hyporheic delineation

Delineation of the hyporheic zone

Introduction

The hyporheic zone is the area beneath and adjacent to streams and rivers where surface and groundwaters mix. This important zone provides habitat to a unique biotic community, serves as a hydrologic link between terrestrial and aquatic ecosystems, and enhances productivity through the accelerated transformation of nutrients. (See Center for Water and Watershed Studies' *Hyporheic Zones* Fact Sheet for more information). Determining the presence and extent of hyporheic zones is critical when making management decisions for stream and riparian systems because hyporheic zones may be affected by land management activities. An initial indicator of hyporheic zone presence may be as simple as the abundance of gravelly, porous sediment adjacent to and beneath the stream, which may then warrant further delineation. Methods for determining the presence and extent of hyporheic zones vary in cost, labor intensity, time, and quality and quantity of information provided. Below are descriptions of some suggested methods. A reference list for further information is included.

Tracer studies

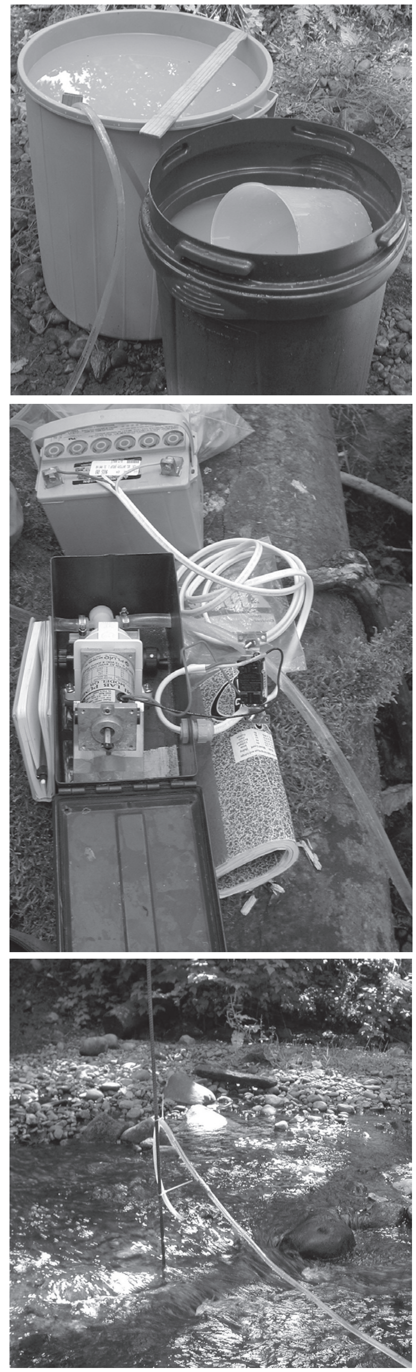
Conservative tracer injections are performed using wells or piezometers installed throughout a selected stream reach and adjacent valley at varying subsurface depths. A conservative solute (e.g., NaCl), which will not be biologically or physically absorbed by the stream is injected into the stream at the top of the reach. Using an electrical conductivity meter, or a chloride probe, the solute concentration in the wells is measured over time. This process provides information about the lateral and vertical extent of the hyporheic zone as well as an idea of subsurface water retention time.

Conservative tracer injections can be performed without wells, measuring the solute's concentrations over time in the channel surface water at distances downstream of the injection point. (This method also uses electrical conductivity meters or chloride probes.) Computer programs (e.g., OTIS and OTIS-P developed by the U.S. Geological Survey) estimate both an overall volume of transient water storage and an exchange rate between the surface and subsurface water for the given reach. However, this storage volume estimate includes all forms of transient storage, such as pools and backwaters, and care must be taken to identify only that portion attributable to the amount of hyporheic storage. This method does not delineate the lateral and vertical extent of the hyporheic zone, and the models can be difficult to set up and use.

Natural solute tracers (pH, temperature, electrical conductivity, and various ions) can be used when the groundwater and surface water are known to vary significantly in one of these variables. Water samples are extracted from the hyporheic wells and the given variable measured (using temperature probes, pH/conductivity meters, or ion analysis). If the measured variable's level is definitively not that of groundwater or surface water but rather in between, then a degree of connectivity is inferred.

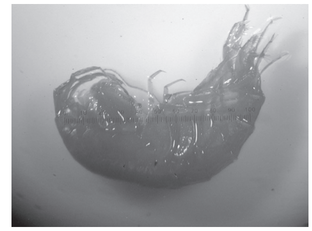
Hyporheic invertebrate mapping

Invertebrate samples are drawn from hyporheic wells and species are identified. Invertebrates can be classified as those that only live in groundwater, those that prefer groundwater or surface water



Conservative tracer injection setup. The NaCl mixture (top) is pumped through a tube (middle) to a mixing zone in the middle of the stream (bottom).

but can be found in either location, and those that may live in surface water. This method requires skillful and accurate identification of the organisms since certain species may switch habitats depending on life stage. Due to uncertainties in invertebrate distribution and life histories, invertebrate mapping can imply connectivity between groundwater and surface water systems, but cannot determine the relative amounts of surface and groundwater in the hyporheic zone. Invertebrates common in hyporheic zones include microcrustaceans, oligochaetes, water mites, and early larval stages of stoneflies and mayflies.



Invertebrates (stonefly, top and amphipod, bottom) typically found in the hyporheic zone

Piezometric head

Monitoring of hydraulic conductivity (the rate water flows through sediment) using wells can indicate the existence of a hyporheic zone. If the water level patterns in the wells throughout an off-channel grid parallel the water level patterns in the stream, then connectivity is inferred. This method is often used in larger rivers where flow volume make tracer studies difficult.

Wells within the active channel provide vertical hydraulic gradient data. If water levels within the wells are below or above the surface water level, then pressure head (height of water resulting from surrounding geology and atmospheric pressure) differences exist between the subsurface and surface water, and hyporheic exchange occurs. Upwellings exist where the pressure in the well is higher than the water in the stream and downwellings occur where pressure in the well is lower than the water in the stream.

Ground penetrating radar (GPR)

Radar signals provide detailed shallow stratigraphy—information on the depths of different types of sediment layers—as well as the depth of the groundwater table. By interpreting characteristics such as the hydraulic conductivity of these sediments, these data support a rough, initial delineation of the hyporheic zone. Advantages of this method include rapid data collection, continuous profile of subsurface sediment layers, ability to work over frozen ground, and the ability to work through pavement. Disadvantages include the need to know radar velocity to convert time data to depth information, the complexity of operating the equipment, and the possibility of interference from trees, overhead and buried utilities, and scrap metal. Although initial interpretation can be done in the field, accurate interpretation requires approximately 3-4 days per field day. As well, radar penetration is limited in areas with electrically conductive sediment or water, and thin clay layers can give disproportionately strong reflections.

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