An investigation of ground water-surface water interaction in the Flint Creek Valley, Granite County, Montana
by Martha Hoffman Kauffman

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University

Abstract:
Closure of several basins in Montana to new surface-water allocations has created a higher demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. This investigation characterizes the interaction of surface water, irrigation, and ground water in the Flint Creek valley, Granite County, Montana, using MODFLOW, a numerical ground-water flow model. The model was calibrated to ground-water and surface-water measurements collected by the Department of Natural Resources and Conservation and the U.S. Geological Survey for the Flint Creek Return Flow Study.

Reasonable ranges for transmissivity and storage values that could be assigned during model calibration were determined from aquifer test results, analysis of specific capacity data, examination of surface water gains and changes in ground-water storage, and published tables. Acceptable ranges for net recharge on sprinkler irrigated, flood irrigated and unirrigated lands were established using precipitation, irrigation, and crop evapotranspiration information. The model was calibrated to five quantitative and qualitative targets. Problems that had to be addressed during model development included heterogeneous stratigraphy, abrupt topographic changes, limited data, and realistic calibration targets.

The model calibrated best when elevated benches in the field area were treated as one hydrostratigraphic unit with transmissivity values of 15,000 gpd/ft (186 m^2/d) on the majority of the benches and 1,500 gpd/ft (19 m^2/d) where the gravels thin to the north. The alluvial areas were best modeled as three units with transmissivity values ranging from 10,500 gpd/ft (130 m^2/d) to 29,900 gpd/ft (370 m^2/d). Specific yield values ranged from 0.1 to 0.2 for layer one. Net recharge was best modeled at eight inches (20 cm) per summer season for sprinkler irrigation, 18 inches (46 cm) per season for flood irrigation, and one inch (2.5 cm) per season for unirrigated areas.

Using the calibrated model, several example simulations were performed to test the effect of ground-water withdrawals on streamflow. These examples show that well position in the valley (valley width) and distance from the stream influence the timing of greatest impact on streamflow and whether well water is drawn primarily from storage or from streamflow. The farther the well is from the stream, the more the timing of impact on streamflow is delayed from summer until fall, and the more water is drawn from storage rather than from streamflow. Many other simulations could be explored with this model. The choice of simulations should be constrained by input from a variety of perspectives such as those represented by the members of the Upper Clark Fork Basin Steering Committee.

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Master of Science

in

Earth Sciences

MONTANA STATE UNIVERSITY–BOZEMAN
Bozeman, Montana

November 1999

APPROVAL

of a thesis submitted by

Martha Hoffman Kauffman

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGMENTS

Funding for this project was provided by grants from the Mountain Research Center and the Department of Natural Resources and Conservation (DNRC). I would like to thank Kirk Waren for his time, interest and overall assistance with this project, Bill Uthman for modeling and software advice as well as general support, and Terry Voeller for use of his data. I would also like to thank Rich Moy for DNRC's financial support and his ongoing interest in this project.

I would like to thank my graduate committee for their contributions to this project, Dr. Stephan G. Custer, Dr. William W. Locke III, Dr. Joel E. Cahoon, and Tom Grady. Their advice, insights and encouragement helped tremendously. I would especially like to thank Dr. Custer for the time he devoted to helping me, for the interest he continually showed in the project, and for his genuine concern for students. I appreciated the work Amy Hammersmark did in researching crop evapotranspiration for the Flint Creek valley. I would like to thank Jocelyn McCandless whose courage, wit and strength are an enduring inspiration. Most of all I would like to thank my husband, John and my children Caitlin and Jennifer for their patience, love, and endless cheerleading.

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ABSTRACT

Closure of several basins in Montana to new surface-water allocations has created a higher demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. This investigation characterizes the interaction of surface water, irrigation, and ground water in the Flint Creek valley, Granite County, Montana, using MODFLOW, a numerical ground-water flow model. The model was calibrated to ground-water and surface-water measurements collected by the Department of Natural Resources and Conservation and the U.S. Geological Survey for the Flint Creek Return Flow Study.

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CHAPTER 1

INTRODUCTION

Streams, lakes and reservoirs supply most of the water used for irrigation, industry, drinking water, and recreation in Montana. As demand grows, there is increasing competition for a finite resource. In several basins, surface-water allocations have exceeded supply and these basins have been closed to future allocations. Closures have occurred in the Clark Fork River Basin, the Upper Missouri and parts of the main stem of the Missouri. As basins are closed, there is an increasing demand for ground-water resources. Concerns have been raised regarding the impact these actual and planned ground-water withdrawals may have on existing water rights and dry-season surface flows needed for fisheries and irrigation. Important questions include: How close to the stream can a withdrawal occur before it produces important deleterious effects? Are there areas where ground-water withdrawal will likely have no effect on the stream? If such areas exist, how are they recognized and where are they? What impact do irrigation return flows via ground water have on stream flow?

These questions are important but difficult to answer because of the complexity of irrigated intermontane valley systems and a lack of data. Flint Creek, a tributary to the Clark Fork River, which flows through an irrigated intermontane valley, was closed to new surface water allocations in 1991. The Upper Clark Fork Basin Steering Committee, with representatives from agriculture, fisheries, recreation, industry, county planning agencies and regulatory bodies initiated the closure and are currently grappling with the difficult issue of water management for the Upper Clark Fork Basin. Several agencies have recognized the need for more information on which to base management decisions. The Montana Department of Natural Resources (DNRC) Water Management Bureau, in cooperation with the U.S. Geological Survey (USGS) initiated the Flint Creek Return Flow Study, which was conducted from 1994-1997. The study focused on the Flint Creek basin, a major tributary to the Clark Fork River in Granite County, Montana (Fig. 1). The purpose of the DNRC study was to analyze aquifer recharge from irrigation and to quantify the amount and timing of irrigation return flows (Voeller and Waren, 1997). Although the U.S. Bureau of Reclamation is developing a surface water model to analyze reservoir operations and irrigation timing, no ground water modeling was planned to test the linkage between ground water and surface water. The purpose of this study is to develop a calibrated numerical ground-water model that characterizes stream-aquifer interactions in the Flint Creek valley so that questions regarding management of water in the basin can be explored.

Study Area

Flint Creek, a tributary to the Clark Fork River in Western Montana, is part of the Upper Columbia River basin. The confluence of Flint Creek with the Clark Fork River is

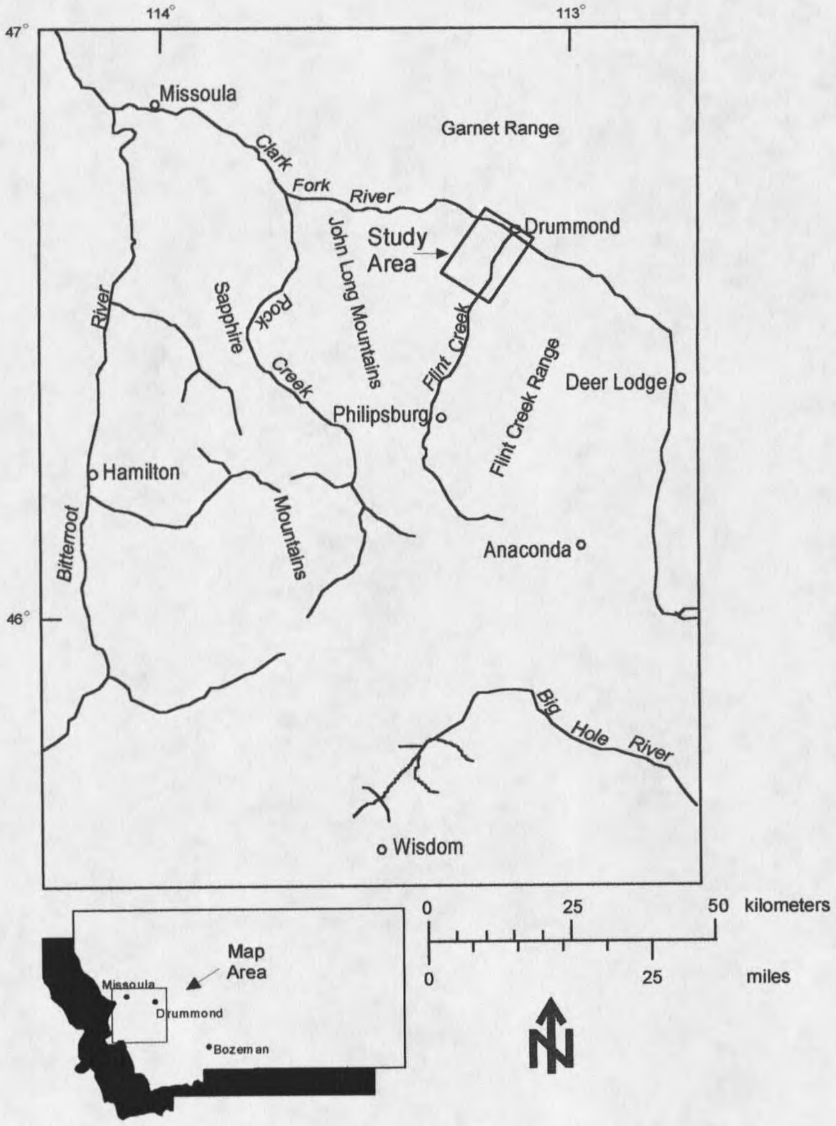

Figure 1. Location of study area in southwestern Montana (modified from Wallace et al., 1989)

near the town of Drummond, approximately 25 miles (40 kilometers (km)) northwest of Deer Lodge and 40 miles (60 km) southeast of Missoula (Fig. 1). Flint Creek flows north, and has a drainage area of approximately 500 square miles (1,300 km^2) (Voeller and Waren, 1997).

Two large valleys lie within the drainage area, which is surrounded by mountainous terrain (Fig. 2). The Philipsburg valley is located in the upper reaches of Flint Creek near Philipsburg, while the Flint Creek valley is located in the lower reaches near Drummond. A narrow canyon separates the two basins. Flint Creek enters the Flint Creek valley at an elevation of approximately 4,360 feet (1,329 meters (m)), and exits at the confluence with the Clark Fork River at an elevation of approximately 3,950 feet (1,204 m). The local physiography of the Flint Creek valley is dominated by the alluvial floodplains of Flint Creek and Lower Willow Creek. The floodplains are flanked by elevated benches, which rise 100 to 300 feet (30 to 91 m) above the alluvium.

Flint Creek is the largest stream in the drainage basin. The average annual flow of Flint Creek is 137 cubic feet per second (cfs) (4 m^3/s) near its confluence with the Clark Fork River (U.S. Geological Survey, 1999). Flows can range from four cfs (0.1 m^3/s) in August to 1,100 cfs (31 m^3/s) during a snowmelt event (usually in June, although high flow events occasionally occur during winter thaws). Flow in Flint Creek originates from reservoir storage, unregulated tributaries (Boulder Creek and Fred Burr Creek), regulated tributaries (Lower Willow Creek), and ground water (Fig. 2). Georgetown Lake, in the headwaters of Flint Creek, has active storage of 31,000 acre-feet (ac-ft)