Report for 2005WA115B: Using Stable Isotopes to Trace Nitrate Sources and Surface Water-Groundwater Interactions in the Upper Yakima River Drainage

Publications

- Conference Proceedings:
  - Gazis, Carey A., 2005, Stable Isotope Studies of Surface Water-Groundwater Interactions in the Upper Yakima River Drainage, Washington, "in" Geological Society of America 2005 Annual Meeting, Salt Lake City, Utah, October 16-19, 2005, Abstracts with Programs 37(7) p. 213.
  - Gazis, Carey A. and Sarah Taylor. 2005. Geochemical Studies of Surface Water-Groundwater Interactions in the Upper Yakima River Drainage, Washington (poster), "in" Proceedings of the Conference Groundwater Under the Pacific Northwest: Integrating Research, Policy, and Education, November 2-3, 2005, Stevenson, Washington. http://www.swwrc.wsu.edu/conference2005/proceedings/Nov_2/Poster%20Session/Gazis.C.abstract.htm

Report Follows

PROBLEM AND RESEARCH OBJECTIVES

The Yakima River basin is one of the most intensively irrigated areas in the country, with approximately 500,000 acres irrigated. In addition, the river is typical of the arid west in that many other constituencies (e.g. municipal water suppliers, fisheries, recreational users) are placing demands on the limited water supply. This research addressed the question of how irrigation practices impact surface water-groundwater interactions and water quality in the upper Yakima River basin. The research objectives were:

1. To identify recharge and discharge zones for groundwaters from different levels in the Ellensburg aquifer;
2. To constrain flow paths of groundwater in one direction and characterize their seasonal variations;
3. To determine the extent to which irrigation waters infiltrate wells in the area and trace the fate of these irrigation waters;

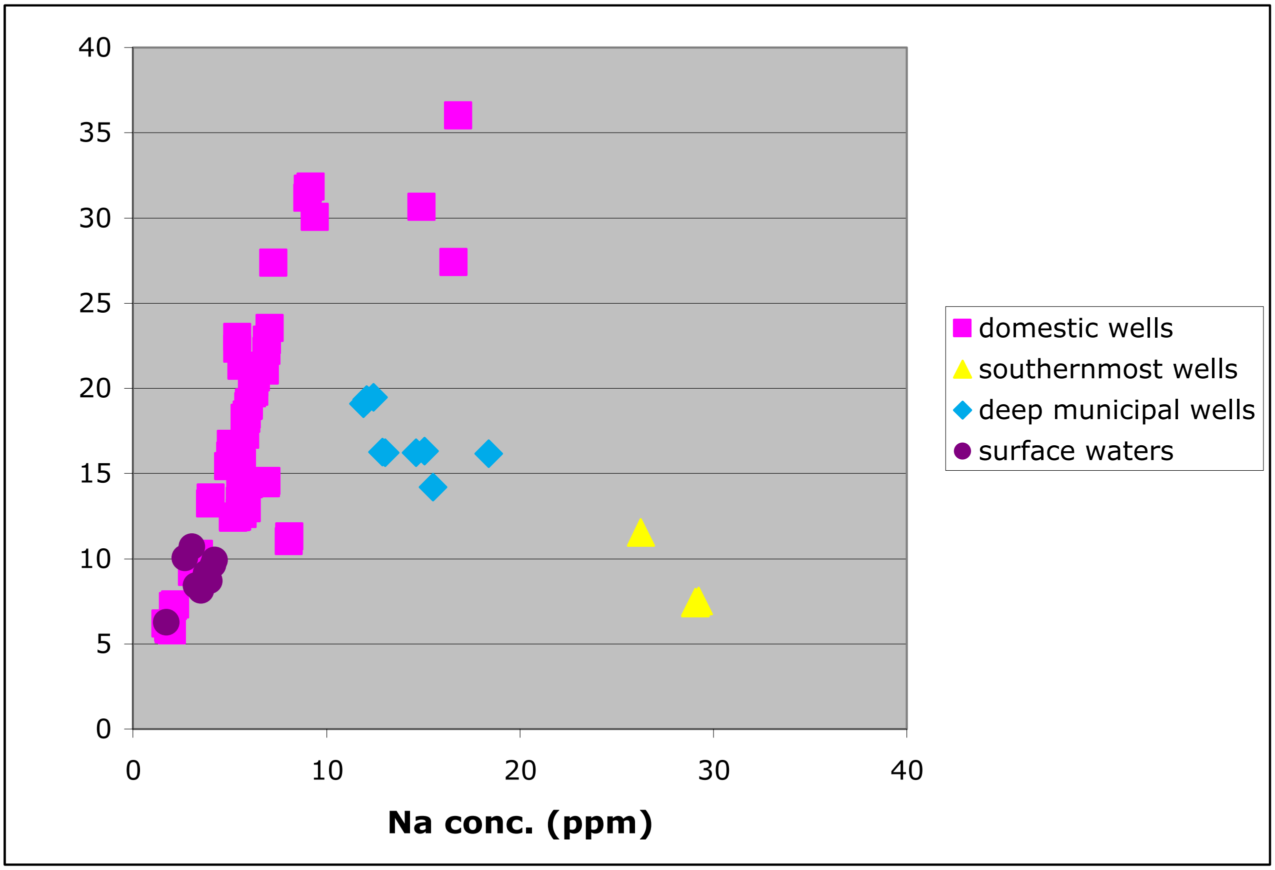
METHODOLOGY

Twenty-five wells, positioned along a transect perpendicular to the Yakima River were sampled every two months throughout the year. Most of these wells are completely within the Ellensburg formation, a volcaniclastic sedimentary unit that is over 1000 meters thick in parts of the Ellensburg basin. Alkalinity, pH, conductivity, and dissolved oxygen content were measured in the field during sampling. In the laboratory samples were processed and analyzed for: 1) stable isotope composition using a gas source isotope ration mass spectrometer (IRMS); 2) major ion concentrations using and ion chromatograph (IC); and 3) trace element concentrations using a inductively coupled plasma mass spectrometer (ICP-MS). These data were compared to similar data for streams, irrigation water, and precipitation.

PRINCIPAL FINDINGS AND SIGNIFICANCE

H and O isotopic compositions for these groundwater samples, are compared to local stream water, irrigation water and precipitation data and interpreted in terms of mass balance models to determine the contributions of geochemically distinct source waters (e.g. snowmelt, irrigation waters) to the groundwater and how these contributions change seasonally. Local precipitation and surface waters form a local meteoric water line on a δD- $\delta^{18}O$ plot with equation: $\delta D = 6.6\ \delta^{18}O - 10.7$. Irrigation waters and their source, the Yakima River, generally fall above this local meteoric water line with relatively heavy isotopic compositions. Groundwaters from some of the shallow domestic wells also tend to be isotopically heavier and plot near the local surface and irrigation water, particularly when sampled during the irrigation season. Often these shallow groundwaters also have elevated nitrate and sulfate concentrations. These geochemical characteristics indicate that these groundwaters are mixing with surface waters throughout the year, including nitrate-rich irrigation waters during the irrigation season. Groundwaters from deeper wells are isotopically lighter and have a narrower range of values, comparable isotopically to spring snowmelt. The two southernmost domestic wells, which draw from an aquifer in the Columbia River basalts, are isotopically distinct, with δD values that are lower than all but the lightest winter precipitation.

Major cations in groundwaters and surface waters are typically dominated by magnesium and calcium. However, the southernmost wells have relatively high concentrations of sodium, while deep municipal wells have intermediate sodium concentrations (See figure). Anion geochemistry is dominated by bicarbonate. Concentrations of selected trace elements (Ti, V, Cr, Mn, As, Rb, Sr, Ba) tend to be distinctly different from well to well, but remain relatively constant throughout the year in any given well.



These geochemical patterns can be interpreted in terms of a water-rock interaction and anthropogenic effects due to current and past land use practices. Waters within different aquifers (e.g., Ellensburg formation vs. Columbia River basalts) and different subaquifers (e.g., different units within the Ellensburg formation) retain distinct geochemical signatures that are acquired through water-rock interactions. In addition to their natural chemistry, groundwater samples from some wells have relatively high concentrations of arsenic, which may be due to interaction with soils in areas where arsenical pesticides were used on orchards. The geochemical signatures derived from interactions with soils and rocks remain relatively constant throughout the year, unlike changes due to irrigation practices. Locations where irrigation waters mix with domestic well water have been identified using nitrate and sulfate concentrations and stable isotope ratios. We are currently looking in more detail at the spatial patterns of these geochemical variations.