust color) | 100 | 80 | 100 |
| 3 | Largest visible volume of leachate | 100 | 90 | 100 |
| 4 | Below last visible leachate | 100 | 100 | 90 |
| 5 | Before confluence with James River | 100 | 90 | 100 |




* 48-hr. test with tributary water (a later 7 day chronic test also proved to be non-toxic)
** 96-hr. test with tributary water using larval Fathead Minnows
*** 96-hr. test on elutriate water from sediments

Figure 2. Percent survival of test species exposed to water and sediments from one control site upstream and four sample sites downstream from a landfill in a small unnamed creek, Richmond National Battlefield Park, Virginia.

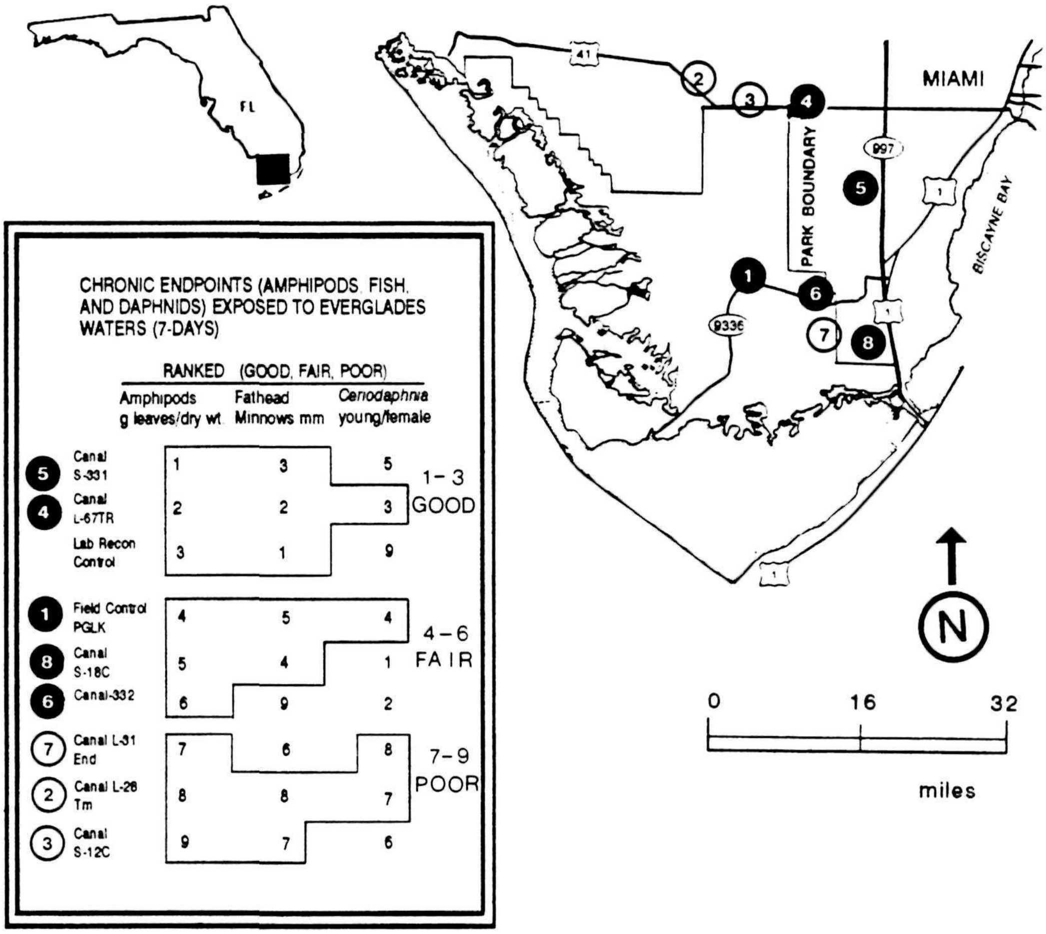



Figure 3. Locations of biomonitoring sites in Everglades National Park, Florida. The insert shows the relative ranking (good, fair, poor) of those sites based on three chronic test endpoints (feeding rate of amphipods, growth rate of larval Fathead Minnows, and reproduction rate of *Ceriodaphnia dubia*). Blocks represent endpoint agreement among the three catagories. Closed circles represent those sites that ranked in the "good" or "fair" categories whereas sites ranked in the "poor" category are shown as open circles.

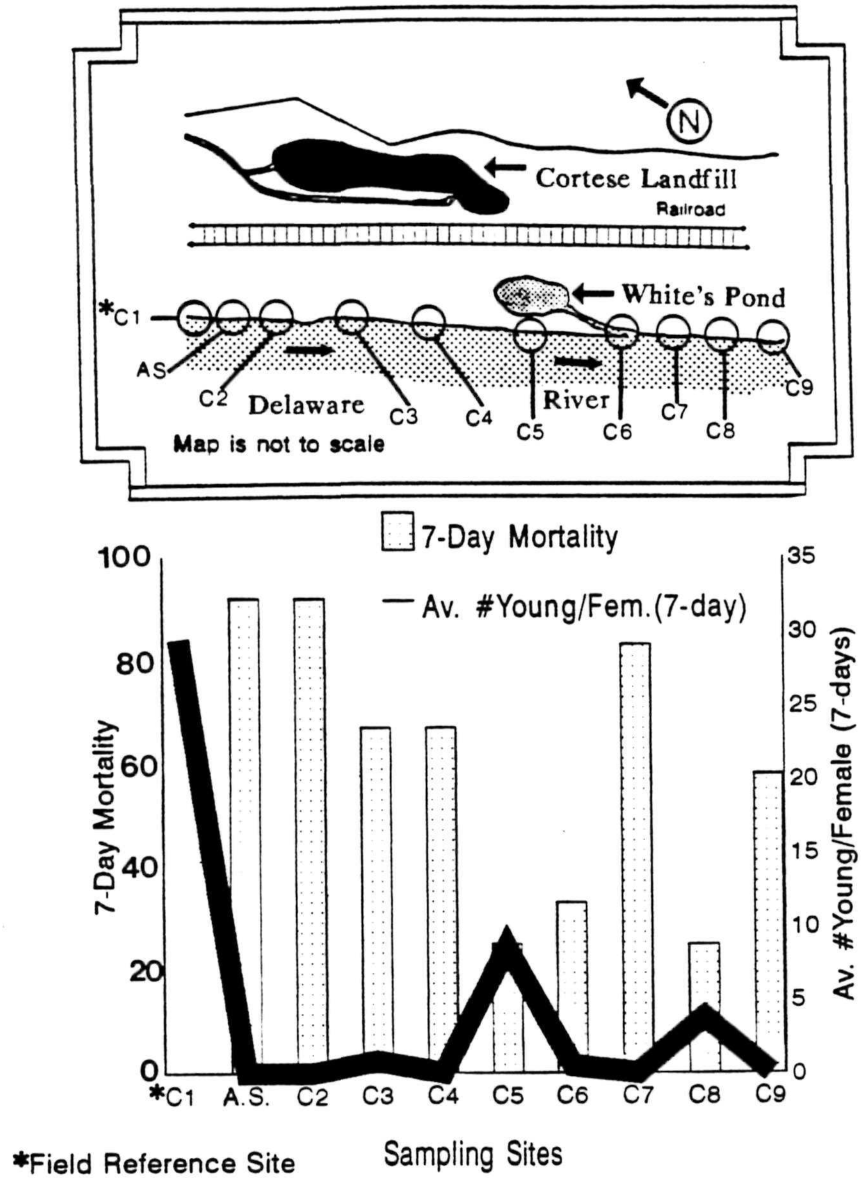



Figure 4. Biomonitoring sample sites of leachates entering the Delaware River (Upper Delaware Scenic and Recreational River, New York) below a Superfund landfill. Data shown in the bar graph represent the 7-day mortality of the test species, *Ceriodaphnia dubia*, and the line graph represents the average number of young produced per female *dubia* that survived the exposure after 7 days.

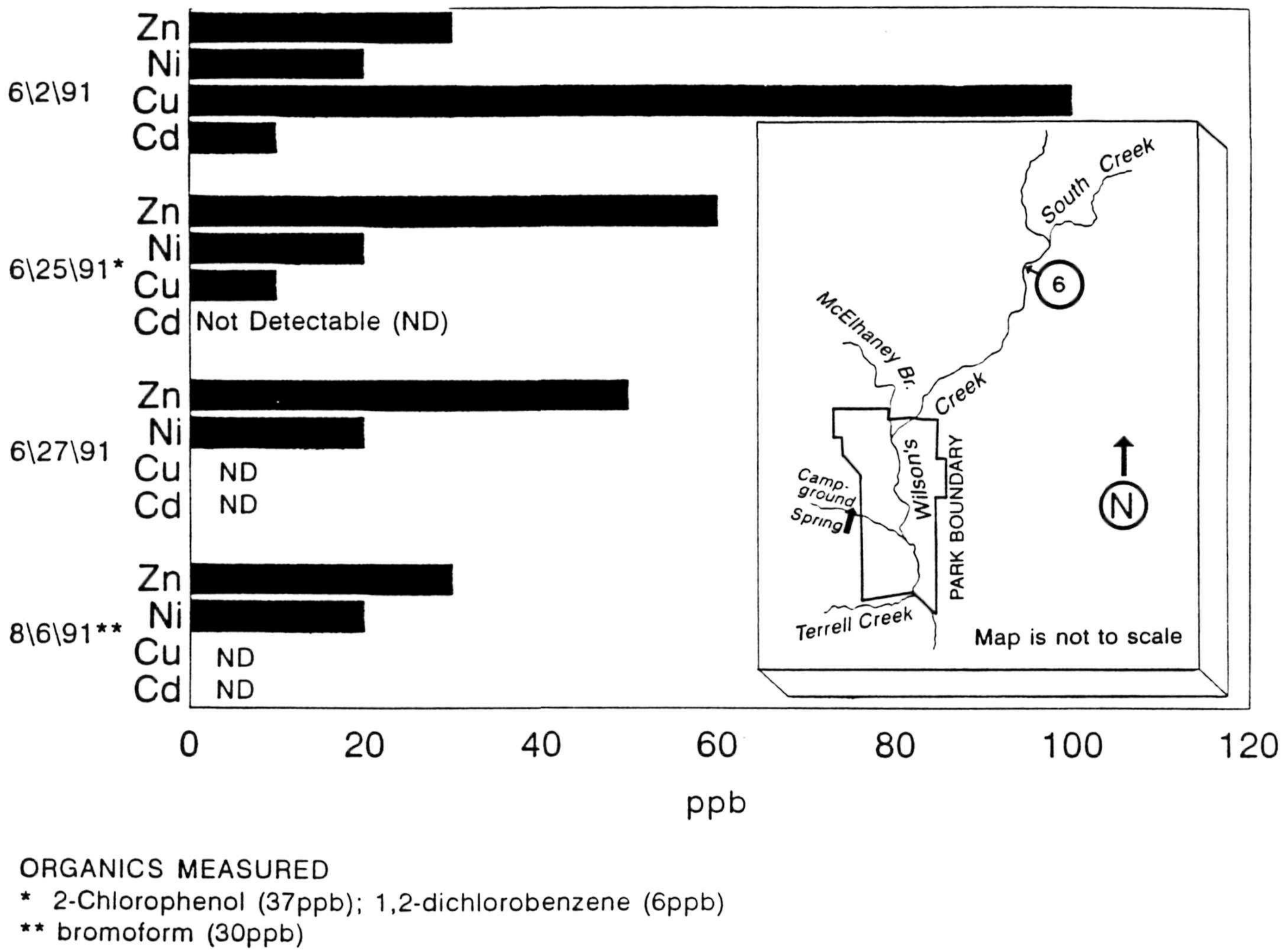



Figure 5. Location of biomonitoring site 6 with respect to Wilson's Creek National Battlefield Park, Missouri. In previous studies, site 6 was chronically toxic to daphnids. By using Toxicity Identification Evaluation (TIE) procedures, combinations of zinc (Zn), nickel (Ni), and copper (Cu) were judged to be responsible for the toxicity.