BRIEF NOTE

Difficulties in Determining Factors that Influence Effective Groundwater Recharge in Ohio[1]

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ABSTRACT. **As part of a COSI Academy research project, data from a recent statewide analysis of effective groundwater recharge were reexamined by students to further discern relations between recharge and selected environmental characteristics of individual drainage basins: 1) location of the main stem of a river relative to coarse and fine surficial sediments and 2) influence of land use. Lack of sufficiently detailed data was the principal difficulty in most phases of the examination. Other than a potential relation between recharge and the percentages of agricultural and forested land, no relations were found in visual comparisons of mapped and tabulated data.**

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INTRODUCTION

Effective groundwater recharge can be defined as the amount of precipitation that reaches the water table. Most of this recharge water eventually discharges to streams.

Effective recharge was the focus of a recent study by the US Geological Survey (USGS) and the Ohio Department of Natural Resources (ODNR) (Dumouchelle and Schiefer 2002) in which the USGS developed spatially representative estimates of effective groundwater recharge for Ohio (on the basis of streamflow record) and made interbasin comparisons of the recharge estimates. Precipitation, soil infiltration rate, and proportion of coarse glacial sediments in a basin were found to be the principal predictors of effective recharge, although the generally weak correlation between these factors and recharge rates indicate that additional factors probably are influencing recharge. Two particular factors seemed to merit further attention: 1) the location of the main stem of a river relative to coarse and fine surficial sediments and 2) influences of land use.

This paper documents several research avenues taken by 5 student researchers in collaboration with 2 USGS mentors during the 2000-2001 academic-year session of COSI Academy. (COSI Academy is an extracurricular program of Center of Science and Industry (Columbus) that enables talented high-school students to experience real-world science and technology projects.) Our project followed up on the original research of Dumouchelle and Schiefer (2002) and attempted to determine what factors besides precipitation, soil infiltration rate, and proportion of coarse glacial sediments might be influencing effective groundwater recharge rates.

MATERIALS AND METHODS

The study areas consisted of 9 drainage basins selected from the original set of 103 basins throughout Ohio (Dumouchelle and Schiefer 2002). These 9 basins seemed to have the proper geologic setting or necessary land-use data to facilitate the student-driven analysis. We analyzed the data visually by comparing tabulated recharge data with maps showing glacial-sediment type, glacial-sediment thickness, and land use. The use of qualitative visual analysis was largely in response to constraints of technology and time: a computerized geographic information system (GIS) was unavailable at COSI, and our core research time was only a few hours once a month at COSI.

The factors and the approaches we took in each analysis were the following:

Location of coarse and fine surficial materials in relation to the stream. The question was whether the proportion of coarse and fine surficial materials in a basin affects streamflow record differently (and hence affects computed recharge rates) if these materials are concentrated along stream valleys rather than distributed more evenly throughout the basin. Our approach was to examine surficial-geology maps of Ohio (with the study basins superimposed upon them) and compare the distribution of sediment texture and thickness to computed recharge values for the basins. One set of maps showed the type of surficial sediments; the other set showed approximate thickness of glacial sediments in 50-ft increments. Statewide maps were used to target 5 basins for a more detailed examination, and larger scale maps of the same kind were then generated by the USGS mentors for those basins.

Land use. We investigated whether the effects of various land-use types on the recharge estimate were discernable and, if so, what the effects were. Two sets of land-use maps (mid-1970s and mid-1990s; ODNR 2001) were ultimately generated for 2 counties (Portage and Greene), encompassing 4 basins, so that changes in land use and effective recharge over time could be tracked.

RESULTS

Location of coarse and fine surficial materials in relation to the stream. Visual inspection indicated no

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consistent pattern of increased or decreased recharge in response to the location and thickness of glacial sediments relative to the main stem of the stream. We saw a possible relation between glacial-sediment thickness and effective recharge, but the relation was weak at best: in general, basins with thicker glacial sediments appeared to have slightly greater effective recharge, but exceptions to this generalization were numerous.

Land use. In contrast to the absence of visible basin-characteristic/recharge relations in the other analysis, the comparison of land use and effective recharge yielded a possible relation between area of land in agriculture and recharge. We first looked at 3 basins in Portage County for which land-use data were available for 1977 and 1994 (ODNR 2001). These maps differed considerably in the number of land-use categories and, apparently, in the criteria governing how various land-use types (especially urban land) were mapped. Even allowing for these problems in our visual comparisons, we noticed that an apparent decrease in land being used for agriculture and an increase in forested areas corresponded to an increase in effective recharge in 2 of the basins (from 8 to 10 inches and 5 to 6 inches; Dumouchelle and Schiefer 2002), as computed by subdividing the streamflow record into approximately pre- and post-1977 periods. We also examined data for a basin in Greene County where land-use data were available for 1975 and 1994, and we found a similar decrease in agricultural land, increase in forested land, and increase in effective recharge (from 9 to 10 inches). A subsequent analysis of pre- and post-1977 precipitation near the basins—a potential confounding factor—showed that precipitation differences explained less than half of the recharge increase for the Portage County basins and none of the increase for the Greene County basin.

DISCUSSION

Overall, the principal result of our investigation was to reveal apparent difficulties in determining factors that influence effective groundwater recharge in Ohio. This result, however, is not surprising. Previous literature indicates that finding a clear relation between streamflow characteristics (in our case, effective recharge as inferred from streamflow) and landscape characteristics is difficult for Ohio, particularly on a statewide scale (Schneider 1957; Cross 1949).

As is evident from our work and the previous work cited, future researchers who wish to refine the knowledge of what determines effective recharge in Ohio can expect an imposing set of tasks, particularly if they wish to investigate a large part of the state. Success will be most likely if the future researchers can work on a fairly small area (a few basins or a region of the state), have quantitative geospatial-analysis tools (specifically, GIS) to work with, and have adequate time to edit or enhance data sets as needed. Researchers interested in comparisons of recharge with land use might do well to aggregate before-and-after, county-scale data themselves (so that there is greater continuity in mapping criteria than we found in our investigation) and determine whether any major changes in water withdrawals from or wastewater discharge to the stream of interest could skew streamflow-based recharge estimates.

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