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Peak Flows at the Alaska Highway from the Rhoads-Granite Creek Drainages Mt. Hayes Quadrangle, Alaska

By

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INTRODUCTION

Riverine flooding often is not noticed until it impacts man's activities. Clearing of natural vegetation and landforms can result in higher peak discharges, thus more noticeable flooding. Riverine processes are dynamic and can also result in changes that produce dramatic effects. All of the above seem to be involved in the flooding and erosion problems related to the ephemeral discharge of the Rhoads and Granite Creek drainages onto recently cleared agricultural lands near the Alaska Highway.

The area affected is the agricultural and surrounding land 14 miles southeast of Delta Junction along the Alaska Highway. Granite Creek, Rhoads Creek, Till Valley Creek and two other unnamed creeks originate in the Granite Mountains and at normal flows disappear into alluvium and morainal material at the foot of the mountains. The upper part of the recharge area is heavily forested and is becoming criss-crossed by an increasing number of trails. The lower part of the recharge area has been cleared for agricultural projects.

Down gradient from the cleared agricultural lands, separated by a green belt, is Clearwater Creek, a clear-water, spring-fed stream with important fishery and recreational values. Because of the spring-fed nature, streamflow in Clearwater Creek varies little and usually has no ice cover in winter. When observed from May 1977 to July 1979, discharge ranged between 650 and 773 cubic feet per second (cfs) (Wilcox 1980). From the beginning of the Delta agriculture development concern about the impact of large scale land clearing on this creek has existed. Originally, these concerns focused primarily on sediment loading and pesticide and fertilizer inputs from cleared land. The increased awareness of the flooding and erosion potential from the Rhoads-Granite drainages have added this to the list of possible impacts.

The flooding from Rhoads-Granite Creeks have been, to date, largely unquantified events. The magnitudes of the flooding events have only been estimated in a few instances and the return period or probability of these flows only cursorily guessed at. Normal methods of estimating flood peaks from ungaged drainages are not appropriate for this drainage because of the large losses of stream flow to ground water, the absence of a stream channel large enough to carry the discharges that occur during flood events, and the heavily forested nature of overland terrain inundated by flood events. These conditions combine to reduce and attenuate flows that would be expected from a drainage of this size. Using the HEC-1 computer model and observed estimated peak flows at the highway and at a gage site on upper Granite Creek, a flood model for the drainage was developed to estimate flood peaks of specified return periods or probability for flows of the Rhoads-Granite Creek drainage where it crosses the Alaska Highway. Because of the nature of the inputs, this model is highly speculative. It is expected that future field work will allow refinement.

METHODS:

As described above, the problem with this study was to estimate peak flows at a site not appropriate for conventional estimating techniques. Information available included observed peak flows for a storm on June 19, 1986 at the Alaska Highway crossing and at a gage site on Granite Creek at the foot of the mountains and the precipitation for that storm from a precipitation gage site in the Granite Mountains. Peak flows for Granite Creek at this upper site can be estimated using conventional methods. The approach taken was to estimate return period peak flows for the upper Granite Creek site, use the HEC-1 computer program to model the drainage basin based on the observed June 19, 1986, storm, and run the calibrated model with the various return period flows at the upper Granite Creek gage site. The principal assumption is that if the model works for the June 19 storm, it will also work for storms of other intensities. Construction of this model consisted of five parts: 1) estimation of flows from the June 19, 1986 storm; 2) acquisition of precipitation data from June 19 storm; 3) estimation of peak flows for Upper Granite

Creek for 2, 5, 10, 25, 50, and 100 year return period; 4) calibration of the HEC-1 model with basin characteristics, rainfall, and discharge information; and 5) running the model with the return period flows developed in part 3.

1. Estimation of flows at the Upper Granite Creek and Alaska Highway sites.

The Upper Granite Creek gage site is located in the NW¼, Section 14, T13S, R11E at the foot of the Granite Mountains at approximately 1825 feet above mean sea level. This site was visited on June 19 with the intention of establishing a stream gage and making a discharge measurement by wading the stream. The stream discharge was so large that wading the stream was impossible. High water levels were marked and surveyed at a later visit when wading the stream was possible. With the survey results and using the slope-area conveyance method a peak discharge of 800 cfs was estimated. Figure 1 shows the location of the upper Granite Creek gaging site as well as other features of the Rhoads-Granite Creek drainage.

The Rhoads-Granite Creek drainage peak flow from the June 19 storm was observed crossing the Alaska Highway on June 20. The cross-sectional area and velocity of the flow in two channels was estimated by Soil Conservation Service personnel. From these observations the flow at the highway crossing was estimated to be 350 cfs.

2. Precipitation data from Granite Mountain.

The Granite Mountain precipitation gage is located in the SW¼, Section 33, T13S, R12E, near the headwaters of Granite Creek and approximately 3800 feet above mean sea level (see Figure 1). The gage consists of an aluminum can 12 inches in diameter and 10 feet high. An "Alter Shield" has been attached to break the force of the wind that blows over the orifice of the can.

While this shield is not the most effective available, no other type had been installed due to adverse weather conditions. The Alter shield is known to underestimate precipitation by as much as 30 percent when compared to a Wyoming type shield which is considered the best currently available. The underestimation problem is more of a concern in winter because snow flakes, less dense than rain, are more affected by wind.

The rain gage is connected to a stilling well which rises as precipitation is added to the gage. The changes in fluid levels are read half-hourly by an Omnidata datapod model 214. The Omnidata recorder is programmed to establish a fluid level trend line and then to record deviations greater than 0.02 feet from the trend line and at least once per day. Thus during periods of no precipitation the recorder will record data only once per day, while during an intense storm the recorder may record at half-hour intervals. The Granite Mountain gage recorded 2 inches of rain during June 19. What is unknown is the contribution of snow and ice melting to the June 19 discharge.

3. Estimating return period flows for the Upper Granite Creek site.

Methods for estimating peak flows at ungaged sites published by the U.S. Geological Survey (Lamke 1979, Parks 1984) gave results that indicate the June 19 peak flow at the Upper Granite Creek gage site has greater than a 10 year return period (or less than a ten percent chance of happening in any given year). However, Soil and Water Conservation District observers estimated that the flows crossing the Alaska Highway on July 20-21 were approximately the same as flood flows across the highway that had occurred six of the previous nine years (Boyer 1987). Based on this information the June 19 peak flow at the upper gage site was assumed to be similar to a two year peak flow (or a peak flow with a 50 percent chance of happening in any given year). On a discharge/area basis this peak flow is similar to the two year peaks for Ruby and McCallum Creeks, two nearby, gaged creeks for which peak flows for 2 to 50 year return periods have been published by the U.S. Geological Survey (Jones 1983). Using the average discharge/area yield (cfs/square mile) for the 5, 10, 25, and

50 year peak flows for these two creeks, peak flows for these return periods were estimated for the upper gage site. The 100 year peak flow was estimated by developing a ratio of 100 year flows to 50 year flows from the results of other peak flow estimating methods. From these other methods it appeared that the 100 year flow should be approximately 1.4 times the 50 year flow.

4. Calibration of HEC-1 model with basin characteristics and June 19 storm rainfall and discharge.

HEC-1 is a program developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center to model peak runoff from precipitation data. With the program one can divide the watershed into subbasins, spatially distribute rainfall events, and use a variety of methodologies to model the rainfall event (U.S. Army Corps of Engineers 1981). The calibration approach was much more empirical than theoretical. Precipitation and discharge estimates at the upper gage site and at the road crossing for one storm were known. The goal during calibration was to make the model produce the desired discharges with the rainfall that fell during June 19. Basic assumptions with model development were that the mountain subbasins had adequate channel capacity for anticipated flows and little channel losses while the lower subbasins have inadequate channel capacity for high flows, high overbank resistance to flow due to the heavily forested nature of the area, and large channel losses to ground water.

All subbasin physical characteristics, such as area, channel length, channel slope, overland flow slope, were measured from the U.S.G.S. 1:63,360 scale maps. Some physical characteristics, such as channel width and shape were estimates (guesses). Of 17 total subbasins, 9 were treated as mountain subbasins. Kinematic routing was used to estimate overland flow and pass the storm input through these stream reaches. In the remaining 8 subbasin storm input was modeled by the SCS unit hydrograph method and flow routed through the subbasins by the normal-depth storage and outflow method (U.S. Army Corps of Engineers 1981). HEC-1 has no good method of including the large channel losses that occur in the lower reaches of the Rhoads-Granite Creek drainage so those were modeled by including diversions at the downstream end of subbasins that were believed to be affected by large channel losses. The amount of diversion at these points was based on channel length with the assumption that channel losses within a subbasin were based on channel length.

Figure 2 is a schematic diagram of the Rhoads-Granite Creek model. Each box represents a subbasin (G1 stands for the first Granite Creek subbasin, for example) or a model routine, such as a combination of flows from two or more subbasins (COMn) or routing of flow through a stream reach (RTn) (see Figure 1 for the geographic location of the model components).

Figure 2. Schematic diagram of Rhoads-Granite Creek model

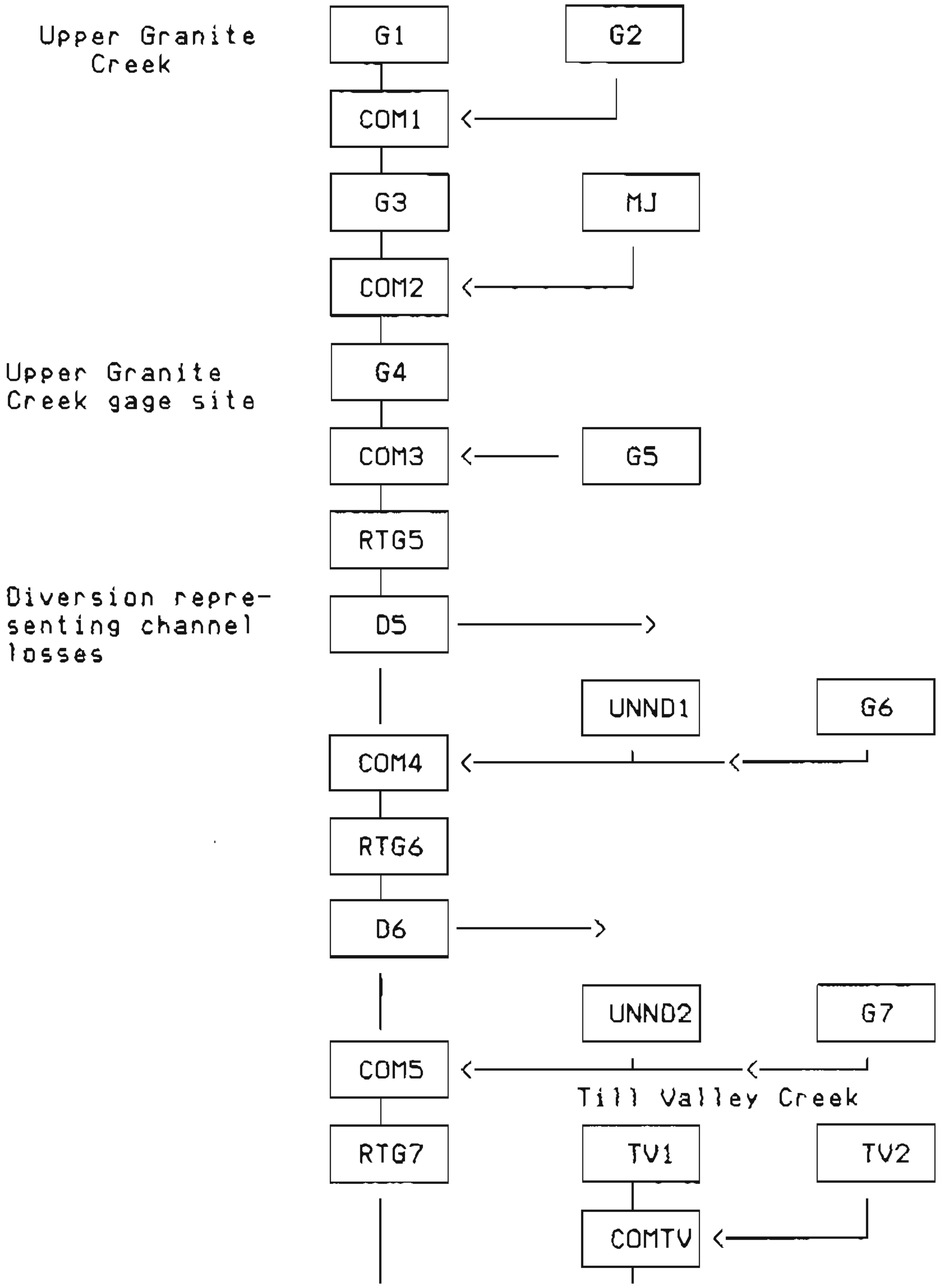
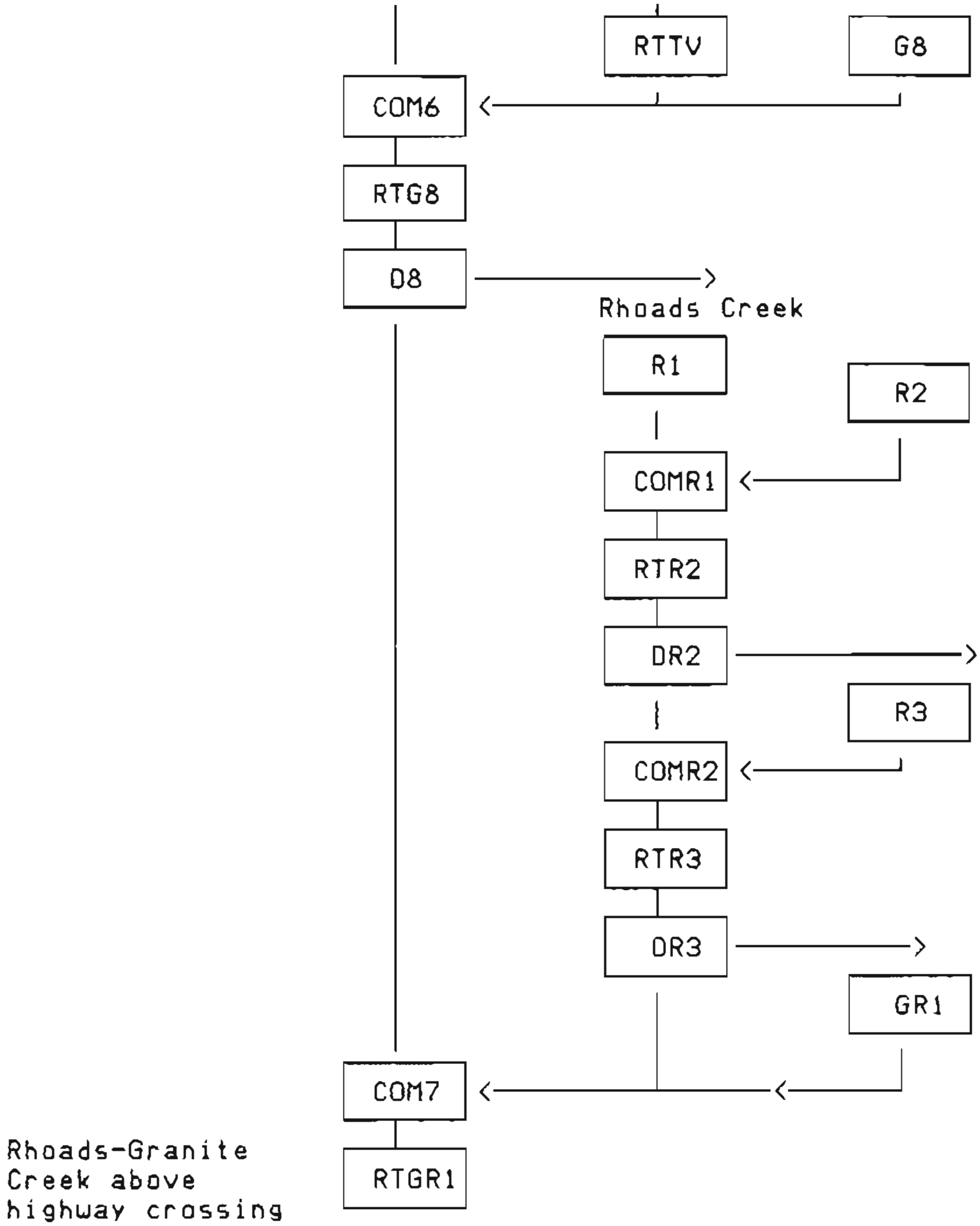


Figure 2. (cont) Schematic diagram of Rhoads-Granite Creek model



Once the subbasin data was edited for accuracy, the model was run with the June 19 storm data to determine closeness to the June 19 storm peak flows at the upper gage site and at the highway crossing. Subbasin parameters were adjusted until peak flows matched the June 19 estimates. Channel and overbank roughness coefficients, curve numbers, and channel losses (diversions out of the system) are the parameters which were adjusted to make the model fit the observed discharges.

5. Model operation.

With the model closely estimating the June 19 and June 20 peak flows with the June 19 rainfall as input, the rainfall data set was changed to have the model calculate at the Upper Granite Creek gage site the return period flows estimated in part 3 above. The June 19 storm peak at the upper gage site approximated the estimated 5 year peak and for this report that flow is considered the 5 year peak. For the 2, 10, 25, 50 and 100 year peaks, new storms were introduced to model those flows. Also, rainfall was gradually reduced to estimate the maximum flow at the upper gage site that corresponds to no flow at the highway crossing.

RESULTS AND DISCUSSION:

The Rhoads-Granite Creek drainage above the Alaska Highway crossing has a total area of approximately 81 square miles. For this study the drainage was divided into mountain and forested drainages. As described above, the flow at the Alaska Highway crossing originates in the mountains and is slowed down, and except for infrequent storms, is totally lost in the lower forested part of the drainage. The mountain drainage has an area of 47.1 square miles and the forested drainage 34.1 square miles. Of that, upper Granite Creek (the Granite Creek drainage above the gage site) has an area of 32.2 square miles, approximately 40 percent of the total area and 68 percent of the mountainous area. The mountainous portion of the Rhoads Creek drainage has an area of only 4.64 square miles. Thus, while the road crossing flows have frequently described as coming from Rhoads Creek, most of the flow can be attributed to the upper Granite Creek drainage.
The remainder of the mountainous part of the drainage (10.1 square miles) is comprised of Till Valley Creek and two unnamed creeks.

Pertinent to the flooding at the highway crossing is the evidence that Granite Creek just below the present upper gage site has changed channels within the past five to ten years (see Figure 1). Previous to the channel change it appears that the total Granite Creek flow was directed in a more westerly channel. Flow in this channel would cross the Alaska Highway approximately five miles closer to Delta Junction. Dividing the flow carried by the present Rhoads-Granite Creek system of channels so that 60 percent was carried in a totally different channel system would create much greater surface area for system losses and allow for much greater attenuation of flood peaks. This may be part of the reason flood peaks across the Alaska Highway were not noticed until recently. The recent channel change appears to be permanent with little chance of natural redirection to the older channel.

Table 1 presents the return period flows for the upper gage site with the corresponding flow at the highway crossing estimated by the HEC-1 model and the time the peak takes to reach the highway crossing from the beginning of the storm. The predicted flows above the highway range from 320 to 3730 cfs. The time it takes these flows to reach the Alaska Highway from the start of the storm ranges between 48 and 31.5 hours, respectively. The flows at the highway are between 38 to 69 percent of those predicted for the upper site. When flows at the upper site drop below 300 cfs the model shows no flow at the highway. Previous work by Ed Grey of the Soil Conservation Service indicated that the culverts at the Alaska Highway could pass 130 cfs. Thus, the estimated 2 year return peak flow (or flow that has a 50 percent chance happening in any given year) would be too much for the highway culverts.

Table 1. HEC-1 Model Results.

RETURN PERIOD	UPPER GRANITE PEAK (cfs)	ALASKA HIGHWAY PEAK (cfs)	TIME OF PEAK AT GAGE (1)	TIME OF PEAK AT HIGHWAY (1)	RATIO OF HYW TO GRANITE	CHANNEL LOSSES (cfs)
Q2	840	320	18.0	48.0	0.38	379
Q5	1300	770	10.5	40.5	0.59	415
Q10	2070	1090	10.0	37.5	0.53	433
Q25	3020	1600	10.5	34.5	0.53	436
Q50	3900	2030	10.5	33.0	0.52	440
Q100	5400	3730	13.0	31.5	0.69	440

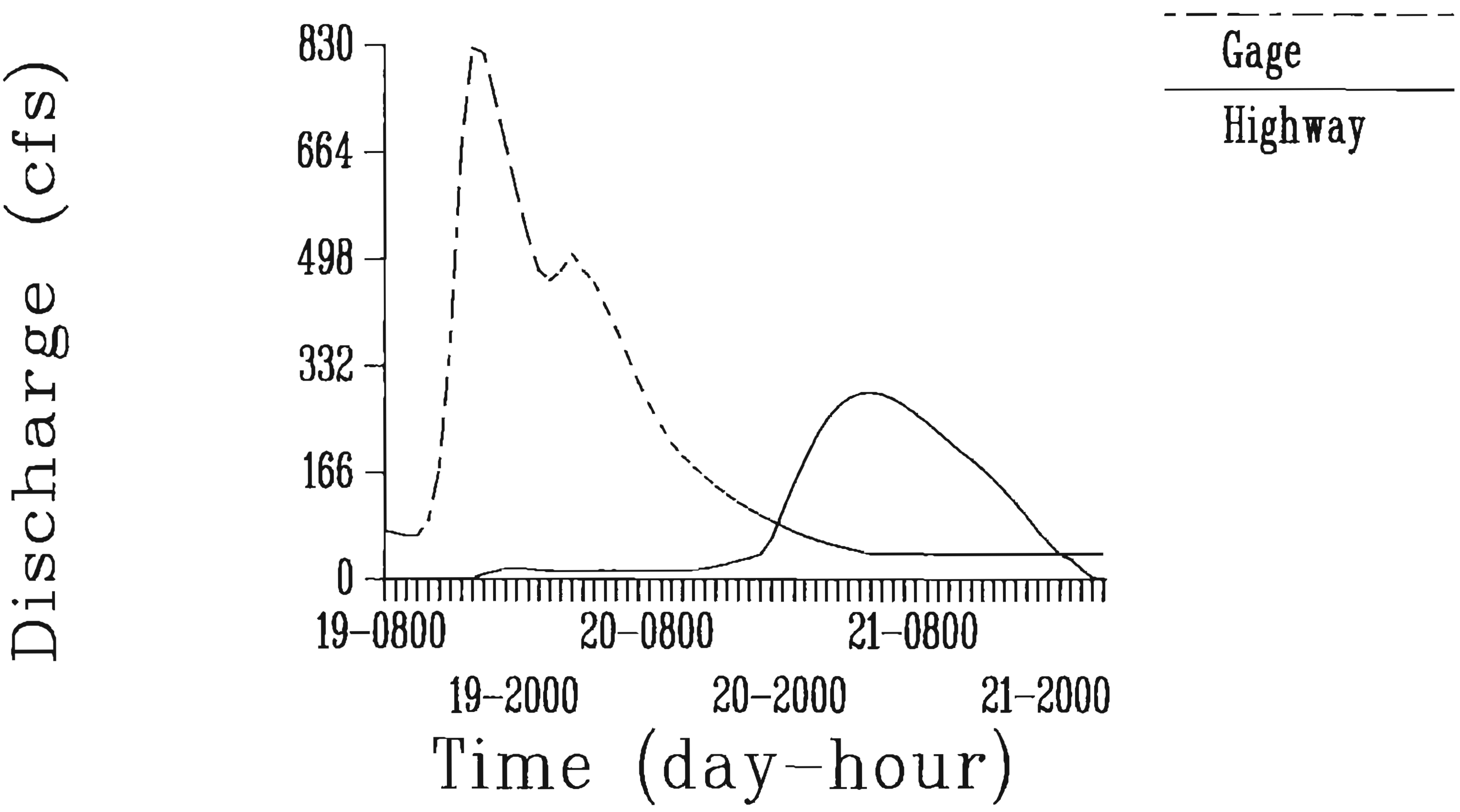
Flows less than 300 cfs at the Upper Granite Creek site do not make it to the Alaska Highway

(1) Hours from start of storm precipitation.

These results tend to fit the observed flows of the past few years. The storm of last year is estimated to fit in the range of a two year event or, in other words, is an event with a 50 percent chance of happening in any given year. Recent flooding across the highway appear to fall in the this range. Larger flows than these have not been reported. Because of the recent joining of the Rhoads and Granite Creek channels, it is not surprising that larger floods have not been observed.

Figure 3 shows the hydrographs at the upper gage site and above the highway crossing as estimated by the model for the June 19 storm. This information is important because knowing the duration and volume of the flow crossing the highway may be as important as knowing the instantaneous peak flow. Of note are the lag in time and attenuation

Figure 3. June 19 storm hydrograph at highway and gage



in peak caused by the forested area during a flood. The peaks predicted by HEC-1 fit well but it is unknown how well the complete hydrographs fit the actual June 19 storm hydrographs at these sites. Valuable information for improvement of the model would be complete hydrogaphs for a particular storm at both sites.

The potential for error in this analysis should not be overlooked. Three major possible sources exist: 1) error in the estimation of the peak flows observed this summer; 2) error in the estimation of the return period flows for the upper gage site; and 3) the assumption that if the computer model fit the June 19 storm, it would model other storms as well.

The June 19-20 peak flows at the upper gage site and above the highway crossing were only estimated. The peak at the upper site was determined by the slope-area method with one cross section. High water marks were available to determine the slope of the peak flow. The estimated flow is sensitive to Manning's n for which 0.040 was chosen. The flow estimated at the lower site was based on cross sections and estimated average surface velocities. Small changes in the velocities can result in considerable changes in computed discharge.

The estimation of the return period flows at the upper gage site is based on Upper Granite Creek having floods similar to those at Ruby and McCallum Creeks. This assumption appears good for more frequent floods, such as the two year peak flow, but may not work as well for more infrequent floods. The periods of record for the two gaged basins are 16 and 18 years, a good database for Alaska. Still, 18 years of record is not long enough to confidently predict a 100 year peak flow.

Assuming that the June 19-20 flows and the return period peak flows are reasonably accurate, that the model correctly estimates June 20 flow at the highway crossing is no guarantee that the model correctly estimates the other return period flows at the highway. The model is sensitive to several factors that, if changed, would significantly affect the estimated flows. Most important is the amount of channel losses. If channel losses occur differently than as modeled, for example, less at lower flows or more at higher flows, estimated flows would be different. Also, changes in channel widths which were estimated and overbank resistance could affect the model results. Field work this coming summer could refine these parameters.

It should be noted that the model was not designed to accurately predict peak flows from a given rainfall event at any point within the drainage. Two reasons exist for this. One is that rainfall input was used solely to drive the model. For different return period discharges at the upper gage site, rainfall was added to or subtracted from the June 19 storm data until the desired flow was achieved. For running the model the important values were the discharges at the upper gage site, not initial rainfall data. Secondly, the June 19 storm flood was affected by snowmelt at higher elevations which is not considered in the rainfall data used to develop the discharge at the upper gage site. The June 19 storm was relatively early in summer with snow still in the mountains. A period of warm, sunny weather could have induced a high base flow and made the antecedent conditions ripe for proportionately high runoff from any rainfall. Similar storms occurring later in the summer might not have produced the same runoff.

FUTURE WORK:

Much can be done to improve the results of this model or at least to develop more confidence in the results. Discharge at the highway needs to be better measured or estimated. A stage-discharge relationship needs to be developed for a reach (or reaches) above the highway crossing, ideally, with some device to record peaks and times of peaks. The drainage system between the lower and upper sites needs to be investigated to determine flood paths and channel characteristics. The upper site stream and precipitation gaging program should be continued to develop more information on the characteristics on the upper portions of the drainage system.