Water Resources Budget

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Abstract/Summary of Concerns

As part of the Illinois River Watershed Assessment, the Bureau of Reclamation was assigned the task of developing a surface water budget of the Illinois River Basin, located in southwestern Oregon. The basin was divided into 32 watersheds (referred to as sub-watersheds of the Illinois River Basin), mimicking sub-watershed structure of the Oregon Water Resources Department water availability analysis program. Because this was an appraisal-level effort, the water budget was developed only with available data sources. Several data sets were required to develop the surface water budget for the Illinois River Basin, including streamflow, precipitation, evaporation, land use, crop types, municipal and industrial water use, domestic use, "other" uses of water, such as mining and stock watering, storage operations, return flows, water rights and ground water use data. The process of developing the budget involved development of natural flows, development of demands, analysis of storage operations, determination of possible return flow scenarios and a trial-and-error-based balancing procedure geared to known streamflow records. It is stressed that the figures determined in the final water balance in this investigation should be viewed with caution. If more detailed studies are warranted, a detailed data collection program should be instituted regarding diversion, return flow, storage operations and consumptive use. The water budget presented in this report represents a good starting point for the next level of study.

Introduction

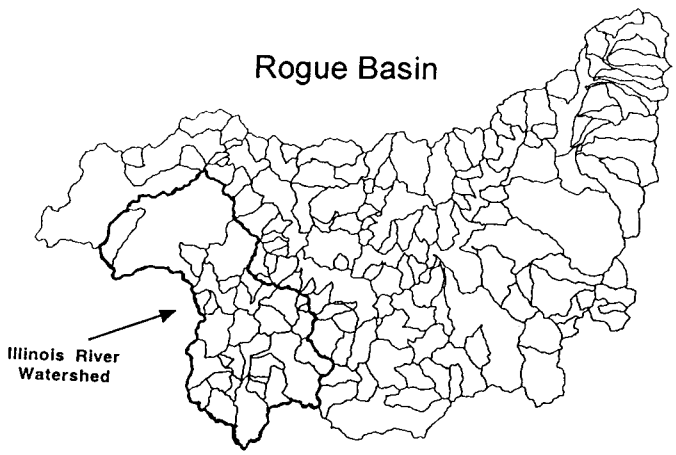
As part of the ongoing Illinois River Watershed Assessment, the Bureau of Reclamation was assigned the task of developing a surface water budget of the Illinois River Basin, located in southwestern Oregon. The budget is just one part of the assessment, which includes a basin-wide analysis of land use, fisheries, water quality, erosion, sedimentation and water use. The surface water budget was developed at an appraisal level of detail using existing data sources. No attempt to develop new data sources was made.

The following sections outline the assumptions and methods used to develop the water budget. Results of the budget and recommendations for its enhancement are also included.

Setting

The Illinois River, a tributary to the Rogue River in southwestern Oregon, flows into the Rogue River at river mile 27, approximately 20 miles northeast of Gold Beach, Oregon.

It drains all of southwestern Josephine County and a small portion of eastern Curry County, Oregon. In addition, the headwaters of both the East and West Forks of the Illinois River drain small areas of Del Norte County, California. The drainage area of the Illinois River is approximately 628,500 acres (982 square miles). The Illinois River Basin makes up approximately one-fifth of the entire Rogue River Basin system (see map below).



The topography of the Illinois River Basin is quite diverse. Elevations in the valley range from approximately 7,000 feet mean sea level (MSL) in the mountains and 1,500 feet in the valleys. Much of the terrain of the valley is characterized by rugged and steep slopes (between 11 and 60 percent slope), with the exception of a broad alluvial plain south and east of the City of Cave Junction and a smaller alluvial plain in the Deer Creek watershed near the Town of Selma. These areas are generally narrow and comprised of alluvial material up to 180 feet thick. Slopes in the valley areas are generally less than 10 percent.

Most of the basin population resides in the valley plain areas. Little development has occurred outside these areas, although some irrigation operations exist. The Federal Government owns or manages vast tracts of land within the basin, most of which lie outside the main population centers.

The basin climate is sub-humid-to-humid with marked marine features. The dominance of moist marine air masses in the region provides for relatively mild winters with temperatures occasionally dropping below freezing. During the winter months, most storms that occur in the basin originate from the North Pacific Ocean. The coastal mountains do provide some protection from the more violent storms that move into the area; however, flood-producing storms do occur and are not uncommon in winter and spring. During summer, weather patterns are primarily influenced from the south. As a result, the basin experiences warm, dry summers. Convective thunderstorms are common to the area during the summer and fall and can produce local flooding. The average frost-free period is about 170 days. Low humidity and high temperatures are common in mid-summer and result in high rates of evapotranspiration.

Annual precipitation of the area varies throughout the basin, ranging from 100 inches in the lower Illinois canyon area to only 35 inches in the area near Selma. Most precipitation occurs between November and April in the form of rain below 4,000 feet MSL and snow above this level. The driest period of the year is between June and August (only 2 percent of the annual precipitation) during the peak irrigation growing season (Illinois Valley Watershed Council, 1995).

Scope and Objectives

This effort was part of a multi-agency study of the Illinois River Watershed. The lead agency, the Natural Resources Conservation Service, developed a plan of work consisting of 21 products. The Bureau of Reclamation was assigned the task of completing three of the 21 products of an assessment of surface water availability in the form of a valley-wide surface water budget. This assessment was considered to be part of Phase 1 of the Illinois River Watershed Assessment – Technical Assessment. Once Phase 1 agency assignments are complete, public participation and project formulation will take place (Phase 2). Phase 3 would then involve individual project implementation.

The objective of the Bureau of Reclamation's assignment is to develop an appraisal-level water budget of the Illinois River Watershed. Originally this budget was to detail both surface and groundwater resources; however, groundwater data was very limited. Instead, BOR has concentrated on a surface water budget, which includes an estimate of surface returns from groundwater use. The final budget was intended to define, in broad terms, the annual surface water supply cycle of the valley, to include natural flow, diversions, consumptive use, return flows and effects of storage. The data developed in this budget could then be utilized as a database for hydrologic modeling to assess the effects of future projects and development in the Illinois River Watershed.

Budget Organization and Data Requirements

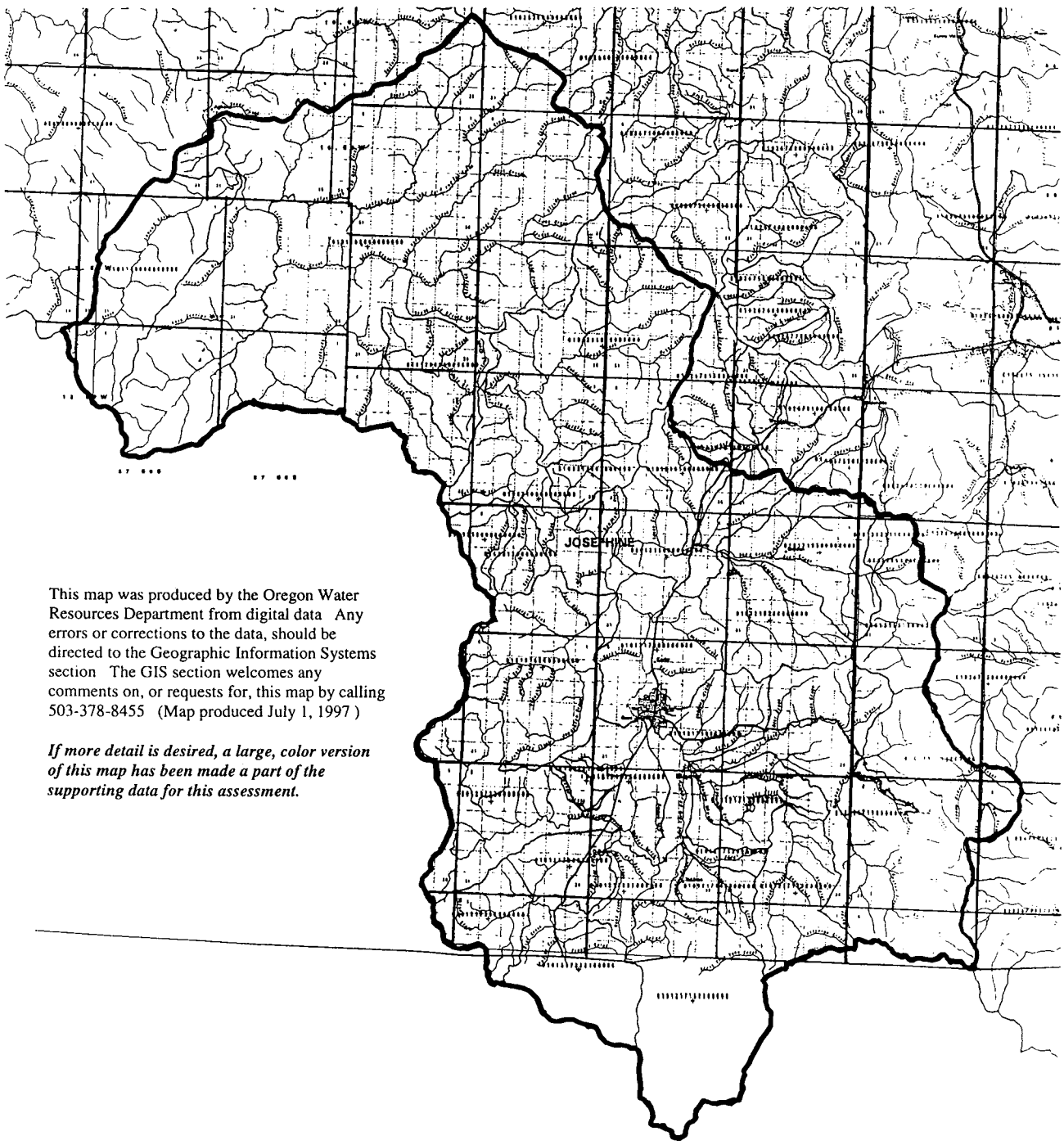
The procedures used to develop the water budget for the Illinois Basin are described in the following sections in terms of budget structure, organization and data requirements:

Budget Structure/Organization: The Illinois River Basin consists of several major tributary streams, each unique in its pattern of hydrology, climate, storage operations and diversion practices. Several areas in the basin are of special interest to various entities, such as Sucker and Rough and Ready Creeks. Because of these complexities, a plan had to be devised for structuring the river basin into representative sub-watersheds that would provide information on water supply, flow levels, etc., in a useful manner. Also, the final budget had to be arranged in an understandable format so that other entities interested in information provided by the water budget could easily interpret the developed data.

Sub-watershed Organization: Because Oregon Water Resources Department (OWRD) already developed a water availability budget based on several sub-watersheds, it was decided to utilize the State's sub-watershed structure. This structure consisted of 32 sub-watersheds and was based on the best available demand data from the State of Oregon

(Rick Cooper, OWRD, personal communication). Figure 2 illustrates the sub-basin breakdown and Table 1 lists the sub-watersheds and their respective drainage areas. Also listed are the individual sub-watershed designations used by the State of Oregon as part of its water availability study program. Two designations were used: a long-form numerical designation and a short (five-character) designation. The shorter sub-watershed designations, along with a text descriptor, were used throughout this study.

Figure 2. Water Availability Basins: Illinois Basin (as produced by the Oregon Water Resources Department)



Budget Presentation Organization: The surface water budget was developed on a spreadsheet using Microsoft Excel. The budget is broken down into a separate spreadsheet for each sub-watershed in an upstream-to-downstream arrangement. Each individual spreadsheet begins with inflows, including natural inflows of the sub-watershed of interest and depleted "budget" flows from upstream watersheds. Demands are listed in order of irrigation, municipal, industrial and domestic, livestock and "other" demands. Also included are storage budget scenarios encompassing all estimated storage facilities in the sub-watershed. In some cases, where a more prominent storage facility exists, such as Lake Selmac, a separate budget is included. These storage budgets account mainly for losses to downstream flows due to filling operations and evaporation. Demands on the storage sites were assumed to be represented in the demand sections of the spreadsheets. As a whole, each individual water budget spreadsheet displays inflow, demand, losses and outflow. No attempt to break out individual demands on a point-to-point basis was made due to lack of available data. The final budget spreadsheets for each of the sub-watersheds are contained in Appendix F.

Data Collection: Several data sets were required to develop the surface water budget for the Illinois River Basin. Because this was an appraisal-level effort, the water budget was developed only with available data sources. No effort was made to collect and interpret new data sets. However, available data was subject to interpretation and modification, depending on assumptions made in the development of the budget. Data mainly consisted of streamflow, precipitation, evaporation, land use, crop types, municipal and industrial water use, domestic use, "other" uses of water, such as mining and stock watering, water right data, and ground water use data.

A primary source of data used in this study was from the Oregon Water Resources Department water availability database (Rick Cooper, OWRD, personal communication). These data consisted of a breakdown of use estimates in several sub-watersheds in the Illinois Basin. These data were used along with developed estimates of natural flows, system efficiencies, return flows, storage operations and crop consumptive use to complete the budget. The types, sources and use of the above data is described in the following sections:

Streamflow Data: Recorded streamflow data was paramount to development of the Illinois River water budget. These data were used for development of natural flows and as a calibration tool at various points in the basin. Data were collected from existing and discontinued U.S. Geological Survey (USGS) stream gauging stations. Table 2 lists the gauges used in the study, their designation, period of record, drainage area, and pertinent remarks. For purposes of this study, it was assumed that gauging records were accurate and reflected actual streamflow conditions in the valley.

Climatological Data: Climate data records used in preparing the water budget included precipitation, evaporation and temperature. These records were used in the development of natural flow (to determine patterns of natural flow based on precipitation variation throughout the basin), crop consumptive use and storage (lake and pond) evaporation. Data was collected from a variety of stations in the basin. The primary climatological

station in the valley was near Cave Junction. This station, located near the primary water use zone, maintains a suite of data, including precipitation, temperature and evaporation.

Table 2:
Existing & Discontinued Streamgauge Stations of the Illinois Valley Watershed

Station Name	Station No.	Drainage Area (mi2)	Period of Record
Existing Station:			
Illinois River near Cave Junction	14377100	380	1961-present
Discontinued Stations:			
East Fork Illinois River near Takilma	14372500	42.3	1926; 27-32; 41-91
Althouse Creek near Holland	14373500	24.3	1947-53
Sucker Creek near Holland	14375000	76.2	1942-65
Sucker Creek below Little Greyback			
Creek near Holland	14375100	83.9	1966-91
Elk Creek near O'Brien	14375400	26.6	1986-91
West Fork Illinois River below Rock			
Creek near O'Brien	14375500	42.4	1955-85
West Fork Illinois River below O'Brien	14376500	49.7	1947-54
Illinois River at Kerby	14377000	364	1926-61
Deer Creek near Dryden	14377500	22	1942-56
Illinois River near Selma	14378000	665	1957-68
Illinois River near Agness	14378200	988	1961-81

Source: US Geological Survey, 1998

Domestic, Municipal and Industrial (MD&I) Water Demands: Problems of determining actual levels of MD&I demand were encountered early in this study. Initially, water right data was used in an attempt to quantify actual municipal, domestic and industrial uses. However, it was not clear how accurately the water rights database reflected use. A second data source, the Oregon Water Resources Department's water availability database, was determined to offer a better picture of MD&I demand in the valley. This was because the demands were broken down into the sub-watersheds used in this study, and they are currently in use by the State of Oregon to determine water availability (Rick Cooper, OWRD, personal communication). This data set included an estimate of raw water diversions and consumptive use for each sub-watershed at 1995 levels. Assumptions would have to be made, however, regarding system efficiency, return flow patterns, and losses to deep percolation for each sub-watershed. Also, since data was only available for 1995, assumptions would have to be made about past MD&I demand levels so that a period of record could be developed for an annual budget over several years. This "historic" use data was determined using population estimates of Josephine County over the 28-year period of record (1962-1990) used in this study.

Irrigation Water Demand: Early in this study, an attempt to determine the level of water used by irrigation from the State of Oregon's water right database was made. As a result of several discussions with State officials (Norm Daft and Rick Cooper, OWRD, personal communication), the accuracy of the water right database compared to actual use was questionable. The State database may not actually reflect non-use or abandoned rights in the valley. The problem was encountered in other Bureau of Reclamation studies in other parts of the State (Bureau of Reclamation, 1992). U.S. Department of Agriculture

records indicate that irrigation in the southwestern portion of the State has been decreasing since the 1950's (Department of Commerce, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987 and 1992). Therefore, it is speculated that the State water right database probably overestimates the amount of acreage under surface water irrigation due to unreported water right abandonment or non-use.

A second attempt to estimate the amount of water in irrigation water use for the Illinois Basin was based on reported irrigated acreage from the U.S. Department of Commerce Census of Agriculture (Department of Commerce, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987 and 1992). Data was collected at approximate five-year intervals. Data from these years indicated a noticeable trend of reduced acreage in the 1960's. This trend continued through the1990's and is illustrated in Figure 4 (located in the Water Budget Development Assumptions and Methodology section under the Historic Irrigation Demands discussion). Irrigated acreage was nearly halved during this time frame. This trend was observed in the State of Oregon as a whole.

As a check, a sensitivity analysis of precipitation records was performed to determine if the irrigation trend was weather-related. Findings from this analysis indicated that the general level of irrigated acreage was not significantly influenced by the precipitation each year. Rather, the probable cause of the reduction was population migration from farm to more urban settings. Also, the influx of new residents (the population more than doubled from 1960 to the present) indicates that land use is changing in the area away from irrigated agriculture to a more residential environment. One detail lacking from the Department of Commerce figures was the breakdown of irrigation from surface and groundwater sources. More detail on how this problem was handled is described in the Methods and Assumptions section.

Consumptive use for irrigated crops in the basin on a per-acre basis was determined by using the Blaney-Criddle crop consumptive use methodology. This methodology determined the irrigation requirement of crops in the basin based on local precipitation and temperature records. The climatological records used for the Illinois River Basin were from the Cave Junction climatological station. This station was in proximity to most of the irrigated lands in the valley. Several types of crops are grown in the basin, including barley, oats, vegetables, grasses/hay and orchards. By far, the greatest amount of land was in hay/grasses (over 70 percent), with orchards following. The consumptive use analysis concentrated on the grasses as a basis of computation. Acreage was grouped in five-year increments and was then applied to the computed consumptive use per acre for the basin. Sub-watershed acreage was based on State water availability data (Rick Cooper, OWRD, personal communication) and modified for each time frame based on the percentage of present-day acres irrigated to the number of past year acreage. The acreage level for 1995 was assumed to be 9,545 acres.

Livestock and "Other" Water Use: Use of water by livestock in 1995 (present) was primarily based on the OWRD water availability data. The number of farms with livestock production was assumed to be at the 1992 level since no data for 1995 was available. Water use by livestock was then adjusted back in time based on the number of

total farms for each year reported as compared to the 1992 level. Farm/livestock data was obtained from the U.S. Department of Commerce Census of Agriculture for the years 1959, 1964, 1969, 1974, 1978, 1982, 1987 and 1992.

Water Budget Development Assumptions and Methodology

The Illinois Basin surface water budget development consisted of a multi-step process. These steps consisted of data collection, development of natural flows, development of demands, analysis of storage operations, determination of possible return flow scenarios and balancing procedures. The balancing procedures essentially were used to fine-tune the assumptions used in the model in a consistent basis for each sub-watershed. Each step is described in the remainder of this section.

Natural Flow Development: For purposes of this study, natural flow was considered to be the runoff naturally produced by the watershed under conditions without the influence of man. The only depletion of these flows was from deep percolation and use by natural vegetation. A major step in development of the Illinois Basin water budget was the determination of natural flow conditions for each of the 32 sub-watersheds. This step was co-mingled with development of demand data. The procedure used consisted of three general steps: 1) development of natural flow conditions based on streamflow and climatological records; 2) refinement of the natural flow estimate for each sub-watershed considering demand, return flows and storage operations; and 3) fine-tuning the flow estimates for a final budget balance. Several stream gauges were used in the initial development of natural flows. One stream gauge currently exists in the basin: the Illinois River near Kerby, Oregon. Several records also exist from discontinued gauges. Table 2, displayed earlier in this section, lists the existing and discontinued stream gauge stations in the Illinois Basin.

Initially, stream gauge records were sought that indicated conditions with a minimal influence by man upstream. Such gauges would be assumed to have a natural or near-natural flow condition. These gauges then could be used to estimate natural streamflows in other parts of the valley by way of drainage area ratios and precipitation/runoff evaluations. Generally, many areas of the basin had to be considered hydrologically similar, with the exception of drainage area and precipitation. The first attempt at natural flow development used this assumption. Initial estimates of natural flows then were developed for each of the sub-watersheds in the Illinois Basin.

Once the initial natural flow data set was established, it was assumed that each sub-watershed's natural runoff was adjusted for size and precipitation patterns. The next step then was to insert broad estimates of demand and return flows and fit to major gauges that reflected depleted flow conditions. The major gauges used for this step were:

The Illinois River near Cave Junction (USGS gauge #14377100)
The Illinois River near Selma (USGS gauge #14378000)
The Illinois River near Agness (USGS gauge #14378200)

This step was used to determine if any major anomalies were present in the first attempt at natural flow development. Generally, flow, precipitation and drainage area patterns appear to be fairly consistent with the gauged records at this stage. The final step was to insert the natural flow data, still considered preliminary, into the final water budget and attempt to balance. This approach indicates a major area of concern in the study – the lack of detailed demand and return flow data. In the process of this balancing procedure, assumptions required refinement based on early balance attempts and professional judgment.

The first attempt at a final balance revealed a potential error of 10 percent in the upper basin above Cave Junction. This error was generally consistent in the non-irrigation season, but varied during the irrigation months. It was assumed that this generally indicated that preliminary estimates of natural flow in the upper basin contained a scientific error of about 10 percent throughout the basin. The results also indicated that refinement of irrigation demand was necessary to remove some of the error suspected in the spring, summer and early fall periods. It was assumed that some adjustment would be necessary because the actual acreage of crop types, the division of ground and surface water irrigation, and anomalies such as spraying crops with water to prevent frost damage were not fully known. Therefore, an assumption was made that if the irrigated crop level of demand, return flow pattern, and change of acreage under production through the season could be modified so that the irrigation month balance could be brought into line with the non-irrigation months, much of the uncertainty of irrigation demand could be reduced. The adjustment procedures and assumptions used in this procedure for irrigation are discussed in greater detail in the Development of Demand, Consumptive Use and Storage Data section.

Once the computation of natural flows was in a consistent pattern, it was assumed that demand, return flow and storage data were refined as far as practicable. The final method then was to adjust the natural flows on a proportional basis throughout the basin. This meant that each sub-watershed was adjusted in a consistent and proportional manner to reach the final balance. Once the recorded (depleted) flow was attained at the stream gauge sites, all natural flow, demand, storage and return flow was accounted for upstream.

Development of Demand, Consumptive Use and Storage Data: The second step in the water budget process involved computation of diversion demand and consumptive use data for the basin. Demand estimates were developed for present and historic conditions for a variety of uses as described in the remainder of this section.

Present (1995) Demand Computations: One of the most important data sets needed to complete a basin water budget was the level of water demands existing in the basin. Due to data limitations, 1995 demand levels were assumed to represent present demand conditions in the Illinois River Basin. Demands included estimating all raw surface water diversions on the mainstem river and its tributaries and the amount of water consumptively used from diversions. Demands investigated as part of this study included municipal, domestic, industrial, irrigation, livestock/other and depletions by evaporation

of reservoirs. Ground water diversions were not actually a part of this budget; however, surface water returns from ground water use were considered in the budget. Derivation of each demand category is discussed in the next several paragraphs.

1995 Municipal, Domestic and Industrial Demands: Very little information was available regarding actual diversions from cities, domestic users and industry in the study area. OWRD did provide water right information; however, this data was questionable as to how well the database represented actual conditions. In addition, the basin watermaster indicated that several residences throughout the valley were obtaining water from unregistered wells, adding further doubt to the actual surface water demand. OWRD did, however, have estimates of MD&I, and domestic use as part of its water availability database (Rick Cooper, OWRD, personal communication). This database included estimations of raw water diversions and consumptive use for each sub-watershed used in the water budget. It was decided to use the State estimations to account for diversions and consumptive use by households and cities. Until more detailed information is developed, this was the best information available.

1995 Irrigation Demands: Two sources of irrigation demand data were used to derive initial estimates of irrigation demand and consumptive use level for 1995. The first estimate was from the Oregon Water Resources Department water availability studies (Rick Cooper, OWRD, personal communication). This source estimated the total basin acreage under irrigation at 9,545 acres. The second estimate was from the Census of Agriculture (U.S. Department of Commerce, 1992), which also estimated total acreage for 1995 at 9,545 acres. What was not clear from these sources was the exact distribution of crop types, irrigation application methods and whether some of the acreage was irrigated from ground water. After consultations with the watermaster's office, an application efficiency of 60 percent was assumed. Conveyance efficiency was not known. Therefore, the final estimate of irrigation demand was considered one of the weaker estimates of the budget. After all other demands were set in the budget, the final adjustment to the budget would be from the irrigation sector in terms of adjusting the acreage irrigated by surface water.

The amount of water consumed for the resulting acreage in each sub-watershed was therefore adjusted to the prevailing climate each year as part of the modified Blaney-Criddle computations. Further adjustments would have to be made to the above to account for some acreage with shorter growing seasons and specialty crops such as grapes, which use less water later in the growing season. Regarding return flows from irrigation, it was assumed that most of the water not consumed would return to the river the first month, with some delayed returns over the next several months. The assumption was made that the general efficiency of the irrigation operations in the basin was as high as 65 percent, as most irrigators now use sprinkler systems (Norm Daft, OWRD, personal communication). Initial estimates of return flow patterns were based on other studies in the area (Bureau of Reclamation, 1990). The final determination was based on a trial and error method in the final water budget. This included a return flow period lasting for four months. The return flow pattern was assumed to be consistent throughout the Illinois Basin watershed for computational purposes. However, it is recognized that different soil

types, slopes, underlying bedrock and proximity to the local stream or river do play a part in varying the return flow rate from a particular irrigation site. Return flows are discussed in more detail in the Development of Return Flows section.

1995 "Other" Demands: Very little information was available regarding actual diversions from livestock, mining and other uses in the study area. OWRD did provide water right information; however, this data was questionable as to how well the database represented actual conditions. OWRD did, however, have estimates of livestock/other use as part of its water availability database (Rick Cooper, OWRD, personal communication). This database included estimations of raw water diversions and consumptive use for each sub-watershed used in the water budget. It was decided to use the State estimations to account for diversions and consumptive use by these use categories.

1995 Storage Operations Demands: Most storage in the Illinois Valley consists of small ponds and lakes. The largest facility is Lake Selmac, an impoundment located on McMullin Creek near the central portion of the basin. The lake capacity is approximately 1,675 acre-feet and is generally maintained at the same storage level during the year. Other large facilities with data in the basin include Spaulding Pond, Tall Timber Lake, Sowell Lake, Circle "W", Rough and Ready Mill Pond, and Indian Lake. Summaries of the location, dam height and estimated storage capacity for each of these facilities is listed in Table 3.

Table 3. Illinois Basin Storage Facilities with Known Data

Impoundment Name	Impoundment Location (Stream/Sub-Watershed	Dam Height (feet)	Storage Capacity (acre-feet)
Circle "W"	Clear Cr/70995	22	14
Indian Lake	W Fork Illinois R/70996	10	23
Rough and Ready Pond	Wood Cr/71024	16	108
Lake Selmac	Thompson/McMullin Cr/71002	33	1,675
Sowell Lake	Illinois R/70980	26	47
Spaulding Pond	Bridge Cr/71018	37	25
Tall Timber Lake	Deer Cr/70991	28	20

Source: OWRD, 1997

Other smaller impoundments, in the form of stock water ponds, are also present in the basin. OWRD provided estimates of storage surface areas in each sub-watershed. In order to estimate the volume of storage, surface areas were combined for each sub-watershed into a single impoundment and then estimated by using existing area-capacity tables. For combined surface areas of 20 acres or less, the Tall Timber area-capacity table was used to estimate total storage volume. Table 4 below lists the estimated storage capacity in use for each sub-watershed, excluding the storage listed in Table 3 above.

Table 4. Estimated Storage Capacity for Sub-Watersheds in the Illinois Valley (Excluding Storage Presented in Table 3)

Sub-Watershed Number	Sub-Watershed Description (tributary to:)	Sub-Watershed State Water Availability Designation (Short Form)	Estimated Total Sub-Watershed Storage Capacity (acre-feet)
1	W Fork Illinois R Headwaters	71022	0.2
2	Whiskey Cr (W Fork Illinois R)	14375500	0.4
3	Wood Cr (W Fork Illinois R)	71024	0
4	W Fork Illinois R near O'Brien	70996	3.4
5	Rough and Ready Creek (W Fork)	71010	0
6	Parker Cr (W Fork Illinois R)	71024	3.5
7	Elder Cr (E Fork Illinois R)	70978	0
8	W Fork Illinois R at the Mouth	70997	9.6
9	E Fork Illinois R Headwaters	70979	0.9
10	Little Elder Cr (E Fork Illinois R)	71202	0
11	Althouse Cr Headwater (E Fork)	69809	0
12	Lower Althouse Cr to Mouth (E Fork)	69810	0
13	Greyback Cr (Sucker Cr)	71199	0
14	Sucker Cr less Greyback Cr (Illinois R)	69808	0
15	Illinois R at Cave Junction	70980	6.4
16	Illinois R near Kerby	72843	8.3
17	Josephine Cr (Illinois R)	70977	0
18	Fall Creek (Illinois R)	71021	0
19	Rancherie Cr (Illinois R)	71205	0
20	S Fork Deer Cr (Deer Creek)	71014	0
21	N Fork Deer Cr (Deer Creek)	71027	0
22	Deer Cr Headwaters (Illinois R)	14377500	0
23	Deer Cr (Illinois R)	70991	0.0
24	Thompson/McMullin Cr (Deer Cr)	71002	0.3
25	Clear Cr (Deer Cr)	70995	13.9
26	Lower Deer Cr (Illinois R)	70992	5.0
27	Sixmile Cr (Illinois R)	71019	0
28	Bridge Cr (Illinois R)	71018	0
29	Illinois R at Selma	14378000	0
30	Illinois R above Klondike Cr	72844	0.5
31	Lawson Cr (Illinois R)	71031	0
32	Illinois R at Mouth/Agness Gauge	72845	0

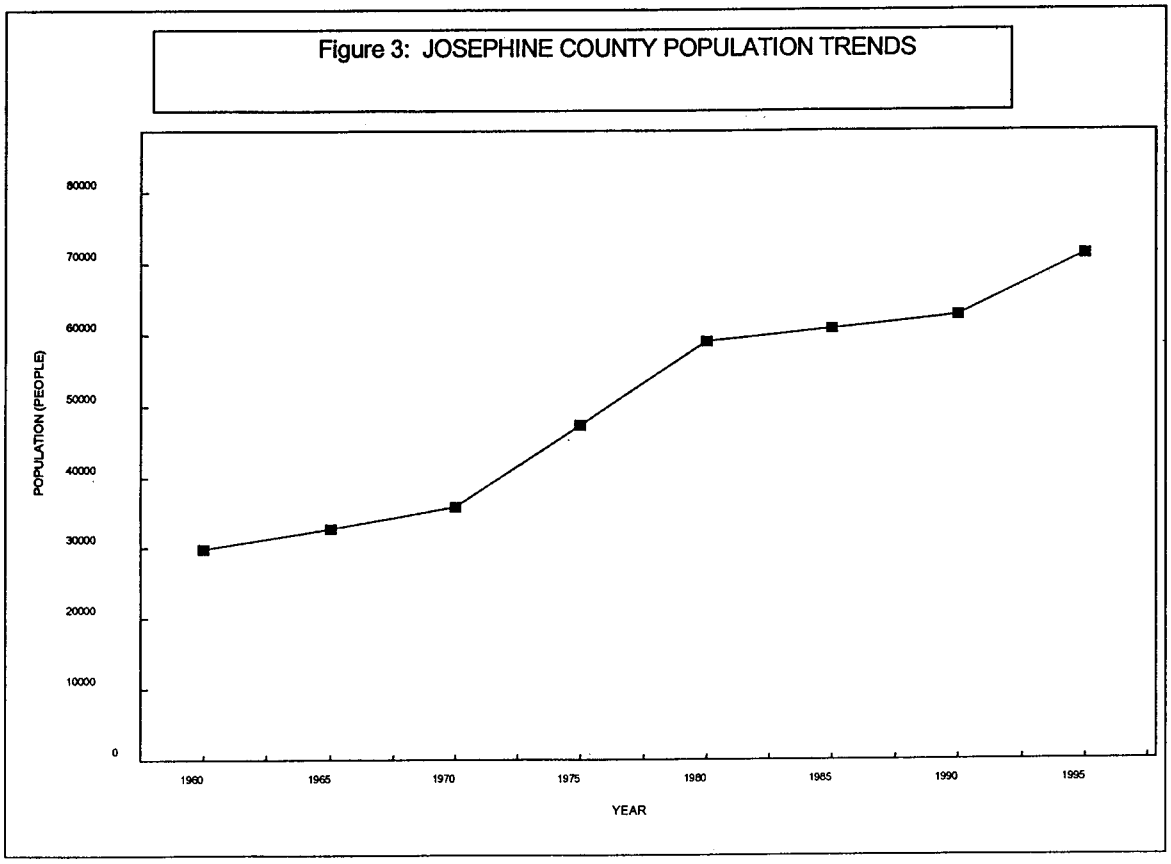
Historic (1962-1990) Demand Computations: One of the most important data sets needed to complete a basin water budget is the level of historic water demands present in the basin. Due to data limitations, 1995 demand levels were assumed to represent baseline demand conditions by which historic demands were derived. Demands investigated as part of this study included municipal, domestic, industrial, irrigation, livestock/other and depletions by evaporation of reservoirs. Ground water diversions were not actually a part of this budget; however, surface water returns from ground water use were considered. Derivation of each historic demand category is discussed in the next several paragraphs:

Historical Municipal, Domestic and Industrial Demands: Very little information was available regarding historic diversions from cities, domestic users and industry in the study area. OWRD did provide current water right information; however, this data was questionable as to how well the database represented historic water use conditions. In addition, the basin watermaster indicated that several residences throughout the basin were obtaining water from unregistered wells, adding further doubt to the actual demand. OWRD did, however, have estimates of present-day MD&I and domestic use as part of its water availability database (Rick Cooper, OWRD, personal communication). This database included estimations of raw water diversions and consumptive use for each sub-watershed used in the water budget. It was decided to use the State estimations to account for diversions and consumptive use by households and cities as a starting point for developing historic use data.

The best information available to estimate the trend of water use by cities, industry and individuals was population. Population has generally been on the rise in the study area according to County statistics. Based on the assumption that domestic and city use trends have generally remained constant on a per capita basis, it was decided to calculate past water use by adjusting demands in line with population estimates. Portland State University provided population estimates in five-year increments. Demand was adjusted proportionally based on these data. Table 5 lists population statistics used in this study and the corresponding demand adjustment coefficient. Figure 3 illustrates the general trend of population in the area since the late 1950's.

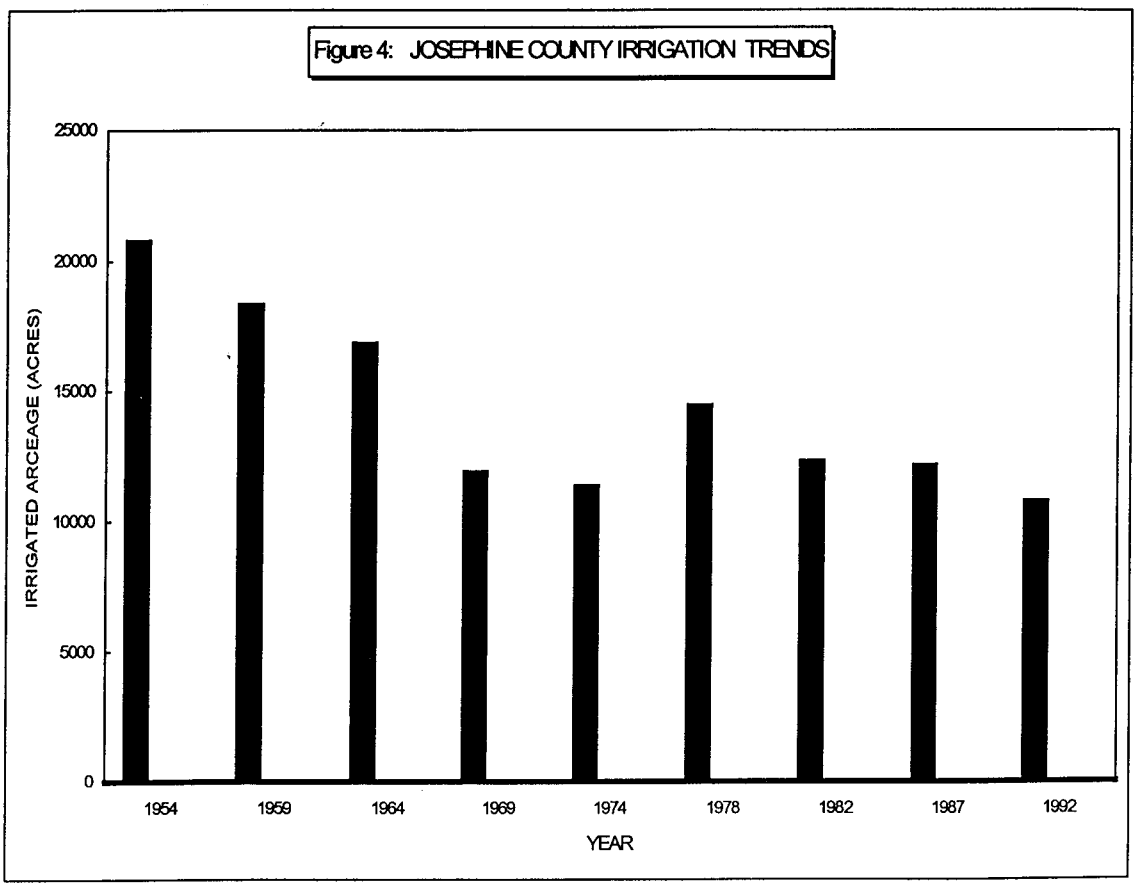
Table 5. Josephine County Population Statistics

Josephine County	Census 1960	Estimated 1965	Census 1970	Estimated 1975	Census 1980	Estimated 1985	Census 1990	State Est. 1995
County Population	29917	32831.5	35746	47300.5	58855	60752	62649	71100
% change from last decade	N/A		19.5		64.6		6 4	13.5
% annual change from last decade	N/A		1.9		6.5		0.6	2.7
Annual change from last decade	N/A		582.9		2310.9		379.4	1690.2
% of 1995 level	42.1	46.2	50.3	66.5	82.8	85.4	88.1	100.0



Historic Irrigation Demands: Very little information was available regarding historic diversions from irrigators. OWRD did provide water right information; however, this data was questionable as to how well the database represented actual historic water use conditions.

The best information available to estimate the trend of water use by irrigators was assumed to be in the agricultural statistic tables reported by the Census of Agriculture (U.S. Department of Commerce. 1959, 1964, 1969, 1974, 1978, 1982, 1987, and 1992), which was also used to estimate present (1995) irrigation demands. These data are illustrated in Figure 4. What was not clear from these sources was the exact distribution of crop types, irrigation application methods, and whether some of the acreage was irrigated from ground water. After consultations with the watermaster's office, an application efficiency of 60 percent was assumed. Conveyance efficiency was not known. Therefore, the final estimate of irrigation demand was considered one of the weaker estimates of the budget. After all other demands were set in the budget, the final adjustment to the budget would be from the irrigation sector in terms of adjusting the acreage irrigated by surface water.



The amount of water consumed for the resulting acreage in each sub-watershed was, therefore, adjusted to the prevailing climate each year as part of the modified Blaney-Criddle computations. Further adjustments would have to be made to the above to account for some acreage with shorter growing seasons and special crops such as grapes, which use less water later in the growing season. Regarding return flows from irrigation, it was assumed that most of the water not consumed would return to the river the first month, with some delayed returns over the next several months. The assumption was made that the general efficiency of the irrigation operations in the basin was possibly as high as 65 percent, as most irrigators now use sprinkler systems (Norm Daft, OWRD, personal communication).

As a result, final acreage reported in the budget should be viewed with caution. The budget is assumed to represent the final diversion volume for irrigation without regard to actual acreage and efficiencies. Acreages were adjusted to about 50 percent of total in the final budgets.

Historic Livestock and "Other" Demands: Very little information was available regarding historic diversions from livestock and "other" uses such as mining in the study area. OWRD did provide current water right information; however, this data was questionable as to how well the database represented actual conditions and did not provide information related to past uses. OWRD did, however, have current estimates of

livestock/other use as part of its water availability database (Rick Cooper, OWRD, personal communication). This database included estimations of raw water diversions and consumptive use for each sub-watershed used in the water budget. The current number of farms with livestock production was assumed to be at the 1992 level since no data for 1995 was available. For historic conditions, water use by livestock was then adjusted back in time based on the number of total farms for each year reported as compared to the 1992 level. Farm/livestock data was taken from the U.S. Department of Commerce Census of Agriculture for the years 1959, 1964, 1969, 1974, 1978, 1982, 1987 and 1992. Until more detailed information becomes available, this was considered the best way to compute livestock and other water use demand.

Historic Storage Operations Demands: No historic impoundment or operational data was available for the Illinois Basin. Historically, it is known that most storage in the Illinois Basin consists of small ponds and lakes. The largest facility is Lake Selmac, an impoundment located on McMullin Creek near the central portion of the basin. It is assumed that for the period of record used in this analysis Lake Selmac has essentially been unchanged. The same assumption was used for other larger facilities (Spaulding Pond, Tall Timber Lake, Sowell Lake, Circle "W", Rough and Ready Mill Pond and Indian Lake) and smaller facilities basin-wide. Operational criteria were assumed to be unchanged from the criteria used for existing conditions. For more detail on these impoundments, refer to the discussion on existing storage use presented earlier in this section.

Development of Return Flow Scenarios

MD&I and Domestic Return Flows: Return flow for municipal, industrial and domestic or residential uses relying on the surface water of the Illinois Basin were based on the assumption of a limited return lag period of less than one month. Therefore, in the monthly water budget, MD&I and domestic returns occurred in the same month as the diversion. Essentially, return flows were equal to the diversion rate minus the consumptive use of the diversion. Of this amount, an additional 10 percent was assumed to be lost to deep percolation based on professional judgment. No actual studies exist as to the amount of deep percolation that may take place in the Illinois Basin. However, during the water budget computation process, it was determined that some flow may indeed be lost to the local sub-watershed and may or may not reappear further downstream in the Illinois or Rogue River watersheds. Therefore, an assumed deep percolation rate of 10 percent was used valley-wide in this analysis.

Irrigation Return Flows: Probably the most difficult component of the watershed water budget was the estimation of return flows from irrigation. No data exists in the Illinois River watershed concerning the return flows from irrigation diversions. In addition, return flow levels can vary as a result of water appellation procedures, field drainage efficiency, soil types, slope, geology and field location relative to the stream or river. Because this was assumed the weakest part of this analysis, it was decided that return flows would be determined from other studies and professional judgment, and then be fine tuned as a final budget calibration.

Initial estimates of return flow patterns were based on other studies in the area (Bureau of Reclamation, 1990). The final determination was based on a trial and error calibration to gauge data in the final water budget. Based on this calibration, it was assumed that return flows for an irrigated parcel would last for four months. The return flow pattern was assumed to be consistent throughout the Illinois River watershed for computational purposes.

1. Portion of return flow lost to deep percolation/evaporation: 10 percent
2. Portion of remaining flows returning in the same month: 90 percent
3. Portion of remaining flows returning in the following month: 2.5 percent
4. Portion of remaining flows returning in the third month: 1.25 percent
5. Portion of return flows returning in the fourth month: 1.25 percent
6. The remaining 5 percent return flow may return in later months in smaller increments or be lost to the local watershed due to deep percolation.

Livestock and "Other" Demand Return Flows: Return flow for livestock and "other" uses such as mining that rely on the surface water of the Illinois Basin were based on the assumption of a limited return lag period of less than one month. Therefore, in the monthly water budget, returns from these uses occurred in the same month as the diversion. Essentially, return flows were equal to the diversion rate minus the consumptive use of the diversion. Of this amount, an additional 10 percent was assumed to be lost to deep percolation that may take place in the Illinois Basin. However, during the water budget computation process, it was determined that some flow may indeed be lost to the local sub-watershed and may or may not reappear further downstream in the Illinois or Rogue River watersheds. Therefore, an assumed deep percolation rate of 10 percent was used valley-wide in this analysis.

Groundwater Demand Return Flows: Although ground water was not the focus of this water budget study, it is recognized that return flows from pumped ground water use can contribute to surface water supplies. In addition, wells located in the proximity of surface water can influence the hydrologic character of that water through pumping.

It was not within the scope of this study to examine the effect of pumping on surface water flows. This influence may indeed be covered by the deep percolation assumptions used in this study. However, it was decided because most ground water use in the Illinois Basin is domestic, return flows from this use should be treated as were domestic and surface water return flows. Therefore, for surface returns from ground water use (based on OWRD data) utilized the assumption of a limited return lag period of less than one month. Thus, in the monthly water budget, returns from these uses occurred in the same month as the diversion. Essentially, return flows were equal to the diversion rate minus the consumptive use of the diversion. Of this amount, an additional 10 percent was assumed to be lost to deep percolation that may take place in the Illinois Basin. However, during the water budget computation process, it was determined that some flow may indeed be lost to the local sub-watershed and may or may not reappear further downstream in the Illinois or Rogue River watersheds.

Budget Balancing Procedures and Fine Tuning

The final water budget for each sub-watershed was developed after all assumptions regarding demands, consumptive use, return flows, effect of storage, evaporation and natural runoff were complete. Each set of parameters was entered into an Excel spreadsheet so that a trial and error procedure could be used to finalize the balancing towards established streamflow records. Since no detailed data existed for demand and consumptive use, these data were kept constant in the fine-tuning procedure. The main budget component that was used for the final adjustment was return flows. Return flows for each component were adjusted consistently throughout the period of record of the budget until consistent results were obtained.

The round of adjustments brought most of the sub-watershed budgets to within approximately one percent of the established streamflow data. This was deemed to be the limit of the fine-tuning by changing the return flow pattern of agricultural use (as described above). Once this point was reached in the budgeting process, it was decided that the final balancing component would be the adjustment of estimated natural flow to match streamflow records. It is realized that any of the inflow-outflow components of the budget could have been adjusted; however, for the sake of consistency in this data-poor study, the most appropriate component to change was natural flow. Once this final adjustment was made, the budget was calibrated to the recorded flows. The final results of the budget balancing procedure can be found in Appendix F.

Results and Discussion

The surface water budget for the Illinois River Basin in southwestern Oregon was done at an appraisal level of detail. No detailed records existed for historic diversions, consumptive use and return flows. In addition, no accurate database existed for cropping patterns, conveyance, on-site efficiencies and the influence of ground water usage. The most detailed information that formed the backbone of this water budget was streamflow and precipitation data.

As a result, the main concern in development of this budget was to maintain a level of simplicity and consistency. Throughout the watershed, assumptions as to conveyance and on-site system efficiencies, storage operations, return flow patterns, cropping patterns and water losses to the surface system due to deep percolation were made. The initial natural flow estimation was based on the 30-year average of rainfall across the valley and gauged streamflow. This was only adjusted as a final fine-tuning step in the water balance.

It is stressed that the figures in the final water balance in this investigation should be viewed with caution. If more detailed studies are warranted, a detailed data collection program should be instituted regarding diversion, return flow, storage operations and consumptive use. The water budget presented in this report represents a good starting

point for the next level of study. A brief overview of results is presented in the remainder of this section.

Overview of Results: The Illinois River Basin is characterized generally by rural water use. Types of consumptive use of local water supplies are from municipal, domestic, irrigation, mining, livestock and evaporative losses from local ponds, lakes and reservoirs.

The Illinois River, without the influence of man, would have an average annual natural flow of 2,903,891 acre-feet per year based on the 28-year period of record used in this analysis. This equates to an average daily flow of 4,015 cfs. Based on gauged records, it is estimated that the annual net flow derived from the Illinois Basin averages 2,894,612 acre-feet per year. This means that approximately 9,279 acre-feet are consumed in the basin on an average annual basis (equating to just under 13 cfs on a daily basis). Approximately 81 percent of this consumption occurs in the upper basin above the Kerby streamflow gauge.

One may conclude that the actual amount of natural flow depletion is very small as compared to the overall natural flow in the basin. This in part is due to the fact that diversions do not necessarily equate to consumptive use. Only portions of the diversions are considered consumed by the user. The majority of the diverted water returns to the watershed as return flows. Some of the non-consumed water that is diverted in the basin is lost to the surface water system as deep percolation. Some of this water, however, does eventually return to the surface well downstream of the diversion and use point.

On an annual average basis, the percentage of the water consumed in the Illinois Basin is estimated as follows:

Irrigation Consumption:	86%
Municipal and Domestic Consumption:	5%
Industry Consumption:	2%
"Other" Use Consumption:	1%
Net Lake Evaporation Consumption:	6%
Total:	**100%**

One addition to the water budget was estimated return flows from ground water pumping. This amounted to about 1,540 acre-feet per year or less than 1 percent of the total budget. It should be noted that water lost to deep percolation in the upper basin probably returns in the lower basin and is accounted for in the final budget balance.

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