RECLAMATION

Managing Water in the West

Extension of Natural Flow Data in the Upper John Day River Basin

U.S. Department of the Interior
Bureau of Reclamation

Updated December 2005

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Prepared for:
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Bureau of Reclamation
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Bureau of Reclamation
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Introduction

This investigation was conducted to serve as an extension to the upper John Day Point Flow Study, originally completed in 1990. The original effort was initiated by the Bureau of Reclamation (Reclamation) Pacific Northwest Regional Office located in Boise, Idaho as a cooperative interagency effort sponsored by Reclamation and the John Day Basin Council. The goal of the study was to determine and achieve a more desirable seasonal distribution of runoff for reducing seasonal water shortages in the upper John Day basin. It was deemed to be at an appraisal level of effort because the work was completed using only existing data with no new data collection taking place.

The current (2004) effort was requested by the Reclamation John Day Field Office for meeting the goal of extending the 1990 study natural flow estimations from 1988 to 2002 in selected drainage areas in the upper John Day and upper Middle Fork of the John Day Rivers. This study is considered to be at an appraisal level regarding the computation of natural flow in these areas. The selected watersheds are listed in Table 1 below.

Table 1: Study Target Watersheds

River Basin	Selected Study Area	Drainage Area (sq mi)	River Mile	County
John Day River	Mainstem between Rail Creek and Prairie City (below Strawberry Creek confluence)	150.61	12.7-26.3[1]	Grant
	Reynolds Creek (1990 basin 25)	32.45	21.0[1]	Grant
	Dad's Creek (1990 basin 21)	12.05	14.9[1]	Grant
Middle Fork	Middle Fork mainstem between Clear and Camp Creeks	173.51	0.0-17.8[2]	Grant
	Granite Boulder Creek (1990 Basin 19)	11.37	8.4[2]	Grant

[1] Mile 0.0 located at John Day River, near John Day gaging station.
[2] Mile 0.0 located above Middle Fork and Camp Creek confluence.

Included in this report are descriptions of the study area's physical characteristics, study methodology and results. Appendices include comparisons of the 1990 versus 2004 results and listings of the computed natural flows.

Study Area Characteristics

The John Day River Basin is located in north-central Oregon and drains an area of about 8,000 square miles (see Figure 1). The Blue Mountains form the northern, eastern, and southern boundaries of the basin. The divide between the Deschutes River drainage and the John Day Basin forms the western boundary.

The mainstem of the John Day River flows 281 miles from its headwaters in the Blue Mountains to its confluence with the Columbia River. The upper basin areas, which are within the scope of this study, include the upper mainstem and upper Middle Fork basins. These areas consist of diverse relief and land forms.

The upper basin areas lie in the Blue Mountains portion of the Columbia Plateau. This area extends east to northeast from the Deschutes Valley through the Ochoco, Strawberry, and Blue Mountains. The area is generally characterized by variable relief with individual ranges separated by faulted valleys and synclinal basins containing late Cenozoic beds and lava flows. All of the ranges are surrounded by or consist partly of the elevated and dissected surface of the Columbia River Plateau. Many of the mountains antedate the lava flows and stand as islands above the lava seas. Some of the oldest rocks in Oregon are found in this area. The younger areas consist of lava flows and other volcanic material with inter-bedded sedimentary material. These beds are composed mainly of unconsolidated alluvial and glacial materials which occupy the valley areas and form many of the agricultural lands (Reclamation, 1990).

The climate of the John Day River Basin is characterized by semi-arid conditions with hot summers and cool winters. Along the river, annual precipitation averages between 12 and 20 inches with higher amounts in the upper elevations. The months from July through September are usually dry. Normal January and July temperatures in the central basin areas are about 33.5 and 70 degrees F. Extremes recorded in that area are a maximum of 111 and a minimum of minus 33 degrees F. The average frost-free period is about 130 days and the growing season averages about 180 days for forage crops. Brief description of the individual study watersheds follows in the next four sections (Reclamation, 1990).

Upper Mainstem above Prairie City

The upper mainstem of the John Day study area extends from the headwaters of the John Day River to just upstream of the town of Prairie City, Oregon and lies entirely in Grant County. The drainage area consists of 254 square miles and is characterized by varied topography, soils, land use, and hydrological and meteorological conditions.

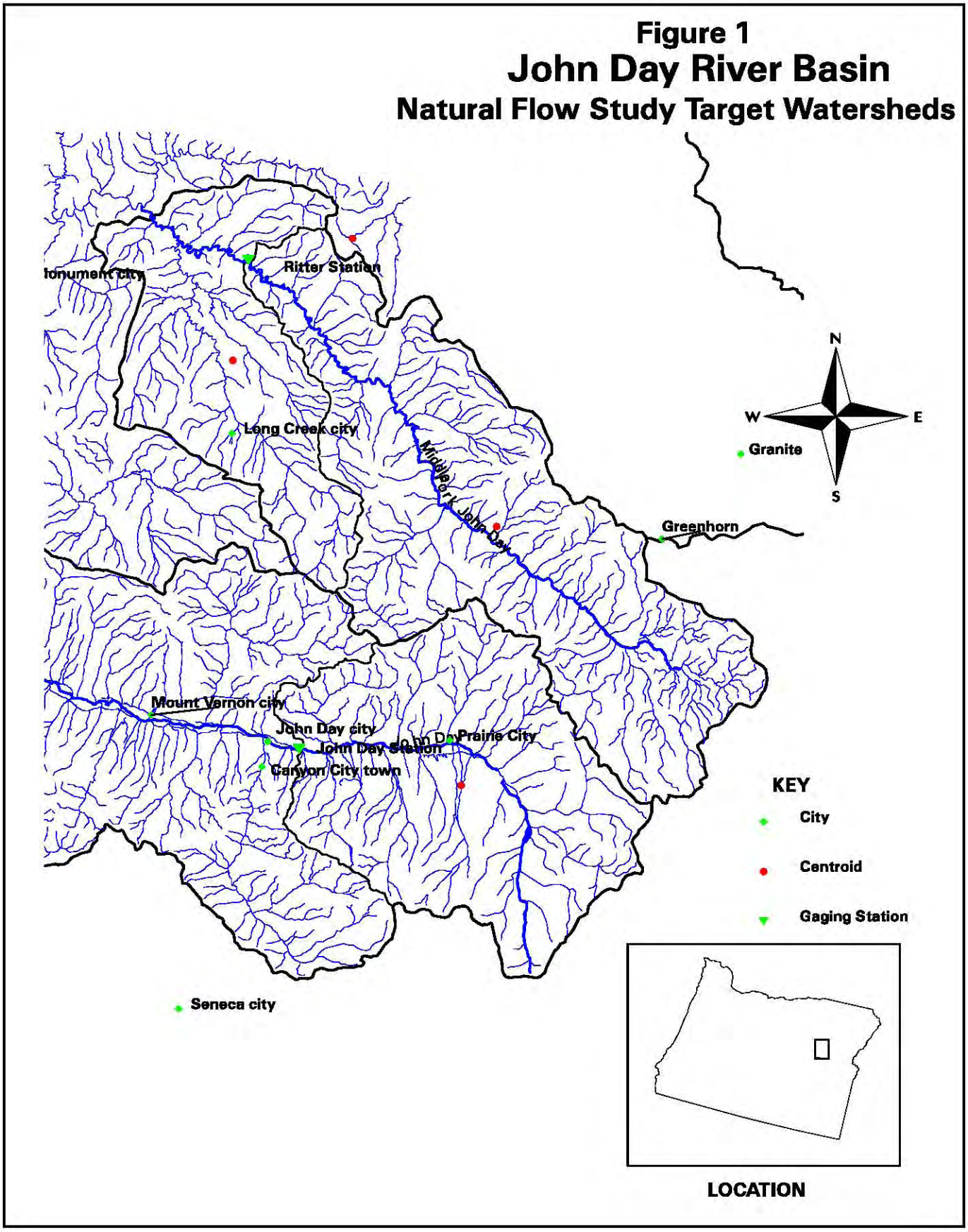
Figure 1
John Day River Basin
Natural Flow Study Target Watersheds
Ionument city
Ritter Station
Long Creek city
Middle Fork John Day
Granite
Greenhorn
Mount Vernon city
John Day city
John Day Station
John Day
Prairie City
Canyon City town
Seneca city
N
W
E
S
KEY
City
Centroid
Gaging Station
LOCATION

The upper mainstem basin originates in the northern slopes of the Strawberry Mountain Range of the Blue Mountains. Elevations range from 9,038 feet in the Strawberry range to 3,537 feet at Prairie City. Steeper slopes in the higher elevations give way to gentler topography in the lower lying areas near the river. Thirteen major tributaries flow into the mainstem between the headwaters and Prairie City (Five from the south and seven from the north and west). Major southern tributaries are Rail and Roberts Creeks, Winegar Gulch, Graham Creek Strawberry and Slide Creeks. Major tributaries to the north and west are Thompson Gulch, Deardorff , Reynolds, Isham, Dans, Jeff Davis and Dads Creeks. Three active stream gaging sites are in the basin: Strawberry Creek above Slide Creek and John Day River near John Day, and Blue Mountain Hot Springs near the John Day headwaters which has intermittent records (Reclamation, 1990).

Soils in the upper mainstem basin vary with elevation and location. A soil survey of the area (Grant County) was completed and published by the Soil Conservation Service (SCS), (Dyksterhuis, 1981). Land use and cover tends to be arranged by elevation. The predominant cover of the upper elevations is forestland consisting primarily of softwood species. Nearly one-half of the basin is found under this cover. Very few areas consisting of hardwoods were found. As one approaches the middle to lower elevations, cover types change to rangeland species. The southern, western and eastern areas are primarily herbaceous rangeland while the north-central area consists of mixed rangeland cover types. The low elevation areas along the John Day River and major tributaries to the south are mainly in cropland and pasture. Hence, these areas are the major irrigation water use areas in the upper mainstem basin. Approximately 22,000 acres are irrigated in the area above the city of John Day (Reclamation 1990).

No major water bodies exist in the basin. Only a few small lakes and ponds were found; these are in the headwaters area of Strawberry Creek. Streamflows appear to be variable and are precipitation and snowmelt driven. Precipitation is highest in the southern areas centering on the headwater area of the John Day River with rainfall averaging about 45 inches per year. The northern and eastern rims of the basin are characterized by 21 to 24 inches of rainfall per year. Valley areas in the mid-to-low elevations range from less than 17 to about 22 inches per year. These patterns result in variations of streamflow between the southern and northern tributaries. Southern basins are characterized by higher, more sustained flows while northern and western basins demonstrate lower, more varying flow patterns. The average annual runoff for the entire area above the John Day gage is approximately 147,300 acre-feet.

Upper Middle Fork

The upper Middle Fork of the John Day River is located north of the mainstem study area flowing generally parallel in a northwesterly direction. The drainage area is 193 square miles and lies entirely in Grant County. This watershed exhibits

less diversity than the upper mainstem area but still is characterized by a mixture of topographic, soil, land use, and hydrological conditions.

The upper Middle Fork study area originates on the western slopes of the Blue Mountains. Elevations range from 8,131 feet on Vinegar Hill in the northern headwaters of Vinegar Creek to 3,467 feet just above the confluence with Camp Creek. Steep slopes in the higher elevations give way to gentler topography in the areas along the river. This reach of the Middle Fork drops a total of 3,258 feet in 22 miles or 148 feet per mile. Major tributaries are Summit Creek, Clear, Bridge, Davis, Vinegar, Vincent, Granite Boulder, Ruby, Beaver, Big Boulder Creeks and Placer Gulch. Only one gauging station is active on the river at Ritter, which is about 34 river miles downstream (Middle Fork of the John Day at Ritter, OR) from the study area's most downstream point. Annual average recorded flow at the Ritter gage is 186,000 acre-feet per year.

Land use in the area is similar in pattern to the upper John Day mainstem except that less acreage is devoted to irrigation along the river and lower tributary areas. Nearly all of the basin consists of softwood forest cover. The remainder is mixed rangeland and cropland. No major water bodies exist in the area.

Flows in the area are less variable with lower extremes as found in the upper John Day. Average annual precipitation is highest (37 inches per year) along the headwater areas of Big Boulder, Granite Boulder and Vinegar Creeks. The southern areas are characterized by annual precipitation amounts of about 25 inches along the river up to about 30 inches in the headwaters area of Ruby Creek. The slopes in the eastern portion of the basin average about 25 to 30 inches of precipitation per year. Valley areas range from 20 to 25 inches annually. Average annual natural flow in the study area, based on the 1990 study above the Camp Creek confluence is estimated be approximately 139,500 acre-feet (Reclamation, 1990).

Natural Flow Development

Natural flows are assumed to represent river, stream, and sheet runoff or overland flow conditions before the influence of human activity. The flow derivation for the current study is essentially an update of the previous effort completed by Reclamation in 1990. A recap of that effort and the updated methodology is described in the next several sections.

The current study computes natural flow for several drainage areas studied in the 1990 Reclamation effort. An attempt to develop and extend the original work was considered, however the detail required was well beyond the scope of this study. To duplicate the 1990 study would have required a full water budget approach of each watershed in the upper John Day and Middle Fork areas and afterward attempting to adjust final figures by precipitation bands in each watershed. Instead, this study attempted the developing of natural flows based on the 1990 study that could be extended to 2003. Because the earlier study had already been peer reviewed and released it was assumed that it provided an acceptable set of natural flow data that could be used as a basis for extending the flow record. A brief synopsis of the 1990 procedures is included below, followed by a description of methods used in the present study.

Procedures Used in the 1990 Study

Upper John Day – Southern (North-Facing) Watersheds

Natural flow was derived for the study area for the period of January 1969 through December 1988. The 1990 study divided the drainage into 13 sub-watersheds and 11 intervening drainage areas to represent surface overland flow. These areas were then grouped into southern and northern watersheds due to observed precipitation variations in these areas. The southern watersheds are characterized by generally north-facing slopes with high precipitation (up to 45 inches annually – based on pre-1960 precipitation records) in the higher elevations and comparatively moderate precipitation (less than 20 inches annually) in the valley areas. The northern watersheds were characterized by south and west-facing slopes with moderate precipitation. The annual precipitation range in these areas ranged from 21 to 24 inches in the valleys and summit areas, respectively, based on the records at that time.

The combination of basin precipitation variability and lack of runoff data led to difficulty in determining natural flows. Natural streamflow data was only available from one gage, the U.S. Geological Survey (USGS) gage designated as Strawberry Creek above Slide Creek. Flow from this gage was influenced by storage in a natural lake upstream. In order to compute natural flow conditions at the Strawberry Creek gage, the streamflow depletions in the form of lake surface evaporation were estimated and used to compute the natural (non-lake impacted)

streamflow at the gage. Note that an operations analysis determined that the lake was usually full and in a spill condition most months of the year. Therefore, change in storage effects was deemed to be minimal and only evaporation impacts were considered.

It was determined that the Strawberry Creek data only represented runoff conditions for watersheds in the southern portion of the study area due to retarded snowmelt on north-facing slopes. Other gaged streamflow data were examined for their appropriateness in determining natural runoff for the northern watersheds.

Initially, a simple rainfall-runoff estimation approach was determined to be the best method of estimating natural runoff. First, drainage area and average centroidal precipitation data of each sub-basin were compared to that of a base gage in a hydrologically similar watershed with recorded long-term runoff data. Next, the ratio of the sub-basin and base gage drainage areas was multiplied by the ratio of the precipitation of the target watershed and base gage watershed. The resulting factor was then multiplied by the base gage flows to obtain natural flow (Equation 1).

(Target Watershed Drainage Area /Base Gage Drainage Area) X

(Target Watershed Centroidal Precipitation/Base Gage Centroidal Precipitation)

X (Base Gage Natural Flows) (1)

Each target watershed's drainage area and centroid were determined by digitized and planimetered mapping techniques. The mean annual precipitation for each watershed was then computed by examining the known mean annual precipitation from available data (pre-1960). It should be noted that in this study an attempt was made to map monthly precipitation patterns using SYMAP, a program that computes spatial variations by mapping precipitation contours over an area of interest, but spatial variations due to the effects of topography were deemed not adequately represented by the program and the SYMAP results were disregarded for the study. One valuable piece of information that was derived from these SYMAP runs, however, was that the spatial variation of late spring and summer precipitation was much less than the variations of the fall and winter periods which were therefore more difficult to compute. Therefore, it was assumed for this level of study, that any adjustments to natural flow with regard to orographic effects during spring and summer could be considered insignificant since the effects on natural runoff are minimal. Winter and spring flow adjustments were conducted however. It was concluded that the winter and spring flows were less reliable than the irrigation season flows.

Upper John Day Northern (South and West-Facing) Watersheds

Several streamgages were examined for use as a base for computing the natural runoff of the northern watersheds. These gages included the Strawberry Creek above Slide Creek gage, the John Day River near John Day gage (USGS gage number 14038530), and the Middle Fork John Day River at Ritter gage (USGS gage number 14044000).

The Strawberry Creek streamflow data was investigated first as it is the only long term recorded streamflow in the study area not influenced by upstream diversions. The computed natural flows from this gage were considered to be too high to represent natural streamflow conditions in the northern sub-basins because the gage is situated in an area of very high precipitation. In contrast, the northern watersheds are located in areas of considerably lower precipitation. The Strawberry Creek data was therefore rejected for south facing watershed since it would tend to overestimate the natural flow conditions.

The recorded streamflow data of the John Day gage was then reviewed. After close analysis, it was concluded that only the fall and winter flows reasonably estimate the natural flow because no known diversions occurred during these periods. It should be understood that some uses do occur during the winter periods such as stock watering, but no records are available to determine the magnitude of this use. This was verified by Mr. Jerry Rodgers, Watermaster for the John Day Basin in the late 1980s, that the ditches on the upper mainstem run water all winter long for watering stock. For purposes of the 1990 study, these uses were assumed insignificant. (One area that could have been problematic in hindsight of this study was the potential effect of late summer or fall return flows from the irrigation season. These flows are probably minimal by the December through February time period, however there is no data available to confirm this statement). The spring and summer flow data could not be used due to an unknown amount of irrigation depletion occurring upstream. Using the recorded data of the John Day gage to compute natural flows of the northern watersheds tended to overestimate the natural runoff because the gage measures the runoff of the southern as well as northern sub-basins. Since the northern sub-basins do not have areas of as high precipitation that occurs in the southern areas, the data was not used for natural flow computation of northern watersheds. However, it should be noted that since the winter and spring flows from the John Day gage represent natural conditions for the entire study reach, the data was used to make adjustments to natural flow estimates of northern and southern watersheds.

Finally, the recorded streamflows at the Ritter gage were examined. The drainage area above the Ritter gage is less impacted by irrigation diversions in summer than that of the area above the John Day River gage at John Day and more reasonably represents areas with precipitation patterns of the northern watersheds than the drainage area above the Strawberry Creek gage. For study purposes, the recorded winter flows were assumed to be natural since there are no known diversions during

the winter months and late season return flow impacts may be minimal. As with the John Day gage, it is understood that some uses do occur during the winter periods such as stock watering, but no records are available to determine the magnitude of this use - therefore, these uses were assumed insignificant. The summer flows at the gage were also assumed to represent natural conditions because few diversions occur upstream when compared to the flows above the John Day gage. Therefore, in the 1990 study, it was assumed that streamflow conditions for the northern watersheds could be adequately computed from the streamflow recorded at the Ritter gage and the rainfall-runoff technique described earlier.

Because precipitation varies widely within some individual sub-basins (higher precipitation at higher elevations), a final adjustment was conducted to offset the effects of areas characterized by high precipitation areas.

Upper John Day Southern (North-Facing) Watersheds

As in the northern areas, computation of natural flows in the southern sub-basins was complicated by diverse precipitation patterns. Three streamflow gages were investigated for use as base gages in the natural flow computations: the Strawberry Creek, John Day, and Ritter gages.

Recorded runoff at the Ritter gage was determined as not appropriate for representing runoff conditions in the southern watersheds. This is due to the difference in precipitation characteristics of the Ritter drainage and the southern watersheds. Precipitation above the Ritter gage was generally lower and could underestimate runoff in the southern drainages. Data from this gage was better suited to represent runoff conditions in the northern areas of the study reach and was therefore rejected for use in the southern watershed runoff computations.

It was also determined that flow data from the John Day gage was not appropriate for use in determining natural flows in these south aspect watersheds. This was due to the assumption that the influence of the lower precipitation patterns and runoff of the northern watersheds of the area as measured at the gage could cause the flow of these areas to be underestimated.

It was determined that the recorded flow of the Strawberry Creek watershed best represented runoff conditions and basin precipitation characteristics of the southern watersheds. However, adjustments to the data are necessary to include the effects of runoff from the lower valley areas, especially during the winter months. An initial adjustment was performed by using the basin rainfall-runoff computation technique described earlier. A second adjustment, as final calibration, was made to compensate for areas of very high precipitation.

Upper John Day 1990 Study Calibration Technique.

When comparing the computed combined natural flow for the study reach during fall and winter periods to recorded natural flows at the John Day gage, it was found that the combined flows were typically less than the gaged flows. Therefore, it was necessary to adjust the computed natural flow of the northern and southern areas to approximate the measured natural flows. Since the original rainfall/runoff coefficients were based on each watershed's centroidal alignment with the mean annual precipitation patterns (pre-1960), the influence of high precipitation on runoff in the headwater areas of some basins was not adequately represented. To correct for this condition, a weighted precipitation adjustment was made for high precipitation areas. The weighted correction for all watersheds equaled the difference between the computed and measured flows. The weighing factors to be applied were determined by measuring the drainage area of each sub-basin lying in the 30 to 40 inch, 40 to 50 inch and 50+ inch bands of mean annual precipitation. This was completed by planimetering and weighting each precipitation band against the total area in the bands. The portion in the 40 to 50 inch band for example carried a heavier weight (1.29% based on a 45 to 35 inch ratio of the midpoint of each band) than those in the 30 to 40 inch band. Details of the weighing procedure can be reviewed in the 1990 report.

The weighing factors were only applied to the estimates of natural flow for months of October through March. The calibration resulted in computed natural flows which equalled the gaged natural flows at the John Day gage. Since spring and summer precipitation patterns for the 1969-88 period are less variable than in fall and winter (from SYMAP monthly precipitation runs), it was assumed that no correction was required for these periods. It was observed that the computed natural streamflows during the spring and summer months were greater than the recorded flows. The difference is assumed to represent spring and summer consumptive use.

Upper Middle Fork Watersheds

The technique used to estimate the natural runoff conditions in the upper Middle Fork reach was similar to that used in the upper John Day River area. Flows at the Ritter gage and precipitation patterns were used as a basis of computation. Natural flows were computed for only three years due to study time limitations. These years were chosen to represent average (1972), wet (1984) and dry (1988) conditions. Flows for 1981 were also computed as a basis for a water quality companion study since that was the only year with available quality data.

The recorded flows at the Ritter gage were used to represent natural conditions affected by irrigation and other uses of man. Therefore, all of the acreage and respective crop types were estimated in the area along with depletions from other uses (M&I uses in the upper Middle Fork appear to be abandoned). The flow depletions due to irrigation were estimated by the modified Blaney-Criddle method

of determining plant consumptive use. Other losses from other uses were also estimated. These losses were then added to the recorded runoff at the Ritter gage to determine natural runoff at the gage.

Because this study required more detail about streamflow conditions in several tributaries, the above analysis was extended to estimate natural flow conditions in several tributaries (25) and at several points along the river. This was conducted in a similar fashion as on the upper John Day mainstem area. Precipitation patterns were used to determine flow variability in the basin.

A simple rainfall-runoff estimation approach was determined to be the best method of estimating natural runoff in individual tributaries. First, drainage area and average precipitation data of each sub-basin were compared to that of the Ritter streamflow gage (base gage). Next, the ratio of the target watershed and the gage drainage areas was multiplied by the ratio of the precipitation of the watershed and base watershed as described in Formula 1. The resulting factor was then multiplied by the base gage flows to obtain natural flow. Each target watershed's drainage area and centroid were determined by electronic digitizing. The mean annual precipitation for each sub-basin was then computed by examining the known mean annual precipitation (pre-1960) which was the best available information regarding general precipitation patterns.

Upper Middle Fork 1990 Study Calibration Technique

When comparing the computed combined natural flow for the study reach during fall and winter periods to recorded natural flows at the Ritter gage, it was found that the computed flows were less than the gaged flows. Therefore, it was necessary to adjust the computed natural flow of the target watersheds to approximate the measured natural flows. Since the original rainfall/runoff coefficients were based on each watershed's centroid alignment with the mean annual precipitation patterns, the influence of high precipitation on runoff in the headwater areas of some basins was not adequately represented. To correct for this condition, a weighted precipitation adjustment was made for high precipitation areas. The weighted correction for all watersheds were adjusted to equal the difference between the computed and measured flows. The weighing factors that were applied were determined by measuring the drainage area of each watershed lying in the 30 to 40 inch and the 40 to 50 inch bands of mean annual precipitation. The portion of drainage area in each precipitation band was digitized (planimetered) and weighted against the total area in the bands. For example the portion in the 40 to 50 inch band carried a heavier weight (1.29% based on a 45 to 35 inch ratio of the midpoint of each band) than those in the 30 to 40 inch band. More detail regarding this weighing procedure can be found in the 1990 report.

The final results of the natural flow study in the upper John Day and Middle Fork Rivers served as a starting point for a point flow study. This point flow study was

developed for modeling wet, dry, and average monthly streamflow conditions in the area. Consumptive uses were applied to the area in the form of a water budget that considered irrigation, municipal and industrial, and other uses and their resultant return flows to estimate fishery flow conditions throughout the upper John Day River Basin. The 2004 study in contrast was only concerned with computing natural flows in the four specified drainage areas listed in Table 1. No point flow model was developed in this effort.

Procedures used in the 2004 Study

The present study was intended to extend the natural flow estimates derived in the previous effort. The 1969 to 1988 natural flows were modified based on updated precipitation data and extended to September 2003. The work is considered to be at an above appraisal level, however it must be pointed out that the results of this study could be improved upon if greater detail were required. Several assumptions were made regarding the extension of the 1990 study data.

1. The precipitation records used in the 1990 study were based on pre-1960 data. These were the only aerial data available at the time. They were however, considered to represent long-term precipitation patterns as affected by orographic conditions in the region. In 2004, advancement in GIS technology and precipitation data from the Oregon Water Resources Department (OWRD) allowed for an update of aerial precipitation conditions that partially coincided with a portion of the study period (1961 to 1990). Thus, the aerial average precipitation maps were updated and were assumed to be a more viable data set.

2. The individual watershed natural flows conducted in 1990 were the most detailed available. Thus it was assumed these could be used as a basis of comparison for the updated 1989 through 2003 natural flows.

3. Centroidal locations and values from the 1990 study required GIS checking and updating to serve in the current effort.

4. Summer and fall natural flows were developed with at least appraisal level accuracy and detail in the 1990 study. Winter flows were based on less certainty and an assumption of insignificant consumptive use during these months. In addition, the winter and high spring flows are much more variable throughout the study area. The final confidence in the winter flow predictions then would be less than the summer and fall periods.

The procedures used in this study were the result of several failed attempts at developing the natural flows through various techniques. The lack of available

natural or undepleted streamflow in the area limited the detailed evaluation of natural flows. In order to duplicate the study of the 1990s, a complete reconstruction and calibration of each of the dozens of watersheds and intervening flow areas would have to be conducted and tied to the gages in the lower basin. This was considered to be outside the scope and budget of this study, and that an abbreviated process of computing the natural flows by standard hydrologic techniques would be required utilizing the 1990 study as a platform for checking results. The flows developed in this effort could be improved upon by a more detailed analysis; however the effort required may not produce significantly different results. What is anticipated is that the high spring flow patterns might be improved. However, the lower irrigation season flows, more critical to habitat and fishery survival appear to be in line with what is expected and what could be derived by a more detailed study.

Data Collection and Updates.

Climate Data

Early in this study it was decided that precipitation and mapping information required updating by GIS techniques. Aerial precipitation data were obtained through OWRD and overlaid on the study area. The most current information was from 1961 to 1990, which partially overlapped the 1989 to 2003 study period and fully overlapped the 1990 study period from 1969 to 1988. Therefore, the updated precipitation information was applied to the full 1969 to 2003 period as an update. Variations between the old data set were observed primarily in the upper elevation areas where annual amounts appeared to be significantly reduced in the newer data set.

The mapping of the specific study watersheds was also conducted by using GIS. All the 1990 study areas that fell within or peripheral to the 2004 reaches were remapped. Basin areas were recomputed and centroid locations adjusted based on digitized information. Centroidal precipitation estimates were also recomputed based on the updated aerial precipitation information. The updated watershed (1990 study and targeted 2004 study) and centroidal data are presented in Figure 2 and the updated precipitation map overlay is displayed in Figure 3. Tables 2 and 3 list the breakdown of individual data derived for each watershed area in the Middle Fork and mainstem respectively while Table 4 lists data regarding the upper John Day and Middle Fork full drainage reaches.

Evaporation data was extended from the 1990 study at the Malheur Experiment Station, which is located to the south of the study area. This climate station offered the only continuous record of evaporation in the region. This was applied to the update of the Strawberry Creek gage natural flow depletions with regard to Strawberry Lake.

Streamflow Data

The first step in the flow development process was to review the streamgage records for the area. Sporadic instantaneous flow measurements were obtained in the area, however these offered little for calibration or estimation techniques. The USGS gage at Strawberry Creek above Slide Creek was still in operation from 1989 through 2003. This gage would once again serve as a valuable data source for this study, however it was deemed to still be more representative of north-facing watersheds which were not generally targeted for this study. The USGS gage at Blue Mountain Hot Springs near the John Day River headwaters also had available data, but the record was not continuous. This gage record also consisted of some irrigation upstream resulting in some regulation of flows but was still considered for comparative purposes.

A second gage to the north of the area, the Umatilla River above Meacham Creek appeared to have possibilities for the west and south-facing watershed. Reynolds, Dad's, and Granite Boulder Creek all fit into this category. The larger mainstem reaches consisted of both south and north facing sloped drainage. Though outside the study area, the Umatilla gage represented similar precipitation levels and a northwesterly aspect which appeared to be more representative of several of the target watersheds.

Upon selection and review of the available streamflow data, the Strawberry Creek natural flow was updated and extended based on the updated precipitation and evaporation data. This task was accomplished through a simple water budget of the lake for computing evaporation depletions. These depletions were added to the gaged data to arrive at natural flows. The final correlation of these data with the 1990 study computations resulted in an R^2 value of 0.99. This gage data was compared to the partial records at Blue Mountain Hot Springs and indicated a fair correlation with the estimated natural flows at Strawberry Creek. Because the Strawberry Creek flows had better continuity and could be converted to natural flow by a simple water budget of the small lake upstream of the gage, and because of the gage's proximity with the watersheds under study, it was deemed that the Strawberry Creek gage would yield a more consistent and continuous representation of natural flow.

The Umatilla gage also consisted of a long period of record that overlapped the 1990 study period through 2003. The USGS stated that the records at this gage were considered good and were not influenced by any diversions or depletions upstream. Thus, the recorded flows for this gage were considered to represent natural conditions. Pertinent data for these two gages, as well as other gages in the area are listed in Table 4.

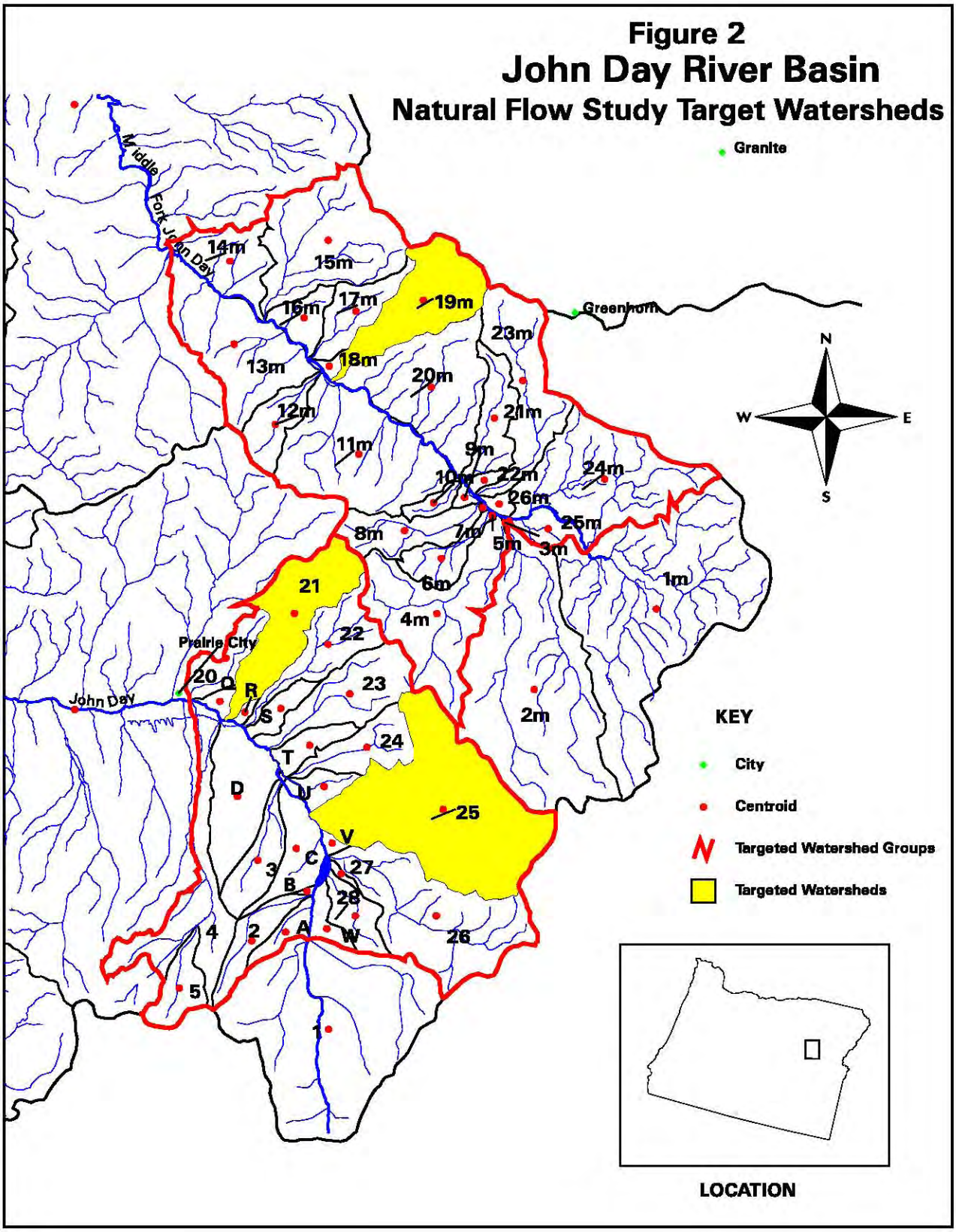
Figure 2
John Day River Basin
Natural Flow Study Target Watersheds
Granite
Middle Fork John Day
Greenhorn
Prairie City
John Day
N
W
E
S
KEY
City
Centroid
Targeted Watershed Groups
Targeted Watersheds
LOCATION

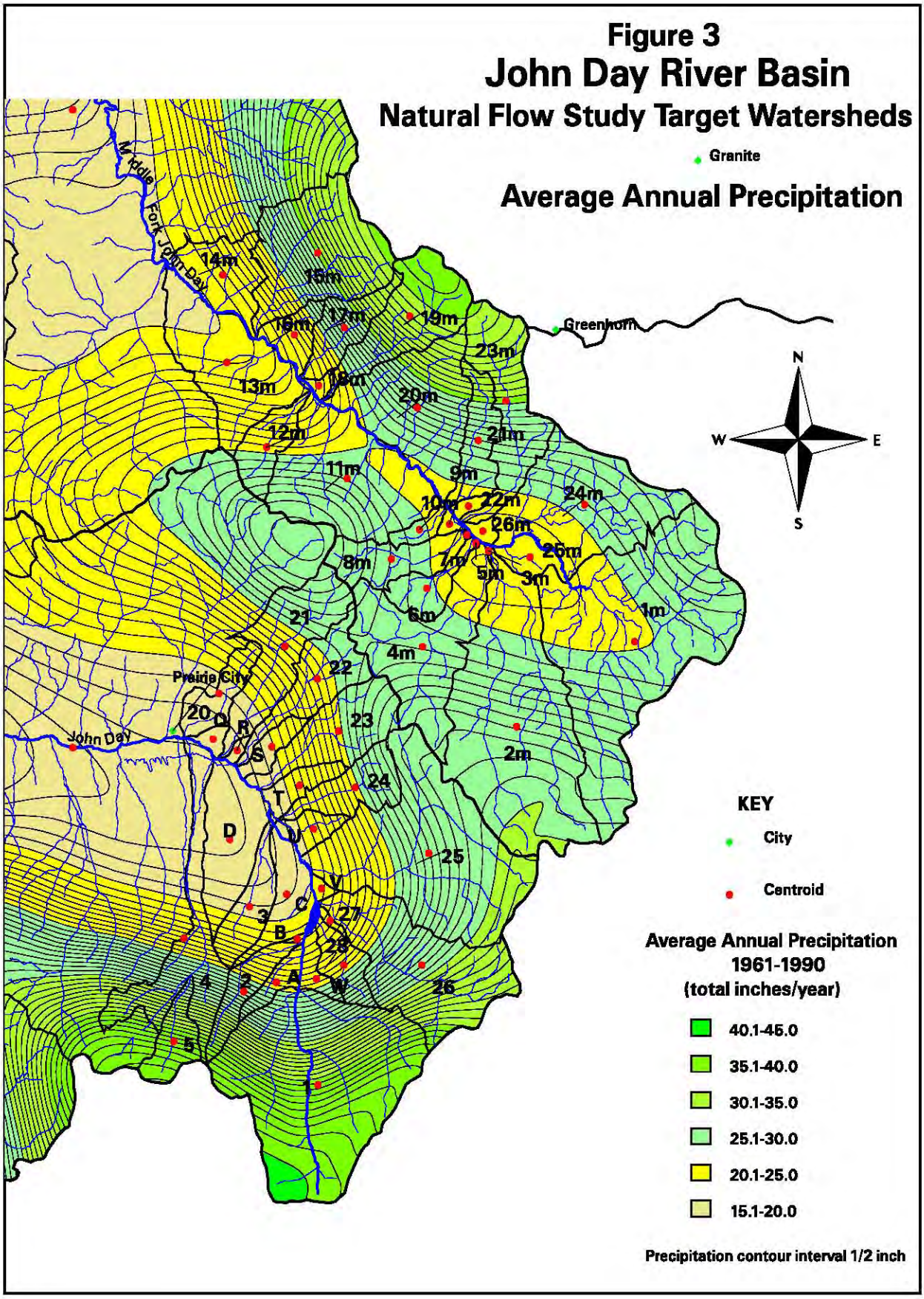
Figure 3
John Day River Basin
Natural Flow Study Target Watersheds
Granite
Average Annual Precipitation
Middle Fork John Day
Greenhorn
Prairie City
John Day
N
W
E
S
KEY
City
Centroid
Average Annual Precipitation
1961-1990
(total inches/year)
40.1-45.0
35.1-40.0
30.1-35.0
25.1-30.0
20.1-25.0
15.1-20.0
Precipitation contour interval 1/2 inch

Table 2: Middle Fork Watershed designations and pertinent areas

Watershed Designation	Drainage Area	Mean Annual Precipitation (inches) 1961-1990	Area (sq miles)
Middle Fork of the John Day River above Ritter, OR			
1m	Middle Fork John Day, Squaw Creek, Summit Creek	24.92	44.26
2m	Clear Creek, Dry Fork Clear Creek	28.34	36.64
3m	Untitled	24.04	0.11
4m	Bridge Creek, Lunch Creek	25.84	17.69
5m	Untitled	24.19	0.07
6m	Placer Gulch	25.18	3.69
7m	Untitled	24.39	0.07
8m	Davis Creek	26.03	6.37
9m	Untitled	24.68	0.53
10m	Untitled	25.20	1.42
11m	Butte Creek, Sulphur Creek, Riverside Creek	25.85	20.32
12m	Ruby Creek, West Fork Ruby Creek	24.56	4.58
13m	Sunshine Creek, Middle Fork Sunshine Creek, East Fork Sunshine Creek, Balance Creek, Dunston Creek	20.49	15.58
14m	Coyote Creek, East Fork Coyote Creek, Horse Creek	20.81	7.20
15m	Big Boulder Creek, Badger Creek, Wray Creek, Myrtle Creek	30.31	18.00
16m	Dry Creek	22.50	3.28
17m	Beaver Creek, Corey Creek	27.75	5.23
18m	Untitled	22.60	0.64
19m	Granite Boulder Creek, West Fork Granite Boulder Creek, Blackeye Creek, Ingram Creek, Lemon Creek	34.03	11.37
20m	Tincup Creek, Little Boulder Creek, Windlass Creek, Murdock Creek, Flat Creek, Caribou Creek, Hunt Gulch	27.83	16.74
21m	Vincent Creek	26.99	5.52
22m	Vinegar Creek, Blue Gulch	24.65	0.68
23m	Untitled	30.21	11.98
24m	Mill Creek, Crawford Creek, Sixteen Gulch	25.42	19.22
25m	Untitled	24.19	2.46
26m	Untitled	24.30	0.76

Table 3: John Day River (mainstem) washershed designations and pertinent data.

Watershed Designation	Drainage Area	Mean Annual Precipitation (inches) 1961-1990	Area (sq miles)
John Day River above Prairie City, OR			
1	John Day River, Rail Creek, Roberts Creek, Call Creek	35.55	38.63
2	Winegar Gulch	26.56	4.22
3	Graam Creek	19.58	5.21
4	Strawberry Creek, Onion Creek	22.96	12.68
5	Slide Creek	36.62	4.15
20	Slaughter House Gulch	19.40	4.16
21	Dads Creek	23.89	12.05
22	Jeff Davis Creek	24.12	7.56
23	Dans Creek, Eureka Gulch	24.72	9.51
24	Isham Creek	24.76	5.91
25	Reynolds Creek, North Fork Reynolds Creek, Mossy Gulch, Axe Gulch	27.26	32.45
26	Deardorff Creek	29.46	19.89
27	Untitled	21.24	0.38
28	Thompson Gulch	24.11	3.83
A	Untitled	24.21	2.13
B	Untitled	20.81	0.15
C	Untitled	19.44	5.78
D	Untitled	18.37	9.90
Q	Untitled	18.67	0.94
R	Untitled	18.80	0.45
S	Untitled	19.98	2.18
T	Untitled	20.71	2.65
U	Untitled	20.63	2.03
V	Untitled	20.36	0.52
W	Untitled	23.87	1.88

Table 4: Streamgages utilized for natural flow computation in the John Day Study Area

USGS Designator	**Description**	**Drainage Area (square miles)**	**Period of Record**	**Remarks**
14037500	Strawberry Creek above Slide Ck near Prairie City, OR	7	1931-91 (USGS); 1992-2004 (OWRD)	Records fair/storage upstream
14038530	John Day River near John Day, OR	386	1968-94; 1996-2004	Records fair/diversions
1404400	Middle Fork John Day River at Ritter, OR	515	1920-2004	Records fair/diversions
1402000	Umatilla R above Meacham Creek	131	1933-2004	Records good/no diversions

Early Methodology Using Precipitation/Drainage Area Ratios

Upon development and integration of the climate and GIS information, a process to utilize a similar combined drainage area ratio and precipitation ratio technique was envisioned for computing natural flows. Several attempts to match the new precipitation versus drainage area ratios with runoff resulted in poor correlations with the 1990 study results. The Strawberry Creek relationships yielded consistently higher flows generally offset in distribution by one month. This was assumed to occur due to the higher precipitation environment of the Strawberry Creek drainage above the Slide Creek confluence and the delay in melt driven runoff due to the northern aspect of the drainage. The results of correlating the Umatilla gage were much better, however spring and winter flows would still probably require some form of adjustment. Based on these observations it was decided to utilize a regression method of computing the natural flows.

Regression Methodology

Upon reviewing results of the ratio adjustment technique a shift to regression analysis was performed. Several regressions between the Strawberry Creek and Umatilla natural flow gage data were conducted with the 1990 results of natural flow. This technique of course was based on the assumption that the 1990 computations of natural flow were reasonably accurate. Considerations regarding watershed aspect characteristics and snowmelt patterns driven by temperature and aspect with respect to solar energy were considered. Regressions were run for the entire period of record and on a month-to-month basis. Regressions were also derived for the effects of delayed snowmelt driven runoff by offsetting regressions to account for apparent delays in snowmelt from north facing slopes. Results using this methodology were improved leading to the following assumptions used in the final analysis.

1. North facing slopes are better represented through correlation with the Strawberry Creek gage. However the John Day mainstem reach targeted by the study correlated well with the Strawberry gage data.

2. West and south facing watersheds correlated better with the Umatilla gage natural flows. The Middle Fork mainstem reach targeted by the study also correlated better with the Umatilla gage.

3. Summer low flows during the irrigation season generally correlated well using the regression technique.

4. Winter and spring high flows did not correlate as well with the 1990 data but were assumed reasonable to use for the level of this study. These flows also were represented with a higher level of uncertainty in the 1990 study. Early peak flows correlated fairly well on a month-to-

month average basis, however utilizing these correlations may not add any value to a more consistent approach for the period of record.

In the final analysis the correlation of the south and west-facing watersheds (Reynolds, Dad's, and Granite Boulder Creeks) were conducted using the Umatilla gage natural flows. The mainstem John Day River was correlated with Strawberry Creek and the Middle Fork mainstem flows were computed using the Umatilla gage. Correlation of results is displayed in Table 3 below. Results of these the natural flow computations for each target watershed are tabulated in Appendix A. Flow exceedance data, also presented for each drainage, are presented in Appendix B.

Conclusions and Recommendations

The above study and results were based on limited data and several simplifying assumptions. The results are considered to be at and above appraisal level in the summer months and appraisal level for winter and spring peak runoff periods. It is believed that these flows are adequate for assessing habitat and fishery conditions. Further adjustments could be made if future gage flow data were taken in the target watershed areas.

Because the John Day Basin lacks much of the important data to do a detailed analysis, it is recommended that an intense field data collection program be established to better quantify the natural flows of the area. The following recommendations, originally outlined in the 1990 study are still considered valid in 2004.

1. Establish continuous stream gaging stations above the most upstream irrigation diversion on the mainstem river and tributaries in areas critical to future studies.

2. Establish a continuous stream gaging station at intermediate points in the study reach, at critical flow points of interest.

3. Establish continuous stream gaging stations at the mouth of pertinent tributaries.

4. Establish a flow measurement program for all canal diversions. This would allow for more detailed water budgeting techniques to be applied for natural flow estimation.

5. Establish a data collection program with attention given to the determination of the conveyance system efficiencies, on-farm efficiencies, irrigation water use, and operational waste.

6. Determine physical characteristics of canal and ditch systems such as diversion capacity, carrying capacity, turnout locations, service areas, and source of supply.

7. Refine the farm irrigation requirement estimates to include a contribution of shallow ground water and the impact of sub-irrigation practices.

8. Complete an irrigation return flow study and stream accretion flow study which allows for the determination of natural seepage gains and unused irrigation diversions.

9. Establish a companion water quality data gathering program to work with the streamflow data program. This will allow for more accurate data if modeling is considered in the future.

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Appendix A: Computed Natural Flow Data

Computed monthly natural flow for targeted watersheds in acre-feet per month and mean daily cubic feet per second per month.

Table A1A: REYNOLDS CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	2452.7	827.0	1804.4	4091.9	2462.9	710.5	359.8	202.4	203.6	245.9	262.9	387.9	14011.8
1970	3016.0	1627.7	1822.8	2055.1	3080.4	1113.4	312.0	240.8	264.2	367.0	709.7	779.5	15388.6
1971	2693.6	2020.3	1482.3	2058.8	2173.9	1304.7	423.1	290.6	252.2	264.0	602.1	1123.8	14689.4
1972	1561.5	2282.8	4917.3	2474.1	3149.0	1040.2	351.2	296.3	266.6	290.9	339.0	1158.8	18127.7
1973	1166.0	618.5	952.4	1091.5	896.9	335.0	233.5	232.7	243.1	281.6	1704.4	3294.7	11050.4
1974	2811.0	1610.7	2465.6	4261.7	4025.8	2852.7	553.4	296.8	256.0	275.2	302.4	802.1	20513.5
1975	2920.4	1312.5	2084.2	1833.8	3981.0	1433.4	507.9	330.8	261.9	383.1	867.5	3568.2	19484.8
1976	2282.0	1397.3	1535.7	3421.0	3131.1	841.8	299.0	309.7	247.9	280.3	295.8	290.1	14331.8
1977	352.3	338.0	995.4	2144.7	920.6	384.9	263.8	275.8	292.8	332.4	951.8	2941.1	10193.7
1978	1718.8	1448.2	1949.1	2103.3	1406.0	487.9	331.3	269.9	269.8	247.1	273.3	763.9	11268.4
1979	332.1	1465.1	2416.7	3022.6	3073.6	635.5	301.3	260.2	248.2	303.7	345.6	685.4	13089.7
1980	1244.7	1411.5	1686.5	2182.7	1383.5	774.4	304.9	245.8	242.1	306.8	428.6	1558.0	11769.6
1981	735.9	2744.2	1725.8	2460.5	1459.8	934.0	314.7	240.5	216.2	275.7	421.4	1300.2	12828.8
1982	1876.3	4090.4	2484.0	2813.1	3015.0	1061.9	443.9	265.3	267.8	428.2	726.6	1593.2	19065.9
1983	2082.9	1930.6	2902.8	1929.0	2234.9	558.4	335.8	254.3	232.5	246.3	416.2	787.1	13910.6
1984	2158.3	1400.9	3325.3	2469.4	2588.7	1779.6	402.2	284.5	265.6	312.9	938.3	848.9	16774.7
1985	478.6	635.5	1431.0	3770.3	2253.7	779.5	300.6	268.8	271.2	362.2	629.7	460.7	11641.9
1986	1105.8	3277.0	2659.7	1487.8	1102.9	391.0	270.2	225.6	241.9	245.0	1144.8	605.9	12757.5
1987	520.0	1361.6	2102.0	1727.5	872.3	330.5	259.7	223.1	210.0	223.9	237.6	320.9	8389.0
1988	667.8	1073.6	1488.4	2708.8	1155.6	608.3	273.3	218.8	207.9	223.7	723.3	905.6	10255.0
1989	1105.9	743.9	3391.8	4148.8	2501.1	761.0	286.7	255.2	229.5	236.5	293.4	365.7	14319.5
1990	799.4	1084.2	1645.4	1984.1	2000.0	1188.6	299.7	204.4	197.5	304.3	519.4	600.5	10827.3
1991	1229.0	1659.2	1598.1	2269.1	3221.5	1104.3	386.0	261.4	216.8	235.9	1202.0	1451.0	14834.4
1992	756.0	1661.0	1028.7	1298.3	442.8	253.6	243.1	241.9	219.7	228.2	531.7	657.5	7562.5
1993	538.2	636.3	3088.8	3602.9	4222.5	831.8	342.4	259.7	222.1	236.0	229.6	318.7	14529.0
1994	1438.0	429.2	2182.4	2264.8	1268.4	432.2	260.8	210.9	210.6	245.1	759.7	1709.4	11411.6
1995	1903.2	3436.9	2043.3	2210.2	3214.9	813.6	347.8	235.7	212.0	266.7	1809.0	2129.2	18622.6

Table A1A: REYNOLDS CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	1775.0	4999.2	2099.7	3111.1	1775.6	501.0	294.4	235.2	224.8	297.4	872.9	2234.1	18420.5
1997	2732.0	2536.8	3738.1	4184.9	2808.1	675.4	315.2	235.7	240.5	315.7	505.8	695.3	18983.5
1998	1452.9	1032.5	1943.8	1734.4	2529.1	770.0	330.2	244.0	244.8	253.5	808.0	1945.9	13289.1
1999	2060.7	1131.7	2236.1	2088.2	2538.7	804.3	304.1	242.6	208.7	225.3	548.0	1339.2	13727.7
2000	945.4	1683.7	2053.2	2873.8	1540.5	1170.8	321.9	229.1	272.2	420.4	469.0	569.9	12550.0
2001	945.4	1683.7	2053.2	2873.8	1540.5	1170.8	321.9	229.1	272.2	420.4	469.0	569.9	12550.0
2002	1137.6	1208.6	1823.6	3678.7	2189.9	760.4	300.8	227.7	212.8	239.5	275.2	334.2	12389.0
2003	1558.8	1668.5	3428.9	2389.2	1533.5	403.8	234.6	201.0	219.2				
AVG	1501.55	1670.53	2188.19	2594.85	2219.86	857.13	326.60	249.90	239.00	288.85	635.70	1149.89	13928.22

Table A1B: REYNOLDS CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	40.0	14.9	29.4	68.9	40.1	12.0	5.9	3.3	3.4	4.0	4.4	6.3	19.4
1970	49.1	29.4	29.7	34.6	50.2	18.7	5.1	3.9	4.4	6.0	11.9	12.7	21.3
1971	43.9	36.4	24.2	34.7	35.4	22.0	6.9	4.7	4.2	4.3	10.1	18.3	20.3
1972	25.4	39.8	80.1	41.7	51.3	17.5	5.7	4.8	4.5	4.7	5.7	18.9	25.1
1973	19.0	11.2	15.5	18.4	14.6	5.6	3.8	3.8	4.1	4.6	28.7	53.7	15.3
1974	45.8	29.1	40.2	71.7	65.6	48.0	9.0	4.8	4.3	4.5	5.1	13.1	28.4
1975	47.6	23.7	34.0	30.9	64.9	24.1	8.3	5.4	4.4	6.2	14.6	58.1	27.0
1976	37.2	24.3	25.0	57.6	51.0	14.2	4.9	5.0	4.2	4.6	5.0	4.7	19.8
1977	5.7	6.1	16.2	36.1	15.0	6.5	4.3	4.5	4.9	5.4	16.0	47.9	14.1
1978	28.0	26.1	31.8	35.4	22.9	8.2	5.4	4.4	4.5	4.0	4.6	12.4	15.6
1979	5.4	26.4	39.4	50.9	50.1	10.7	4.9	4.2	4.2	4.9	5.8	11.2	18.1
1980	20.3	24.6	27.5	36.7	22.5	13.0	5.0	4.0	4.1	5.0	7.2	25.4	16.3
1981	12.0	49.5	28.1	41.4	23.8	15.7	5.1	3.9	3.6	4.5	7.1	21.2	17.8
1982	30.6	73.8	40.5	47.4	49.1	17.9	7.2	4.3	4.5	7.0	12.2	26.0	26.4
1983	33.9	34.8	47.3	32.5	36.4	9.4	5.5	4.1	3.9	4.0	7.0	12.8	19.2
1984	35.2	24.4	54.2	41.6	42.2	30.0	6.6	4.6	4.5	5.1	15.8	13.8	23.2
1985	7.8	11.5	23.3	63.5	36.7	13.1	4.9	4.4	4.6	5.9	10.6	7.5	16.1
1986	18.0	59.1	43.3	25.0	18.0	6.6	4.4	3.7	4.1	4.0	19.3	9.9	17.7
1987	8.5	24.6	34.2	29.1	14.2	5.6	4.2	3.6	3.5	3.6	4.0	5.2	11.6
1988	10.9	18.7	24.2	45.6	18.8	10.2	4.5	3.6	3.5	3.6	12.2	14.8	14.2
1989	18.0	13.4	55.3	69.8	40.7	12.8	4.7	4.2	3.9	3.9	4.9	6.0	19.8
1990	13.0	19.6	26.8	33.4	32.6	20.0	4.9	3.3	3.3	5.0	8.7	9.8	15.0
1991	20.0	29.9	26.0	38.2	52.5	18.6	6.3	4.3	3.7	3.8	20.2	23.6	20.5
1992	12.3	28.9	16.8	21.9	7.2	4.3	4.0	3.9	3.7	3.7	9.0	10.7	10.5
1993	8.8	11.5	50.3	60.7	68.8	14.0	5.6	4.2	3.7	3.8	3.9	5.2	20.1
1994	23.4	7.7	35.6	38.1	20.7	7.3	4.2	3.4	3.5	4.0	12.8	27.8	15.8
1995	31.0	62.0	33.3	37.2	52.4	13.7	5.7	3.8	3.6	4.3	30.5	34.7	25.8

Table A1B: REYNOLDS CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	28.9	87.1	34.2	52.4	28.9	8.4	4.8	3.8	3.8	4.8	14.7	36.4	25.5
1997	44.5	45.8	60.9	70.5	45.7	11.4	5.1	3.8	4.0	5.1	8.5	11.3	26.3
1998	23.7	18.6	31.7	29.2	41.2	13.0	5.4	4.0	4.1	4.1	13.6	31.7	18.4
1999	33.6	20.4	36.4	35.2	41.4	13.5	5.0	4.0	3.5	3.7	9.2	21.8	19.0
2000	15.4	29.3	33.5	48.4	25.1	19.7	5.2	3.7	4.6	6.8	7.9	9.3	17.4
2001	15.4	30.4	33.5	48.4	25.1	19.7	5.2	3.7	4.6	6.8	7.9	9.3	17.4
2002	18.5	21.8	29.7	61.9	35.7	12.8	4.9	3.7	3.6	3.9	4.6	5.4	17.1
2003	25.4	30.1	55.9	40.2	25.0	6.8	3.8	3.3	3.7				
AVERAGE	24.46	29.85	35.65	43.68	36.17	14.43	5.32	4.07	4.02	4.71	10.70	18.73	19.27

Table A2A: DAD'S CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	795.8	261.3	582.7	1334.7	799.1	223.0	107.7	56.0	56.4	70.3	75.9	117.0	4479.8
1970	981.0	524.6	588.7	665.1	1002.2	355.5	92.0	68.6	76.3	110.1	222.8	245.7	4932.5
1971	875.0	653.6	476.8	666.3	704.1	418.4	128.5	85.0	72.3	76.2	187.4	358.9	4702.6
1972	502.8	739.9	1606.1	802.8	1024.7	331.4	104.9	86.9	77.1	85.1	100.9	370.4	5832.9
1973	372.8	192.8	302.6	348.3	284.3	99.6	66.2	65.9	69.3	82.0	549.8	1072.6	3506.2
1974	913.6	519.0	800.0	1390.5	1313.0	927.3	171.4	87.0	73.6	79.9	88.9	253.1	6617.3
1975	949.5	420.9	674.7	592.3	1298.2	460.7	156.4	98.2	75.6	115.4	274.6	1162.5	6279.1
1976	739.7	448.8	494.3	1114.1	1018.8	266.2	87.7	91.3	70.9	81.6	86.7	84.8	4585.0
1977	105.3	100.6	316.7	694.5	292.1	116.0	76.2	80.1	85.7	98.7	302.3	956.4	3224.6
1978	554.5	465.5	630.2	680.9	451.7	149.9	98.4	78.2	78.1	70.7	79.3	240.6	3577.9
1979	98.6	471.1	783.9	983.1	999.9	198.4	88.5	75.0	71.0	89.3	103.0	214.8	4176.6
1980	398.7	453.5	543.9	707.0	444.3	244.0	89.7	70.2	69.0	90.3	130.4	501.6	3742.7
1981	231.4	891.6	556.8	798.4	469.4	296.5	92.9	68.5	60.5	80.1	128.0	416.9	4090.9
1982	606.3	1334.2	806.1	914.3	980.7	338.6	135.4	76.7	77.5	130.2	228.3	513.2	6141.4
1983	674.2	624.1	943.8	623.6	724.2	173.0	99.8	73.0	65.9	70.4	126.3	248.2	4446.5
1984	699.0	450.0	1082.7	801.3	840.5	574.5	121.7	83.0	76.8	92.3	297.9	268.5	5388.1
1985	146.8	198.4	459.9	1229.0	730.4	245.7	88.3	77.8	78.6	108.5	196.5	140.9	3700.7
1986	353.0	1066.8	863.9	478.6	352.0	118.0	78.3	63.6	69.0	70.0	365.8	188.6	4067.5
1987	160.4	437.1	680.5	557.4	276.2	98.1	74.8	62.8	58.5	63.0	67.6	95.0	2631.3
1988	209.0	342.4	478.8	880.0	369.4	189.4	79.3	61.4	57.8	63.0	227.2	287.1	3244.7
1989	353.0	234.0	1104.5	1353.4	811.7	239.6	83.7	73.3	64.9	67.2	85.9	109.7	4581.0
1990	252.2	345.9	530.4	641.7	646.9	380.2	88.0	56.6	54.4	89.5	160.2	186.8	3432.9
1991	393.5	534.9	514.8	735.4	1048.5	352.5	116.3	75.4	60.7	67.0	384.6	466.5	4750.2
1992	238.0	535.5	327.6	416.3	135.0	72.8	69.3	69.0	61.7	64.5	164.2	205.6	2359.5
1993	166.4	198.6	1004.9	1173.9	1377.6	262.9	102.0	74.8	62.5	67.0	64.9	94.2	4649.8
1994	462.2	130.5	706.9	734.0	406.4	131.5	75.2	58.8	58.7	70.0	239.2	551.4	3625.0
1995	615.1	1119.3	661.2	716.1	1046.4	256.9	103.8	66.9	59.1	77.1	584.2	689.4	5995.6

Table A2A: DAD'S CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	573.0	1633.0	679.7	1012.3	573.2	154.1	86.2	66.8	63.4	87.2	276.4	723.9	5929.2
1997	887.6	823.4	1218.4	1365.3	912.6	211.5	93.1	66.9	68.5	93.2	155.7	218.0	6114.3
1998	467.1	328.9	628.5	559.6	820.9	242.6	98.0	69.7	69.9	72.8	255.1	629.2	4242.2
1999	666.9	361.5	724.6	676.0	824.1	253.9	89.4	69.2	58.0	63.5	169.6	429.7	4386.4
2000	300.2	543.0	664.5	934.2	495.9	374.4	95.3	64.8	78.9	127.6	143.6	176.8	3999.2
2001	300.2	543.0	664.5	934.2	495.9	374.4	95.3	64.8	78.9	127.6	143.6	176.8	3999.2
2002	363.4	386.8	589.0	1198.8	709.4	239.4	88.3	64.3	59.4	68.2	79.9	99.3	3946.3
2003	501.9	538.0	1116.7	774.9	493.6	122.2	66.6	55.5	61.5				
AVG	483.1	538.6	708.8	842.52	719.2	271.2	96.8	71.6	68.0	70.0	84.4	357.0	4325.1

Table A2B: DAD'S CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	13.0	4.7	9.5	22.5	13.0	3.8	1.8	0.9	0.9	1.1	1.3	1.9	6.2
1970	16.0	9.5	9.6	11.2	16.3	6.0	1.5	1.1	1.3	1.8	3.8	4.0	6.8
1971	14.3	11.8	7.8	11.2	11.5	7.0	2.1	1.4	1.2	1.2	3.2	5.8	6.5
1972	8.2	12.9	26.2	13.5	16.7	5.6	1.7	1.4	1.3	1.4	1.7	6.0	8.1
1973	6.1	3.5	4.9	5.9	4.6	1.7	1.1	1.1	1.2	1.3	9.3	17.5	4.9
1974	14.9	9.4	13.0	23.4	21.4	15.6	2.8	1.4	1.2	1.3	1.5	4.1	9.2
1975	15.5	7.6	11.0	10.0	21.2	7.8	2.5	1.6	1.3	1.9	4.6	18.9	8.7
1976	12.1	7.8	8.1	18.8	16.6	4.5	1.4	1.5	1.2	1.3	1.5	1.4	6.3
1977	1.7	1.8	5.2	11.7	4.8	2.0	1.2	1.3	1.4	1.6	5.1	15.6	4.5
1978	9.0	8.4	10.3	11.5	7.4	2.5	1.6	1.3	1.3	1.2	1.3	3.9	5.0
1979	1.6	8.5	12.8	16.6	16.3	3.3	1.4	1.2	1.2	1.5	1.7	3.5	5.8
1980	6.5	7.9	8.9	11.9	7.2	4.1	1.5	1.1	1.2	1.5	2.2	8.2	5.2
1981	3.8	16.1	9.1	13.4	7.6	5.0	1.5	1.1	1.0	1.3	2.2	6.8	5.7
1982	9.9	24.1	13.1	15.4	16.0	5.7	2.2	1.2	1.3	2.1	3.8	8.4	8.5
1983	11.0	11.3	15.4	10.5	11.8	2.9	1.6	1.2	1.1	1.1	2.1	4.0	6.2
1984	11.4	7.8	17.6	13.5	13.7	9.7	2.0	1.4	1.3	1.5	5.0	4.4	7.5
1985	2.4	3.6	7.5	20.7	11.9	4.1	1.4	1.3	1.3	1.8	3.3	2.3	5.1
1986	5.8	19.2	14.1	8.1	5.7	2.0	1.3	1.0	1.2	1.1	6.2	3.1	5.6
1987	2.6	7.9	11.1	9.4	4.5	1.7	1.2	1.0	1.0	1.0	1.1	1.5	3.6
1988	3.4	6.0	7.8	14.8	6.0	3.2	1.3	1.0	1.0	1.0	3.8	4.7	4.5
1989	5.8	4.2	18.0	22.8	13.2	4.0	1.4	1.2	1.1	1.1	1.4	1.8	6.3
1990	4.1	6.2	8.6	10.8	10.5	6.4	1.4	0.9	0.9	1.5	2.7	3.0	4.8
1991	6.4	9.6	8.4	12.4	17.1	5.9	1.9	1.2	1.0	1.1	6.5	7.6	6.6
1992	3.9	9.3	5.3	7.0	2.2	1.2	1.1	1.1	1.0	1.1	2.8	3.3	3.3
1993	2.7	3.6	16.4	19.8	22.4	4.4	1.7	1.2	1.1	1.1	1.1	1.5	6.4
1994	7.5	2.4	11.5	12.4	6.6	2.2	1.2	1.0	1.0	1.1	4.0	9.0	5.0
1995	10.0	20.2	10.8	12.1	17.0	4.3	1.7	1.1	1.0	1.3	9.8	11.2	8.3

Table A2B: DAD'S CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	9.3	28.4	11.1	17.0	9.3	2.6	1.4	1.1	1.1	1.4	4.7	11.8	8.2
1997	14.5	14.9	19.8	23.0	14.9	3.6	1.5	1.1	1.2	1.5	2.6	3.6	8.5
1998	7.6	5.9	10.2	9.4	13.4	4.1	1.6	1.1	1.2	1.2	4.3	10.3	5.9
1999	10.9	6.5	11.8	11.4	13.4	4.3	1.5	1.1	1.0	1.0	2.9	7.0	6.1
2000	4.9	9.5	10.8	15.7	8.1	6.3	1.6	1.1	1.3	2.1	2.4	2.9	5.5
2001	4.9	9.8	10.8	15.7	8.1	6.3	1.6	1.1	1.3	2.1	2.4	2.9	5.5
2002	5.9	7.0	9.6	20.2	11.6	4.0	1.4	1.0	1.0	1.1	1.3	1.6	5.5
2003	8.2	9.7	18.2	13.0	8.0	2.1	1.1	0.9	1.0				
AVERAGE	7.9	9.6	11.6	14.2	11.7	4.6	1.6	1.2	1.1	1.4	3.3	6.0	6.2

TABLE A3A: GRANITE BOULDER CREEK (TRIBUTARY TO THE MIDDLE FORK JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	1547.1	530.7	1141.8	2572.0	1553.5	457.8	238.6	140.2	140.9	167.4	178.0	256.2	8924.1
1970	1899.3	1031.3	1153.3	1298.6	1939.6	709.8	208.7	164.2	178.8	243.1	457.3	501.0	9784.9
1971	1697.8	1276.8	940.4	1300.9	1372.8	829.4	278.2	195.3	171.3	178.7	390.0	716.3	9347.7
1972	989.9	1440.9	3088.1	1560.5	1982.5	664.0	233.2	198.9	180.3	195.5	225.6	738.2	11497.5
1973	742.7	400.3	609.1	696.1	574.4	223.1	159.6	159.1	165.6	189.7	1079.3	2073.6	7072.5
1974	1771.2	1020.7	1555.2	2678.2	2530.7	1797.3	359.6	199.2	173.7	185.7	202.7	515.1	12989.2
1975	1839.5	834.2	1316.8	1160.2	2502.7	909.8	331.1	220.5	177.4	253.2	556.0	2244.6	12346.0
1976	1440.4	887.2	973.8	2152.6	1971.3	539.9	200.6	207.3	168.6	188.9	198.6	195.0	9124.2
1977	233.9	225.0	636.0	1354.5	589.2	254.3	178.6	186.1	196.7	221.5	608.7	1852.5	6536.8
1978	1088.2	919.1	1232.3	1328.7	892.7	318.7	220.8	182.3	182.3	168.1	184.5	491.2	7208.8
1979	221.3	929.6	1524.6	1903.4	1935.3	410.9	202.0	176.3	168.8	203.5	229.7	442.1	8347.5
1980	791.9	896.1	1068.1	1378.3	878.6	497.8	204.3	167.3	165.0	205.4	281.6	987.7	7522.2
1981	473.7	1729.4	1092.6	1552.0	926.3	597.6	210.4	164.0	148.8	186.0	277.1	826.6	8184.4
1982	1186.8	2571.1	1566.7	1772.5	1898.7	677.6	291.2	179.5	181.1	281.4	467.9	1009.7	12084.1
1983	1316.0	1220.7	1828.6	1219.7	1410.9	362.7	223.6	172.6	159.0	167.6	273.9	505.7	8860.8
1984	1363.0	889.5	2092.7	1557.6	1632.2	1126.3	265.1	191.5	179.7	209.3	600.3	544.4	10651.6
1985	312.9	410.9	908.3	2370.9	1422.7	501.0	201.6	181.7	183.2	240.1	407.3	301.7	7442.3
1986	705.0	2062.5	1676.6	943.8	703.2	258.1	182.6	154.7	164.9	166.8	729.4	392.4	8139.9
1987	338.7	864.9	1327.9	1093.7	559.0	220.3	176.0	153.1	144.9	153.6	162.2	214.3	5408.5
1988	431.1	684.9	944.2	1707.3	736.2	393.9	184.5	150.4	143.6	153.5	465.8	579.8	6575.2
1989	705.1	478.7	2134.3	2607.6	1577.4	489.4	192.9	173.2	157.1	161.5	197.1	242.3	9116.5
1990	513.4	691.5	1042.4	1254.2	1264.1	756.8	201.0	141.4	137.1	203.9	338.3	389.0	6933.0
1991	782.1	1051.0	1012.8	1432.3	2027.8	704.1	255.0	177.1	149.2	161.1	765.2	920.8	9438.4
1992	486.3	1052.1	656.8	825.4	290.5	172.2	165.6	164.9	151.0	156.3	346.0	424.7	4891.7
1993	350.1	411.4	1944.8	2266.3	2653.7	533.7	227.7	176.0	152.5	161.2	157.2	212.9	9247.4
1994	912.7	282.0	1378.1	1429.6	806.7	283.9	176.7	145.5	145.3	166.9	488.6	1082.4	7298.3
1995	1203.6	2162.5	1291.2	1395.5	2023.7	522.3	231.1	161.0	146.2	180.4	1144.7	1344.8	11806.9

TABLE A3A: GRANITE BOULDER CREEK (TRIBUTARY TO THE MIDDLE FORK JOHN DAY RIVER) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	1123.4	3139.3	1326.5	1958.8	1123.8	326.9	197.7	160.7	154.2	199.6	559.4	1410.4	11680.6
1997	1721.8	1599.7	2350.8	2630.2	1769.4	435.9	210.7	161.0	164.0	211.0	329.8	448.3	12032.6
1998	922.0	659.2	1229.0	1098.0	1594.9	495.0	220.1	166.2	166.7	172.1	518.8	1230.3	8472.2
1999	1302.1	721.2	1411.7	1319.3	1600.9	516.5	203.8	165.3	144.1	154.5	356.2	850.9	8746.4
2000	604.7	1066.3	1297.4	1810.5	976.8	745.7	214.9	156.9	183.8	276.5	306.9	369.9	8010.1
2001	604.7	1066.3	1297.4	1810.5	976.8	745.7	214.9	156.9	183.8	276.5	306.9	369.9	8010.1
2002	724.9	769.3	1153.8	2313.7	1382.8	489.0	201.7	156.0	146.7	163.4	185.7	222.6	7909.4
2003	988.2	1056.8	2157.5	1507.4	972.4	266.1	160.3	139.3	150.7				
AVG	952.4	1058.1	1381.8	1636.0	1401.6	549.5	217.8	169.9	163.0	167.8	194.2	711.6	8618.3

TABLE A3B: GRANITE BOULDER CREEK (TRIBUTARY TO THE MIDDLE FORK JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	25.2	9.6	18.6	43.3	25.3	7.7	3.9	2.3	2.4	2.7	3.0	4.2	12.3
1970	30.9	18.6	18.8	21.9	31.6	11.9	3.4	2.7	3.0	4.0	7.7	8.2	13.5
1971	27.7	23.0	15.3	21.9	22.4	14.0	4.5	3.2	2.9	2.9	6.6	11.7	12.9
1972	16.1	25.1	50.3	26.3	32.3	11.2	3.8	3.2	3.0	3.2	3.8	12.0	15.9
1973	12.1	7.2	9.9	11.7	9.4	3.8	2.6	2.6	2.8	3.1	18.2	33.8	9.8
1974	28.9	18.4	25.3	45.1	41.2	30.3	5.9	3.2	2.9	3.0	3.4	8.4	18.0
1975	30.0	15.0	21.5	19.5	40.8	15.3	5.4	3.6	3.0	4.1	9.4	36.6	17.1
1976	23.5	15.5	15.9	36.2	32.1	9.1	3.3	3.4	2.8	3.1	3.3	3.2	12.6
1977	3.8	4.1	10.4	22.8	9.6	4.3	2.9	3.0	3.3	3.6	10.2	30.2	9.0
1978	17.7	16.6	20.1	22.4	14.5	5.4	3.6	3.0	3.1	2.7	3.1	8.0	10.0
1979	3.6	16.8	24.8	32.0	31.5	6.9	3.3	2.9	2.8	3.3	3.9	7.2	11.6
1980	12.9	15.6	17.4	23.2	14.3	8.4	3.3	2.7	2.8	3.3	4.7	16.1	10.4
1981	7.7	31.2	17.8	26.1	15.1	10.1	3.4	2.7	2.5	3.0	4.7	13.5	11.3
1982	19.3	46.4	25.5	29.8	30.9	11.4	4.7	2.9	3.0	4.6	7.9	16.5	16.7
1983	21.4	22.0	29.8	20.5	23.0	6.1	3.6	2.8	2.7	2.7	4.6	8.2	12.3
1984	22.2	15.5	34.1	26.2	26.6	19.0	4.3	3.1	3.0	3.4	10.1	8.9	14.7
1985	5.1	7.4	14.8	39.9	23.2	8.4	3.3	3.0	3.1	3.9	6.9	4.9	10.3
1986	11.5	37.2	27.3	15.9	11.5	4.3	3.0	2.5	2.8	2.7	12.3	6.4	11.3
1987	5.5	15.6	21.6	18.4	9.1	3.7	2.9	2.5	2.4	2.5	2.7	3.5	7.5
1988	7.0	11.9	15.4	28.7	12.0	6.6	3.0	2.5	2.4	2.5	7.8	9.4	9.1
1989	11.5	8.6	34.8	43.9	25.7	8.2	3.1	2.8	2.6	2.6	3.3	3.9	12.6
1990	8.4	12.5	17.0	21.1	20.6	12.7	3.3	2.3	2.3	3.3	5.7	6.3	9.6
1991	12.7	19.0	16.5	24.1	33.0	11.9	4.2	2.9	2.5	2.6	12.9	15.0	13.1
1992	7.9	18.3	10.7	13.9	4.7	2.9	2.7	2.7	2.5	2.5	5.8	6.9	6.8
1993	5.7	7.4	31.7	38.2	43.2	9.0	3.7	2.9	2.6	2.6	2.6	3.5	12.8
1994	14.9	5.1	22.5	24.1	13.1	4.8	2.9	2.4	2.4	2.7	8.2	17.6	10.1
1995	19.6	39.0	21.0	23.5	33.0	8.8	3.8	2.6	2.5	2.9	19.3	21.9	16.3

TABLE A3B: GRANITE BOULDER CREEK (TRIBUTARY TO THE MIDDLE FORK JOHN DAY RIVER) COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	18.3	54.7	21.6	33.0	18.3	5.5	3.2	2.6	2.6	3.3	9.4	23.0	16.2
1997	28.1	28.9	38.3	44.3	28.8	7.3	3.4	2.6	2.8	3.4	5.6	7.3	16.6
1998	15.0	11.9	20.0	18.5	26.0	8.3	3.6	2.7	2.8	2.8	8.7	20.0	11.7
1999	21.2	13.0	23.0	22.2	26.1	8.7	3.3	2.7	2.4	2.5	6.0	13.9	12.1
2000	9.9	18.6	21.1	30.5	15.9	12.6	3.5	2.6	3.1	4.5	5.2	6.0	11.1
2001	9.9	19.2	21.1	30.5	15.9	12.6	3.5	2.6	3.1	4.5	5.2	6.0	11.1
2002	11.8	13.9	18.8	39.0	22.5	8.2	3.3	2.5	2.5	2.7	3.1	3.6	10.9
2003	16.1	19.1	35.1	25.4	15.8	4.5	2.6	2.3	2.5				
AVERAGE	15.5	18.9	22.5	27.5	22.8	9.3	3.6	2.8	2.7	3.2	6.9	11.9	12.3

TABLE A4A: JOHN DAY RIVER BETWEEN RAIL CK AND PRAIRIE CITY (BELOW STRAWBERRY CK CONFLUENCE) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	5580.9	4492.9	4315.1	7716.4	18964.8	20459.1	10030.0	6136.3	4503.6	4311.5	4069.7	4478.3	95058.7
1970	5751.8	5267.6	5094.2	5062.0	23746.2	54370.9	18017.1	6945.5	4837.5	4656.7	5958.4	6113.4	145821.2
1971	6058.7	6335.5	5390.7	7013.5	29378.0	39207.1	18692.8	8495.4	5224.5	4775.5	4498.1	4732.8	139802.8
1972	4370.3	4176.6	5682.3	5645.7	19557.4	38971.3	13339.2	5978.1	4554.9	4372.0	4267.6	4156.6	115072.0
1973	4372.8	4002.4	3876.3	4603.9	19022.2	19755.5	9022.4	4909.8	4032.3	4032.4	8592.4	7303.1	93525.4
1974	5756.2	4914.7	5854.6	7506.6	20076.2	72935.4	27808.4	8781.6	5190.9	4529.5	4184.6	4242.0	171780.7
1975	4078.5	4040.6	4254.9	4074.1	12189.5	46535.1	31256.9	8968.7	4983.4	4621.7	4768.8	4828.2	134600.4
1976	4725.1	4269.0	4157.7	5209.6	25064.2	23676.3	13777.5	7650.0	5299.7	4498.6	4268.7	4131.8	106728.1
1977	3794.9	3543.5	3658.1	4643.0	8127.6	13662.7	6381.4	4253.7	3919.5	4200.0	4181.0	5662.2	66027.5
1978	4677.0	4224.7	5395.7	9531.6	17945.0	29979.7	15846.5	7090.5	4943.0	4444.0	4149.1	4279.7	112506.5
1979	4024.4	3747.4	4264.6	4890.0	25644.9	30864.9	12760.6	6237.6	4726.3	4397.7	4506.6	4340.7	110405.7
1980	4272.5	4125.2	4417.9	8315.0	26223.8	29417.9	19969.3	7599.3	5064.9	4603.8	4772.7	5248.3	124030.8
1981	5526.7	6067.8	5966.1	8869.2	25778.8	28424.7	10986.9	5721.8	4347.5	4134.6	5043.1	6109.0	116976.3
1982	5236.5	6488.6	6196.2	7243.5	22700.0	37410.0	25685.7	11263.7	6559.5	6063.1	5796.3	5313.2	145956.4
1983	4973.0	4843.8	6641.3	6515.0	24002.5	52877.1	31159.5	9612.3	5844.0	5024.8	5229.4	4914.7	161637.4
1984	6000.5	5473.1	6189.5	8925.5	26081.4	48772.0	39094.3	11361.6	6547.7	5180.9	5078.2	4724.3	173429.2
1985	4283.8	3973.8	3998.8	10409.2	25091.6	23434.3	8821.4	5017.6	4516.9	4414.2	5016.4	5291.0	104268.8
1986	4546.2	5371.2	11717.0	11315.1	21678.0	31104.5	9850.1	5646.8	4714.9	4933.5	4932.0	4611.1	120420.3
1987	4166.2	4231.3	5028.8	11142.7	33844.9	13072.8	7543.9	4986.9	4035.9	3722.7	3704.0	4185.7	99665.8
1988	3926.0	3697.6	4279.7	7689.6	17524.4	17760.3	8315.5	4869.2	3997.7	3742.1	4042.0	4190.6	84034.6
1989	3974.6	3775.9	4844.9	9245.0	20551.0	25560.6	10021.6	5909.8	4829.7	4322.8	4453.6	4525.3	102014.9
1990	4183.2	3955.4	4277.5	9796.3	16255.0	19114.1	9937.7	5387.6	4131.7	4031.3	4191.5	4013.7	89274.8
1991	3880.7	3792.7	3939.7	4840.2	11935.0	28083.5	16277.4	6100.7	4224.3	4070.8	5550.7	5756.3	98451.9
1992	4550.6	4337.9	5688.8	8467.5	13104.1	9467.5	7130.5	4500.7	4007.6	3932.2	4196.6	4205.4	73589.4
1993	3977.0	3933.4	5993.5	7780.7	43327.2	45627.2	16312.1	8492.4	5193.1	4581.2	4166.8	4028.5	153413.0
1994	4039.7	3777.8	4403.7	7549.8	17384.0	14865.3	6841.2	4241.9	3647.4	3688.9	3942.0	4058.7	78440.4
1995	4216.0	6107.4	9136.1	8521.4	17498.9	46181.7	22521.5	9507.4	5479.7	5249.8	5973.4	10402.5	150795.9

TABLE A4A: JOHN DAY RIVER BETWEEN RAIL CK AND PRAIRIE CITY (BELOW STRAWBERRY CK CONFLUENCE) COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	7024.1	8148.6	8590.3	12915.8	30162.3	32745.0	15457.4	7163.9	5133.1	4787.6	7510.8	8814.2	148452.9
1997	11821.6	7777.2	7879.3	14340.1	54948.7	43759.4	16137.4	7909.5	5368.4	5819.1	5058.7	4716.0	185535.3
1998	4703.7	4624.6	8114.7	11516.7	39086.5	36343.8	19044.6	7807.6	5158.1	4576.5	4475.2	4687.4	150139.4
1999	5216.4	4359.8	6031.0	9272.8	24909.3	68453.3	22057.0	8759.2	5288.4	4772.0	4802.4	5515.2	169436.8
2000	4606.2	4583.2	5681.9	16908.7	29620.7	32709.8	11679.7	5627.6	4508.5	4364.5	4323.4	4334.7	128949.2
2001	5536.6	4580.0	4608.7	7626.8	25536.8	16727.7	7216.7	4057.9	3933.4	4218.8	4974.7	4588.1	93606.1
2002	4622.1	4016.4	4328.9	12201.5	18124.0	26720.1	10567.2	5126.5	3981.0	2784.5	2784.5	2784.5	98041.1
2003	2784.5	2784.5	2784.5	2784.5	2784.5	2784.5	2784.5	2784.5	2784.5				
AVG	4893.1	4681.2	5505.2	8288.3	23082.0	32052.4	15209.9	6711.5	4729.0	4868.1	4466.5	4893.9	118339.7

TABLE A4B: JOHN DAY RIVER BETWEEN RAIL CREEK AND PRAIRIE CITY (BELOW STRAWBERRY CREEK CONFLUENCE) COMPUTED NATURAL FLOWS

(MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	90.9	81.0	70.3	129.9	309.0	344.4	163.4	100.0	75.8	70.2	68.5	73.0	131.5
1970	93.7	95.0	83.0	85.2	386.9	915.3	293.5	113.2	81.4	75.9	100.3	99.6	201.8
1971	98.7	114.3	87.8	118.1	478.6	660.1	304.5	138.4	88.0	77.8	75.7	77.1	193.4
1972	71.2	72.7	92.6	95.0	318.6	656.1	217.3	97.4	76.7	71.2	71.8	67.7	159.2
1973	71.2	72.2	63.2	77.5	309.9	332.6	147.0	80.0	67.9	65.7	144.7	119.0	129.4
1974	93.8	88.6	95.4	126.4	327.1	1227.9	453.1	143.1	87.4	73.8	70.4	69.1	237.7
1975	66.4	72.9	69.3	68.6	198.6	783.4	509.2	146.1	83.9	75.3	80.3	78.7	186.2
1976	77.0	74.3	67.7	87.7	408.3	398.6	224.5	124.6	89.2	73.3	71.9	67.3	147.7
1977	61.8	63.9	59.6	78.2	132.4	230.0	104.0	69.3	66.0	68.4	70.4	92.2	91.4
1978	76.2	76.2	87.9	160.5	292.4	504.7	258.2	115.5	83.2	72.4	69.9	69.7	155.7
1979	65.6	67.6	69.5	82.3	417.8	519.6	207.9	101.6	79.6	71.6	75.9	70.7	152.8
1980	69.6	71.8	72.0	140.0	427.2	495.3	325.3	123.8	85.3	75.0	80.3	85.5	171.6
1981	90.0	109.4	97.2	149.3	420.0	478.5	179.0	93.2	73.2	67.4	84.9	99.5	161.9
1982	85.3	117.0	100.9	121.9	369.8	629.8	418.5	183.5	110.4	98.8	97.6	86.6	202.0
1983	81.0	87.4	108.2	109.7	391.0	890.2	507.6	156.6	98.4	81.9	88.0	80.1	223.7
1984	97.8	95.3	100.8	150.3	424.9	821.1	636.9	185.1	110.2	84.4	85.5	77.0	240.0
1985	69.8	71.7	65.1	175.2	408.8	394.5	143.7	81.7	76.0	71.9	84.5	86.2	144.3
1986	74.1	96.9	190.9	190.5	353.2	523.6	160.5	92.0	79.4	80.4	83.0	75.1	166.6
1987	67.9	76.3	81.9	187.6	551.4	220.1	122.9	81.2	67.9	60.7	62.4	68.2	137.9
1988	64.0	64.4	69.7	129.5	285.5	299.0	135.5	79.3	67.3	61.0	68.0	68.3	116.3
1989	64.8	68.1	78.9	155.6	334.8	430.3	163.3	96.3	81.3	70.4	75.0	73.7	141.2
1990	68.2	71.3	69.7	164.9	264.8	321.8	161.9	87.8	69.6	65.7	70.6	65.4	123.5
1991	63.2	68.4	64.2	81.5	194.4	472.8	265.2	99.4	71.1	66.3	93.4	93.8	136.2
1992	74.1	75.5	92.7	142.6	213.5	159.4	116.2	73.3	67.5	64.1	70.6	68.5	101.8
1993	64.8	70.9	97.6	131.0	705.9	768.1	265.8	138.4	87.4	74.6	70.1	65.6	212.3
1994	65.8	68.1	71.7	127.1	283.2	250.3	111.5	69.1	61.4	60.1	66.4	66.1	108.5
1995	68.7	110.2	148.8	143.5	285.1	777.5	366.9	154.9	92.3	85.5	100.6	169.5	208.7

TABLE A4B: JOHN DAY RIVER BETWEEN RAIL CREEK AND PRAIRIE CITY (BELOW STRAWBERRY CREEK CONFLUENCE) COMPUTED NATURAL FLOWS

(MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	114.4	141.9	140.0	217.4	491.4	551.3	251.8	116.7	86.4	78.0	126.4	143.6	205.4
1997	152.6	140.3	128.4	241.4	895.2	736.7	262.9	128.9	90.4	94.8	85.2	76.8	256.7
1998	76.6	83.4	132.2	193.9	636.8	611.8	310.3	127.2	86.8	74.6	75.3	76.4	207.7
1999	85.0	78.6	98.3	156.1	405.8	1152.4	359.4	142.7	89.0	77.7	80.8	89.9	234.4
2000	75.0	79.8	92.6	284.7	482.6	550.7	190.3	91.7	75.9	71.1	72.8	70.6	178.4
2001	90.2	82.6	75.1	128.4	416.0	281.6	117.6	66.1	66.2	68.7	83.7	74.7	129.5
2002	75.3	72.4	70.5	205.4	295.3	449.8	172.2	83.5	67.0	45.4	46.9	45.4	135.7
2003	45.4	50.2	45.4	46.9	45.4	46.9	45.4	45.4	46.9				
AVERAGE	79.7	83.8	89.7	139.5	376.1	539.6	247.8	109.3	79.6	72.8	80.9	82.1	168.56

TABLE A5A: MIDDLE FORK OF THE JOHN DAY RIVER BETWEEN CLEAR AND CAMP CREEKS COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	15909.1	5457.4	11741.2	26448.2	15974.9	4707.9	2453.2	1441.6	1448.8	1721.2	1830.2	2634.2	91767.7
1970	19531.1	10605.1	11859.4	13353.2	19945.5	7298.7	2145.8	1688.3	1838.4	2499.5	4702.7	5152.0	100619.7
1971	17458.5	13129.1	9670.5	13376.9	14117.1	8528.3	2860.4	2008.1	1761.3	1837.4	4010.8	7365.5	96123.8
1972	10179.5	14817.3	31755.3	16046.9	20386.5	6827.8	2397.7	2045.1	1853.8	2010.1	2319.6	7590.7	118230.2
1973	7636.9	4116.7	6263.4	7157.8	5906.6	2293.9	1641.0	1635.9	1702.7	1950.5	11098.6	21323.1	72727.2
1974	18213.1	10496.1	15992.4	27540.1	26023.6	18481.4	3698.3	2048.1	1786.0	1909.4	2084.1	5297.0	133569.6
1975	18916.3	8578.7	13540.3	11930.3	25735.8	9355.9	3405.3	2267.1	1824.0	2603.3	5717.5	23081.2	126955.8
1976	14812.1	9123.6	10013.9	22135.3	20271.4	5551.9	2062.5	2131.4	1733.5	1942.3	2042.0	2005.0	93825.0
1977	2404.9	2313.4	6540.0	13929.0	6058.8	2614.6	1836.4	1913.5	2022.4	2277.4	6259.3	19049.5	67219.1
1978	11190.6	9451.0	12671.6	13662.7	9179.6	3277.1	2270.0	1875.1	1874.7	1728.4	1897.0	5051.3	74129.2
1979	2275.4	9559.5	15677.8	19573.3	19901.2	4225.7	2076.9	1812.7	1735.6	2092.4	2361.7	4546.5	85838.6
1980	8142.8	9215.1	10983.4	14173.7	9035.2	5119.1	2100.6	1720.2	1696.5	2112.3	2895.7	10156.8	77351.4
1981	4871.1	17783.9	11235.8	15959.5	9525.6	6145.1	2163.2	1686.2	1530.3	1912.4	2849.0	8499.5	84161.6
1982	12203.8	26439.0	16110.6	18226.5	19525.0	6967.6	2994.0	1845.6	1862.1	2893.3	4811.7	10383.0	124262.1
1983	13532.1	12552.3	18803.2	12542.0	14508.8	3730.1	2299.0	1774.7	1634.8	1723.3	2816.1	5200.3	91116.9
1984	14016.4	9147.2	21519.5	16017.1	16784.0	11581.8	2725.7	1969.0	1847.7	2152.0	6172.9	5598.2	109531.4
1985	3217.1	4225.7	9340.5	24380.7	14630.1	5152.0	2072.8	1868.2	1883.7	2468.6	4188.7	3102.0	76530.1
1986	7249.3	21209.0	17240.5	9705.5	7230.8	2653.7	1877.5	1590.6	1695.5	1715.0	7500.2	4035.5	83703.2
1987	3483.4	8894.3	13654.5	11246.6	5748.3	2265.1	1809.6	1574.2	1489.9	1579.3	1667.7	2203.4	55616.4
1988	4433.4	7042.7	9709.6	17556.1	7570.1	4050.9	1897.0	1546.4	1476.5	1578.3	4790.1	5962.2	67613.4
1989	7250.4	4922.7	21947.2	26814.2	16220.6	5032.7	1983.4	1780.8	1615.3	1660.6	2026.6	2491.3	93745.8
1990	5279.5	7110.6	10719.2	12896.7	12998.5	7781.9	2066.7	1453.9	1409.7	2096.5	3479.3	4000.5	71293.0
1991	8042.0	10807.6	10414.9	14728.8	20852.2	7240.1	2621.8	1820.9	1534.1	1656.4	7868.3	9469.0	97056.3
1992	5000.9	10818.9	6753.8	8487.2	2986.8	1770.6	1702.7	1695.5	1552.6	1607.1	3558.4	4367.6	50302.1
1993	3600.6	4230.8	19998.9	23304.3	27288.2	5488.2	2341.2	1809.6	1568.0	1657.5	1616.3	2189.0	95092.6
1994	9385.8	2899.4	14171.6	14701.1	8294.9	2919.0	1816.8	1496.1	1494.0	1716.1	5024.5	11130.5	75049.7
1995	12376.5	22237.1	13277.1	14350.5	20810.1	5371.0	2376.1	1655.4	1503.3	1854.9	11771.0	13829.2	121412.2

TABLE A5A: MIDDLE FORK OF THE JOHN DAY RIVER BETWEEN CLEAR AND CAMP CREEKS COMPUTED NATURAL FLOWS (ACRE-FEET/MONTH)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	11552.0	32281.7	13640.1	20142.9	11556.1	3361.0	2032.7	1652.3	1585.5	2052.3	5752.4	14503.7	120112.7
1997	17705.2	16449.9	24174.1	27046.6	18194.6	4482.7	2166.4	1655.4	1686.3	2169.5	3391.9	4610.2	123732.6
1998	9481.4	6778.5	12637.7	11290.8	16400.5	5090.3	2263.0	1708.9	1714.0	1769.5	5335.0	12651.0	87120.7
1999	13389.2	7415.9	14517.0	13566.0	16462.2	5311.4	2095.4	1699.6	1481.7	1588.6	3663.3	8750.4	89940.8
2000	6218.2	10964.9	13340.9	18617.1	10044.8	7667.8	2209.6	1613.3	1889.8	2842.9	3155.4	3804.2	82368.8
2001	6218.2	10964.9	13340.9	18617.1	10044.8	7667.8	2209.6	1613.3	1889.8	2842.9	3155.4	3804.2	82368.8
2002	7453.9	7910.4	11864.5	23791.6	14219.9	5028.6	2073.9	1604.0	1508.4	1680.1	1909.4	2288.7	81333.5
2003	10162.0	10867.3	22185.7	15500.9	9999.5	2736.0	1648.2	1432.3	1549.5				
AVG	9794.1	10880.5	14208.8	16823.4	14412.4	5650.8	2239.8	1746.7	1676.6	1725.9	1997.1	7317.9	88623.5

TABLE A5B: MIDDLE FORK OF THE JOHN DAY RIVER BETWEEN CLEAR AND CAMP CREEKS COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1969	259.2	98.4	191.3	445.3	260.3	79.3	40.0	23.5	24.4	28.0	30.8	42.9	127.0
1970	318.2	191.3	193.2	224.8	325.0	122.9	35.0	27.5	30.9	40.7	79.2	83.9	139.2
1971	284.4	236.8	157.6	225.2	230.0	143.6	46.6	32.7	29.7	29.9	67.5	120.0	133.0
1972	165.8	258.1	517.4	270.1	332.1	114.9	39.1	33.3	31.2	32.7	39.0	123.7	163.6
1973	124.4	74.3	102.0	120.5	96.2	38.6	26.7	26.7	28.7	31.8	186.8	347.4	100.6
1974	296.7	189.3	260.5	463.6	424.0	311.1	60.3	33.4	30.1	31.1	35.1	86.3	184.8
1975	308.2	154.7	220.6	200.8	419.3	157.5	55.5	36.9	30.7	42.4	96.3	376.0	175.7
1976	241.3	158.9	163.1	372.6	330.3	93.5	33.6	34.7	29.2	31.6	34.4	32.7	129.8
1977	39.2	41.7	106.5	234.5	98.7	44.0	29.9	31.2	34.0	37.1	105.4	310.4	93.0
1978	182.3	170.5	206.4	230.0	149.6	55.2	37.0	30.5	31.6	28.2	31.9	82.3	102.6
1979	37.1	172.4	255.4	329.5	324.2	71.1	33.8	29.5	29.2	34.1	39.8	74.1	118.8
1980	132.7	160.5	178.9	238.6	147.2	86.2	34.2	28.0	28.6	34.4	48.7	165.5	107.0
1981	79.4	320.8	183.1	268.7	155.2	103.5	35.2	27.5	25.8	31.2	48.0	138.5	116.5
1982	198.8	476.9	262.5	306.8	318.1	117.3	48.8	30.1	31.3	47.1	81.0	169.2	171.9
1983	220.5	226.4	306.3	211.1	236.4	62.8	37.5	28.9	27.5	28.1	47.4	84.7	126.1
1984	228.4	159.3	350.6	269.6	273.4	195.0	44.4	32.1	31.1	35.1	103.9	91.2	151.6
1985	52.4	76.2	152.2	410.4	238.4	86.7	33.8	30.4	31.7	40.2	70.5	50.5	105.9
1986	118.1	382.6	280.9	163.4	117.8	44.7	30.6	25.9	28.5	27.9	126.3	65.7	115.8
1987	56.8	160.4	222.5	189.3	93.7	38.1	29.5	25.6	25.1	25.7	28.1	35.9	77.0
1988	72.2	122.7	158.2	295.6	123.3	68.2	30.9	25.2	24.9	25.7	80.6	97.1	93.6
1989	118.1	88.8	357.6	451.4	264.3	84.7	32.3	29.0	27.2	27.1	34.1	40.6	129.7
1990	86.0	128.3	174.6	217.1	211.8	131.0	33.7	23.7	23.7	34.2	58.6	65.2	98.6
1991	131.0	194.9	169.7	248.0	339.7	121.9	42.7	29.7	25.8	27.0	132.5	154.3	134.3
1992	81.5	188.4	110.0	142.9	48.7	29.8	27.7	27.6	26.1	26.2	59.9	71.2	69.6
1993	58.7	76.3	325.8	392.3	444.6	92.4	38.1	29.5	26.4	27.0	27.2	35.7	131.6
1994	152.9	52.3	230.9	247.5	135.1	49.1	29.6	24.4	25.2	28.0	84.6	181.3	103.8
1995	201.6	401.1	216.3	241.6	339.0	90.4	38.7	27.0	25.3	30.2	198.2	225.3	168.0

TABLE A5B: MIDDLE FORK OF THE JOHN DAY RIVER BETWEEN CLEAR AND CAMP CREEKS COMPUTED NATURAL FLOWS (MEAN DAILY CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1996	188.2	562.2	222.2	339.1	188.3	56.6	33.1	26.9	26.7	33.4	96.8	236.3	166.2
1997	288.5	296.7	393.8	455.3	296.4	75.5	35.3	27.0	28.4	35.3	57.1	75.1	171.2
1998	154.5	122.3	205.9	190.1	267.2	85.7	36.9	27.8	28.9	28.8	89.8	206.1	120.5
1999	218.1	133.8	236.5	228.4	268.2	89.4	34.1	27.7	24.9	25.9	61.7	142.6	124.5
2000	101.3	191.0	217.3	313.4	163.6	129.1	36.0	26.3	31.8	46.3	53.1	62.0	114.0
2001	101.3	197.8	217.3	313.4	163.6	129.1	36.0	26.3	31.8	46.3	53.1	62.0	114.0
2002	121.4	142.7	193.3	400.5	231.7	84.7	33.8	26.1	25.4	27.4	32.1	37.3	112.5
2003	165.6	196.0	361.4	261.0	162.9	46.1	26.9	23.3	26.1				
AVERAGE	159.6	194.4	231.5	283.2	234.8	95.1	36.5	28.5	28.2	32.5	71.2	122.7	126.2

Appendix B: Flow Exceedance Data

Monthly exceedance tables for natural flow for targeted watersheds in mean daily cubic feet per second per month.

TABLE B1: REYNOLDS CREEK (TRIBUTARY TO THE JOHN DAY RIVER) MONTHLY NATURAL FLOW EXCEEDANCE LEVELS (MEAN DAILY CFS)

(Values carried out to 2 decimals to distinguish classes)

% EXCEED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.94	5.41	6.10	15.52	18.38	7.21	4.27	3.80	3.30	3.32	3.64	3.87	4.73
5.88	5.74	7.74	16.22	21.86	14.21	5.56	3.80	3.30	3.43	3.65	4.00	5.19
8.82	7.80	11.16	16.76	25.05	14.61	5.64	3.96	3.33	3.50	3.67	4.43	5.23
11.76	8.47	11.46	23.31	29.08	15.00	6.48	4.23	3.44	3.51	3.72	4.60	5.44
14.70	8.77	11.48	24.15	29.20	17.97	6.58	4.25	3.56	3.53	3.84	4.63	5.96
17.64	10.88	13.42	24.25	30.87	18.83	6.80	4.30	3.63	3.55	3.85	4.94	6.32
20.58	11.99	14.92	25.02	32.47	20.66	7.28	4.40	3.68	3.57	3.85	4.98	7.51
23.52	12.32	18.62	26.04	33.40	22.54	8.21	4.45	3.71	3.58	3.90	5.09	9.28
26.46	13.02	18.70	26.81	34.60	22.91	8.43	4.67	3.73	3.64	3.99	5.71	9.28
29.40	15.40	19.56	27.48	34.66	23.78	9.40	4.80	3.73	3.65	3.99	5.82	9.78
32.34	15.40	20.41	28.12	35.16	25.0	10.24	4.87	3.79	3.70	4.01	7.01	9.87
35.28	18.01	21.80	29.40	35.41	25.10	10.70	4.88	3.83	3.70	4.01	7.09	10.71
38.22	18.02	23.67	29.70	36.11	25.10	11.37	4.90	3.84	3.74	4.03	7.22	11.17
41.16	18.53	24.33	29.71	36.75	28.93	11.96	4.90	3.84	3.79	4.13	7.90	11.33
44.10	19.00	24.40	31.67	37.21	32.58	12.80	4.91	3.92	3.86	4.30	7.90	12.45
47.04	20.02	24.56	31.75	38.13	35.42	12.81	4.96	3.92	3.91	4.35	8.51	12.70
49.98	20.28	24.58	33.29	38.20	35.68	12.96	4.97	3.94	4.05	4.48	8.74	12.82
52.92	23.43	26.12	33.45	40.20	36.41	13.04	5.08	3.95	4.07	4.49	8.95	13.07
55.86	23.67	26.43	33.45	41.42	36.72	13.12	5.13	3.98	4.08	4.57	9.23	13.83
58.80	25.40	28.93	33.96	41.57	40.13	13.54	5.13	4.00	4.09	4.59	10.14	14.75
61.74	25.44	29.05	34.21	41.65	40.75	13.70	5.24	4.14	4.12	4.74	10.60	18.31
64.68	28.00	29.32	34.25	45.60	41.20	14.00	5.24	4.16	4.17	4.85	11.95	18.88
67.62	28.92	29.36	35.56	47.36	41.36	14.17	5.38	4.23	4.18	4.95	12.18	21.18
70.56	30.57	29.93	36.43	48.38	42.18	15.72	5.40	4.24	4.25	4.96	12.23	21.82
73.50	31.01	30.10	39.37	48.38	45.75	17.51	5.47	4.26	4.31	5.00	12.79	23.64
76.44	33.57	30.37	40.17	50.88	49.12	17.88	5.58	4.32	4.41	5.10	13.60	25.38
79.38	33.94	34.82	40.47	52.38	50.07	18.59	5.67	4.38	4.45	5.14	14.60	25.96
82.32	35.16	36.44	43.33	57.59	50.19	18.74	5.72	4.40	4.47	5.42	14.70	27.85
85.26	37.18	39.76	47.29	60.65	51.01	19.71	5.86	4.49	4.49	5.90	15.80	31.70
88.20	39.96	45.76	50.32	61.93	51.30	19.71	6.29	4.63	4.51	5.98	16.02	34.69
91.14	43.88	49.50	54.18	63.47	52.38	20.01	6.55	4.73	4.54	6.24	19.27	36.40
94.08	44.51	59.11	55.26	68.89	52.48	21.96	6.89	4.83	4.57	6.85	20.24	47.92
97.02	45.80	61.99	55.90	69.84	64.86	24.13	7.23	4.84	4.58	6.85	28.69	53.68
99.96	47.58	73.78	60.90	70.45	65.59	29.96	8.27	5.05	4.58	6.98	30.45	58.13

TABLE B2: DAD'S CREEK (TRIBUTARY TO THE JOHN DAY RIVER) COMPUTED MONTHLY NATURAL FLOW EXCEEDANCE LEVELS (MEAN DAILY CFS)
(Values carried out to 2 decimals to distinguish classes)

% EXCEED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.94	1.61	1.81	4.93	5.86	2.20	1.23	1.08	0.91	0.92	1.03	1.09	1.38
5.88	1.71	2.35	5.16	7.01	4.50	1.65	1.13	0.92	0.95	1.03	1.14	1.53
8.82	2.39	3.48	5.34	8.06	4.63	1.68	1.22	0.96	0.97	1.03	1.28	1.55
11.76	2.61	3.58	7.49	9.38	4.76	1.95	1.22	1.00	0.98	1.05	1.33	1.62
14.70	2.71	3.58	7.77	9.42	5.74	1.99	1.24	1.02	0.98	1.09	1.35	1.79
17.64	3.40	4.22	7.80	9.97	6.02	2.21	1.28	1.04	0.99	1.09	1.45	1.91
20.58	3.77	4.71	8.05	10.50	6.62	2.52	1.29	1.05	1.00	1.09	1.46	2.30
23.52	3.88	5.93	8.39	10.80	7.24	2.60	1.36	1.06	1.00	1.11	1.50	2.88
26.46	4.11	5.96	8.64	11.20	7.36	2.91	1.40	1.06	1.02	1.14	1.70	2.88
29.40	4.89	6.24	8.86	11.22	7.65	3.19	1.43	1.07	1.02	1.14	1.73	3.04
32.34	4.89	6.52	9.07	11.38	8.08	3.34	1.43	1.09	1.04	1.15	2.13	3.07
35.28	5.75	6.98	9.49	11.46	8.08	3.56	1.44	1.09	1.05	1.15	2.15	3.35
38.22	5.75	7.59	9.59	11.69	9.34	3.75	1.44	1.09	1.07	1.15	2.19	3.50
41.16	5.92	7.82	9.60	11.90	10.54	4.03	1.44	1.12	1.09	1.19	2.42	3.55
44.10	6.07	7.84	10.24	12.06	11.47	4.03	1.46	1.12	1.11	1.24	2.42	3.92
47.04	6.41	7.88	10.27	12.36	11.56	4.08	1.46	1.12	1.15	1.26	2.62	4.00
49.98	6.49	7.90	10.77	12.38	11.80	4.11	1.50	1.13	1.16	1.30	2.70	4.04
52.92	7.53	8.40	10.83	13.44	11.90	4.14	1.51	1.13	1.16	1.30	2.76	4.12
55.86	7.61	8.50	10.83	13.49	13.02	4.27	1.52	1.14	1.17	1.33	2.86	4.38
58.80	8.18	9.33	10.99	13.52	13.22	4.33	1.55	1.19	1.18	1.34	3.15	4.68
61.74	8.19	9.36	11.07	14.81	13.37	4.43	1.55	1.19	1.19	1.39	3.31	5.85
64.68	9.03	9.46	11.09	15.39	13.43	4.48	1.60	1.22	1.20	1.42	3.75	6.03
67.62	9.33	9.46	11.52	15.73	13.69	4.99	1.60	1.22	1.22	1.45	3.83	6.79
70.56	9.88	9.65	11.81	15.73	14.87	5.58	1.63	1.23	1.24	1.46	3.84	7.00
73.50	10.02	9.79	12.77	16.55	15.98	5.70	1.66	1.25	1.27	1.47	4.03	7.60
76.44	10.87	11.26	13.03	17.04	16.29	5.93	1.69	1.27	1.28	1.50	4.29	8.17
79.38	10.98	11.79	13.13	18.76	16.33	5.98	1.71	1.27	1.29	1.52	4.62	8.36
82.32	11.39	12.89	14.07	19.76	16.60	6.30	1.76	1.31	1.30	1.61	4.65	8.98
85.26	12.05	14.85	15.38	20.18	16.69	6.30	1.90	1.35	1.30	1.77	5.02	10.25
88.20	12.96	16.08	16.37	20.69	17.05	6.40	1.98	1.38	1.32	1.79	5.09	11.23
91.14	14.26	19.24	17.64	22.47	17.08	7.04	2.09	1.42	1.32	1.88	6.16	11.79
94.08	14.46	20.19	17.99	22.78	21.15	7.76	2.21	1.42	1.33	2.08	6.48	15.58
97.02	14.88	24.07	19.85	22.98	21.39	9.67	2.55	1.49	1.33	2.08	9.26	17.47
99.96	15.47	28.44	26.17	23.41	22.44	15.61	2.79	1.60	1.44	2.12	9.83	18.94

TABLE B3: GRANITE BOULDER CREEK (TRIBUTARY TO THE MIDDLE FORK JOHN DAY RIVER) COMPUTED MONTHLY NATURAL FLOW EXCEEDANCE LEVELS (MEAN DAILY CFS)

(Values carried out to 2 decimals to distingish classes)

% EXCEED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.94	3.60	4.06	9.92	11.72	4.73	2.90	2.60	2.28	2.31	2.50	2.65	3.18
5.88	3.81	5.09	10.36	13.89	9.11	3.71	2.70	2.30	2.37	2.50	2.73	3.47
8.82	5.10	7.22	10.70	15.89	9.36	3.76	2.87	2.37	2.42	2.52	3.00	3.49
11.76	5.52	7.41	14.80	18.41	9.60	4.28	2.88	2.45	2.43	2.55	3.11	3.63
14.70	5.70	7.42	15.32	18.48	11.46	4.34	2.91	2.49	2.44	2.62	3.13	3.95
17.64	7.02	8.63	15.38	19.53	11.99	4.78	2.97	2.52	2.45	2.63	3.32	4.17
20.58	7.72	9.57	15.87	20.53	13.14	5.37	3.01	2.54	2.46	2.63	3.34	4.91
23.52	7.92	11.89	16.50	21.11	14.31	5.50	3.14	2.56	2.47	2.66	3.41	6.03
26.46	8.36	11.93	16.98	21.86	14.54	6.11	3.22	2.56	2.51	2.72	3.80	6.03
29.40	9.85	12.47	17.40	21.90	15.09	6.63	3.27	2.59	2.51	2.72	3.87	6.34
32.34	9.85	13.01	17.80	22.21	15.91	6.92	3.27	2.62	2.54	2.73	4.61	6.39
35.28	11.49	13.88	18.60	22.37	15.91	7.34	3.28	2.62	2.57	2.73	4.66	6.92
38.22	11.49	15.05	18.79	22.80	18.31	7.71	3.29	2.62	2.60	2.74	4.74	7.20
41.16	11.81	15.45	18.80	23.20	20.59	8.23	3.29	2.67	2.64	2.80	5.17	7.30
44.10	12.10	15.49	20.02	23.49	22.37	8.24	3.32	2.67	2.68	2.91	5.17	8.00
47.04	12.74	15.60	20.08	24.07	22.53	8.33	3.33	2.69	2.76	2.94	5.55	8.16
49.98	12.90	15.61	21.04	24.11	22.99	8.38	3.40	2.69	2.78	3.03	5.70	8.24
52.92	14.87	16.58	21.14	26.13	23.18	8.43	3.43	2.71	2.78	3.03	5.83	8.39
55.86	15.02	16.77	21.14	26.22	25.31	8.70	3.43	2.73	2.79	3.08	6.00	8.87
58.80	16.13	18.32	21.45	26.27	25.70	8.79	3.50	2.81	2.81	3.09	6.57	9.45
61.74	17.73	18.41	21.61	28.74	25.98	8.99	3.50	2.82	2.84	3.18	6.86	11.67
64.68	18.30	18.57	21.63	29.84	26.08	9.09	3.59	2.87	2.84	3.25	7.70	12.03
67.62	19.33	18.60	22.45	30.48	26.59	10.06	3.60	2.87	2.88	3.32	7.84	13.47
70.56	19.61	18.96	23.00	30.48	28.83	11.18	3.64	2.88	2.92	3.32	7.88	13.86
73.50	21.21	19.23	24.84	32.04	30.93	11.41	3.71	2.92	2.99	3.35	8.23	15.00
76.44	21.44	22.02	25.34	32.98	31.53	11.85	3.76	2.96	3.01	3.41	8.73	16.09
79.38	22.21	23.03	25.52	36.24	31.60	11.95	3.80	2.97	3.02	3.44	9.36	16.45
82.32	23.47	25.09	27.31	38.15	32.12	12.55	3.89	3.03	3.04	3.61	9.42	17.63
85.26	25.21	28.85	29.79	38.95	32.30	12.55	4.15	3.12	3.05	3.91	10.11	20.04
88.20	27.66	31.19	31.69	39.91	32.97	12.74	4.32	3.18	3.07	3.96	10.25	21.91
91.14	28.05	37.20	34.09	43.30	33.04	13.96	4.53	3.24	3.08	4.12	12.28	22.98
94.08	28.86	39.01	34.77	43.90	40.77	15.32	4.74	3.24	3.09	4.50	12.88	30.18
97.02	29.97	46.38	38.30	44.28	41.23	18.96	5.40	3.38	3.09	4.50	18.17	33.78
99.96	30.94	54.67	50.31	45.09	43.23	30.26	5.86	3.59	3.31	4.58	19.27	36.57

TABLE B4: JOHN DAY RIVER BETWEEN RAIL CK & PRAIRIE CITY (BELOW STRAWBERRY CK) COMPUTED MONTHLY NATURAL FLOW EXCEEDANCE LEVELS (MEAN DAILY CFS)

(Values carried out to 2 decimals to distingish classes)

% EXCEED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.94	61.83	63.92	59.60	68.59	132.41	159.39	103.97	66.11	61.40	45.36	46.88	45.36
5.88	63.22	64.40	63.15	77.51	194.44	220.08	111.46	69.11	65.99	60.10	62.36	65.39
8.82	63.96	67.59	64.19	78.16	198.59	230.01	116.17	69.30	66.22	60.65	66.36	65.63
11.76	64.75	68.11	65.15	81.48	213.49	250.26	117.57	73.33	67.02	60.97	68.05	66.12
14.70	64.79	68.14	67.74	82.32	264.83	281.61	122.90	79.33	67.30	64.06	68.51	67.32
17.64	65.56	68.41	69.32	85.22	283.22	298.99	135.48	79.99	67.47	65.68	69.85	67.72
20.58	65.81	70.95	69.48	87.70	285.09	321.79	143.72	81.25	67.88	65.69	70.15	68.19
23.52	66.45	71.35	69.69	95.05	285.51	332.58	146.99	81.75	67.94	66.32	70.39	68.27
26.46	67.88	71.68	69.72	109.68	292.36	344.43	160.48	83.52	69.56	67.36	70.45	68.51
29.40	68.15	71.84	70.30	118.07	295.28	394.52	161.91	87.77	71.12	68.43	70.56	69.11
32.34	68.69	72.19	70.53	121.94	308.97	398.59	163.27	91.68	73.19	68.73	70.65	69.72
35.28	69.61	72.45	71.75	126.37	309.91	430.31	163.41	92.00	75.82	70.24	71.84	70.62
38.22	69.79	72.74	71.98	127.10	318.63	449.83	172.16	93.22	75.90	70.43	71.86	70.72
41.16	71.20	72.88	75.08	128.40	327.08	472.79	179.00	96.28	76.04	71.11	72.79	72.96
44.10	71.24	74.35	78.93	129.46	334.82	478.53	190.29	97.39	76.68	71.23	74.98	73.73
47.04	74.07	75.55	81.93	129.91	353.18	495.25	207.90	99.39	79.38	71.65	75.34	74.75
49.98	74.14	76.20	82.99	130.99	369.83	504.71	217.32	99.97	79.57	71.92	75.73	75.12
52.92	75.04	76.32	87.83	139.98	386.87	519.61	224.46	101.62	81.31	72.40	75.87	76.37
55.86	75.30	78.64	87.91	142.55	391.05	523.64	251.83	113.16	81.44	73.29	80.28	76.83
58.80	76.20	79.82	92.57	143.46	405.82	550.67	258.17	115.52	83.22	73.79	80.35	76.97
61.74	76.63	81.04	92.58	149.31	408.35	551.26	262.91	116.71	83.90	74.56	80.85	77.11
64.68	76.98	82.61	92.68	150.26	408.79	611.85	265.19	123.81	85.27	74.64	83.03	78.66
67.62	81.02	83.42	95.38	155.64	416.04	629.80	265.76	124.63	86.42	75.01	83.75	80.07
70.56	84.99	87.37	97.20	156.11	417.81	656.08	293.53	127.20	86.84	75.30	84.45	85.51
73.50	85.31	88.65	97.65	160.46	419.99	660.05	304.54	128.86	87.39	75.87	84.90	86.20
76.44	90.04	95.01	98.26	164.92	424.92	736.69	310.27	138.36	87.43	77.75	85.16	86.56
79.38	90.20	95.32	100.84	175.24	427.24	768.14	325.34	138.41	87.95	77.80	85.49	89.85
82.32	90.92	96.88	100.95	187.59	478.63	777.47	359.35	142.70	89.03	78.00	88.04	92.25
85.26	93.71	109.45	108.20	190.49	482.58	783.42	366.92	143.07	89.22	80.38	93.45	93.78
88.20	93.78	110.16	128.37	193.88	491.40	821.08	418.47	146.12	90.38	81.86	97.58	99.53
91.14	97.76	114.28	132.20	205.41	551.40	890.19	453.05	154.89	92.25	84.41	100.31	99.60
94.08	98.71	117.04	139.95	217.44	636.80	915.33	507.65	156.60	98.38	85.53	100.56	118.98
97.02	114.44	140.28	148.85	241.42	705.88	1152.41	509.24	183.51	110.23	94.80	126.44	143.60
99.96	192.60	141.91	190.89	284.66	895.22	1227.87	636.92	185.10	110.43	98.78	144.65	169.48

TABLE B5: MIDDLE FOR OF THE JOHN DAY RIVER BETWEEN CLEAR AND CAMP CREEKS COMPUTED MONTHLY NATURAL FLOW EXCEEDANCE LEVELS (MEAN DAILY CFS)

(Values carried out to 2 decimals to distinguish classes)

% EXCEED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2.94	37.07	41.73	102.04	120.50	48.66	29.81	26.74	23.49	23.73	25.71	27.21	32.66
5.88	39.18	52.30	106.55	142.88	93.65	38.13	27.74	23.69	24.39	25.73	28.08	35.66
8.82	52.41	74.26	110.03	163.39	96.23	38.62	29.48	24.37	24.86	25.88	30.81	35.90
11.76	56.75	76.22	152.18	189.34	98.71	44.02	29.60	25.19	24.94	26.18	31.94	37.29
14.70	58.66	76.31	157.55	190.08	117.80	44.68	29.92	25.65	25.08	26.99	32.14	40.59
17.64	72.23	88.79	158.19	200.85	123.33	49.14	30.59	25.91	25.15	27.00	34.12	42.92
20.58	79.36	98.44	163.15	211.15	135.14	55.17	30.91	26.13	25.31	27.05	34.38	50.54
23.52	81.47	122.27	169.68	217.12	147.20	56.58	32.31	26.28	25.39	27.37	35.09	61.98
26.46	86.01	122.65	174.64	224.80	149.55	62.80	33.12	26.28	25.76	27.94	39.05	61.98
29.40	101.31	128.26	178.94	225.20	155.19	68.20	33.60	26.65	25.83	27.96	39.76	65.18
32.34	101.31	133.76	183.05	228.38	163.65	71.14	33.67	26.92	26.14	28.04	47.41	65.75
35.28	118.11	142.68	191.29	230.01	163.65	75.47	33.77	26.97	26.40	28.08	47.96	71.16
38.22	118.12	154.74	193.21	234.49	188.27	79.26	33.79	26.97	26.69	28.16	48.75	74.07
41.16	121.44	158.89	193.30	238.61	211.77	84.66	33.84	27.47	27.19	28.83	53.12	75.11
44.10	124.42	159.30	205.89	241.59	230.00	84.73	34.14	27.51	27.52	29.93	53.12	82.29
47.04	131.02	160.43	206.44	247.49	231.67	85.70	34.22	27.62	28.39	30.22	57.10	83.94
49.98	132.66	160.49	216.31	247.96	236.38	86.18	34.96	27.69	28.54	31.11	58.57	84.72
52.92	152.91	170.47	217.35	268.68	238.35	86.73	35.24	27.84	28.56	31.16	59.91	86.30
55.86	154.47	172.43	217.35	269.65	260.26	89.42	35.29	28.03	28.67	31.64	61.67	91.21
58.80	165.84	188.42	220.60	270.15	264.27	90.42	36.00	28.91	28.86	31.78	67.52	97.14
61.74	182.32	189.32	222.22	295.56	267.20	92.39	36.00	29.01	29.18	32.75	70.52	120.00
64.68	188.20	190.96	222.46	306.84	268.20	93.47	36.87	29.48	29.22	33.44	79.17	123.67
67.62	198.82	191.29	230.88	313.42	273.44	103.45	36.98	29.53	29.65	34.09	80.64	138.47
70.56	201.64	194.94	236.51	313.42	296.43	114.95	37.46	29.67	30.07	34.16	81.01	142.56
73.50	218.14	197.78	255.42	329.52	318.10	117.30	38.14	30.07	30.71	34.41	84.59	154.27
76.44	220.46	226.41	260.55	339.11	324.23	121.89	38.71	30.44	30.95	35.06	89.81	165.47
79.38	228.35	236.82	262.47	372.65	324.95	122.87	39.06	30.55	31.11	35.34	96.25	169.16
82.32	241.32	258.05	280.88	392.33	330.26	129.09	39.97	31.17	31.21	37.10	96.84	181.34
85.26	259.19	296.72	306.34	400.53	332.14	129.09	42.71	32.08	31.35	40.22	103.92	206.11
88.20	284.43	320.78	325.82	410.45	339.04	131.01	44.41	32.72	31.56	40.72	105.38	225.31
91.14	288.45	382.56	350.59	445.26	339.72	143.57	46.60	33.32	31.71	42.41	126.27	236.29
94.08	296.73	401.10	357.56	451.42	419.29	157.51	48.78	33.37	31.82	46.32	132.46	310.35
97.02	308.18	476.89	393.84	455.33	423.98	194.98	55.48	34.73	31.82	46.32	186.84	347.40
99.96	318.20	562.20	517.36	463.64	444.58	311.14	60.25	36.94	34.05	47.14	198.16	376.04