The Hydrology and Geochemistry of the Deep Creek Watershed, McCall, Idaho

Mantez A. McDonald
Department of Geology, Central Michigan University, Mt. Pleasant, MI. 48859
Faculty Sponsor: Jane Matty, Central Michigan University

Andrew J. Logan
Department of Geology, Amherst College, Amherst Mass. 01002
Faculty Sponsor: Jack T. Cheney, Amherst College

Introduction

Payette Lake, located near McCall, Idaho, is the source of the town's drinking water. It is used extensively for recreation. Parts of the Payette Lake watershed are logged, and in 1994 a significant portion of the lake's watershed was burned by the Blackwell fires. Both fire and logging increase the amounts of nutrients transported from the watershed by runoff and stream flow. Increased nutrient loading resulting from burned and logged catchments could reduce the quality of water in Payette Lake. Logging should have less of an effect on nutrient loading on the system.

To assess the relative impacts of logging and fire on water quality, six catchments with different characteristics were studied (Table 1). This project focused on the hydrology and geochemistry of the Deep Creek watershed, which were both logged and burned. The relationship that Deep Creek has to the other catchments is that at the start of the study Deep Creek was to be the control site. On further investigation, it was found out that Deep Creek had been affected by both fire and logging.

Table 1

Watershed	Condition
Cougar Creek	Burned
Dead Horse Creek	Logged
Deep Creek	Burned and Logged
Lemah Creek	Burned and Logged
Pearl Creek	Burned and Logged
Trail Creek	Burned

Methods

Chemical analysis of water samples, monitoring of stream stage, stream discharge measurements, and mapping of surficial sediments in the watershed were employed. Stream discharge was used, along with chemical data, to estimate the total nutrient load leaving the catchment.

Chemical Analysis: There were eighteen samples analysised within Deep Creek. These samples were collected at various points within the catchment. Each point was then mapped to show the position within the catchment. Each sample was analysised for pH, conductance, Acid Neutralizing Capacity, and Ion chromatography that were used for analysis of sulfate, nitrate, and chloride. Accuracy of ANC data was evaluated by performing a lad split and doing a blind double analysis of a single sample. Accuracy was evaluated as described for ANC analysis above. Estimated errors are: SO4 +/-0.005; NO3 +/- 0.01; Cl +/- 0.38.

Stream flow measurements: Stream flow was measured using a Swoffer meter, which measures stream depth and velocity. Discharge was calculated from Swoffer meter data, using the 0.6 method (velocity at 0.6 of the depth). A staff gage station was installed at the gage station and a pressure transducer connected to a Campbell Scientific 21x datalogger to measure the stage of the stream. This instrument measured stream and air temperature, precipitation and stage levels at 10 minute intervals.

Results

Geology: Bedrock geology in this area is due largely to the intrusion of the Idaho batholith during the Cretaceous. The majority of the bedrock units in this area, including the tonalite seen in our catchment, were formed during this period. Approximately 75% of the Deep Creek watershed consist of exposed bedrock. There was a 50/25% split between tonalite and metasediment, respectfully. The medasediment rocks showed signs of high grade metamorphism, with high concentrations of garnet. Differential weathering was observed in essentially all the metasedimentary rocks.

Most of the landscape seen in the area today was formed by Pleistocene glaciation. Seventeen percent of the Deep Creek watershed is covered by thick (greater than 3m) surficial sediments, the vast majority of which is thick till. The only region of thick, non-till surficial sediments are the area of glacial lake deposits overlain by meandering stream deposits, observed in an auger hole obtained in the meadow's region in the west-central portion of the watershed. The material that makes up the till is composed of 50% sand, 25% boulders, 10% silt, 10% pebbles and 5% clay.

Hydrology: A stage/discharge relationship for the main creek was obtained using 11 discharge measurements, which ranged from 24 cfs to 146 cfs. The hydrograph exhibits a strong daily variation in flow, with a double peak observed on the first day of measurement (6/26/96) and single peaks observed thereafter (Fig. 1). Total nutrient load was calculated by measuring the amount of runoff from the unit hydrograph and multiplying that by the nutrient load from the samples collected. The daily peaks occur consistently between 19:30-20:00, and the daily lows between 11:30-12:00. The annual precipitation rate in McCall area is 40 inches of water equivalent/year. During the past year the area received an amount totaling about 20-30% above average (approximately 55 inches of water equivalent). The unit hydrograph was used to calculate the daily amount of runoff by integrating the area under the curve for each day (Fig. 2). Unit hydrograph data indicates that Deep Creek had the most runoff over the period studied (7.09 inches over 18 days) compared to the other catchments.

A distributary leaves Deep Creek approximately a quarter mile upstream from the gage station . A stage/discharge relationship was obtained for this section of the creek also. The range of data from this stream is 8 cfs (100% of the main stream volume) to 20 cfs (21% of the main stream volume). The 8 cfs represents the final days of measurements. This means that the distributary was removing the same amount of water from the catchment as the main stream at this time.

ANC and Specific Conductance: By far the highest ANC and specific conductance values were registered at site 2, in the lower tributary of the creek (Fig. 3). A comparison between sites 1(gage station) and 5(lower tributary) shows significant differences in ANC and conductance levels above and below the confluence of the lower tributary. This suggests that the tributary (site 5) has a highly significant influence on the values of the main stream. Also, a significant difference was observed between high and low flow at the gage station, with increases in ANC and conductance at low flow. Water from site 3, in an area of metsedimentary outcrops, demonstrated higher values than water from site 4 (in an area of thin sediment, with no metsedimentary bedrock) collected at the same time.

Nutrients: Eighteen water samples were taken in the Deep Creek water shed at 10 locations. Samples were taken at both maximum and at minimum flow. Significant differences in Cl concentration were found within the watershed. The highest levels of Cl were measured in the northern section of the watershed. Concentrations of NO3 were highest in the northern section of the watershed . This is where the greatest amount of burning occurred. Other then the northern section, the concentrations were the same. Sulfate concentrations were highest in the northern section of the catchment. The major result from the chemical analysis is that there is a significant difference in concentrations during high and low flow.

Discussion

Hydrology: Deep Creek has little groundwater storage space within its surficial sediment. The catchment is approximately 15% thick till, nearly all of which is located in the lower tributary's drainage area. The significant daily variations in discharge, and the lack of groundwater storage spaces, suggest that snow melt has been the major source of water in the drainage area for this time. The response of the watershed to precipitation is unknown, since there were no significant rainfall events for which we have continuous discharge data. We would hypothesize, however, the high percentage of bedrock and thin sediment in the catchment would cause the stream to respond quickly to rain events.

ANC: The ANC measured at the outflow of Deep Creek is higher than expected. This is attributed to the lower tributary, which drains an area containing most of the thick till in the catchment, as well as areas of metasedimentary rock. There is significantly higher ANC recorded at site 3 then at site 4, which we attribute to the effect of rapidly weathering metasedimentary rock near site 3. However the ANC recorded at site 3 was not as high as expected based on observed calcite weathering. Calcite weathers rather easily in slightly acidic solutions, and will increase the amount of HCO_3 in solution.

Nutrients: There are essentially no insources of Cl and SO_4 in the watersheds in this region. This would explain the rather consistent concentration values. The main source of nutrient loading in the lower portion of the watershed would come from the water generated from the lower tributary. It is hypothesized that this tributary has source water that is from deep fracture circulating water. This is just a hypothesis that was not examined during this study. The source of NO_3 within the watershed comes from the northern portion of the watershed. This is because the area has significant fire damage and is releasing ash particles into the stream system, which are dissolving and releasing the nutrients. We also believe that nutrient loading is heaviest during the time of the year when runoff is heaviest, thus when snow melt is greatest.

Conclusion: Observations lead us to believe that NO_3 loading is only significant during the period of the year when snow melt is heaviest, and overland flow in the burned areas is high. As the snow pack melts from the burned area, we observed a significant decrease in the NO_3 levels of the water leaving the catchment at site 1. Since, looking at the unit hydrograph data (Fig. 2), Deep Creek has the highest flow at its outlet of all the watershed studied. The majority of the flow from Deep Creek takes place during this period of high flow, when NO_3 levels are highest. Deep Creek should contribute significantly to the nutrient loading of Payette Lake. The nitrate load received from Deep Creek during this study is 721 Kg that is more than Dead Horse 225 Kg that is only logged. Therefore, the long term effects of logging appear to be minimal, while burning seems to have a very significant impact on the system.

Figure 1
Total Discharge Vs. Days

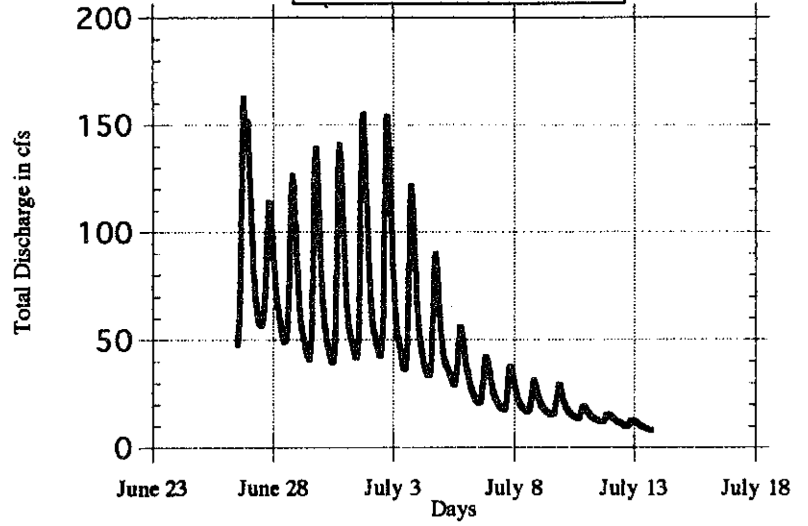

Figure 2
Unit hydrograph Vs. Days

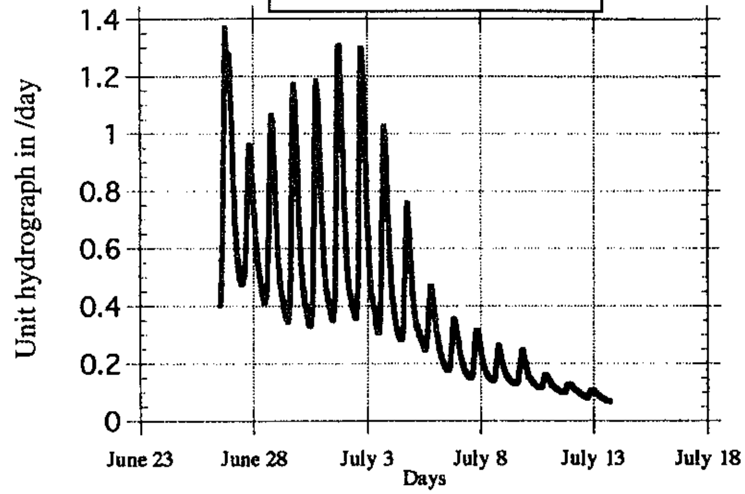

Figure 3
Drawing of the lower portion of the watershed