Hydrologic Process Identification
For
Eastern Oregon

Prepared for

Oregon Watershed Enhancement Board

Prepared by

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February 28, 2001

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Hydrologic Process Identification for Eastern Oregon

1.0 INTRODUCTION

The purpose of this study is to determine the hydrologic processes which produce peak flows in streams situated in eastern Oregon. This report was prepared at the request of the Oregon Watershed Enhancement Board to provide a background hydrologic reference for Watershed Councils and others embarking on watershed assessments. Background information on both the season in which peak flows occur and the type of hydrologic processes which generate peak flows can support watershed analyses undertaken to assess land use impacts on aquatic resources. Peak flow increases in response to land use activities can be problematic if they alter the channel geometry and subsequently produce negative impacts to aquatic habitat. Analysts conducting watershed studies should understand which types of hydrologic processes are producing peak flows in their watershed prior to selecting appropriate analysis tools.

Background on Peak Flow Generating Processes

Several distinct types of peak flow generating processes can occur in eastern Oregon watersheds including rainstorms, winter and spring rain-on-snow events, spring snowmelt, and cloudburst storms or thunderstorms. A combination of antecedent climatic variables such as temperature, precipitation, snowpack, wind, solar radiation, etc influence the generation of peak flows.

Winter peak flows are generally produced by rainfall or rain-on-snow events and as illustrated in Figure 1 show a distinct large spike in the hydrograph during a period of relatively low flow (MacDonald and Hoffman 1995). Temperature can influence the form of the precipitation (rain vs. snow) and also the condition of the ground (i.e. frozen). Precipitation falling as rain in a forested watershed does not route directly to the stream, however, as the impervious nature of the ground surface increases a corresponding increase of overland flow occurs. Frozen ground constitutes an impervious surface thus rainfall striking the ground will be immediately routed to the channel resulting in a rainfall generated peak flow. If snowpack is melted as well, the peak flow is augmented correspondingly, a rain-on-snow event. The USGS uses a temperature index (TI) as a variable in two of their four regional flood frequency regression equations (Harris, 1983). The temperature index, representing the mean minimum January air temperature, provides an indication of areas susceptible to snow and frozen ground conditions. When possible, temperature data along with rainfall and snow depth data were investigated to assign a hydrologic process to each event.

Spring peak flows produced during the snowmelt period are initiated by increased solar radiation and occur over a sustained period of time (up to several weeks). The spring rain-on-snow process can cause a quick spike on the already elevated high flow portion of the hydrograph (sustained by spring snowmelt) as shown in Figures 2 and 3. Spring and summer thunderstorms

are often very localized and can produce a distinct quick spike in the hydrograph similar to winter peak flows (Figure 4).

Figure 1: Example Winter Rain-on-Snow Hydrograph

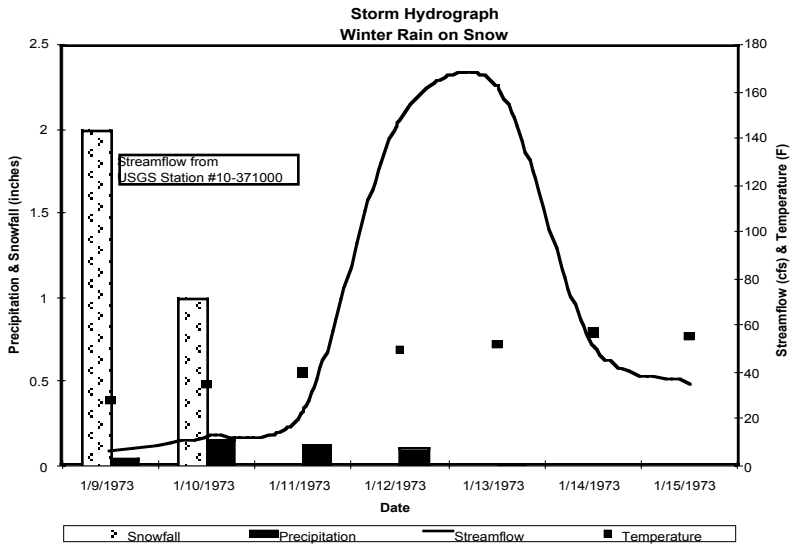


Figure 2: Example Spring Rain-on-Snow Hydrograph

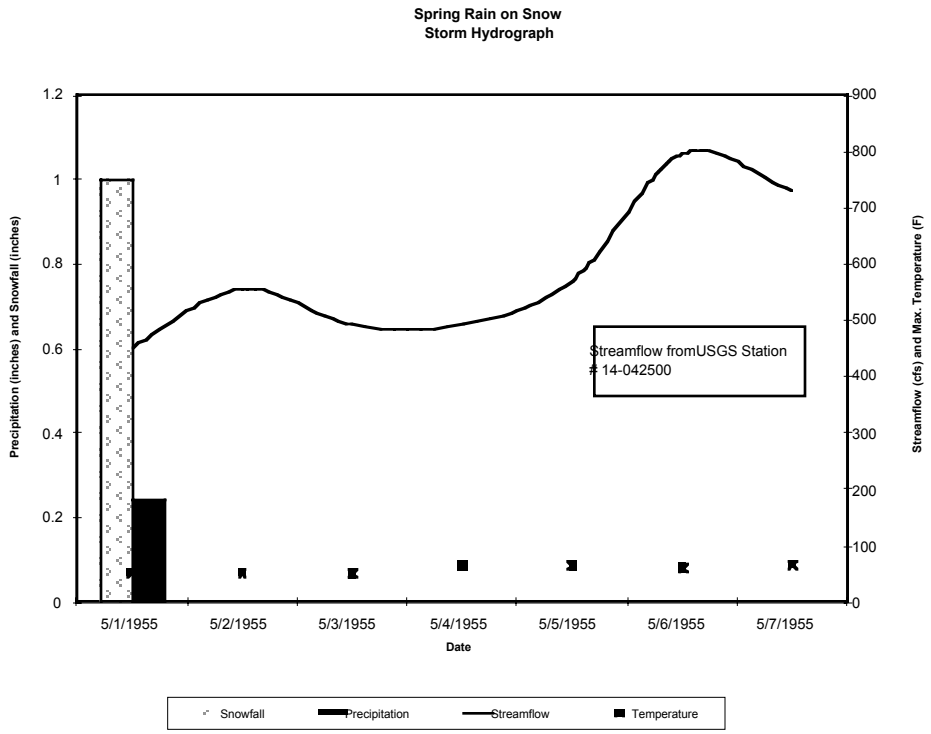


Figure 3: Example Snowmelt Hydrograph

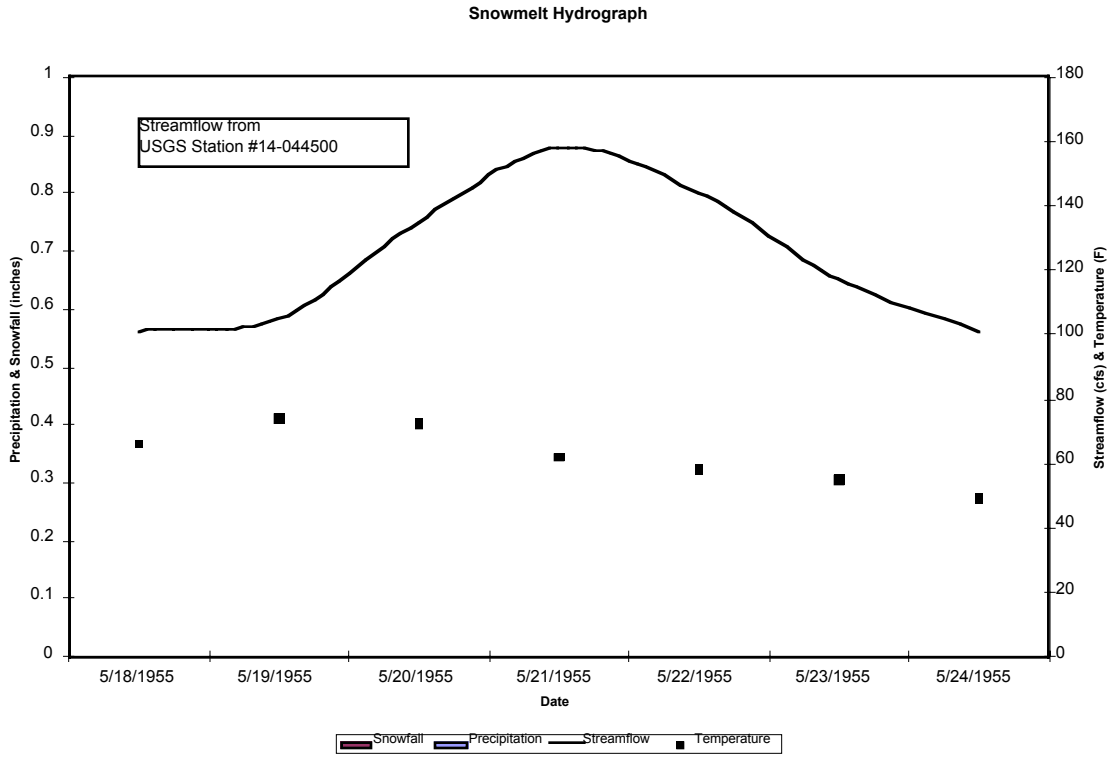
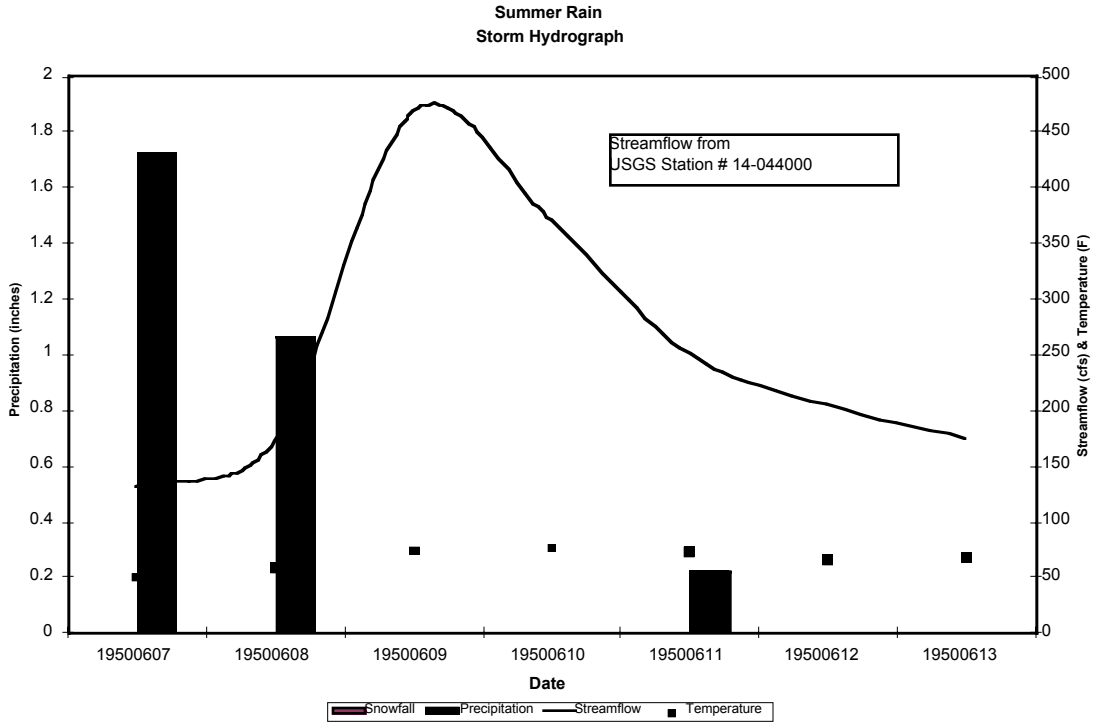


Figure 4: Example Summer Rain Hydrograph



1.1 Description of Study Area

The focus for this study encompasses all the lands in the state of Oregon east of the Cascade Mountain Range. Eastern Oregon covers a large area including four major mountain ranges (Cascades, Blue, Ochoco, and Wallowas), part of the Columbia River basin and high plateaus (i.e. lava plains, and Owyhee uplands). The climatologic and hydrologic patterns differ across this large area and can be better understood when the landscape is divided into smaller spatial units. Several spatial classification systems are currently available which have divided this report's study area into regions of similar characteristics. Three of these systems will be discussed in this report: ecoregions as delineated using EPA guidelines (Oregon Natural Heritage Program), physiographic regions used by the U.S. Geological Survey (USGS) (Harris, 1982), and climatic zones identified by Oregon Climate Service (OSC, 1999).

Ecoregions are defined as areas of general similarity in the type, quality, and quantity of environmental resources (e.g. geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology). As such, they provide a spatial framework for ecosystem research, assessment, management, and monitoring. Kagan (2001) and Pater, et. al. (1997) delineated a hierarchical set of ecoregions for Oregon; the Level III and Level IV ecoregions in eastern Oregon are described in Table 1.

Physiographic areas are identified based on meteorologic and hydrologic patterns. For the purpose of estimating the magnitude and frequency of floods in eastern Oregon, the USGS

(Harris, 1982) identified four principal physiographic areas (Table 2). Specific climate zones are delineated by Oregon Climate Service; those pertinent to this report are described in Table 3.

The overlap between the ecoregions and the climate zones is apparent on Map 1; physiographic zone boundaries were not available digitally. While similarity exists among the regions designated in these three classification systems, differences occur along the edges of the boundaries. Most noticeable is that the South Central climate zone (Zone 7) includes most of the Basin and Range, Lava Plains, and part of the East Cascades ecoregions. The physiographic regions are general boundaries and include a variety of ecoregions. Physiographic Region 1, the Southeast Region, is similar to the climate zone South Central, Zone 7, but covers most of the southern section of Eastern Oregon. Physiographic Region 2 is mainly the Blue Mountains and Lava Plains. Physiographic Region 3 includes Columbia Basin ecoregion and the western side of the Lava Plains Ecoregion, and Region 4 corresponds well with the Eastern Cascades Ecoregion.

For the purpose of this investigation, we have presented data and organized findings primarily using the Level III Ecoregions in Pater (1997) and Kagan (2001). For ease in analysis and presentation, information is often summarized or sorted by county in addition to ecoregion.

Table 1: Description of Eastern Oregon Ecoregions (Pater [1997]and Kagan [2001])

Ecoregion	Description
West Cascades (Ecoregion 4)	The Cascades Range is mountainous with steep ridges and wide river valleys resulting from alpine glaciation. The moist temperate climate supports a highly productive coniferous forest.
East Cascades (Ecoregion 9)	The East Cascades is less steep and has fewer streams than the West Cascades. This region exhibits greater temperature extremes and less precipitation than the ecoregions to the west. Annual precipitation ranges from 14 to 26 inches.
Columbia Basin (Ecoregion 10)	This region is greatly influenced by the Columbia River. Most of the topography is wide lava plains cut by rivers that flow into the Columbia River. The climate is dry with less than 15 inches of rainfall per year.
Lava Plains (Ecoregion 11)	This region is a high lava plateau cut by the Deschutes, John Day and Crooked River. Elevations range from 3,500 and 4,500 feet. The climate is arid, with less than 20 inches per year.
Blue Mountains (Ecoregion 11)	This ecoregion includes three mountain ranges: Blue Mountain, Ochoco, and Wallowa mountains. The area has deep canyons, high plateaus, broad river valleys, and mountain lakes, forests and meadows. Short dry summers and long cold winters characterize this region.
Basin and Range (Ecoregion 10)	The Basin and Range area is typified by flat basins cut by north-south mountain ranges. The climate tends to be dry with an extreme range of daily and seasonal temperatures.
Owyhee Uplands (Ecoregion 0*)	The Uplands region is a broad, rolling plateau cut by deep river canyons. The elevation ranges from 2,000 to 6,000 feet. The climate is extreme with wet springs, cold winters and hot summers.

* More recent ecoregions designations by the ONHP have not yet been integrated into the numbering scheme.

Table 2: Description of Eastern Oregon Physiographic zone (USGS & Harris, 1982)

USGS Physiographic Zone	Description
Eastern Cascades Region	Average annual precipitation, which mainly occurs as snow, ranges from 20 inches to more than 100 inches at higher elevations. Peak streamflows are usually caused by snowmelt.
Northeast Region	Average annual precipitation mostly ranges from 10 to greater than 80 inches in the Wallowa Mountains. Peak streamflows result from snowmelt and rainfall. Cloudbursts are common.
North Central Region	Average annual precipitation is usually between10 and 25 inches. Peak streamflows are caused by snowmelt, rainfall and occasional summer cloudburst storms.

Southeast Region	Average annual rainfall ranges from 10 to 30 inches. Peak streamflows result from snowmelt and rainfall. Cloudbursts are common.

Table 3: Description of Eastern Oregon Climate Zones (OCS & G. Taylor, 1999)

Climate Zone	Description
Northern Cascades (Zone 4)*	This zone extends south from the Columbia River to latitude 43:50:00, and has an average elevation greater than 9,000 feet. Most precipitation falls in the winter with snowfall varying with elevation. The average annual precipitation is greater than 80 inches with peaks above 150 inches per year, which usually falls as snow. Temperature correlates with elevation and ranges from the low 60's in the summer to middle 30's in the winter.
North Central (Zone 6)	This zone is in the rain shadow of the Cascades, and extends from the Columbia Basin south to mountain country. The climate is dominated by winter rainfall with average annual precipitation ranging from 12 to more than 40 inches depending on elevation. The temperature is moderated by the maritime influence of the Columbia River.
Northeastern Oregon (Zone 8)	This area is the northeastern section of the state that is mountain and valley topography. The annual average precipitation is greater than 20 inches. Most of the precipitation occurs in the winter and late spring. This zone has a range of temperatures from the 30's in the winter to 80's in the summer.
Southwest Valleys (Zone 3)*	This is one of the more rugged topography of the state, which strongly influences precipitation. Average annual precipitation ranges from 20 inches to greater than 120 inches at higher elevations. Most precipitation falls in the winter months. During the summer, this zone is the warmest with temperatures in the 90's, but winters cool to the low 30's.
High Plateau (Zone 5)	This zone is bordered by the Cascades to the west and minor mountain ranges to the south and east. Average annual precipitation ranges from 12 to 20 inches and is dependent on elevation and east-west orientation, with the western areas getting as much as 65 inches per year. The mean daily temperature ranges from 60's in the summer to 30's in the winter.
South Central (Zone 7)	This zone is the largest and is mostly high desert – prairie region. The average precipitation is low, about 15 inches per year. Most falls in the winter months. The summers are moderate with mean daily temperatures in the 60's and winters are cool with temperatures in the 30's.
Southeastern Oregon (Zone 9)	This zone varies in topography with high desert, mountains, plateaus and river valleys. The precipitation is scattered throughout the year and is usually less than 15 inches per year. The summers are warm with temperatures in the 90's and winters are cool with temperatures in the 30's

* (note: no streamgages or climate stations are located in this zone, only SNOTEL and snow course sites)

2.0 METHODS OF HYDROLOGIC ANALYSIS

2.1 Data Collection

In order to identify the hydrologic processes present in eastern Oregon, all available data from streamflow, climate, snow course and SNOTEL stations located within or near the study area were identified and summarized. U.S. Geological Survey (USGS) streamflow station information was obtained from EarthInfo Inc. (EarthInfo, 1996), from the USGS publications and their web site. Climate station data were acquired from the Desert Research Institute, Western Regional Climate Center in Reno, Nevada. Snow course and SNOTEL station information was obtained from the Natural Resources Conservation Service (NRCS) website.

Numerous streamflow, climate stations, and snow course and SNOTEL sites are located in eastern Oregon. All of these data series provided useful information, however, some of the streamflow stations were not appropriate for analysis of peak flows due to limited data, regulation of flows etc. Streamflow stations were reviewed for inclusion in this study based on the selection criteria discussed below. Maps 2, 3 and 4 show the selected streamgages, climate stations, and snow stations, respectively.

2.2 Stream Gage Selection

Selection criteria were developed and systematically applied to all of the 376 streamflow stations prior to analysis of peak flows. The following criteria were used in this study and are similar to those used in MacDonald and Hoffman (1995):

1) the streamflow station must have at least ten years of continuous data;
2) the gage must be located in a drainage basin smaller than 150 square miles; and,
3) the watershed must not have large lakes or regulation which would affect peak flows.

To obtain a representative sample size for flood frequency analysis, a minimum of ten years of continuous streamflow or annual peak flow data was selected as a criterion. Some gage records initially indicated a sufficient period to meet this criterion, however when actually examining the data, the records had missing dates, flows, or both. If the missing information reduced the record to an unusable point (i.e. less than 10 years of record), these gage records were eliminated from further analysis. In one case, a gage with less than 10 years was retained because it was the only gage closest to meeting the criterion in the whole of Gilliam County.

Gilliam County, located in Columbia Basin Ecoregion, has three USGS streamgage sites. One has a drainage area greater than 150 square miles and was deleted from the analysis. The other two gages did have drainage areas less than 150 miles but only one (14-047470) had 10 years of data. Inspecting the data for 14-047470, revealed that three years had unknown discharges, dropping the total years to 7. The other gage had only six years of data, so 14-047470 was retained as a representative for Gilliam County even though it did not meet the 10-year requirement.

This study was limited to gages draining basins less than 150 mi^2 because larger basins incorporate more spatial and temporal variability in meteorologic conditions which makes it more difficult to ascribe a specific peak flow to a particular cause (MacDonald and Hoffman, 1995). Since large lakes and diversions complicate the analysis of how peak flows relate to climatic conditions, watersheds with these features were excluded from this study. Streamflow records which reported regulated flows for canals, diversions or mine drainage tributaries were not included in the this analysis. Information on diversion history was difficult to obtain however, and therefore there may be stations included in this report that record streamflow depleted by numerous withdrawals. In attempt to quantify the withdrawals, county water masters were contacted. Many of the streams had small drainage areas, with low average flows so the withdrawals were not monitored. In many cases, the U.S. Geological Survey did not maintain details on diversions and or regulation on discontinued gages. The irrigation season in which most diversions would occur spans the period April 1 through September 30. The spring and summer peak flows are, therefore, the most affected by any diversions.

MacDonald and Hoffman (1995) also used a criterion focused on overlapping SNOTEL and streamflow records. This criterion was not applied in this study due to the distribution of SNOTEL sites and limited overlapping SNOTEL and streamflow data. The SNOTEL sites in eastern Oregon are mostly situated in the Cascades and Blue Mountain regions; the Columbia Basin Ecoregion and Lava Plains do not have any SNOTEL or snow course and the Owyhee has only 2 snow course sites (Map 3 and Table 4). Snow course data, while available in some areas, were insufficient to analyze in conjunction with streamflow data since snowpack was measured once or twice per month and no continuous measurement of precipitation was available at these sites.

Of the 376 streamflow gaging stations located in eastern Oregon, 126 met the criteria stated above (Table 4 and Map 2). Most of these gages were located in the Blue Mountains ecoregion with the East Cascades region second in representation. Much of the large expanse of area in the Basin and Range and Owyhee Uplands ecoregions are not well represented by streamflow records or climate records.

Table 4: Number of Streamflow, Climate, and Snow Stations in Ecoregions

Type of Data Collection Station	*West Cascades*	*East Cascades*	*Columbia Basin*	*Blue Mountains*	*Lava Plains*	*Basin and Range*	*Owyhee Uplands*	***Total***
Streamflow	4	30	14	55	12	5	6	126
Climate	2	12	9	18	15	4	4	64
SNOTEL	20	7	0	24	0	2	0	53
Snow Course	20	22	0	20	0	10	2	74

Summary tables listing each of the streamflow, climate and snow stations are located in Appendix I *Background data tables of eastern Oregon.* To facilitate presentation, the information is

reported according to the County in which the collection sites are located with additional cross-reference to ecoregion. The list of streamflow stations, omitting those that did not meet the criteria, is otherwise comprehensive including all the continuous streamflow recording gages as well as annual peak flow stations maintained by the USGS.

2.3 Hydrologic Process Identification Methods

Identification of Dominant Season of Peak Flow Occurrence

The dominant season of peak flow occurrence was determined by analyzing the annual peak flow series for each gage that met the criteria. Peak flows were then classified by season (winter, spring, summer, or fall) and a graphical illustration of the monthly peak flow distribution was generated for each gage (Appendix II).

Rain-on-snow events generally occur during the late fall and winter season or in the springtime. For purposes of this report, the late fall/winter season will be referred to as *Winter* covering the period from November 1 to March 20; early fall (*Fall*) covers the period from September 21 until November 1. Winter rain-on-snow events can begin to occur in November when a shallow snowpack may have developed. It is rare for this to occur as early as October. The first day of spring, March 20, was selected as the cutoff date between the winter and spring seasons; therefore, the *Spring* season ranges from March 21 until June 20 and *Summer* ranges from June 21 through September 20.

For each gage, the annual peak flows were tallied by season (Tables 7A to 7H). Then to each gage a code was assigned describing the dominant season or mix of seasons in which peak flows occurred. Some gages showed clearly that the peak flows occurred primarily in one season, while others showed a mix of seasonal occurrence. It was necessary to develop additional categories of peak flow dominance to describe the patterns that emerged. Several of the gages showed the majority of the annual peak flows occurring in either the winter or spring and yet the largest of the peak flows systematically occurred in a different season; for instance, peak flows at some gages occurred most often in the spring, but most of the top five occurred in winter. These cases were coded as spring dominant with winter large peaks. Maps 2, 4 and 5 show the stream gages color-coded by the six designated peak flow season descriptors:

1. clear winter dominance
2. clear spring dominance
3. spring with largest flows in winter
4. winter with largest flows in spring
5. mix of winter and spring occurrences
6. mix of spring and summer peak flow or just summer peak occurrences

This coding was used to describe the majority of peak flows recorded at a gage; peak flows may have occurred in other seasons as well. Most of the gages had occurrences in several seasons as noted in Tables 7A through 7H.

Identification of Specific Type of Hydrologic Process

Once the dominant season of peak flow occurrence was identified, further analysis was conducted to determine which specific types of hydrologic process were active (e.g. winter rainstorm, winter rain-on-snow, spring rain-on-snow events or spring snowmelt peaks). In most cases, to determine the dominant hydrologic process, the annual maximum flows were associated with nearby snowmelt and climatic data for overlapping periods of record.

Available climate data (precipitation, snowfall, snow depth, snow water equivalent, temperature) from nearby stations were compiled for five days preceding a peak flow event. This time frame was selected since streamflow tends to respond to an individual rainfall event (MacDonald and Hoffman 1995). The nearest climate station with overlapping records was used to evaluate the presence of rainfall in a basin. The closest SNOTEL or snow course stations were also examined. From this information, the type of event was determined; that is, whether the peak flow was attributed to rainfall only (WR= Winter Rain, SPR = Spring Rain, or SumR=Summer Rain), snowmelt only (SM), rain-on-spring snowmelt (SROS), or winter rain on snow (WROS) or unknown (UNK). Each peak flow in the annual maximum series that overlapped with the corresponding climate data was assigned one of the event types.

In some regions, the comparison of streamflow to SNOTEL or climate data was a straightforward exercise. In other regions such as eastern Oregon, difficulties in discerning the dominant process arose particularly due to the lack of overlapping SNOTEL, climate, and streamflow data. Each streamflow station was linked to a nearby climate and SNOTEL station for antecedent dates of each peak flow, however overlap was sparse and often the overlap did not cover all peak flows at a station. In addition, several of the climate stations had missing data points (often temperature). In the absence of adequate SNOTEL and climate data, the following assumptions were made to assign a hydrologic process to a peak flow event.

Assumptions for winter peak flows:

1). If rain occurred and snowfall or snowdepth (no matter how little) were recorded in any of the five preceding days, then the event was categorized as a WROS.

2). If rain occurred but no snowfall or depth was recorded, the peak flow was assumed to be produced by a winter rainstorm.

3.) In the absence of recorded rain or snow on any of the preceding days during a winter peak flow event, the type of generating process was unknown. In this case, the climate station did not appear to pick up the storm that the watershed experienced; this unknown category could include winter snowmelt induced peaks however, these were deemed to be limited due to cold temperatures in eastern Oregon.

Assumptions for Spring Peak Flows:

1) If rain was recorded at the station, the peak flow was assigned to the Spring Rain/Spring Rain-on-snow category.

2) In the absence of recorded rain or snow on any of the days preceding an April or May peak flow event, the peak flow was assumed to be generated by solar-radiation or wind induced snowmelt.

Assumptions for Summer Peak Flows:

1) In the absence of recorded rain or snow on any of the preceding days, peak flows were assumed to be generated by a localized storm cell centered over the watershed not detected in the nearby climate station data; the peak flow was counted as a summer rainstorm.

In several of the eastern Oregon ecoregions (West Cascades, northern portion of the East Cascades, Columbia Basin, Lava Plains, and Owyhee Uplands), the majority of annual peak flows occurred in the winter season. Where winter was the dominant season, the hydrologic process question was reduced to discerning rainfall events from rain-on-snow events. The majority of annual peak flows in the remaining eastern Oregon ecoregions (southern portion of the East Cascades, Blue Mountains, and Basin and Range) occurred in the springtime. Where spring was the dominant season, the hydrologic process was reduced to differentiating snowmelt events from spring rain-on-snow events and the occasional spring cloudburst storm.

The potential role of snowmelt in producing peak flows in some of these ecoregions was better understood by conducting a correlation analysis to define more specifically the likelihood that snowmelt was available to contribute to the peak flows. Snow water equivalent versus elevation equations were derived to determine the elevation above which a snowpack developed under average conditions. Equations were computed for the months of January and February for each of the ecoregions demonstrating winter peak flow dominance; equations were developed for April and May for each spring dominated ecoregion. The equations served to identify the elevation below which on average only minimal snow water equivalent is available to be melted or an approximate snow level for each given season in each ecoregion (Tables 5a and 5b).

Table 5a: Estimated Snow Levels* for Ecoregions with Winter-Dominated Peak Flows

Ecoregion	January/February Snow Level (feet)
West Cascades	2000
Northern Section of East Cascades	3500
Owyhee	4700

***Snow levels estimated by monthly correlation of snow water equivalent and elevation of stations**

Table 5b: Estimated Snow Levels* for Ecoregions with Spring-Dominated Peak Flows

Ecoregion	April/May Snow Level (feet)
Blue Mountains	3600
Southern Section of East Cascades	3500
Basin and Range	5500

***Snow levels estimated by monthly correlation of snow water equivalent and elevation of stations**

These estimated snow levels (shaded areas on Map 6 [to be produced when DEM's are available]) were assumed to apply across the region. Winter peak flows occurring in basins below the regional snow level (Table 5a) were assumed to be predominantly rain generated; winter peak flows occurring in basins with mean basin elevation above the regional snow level were assumed to have more frequent rain-on-now events. Spring rain versus rain-on-snow was not discernable using only the climate data. Spring peak flows occurring in basins below the regional snow level (Tables 5b) were assumed to be predominantly rain generated while those occurring in basins with mean basin elevation above the snow level were assumed to have a snowmelt contributing to the runoff.

3.0 FINDINGS

3.1 General Findings

Peak flows on streams situated in eastern Oregon can be produced by many hydrologic processes including winter rainstorms, winter rain-on-snow, snowmelt, spring rain-on-snow, and spring or summer cloudburst or thunderstorms. For most areas in eastern Oregon, several of these processes have been active in any given watershed. Even the season in which peak flows occurred in eastern Oregon is not as clearly discernable as in western Oregon (Greenberg, 1998). Analysis of the gaged records showed that in some basins the annual peak flow series contained only one event type, while in other basins several processes occurred. In the latter case, the type of hydrologic process may have varied with the magnitude of the event. For example, in some basins, winter rain-on-snow events generally produced larger storms which occurred less frequently while the smaller (one to three-year events) tended to be snowmelt driven. For some gages, a dominant peak flow season did not emerge.

Organizing the coded streamflow stations spatially by ecoregion (Map 5) did facilitate identification of patterns in peak flow occurrence. A unique distribution of peak flows throughout the year (Table 6) was shown in each ecoregion.

A few patterns emerged and lead to the following general conclusions:

1. Winter peak flows are more common in the northern and western portions of eastern Oregon;

2. Spring peak flows are typically snowmelt driven in the northern and western portions of eastern Oregon;
3. As one moves eastward from the cascade crest spring processes become more active;
4. Spring and summer rainstorms, cloudbursts, or thunderstorms are active producers of peak flows primarily in the high plains areas and the south eastern portion of the state
5. Blue Mountains region and the southern portion of the East Cascades region are very mixed in terms of hydrologic response. The many micro-climates make it possible for any of the hydrologic processes to produce peak flows.

Table 6: Season of Peak Flow for each Ecoregion

Ecoregion stations		#	Peak Flow Occurrence by Season (%)			
			Fall	**Winter**	**Spring**	**Summer**
West Cascades		4	1%	68%	29%	2%
East Cascades	North	11	2%	82%	15%	1%
East Cascades	South	19	7%	25%	57%	12%
Columbia Basin		14	0	64%	34%	3%
Blue Mountains		55	0	31%	63%	7%
Lava Plains		12	1%	65%	23%	10%
Basin and Range		5	1%	25%	71%	3%
Owyhee Uplands		6	1%	58%	22%	19%

3.2 Detailed Findings: West Cascades Ecoregion (4)

The West Cascades Ecoregion (Table 7A) straddles the crest of the Cascade Mountain Range and as such transitions from western Oregon to eastern Oregon. Most of the area within the West Cascades Ecoregion was addressed in the Western Oregon Hydrologic Process report (Greenberg, 1998). A small area of the West Cascades Ecoregion overlaps with several primarily eastern Oregon counties (Hood River, Wasco, Jefferson, Deschutes, and Klamath). This area was included here to provide contiguous coverage of Oregon between this report and the Western Oregon companion document.

Overall, the peak flows from the four streamflow stations investigated in this ecoregion showed winter dominance with 68% of all peaks occurring in the winter months and 29% in spring. At the individual streamflow station level, however, the dominance was split. One of the stations showed most of the peaks occurred in spring and one was mixed with peaks flow distribution almost evenly between winter and spring. The remaining two stations showed clear winter dominance. The two winter stations drained larger basins and were located at lower elevations than the spring dominated stations suggesting that spring snowmelt processes were more active

in the higher elevation watersheds.

The two stations with winter-dominated peak flows were analyzed using corresponding climate data to determine which hydrologic processes were active in generating peak flows. There were no overlapping climate or snow data available to investigate the spring stations in this ecoregion. Of the 13 peak flow events from the two stations melting snow played a role in augmenting the peak flows in nearly all years. Winter-rain-on-snow events are known as a main producer of peak flows in the West Cascades Ecoregion. Winter rainstorms can also produce peak flows, however, for most events snowmelt augments the rain-generated peak flows.
No data were available to determine which spring processes have been active in this area. Annual precipitation in this ecoregion ranges from 80 to over 150 inches, most of which falls as snow between the months of November and March. The high elevation basins and distribution of precipitation in the winter months both lead to the conclusion that spring snowmelt is the likely producer of spring peak flows in this area.

Future analyses of watersheds in the West Cascades Ecoregion should focus primarily on the winter rain-on-snow processes and, to a lesser extent, explore the factors that influence spring snowmelt.

3.3 Detailed Findings: East Cascades Ecoregion (9)

The East Cascades Ecoregion showed distinct differences in season of peak flow from the north to the south. Investigation of the annual peak flows at 30 stations revealed a clear demarcation of winter dominance in the north and spring /mixed dominance in the southern portion of the region, therefore this ecoregion was divided into two sections. The northern portion was designated as all those areas in the East Cascades ecoregion and also in Hood River, Jefferson, and Wasco Counties (11 stations). The southern counterpart includes those areas located in the East Cascades ecoregion and also in Deschutes, Klamath, and Lake Counties (19 stations). Of note were the distinct difference in elevation of the gages between the northern section and the southern section: all northern stations were located at elevations lower than 3600 ft (10 are less than 3000 ft) while all but two southern stations are above 4000 ft.

North portion of East Cascades Ecoregion (9N)

In the Northern portion of the East Cascades Ecoregion (Table 7B), peak flows from 11 streamflow stations showed 82% of all annual peak flow events investigated occurred in the winter months and 15 % in the spring. One station showed a higher percentage of peak flows occurring in the springtime (40% at USGS station #14-095500) but still had winter peak flows representing several of the largest floods. In addition, this station had both a larger drainage area than most (107 mi^2) and a higher elevation (3500 ft).

Four of the 11 stations in this area had overlapping climate data allowing for assessment of active hydrologic processes. Thirty-five events were investigated from these four stations, 24 of which were winter rain-on-snow events and 7 winter rainstorms. Spring rain-on-snow and snowmelt

processes also produced peak flows in these watersheds but infrequently. Much of the land in the northern portion of the East Cascades Region is above 3000 feet in elevation and under average conditions would have snow on the ground during the months in which winter peak flows occur. Based on this information, winter peaks in the East Cascades Region were generated by rain-on-snow processes. Future analyses of watersheds in or near the northern half of the East Cascades should focus primarily on the winter rain-on-snow processes.

South Portion of the East Cascades Ecoregion (9S)

The overall results for this sub-ecoregion (Table 7C) identified that 57% of all annual peak flow values investigated at the 19 stations in the southern portion of the East Cascades Ecoregion occurred in the spring months while 25% happened in winter. Of the 19 stations, 8 showed clearly that spring peak flows were more common. While a few sporadic winter peaks occurred in the annual peak flow series at four of these 8 stations, peak flows of all magnitudes occurred almost exclusively in the spring. These stations, clearly influenced by spring peak flow processes, were all located in Deschutes and northern Klamath Counties near the northern boundary of the southern section of the East Cascades Ecoregion. Nine streamflow stations showed some sort of mix of peak flow occurrence between the winter and spring season. The majority of the mixed stations experienced the largest flows during the winter months.

Five of the 19 stations were investigated for hydrologic process using overlapping climate data. These stations showed a fairly even split between hydrologic processes generating peak flows in this ecoregion. In combination, the spring snowmelt and spring rain/rain-on-snow accounted for slightly more peak flows than did winter rain and rain-on-snow processes. Summer rainstorms were also identified as a regular producer of annual peak flows. Future analyses of watersheds in the southern half of the East Cascades will need to address all hydrologic processes.

3.4 Detailed Findings: Columbia Basin Ecoregion (10)

Peak flows in the Columbia Basin Ecoregion (Table 7D) predominantly occur in the winter months; 64% of all the annual peak flows investigated at 14 stations occurred in the winter months. Individual station summaries showed that at nine of the 14 stations, peak flows in the winter months were more common than spring peaks. At four of the stations, however, spring peak flows outnumbered winter (54% to 70% of the annual peak flow series occurred in spring). The distribution of precipitation throughout the year confirms that rainstorms do occur in the winter but also in April and May. Very few summer peak flows occur in this ecoregion.

While season of peak flow occurrence was straightforward in the Columbia Basin, hydrologic process distinction was not as easy. It was difficult to discern between ROS events (in either season) and rainstorms in this ecoregion due to the paucity of SNOTEL or snow course stations. Since no snow data collection stations were located in this ecoregion snow elevation could not be determined. A group of snow stations near the border between the Columbia and Blue Mountain ecoregions were investigated to determine a crude estimate of the snow level. Judging from the eight snow stations near the border of the Columbia Ecoregion, minimal snowpack development

was estimated below approximately 3000 ft on average during January or February. Five of the 14 stations had some amount of overlapping climate and streamflow data to allow hydrologic process determination. Even with the lack of SNOTEL data, several WROS events were discernable from the climate records; most of these events however recorded minimal snowfall or snow depth amounts at the nearby climate stations.

In watersheds below 3000 feet in elevation, most of the peak flows were likely produced by winter rainstorms due to the relatively low elevations and maritime influence of the Columbia River. Winter rain-on-snow events occurred particularly in watersheds with areas above 3000 ft; these WROS events produced some of the larger flows, however the volumetric contribution of the snowmelt to the runoff amount was limited.

Future analyses of watersheds in or near the Columbia Basin Ecoregion should focus primarily on the winter rain and rain-on-snow processes and to a lesser extent explore the issues associated with spring rainstorms.

3.5 Detailed Findings: Blue Mountain Ecoregion (11)

The Blue Mountain Ecoregion (Table 7E), when analyzed in its entirety, reported 63% of the annual peak flows (from 55 streamflow stations) occurred in the springtime. While spring peak flows were more common overall, winter storms consistently generated peak flows in this ecoregion and often the gages showed a mix of peak flow occurrences between both seasons. Twenty-four of the 55 gages demonstrated that the majority of peaks were in the springtime, 12 showed clear winter majority, and the remaining 19 reported some sort of mix.

The topographic intricacies in this ecoregion produce numerous microclimates each with slightly different hydrologic responses. No discernable pattern emerged at the level III ecoregion scale. An additional scale of the ecoregion classification scheme, level IV, was used to organize the findings for this ecoregion. These sub-ecoregions did aid in the detection of patterns in the season of peak flow occurrence. Of 12 sub-regions, 6 showed clear patterns (2 winter and 4 spring), 4 showed some sort of mix, and 2 did not have any stations within the boundaries.

Specific categorization follows:

Sub-ecoregion	Primary Peak Flow Season
11a	winter
11b	winter or spring
11c	winter or mixed
11d	spring
11e	spring
11f	spring

11g	no stations
11h	spring
11i	winter or spring
11k	winter or mixed
11l	spring or mixed
11m	no stations

*11j is very small and not applicable at this scale therefore it was lumped into adjacent units.

Nineteen of the 55 stations had some daily streamflow records that overlapped with climate data. Analysis of the hydrologic processes at these 19 stations revealed that both spring and winter processes are responsible for peak flows. Spring rain/rain-on-snow and snowmelt processes clearly produced the most peak flows in the Blue Mountain Ecoregion. Winter rain and rain-on-snow processes also actively generated annual peak flows. Summer rainstorms rarely generated a flow large enough to be an annual peak.

Future analyses of watersheds in or near the Blue Mountain sub-ecoregions 11a, 11c, 11i, or 11k should focus primarily on the winter rain and rain-on-snow processes and to a lesser extent spring processes. Studies undertaken in watersheds in or near the Blue Mountain sub-ecoregions 11d, 11e, 11f, 11h, or 11l should focus primarily on the spring processes and secondarily on winter rain and rain-on-snow. Watershed analyses in uncategorized sub-regions and 11b will need to address both winter and spring processes.

3.6 Detailed Findings: Lava Plains Ecoregion (11)

In the Lava Plains Ecoregion, 65% of the annual peak flows recorded at 12 streamflow stations occurred during the winter months (Table 7F). While spring peak flows were represented in the annual peak flow series at all the gages in this ecoregion, winter was clearly the more common season in which peak flows occurred. All but one of the gages (#14-095200) showed clear winter dominance; this station appears to be an anomaly potentially due to influence by regulation as explained below.

The hydrologic processes generating peak flows from 8 of the 12 stations were determined from overlapping climate and streamflow data. The distinction between processes was difficult in this ecoregion due to the lack of snow data; no snow data collection stations were located in the Lava Plains Ecoregion. All assignment of process was done from climate station information, therefore the documentation of WROS events was potentially underestimated.

The analysis showed that many different processes generated peak flows in this ecoregion, however, winter rainstorms accounted for the largest number of peak flows with winter rain-on-snow the second most common process. Spring rain and rain-on-snow and snowmelt also produced peak flows though not as often. Infrequently, summer rainstorms produced peaks in this ecoregion (at 5 of the 13 stations) with the exception of one gage (#14-095200). At this gage, spring and summer peaks were more common than winter with summer rainstorms proving to be

the most frequent process represented. The USGS remarks do indicate that this gage was regulated in one year and given the divergence in season of peak flow from all other gages in this ecoregion, questions remain regarding how influenced this gage may be by regulation.

Future analyses of watersheds in or near the Lava Plains ecoregion should focus primarily on the winter rain and rain-on-snow processes and to a lesser extent explore the factors that influence spring processes.

3.7 Detailed Findings: Basin and Range Ecoregion (10)

Annual peak flows recorded at five stations in the Basin and Range Ecoregion indicated that spring (71%) was the dominant season for peak flows (Table 7G). While spring dominance was clear in this ecoregion, some of the largest peaks occurred in the winter (winter peaks were among the top five flood events at 4 of the 5 stations). The streams in this ecoregion tended to experience some peak flows in winter, however, spring peak flows were more common at all but one of the stations. At this station (#10-371000), 58% of the peaks occurred in the winter (Table 7G). Summer rainstorms also produced peak flows in this ecoregion although infrequently (3% of all peaks investigated). Spring and summer peak flows were more common at the stations in the eastern portion of this ecoregion, however, there was very little data to support regional conclusions with confidence.

Three of the five stations had records that overlapped with climate data. These stations showed a fairly even split between hydrologic processes generating peak flows in this ecoregion. Winter rain and rain-on-snow processes caused peak flows in this region as did snowmelt, spring rain, and rain-on-snow. No summer peak flows overlapped with available climate data.

The Basin and Range Ecoregion was large and had limited streamflow stations. Only 4 gages in a region of nearly 14,500 square miles did not present an adequate distribution to draw any regional conclusions. More data should be collected on small streams in this ecoregion. Future analyses of watersheds in or near the Basin and Range Ecoregion should focus on spring processes but must also be prepared to address factors which influence winter rain and winter-rain-on-snow.

3.8 Detailed Findings: Owyhee Uplands (0)

Overall, 58% of the annual peak flows investigated at six streamflow stations in this ecoregion occurred in winter. While winter appeared as the dominant season of peak flows in the Owyhee Uplands (Table 7H), the notable difference for this ecoregion was the presence of spring and particularly summer rainstorms causing peak flows at almost all of the gages. In this ecoregion, a substantially higher percentage (19%) of peak flows occurred in the summer than in other eastern Oregon ecoregions.

Summaries of the individual gages (Table 7H) show that summer peak flows constituted from 6% to 40% of the annual peak flow record and greater than 20% at 4 of the 6 gages. Four of the six gages show fairly even split between seasons similar to the pattern of rainfall distribution

experienced in this region. At two of the gages (#13-213900 and #13-229400), the annual peak flows occurred almost exclusively in the winter (88% and 90%, respectively). These stations were both located near the northern tip of the ecoregion bordering the Blue Mountain Ecoregion. There may also be some relationship between elevation and the season of peak flow occurrence since winter processes were more prominent in the basins with drainages above approximately 3000 feet; however, there was very little data in this ecoregion to support regional conclusions with confidence.

Three of the six stations had some overlap with climatic data. Investigation of these stations illustrated that both winter processes (WR and WROS) were actively generating the largest number of peak flows but all types of processes were represented in the Owyhee Uplands. These numbers may have underestimated the spring and summer processes a bit due to the lack of overlapping data; few of the stations with more propensity for spring and summer peak flows had overlapping data available to analyze.

The Owyhee Uplands Ecoregion is large and has limited streamflow stations. Only 6 gages in a region of nearly 9,300 square miles did not present an adequate distribution to have confidence in any regional conclusions. More streamflow data should be collected on a continuous basis in some of the streams in this ecoregion. Future analyses of watersheds in or near the Owyhee Uplands Ecoregion should focus primarily on the winter rain and rain-on-snow processes but also address spring and summer rainstorm/thunderstorm issues.

Table 7A. Streamflow Stations Investigated in the West Cascades Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
West Cascades Region								
14113400	DOG RIVER NEAR PARKDALE, OR	Hood River	-	5 (42)	6 (50)	1 (8)	2 winter 2 spring+ 1 summer	5
14118500	WEST FORK HOOD RIVER NEAR DEE, OR	Hood River	-	55 (90)	6 (10)	-	winter	1
11505550	LOST CREEK NEAR ROCKY POINT, OR	Klamath	-	4 (25)	12 (75)	-	1 winter 4 spring+	2
14055500	ODELL CREEK NEAR CRESCENT, OR	Klamath	1 (2)	27 (62)	15 (34)	1 (2)	winter	1
Total = 133			**1**	**91**	**39**	**2**		
Percentage			**1%**	**68%**	**29%**	**2%**		

"+" = when flood of record occurs

Table 7B and 7C. Streamflow Stations Investigated in the East Cascades Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
East Cascades Region								
Northern Counties: Hood River, Jefferson and Wasco								
14090350	JEFFERSON CR NR CAMP SHERMAN, OR	Jefferson	1 (7)	10 (71)	3 (22)	-	4 winter+ 1 fall	1
14090400	WHITEWATER RIVER NEAR CAMP SHERMAN, OR	Jefferson	-	10 (71)	3 (21)	1 (8)	winter	1
14092750	SHITIKE CR, AT PETERS PASTURE, NR WARM SPRINGS, OR	Jefferson	-	12 (80)	3 (20)	-	winter	1
14095500	WARM SPRINGS RIVER NEAR SIMNASHO, OR	Wasco	-	9 (60)	6 (40)	-	3 winter+ 2 spring	1
14096300	MILL CREEK, NR BADGER BUTTE, NR WARM SPRINGS, OR	Wasco	1 (6)	13 (88)	1 (6)	-	4 winter+ 1 spring	1
14096850	BEAVER CREEK, BLW QUARTZ CR, NR SIMNASHO, OR	Wasco	-	14 (93)	1 (7)	-	winter	1
14097200	WHITE RIVER NEAR GOVERNMENT CAMP, OR	Wasco	1 (8)	9 (75)	2 (17)	-	winter	1
14100800	JORDAN CREEK NEAR TYGH VALLEY, OR	Wasco	-	13 (93)	1 (7)	-	winter	1
14104100	RAMSEY CREEK NEAR DUFUR, OR	Wasco	-	15 (94)	1 (6)	-	winter	1
14105850	SOUTH FORK MILL CREEK NEAR THE DALLES, OR	Wasco	-	12 (75)	4 (25)	-	winter	1
14113200	MOSIER CREEK NEAR MOSIER, OR	Wasco	-	18	-	-	winter	1
Total = 164			**3**	**135**	**25**	**1**		
Percentage			**2%**	**82%**	**15%**	**1%**		
East Cascades Region								
Southern Counties: Deschutes, Klamath and Lake								
14050500	CULTUS RIVER AB CULTUS CR NR LA PINE, OR	Deschutes	12 (21)	1 (2)	32 (56)	12 (21)	spring	2
14051000	CULTUS CR AB CRANE PRAIRIE RES NR LA PINE, OR	Deschutes	-	7 (13)	48 (86)	1 (1)	1 winter+ 4 spring	2

14052000	DEER CR AB CRANE PRAIRIE RES NR LA PINE, OR	Deschutes	-	9 (17)	45 (83)	-	3 winter+ 2 spring	3
14053000	CHARLTON CR AB CRANE PRAIRIE RES NR LA PINE, OR	Deschutes	-	2 (5)	38 (95)	-	4 spring+ 1 winter	2
14054500	BROWN CREEK NEAR LA PINE, OR	Deschutes	16 (29)	17 (31)	2 (4)	20 (36)	1 fall 3 winter+ 1 summer	6
14057500	FALL RIVER NEAR LA PINE, OR	Deschutes	11 (20)	10 (19)	20 (37)	13 (24)	4 spring+ 1 summer	2
14073000	TUMALO CREEK NEAR BEND, OR	Deschutes	2 (3)	17 (25)	37 (55)	11 (17)	4 winter+ 1 summer	3
14075000	SQUAW CREEK NEAR SISTERS, OR	Deschutes	3 (4)	25 (32)	33 (42)	17 (22)	4 winter+ 1 summer	3
11491800	MOSQUITO CREEK NEAR SHEVLIN, OR	Klamath	-	5 (31)	9 (56)	2 (13)	3 winter+ 2 spring	3
11501300	CRYSTAL CREEK NEAR CHILOQUIN, OR	Klamath	-	8 (47)	9 (53)	-	3 winter+ 2 spring	5
11504000	WOOD RIVER AT FORT KLAMATH, OR	Klamath	-	14 (58)	9 (38)	1 (4)	3 winter+ 1 spring 1 summer	1
11509400	KLAMATH RIVER TRIBUTARY NEAR KENO, OR	Klamath	-	7 (58)	5 (42)	-	winter	5
14061000	BIG MARSH CR HOEY RANCH NR CRESCENT, OR	Klamath	1 (3)	8 (25)	23 (72)	-	3 spring+ 2 winter	2
10390400	BRIDGE CREEK NR THOMPSON RESERVOIR, OR	Lake	-	4 (25)	12 (75)	-	2 winter+ 3 spring	2
11341000	THOMAS CREEK NEAR LAKEVIEW, OR	Lake	-	7 (28)	18 (72)	-	2 winter+ 3 spring	2
11341100	SALT CREEK NEAR LAKEVIEW, OR	Lake	-	8 (44)	10 (56)	-	winter	5
11341200	CRANE CREEK NEAR LAKEVIEW, OR	Lake	-	7 (44)	9 (56)	-	3 winter+ 2 spring	5
11494800	BROWNSWORTH CREEK NEAR BLY, OR	Lake	-	6 (43)	8 (57)	-	2 winter+ 3 spring	5
11497800	CURRIER CREEK NEAR PAISLEY, OR	Lake	-	5 (31)	11 (69)	-	2 winter 3 spring+	2
Total No. [667]			45	167	378	77		
Percentage			7%	25%	57%	12%		

+ = when flood of record occurs

Table 7D. Streamflow Stations Investigated in the Columbia Basin Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
Columbia Basin Region								
14047470	JUNIPER CANYON TRIBUTARY NEAR MIKKALO, OR	Gilliam	-	4 (57)	2 (29)	1 (14)	3 winter 2 spring 1 summer+	5
14034470	WILLOW CREEK ABV WILLOW CR LAKE, NR HEPPNER, OR	Morrow	-	7 (44)	9 (56)	-	4 winter+ 1 spring	5
14034500	WILLOW CREEK AT HEPPNER, OR	Morrow	-	24 (55)	19 (43)	1 (2)	3 winter 2 spring+	1
14034800	RHEA CREEK NEAR HEPPNER, OR	Morrow	-	21 (70)	8 (27)	1 (3)	3 winter 2 spring+	1
14048020	GRASS VALLEY CANYON NR GRASS VALLEY, OR	Sherman	-	16	-	-	winter	1
14048040	GORDON HOLLOW AT DE MOSS SPRINGS, OR	Sherman	-	15 (88)	2 (12)	-	4 winter+ 1 spring	1
14048300	SPANISH HOLLOW AT WASCO, OR	Sherman	-	15 (94)	1 (6)	-	winter	1
14010500	SO FK WALLA WALLA R NEAR MILTON, OR	Umatilla	-	5 (33)	10 (67)	-	2 winter 3 spring+	2
14011000	NO FK WALLA WALLA RIVER NR MILTON, OR	Umatilla	-	17 (46)	20 (54)	-	winter	3
14011500	WALLA WALLA RIVER NEAR MILTON, OR	Umatilla	-	3 (30)	7 (70)	-	3 winter 2 spring+	3
14016080	DRY CREEK TRIBUTARY NEAR MILTON-FREEWATER, OR	Umatilla	-	9 (69)	4 (31)	-	3 winter 2 spring+	1
14019120	NO FK COLD SPRGS CANYON TRIB NR HOLDMAN, OR	Umatilla	-	6 (55)	3 (27)	2 (18)	2 winter 2 spring 1 summer	1
14020800	MISSION CR AT ST ANDREWS MISSION, OR	Umatilla	-	15 (83)	3 (17)	-	Winter	1
14021600	NELSON CREEK AT PENDLETON, OR	Umatilla	-	12 (80)	1 (7)	2 (13)	4 winter+ 1 summer	1
Total No. [265]			0	169	89	7		
Percentage			0%	64%	34%	3%		

"+" = when flood of record occurs

Table 7E. Streamflow Stations Investigated in the Blue Mountain Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
Blue Mountain Region								
13269300	NORTH FORK BURNT RIVER NEAR WHITNEY, OR	Baker	-	2 (13)	14 (87)	-	4 spring+ 1 winter	2
13270800	S FK BURNT R AB BARNEY CR,NR UNITY, OR	Baker	-	-	18	-	spring	2
13272300	JOB CREEK TRIBUTARY NEAR UNITY, OR	Baker	-	8 (62)	5 (38)	-	2 winter 3 spring+	4
13286300	WATERSPOUT CREEK NEAR BAKER, OR	Baker	-	3 (28)	4 (36)	4 (36)	4 summer+ 1 spring	6
13289100	IMMIGRANT GULCH NEAR RICHLAND, OR	Baker	-	12 (75)	4 (25)	-	4 winter+ 1 spring	1
13290150	NORTH PINE CREEK NEAR HOMESTEAD, OR	Baker	-	5 (36)	8 (57)	1 (7)	1 winter 3 spring+ 1 summer	2
14077800	WOLF CREEK TRIBUTARY NEAR PAULINA, OR	Crook	-	8 (53)	6 (40)	1 (7)	4 winter+ 1 spring	1
14078400	LOOKOUT CREEK NEAR POST, OR	Crook	-	6 (46)	5 (38)	2 (16)	3 winter+ 2 spring	5
14081800	AHALT CREEK NEAR MITCHELL, OR	Crook	-	8 (42)	11 (58)	-	4 winter+ 1 spring	3
14082400	WILDCAT CREEK NEAR PRINEVILLE, OR	Crook	-	5 (42)	7 (58)	-	4 winter+ 1 spring	5
10392300	SILVIES RIVER NEAR SENECA, OR	Grant	-	4 (27)	10 (67)	1 (6)	4 spring+ 1 winter	2
14036800	JOHN DAY RIVER NR PRAIRIE CITY, OR	Grant	-	2 (14)	12 (86)	-	4 spring 1 winter+	2
14037500	STRAWBERRY CR AB SLIDE CR NR PRAIRIE CITY, OR	Grant	-	-	55 (90)	6 (10)	spring	2
14038550	EAST FORK CANYON CR NR CANYON CITY, OR	Grant	-	5 (33)	10 (67)	-	4 spring 1 winter+	2
14038600	VANCE CREEK NR CANYON CITY, OR	Grant	-	3 (21)	11 (79)	-	3 winter+ 2 spring	3
14038750	BEECH CREEK NEAR FOX, OR	Grant	-	4 (33)	7 (58)	1 (8)	3 winter+ 2 spring	3

14038900	FIELDS CREEK NEAR MOUNT VERNON, OR	Grant	-	5 (42)	7 (58)	-	3 winter+ 2 spring	5
14039200	VENATOR CREEK NEAR SILVIES, OR	Grant	-	3 (23)	10 (77)	-	spring	2
14040900	BRUIN CREEK NEAR DALE, OR	Grant	-	1 (8)	10 (77)	2 (15)	4 spring+ 1 summer	2
14041000	DESOLATION CREEK NEAR DALE, OR	Grant	-	2 (17)	10 (83)	-	4 spring+ 1 winter	2
14043800	BRIDGE CREEK NR PRAIRIE CITY, OR	Grant	-	3 (19)	13 (81)	-	spring	2
14043850	COTTONWOOD CREEK NEAR GALENA, OR	Grant	-	4 (27)	11 (73)	-	3 spring+ 2 winter	2
14043900	GRANITE CREEK NEAR DALE, OR	Grant	-	6 (55)	4 (36)	1 (9)	4 winter 1 spring+	1
14044500	FOX CREEK AT GORGE NR FOX, OREG.	Grant	-	16 (57)	12 (43)	-	3 spring+ 2 winter	4
10392800	CROWSFOOT CREEK NEAR BURNS, OR	Harney	-	4 (29)	10 (71)	-	2 winter 3 spring+	2
10393900	DEVINE CANYON NEAR BURNS, OR	Harney	-	6 (35)	11 (65)	-	2 winter 3 spring+	2
14034370	WILLOW CREEK TRIBUTARY NR HEPPNER, OR	Morrow	1 (5)	9 (47)	8 (42)	1 (5)	4 winter+ 1 summer	5
14047350	ROCK CR TRIB NR HARDMAN, OR	Morrow	-	8 (62)	5 (38)	-	4 winter+ 1 spring	1
13322300	DRY CREEK NEAR BINGHAM SPRINGS, OREG.	Umatilla	-	9 (64)	5 (36)	-	4 winter+ 1 spring	1
14010000	S.F. WALLA WALLA RIVER NEAR MILTON-FREEWATER, OR	Umatilla	-	35 (51)	33 (48)	1 (2)	winter	5
14010800	NF WALLA WALLA R NR MILTON FREEWATER, OR	Umatilla	-	17 (74)	5 (22)	1 (4)	winter	1
14019400	ELBOW CREEK NR BINGHAM SPRINGS, OR	Umatilla	-	8 (57)	6 (43)	-	3 winter+ 2 spring	5
14020000	UMATILLA RIVER AB MEACHAM CR NR GIBBON, OR	Umatilla	-	40 (65)	22 (35)	-	winter	1
14022200	NORTH FORK MCKAY CREEK NEAR PILOT ROCK, OR	Umatilla	-	20 (80)	5 (20)	-	4 winter 1 spring+	1
14041900	LINE CREEK NR LEHMAN SPRINGS, OR	Umatilla	-	8 (53)	7 (47)	-	2 winter+ 3 spring	5
14042000	CAMAS CREEK NR LEHMAN, OR	Umatilla	-	12 (60)	8 (40)	-	3 winter+ 2 spring	1
14042500	CAMAS CREEK NEAR UKIAH, OR	Umatilla	-	31 (47)	35 (53)	-	3 winter+ 2 spring	5

13318100	MCINTYRE CREEK NEAR STARKEY, OR	Union	-	6 (43)	7 (50)	1 (7)	3 winter 2 spring+	5
13320000	CATHERINE CREEK NEAR UNION, OR	Union	-	1	74 (99)	-	spring	2
13320400	LITTLE CR AT HIGH VALLEY NR UNION, OR	Union	-	4 (15)	22 (85)	-	4 spring+ 1 winter	2
13321300	LADD CANYON NR HOT LAKE, OR	Union	-	10 (63)	6 (37)	-	3 winter+ 2 spring	1
13323600	INDIAN CREEK NEAR IMBLER, OR	Union	-	-	13	-	spring	2
13324150	RYSDAM CANYON TRIBUTARY NEAR MINAM, OR	Union	-	9 (75)	3 (25)	-	4 winter+ 1 spring	1
13324300	LOOKINGGLASS CREEK NEAR LOOKING GLASS, OR.	Union	-	1 (8)	11 (92)	-	4 spring+ 1 winter	2
13291200	MAHOGANY CREEK NEAR HOMESTEAD, OR	Wallowa	-	3 (27)	8 (73)	-	spring	2
13325000	EAST FORK WALLOWA RIVER NR. JOSEPH, OREG.	Wallowa	-	-	32 (55)	26 (45)	3 summer+ 2 spring	6
13325500	WALLOWA R AB WALLOWA LK NR JOSEPH, OR	Wallowa	-	-	8 (62)	5 (38)	2 summer+ 3 spring	6
13329500	HURRICANE CREEK NEAR JOSEPH, OREG.	Wallowa	-	-	44 (79)	12 (21)	4 spring+ 1 summer	2
13329700	TROUT CREEK TRIBUTARY NEAR CHICO, OR	Wallowa	-	5 (38)	8 (62)	-	3 spring+ 2 winter	2
13329750	TROUT CREEK TRIB AT ENTERPRISE, OR	Wallowa	-	8 (80)	2 (20)	-	3 winter+ 2 spring	1
13330000	LOSTINE RIVER NEAR LOSTINE, OREG.	Wallowa	-	-	53 (76)	17 (24)	4 spring+ 1 summer	2
13330500	BEAR CREEK NEAR WALLOWA, OREG.	Wallowa	-	1 (2)	59 (94)	3 (5)	spring	2
13333050	BUFORD CREEK NEAR FLORA, OR	Wallowa	-	8 (53)	7 (47)	-	3 winter 2 spring+	5
13333100	DOE CREEK NEAR IMNAHA, OR	Wallowa	-	5 (33)	10 (67)	-	4 spring 1 winter+	2
14046300	BIG SERVICE CREEK NEAR SERVICE CREEK, OR	Wheeler	-	5 (46)	6 (54)	-	4 winter+ 1 spring	5
Total = 1271			0	388	797	86		
Percentage			0%	31%	63%	7%		

"+" = when flood of record occurs

Table 7F. Streamflow Stations Investigated in the Lava Plains Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
Lava Plains Region								
14077500	N. F. BEAVER CREEK NEAR PAULINA, OR	Crook	-	12 (92)	1 (8)	-	4 winter 1 spring+	1
14083500	MILL CREEK NEAR PRINEVILLE, OR	Crook	-	8 (67)	4 (33)	-	Winter	1
14044100	PAUL CREEK NEAR LONG CREEK, OR	Grant	-	8 (73)	3 (27)	-	4 winter+ 1 spring	1
14092300	WILLOW CREEK TRIBUTARY NEAR CULVER, OR	Jefferson	-	7 (64)	2 (18)	2 (18)	4 winter+ 1 spring	1
14092885	SHITIKE CR BL WOLFORD CANYON NR WARM SPRGS, OR	Jefferson	-	17 (85)	3 (15)	-	Winter	1
14093000	SHITIKE CREEK AT WARM SPRINGS, OR	Jefferson	1 (8)	9 (75)	2 (17)	-	Winter	1
14095200	SAGEBRUSH CREEK TRIB NR GATEWAY, OR	Jefferson	1 (7)	3 (20)	6 (40)	5 (33)	1 winter 3 spring+ 1 summer	6
14078200	LIZARD GULCH TRIBUTARY NEAR HAMPTON, OR	Lake	-	7 (50)	5 (36)	2 (14)	3 winter+ 1 spring 1 summer	1
14046900	JOHN DAY R TRIB NR CLARNO, OR	Wasco	-	10 (77)	3 (23)	-	3 winter+ 2 spring	1
14040700	WHISKY CREEK NEAR MITCHELL, OR	Wheeler	-	8 (80)	2 (20)	-	winter	1
14046250	IVES CANYON NEAR SPRAY, OR	Wheeler	-	6 (55)	2 (18)	3 (27)	2 winter 1 spring 2 summer+	1
14046400	DONNELY CR TRIBUTARY NR SERVICE CR, OR	Wheeler	-	6 (46)	3 (23)	4 (31)	1 winter 2 spring 2 summer+	1
Total = 155			**2**	**101**	**36**	**16**		
Percentage			**1%**	**65%**	**23%**	**10%**		

"+" = when flood of record occurs

Table 7G. Streamflow Stations Investigated in the Basin and Range Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
Basin and Range Region								
10397000	BRIDGE CREEK NR FRENCHGLEN, OR	Harney	1 (3)	12 (31)	26 (67)	-	2 winter 3 spring+	2
10406500	TROUT CREEK NEAR DENIO, NV	Harney	1 (1)	3 (4)	65 (93)	1 (1)	1 summer 4 spring	2
10370000	CAMAS CREEK NEAR LAKEVIEW, OR	Lake	-	10 (40)	15 (60)	-	4 winter+ 1 spring	3
10371000	DRAKE CREEK NEAR ADEL, OR	Lake	-	15 (58)	10 (39)	1 (4)	4 winter+ 1 spring	1
10352300	JACKSON CR TRIB NR MCDERMITT, NV	Malheur	-	3 (27)	5 (46)	3 (27)	2 winter 2 spring 1 summer+	2
Total = 171			**2**	**43**	**121**	**5**		
Percentage			**1%**	**25%**	**71%**	**3%**		

"+" = when flood of record occurs

Table 7H. Streamflow Stations Investigated in the Owyhee Uplands Region

Station #	Station Name	County	# peak flows within season (%)				Season in which 5 largest floods occurred	Map Code*
			Fall	Winter	Spring	Summer		
Owyhee Uplands Region								
13213900	MALHEUR RIVER TRIBUTARY NEAR DREWSEY, OR	Harney	-	14 (88)	1 (6)	1 (6)	4 winter 1 summer+	1
13182100	DAGO GULCH NEAR ROCKVILLE, OR	Malheur	-	3 (27)	5 (46)	3 (27)	2 winter 2 spring 1 summer+	3
13219300	MALHEUR RIVER TRIBUTARY NEAR HARPER, OR	Malheur	-	4 (40)	2 (20)	4 (40)	2 winter 1 spring 2 summer+	6
13228300	LYTLE CREEK NEAR VALE, OR	Malheur	-	5 (38)	5 (38)	3 (24)	1 winter 4 spring+	5
13229400	LOST VALLEY CREEK TRIBUTARY NEAR IRONSIDE, OR	Malheur	-	9 (90)	1 (10)	-	4 winter 1 spring+	1
13269200	MOORES HOLLOW TRIBUTARY NEAR WEISER, ID	Malheur	1 (8)	7 (54)	2 (15)	3 (23)	1 fall 2 winter 2 summer+	1
Total = 73			**1**	**42**	**16**	**14**		
Percentage			**1%**	**58%**	**22%**	**19%**		

"+" = when flood of record occurs

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USGS Historical Streamflow Records Webpage

APPENDIX I: BACKGROUND DATA TABLES

Eastern Oregon

Table A-1: Streamflow Gaging Stations
Table A-2: Climate Stations
Table A-3: Snow Course and SNOTEL Station List

Table A - 1: USGS Streamflow Gaging Stations ***EXAMPLE***

Number	Station Number	Station Name	County	Ecoregion	Drainage (sq. mi.)	Elev. (ft)*	LATITUDE	LONGITUDE	Systematic Period of Record	# Years	Annual Peak Period of Record	# Years
1	13269300	NORTH FORK BURNT RIVER NEAR WHITNEY, OREG.	Baker	4	110.00	4000	44:36:00	118:15:10	1964-80	17	1965-1980	16
2	13270800	S FK BURNT R AB BARNEY CR,NR UNITY,OREG.	Baker	4	38.50	4342	44:24:23	118:18:02	1963-81	20	1964-1981	18
3	13272300	JOB CREEK TRIBUTARY NEAR UNITY,OREG.	Baker	4	0.00	4200e	44:27:50	118:12:00			1967-1979	13
4	13286300	WATERSPOUT CREEK NEAR BAKER,OREG.	Baker	4	0.96	2770	44:50:08	117:32:48			1969-1981	12
5	13289100	IMMIGRANT GULCH NEAR RICHLAND,OREG.	Baker	4	6.64	2420	44:47:10	117:08:05			1964-1981	17
6	13290150	NORTH PINE CREEK NEAR HOMESTEAD,OREG.	Baker	4	2.89	4310	45:05:25	116:53:45			1965-1979	14
7	14077500	N. F. BEAVER CREEK NEAR PAULINA, OREG.	Crook	10	64.40	3849	44:10:00	119:44:00	1942-54	12	1942-1953	13
8	14077800	WOLF CREEK TRIBUTARY NEAR PAULINA,OREG.	Crook	4	2.15	4190	44:16:39	119:49:00			1964-1979	15
9	14078400	LOOKOUT CREEK NEAR POST,OREG.	Crook	4	7.53	4625	44:18:40	120:14:24			1966-1979	14
10	14081800	AHALT CREEK NEAR MITCHELL,OREG.	Crook	4	2.28	4680	44:26:00	120:21:05			1956-1979	23
11	14082400	WILDCAT CREEK NEAR PRINEVILLE,OREG.	Crook	4	3.66	4050	44:24:47	120:30:00			1969-1981	13
12	14083500	MILL CREEK NEAR PRINEVILLE,OREG.	Crook	10	78.80	3190	44:20:10	120:40:00			1918-1932	12
13	14050500	CULTUS RIVER AB CULTUS CR NR LA PINE,OREG.	Deschutes	7	16.50	4450	43:49:06	121:47:40	1922-91	58	1923-25, 1938-91	57
14	14051000	CULTUS CR AB CRANE PRAIRIE RES NR LA PINE,OREG.	Deschutes	7	33.20	4545	43:49:17	121:49:22	1923-91	56	1924, 1938-91	55
15	14052000	DEER CR AB CRANE PRAIRIE RES NR LA PINE,OREG.	Deschutes	7	21.50	4520	43:48:18	121:50:18	1924-91	56	1924, 1938-91	55
16	14053000	CHARLTON CR AB CRANE PRAIRIE RES NR LA PINE,OREG	Deschutes	7	15.60	4459	43:46:51	121:50:06	1937-80	43	1937-1979	41
17	14054500	BROWN CREEK NEAR LA PINE,OREG.	Deschutes	7	21.00	4370	43:42:47	121:48:10	1922-91	59	1923-1991	55
18	14057500	FALL RIVER NEAR LA PINE,OREG.	Deschutes	7	45.10	4220	43:47:48	121:34:18	1938-91	55	1938-1990	54
19	14073000	TUMALO CREEK NEAR BEND,OREG.	Deschutes	7	47.30	3567	44:05:16	121:22:18	1973-87	14	1914-1980	67
20	14075000	SQUAW CREEK NEAR SISTERS,OREG. (pre-1982)	Deschutes	7	57.80	3490	44:14:02	121:33:57	1906-95	90	1908-1982	67
		SQUAW CREEK NEAR SISTERS,OREG. (post 1928)	Deschutes	7	45.20	3490	44:14:02	121:33:57	1906-95	90	1983-1994	11
21	14047470	JUNIPER CANYON TRIBUTARY NEAR MIKKALO,OREG.	Gilliam	6	1.94	1480	45:27:51	120:11:54			1972-1981	10
22	10392300	SILVIES RIVER NEAR SENECA,OREG.	Grant	4	18.40	5020	44:10:30	119:12:50			1967-1981	15
23	14036800	JOHN DAY RIVER NR PRAIRIE CITY,OREG.	Grant	4	17.40	4610	44:19:10	118:33:25			1964-1979	14
24	14037500	STRAWBERRY CR AB SLIDE CR NR PRAIRIE CITY,OREG.	Grant	4	7.00	4910	44:20:30	118:39:20	1930-91	62	1931-1991	61
25	14038550	EAST FORK CANYON CR NR CANYON CITY,OREG.	Grant	4	24.80	4080	44:14:45	118:54:40			1964-1979	15
26	14038600	VANCE CREEK NR CANYON CITY,OREG.	Grant	4	6.54	4000	44:17:20	118:58:40			1964-1979	14
27	14038750	BEECH CREEK NEAR FOX,OREG.	Grant	4	1.94	4520	44:34:05	119:06:30			1965-1979	12
28	14038900	FIELDS CREEK NEAR MOUNT VERNON,OREG.	Grant	4	17.50	3150	44:23:35	119:18:25			1967-1979	13
29	14039200	VENATOR CREEK NEAR SILVIES,OREG.	Grant	4	11.90	4460	43:59:55	119:16:30			1967-1979	13
30	14040900	BRUIN CREEK NEAR DALE,OREG.	Grant	4	4.63	4270	44:53:51	118:47:35			1969-1981	13
31	14041000	DESOLATION CREEK NEAR DALE,OREG.	Grant	4	108.00	2907	44:59:20	118:55:10	1949-58	9	1950-1964	13
32	14043800	BRIDGE CREEK NR PRAIRIE CITY,OREG.	Grant	4	6.93	4620	44:32:30	118:32:25			1964-1979	16
33	14043850	COTTONWOOD CREEK NEAR GALENA,OREG.	Grant	4	3.89	4420	44:39:10	118:51:55			1964-1979	15
34	14043900	GRANITE CREEK NEAR DALE,OREG.	Grant	4	1.90	3740	44:53:40	119:00:50			1965-1979	11
35	14044100	PAUL CREEK NEAR LONG CREEK,OREG.	Grant	10	3.50	3760	44:43:26	119:07:54			1969-1979	11

36	14044500	FOX CREEK AT GORGE NR FOX, OREG.	Grant	4	90.20	4240	44:37:10	119:15:45	1930-58	28	1931-1958	28
37	10392800	CROWSFOOT CREEK NEAR BURNS,OREG.	Harney	4	8.50	5250	43:53:55	119:29:50			1966-1979	14
38	10393900	DEVINE CANYON NEAR BURNS,OREG.	Harney	4	4.96	4920	43:46:20	119:00:15			1965-1981	17
39	10397000	BRIDGE CREEK NR FRENCHGLEN, OREG.	Harney	13	30.00	4185	42:50:38	118:50:57	1911-70	41	1911-16, 1938-70	39
40	10406500	TROUT CREEK NEAR DENIO,NEV.	Harney	13	88.00	4352	42:09:20	118:27:30	1932-91	61	1911-1991	70
41	13213900	MALHEUR RIVER TRIBUTARY NEAR DREWSEY,OREG.	Harney	11	2.28	3570	43:46:50	118:21:30			1964-1981	17
42	14113400	DOG RIVER NEAR PARKDALE, OREG.	Hood River	8	4.50	4347	45:24:30	121:31:10	1960-71	12	1960-1971	12
43	14118500	WEST FORK HOOD RIVER NEAR DEE,OREG.	Hood River	8	95.60	802	45:35:55	121:38:05	1932-91	60	1914-15, 1933-91	61
44	14090350	JEFFERSON CR NR CAMP SHERMAN,OREG.	Jefferson	7	27.80	2900e	44:34:18	121:38:17	1983-95	13	1984-1994	11
45	14090400	WHITEWATER RIVER NEAR CAMP SHERMAN, OR.	Jefferson	7	22.90	3200e	44:43:04	121:38:07	1982-95	14	1983-1994	12
46	14092300	WILLOW CREEK TRIBUTARY NEAR CULVER,OREG.	Jefferson	10	7.47	3040	44:30:38	121:04:15			1964-1979	15
47	14092750	SHITIKE CR, AT PETERS PASTURE, NR WARM SPRINGS,	Jefferson	7	22.90	3600e	44:45:02	121:37:56	1982-95	14	1983-1994	12
48	14092885	SHITIKE CR BL WOLFORD CANYON NR WARM SPRGS,OREG.	Jefferson	10	75.80	1600	44:46:20	121:18:15	1974-95	20	1975-1994	20
49	14093000	SHITIKE CREEK AT WARM SPRINGS, OREG.	Jefferson	10	105.00	1380	44:45:51	121:13:57	1911-74	12	1912-1974	12
50	14095200	SAGEBRUSH CREEK TRIB NR GATEWAY,OREG.	Jefferson	10	7.40	1920	44:45:33	121:02:02			1957-1981	25
51	11491800	MOSQUITO CREEK NEAR SHEVLIN,OREG.	Klamath	7	2.40	4920	43:05:40	121:32:50			1964-1981	17
52	11501300	CRYSTAL CREEK NEAR CHILOQUIN,OREG.	Klamath	7	5.77	4190	42:33:45	121:50:20			1964-1981	17
53	11504000	WOOD RIVER AT FORT KLAMATH, OREG.	Klamath	7	90.00	4167	42:42:00	121:59:00	1913-36	18	1912-1936	24
54	11505550	LOST CREEK NEAR ROCKY POINT,OREG.	Klamath	8	13.20	5320	42:29:35	122:11:30			1966-1981	16
55	11509400	KLAMATH RIVER TRIBUTARY NEAR KENO,OREG.	Klamath	7	1.02	4240	42:07:50	121:57:50			1964-1981	18
56	14055500	ODELL CREEK NEAR CRESCENT,OREG.	Klamath	8	39.00	4799	43:32:51	121:57:41	1913-76	47	1933-1975	44
57	14061000	BIG MARSH CR HOEY RANCH NR CRESCENT OREG.	Klamath	7	51.50	4630	43:28:40	121:54:50	1912-58	34	1912-1958	32
58	10370000	CAMAS CREEK NEAR LAKEVIEW,OREG.	Lake	13	63.00	5472	42:12:59	120:06:05	1912-73	25	1913-1973	26
59	10371000	DRAKE CREEK NEAR ADEL,OREG.	Lake	13	67.00	5076	42:12:00	120:00:41	1915-73	25	1915-1973	26
60	10390400	BRIDGE CREEK NR THOMPSON RESERVOIR,OREG.	Lake	7	10.60	4850	43:01:30	121:12:00			1964-1981	16
61	11341000	THOMAS CREEK NEAR LAKEVIEW, OREG.	Lake	7	30.00	4800	42:16:00	120:27:00			1912-1958	25
62	11341100	SALT CREEK NEAR LAKEVIEW,OREG.	Lake	7	5.62	4950	42:17:35	120:20:45			1964-1981	18
63	11341200	CRANE CREEK NEAR LAKEVIEW,OREG.	Lake	7	11.40	5010	42:07:05	120:17:25			1966-1981	16
64	11494800	BROWNSWORTH CREEK NEAR BLY,OREG.	Lake	7	2.20	5480	42:25:40	120:50:20			1964-1981	14
65	11497800	CURRIER CREEK NEAR PAISLEY,OREG.	Lake	7	2.46	6200e	42:42:55	120:52:50			1964-1981	16
66	14078200	LIZARD GULCH TRIBUTARY NEAR HAMPTON,OREG.	Lake	10	19.60	5200e	43:35:20	119:59:00			1964-1981	16
67	10352300	JACKSON CR TRIB NR MCDERMITT,NEV.	Malheur	13	6.60	5100e	42:14:00	117:44:20			1969-1981	12
68	13182100	DAGO GULCH NEAR ROCKVILLE,OREG.	Malheur	11	3.09	3640	43:17:37	117:15:14			1970-1981	12
69	13219300	MALHEUR RIVER TRIBUTARY NEAR HARPER,OREG.	Malheur	11	0.10	2650	43:48:51	117:39:13			1969-1979	11
70	13228300	LYTLE CREEK NEAR VALE,OREG.	Malheur	11	6.46	2320	43:57:26	117:13:33			1969-1981	13
71	13229400	LOST VALLEY CREEK TRIBUTARY NEAR IRONSIDE,OREG.	Malheur	11	1.86	3780	44:18:50	117:54:10			1967-1978	12
72	13269200	MOORES HOLLOW TRIBUTARY NEAR WEISER,IDAHO	Malheur	11	0.90	2560	44:10:10	117:07:30			1964-1979	13
73	14034370	WILLOW CREEK TRIBUTARY NR HEPPNER,OREG.	Morrow	4	1.11	3600	45:13:40	119:20:00			1959-1979	20
74	14034470	WILLOW CREEK ABV WILLOW CR LAKE, NR HEPPNER, OR	Morrow	6	67.60	2400e	45:20:27	119:30:53	1982-94	12	1983-1994	12
75	14034500	WILLOW CREEK AT HEPPNER, OREG.	Morrow	6	96.80	2200e	45:21:02	119:32:56	1951-94	43	1903-1994	44
76	14034800	RHEA CREEK NEAR HEPPNER,OREG.	Morrow	6	120.00	2320	45:15:41	119:37:22	1960-91	32	1961-1991	30
77	14047350	ROCK CR TRIB NR HARDMAN,OREG.	Morrow	4	6.25	3620	45:04:40	119:34:10			1965-1979	14

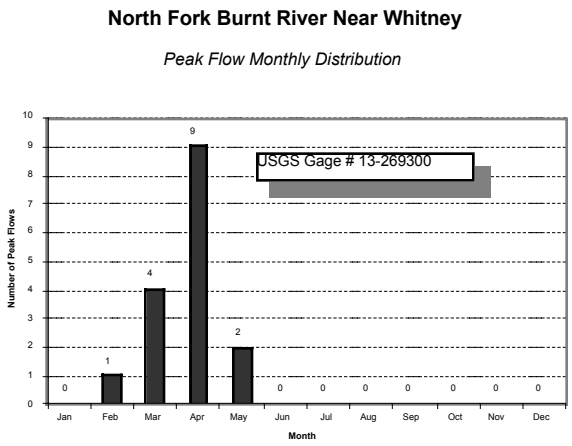
78	14048020	GRASS VALLEY CANYON NR GRASS VALLEY,OREG.	Sherman	6	8.15	2190	45:22:25	120:46:27			1958-1979	22
79	14048040	GORDON HOLLOW AT DE MOSS SPRINGS,OREG.	Sherman	6	8.86	1560	45:30:50	120:40:55			1959-1980	22
80	14048300	SPANISH HOLLOW AT WASCO,OREG.	Sherman	6	8.05	1280	45:35:20	120:41:40			1959-1979	21
81	13322300	DRY CREEK NEAR BINGHAM SPRINGS, OREG.	Umatilla	4	1.37	3960	45:38:10	118:06:55			1965-1979	14
82	14010000	S.F. WALLA WALLA RIVER NEAR MILTON-FREEWATER,OR	Umatilla	4	63.00	2050	45:49:48	118:10:08	1903-91	75	1903-1991	69
83	14010500	SO FK WALLA WALLA R NEAR MILTON, OREG.	Umatilla	6	80.00	1490	45:53:00	118:17:00	1903-45	19	1904-1945	16
84	14010800	NF WALLA WALLA R NR MILTON FREEWATER,OREG.	Umatilla	4	34.40	1940	45:53:06	118:11:06	1969-91	23	1970-1991	22
85	14011000	NO FK WALLA WALLA RIVER NR MILTON, OREG.	Umatilla	6	43.80	1467	45:54:08	118:16:55	1930-69	41	1930-1969	38
86	14011500	WALLA WALLA RIVER NEAR MILTON, OREG.	Umatilla	6	130.00	1310	45:54:00	118:20:00			1906-1929	10
87	14016080	DRY CREEK TRIBUTARY NEAR MILTON-FREEWATER,OREG.	Umatilla	6	1.22	1470	45:53:05	118:23:28			1967-1981	15
88	14019120	NO FK COLD SPRGS CANYON TRIB NR HOLDMAN,OREG.	Umatilla	6	2.86	1055	45:52:40	118:55:10			1967-1981	15
89	14019400	ELBOW CREEK NR BINGHAM SPRINGS,OREG.	Umatilla	4	0.68	2440	45:42:45	118:11:54			1965-1979	14
90	14020000	UMATILLA RIVER AB MEACHAM CR NR GIBBON,OREG.	Umatilla	4	131.00	1855	45:43:11	118:19:20	1933-94	62	1933-1994	62
91	14020800	MISSION CR AT ST ANDREWS MISSION,OREG.	Umatilla	6	4.45	1710	45:38:05	118:37:18			1958-1979	18
92	14021600	NELSON CREEK AT PENDLETON,OREG.	Umatilla	6	2.56	1160	45:40:56	118:48:24			1958-1979	22
93	14022200	NORTH FORK MCKAY CREEK NEAR PILOT ROCK,OREG.	Umatilla	4	48.60	1870	45:30:24	118:36:57	1973-94	22	1973-1994	21
94	14041900	LINE CREEK NR LEHMAN SPRINGS,OREG.	Umatilla	4	2.40	3200e	45:10:10	118:42:40			1965-1979	15
95	14042000	CAMAS CREEK NR LEHMAN,OREG.	Umatilla	4	60.70	3970	45:10:16	118:43:53	1950-1970	21	1951-1970	20
96	14042500	CAMAS CREEK NEAR UKIAH, OREG.	Umatilla	4	121.00	3589	45:09:25	118:49:10	1914-91	70	1915-1991	67
97	13318100	MCINTYRE CREEK NEAR STARKEY,OREG.	Union	4	1.80	4190	45:19:40	118:26:55			1966-1979	14
98	13320000	CATHERINE CREEK NEAR UNION, OREG.	Union	4	105.00	3082	45:09:20	117:46:26	1911-94	74	1912-1994	73
99	13320400	LITTLE CR AT HIGH VALLEY NR UNION,OREG.	Union	4	15.80	3210	45:12:45	117:46:30			1948-1979	26
100	13321300	LADD CANYON NR HOT LAKE,OREG.	Union	4	15.50	3400	45:11:36	118:00:48			1953-1972	16
101	13323600	INDIAN CREEK NEAR IMBLER,OREG.	Union	4	22.00	3800	45:26:00	117:49:20	1938-1950	13	1938-1950	13
102	13324150	RYSDAM CANYON TRIBUTARY NEAR MINAM,OREG.	Union	4	0.99	3290	45:36:55	117:47:45			1967-1979	13
103	13324300	LOOKINGGLASS CREEK NEAR LOOKING GLASS, OR.	Union	4	78.30	3000e	45:43:55	117:51:50	1982-94	13	1983-1994	12
104	13291200	MAHOGANY CREEK NEAR HOMESTEAD,OREG.	Wallowa	4	4.00	3740	45:12:15	116:52:05			1965-1975	11
105	13325000	EAST FORK WALLOWA RIVER NR. JOSEPH, OREG.	Wallowa	4	10.30	4518	45:16:20	117:12:35	1924-83	45	1925-1982	58
106	13325500	WALLOWA R AB WALLOWA LK NR JOSEPH,OREG.	Wallowa	4	43.00	4400	45:17:00	117:12:00	1924-33	10	1924-1940	13
107	13329500	HURRICANE CREEK NEAR JOSEPH, OREG.	Wallowa	4	29.60	4500	45:20:15	117:17:30	1915-78	56	1915-1978	56
108	13329700	TROUT CREEK TRIBUTARY NEAR CHICO,OREG.	Wallowa	4	0.26	4340	45:35:50	117:15:35			1967-1981	15
109	13329750	TROUT CREEK TRIB AT ENTERPRISE,OREG.	Wallowa	4	4.38	3730	45:26:20	117:17:00			1967-1977	11
110	13330000	LOSTINE RIVER NEAR LOSTINE, OREG.	Wallowa	4	70.90	3650	45:26:20	117:25:35	1912-91	71	1913-1991	67
111	13330500	BEAR CREEK NEAR WALLOWA, OREG.	Wallowa	4	68.00	3250	45:31:37	117:33:05	1915-85	63	1915-1985	63
112	13333050	BUFORD CREEK NEAR FLORA,OREG.	Wallowa	4	0.47	4200e	45:53:25	117:17:00			1967-1981	15
113	13333100	DOE CREEK NEAR IMNAHA,OREG.	Wallowa	4	5.20	3750	45:44:50	117:01:20			1965-1979	15
114	14046900	JOHN DAY R TRIB NR CLARNO,OREG.	Wasco	10	1.36	3000	44:54:20	120:34:05			1959-1979	21
115	14095500	WARM SPRINGS RIVER NEAR SIMNASHO, OR.	Wasco	7	107.00	3500e	44:58:10	121:28:35	1949-95	18	1984-1994	11
116	14096300	MILL CREEK, NR BADGER BUTTE, NR WARM SPRINGS, OR	Wasco	7	26.80	3600e	44:51:42	121:37:35	1983-95	13	1984-1993	11
117	14096850	BEAVER CREEK, BLW QUARTZ CR, NR SIMNASHO, OR.	Wasco	7	145.00	2400e	44:57:32	121:23:35	1983-95	12	1984-1994	11
118	14097200	WHITE RIVER NEAR GOVERNMENT CAMP, OREG.	Wasco	7	40.70	2740	45:10:40	121:34:30	1969-82	14	1970-1980	12
119	14100800	JORDAN CREEK NEAR TYGH VALLEY,OREG.	Wasco	7	9.01	2360	45:20:27	121:20:45			1964-1979	14

120	14104100	RAMSEY CREEK NEAR DUFUR,OREG.	Wasco	7	3.87	2850	45:24:03	121:22:47			1964-1980	16
121	14105850	SOUTH FORK MILL CREEK NEAR THE DALLES,OREG.	Wasco	7	28.00	915	45:32:15	121:19:00	1960-75	16	1960-1975	16
122	14113200	MOSIER CREEK NEAR MOSIER, OREG.	Wasco	7	41.50	425	45:38:55	121:22:35	1963-81	20	1964-1980	18
123	14040700	WHISKY CREEK NEAR MITCHELL,OREG.	Wheeler	10	2.22	4200e	44:31:21	119:55:18			1969-1979	11
124	14046250	IVES CANYON NEAR SPRAY,OREG.	Wheeler	10	2.73	2900e	44:51:35	119:42:50			1968-1979	12
125	14046300	BIG SERVICE CREEK NEAR SERVICE CREEK,OREG.	Wheeler	4	5.56	3120	44:53:38	120:04:11			1969-1979	11
126	14046400	DONNELY CR TRIBUTARY NR SERVICE CR,OREG.	Wheeler	10	1.85	2050	44:46:20	120:00:10			1964-1981	18

APPENDIX II: DOMINANT SEASON OF PEAK FLOW OCCURRENCE FOR SELECTED GAGES

EXAMPLES

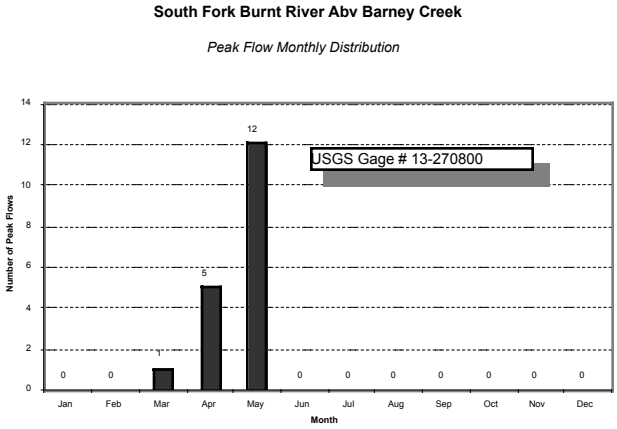
Station Name	**North Fork Burnt River Near Whitney, Or**
Station ID	**13269300**
Param	Streamflow (cfs)
State	OREGON
County	BAKER
Latitude	44:36:00
Longitude	118:15:10
Elevation	4000 (ft)
Start Year	1965
End Year	1980
Num Years	16
Drain Area	110 (mi^2)



Month	# Peaks
Jan	0
Feb	1
Mar	4
Apr	9
May	2
Jun	0
Jul	0
Aug	0
Sep	0
Oct	0
Nov	0
Dec	0
Unk	0
Total	16

Rank	Annual Series (cfs)	Year	Exceedence Probability	Recurrence Interval (years)	Peak Flow Date	Season of Peak Flow
1	1190	1971	5.88%	17.00	04/06/71	spring
2	1010	1974	11.76%	8.50	03/30/74	spring
3	998	1976	17.65%	5.67	04/08/76	spring
4	899	1978	23.53%	4.25	04/01/78	spring
5	870	1972	29.41%	3.40	03/17/72	winter
6	854	1965	35.29%	2.83	04/20/65	spring
7	784	1975	41.18%	2.43	05/11/75	spring
8	760	1969	47.06%	2.13	04/06/69	spring
9	732	1968	52.94%	1.89	02/24/68	winter
10	592	1970	58.82%	1.70	04/06/70	spring
11	544	1966	64.71%	1.55	03/30/66	spring
12	467	1979	70.59%	1.42	03/28/79	spring
13	382	1980	76.47%	1.31	04/20/80	spring
14	291	1967	82.35%	1.21	05/10/67	spring
15	254	1973	88.24%	1.13	04/13/73	spring
16	74	1977	94.12%	1.06	04/07/77	spring

Station Name	**South Fork Burnt River, Above Barney Creek, Near Unity Or**
Station ID	**13270800**
Param	Streamflow (cfs)
State	OREGON
County	BAKER
Latitude	44:24:23
Longitude	118:18:02
Elevation	4342 (ft)
Start Year	1964
End Year	1981
Num Years	18
Drain Area	38.5 (mi^2)



Month	# Peaks
Jan	0
Feb	0
Mar	1
Apr	5
May	12
Jun	0
Jul	0
Aug	0
Sep	0
Oct	0
Nov	0
Dec	0
Unk	0
Total	18

Rank	Annual Series (cfs)	Year	Exceedence Probability	Recurrence Interval (years)	Peak Flow Date	Season of Peak Flow
1	186	1965	5.26%	19.00	04/29/65	spring
2	120	1974	10.53%	9.50	05/09/74	spring
3	118	1975	15.79%	6.33	05/15/75	spring
4	111	1971	21.05%	4.75	05/04/71	spring
5	106	1970	26.32%	3.80	05/20/70	spring
6	94	1972	31.58%	3.17	05/16/72	spring
7	91	1967	36.84%	2.71	05/22/67	spring
8	87	1969	42.11%	2.38	05/14/69	spring
9	82	1976	47.37%	2.11	05/10/76	spring
10	75	1979	52.63%	1.90	05/22/79	spring
11	64	1980	57.89%	1.73	04/24/80	spring
12	61	1964	63.16%	1.58	05/20/64	spring
13	59	1978	68.42%	1.46	03/31/78	spring
14	57	1981	73.68%	1.36	04/23/81	spring
15	49	1966	78.95%	1.27	05/09/66	spring
16	41	1973	84.21%	1.19	04/11/73	spring
17	33	1968	89.47%	1.12	05/20/68	spring
18	29	1977	94.74%	1.06	04/07/77	spring