Section 8

Water Balance

8.1 Introduction

Based upon the information collected in other sections of this report, a preliminary water balance has been prepared for WRIA 35. These numbers represent a preliminary examination of the accounting of the water that is available annually either as ground or surface water within each of the designated implementation areas.

The purpose of developing a preliminary water balance is to enable the Planning Unit to determine water availability throughout WRIA 35. Based on this review the need for additional information to further refine the water balance estimates can be determined, along with assessment of the relative importance of each hydrologic pathway within the context of the global supply of water within the entire basin. The quantities presented are based on mean monthly averages which are summed over an annual basis and presented in terms of an annual volume. These numbers reflect the relative magnitude of water moving through the WRIA and portray the level of present knowledge regarding flow quantities in each delineated implementation area. Although water rights decisions are not made based on the results of this type of water balance calculation, the estimates do provide a framework around which to begin discussing the need for additional data and information under future Level 2 assessment work.

Under ideal conditions, the water balance would use detailed and consistent data for all the major hydrologic pathways. Due to limited data for many of the major hydrologic pathways, the following water balance has been completed for the Tucannon River, Pataha Creek, and Asotin Creek implementation areas. Because of the flow regulation occurring in the Snake River a usable accounting of stream flow for the Middle Snake Implementation Area was not developed. An annual water balance was completed for the Middle Snake River, but errors are high.

8.2 Principal Water Balance Elements

The basic elements of the water balance include an accounting of all inflows and outflows for a given basin. For a basin-wide water balance, the main inflows include precipitation (i.e. rainfall and snowmelt) and any water use returns, while the main outflows are those of stream flow, water use demands, and interbasin transfers of groundwater. This basic definition presumes that there is no net change in storage of water either as surface water or ground water. A summary of these basic components are illustrated in Exhibit 8-1.

It is important to recognize that the only elements placed into the basin-wide water balance are those that actually enter or leave the basin. The exchange of waters from one pathway to another within the subbasin is irrelevant. For example, stream flow is derived from a combination of direct runoff and base flow from shallow ground water. In turn, shallow ground water flow is comprised of recharge (infiltration) from net precipitation and water use returns. In any case, there is no need to account for the individual components of stream flow (and its sub-components) since they exist only as internal elements to each subbasin. The only relevant element is that of the stream flow itself.

Alternatively, a water balance can be conducted for different hydrologic systems in the watershed that include the climatic system, surface water system, ground water system. Both approaches are considered in this section. The advantage of a basin-wide water balance approach is that some of the "internal" hydrologic components such as runoff or baseflow do not have to be quantified. The benefit of conducting hydrologic system water balances is developing a better understanding of the relative magnitudes of some of the internal hydrologic components. In both approaches, the uncertainty associated with the assumptions used to estimate these quantities should be kept in mind.

8.2.1 Water Balance Equations

The two water balance approaches conducted in this section include a basin-wide water balance and hydrologic system water balance. The equations for the two approaches are shown below. The remaining subsections provide further description of these components.

The major components of the ***Basin-wide water balance*** is shown below.

$$PPT + RF = ET + SF + WU + IGW \qquad \text{(Eq. 8-1)}$$

Where: PPT = Precipitation
RF = Return flow from water use
ET = Evapotranspiration
SF = Stream flow
WU = Water use
IGW = Interbasin transfer of groundwater

If the accounting of all of these elements were completely accurate, their sum would be zero. The errors associated with uncertainty in quantifying each of the major components is essentially included in the IGW terms since it is the term derived from all the other terms. The values derived for the basin-wide water balance are based on average annual totals.

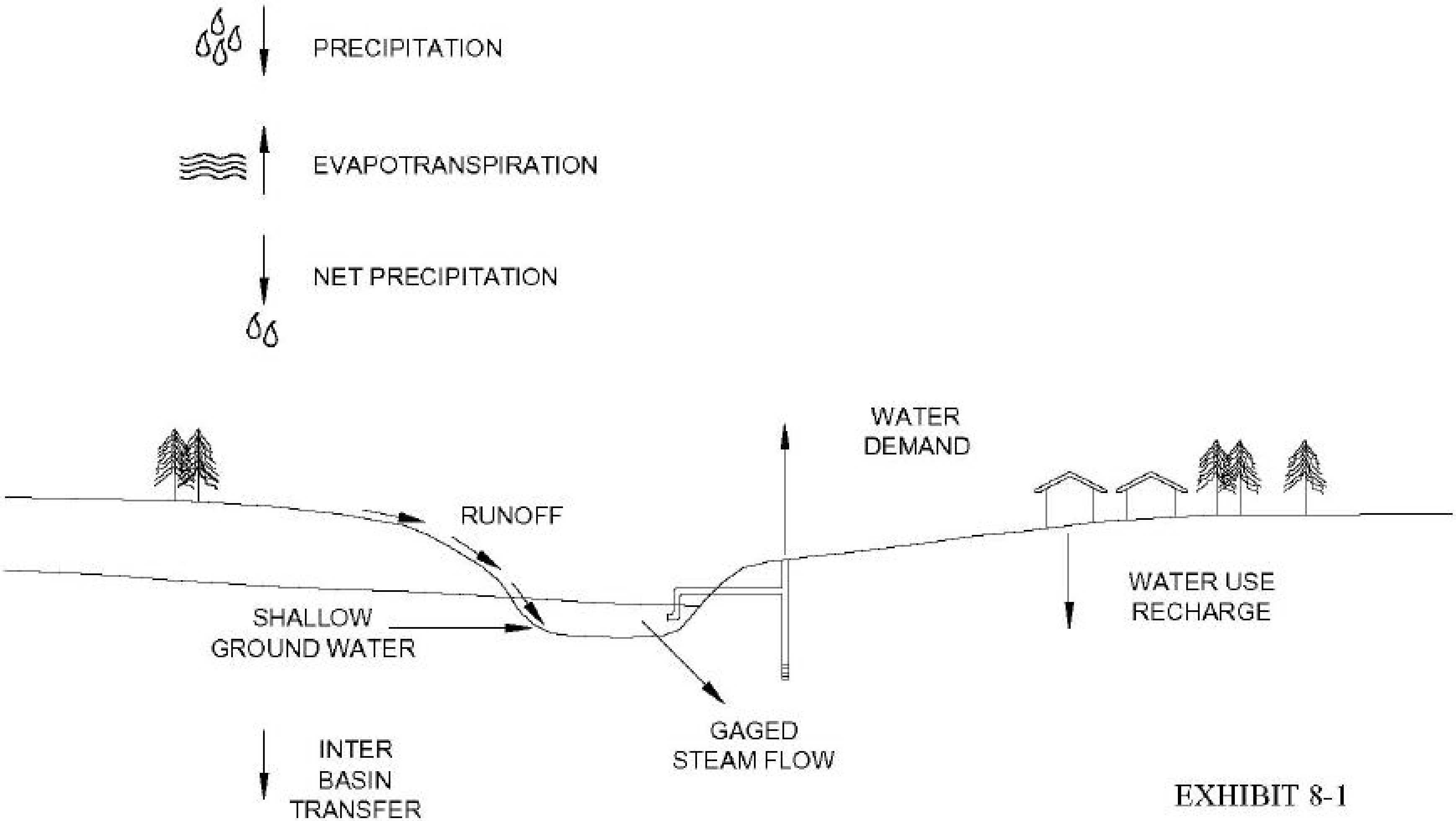

EXHIBIT 8-1

ILLUSTRATION OF THE BASIC
WATER BALANCE ELEMENTS
WRIA 35

Sept. 2004

ECONOMIC AND ENGINEERING SERVICES, INC.

The ***Hydrologic system water balance*** is evaluated on a monthly basis and then summed to calculate mean annual totals. The water balance assessment was completed by dividing watershed hydrology into three hydrologic systems for each implementation area: (1) climatic system (2) surface water system and (3) ground water system. The components of each of these systems are described below and in the following subsections.

The ***Climatic System:*** consists of precipitation, evapotranspiration, surface water runoff and recharge components. The climatic water balance equation (Freeze and Cherry, 1979) is shown below.

$$PPT = ET + RCH + SRO \qquad \text{(Eq. 8-2)}$$

Where: PPT = Precipitation
ET = Evapotranspiration
RCH = Ground Water Recharge
SRO = Surface Water Runoff

Based on available data, independent estimates are calculated for precipitation, evapotranspiration, and surface water runoff. Eq. 8-2 is then used to calculate an estimate for ground water recharge.

The ***Surface Water System*** consists of stream flow, baseflow and surface water runoff components. The surface water balance equation is shown below (Freeze and Cherry, 1979)

$$SF = SRO + BF \qquad \text{(Eq. 8-3)}$$

Where: SF = Stream flow
SRO = Surface Water Runoff
BF = Baseflow

Based on the Ecology (1999) baseflow characteristics study, data is directly available for each of these three terms in Eq. 8-3 for some of the implementation areas. These values are then used to calculate other terms in the hydrologic system.

The ***Ground Water System:*** consists of recharge, consumptive water use, baseflow and ground water transfer/storage components. The ground water balance equation (Sokolov and Chapman, 1974) is shown below.

$$RCH = BF + WU + TRS \qquad \text{(Eq. 8-4)}$$

Where: RCH = Ground Water Recharge
BF = Baseflow
WU = Consumptive Water Use
TRS = Ground Water Transfer/Storage

Based on estimates from the Eq. 8-2 and 8-3 for recharge and baseflow, and by estimating water demands in the basin, Eq. 8-4 is used to estimate the ground water transfer and storage term.

The hydrologic system water balance was only completed for the combined Tucannon River and Pataha Creek implementation areas because the other implementation areas had limited stream flow and baseflow data that precluded this type of analysis.

8.2.2 Precipitation

For the purpose of conducting water balance equations, precipitation is considered to be the combined amounts of rainfall and snowfall. Mean annual precipitation was calculated based on the isopluvial contours developed by Washington State Department of Ecology (refer to Section 2.4). The totals derived for each implementation area are shown in Table 8-1.

As discussed in Section 2.4.2, each implementation area had an associated weather station from which mean monthly precipitation values were obtained. This data was included average percentage of annual precipitation that occurs within a given month. For the hydrologic system water balance where mean monthly precipitation values are needed, the annual precipitation values from Table 8-1 were multiplied by the corresponding mean monthly percentage of precipitation to derive mean monthly values. The data measured for each implementation area's corresponding rain gauge produced different distributions of mean monthly precipitation.

Table 8-1
Mean Annual Precipitation

Implementation Area	Drainage Area (acres)	Mean Annual Precipitation	
		Inches	Ac-Ft/Yr
Middle Snake	647,338	15.58	840,617
Pataha Creek	119,896	18.65	186,274
Tucannon River	201,822	24.14	422,842
Asotin Creek	252,622	20.21	425,475

8.2.3 Evapotranspiration

Evapotranspiration is the combination of water that is evaporated from the soil and that which is transpired by plants as a part of their metabolic processes. Potential evapotranspiration for each watershed was calculated using the Thornthwaite method (Thronthwaite, 1948). The Thornthwaite method is an empirical equation that incorporates average monthly air temperatures to calculate potential evapotranspiration. The Thornthwaite water balance method involves the following formula:

$$E = 1.6(10T/I)^a \qquad \text{(Eq. 8-5)}$$

Where:

E = monthly potential evapotranspiration (cm)
T = mean monthly temperature (degrees celsius)
I = a heat index for a given area which is the sum of 12 monthly index values I;
I is derived from mean monthly temperatures using the following formula:
$I = (T/5)^{1.514}$
$a = 6.75x10^{-7}I^3 – 7.71x10^{-5}I^2 + 1.79x10^{-2}I + 0.49$

The average monthly air temperatures within each implementation area were generally obtained from the same weather stations used to obtain the precipitation data. Table 7-2 provides a summary of the temperature used to calculate the potential and "actual" evapotranspiration values for each implementation area.

The actual evapotranspiration was estimated to equal potential evapotranspiration from late fall (November) through early spring (April), when evapotranspiration approaches total evapotranspiration (Dunne and Leopold, 1978). During the remainder of the year, actual evapotranspiration was assumed to be 50 percent of potential evapotranspiration. This percentage is based on the typical difference between the potential and measured evapotranspiration at the Silcott Island, WA regional station where this information is available. The Silcott Island, WA weather station is operated by the U.S. Bureau of Reclamation and is the closest station within WRIA 35 with this information. For year 2003 (the most complete year on record) the ET rate ranged from ~0.5 in/day in July to 0.02 in/day in March. The average ET rate was ~0.25 in/day.

It is important to note that these estimates provide crude representations for the annual evapotranspiration within each subbasin. They are, however, intended as order of magnitude estimates of the amount of water that is lost over a given year as a function of temperature. Since temperature is the key factor in the equation to calculate ET, the averaging of temperature over the course of the month, especially in the summer months will tend to lower the overall ET totals.

Table 8-2
Estimated Evapotranspiration WRIA 35

Subbasin	Temperature Range (°F) January/July	Annual Potential ET (in.)	Annual Actual ET (in.)	Temperature Source Data
Middle Snake	35.2 – 74.4	25.0	14.8	WaWaWai Station
Pataha Creek	32.3 – 70.4	20.2	11.5	Pomeroy Station
Tucannon River	32.7 – 71.8	20.7	11.9	Dayton1 WSW Station
Asotin Creek	32.5 – 63.8	13.6	7.3	Anatone Station

8.2.4 Stream flow, Baseflow and Surface Water Runoff

Stream flow, baseflow, and surface water runoff are the three components of the surface water system. Stream flow is surface discharge that occurs in a natural channel. Baseflow is derived mainly from ground water seepage into the stream. Surface water runoff is the amount of net precipitation that does not infiltrate into the ground. If the amount of water falling on the ground is greater than the infiltration rate, runoff or overland flow will occur. Runoff specifically refers to the water leaving an area of drainage and flowing across the land surface to points of lower elevation.

Estimates for stream flow are derived from the stream gauges located throughout WRIA 35 using the mean monthly or annual flow over the complete period of record available for each stream gauge. The total stream flow for an implementation area was generally estimated by using the downstream-most stream gauge measurement. The ungauged portion of the implementation area was then assumed to contribute stream flow equal to ratio of land area that is ungauged versus gauged. The Tucannon River and Asotin Creek implementation areas had good gauge data to develop stream flow using this method. Pataha Creek has a gauge with limited period of record but the data was used since it was the only flow data available. The stream flow from Pataha Creek drainage was subtracted from the Tucannon River gauge data. Stream flow gauges are available at the upstream and downstream ends of the Middle Snake implementation area which was used to calculate the net stream flows contributed by the drainage area. However, stream flow data is not considered reliable for the Middle Snake Implementation Area because the period of record for the gauges are different and using the difference between the recorded flows at the two gauges would not include common dam operations. This impacts the entire water balance estimates for this implementation area. Table 8-3 summarizes the stream flow estimates for the annual totals used in the basin-wide water balance. Baseflow and surface runoff are internal components of the basin-wide water balance and were not calculated for this method.

For the hydrologic system water balance (surface water system), the same stream flow gauges were used for Tucannon River and Asotin Creek. Data derived from Ecology’s baseflow characteristics study as presented in Section 7.3 were used as the values for stream flow, baseflow, and runoff. Because complete baseflow and runoff estimates were calculated for Tucannon River (and Pataha Creek) gauge only, these were the only two implementation areas for which the surface water system water balance could be completed. Since Pataha Creek is included as part of the Tucannon River drainage area in the study, the two implementation areas were combined for the hydrologic system water balance. The Middle Snake River implementation area was not evaluated since there was no data to calculate the baseflow and runoff components, and the Asotin Creek gauge did not have a complete baseflow analysis for the winter months. As with the basin-wide water balance, the portions of the implementation area that were not directly gauged were assumed to contribute flows proportional to the ratio of land area gauged and ungauged.

Table 8-3 Summary of Stream Flow Calculations by Implementation Area for Basin-wide Water Balance		
Subbasin	**Area (acres)**	**Mean Annual Volume (acre-ft per year)**
Lower Snake		
USACE Gauge: Little Goose Dam (1970-current)		36,829,312
USGS Gauge: 13343500 (1928-1972)	66,048,000	36,429,975
Net Gauged	511,720	399,337
Ungauged	135,647	105,856
	Total Flow	**505,193**
Asotin Creek		
USGS Gauge: 13335050 (1991-2002)	206,720	74,287
Ungauged	43,182	15,518
	Total Flow	**89,805**
Tucannon River		
USGS Gauge: 13344500 (1994-current)	273,953	123,823
Net gauged (subtract Pataha 1)	154,057	114,923
Ungauged	46,329	34,560
	Total Flow	**149,483**
Pataha Creek		
WSU Gauge: Pataha 1 (1998-2001; 2003)	119,896	**8,900**

8.2.5 Ground Water Recharge

Groundwater recharge is the process by which surface water is added to an aquifer. Ground water recharge is an internal component of the basin-wide water balance and was not calculated for this method. For the hydrologic system water balance, it is one of the components of the climatic system (see Eq. 8-2) and one of the components of the ground water system (see Eq. 8-4). The monthly mean value for ground water recharge was calculated based on the derived values for precipitation (Section 8.2.2), evapotranspiration (section 8.2.3), and the reported values for runoff from the Ecology baseflow studies (Section 8.2.4). These values were plugged into Eq. 7-1 to calculate the estimated recharge to groundwater. Again, because runoff values were only available for the Tucannon River and Pataha Creek implementation areas, the groundwater recharge estimates were only derived for these implementation areas.

8.2.6 Water Demand and Consumptive Use

Sections 3 through 6 for each implementation area includes discussions about current and projected water demands for municipal/domestic demands and agricultural (irrigation) demands. For the basin-wide water balance the net water demand is one of the components of the water balance. The net water demand is the amount of water that leaves the basin due to consumptive use.

Water that is non-consumptive recharges the ground water system. The sources of recharge water include irrigation water from agricultural operations, domestic irrigation water and septic wastewater, and leakage from water conveyances, such as irrigation canals. A significant proportion of water pumped by domestic wells may be returned to unconfined aquifers through household septic drainfields. The majority of this water typically recharges the most shallow aquifer unit encountered, such as the upper basalt flows. These sources may contribute negligible or only minor recharge to confined aquifers, such as deeper basalt flows. Recharge by agricultural, municipal or domestic irrigation occurs when excess water that is not intercepted by plant roots or evaporated from the land surface infiltrates into the subsurface.

For the purposes of the Level 1 assessment water balance, an assumption was made that 70 percent of water demand is non-consumptive and is considered return flow which recharges the ground water. That is, the net (consumptive) water demand in the basin is 30 percent of the water demand. Assumptions made in other studies estimate the rate of consumption to range from 20 to 35 percent of water demand depending on the climatic conditions and water uses. Table 8-4 shows the estimated annual demand volumes for each of the implementation areas.

Table 8-4
Net Water Demand by Implementation Area for Basin-wide Water Balance

Demand	Middle Snake	Asotin Creek	Pataha Creek	Tucannon River
Water Demand	7,190	1,200	6,556	2,134
Return Flows	5,033	840	4,589	1,494
Net Demand	**2,157**	**360**	**1,967**	**640**

For the hydrologic system water balance, consumptive water use is included as part of the ground water system. The reason for this is that the return flow recharges the ground water system whether the source is from surface or ground water. Thus, the net water demand is essentially the consumptive use of ground water. Thus, the net water demands calculated for the basin-wide water balance is used for the ground water system water balance except that the annual demand is allocated by month. It is assumed that 40 percent of the annual municipal/domestic demand is used during the period October through April, and the remaining 60 percent is used from the period May through September. Irrigation use is assumed to occur only during the months May through August. This assumption is similar to those made for the Walla Walla basin (EES, 2003). The percentage distribution for the municipal/domestic use and irrigation use is shown in Table 8-5. Again, this water balance was conducted only for the Tucannon/Pataha implementation areas.

Table 8-5
Allocation of Net Water Demand by Month
For Ground Water System Water Balance

Month	Municipal/Domestic Use	Irrigation
January	5.7%	-
February	5.7%	-
March	5.7%	-
April	5.7%	-
May	12%	21%
June	12%	29%
July	12%	31%
August	12%	19%
September	12%	-
October	5.7%	-
November	5.7%	-
December	5.7%	-

Note: Percentage is of the total annual water demand allocated for each month.

8.2.7 Ground Water Transfer and Storage

Interbasin transfer is the last component of the water balance. It is the volume of water that moves as part of the deep ground water system and accounts for the changes in aquifer storage. This component also accounts for ground water flow out of the watershed or ground water transfer from adjacent watersheds.

The shallow ground water system is defined as any ground water that is in hydraulic continuity with the surface water system (i.e. returns to an adjacent stream eventually). Any remaining ground water is presumed to be part of a larger regional aquifer system that moves as part of deeper, inter-basin transfers of water into and out of a particular basin. It is often very difficult to make a clear distinction between the shallow and deep ground water systems. Moreover, there is limited data available for providing estimates of hydraulic continuity between ground and surface water resources and the interconnection between aquifers. However, the basin-wide water balance accounting does not require this distinction between shallow and deep ground water systems because all shallow ground water, by definition, is actually measured as part of gauged surface stream flow. On the other hand, substantial quantities of water may be moving as part of the deeper system; however, knowledge of the actual volumes of deep ground water flows is often limited or simply unknown. In such cases, basic assumptions are applied as a function of net precipitation. This interbasin transfer of ground water through the deep ground water system in one of the key components of the basin-wide water balance.

With respect to both the basin-wide water balance and the hydrologic water balance for the ground water system, the ground water transfer/storage term is determined by back-calculating the value using the other terms in Eq. 8-1 and 8-4 since there is no data available to quantify it directly otherwise. With respect to the hydrologic system water balance approach, the ground water transfer/storage term is calculated as a residual of the water balance. The ground water transfer/storage component is intended to correlate with seasonal changes in aquifer storage and interbasin flow based on recharge, water use, and other components of watershed hydrology.

8.3 Simplifying Assumptions and Data Limitations

Water balances are used to evaluate the distribution of the various components of watershed hydrology between the overall watershed hydrologic system. The purpose of a water balance is to complete a simple evaluation of the relative influence of an existing or proposed water usage on the overall water resources of a watershed. Before discussing the findings of the water balance it is important to recognize the limitations of water balances in evaluating water resources, as described below.

- The watershed hydrology components were based on previous data compilation and analyses. The assumptions used to develop simplified estimates for each of the watershed components apply to the water balance assessment.

- Water balances are not adequate to evaluate the potential influence of an increase in ground water use for watersheds with complex hydrology or large ground water use. This is because ground water use is dependant upon aquifer hydraulics, spatial and temporal characteristics and capture of natural discharge and water balances can not be used to accurately evaluate any of these factors (Bredehoeft 1997).

- Hydrologic components are presented as total monthly averages based on available data with varying periods of record. Precipitation and stream flow data are not available for some watersheds with the same period of record.

- Static conditions are assumed to be an accurate representation of the hydrologic system within each implementation area. However, watershed systems are dynamic and controlled by water inputs and water outputs. Watersheds with significant consumptive water use or complex hydrology should be evaluated as dynamic systems.

- Implementation area boundaries were assumed to be identical for surface water and ground water hydrologic systems. In reality groundwater flow is complex and the ground water boundaries are not likely identical to surface water boundaries for many watersheds.

- The water balance assessment does not incorporate inter-basin transfer, except as a generalized storage/transfer term. Ground water is likely to be transferred between watersheds during periods of extended ground water pumping.

- The exact relationship between ground water and stream flow is generally unknown. Both surface and ground water use were assumed to capture stream baseflow (instead of stream runoff) due to the limited information available to differentiate between surface water and ground water use. This is likely to be a valid assumption for surface water use for these implementation areas. However, the relationship between ground water use and stream flow has not been established. It is likely that a significant component of ground water use is derived from aquifer through-flow of storage, and only a portion of groundwater use is derived from baseflow.

- Water balances are only valid to describe existing conditions where sufficient empirical data is available. Water balances are widely recognized as inappropriate for predictive analysis due to the simplifying assumptions and an inability of the method to predict changes in hydrologic systems (Bredehoeft 1997, Sophocleous and Champman 1974). For this assessment, water balances can be used as a screening tool to identify watersheds where more detailed analyses may be necessary.

- The water balances were completed at a relatively coarse spatial scale. The concentration of high consumptive water use rates within a given implementation area (e.g. near the City of Clarkston) may require more detailed evaluations.

- Water balances are only crude approximations of potential impact to regional aquifers and aquifer storage. Supplemental analyses that incorporate higher spatial and temporal scale within the watersheds and affected regional aquifers may be required.

The specific limitations of available data and their application are summarized below.

- Dams largely control hydrologic processes in the Middle Snake Subbasin and there is limited available stream flow data that may be applied to water balance equations. For this reason, a detailed monthly water balance was not conducted for the Middle Snake Subbasin

- The Tucannon and Pataha Creek implementation areas were combined for the purposes of conducting an appropriate hydrologic system water balance, because stream flow data was limited for Pataha Creek.

- Available climatological data was limited to four stations within or near the WRIA 35 study area. These data were used to extrapolate approximate values for precipitation and temperature over a relatively large geographic area.

- Hydrograph separation methods used to estimate baseflow and surface water runoff are approximations and relied on the results from the Ecology baseflow characterization study (Ecology 1999). The results were applied for the entire implementation area.

- The estimates of consumptive water use for agricultural, industrial and commercial purposes are not definitive.

8.4 Summary of Water Balance Results

This section includes a discussion of the findings from both the basin-wide water balance based on mean annual values and the hydrologic system water balance for the Tucannon-Pataha implementation areas based on mean monthly values.

8.4.1 Basin-wide Water Balance Estimates

The estimates for the water balance components are shown in Table 8-6. As indicated in the Table 8-6, a wide range of net precipitation (precipitation less estimated evapotranspiration) exists across the watershed. Part of this is a result of the size of the drainage area and part is the result of climate. These numbers range from a high of 272,157 ac-ft/yr to a low of 40,259 ac-ft/yr. This net precipitation can be thought of as the net annual available water. The Tucannon and Asotin Creek implementation areas have the highest net precipitation primarily because of the high rainfall rates in the Blue Mountains area in the upper watersheds.

Gauged stream flow is generally less than estimated net precipitation, with the exception of the Middle Snake estimates. The negative value for interbasin transfer for the Middle Snake would indicate potential significant errors in either the estimated evapotranspiration or stream flow estimates or both. For all of the implementation areas, evapotranspiration estimates have a great deal of uncertainty because of the limited data available spatially. Stream flow estimates for the Tucannon River is considered the most reliable because it includes a majority of the drainage area and has a long period of record, whereas the Pataha Creek gauge has a limited period of record, and the Asotin Creek gauge only cover about half of the implementation area. As discussed previously, the net stream flow in the Middle Snake is difficult to quantify because of the numerous tributaries feeding the mainstem, while the mainstem gauges are regulated by dam operations.

Although water rights decisions cannot necessarily be made based on the results of the water balance estimates presented in this section, the estimates do reflect potential orders of magnitude and illustrate the need for additional work in refining the accounting of water throughout WRIA 35. Whatever errors and uncertainty are associated with the estimates in the basin-wide water balance, it is of interest to note how small the demands are with respect to the overall volume of water(s) within the WRIA. Notwithstanding, the availability of that water cannot be determined until specific numbers are established for in-stream flow needs. Additionally, these numbers do not reflect the impacts of seasonal timing of withdrawals and/or the need to appropriate limited summer-time supplies.

Table 8-6 Summary of Basin-Wide Water Balance by Implementation Area					
	Component	**Lower Snake**	**Asotin Creek**	**Tucannon River**	**Pataha Creek**
	Drainage Area (acres)	647,367	252,622	201,822	119,896
In	Precipitation	840,617	425,475	422,842	186,274
Out	Evapotranspiration	800,359	153,318	200,408	115,181
Net In	**Net Precipitation**	**40,259**	**272,157**	**222,434**	**71,093**
	Net Precipitation per acre	0.062	1.08	1.10	0.59
Out	**Stream Flow**	**505,193**	**89,805**	**149,483**	**8,900**
	Net Stream flow per acre	0.78	0.35	0.74	0.07
Out	Water Demand	7,190	1,200	6,556	2,134
In	Water Use Returns	5,033	840	4,589	1,494
Net Out	**Net Demand**	**2,157**	**360**	**1,967**	**640**
	Net demand per acre	0.003	0.0014	0.0097	0.0053
Out	**Interbasin Transfer**	**-467,091**	**181,992**	**70,985**	**61,553**
	Interbasin Transfer per acre	--	0.72	0.35	0.51

Note: Units are in acre-ft per year

8.4.2 Hydrologic System Water Balance for Tucannon-Pataha

Table 8-7 summarizes the hydrologic water balance estimates for the Tucannon River-Pataha Creek implementation areas. Exhibits 8-2(a-c) show these results graphically.

For the climatic system, precipitation is considered to be the "input" to the system, while evapotranspiration, surface runoff, and recharge are the "outputs" to the system. Based on the precipitation distribution derived from the rainfall gauges in the implementation area, precipitation is generally greatest in winter (Jan-Nov) and lowest in mid-late summer (July-September). Evapotranspiration is usually most significant in summer (July-August), when mean ambient temperatures are greatest. Based on the distribution, the greatest precipitation occurs in December with 80,281 ac-ft/yr mean total for the month. The greatest evapotranspiration occurs in July with a mean monthly total of 54,515 ac-ft/yr. During the summer months when evapotranspiration rates exceed precipitation, there is a net loss of water from the climatic system as indicated by the negative recharge (i.e. loss of water from ground water storage). Note that surface runoff, which is based on Ecology derived values from the baseflow study (Ecology 1999), is a relatively small component of the climatic system. The evapotranspiration component on the other hand is very significant, and the errors and uncertainty associated with estimating its values greatly affect the overall water balance relationship.

For the surface water system water balance, stream flow is considered the "input" while baseflow and surface runoff are considered the "outputs" to the system. Again, estimates for the monthly surface water system components are based on the Ecology study (Ecology 1999).

Stream flow is usually greatest during winter through spring (December-June) and peaks in May. Stream flow is normally lowest during summer through fall (July-October). As discussed in Section 7, the surface water system water balance shows that baseflows are a significant portion of the stream flow in the Tucannon-Pataha system.

For the ground water system water balance, ground water recharge is considered the "input" while consumptive use, baseflow, and ground water transfer/storage are considered "outputs" to the system. Recall, that the transfer/storage term is the "dependent" variable in this relationship and is derived from estimates of the other terms in the water balance. The transfer/storage term corresponds with the recharge term in the climatic system water balance, wherein during the summer months when recharge is "negative" the aquifer loses water from storage.

It should be noted that the transfer/storage term for the annual sum (138,843 ac-ft/yr) compares closely with the interbasin transfer calculated for the basin-wide water balance for the combined Tucannon and Pataha terms from Table 8-6 (132,538 ac-ft/yr). This should compare well since the common terms in both water balance approaches were based on the same approach for estimating their values. The main difference was that the hydrologic model allowed assessment of the "internal" components such as groundwater recharge, surface runoff, and baseflow.

This comparison does not determine whether the estimating methods for evapotranspiration or recharge, or stream flow are accurate. However, keeping in mind the assumptions and limitations discussed in Section 8.4, they do provide a semi-quantitative understanding of the relative magnitudes of these hydrologic components within the basins. In essence, the findings confirm that the overall water demands in the watershed are small compared to the net precipitation and ground water storage components in the watershed. It does not appear that water availability is primary concern with respect to the overall watershed water balance. However, as mentioned previously, the availability of that water cannot be determined on a local level (e.g. for specific stream reaches) until specific numbers are established for in-stream flow needs and seasonal limited summer-time supplies are considered.

Table 8-7

Tucannon-Pataha Subbasin Hydrologic System Water Balance Estimates (acre-ft)

Hydrologic System	Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Climatic	Precipitation	77,849	56,328	62,008	48,636	49,041	43,298	17,684	20,985	28,387	50,421	74,197	80,281	609,116
	Evapotranspiration	-353	-7,553	-19,801	-37,023	-29,246	-40,646	-54,515	-51,536	-37,809	-20,895	-13,833	-2,379	-315,589
	Surface Runoff	-6,139	-6,406	-3,470	-4,004	-4,270	-2,135	-534	-267	-534	-267	-801	-3,737	-32,562
	Recharge	-71,357	-42,369	-38,737	-7,610	-15,524	-518	37,364	30,817	9,955	-29,259	-59,563	-74,165	-260,965
Surface Water	Stream flow	15,747	17,349	17,882	18,950	21,352	13,879	6,139	4,270	4,804	5,872	7,473	12,011	145,728
	Baseflow	-9,342	-10,943	-14,413	-15,213	-17,082	-11,744	-5,605	-4,004	-4,537	-5,605	-6,673	-8,274	-113,433
	Surface Runoff	-6,139	-6,406	-3,470	-4,004	-4,270	-2,135	-534	-267	-534	-267	-801	-3,737	-32,562
Ground Water	Recharge	71,357	42,369	38,737	7,610	15,524	518	-37,364	-30,817	-9,955	29,259	59,563	74,165	260,965
	Consumptive Use	-39	-39	-39	-39	-1,764	-2,405	-2,565	-1,604	-81	-39	-39	-39	-8,689
	Baseflow	-9,342	-10,943	-14,413	-15,213	-17,082	-11,744	-5,605	-4,004	-4,537	-5,605	-6,673	-8,274	-113,433
	Transfer/Storage	-61,976	-31,388	-24,286	7,642	3,321	13,631	45,535	36,424	14,573	-23,616	-52,852	-65,853	-138,843

1 *Monthly values for precipitation were derived from the Dayton1 WSW and Pomeroy gauging stations. Percent precipitation was calculated by the combined mean for the Pataha and Tucannon Subbasin.*

2 *Evapotranspiration was calculated by multiplying the area of the subbasin by ET values (Thornwaithe Method), where the primary factor affecting ET is daily mean ambient air temperatures.*

3 *Surface Runoff was estimated using data collected from the Tucannon gauge (WDOE baseflow data). This assumes that the same unit volume of runoff per acre occurs for all ungauged areas.*

4 *Stream flow was estimated using data collected from the Tucannon gauge (WDOE baseflow data). This assumes that the same unit volume of runoff per acre occurs for all ungauged areas.*

5 *Baseflow was estimated using data collected from the Tucannon gauge (WDOE baseflow data). This assumes that the same unit volume of baseflow per acre occurs for all ungauged areas.*

6 *Consumptive Use was estimated with the assumption that annual MU/DM demand is distributed by percentage throughout the year. Winter usage (Oct-April) is assumed to be 40% of annual volume. Summer usage (May-Sept) is assumed to be 60% of annual volume.*

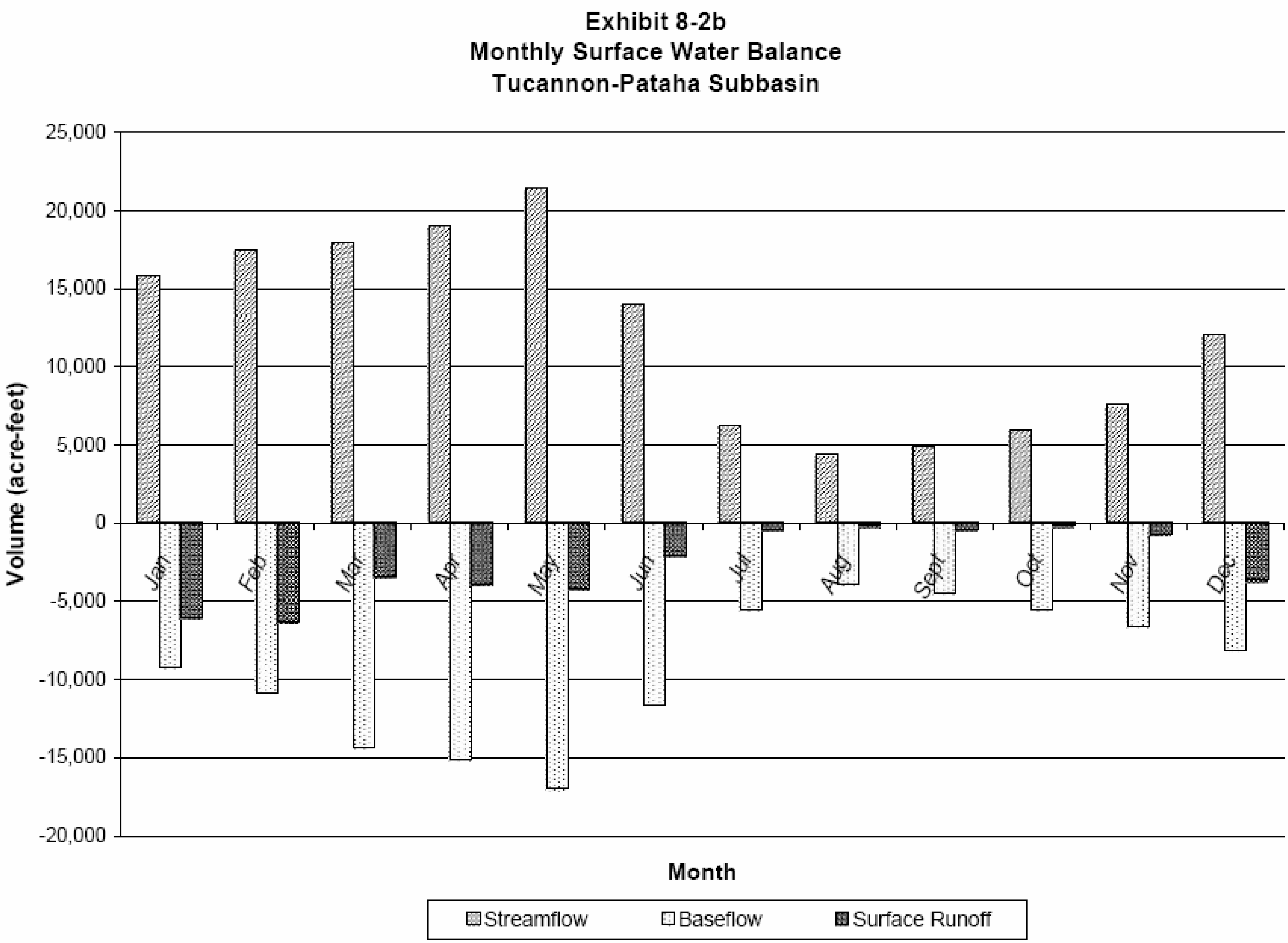
Exhibit 8-2b
Monthly Surface Water Balance
Tucannon-Pataha Subbasin
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
Volume (acre-feet)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month
Streamflow
Baseflow
Surface Runoff

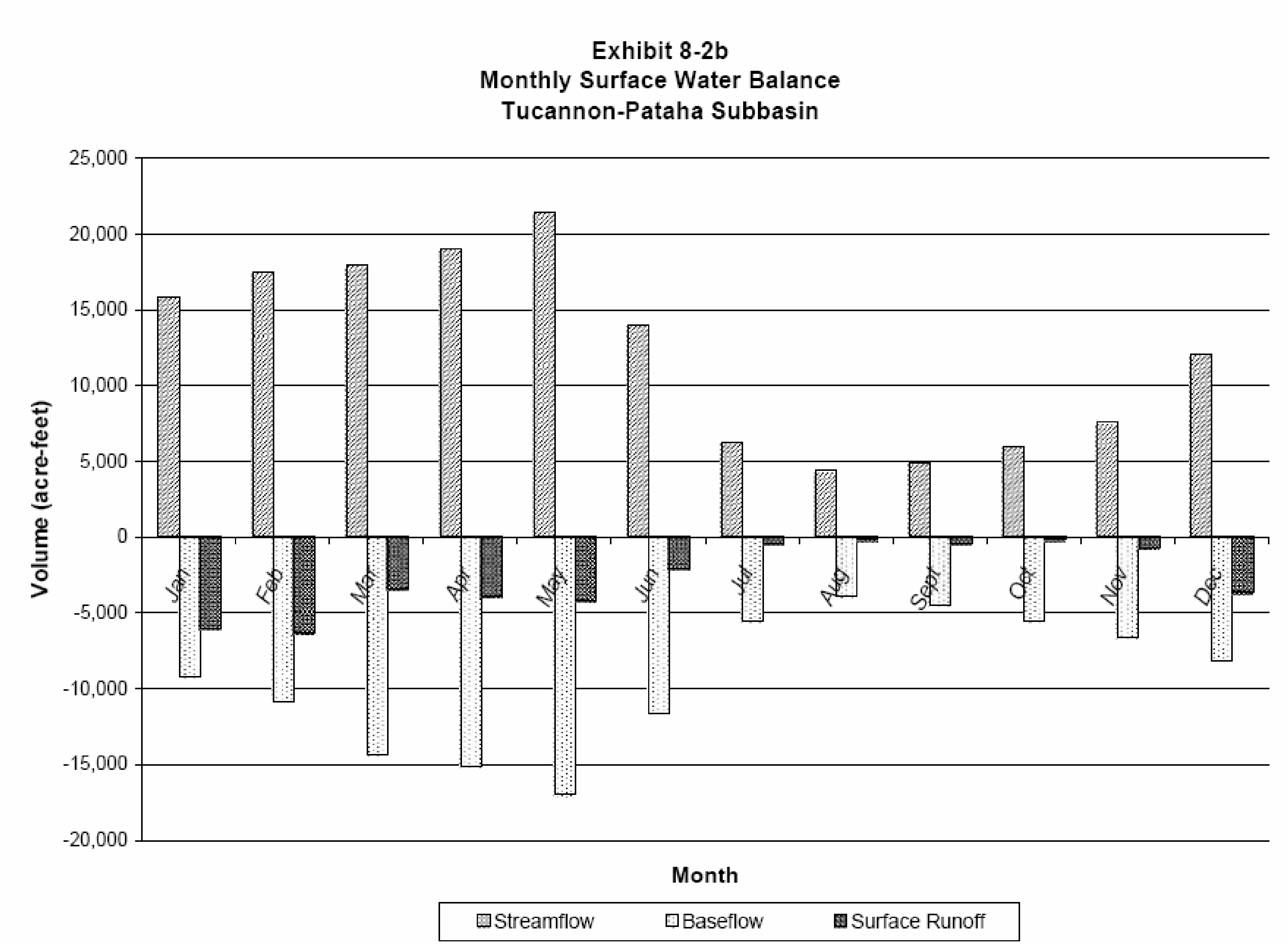
Exhibit 8-2b
Monthly Surface Water Balance
Tucannon-Pataha Subbasin
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
Volume (acre-feet)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
Month
Streamflow
Baseflow
Surface Runoff

Exhibit 8-2c
Monthly Ground Water Balance
Tucannon-Pataha Subbasins