ENGINEERING ASSESSMENT AND ENVIRONMENTAL INVENTORY AND ISSUES REPORT ARTIFICIAL RECHARGE ENHANCEMENT ONION CREEK, HAYS COUNTY, TEXAS

Prepared for the

**BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
AUSTIN, TEXAS**

and the

**TEXAS WATER DEVELOPMENT BOARD
AUSTIN, TEXAS**

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BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT

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EXECUTIVE SUMMARY

PURPOSE

The purpose of this investigation was to perform an engineering and environmental assessment of five artificial recharge enhancement projects on Onion Creek in Hays County, Texas. This investigation, sponsored by the Barton Springs/Edwards Aquifer Conservation District (District), involved detailed field investigations, engineering, geological, and environmental assessments, and a review of institutional requirements related to the implementation of one or more of the following project alternatives (Figure ES-1):

1. Alternative No. 1 - CenTex Reservoir;
2. Alternative No. 2 - Ruby Reservoir;
3. Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation;
4. Alternative No. 4 - Rutherford Dam and Reservoir; and
5. Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry.

The CenTex Reservoir (Alternative No. 1) and Ruby Reservoir (Alternative No. 2) involves the construction and operation of "on-channel" reservoirs situated directly on the Recharge Zone within Onion Creek. These alternatives would temporary impound water over known moderate and high recharge zones of Onion Creek. The CenTex Reservoir (Alternative No. 1) and Ruby Reservoir (Alternative No. 2) were evaluated as individual-stand alone projects and as tandem reservoirs (Alternative No. 3), assuming both reservoirs were constructed.

The fourth alternative (No. 4), Rutherford Dam and Reservoir involves the construction of a dam and reservoir located immediately above the Recharge Zone on Onion Creek. This impoundment would store water during flood events. Water would be subsequently released

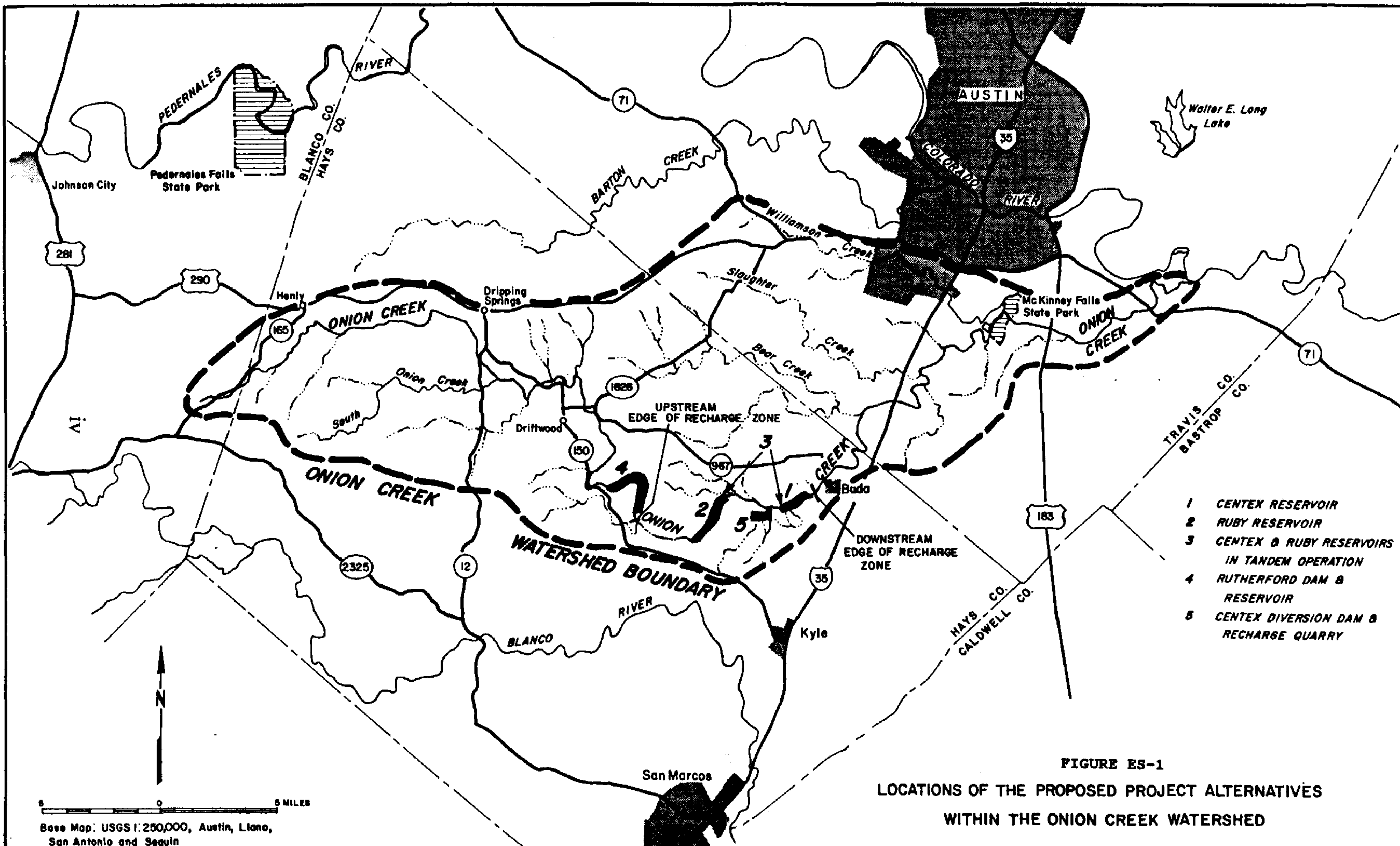

FIGURE ES-1

LOCATIONS OF THE PROPOSED PROJECT ALTERNATIVES WITHIN THE ONION CREEK WATERSHED after a flood subsides at a rate that is less than the maximum recharge rate (approximately 160 cfs) of Onion Creek.

A fifth alternative (No. 5), CenTex Diversion Dam and Recharge Quarry, involves the construction of a diversion dam on Onion Creek above Barber Falls. Flood water would be diverted through a diversion channel to an existing CenTex Materials, Inc., quarry (pit). Water stored in the quarry would be recharged to the Edwards aquifer via a series of recharge wells.

NEED FOR ARTIFICIAL RECHARGE ENHANCEMENT

In 1970, an estimated 70 million gallons of groundwater was withdrawn from the Barton Springs segment of the Edwards aquifer. Dependency on groundwater has increased to over 1.1 billion gallons in 1990. Over the last two decades, major groundwater pumping centers have been developed in the Buda-San Leanna area. These centers provide water to over an estimated 30,000 people, and to numerous industrial, commercial and agricultural entities.

Historically, during hot, dry summer months and extended periods of low rainfall, water levels in the Barton Springs segment of the Edwards aquifer have significantly declined as discharge exceeds natural recharge to the groundwater system. Likewise, springflows from Barton Springs and other associated springs have been considerably reduced to critical levels.

Although conservation plans implemented by the District will "slow down" the increase in dependency on groundwater resources, artificial recharge enhancement projects must be constructed to increase the quantity of water being recharged during storm events. Maintenance of historical groundwater supplies and discharges through Barton Springs can be achieved through implementation of water conservation programs with artificial recharge enhancement projects.

REGIONAL SETTING

The Barton Springs segment of the Edwards aquifer is one of the most productive aquifers in the State of Texas. The aquifer serves as a water supply for more than thirty thousand people in southern Travis and northern Hays Counties, and as a source of agricultural and industrial (commercial) water for many entities. Water consumed from the aquifer is withdrawn by wells, however, natural spring discharge, through Barton Springs and other associated springs, provides a high quality recreational and environmental resource for the City of Austin. In addition, natural spring discharge from the aquifer serves as a portion of the municipal water supply for the City of Austin and other communities located downstream of Austin, and serves to maintain base flow in the Colorado River.

The aquifer is recharged principally by vertical migration of water leakage from streams flowing across its Recharge Zone. Much of the recharge is derived from direct runoff associated with specific rainfall events on and upstream of the recharge area. Onion, Bear, Little Bear, Slaughter, Williamson, and Barton Creeks provide most of the recharge to the aquifer. It is estimated that 34 percent of the 37,400 acre-feet (af) of annual average recharge the aquifer receives from these creeks originates from the Onion Creek watershed located on and above the Recharge Zone.

ONION CREEK GEOLOGICAL SETTING

Extensive field investigations of Onion Creek within the recharge and nearby contributing zones were performed as part of this investigation.

The purposes of these investigations were to collect site specific engineering, geologic and environmental data and to obtain an intimate knowledge of stream flow and recharge characteristics. Topographic surveying efforts were conducted simultaneously with geological and environmental (habitat) investigations. In this manner, site specific geological and environmental features, such as caves, faults, sinkholes, and critical/sensitive habitats, were tied to horizonal and vertical datums.

The topography of Onion Creek through the Recharge Zone in very unique. The creek rises almost 155 feet (ft) from the downstream end to the upstream edge of the Recharge Zone, over a distance of about 50,411 ft (9.55 mi). This results in an average creekbed slope of 16.2 ft per mi. The creek within this reach is characterized by solutional features, collapsed streambed sections and local and regional faults (see Plates 1 and 2). These features have a moderate to high potential for recharge. The most predominant sinkhole and faulting system occur at and near Barber Falls located between Station Nos. 100+00 and 112+00. From the upstream end of Barber Falls to the bottom of the falls' basin, there is an elevation change of approximately 50 ft.

Examination of Plates 1 and 2 shows that solutional features and faulting systems occur in sets or groups and are not evenly distributed throughout the Recharge Zone. These surface expressions suggest that areas of moderate and high recharge potential are isolated in "pockets" and that artificial recharge enhancements should focus in these areas.

ONION CREEK HYDROLOGY WITHIN THE STUDY AREA

Onion Creek enters the Recharge Zone approximately 10 mi west of Buda, and leaves the zone 0.5 mi west of Buda. Onion Creek has a drainage area above the Driftwood USGS gaging station of 124 square miles (sq mi), and a total drainage area of approximately 138.8 sq mi above the Recharge Zone. The Onion Creek watershed located within the Recharge Zone has a drainage area of approximately 26.2 sq mi. This yields a total drainage area of 165.0 sq mi for the Onion Creek watershed above the eastern limit of the Recharge Zone.

Flow of Onion Creek above and below the Recharge Zone is very erratic and has varied from months of very little or no flow to days of major flooding. Examination of stream flow records for the Onion Creek near Driftwood gage, installed in July 1979, indicates that flows entering the Recharge Zone ranged from zero on many consecutive days to a maximum peak of 8,990 cubic feet per second (cfs) on June 6, 1985. Most of the flow volume consists of surface runoff resulting from storm rainfall. However, some stream flow originating above and below the Driftwood gage comes from springs issuing from the Glen Rose Formation, especially after heavy rainfall events. Since June 1979, the average discharge recorded at Onion Creek near Driftwood was 31,590 af per yr. This compares to an average discharge recorded at Onion Creek near Buda, during the period July 1979 through September 1983 of approximately 21,400 af per yr.

Daily stream flow estimates for Onion Creek above the downstream end of the Recharge Zone was developed for the period January 1, 1941 through June 30, 1979. This was performed to facilitate mathematical modeling analyses of the recharge enhancement project alternatives. Based on these analyses, it is estimated that the total average annual flow available for recharge during the 1941 through 1988 period was about 43,100 af. This ranged from a minimum annual flow of 406 af in 1956 to a maximum available flow of 122,259 af in 1973.

Not all the stream flow that enters the Recharge Zone from the Onion Creek watershed is available for recharge. Onion Creek, like other creeks providing recharge to the Barton Springs segment of the Edwards aquifer, has a maximum infiltration rate that can transmit water from the creek bed to the water table. Field and analytical investigations performed, as part of this study, indicate that the maximum recharge rate of Onion Creek is about 160 cfs. These investigations show that about 135 cfs is lost to recharge in the 7.6 creek mi reach above Barber Falls and 25 cfs is lost in the 2.0 creek mi reach below Barber Falls to the downstream end of the Recharge Zone.

Using a maximum recharge rate of 160 cfs, daily estimates of recharge were made. For this analysis, daily estimated available stream flow rates of less than or equal to 160 cfs entering and occurring over the Recharge Zone were "recharged". Likewise, only 160 cfs was recharged when available estimated stream flow was greater than 160 cfs. Using this methodology, it was estimated that of the 43,100 af of available average annual inflow approximately 28,700 af is recharged. This results in an average annual stream flow at Buda (downstream of the Recharge Zone) of about 14,400 af for the 1941 through 1988 period.

RECHARGE ENHANCEMENT ALTERNATIVES: HYDROLOGIC, ENGINEERING AND ECONOMIC ANALYSES

Hydrological analyses of the various project alternatives and "without" conditions were performed using the daily computer simulation model SIMYLD. Onion Creek and tributary inflows for each alternative were estimated by applying appropriate unit runoff ratios to the calculated or measured daily stream flows for Onion Creek near Driftwood. Daily net evaporation data for quadrangles segmented along one degree parallels of latitude and medians of longitude were obtained from the Texas Water Development Board (TWDB). Daily net reservoir evaporation for the study area was computed by applying a weighted average to the appropriate quadrangles evaporation rates reported by the TWDB. Baseline recharge rates were assigned to each creek reach based on actual flow-loss studies performed by the USGS and on investigations performed in this study. The maximum recharge rate of 160 cfs was distributed over the Recharge Zone of Onion Creek. Reservoir area-elevation-capacity relationships for each alternative were developed from field survey information and USGS 7.5 minute topographic quadrangles.

The results from the SIMYLD simulations are summarized in Table ES-1. Values of total and incremental increase in the recharge and resulting outflow below the Recharge Zone (at Buda) for each project alternative are also presented in this table.

TABLE ES-1
SUMMARY OF TOTAL AND INCREMENTAL INCREASE IN RECHARGE AND RESULTING FLOWS AT BUDA FOR EACH PROJECT ALTERNATIVE

ALTERNATIVE	AVERAGE ANNUAL INFLOW (AF)	AVERAGE ANNUAL RECHARGE (AF)	AVERAGE ANNUAL RECHARGE INCREASE (AF)	AVERAGE ANNUAL OUTFLOW (AF)
HISTORICAL-BASE CONDITION	43116	28686	----	14430
CENTEX RESERVOIR	43116	29447	762	13674
RUBY RESERVOIR	43121	29829	1143	13298
CENTEX RESERVOIR AND RUBY RESERVOIR TANDEM OPERATION	43116	30261	1576	12851
RUTHERFORD DAM AND RESERVOIR	43116	32201	3515	10810
CENTEX DIVERSION DAM AND RECHARGE QUARRY	43139	34404	5718	8736

Alternative No. 1 - The CenTex Reservoir, with a capacity of about 271 af, would provide for an additional recharge of 768 af per yr. During the 48 yr simulation period, the increase in recharge for this alternative ranged from zero in seven years to a maximum of 2,477 af in 1957. Therefore, this project alternative would have not provided any additional recharge than occurred historically for about 15% of the time. For 20 of the 48 years simulated, Centex Reservoir would have provided recharge in excess of 762 af per yr. This reservoir would be at or near full capacity about 7% of the time and at zero capacity about 85% of the time. Antioch Cave lies within the storage area of this reservoir. As part of this project, it is proposed that the existing Antioch Cave be modified to provide for additional recharge. Modification of Antioch Cave should be performed whether or not CenTex Reservoir is constructed. The opening to this cave would be enlarged by removing its promontory. Filtration and cave protection devices would be installed around the modified cave opening. This modification would require the excavation and clearing of about 0.5 ac of land. The estimated cost for modification and protection of Antioch Cave is $50,000.

Alternative No. 2 - Ruby Reservoir would provide for an additional recharge of 1,143 af per yr, at a capacity of 435 af. For the simulation period 1941 through 1988, annual recharge (additional) range from zero in 7 years (15% of the time) to a maximum of 3,854 af in 1957. For 20 of the 48 years simulated, this alternative would have provided recharge in excess of 1,143 af per yr. This reservoir would be at or near full capacity about 7% of the time and at zero capacity about 87% of the time. As part of this project, it is proposed that the existing Crippled Crawfish Cave, located in the backwater of Ruby Reservoir, be modified to provide for additional recharge. The opening to this cave would be enlarged by excavating existing overburden material. Filtration and cave protection devices would be installed around the modified cave opening. This modification will require the excavation and clearing of about 0.5 ac of land. Modification of Crippled Crawfish Cave should be performed whether or not Ruby Reservoir is constructed. The estimated cost for modification and protection of Crippled Crawfish Cave is $50,000.

Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation would have provided 1,576 af of additional recharge per yr during the simulation period. Additional recharge would not have occurred in 7 yr of the 48 yr simulation period. However, recharge in excess of the average annual quantity (1,576 af) would have occurred in 44% of the years (21 years out of 48 years). Under this alternative, CenTex Reservoir and Ruby Reservoir would have been at full capacity about 7% of the time and at zero capacity about 86% of the time.

Alternative No. 4 - Rutherford Dam and Reservoir would have a capacity of 3,670 af at a conservation pool elevation of 870 ft above mean sea level. This alternative would provide for an additional recharge of 3,515 af per yr. For 18 years of the 48 year simulation period, this alternative would have provided zero additional recharge. In fact, historical recharge for these 18 individual years would have been slightly decreased due to the capture and maintenance of a minimum 200 af storage capacity in Rutherford Reservoir, which is located upstream of the Recharge Zone. However, during "normal" and above normal stream flow years this alternative would provide for a substantial increase in recharge over historical conditions. Annual recharge exceeded the average annual recharge of 3,515 af in 26 years (54%) of the 48 year simulation period. The maximum recharge simulated for this alternative was 12,682 af which occurred in the year 1957. Rutherford Reservoir would be at maximum capacity approximately 6% of the time and would have a capacity of 200 af or more 85% of the time.

Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry provides for the greatest potential for recharge enhancement of any other alternative evaluated. This alternative would provide an additional 5,718 af of recharge per yr, based on the 1941 through 1988 simulation period. This alternative involves the construction of a diversion dam on Onion Creek where water would be diverted to an existing 1,000 af capacity quarry (recharge reservoir). Recharge wells would be drilled in the reservoir to provide for a total recharge rate of 100 cfs. The recharge quarry would contain about 1,000 af (maximum capacity) of water approximately 3% of the time and contain some water about 7% of the time. Annual recharge for this alternative ranges from a minimum of zero in 7 years to a maximum of 19,231 af in the year 1985. Annual recharge was in excess of 5,718 af for 20 years of the 48 years simulated.

The projected capital, operation and maintenance (O&M), and gallonage (per 1,000 gallons recharged) costs for each project alternative in presented in Table ES-2. The capital cost for each project alternative range from $2.9 million for Rutherford Dam and Reservoir to $0.60 million for the CenTex Reservoir. At an anticipated annual interest rate of 8 percent for 25 years, annual debt service costs range from about $268,000 for Rutherford Dam and Reservoir to approximately $56,000 for CenTex Reservoir. Estimated annual operation and maintenance costs for the alternatives evaluated range from $60,000 for the CenTex Diversion Dam and Recharge Quarry to $15,000 for the Ruby Reservoir alternative. The CenTex Dam and Recharge Quarry alternative would provide for the lowest unit cost of water recharged at $0.10 per 1,000 gallons. However, this alternative will require many years to implement and fully develop, due to current mining activities of CenTex Materials, Inc. CenTex Reservoir, Ruby Reservoir and Rutherford Dam and Reservoir provide comparable costs of about $0.28 to $0.29 per 1,000 gallons of water recharged. The CenTex Reservoir and Ruby Reservoir Tandem Operation is the most expensive alternative at a projected cost of $0.34 per 1,000 gallons.

GROUNDWATER RESPONSE TO RECHARGE

Water level elevations in the Barton Springs segment of the Edwards aquifer fluctuate in response to changes in the amounts of water recharged to and discharged from the aquifer. In relatively "wet" years, i.e., periods of high stream flow, recharge exceeds discharge, causing net water level elevation rises. During dry or below normal stream flow years, discharge from the aquifer, via pumpage and spring discharge, exceeds recharge and causes the quantity of groundwater stored in the aquifer to decrease. This results in a net decline in aquifer water level elevations.

TABLE ES-2
PRELIMINARY PROJECTED COSTS

ALTERNATIVE	CAPITAL COSTS	ANNUAL DEBT SERVICE[1]	ESTIMATED ANNUAL O & M COST	ESTIMATED TOTAL ANNUAL COSTS	ESTIMATED ANNUAL RECHARGE POTENTIAL (AF)	PROJECTED COST PER 1000 GAL[2]
CENTEX RESERVOIR	$601,670	$56,360	$15,000	$71,360	768	$0.29
RUBY RESERVOIR	$952,080	$89,190	$15,000	$104,190	1152	$0.28
CENTEX RESERVOIR AND RUBY RESERVOIR TANDEM OPERATION	$1,553,750	$14,550	$30,000	$175,550	1576	$0.34
RUTHERFORD DAM & RESERVOIR	$2,856,150	$267,560	$50,000	$337,560	3515	$0.28
CENTEX QUARRY	$1,317,890	$123,460	$60,000	$183,460	5718	$0.10

[1] 8% FOR 25 YEARS

[2] (ANNUAL DEBT SERVICE + ANNUAL O & M)/(ESTIMATED ANNUAL RECHARGE POTENTIAL)

Examination of historical water level elevation measurements for a well located in Buda indicates that the average rate of water level elevation decline, during periods of little or no recharge for the 1941 through 1988 period, was about 0.08 ft per day. Whereas, the average rate of water level elevation rise during and immediately following recharge events was approximately 0.2 ft per day. The rate of water level elevation decline at the observation well located in Buda during the 1970s and 1980s decades is probably much higher than that observed for the 48-yr period of analysis. The average rate of water level elevation decline in the last two decades averaged about 0.20 ft per day, during no recharge periods. This higher rate reflects the increased groundwater pumping demands that center in the Buda - San Leanna area.

Very little is known about precise flow patterns in karst formations, however, it is possible that a cone of groundwater depression forms in the Buda - San Leanna area, during extended no-recharge periods and/or during high seasonal pumping periods. If this is the case, additional recharge from Onion Creek resulting from implementation of one or more of the recharge alternatives may tend to flow towards and remain (longer) within the Buda - San Leanna area, thereby becoming more directly useful for beneficial purposes.

Based on statistical relationships developed in this investigation, it was estimated that for every 570 af of recharge originating from Onion Creek results in an average 1.0 ft rise in the Buda well. Using this relationship, it is projected that each artificial recharge enhancement project alternative could potentially result in the water level elevation increases shown in Table ES-3. In addition, results of this study indicate that any increase in water level elevation at the Buda well due to recharge enhancement would tend to increase water level elevations (or piezometric surface) in the San Leanna area and eventually increase discharges through Barton Springs.

TABLE ES-3
PROJECTED INCREASE IN POTENTIAL WATER ELEVATION LEVEL RISE IN THE BUDA WELL (NO. 58-58-101) RESULTING FROM RECHARGE ENHANCEMENT PROJECTS

PROJECT ALTERNATIVE	POTENTIAL WATER LEVEL INCREASE IN THE BUDA WELL RESULTING FROM AVERAGE ANNUAL INCREASE IN RECHARGE	POTENTIAL WATER LEVEL INCREASE IN THE BUDA WELL RESULTING FROM MAXIMUM AVERAGE RECHARGE
CENTEX RESERVOIR	1.3 ft	4.3 ft
RUBY RESERVOIR	2.0 ft	6.7 ft
RUBY AND CENTEX RESERVOIRS TANDEM OPERATION	2.7 ft	9.3 ft
RUTHERFORD RESERVOIR	6.2 ft	22.4 ft
CENTEX DIVERSION DAM AND RECHARGE QUARRY	10.0 ft	15.3 ft

WATER RIGHTS

There are at least three possible scenarios by which water rights for the selected alternative(s) could be secured. First, the District could submit an application to the TWC for a surface water appropriation. An application for water appropriation would have to include permitting of the diversion (recharge) facility(ies), and a request for appropriation of surface water in an amount to satisfy historical recharge volumes and the increased recharged quantity associated with each project to be permitted. Secondly, the District could possibly enter into a cooperative agreement with the Lower Colorado River Authority (LCRA) and/or the City of Austin to assign part of their existing water right appropriations to the selected recharge enhancement project(s). The reasoning behind this approach is that LCRA and the City of Austin would be direct benefactors of the recharge project(s). Approximately 85% of all water recharged to the Barton Springs segment of the Edwards aquifer eventually discharges through Barton and other associated springs into Town Lake. Thirdly, the District may elect to use a combination of the previous two scenarios to secure water rights for the project(s).

SEDIMENT TRANSPORT AND SEDIMENTATION

Estimates of erosion and sedimentation rates for the Onion Creek watershed above Buda were made to determine the average annual expected sediment load entering the Recharge Zone, and the quantity of sediment that may be captured by the recharge enhancement projects. The average annual sediment yield for the Onion Creek watershed above Buda was estimated in this study to be 0.66 tons per ac. This compares to computed sediment yields performed by the Texas Water Development Board of 0.69 tons per ac for the Colorado River at Austin and 0.64 tons per ac for the Blanco River at San Marcos.

For the study area, a sediment yield of 0.66 tons per ac is equivalent to 69,700 tons of sediment per yr or an average of 46 af of sediment per yr. Field observations of floods within the study area indicated that the initial flood surge probably transports an estimated 95 to 98 percent of the sediment load. Following initial flood surges, floodwater (stream flow) entering the study area transports very little sediment load, as evidenced by observing extremely clear, clean water.

If provisions are not made to pass initial sediment laden flood surges in the recharge project alternatives, then a portion of the inflowing sediment will be retained in the reservoirs or recharged. The amount of sediment retained in a reservoir is commonly referred to as "trap efficiency". Using commonly accepted engineering techniques, it is estimated that each project alternative will have trap efficiencies and sediment retention as follows:

Project Alternatives	Trap Efficiency (Percent)	Estimated Volume of Sediment Retained (AF\YR)
CenTex Reservoir	25	11
Ruby Reservoir	45	20
CenTex/Ruby Tandem Operations	50	23
Rutherford Dam and Reservoir	80	36
CenTex Diversion Dam and Recharge Quarry	68	31

Sediment deposition in the recharge reservoirs could be mitigated by providing structural and operational mechanisms to allow initial storm-runoff surges to pass through the impoundment(s) and dam(s). The dam(s) could be equipped with large diameter outflow pipes or gates that would remain open until sediment laden stream flow passes the structure. The gates would be subsequently closed to impound and recharge low sediment content water. In any event, there will be some sediment deposition in the bottom of the reservoirs, and particularly, near upstream dam abutments. Sediment accumulation should be continually monitored and should be mechanically removed if deposition occurs to the point to prevent or restrict recharge.

WATER QUALITY

The water of Onion Creek as it enters and leaves the Recharge Zone exhibits good water quality. Although relatively high concentrations for a few constituents (cadmium, iron, manganese, zinc, and indicator bacteria) have been detected, no organic, inorganic or trace element water quality contamination problems have been identified from the USGS data. A summary of Texas Department of Health and U.S. Environmental Protection Agency drinking water standards for selected water quality constituents is presented in Table 5.6-3. Using these drinking water standards in comparison with water quality data collected by the USGS at the Driftwood and Buda gages, the data indicates that Onion Creek water is suitable as a public drinking water supply source. Monitoring and continual evaluation of indicator bacteria densities should be undertaken.

FINANCING CONSIDERATIONS

The District has two primary sources from which it could possibly secure bonds for the purpose of constructing any of the recharge enhancement projects: the Texas Water Development Board and the open market. The TWDB administers the Water Development Fund. This fund is used to provide loans to political subdivisions for the construction of water supply, wastewater treatment, flood control, regional water and wastewater facilities, and other related projects. Open market funds can be used for a variety of public improvement projects and are available through financing institutions. The District would have to retain the services of a financial advisory and legal bond counsel in order to secure project financing from the TWDB or from open market sources.

The District could undertake these projects on a sole-sponsorship basis or could potentially co-sponsor this effort with other political subdivisions. Recharge enhancement on Onion Creek would benefit Edwards groundwater users, Barton Springs, Town Lake, and the Colorado River downstream of its confluence with Barton Creek. As such, benefactors of these projects would include the District, municipalities including Buda, San Leanna, Sunset Valley, and Austin, individuals and private/public water companies deriving their water supply from the Barton Springs segment of the Edwards aquifer, and the Lower Colorado River Authority. The District could pursue joint project sponsorship with any or all of these entities. However, the Lower Colorado River Authority and the City of Austin probably offer the best financial ability to assist the District is financing and participation in reoccurring operation and maintenance costs.

CONCLUSIONS

Based on the results and findings presented in this investigation the following conclusions are offered:

1. Artificial recharge enhancement on Onion Creek's Recharge Zone is feasible from an engineering, geologic, economic, and environmental viewpoint.

2. Recharge occurs in "pockets" or identifiable areas along Onion Creek over the Recharge Zone that can be classified as moderate or high recharge potential areas. Recharge enhancement activities should focus on these areas.

3. Recharge enhancement could range from an annual average of about 760 af per yr for Alternative No. 1 - CenTex Reservoir to over 5,700 af per yr for Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry.

4. The cost per 1,000 gallons of water recharged ranges from $0.10 for Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry to $0.34 for Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation.

5. The recharge impoundments will be subject to some sediment deposition and accumulation, but can be mitigated through structural, operational and maintenance mechanisms.

6. The water of Onion Creek through the Recharge Zone exhibits good water quality and is suitable as a public drinking water supply source.

7. A Texas Water Rights Permit will be required to construct any of the recharge enhancement projects.

8. All the recharge enhancement projects, except for Rutherford Dam and Reservoir, will be subject to the Texas Water Commission's Edwards Aquifer Rules.

9. Implementation of the recharge enhancement projects may require a permit from the U.S. Army Corps of Engineers and may be subject to the City of Austin's Critical Watershed Ordinance.

RECOMMENDATIONS

The following recommendations are offered as a result of this investigation:

1. The District should immediately determine the interest of the City of Austin and the Lower Colorado River Authority as potential co-sponsors for recharge enhancement on Onion Creek, including participation, ownership, water rights, and/or other activities.

2. The District should avail itself to all opportunities to purchase or secure easements on lands located within project areas.

3. The District should immediately undertake activities to acquire Antioch Cave and Crippled Crawfish Cave.

4. The District should immediately commence permitting (Federal, state and local) as necessary for modification/protection activities on Antioch Cave and Crippled Crawfish Cave.

5. The District should continue hydrologic, hydraulic, water quality, and geologic investigations on Antioch Cave and Crippled Crawfish Cave to determine recharge potential before and after acquisition and modification.

6. The District should continue investigations with CenTex Materials, Inc. to determine the ultimate feasibility of using quarries for recharge enhancement.

7. The District should pursue in a timely manner the implementation of CenTex Reservoir.

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ENGINEERING ASSESSMENT AND ENVIRONMENTAL INVENTORY AND ISSUES REPORT ARTIFICIAL RECHARGE ENHANCEMENT ONION CREEK, HAYS COUNTY, TEXAS

1.0 INTRODUCTION

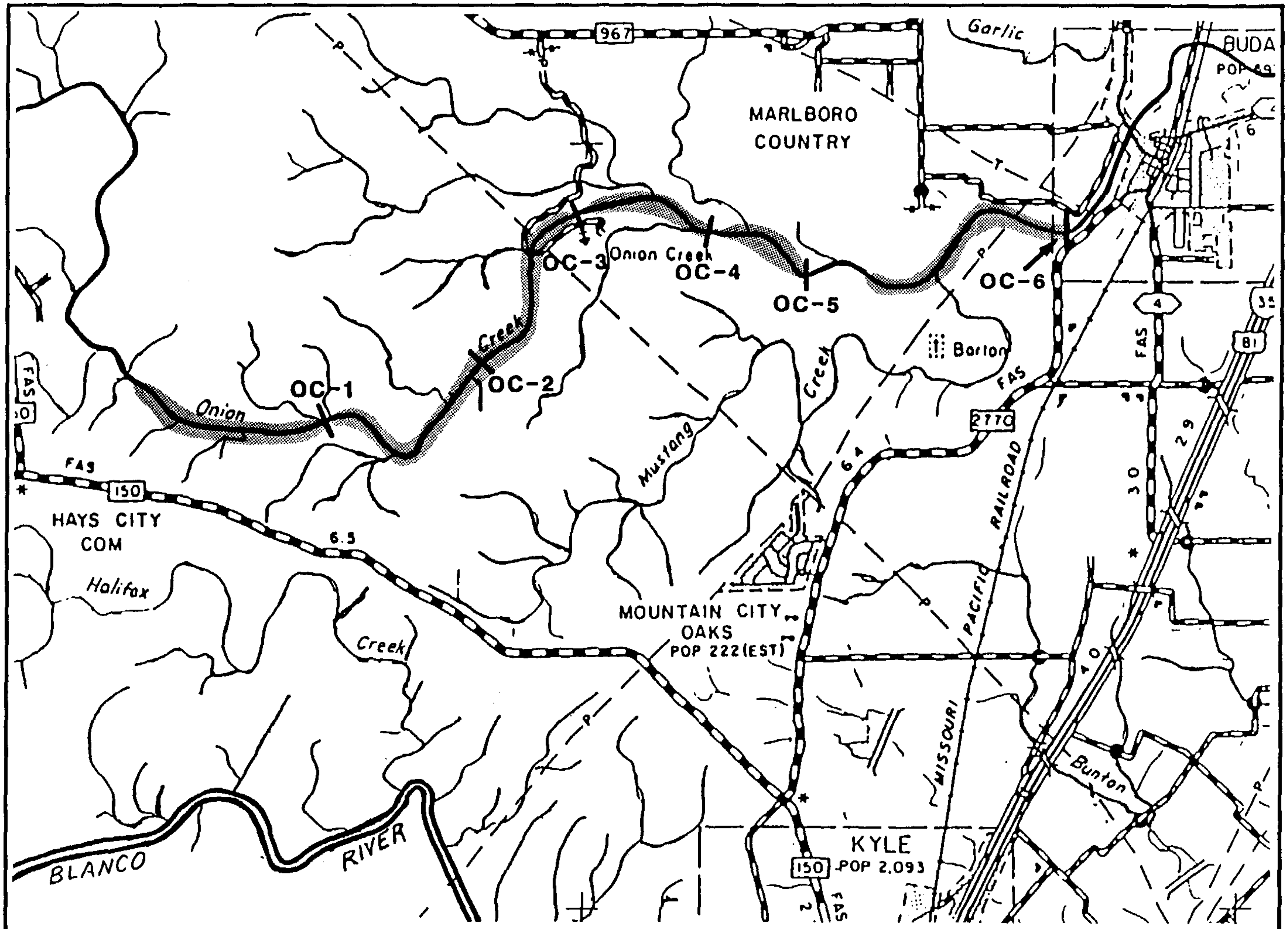
1.1 SPONSORING AGENCIES

This effort was sponsored and administered by the Barton Springs/Edwards Aquifer Conservation District (District), Austin, Texas. In 1991, the District received a grant from the Texas Water Development Board (TWDB) to partially fund the development of a project titled "Engineering Assessment and Environmental Inventory and Issues: Artificial Recharge Enhancement Onion Creek, Hays County, Texas." Under the original TWDB Contract No. 91-483-794, the District received $31,500 in grant funds. The District provided an additional $31,500 of funds and in-kind services to perform this Project. The original contract was amended in June 1991 to expand the scope of work to include a more detailed environmental analysis of alternative recharge enhancement projects. Under the amended contract, the TWDB contributed an additional $7,500 in grant monies, with a District matching contribution in funds and in-kind services.

1.2 PURPOSE OF INVESTIGATION

The overall purpose of this Project was to investigate projects that would enhance and augment the natural recharge occurring in the main channel of Onion Creek to the Barton Springs segment of the Edwards aquifer. Upon Project initiation, it was intended to perform detailed investigations of six on-channel recharge dams and reservoirs (see Figure 1.2-1) identified in the District report titled "Regional Water Plan For The Barton Springs segment of

FIGURE 1.2-1 MAP OF ONION CREEK SHOWING ORIGINAL SIX RECHARGE RESERVOIRS



The Edwards Aquifer" (Rauschuber et al 1990). These proposed projects were located on Onion Creek over the Recharge Zone of the Barton Springs segment of the Edwards aquifer. After performing detailed field surveys and hydrological studies, other artificial recharge alternatives were identified. The Project was consequently modified to assess the feasibility of the following alternatives:

Alternative No. 1 - CenTex Reservoir
Alternative No. 2 - Ruby Reservoir
Alternative No. 3 - CenTex Reservoir and Ruby Reservoir In Tandem Operation
Alternative No. 4 - Rutherford Dam and Reservoir
Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry

This report presents preliminary engineering and geological assessments and environmental analysis of the above listed recharge enhancement alternatives.

1.3 PRINCIPAL INVESTIGATORS

The assessments and evaluations described herein were conducted and written by several principal investigators. Mr. William "Bill" Couch, General Manager, of the District provided technical support and direction for this effort. Mr. Thomas Heathman, Geologist, District, performed detailed geologic assessments of Onion Creek. These assessments included field surveys and development of geologic and potential recharge maps of the Onion Creek channel.

Mr. Donald Rauschuber, P.E., and Mr. Daniel Alfredo Rodriguez, performed surface water and groundwater hydrologic studies, surveyed and prepared center-line and project cross-section maps for this effort. Mr. Rauschuber was also responsible for overall project coordination and administration activities.

Mr. Robert J. Brandes, Ph.D., P.E., R.J. Brandes and Associates, Austin, Texas, conducted mathematical modeling analyses of the various recharge enhancement alternatives. Dr. Brandes also contributed to the water rights and groundwater investigations presented herein.

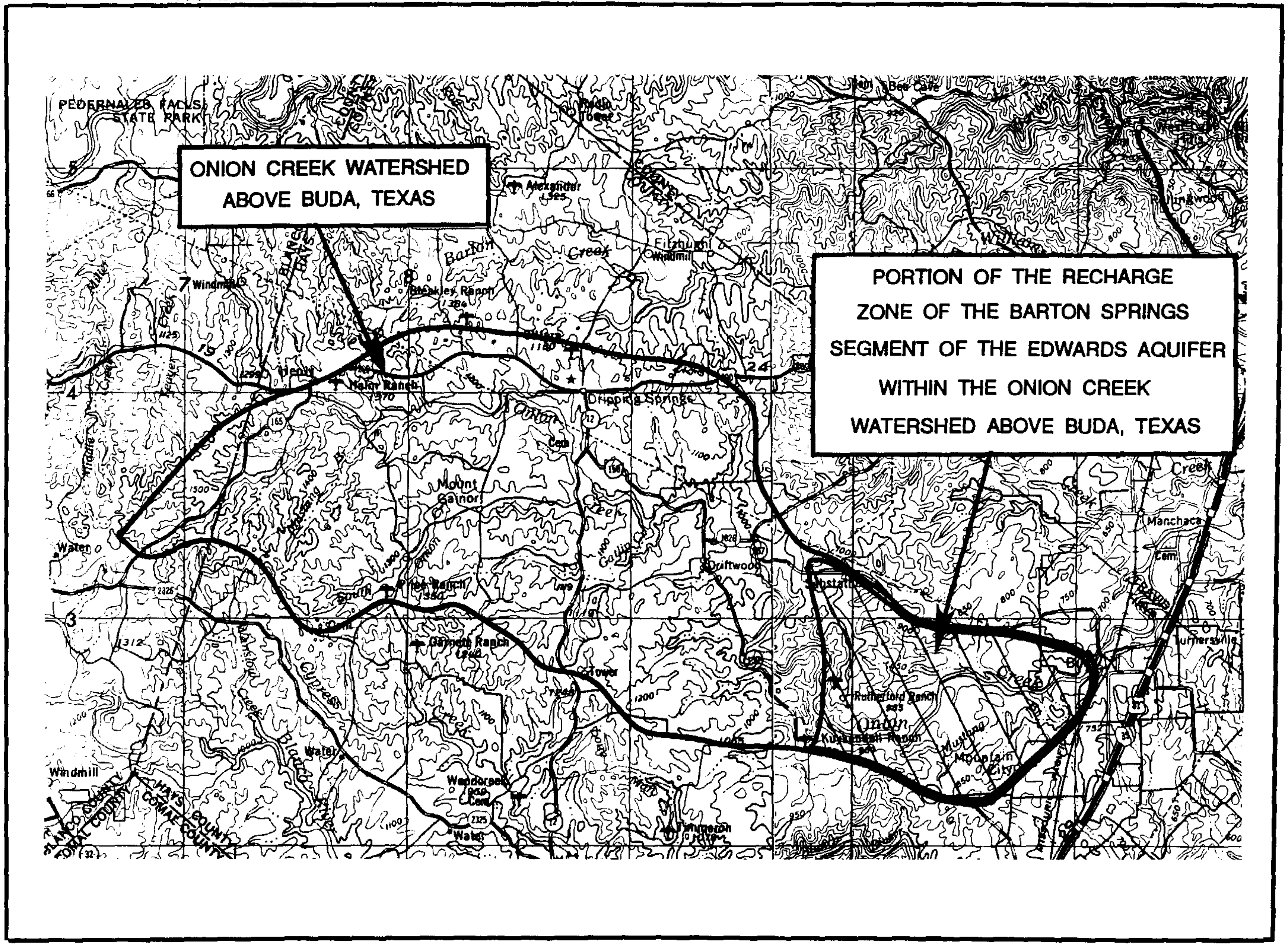
Mariah Associates, Inc. of Austin, Texas developed the preliminary environmental report on the proposed project alternatives. Mariah's effort included field investigations for the five project alternatives.

There were many other professionals who contributed to the work efforts and preparation of this report. These include Mr. Ron Fieseler, Water Resources Planner for the District, and Mr. Doug Allen, Texas Cave Management Association. These individuals assisted in the preparation of this report and performed cave explorations and mapping services that proved to be vital in identifying recharge enhancement alternatives.

1.4 STUDY AREA

The study area for this effort focuses primarily on the Onion Creek watershed located above Buda, Texas (Figure 1.4-1). Within this area, Onion Creek traverses the Recharge Zone of the Barton Springs segment of the Edwards aquifer, herein referred to as the Recharge Zone. The Recharge Zone is approximately 9.6 creek-miles in length. The aquifer's Recharge Zone located within the Onion Creek watershed has a total area of about 26.2 square miles (sq mi). Onion Creek traverses the Recharge Zone in a west to east direction. The Onion Creek watershed above the Recharge Zone, referred to herein as the Contributing Zone is about 138.8 sq mi in area.

FIGURE 1.4-1 MAP OF STUDY AREA SHOWING THE ONION CREEK WATERSHED ABOVE BUDA, TEXAS, INCLUDING THE RECHARGE ZONE OF THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER WITHIN THE ONION CREEK WATERSHED



A more detailed description of the Onion Creek watershed (Contributing Zone), Recharge Zone, and the Barton Springs segment of the Edwards aquifer is presented in Sections 2.0, 3.0 and 4.0 of this report.

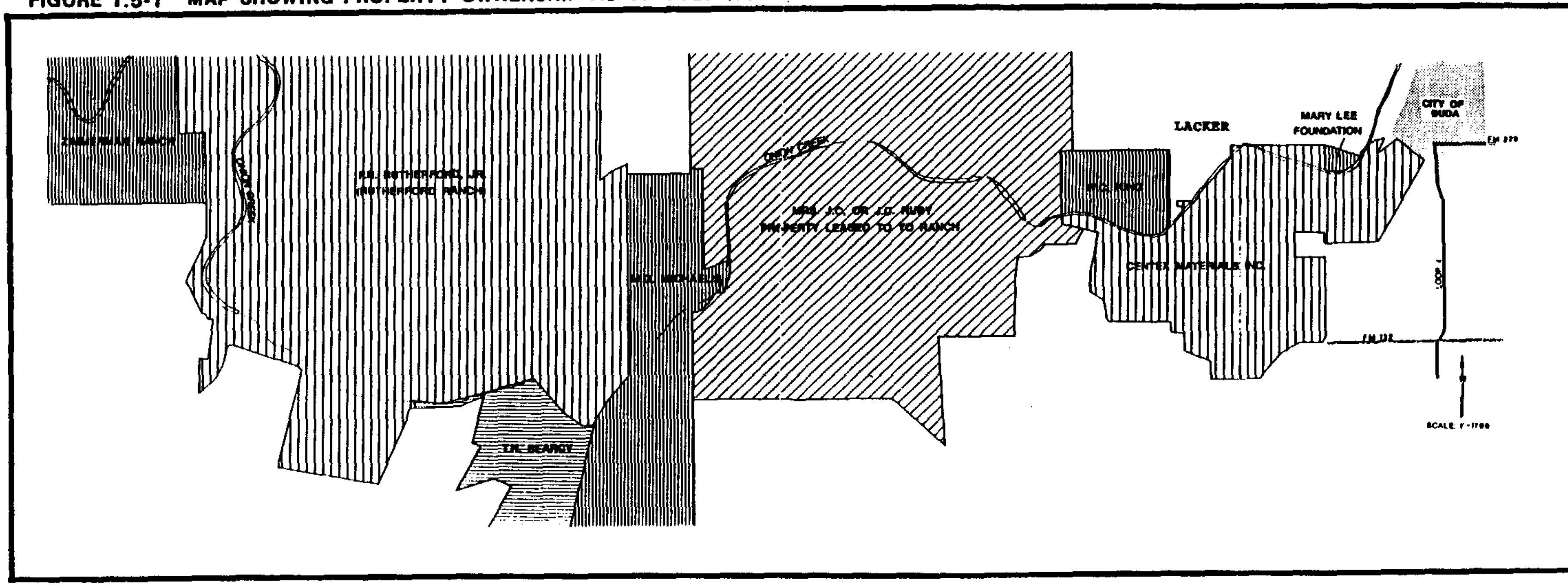
1.5 FIELD INVESTIGATIONS

As a precursor to performing hydrologic and project assessments, extensive field investigations of the Recharge Zone and nearby Contributing Zone were performed. The purposes of the field investigations were to collect site specific engineering, geologic and environmental data and to obtain an intimate knowledge of stream flow and recharge characteristics.

The initial step in performing the field investigations was to identify property owners and obtain permission to enter individual properties. This process took approximately six months to accomplish.

Onion Creek, within the study area, is completely held in private ownership. There are 8 property owners (Figure 1.5-1) who own portions of the Onion Creek streambed over the Recharge Zone. Three property owners, CenTex Materials, Inc., Mr. and Mrs. J.C. Ruby (property leased to YO Ranch) and Mr. Mike Rutherford (Rutherford Ranch) collectively own about 85% of the creek within the study area. Due to the sensitivity and liability concerns related to entering individual properties, legal agreements were negotiated and executed between the Project sponsors and selected land owners. Once required legal agreements were executed, the field activities commenced with an open spirit of cooperation and assistance between the property owners and District personnel/agents.

FIGURE 1.5-1 MAP SHOWING PROPERTY OWNERSHIP AS OF JULY 1991 ALONG ONION CREEK WITHIN THE STUDY AREA



Field investigations commenced at the downstream edge of the Recharge Zone. From this point, a centerline and cross-sectional survey profile of Onion Creek was initiated, using standard engineering surveying and stationing procedures. Survey elevation datums were tied to United States Geological Survey (USGS) elevation reference points and set in feet above mean sea level (ft msl).

1.6 REPORT ORGANIZATION

This report addresses the geological, hydrological engineering, financial, and environmental issues associated with the proposed five project alternatives. Section 2.0 provides a regional overview of the Barton Springs segment of the Edwards aquifer and the surface water and groundwater hydrology in the project area. Section 3.0 presents a description of the geology of the Onion Creek Recharge Zone with particular emphasis on recharge features. A detailed evaluation of historical stream flow, natural recharge and their relationship to developing project alternatives is presented in Section 4.0. This is followed by a physical and economic description of each project alternative (Section 5.0). Section 5.0 also includes a description of unique cases (groundwater response, water rights, and sedimentation), and their relationships to each of the project alternatives. Section 6.0 presents an Environmental Issues and Inventory report followed by a overview of regulatory programs (Section 7.0). Finally, Conclusions and Recommendations are presented in Section 8.0, followed by References Cited and the Appendices (Section 9.0).

2.0 REGIONAL OVERVIEW

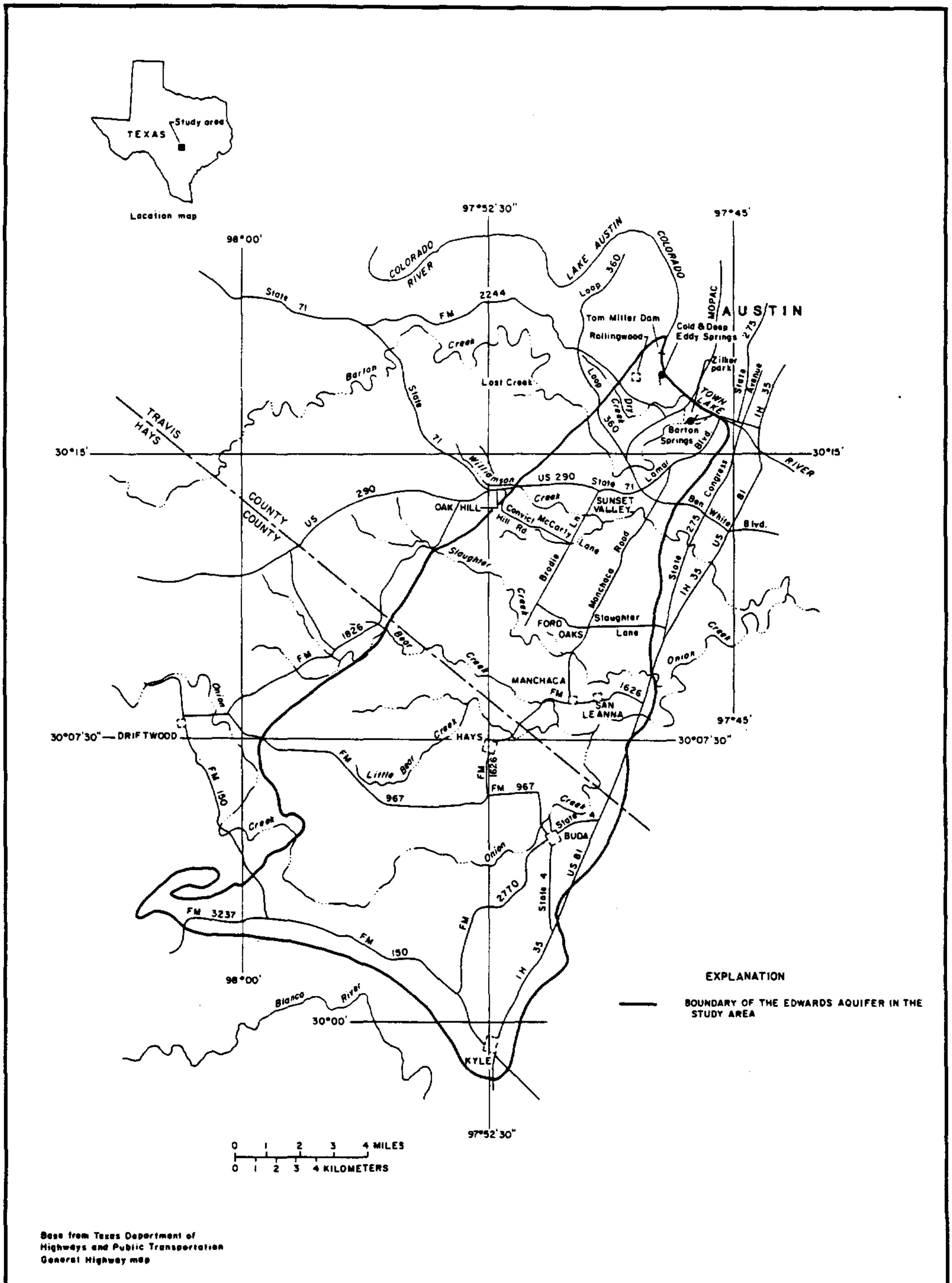
2.1 BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

The Barton Springs segment of the Edwards aquifer includes that portion of the Edwards (Balcones Fault Zone) aquifer system that lies within northern Hays and southern Travis Counties in Central Texas. The Edwards (Balcones Fault Zone) aquifer, which is comprised of highly fractured, vugular, dolomitic limestone, extends over a distance of about 250 mi along a narrow, arc-shaped band that crosses southwestern and central Texas in parts of ten counties from Kinney County, near the Rio Grande, through Uvalde, Medina, Bexar, Comal, Guadalupe, Hays, Travis, Williamson and Bell Counties to the northeast (Klemt et al 1981; Maclay & Small 1984).

Generally, the areal extent of the Barton Springs segment of the Edwards aquifer is considered to be bounded on the north by Town Lake on the Colorado River, on the west by its contact with the Glen Rose Formation of the Trinity Group, on the east by the dividing line between fresh and saline water, i. e. the "bad-water" line that distinguishes those parts of the aquifer with less than and more than 1,000 milligrams per liter (mg/L) of total dissolved solids, and on the south by the groundwater divide (high water levels) near the Blanco River that has been established as the northern limit of the "San Antonio area" Edwards aquifer (Slade et al 1986). This area covers approximately 155 sq mi, with most of the northern third of the area generally developed and urbanized as part of the City of Austin and several other outlying communities. Figure 2.1-1 identifies the boundaries of the Barton Springs segment of the Edwards aquifer as delineated for purposes of this study.

The Barton Springs segment of the Edwards aquifer presently serves as the sole source water supply for more than 30,000 people in northern Hays and southern Travis Counties. The aquifer also provides water for industrial, commercial and some agricultural users. These

FIGURE 2.1-1 DELINEATION OF BARTON SPRINGS/EDWARDS AQUIFER STUDY AREA BOUNDARIES



demands for water are projected to increase as the regional population continues to grow and expand. To supply these demands, pumpage from the Barton Springs segment of the Edwards aquifer should increase.

Historically, during hot, dry summer months and extended periods of low rainfall, water levels in the Barton Springs segment of the Edwards aquifer have significantly declined as discharge exceeded the natural recharge of the groundwater system. Likewise, flow from Barton Springs and other associated springs have been similarly impacted.

Barton Springs, located in Zilker Park near the center of Austin, Texas, is currently the fourth largest spring system in the State with an average flow rate of approximately 50 cubic feet per second (cfs). Besides being the premier aquatic recreational center of Austin, the springs serves as a major source of water supply to Town Lake. Town Lake is used as a drinking water supply for the City of Austin (via the Green Water Treatment Plant), and for cooling water for two of Austin's major power generation facilities (Holly and Seaholm Electrical Generating Plants).

During the period January 1, 1980 through December 1, 1989, Barton Springs provided an estimated average of 33,900 acre-feet (af) of water per year (yr) to Town Lake. Other springs contributed an estimated 7,100 af per yr during the same time period. This results in a total spring contribution to Town Lake of approximately 41,000 af per yr for the 1980's decade.

2.1.1 Hydrogeology

2.1.1.1 Edwards Formation

The Edwards Formation is comprised mostly of hard to soft dolomitic limestone with some interbedded marl present both at the outcrop and in the subsurface. Zones with extensive faulting, fracturing, jointing, weathering, and solution features, such as, honeycombing, sinkholes, and caverns are abundant. These features provide for rapid infiltration of water at the outcrop (Recharge Zone) and rapid movement of groundwater in portions of the aquifer. Extensive faulting, both at the outcrop and throughout the formation, is an important feature of the Edwards. Faulting creates variations in the physical characteristics and dimensions of the aquifer and provides conveyance mechanisms for surface water infiltration and groundwater movement, both of which enhance solution cavity development.

A narrow portion of the Edwards extending along most of the eastern boundary of the Barton Springs segment of the Edwards aquifer is overlain by the Del Rio Clay, which is a relatively impermeable formation that functions as a confining layer for groundwater within the underlying Edwards and associated limestones. In the areas west of this confining layer, particularly where the Edwards outcrops, the groundwater in the Barton Springs segment of the Edwards aquifer is under unconfined, water table conditions.

2.1.1.2 Groundwater Movement

Groundwater movement within the Barton Springs segment of the Edwards aquifer is from areas with the highest water levels in the southwestern and western portions of the system eastward and northeastward to the point of primary discharge at Barton Springs on the lower reach of Barton Creek, just upstream from Town Lake (Slade et al 1985). This generalized pattern of groundwater movement through the aquifer towards Barton Springs is illustrated in Figure 2.1-2.

2.1.1.3 Natural Recharge

The Barton Springs segment of the Edwards aquifer is recharged primarily by infiltration of surface runoff during storm events into fractures and openings in the outcrop area of the Edwards and associated limestones, principally along watercourses and streambeds. Direct infiltration of precipitation falling on the outcrop land surface and subsurface inflows from adjacent formations also contribute to the recharge of the Edwards groundwater system. Several ephemeral creeks that are tributary to the Colorado River cross the outcrop area generally from west to east and contribute the majority of recharge to the aquifer.

The Recharge Zone for the Barton Springs segment of the Edwards aquifer extends generally from the southwest to the northeast along the western half of the aquifer area; it is delineated on the map in Figure 2.1-3 along with other key hydrologic features of the aquifer. The Recharge Zone covers approximately 90 sq mi (Slade et al 1986).

Recent studies conducted by the USGS (Slade et al 1986) and other investigators (Woodruff 1986) have examined the historical hydrologic characteristics of the Barton Springs segment of the Edwards aquifer and its associated surface streams for the purpose of identifying the sources, magnitudes and locations of natural recharge. There are six principal streams that contribute surface recharge to the aquifer across the outcrop area (Recharge Zone). These are Barton Creek, Williamson Creek, Slaughter Creek, Bear Creek, Little Bear Creek and Onion Creek (Figure 2.1-3). The percentage distribution of their average recharge contributions, their maximum mean-daily recharge rates, as determined by the USGS (Slade et al 1986), and their drainage areas above and within the Recharge Zone are listed in Table 2.1-1.

FIGURE 2.1-2 GENERALIZED GROUNDWATER MOVEMENT THROUGH THE BARTON SPRINGS/EDWARDS AQUIFER

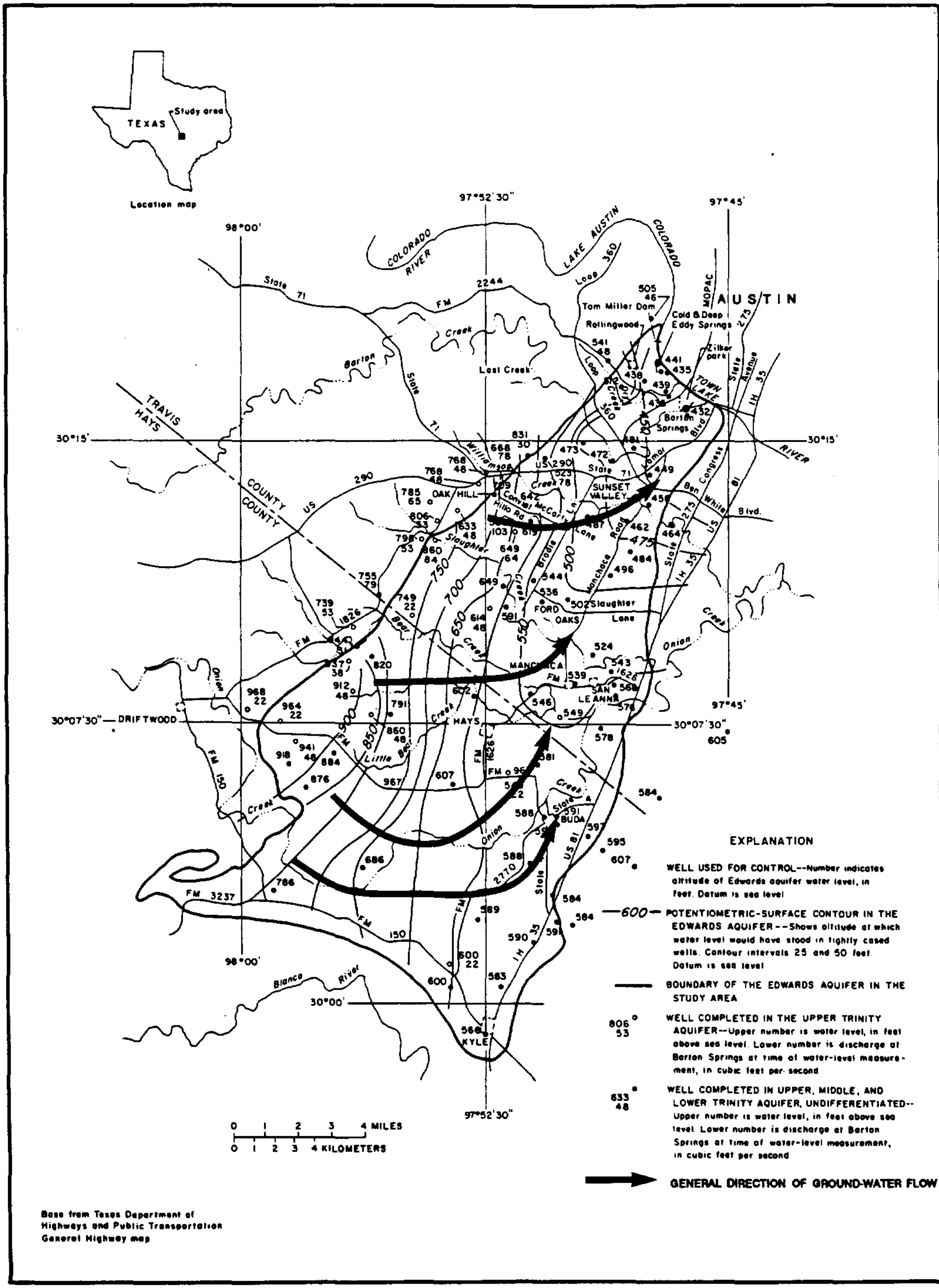


FIGURE 2.1-3 DELINEATION OF BARTON SPRINGS/EDWARDS AQUIFER RECHARGE ZONE AND EDWARDS OUTCROP AREA

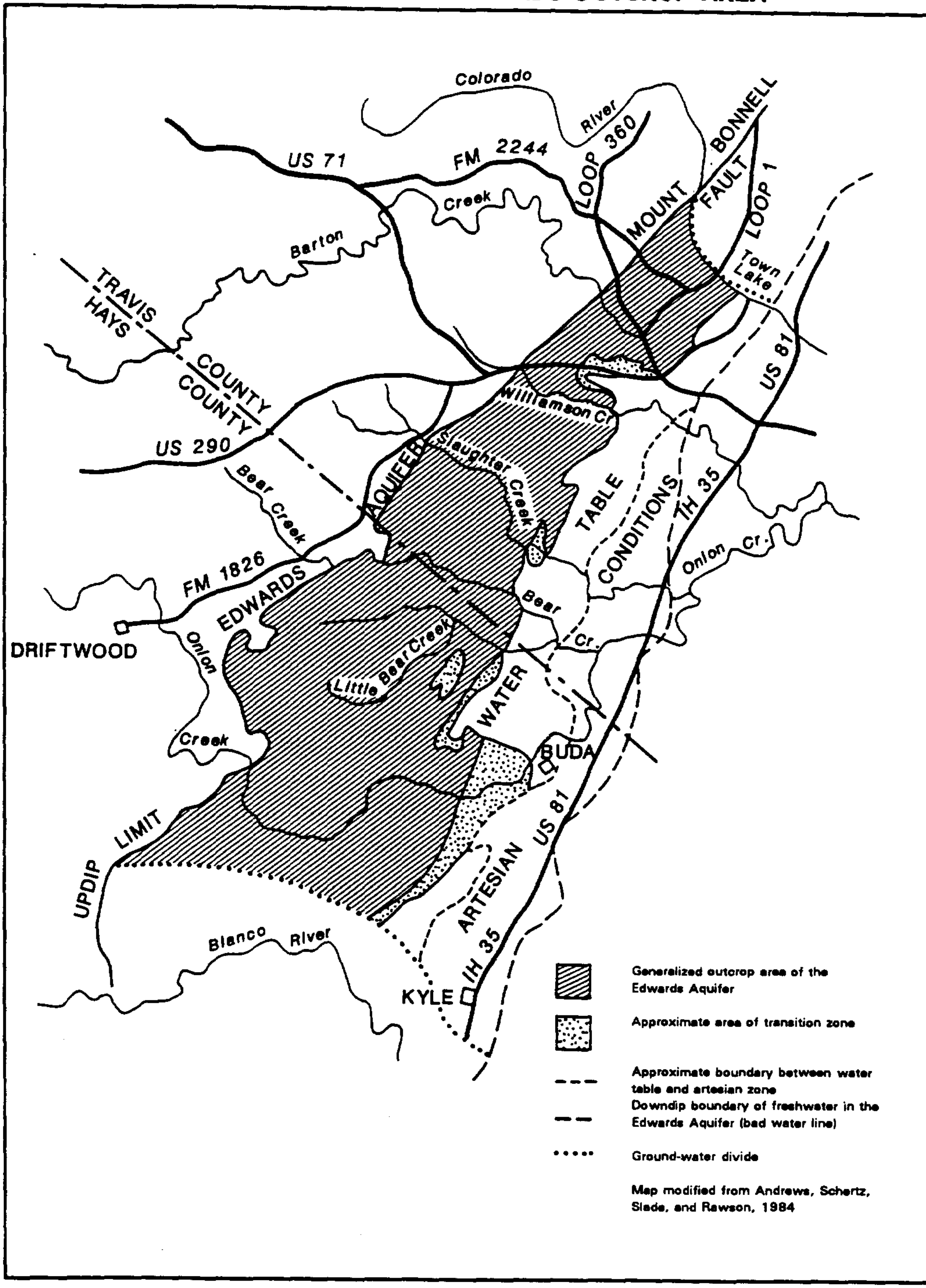


TABLE 2.1-1 WATERSHED RECHARGE CHARACTERISTICS FOR THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

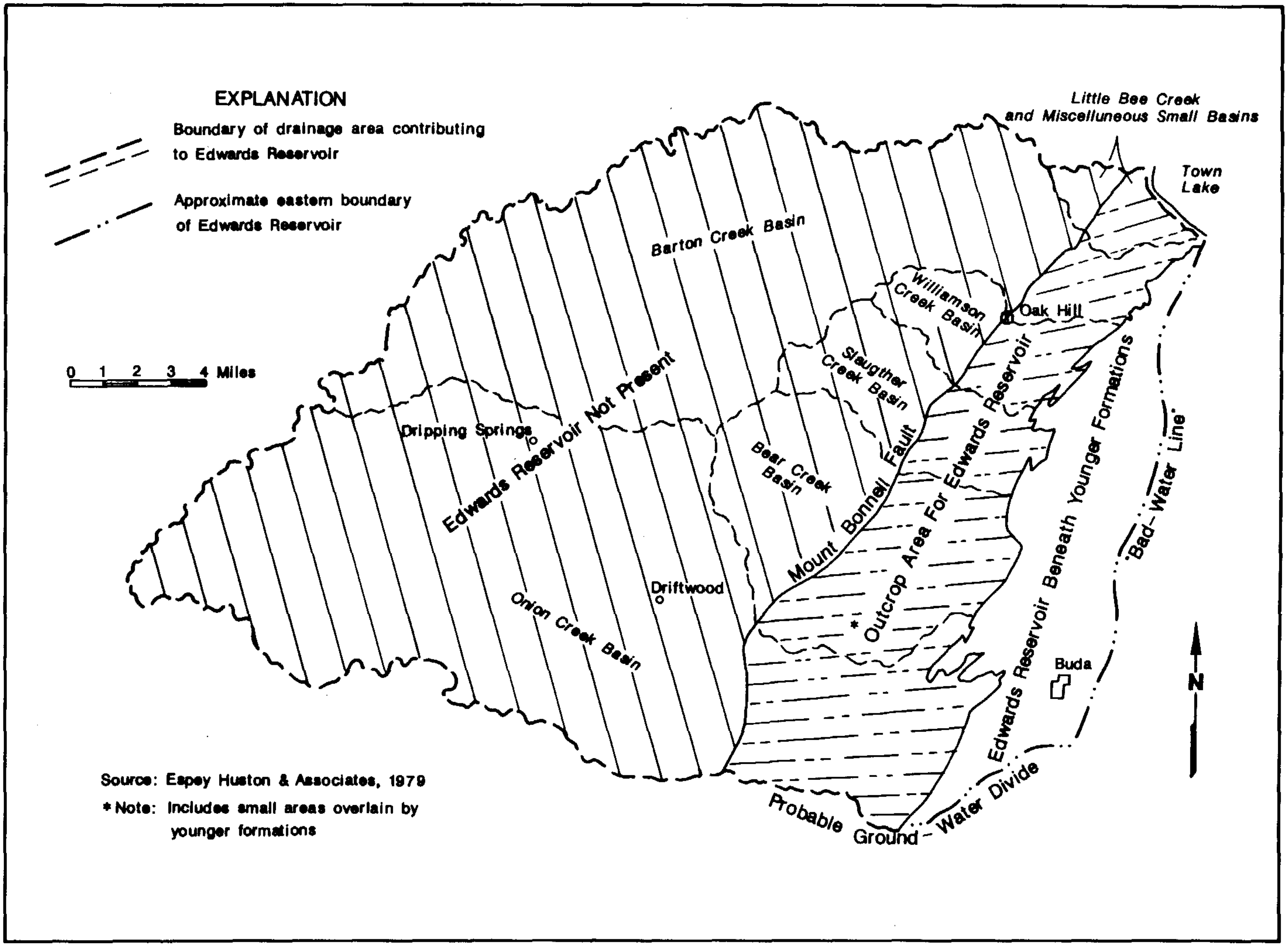
WATERCOURSE	RELATIVE RECHARGE CONTRIBUTION Percent	MAXIMUM MEAN-DAILY RECHARGE RATE cfs	DRAINAGE AREAS ABOVE RECHARGE ZONE Sq. Mi.	DRAINAGE AREAS WITHIN RECHARGE ZONE Sq. Mi.	DRAINAGE AREAS TOTAL Sq. Mi.
Barton Creek	28	30 to about 70	111	9	120
Williamson Creek	6	13	6	7	13
Slaughter Creek	12	52	9	7	16
Bear Creek	10	33	14	6	20
Little Bear Creek	10	about 30	0	19	19
Onion Creek	34	about 120	124	42	166
Combined Watershed	100		264	90	354

The drainage area figures in the table have been derived from watershed areas reported by the USGS for stream flow gages located near the upstream and downstream boundaries of the Recharge Zone (Slade et al 1982), adjusted based on visual inspections to account for deviations between these gaged areas and the actual Recharge Zone.

With the exception of Little Bear Creek, each of these streams has a contributing watershed that extends upstream beyond the Recharge Zone of the Barton Springs segment of the Edwards aquifer. The headwaters of Little Bear Creek originate within the Recharge Zone. According to the USGS, the total contributing drainage area above the Recharge Zone encompasses 264 sq mi. Including the 90 sq mi of area within the Recharge Zone, there is a total of 354 sq mi of drainage area that contributes runoff potentially available for recharge. Of this total area, 165 sq mi, or almost 47 percent, are contained within the Onion Creek basin; Barton Creek encompasses 120 sq mi, or about 34 percent. The drainage area delineations identified on the map in Figure 2.1-4 illustrate the relative sizes of the Onion Creek and Barton Creek watersheds.

From USGS studies based on daily stream flow measurements on each of the six streams and on precipitation data collected throughout the drainage area over the 42-month period beginning in July, 1979, and ending in December, 1982, it has been determined through water budget analyses that an average of six percent of the precipitation that falls on the entire drainage area (354 sq mi) results in surface recharge to the Barton Springs segment of the Edwards aquifer. For an average annual rainfall of 33 inches, this amounts to about 37,400 af of recharge per yr. An average of nine percent of the precipitation, or about 56,100 af per yr, occurs as surface stream flow that discharges past the downstream boundary of the Recharge Zone. The remaining 85 percent of the rainfall is lost to surface retention, shallow infiltration and soil storage, evapotranspiration, and other surface processes. Based on 33 inches of annual rainfall, these losses represent an average of approximately 530,600 af of water that never reaches the groundwater system.

FIGURE 2.1-4 DRAINAGE AREAS OF PRINCIPAL STREAMS CROSSING THE BARTON SPRINGS/EDWARDS AQUIFER RECHARGE ZONE



As indicated in Table 2.1-1, the Barton Creek and Onion Creek watersheds account for over 60 percent of the average surface recharge that enters the Barton Springs segment of the Edwards aquifer, which relates directly to the fact that these two watersheds encompass over 80 percent of the total drainage area that contributes runoff to the Recharge Zone. When considering measures to enhance the recharge to the groundwater system, these two watersheds clearly offer the most potential, based on recharge volume, since they have an abundance of runoff available that normally flows out of the Recharge Zone as stream flow.

Using the nine-percent figure indicated above for the stream flow-to-rainfall fraction and considering 33 inches of average annual precipitation, the total quantity of runoff that would be available for recharge enhancement from the Barton Creek and Onion Creek watersheds is approximately 45,300 af per yr. Certainly, this represents a sizable amount of water considering that only about 4,000 af per yr are currently pumped from the Barton Springs segment of the Edwards aquifer. With this quantity of additional water potentially available and with future water demands in the aquifer area projected to substantially increase beyond current levels of pumpage, the need to develop and implement an effective recharge enhancement program is of paramount importance.

2.2 ONION CREEK WATERSHED: SURFACE WATER HYDROLOGY

The Onion Creek watershed has a total drainage area of about 343 sq mi, of which approximately 165 sq mi lie upstream from Buda, Texas (see Figure 1.4-1). Onion Creek heads in Blanco County and flows in an easterly direction through Hays County before it confluences with the Colorado River in Travis County. The watershed has an average width of about 6 mi.

Major tributaries of Onion Creek include Bear, Little Bear, Slaughter, and Williamson Creeks. These tributaries confluence with Onion Creek downstream of the Recharge Zone. For the periods 1925 through 1929 and 1977 through 1988, the average flow of Onion Creek measured at the USGS gaging station (No. 08159000) located near the confluence of Onion Creek and the Colorado River was 84.1 cfs or 60,930 af per yr. Daily stream flow ranged from consecutive days of zero discharge to a maximum recorded discharge of 76,000 cfs measured on May 28, 1929.

3.0 GEOLOGICAL DESCRIPTION OF ONION CREEK RECHARGE ZONE

3.1 LITERATURE REVIEW

Prior to initiation of the field investigation of Onion Creek through the Recharge Zone, a literature review was undertaken for background information on the geology of Onion Creek in Hays County. Richard M. Smith, Jr., mapped the geology of the area in 1978. His report titled "Geology of the Buda-Kyle Area" (Smith 1978) was used to assist in the delineation of many of the smaller faults and their relationship to the regional trend. Regional geology was obtained from the Austin Sheet of the Geologic Atlas of Texas (Bureau of Economic Geology 1974). The Recharge Zone boundaries were delineated from the United States Geological Survey map titled "Recharge Zone of the Edwards Aquifer Hydrologically Associated With Barton Springs in the Austin Area, Texas" (Slagle and Slade 1986). Area lineament locations and orientations were obtained from the Edwards Aquifer Research and Data Center report titled "Lineaments and the Edwards Aquifer--Barton Springs segment, Travis and Hays Counties, Texas" (Woodruff 1989 and Alexander 1991). These lineaments were mapped by C.M. Woodruff, Jr., Fred R. Snyder, and Albert E. Ogden, and compiled for this report. These reports also discusses the relationship of lineaments to recharge and the hydrology of the Barton Springs segment. Information on recharge to this segment of the Edwards aquifer was primarily found in the report titled "Hydrology and Water Quality of the Edwards Aquifer Associated with Barton Springs in the Austin Area, Texas" (Slade et al 1986).

3.2 FIELD MAPPING

Field surveys of Onion Creek were undertaken from June through October 1991. The site investigations centered on mapping the location and types of recharge features located within the creek bottom and immediate banks of the creek. In addition, locations of significant informative features, such as a stagnant water ponds in the creek bottom, were noted during the survey. The locations of the faults bounding the Recharge Zone were ascertained, and the surveyed locations of other recharge features were taken from the downstream limit of the Recharge Zone.

The centerline profile of Onion Creek is shown in Plates 1 and 2, located in the map pockets attached to this report. The downstream edge of the Recharge Zone was set as Station No. 0+00 and occurs at elevation 666.8 ft msl. The centerline survey progressed to the upstream edge of the Recharge Zone, which occurred at Station No. 504+10.6 at an elevation of 821.5 ft msl. Topographic surveys were also conducted in the Contributing Zone through the Rutherford Ranch and of the existing CenTex Materials, Inc. quarry located immediately south of and adjacent to Onion Creek between Station Nos. 100+00 and 140+00. In addition, cross-section surveys (Appendix A) of Onion Creek were obtained at approximately 0.5 mile (mi) intervals throughout the Recharge Zone.

Topographic surveying efforts were conducted simultaneously with geological and environmental (habitat) investigations. In this manner, site specific geological and environmental features, such as caves, faults, sinkholes, and critical/sensitive habitats, were tied to horizonal and vertical datums. The significant site-specific geological and environmental features located during the field investigations are shown on Plates 1 and 2.

The topography of Onion Creek through the Recharge Zone in very unique. The creek rises almost 155 feet (ft) from the downstream end to the upstream edge of the Recharge Zone, over a distance of about 50,411 ft (9.55 mi). This results in an average creekbed slope of 16.2 ft per mi. The creek within this reach is characterized by solutional features, collapsed streambed sections and local and regional faults (see Plates 1 and 2). These features have a moderate to high potential for recharge. The most predominant sinkhole and faulting system occur at and near Barber Falls located between Station Nos. 100+00 and 112+00. From the upstream end of Barber Falls to the bottom of the falls' basin, there is an elevation change of approximately 50 ft.

Two other significant recharge features specifically located during the field investigations were Antioch Cave (Station No. 29+46.5) and Crippled Crawfish Cave (Station No. 318+93.5). These caves can provide a conduit to the water table and provide a major opportunity to enhance recharge.

Examination of Plates 1 and 2 shows that solutional features and faulting systems occur in sets or groups and are not evenly distributed throughout the Recharge Zone. These surface expressions suggest that areas of moderate and high recharge potential are isolated in "pockets" and that artificial recharge enhancements should focus in these areas.

Mapping of the two caves (Antioch Cave and Crippled Crawfish Cave) found during the field survey was undertaken in August and October of 1991. Due to water entering Antioch Cave from upstream springs located in the banks of the creek, the survey and mapping of the Antioch Cave was not complete by the time of publishing of this report. Further mapping of this cave is anticipated when flows into the cave opening decrease.

3.3 SITE GEOLOGY

The creek bed of Onion Creek is covered by Quaternary alluvium throughout much of the Recharge Zone. Outcrops of Edwards and associated limestones are discontinuous and vary in size. The alluvium is predominantly a boulder-gravel conglomerate at the upstream end of the Recharge Zone, which grades to a gravel-clay conglomerate by the location of the Antioch Cave (Station No. 20+07.6). The boulder-gravel conglomerate is white to light gray-tan, well cemented with lime mud, well rounded and poorly sorted lying on the surface of the limestone creek bed. Thickness varies tremendously, but several erosional exposures indicate three to five ft of thickness for this conglomerate. The gravel-clay conglomerate is predominantly gray to light brown where the surface is not covered by growth. This conglomerate tends to support a varied grass and shrub community, which in turn captures additional fine sediments. The gravel-clay conglomerate is poorly cemented, clay and silt filled, well rounded and poorly sorted. No estimates of thickness can be made due to the lack of erosional surfaces through this conglomerate. However, due to the clay filling of this conglomerate, several stagnant ponds were observed through this section on the downstream end of the Recharge Zone.

Where the Edwards Limestone is exposed, it is predominantly a light grey-tan to light grey, dense, hard, microcrystalline dolomitic limestone with abundant chert nodules. It occasionally becomes softer, nodular, marly, and very fossiliferous. Fossils found in the nodular marly member include ammonites, pelecypods, and Exogyra sp. The dolomitic limestone beds tend to support the formation of vertical cliffs, with the exception of the nodular unit, which tends to form a recessed bed within the more dense dolomitic limestone. Where exposed, faults and fractures are common, with fracture intensities ranging from fractures every ten to fifteen ft apart to three or more fractures per foot. Intensely fractured areas exhibited three or four directions of fracturing, often thirty to sixty degrees apart in direction. An occasional fold was found in association with the faults, and one area on the YO Ranch, ending at Station No. 189+81.9, exhibited an undulating dip to the beds, which often dips four different directions within a twenty square foot area. These features possibly indicate subsurface collapse zones underlying the creek bottom.

3.4 POTENTIAL HIGH RECHARGE AREAS

Surface exposure areas of: faulting, intersection of multiple fracture sets and high fracture frequency (intense fracturing), jointing, folding, collapsed stream bed, and solution channel development were considered to be areas of currently identifiable high recharge potential. Many of these surface exposure areas are associated with development of solution weathering features such as cavities and vuggy porosity, "honeycombing," solution channels, caves, and collapse features.

Intense fracturing is defined as those areas with two or more directions of fracturing and areas where fractures were less than two feet apart. The majority of these intensely fractured areas were associated with faults and folds (mapped and inferred) in the Edwards Formation rocks. Once these areas of faulting and intense fracturing were plotted on the center line profile, a grouping of recharge features became apparent. These groupings (based on surface outcrop descriptions, measurements, and interpretations) were then classified as high or moderate recharge potential. Due to the large amount of alluvial cover on bedrock in the creek bottom, low recharge potential was not used as a classification. Those areas that are not rated, therefore, are not low recharge potential areas, but rather predominantly covered areas. The only low potential recharge areas found were those with standing water (during late summer) as noted on the center line profile.

In the CenTex Material, Inc. quarry, only Mustang Branch fault is seen as having high recharge potential. Those fractures with springs issuing from them during high aquifer levels are interpreted to provide moderate to low recharge potential during periods of low aquifer water levels. In order to facilitate recharge in the quarry, consideration should be given to drilling recharge wells through the lower Edwards, or until large recharge features were intercepted, such as a fault or cave.

3.4.1 Hydrogeologic Features Effecting Recharge

Significant recharge features are defined as those structural and dissolution features where rapid infiltration to the subsurface may occur. These features include faults, fractures, caves, solution channels, and sinkholes within the creek bed and on the immediate banks of the creek.

Slade et al. (1986) reports that recharge occurs along fractures and other openings that cross the creeks and through these features, water reaches the water table very quickly. For the purpose of recharge enhancement to the Barton Springs segment of the Edwards aquifer, the site surveys focused on the identification and location of these hydrogeologic features commonly associated with high recharge potential in this region.

During the field surveys, numerous hydrogeologic features were identified as significant recharge features including: faults, fracture zones, solution channels, sinkholes, and caves. The centerline profiles of Onion Creek (see Plate 1), indicates that there are numerous elongated sinkholes and solution features ranging from a few feet to approximately 2,400 feet long, usually associated with collapsed stream bed sections. Most of these features were dry during the initial field work, although rare ponds of stagnant water were found throughout the Recharge Zone. The survey identified many areas where hydrogeologic features (commonly associated with high recharge rates in the region) were visible in the creek bottom. The survey focused on the intensity of the faulting and fracturing (as a primary control) in order to assess the recharge potential of segments of the creek. Pulverized, fractured rocks (i.e. fault gouge) provide more available surface area for rock/water interaction in the chemical dissolution (weathering) process, thereby enhancing solution opening development. This pulverized/fractured rock is also less resistant to mechanical erosion.

In addition, two caves (Antioch Cave and Crippled Crawfish Cave) were identified during these surveys, both of which are within the normal banks of the creek. Discussions with local residents indicate both caves were occasionally covered by debris and sediment, however, floods during January 1991 washed the debris and sediment away from the cave openings to expose these features to recharge. Ongoing exploration of these caves indicates both are good conduits for recharge waters.

3.4.1.1 Antioch Cave Exploration and Description

Antioch Cave, located at Station No. 20+07.6, was explored in August 1991[1] and a schematic drawing was prepared (Figure 3.4-1) . The entrance is a wedge shaped opening approximately 3 ft long and 1.5 ft wide. The cave is located in the bed of Onion Creek (Figure 3.4-2) at the end of a promontory (Figure 3.4-3) and is formed along a distinctive north trending joint. Water entering the cave forms a whirlpool at the surface when the water is approximately five ft deep. The cave drops about 3 ft to 4 ft to a floor sloping gently to the north. It follows the joint in and down another 3 ft to 5 ft to a constriction.

Beyond the constriction (Figure 3.4-4) is a 25 ft to 30 ft vertical drop, at the south end of an approximately 14 ft long fissure. The fissure narrows to a foot or less near the surface, averages 3 ft to 5 ft wide, and opens into a 10 ft wide, 12 ft long and 10 ft to 12 ft high room. At the time of initial exploration, a small stream of water was entering the cave, creating a waterfall into the main room. The water lands on a gravel and cobble strewn floor, passes through and around the cobbles, and disappears under a ledge at the north end of the room.

Approximately 4 ft above this ledge, a 2 ft to 3 ft high and 8 ft to 12 ft wide crawlway (Figure 3.4-5) extends toward the north. This crawlway is formed along a bedding plane with a bedrock floor and ceiling. The sides of the passages at times appear to be a concretion of gravel and fine sediment, but bedrock is also present. This passage extends north for 50 ft to 75 ft to a "Y" shaped intersection. The right hand passage was explored for an additional 150 ft to 200 ft before exploration was halted. At this point the passage was smaller, but continued on. The left hand passage was not entered, but continues out of sight at approximately the same size.

[1] Antioch Cave was explored by Mr. Ron Fieseler, District staff, Mr. Mike Warton, area caver, and Mr. Charlie Savvas, area caver.

FIGURE 3.4-1 SCHEMATIC DRAWING OF ANTIOCH CAVE

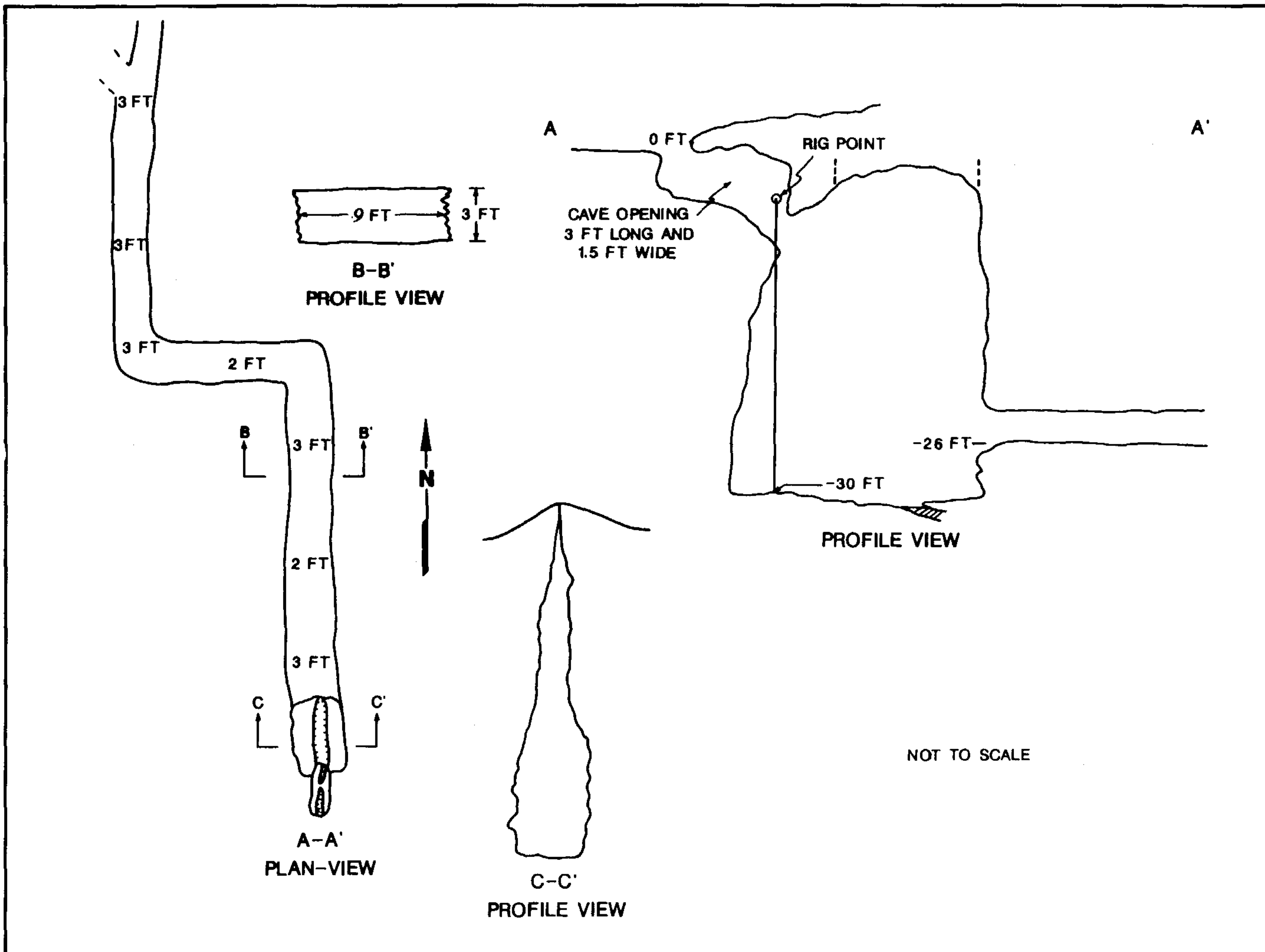


FIGURE 3.4-2 PHOTOGRAPH OF ONION CREEK LOOKING DOWNSTREAM OF ANTIOCH CAVE

FIGURE 3.4-3 PHOTOGRAPH OF ANTIOCH CAVE ILLUSTRATING PROMONTORY

FIGURE 3.4-4 PHOTOGRAPH OF THE OPENING OF ANTIOCH CAVE

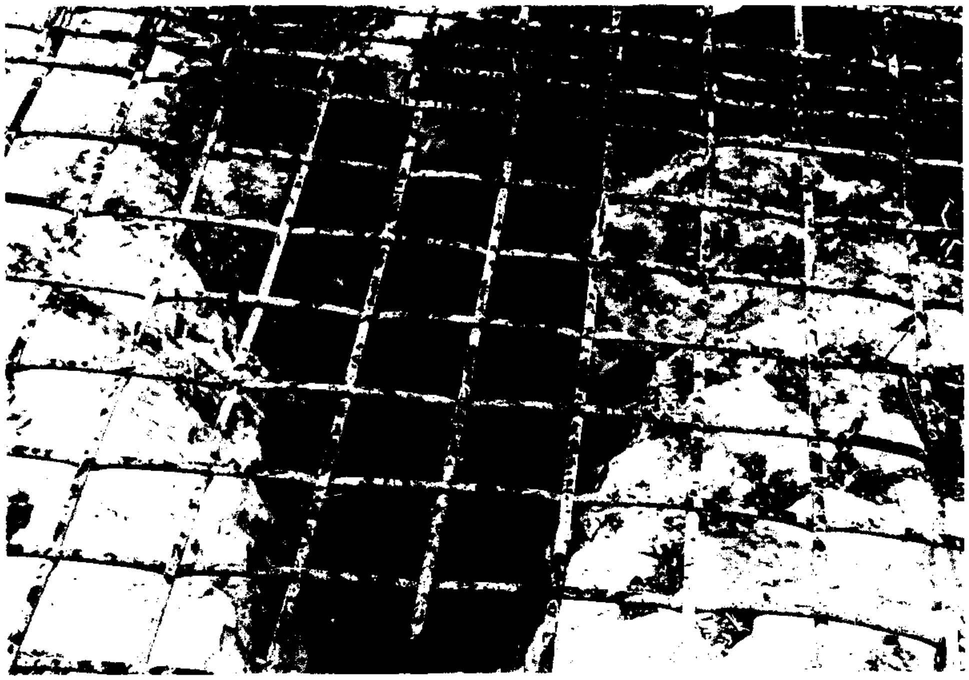


FIGURE 3.4-5 PHOTOGRAPH OF THE MAIN CRAWLWAY IN ANTIOCH CAVE

The crawlway and the room were essentially scoured clean by floodwaters. A small amount of sediment, a dead fish, and small sticks and leaves were observed. The only animal seen during this exploration was a common cave cricket. The crawlway is an obvious flood stage conduit, but may not be the primary drainage path. Even with exploration incomplete, it is obvious that this cave is a major recharge feature.

3.4.1.2 Crippled Crawfish Cave Exploration and Description

Crippled Crawfish Cave, located at Station No. 318+96.1, was explored and mapped (Figures 3.4-6) in October 1991[2]. This cave is approximately 1.5 ft above the center line of the creek. The opening for this cave is approximately 1.5 ft in diameter (Figures 3.4-7 and 3.4-8). Crippled Crawfish Cave continues in an easterly direction under the creek at a depth of approximately 22 to 23 ft. Exploration of the cave indicates the cave to be an important recharge feature which floods completely. Very little silt, mud, or surface organics were encountered. From the small entrance a series of four short climbdowns leads to an approximately 10 ft diameter room (Big Room). From there a low, wide crawlway extends horizontally for about 90 ft to a junction. To the right is a debris-filled crawlway too low to enter. To the left is a small dome, followed by a 5 ft drop into the final crawlway. This becomes too tight and splits up, and a very narrow ceiling fracture extends upwards to a possible upper level.

A fair amount of air flow was detected at the far end of the cave. No major discernable water inlets were observed other than the surface entrance. Some small fractures and tubes may carry in additional water but were all small in comparison to the main water conduit (the

[2] Crippled Crawfish Cave was explored by Mr. Ron Fieseler, District Staff, Mr. Doug Allen, Texas Cave Management Association, and Mr. Peter Sprouse, area caver.

FIGURE 3.4-6 MAP OF CRIPPLED CRAWFISH CAVE HAYS COUNTY, TEXAS

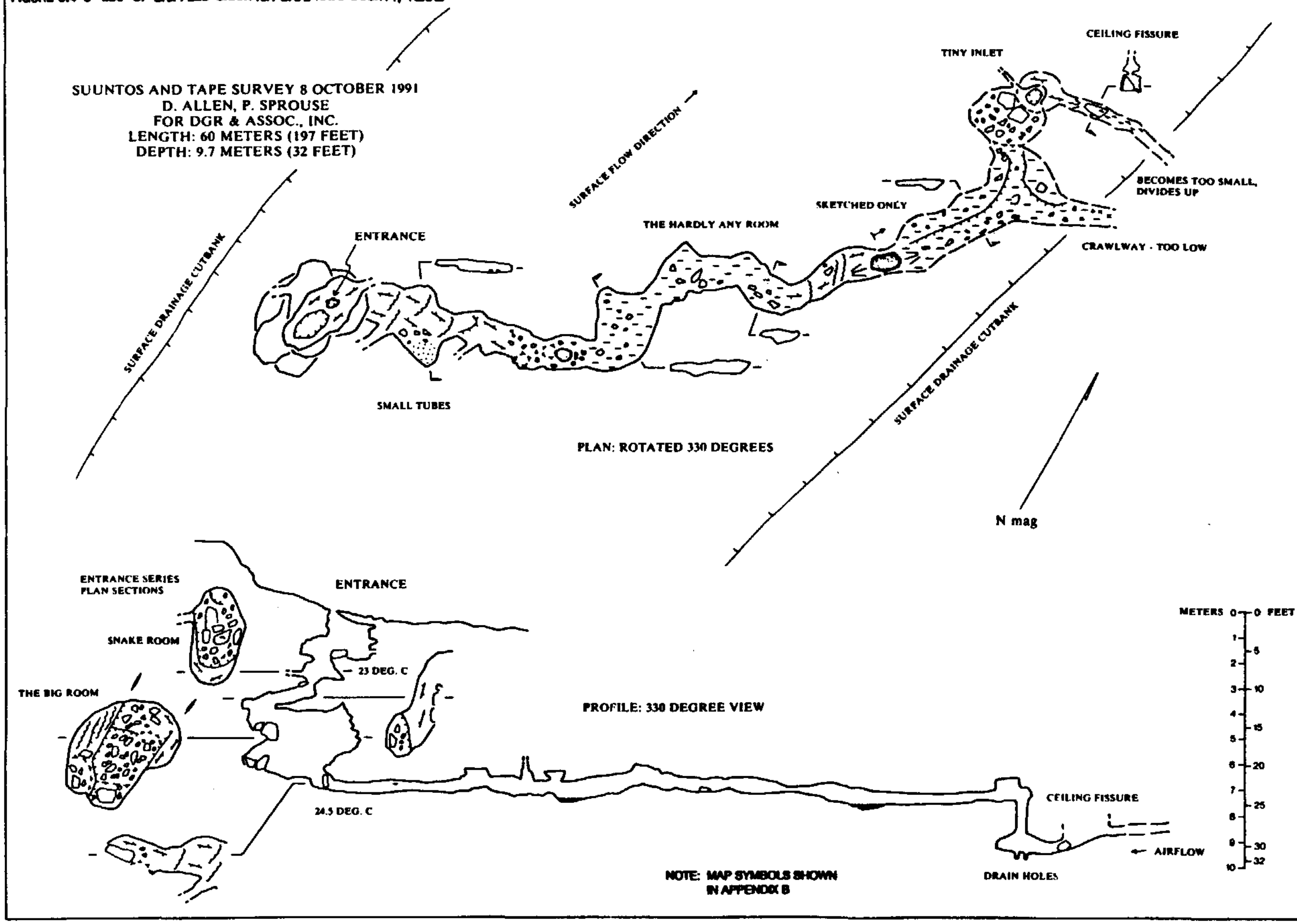


FIGURE 3.4-7   PHOTOGRAPH OF OPENING OF CRIPPLED CRAWFISH CAVE

FIGURE 3.4-8   PHOTOGRAPH OF CAVER ENTERING CRIPPLED CRAWFISH CAVE

FIGURE 3.4-9 PHOTOGRAPH OF A CRAWLWAY IN CRIPPLED CRAWFISH CAVE

4.0 EVALUATION OF HISTORICAL STREAM FLOW AND NATURAL RECHARGE

In order to evaluate historical stream flow and recharge characteristics of Onion Creek, a detailed evaluation of recorded (measured) and mathematically generated stream flows was performed. This analysis included monthly and daily evaluation of USGS gaging stations and National Weather Service precipitation data. For the purposes of this report, daily and monthly stream flows for Onion Creek above and below the Recharge Zone of the Barton Springs segment of the Edwards aquifer were developed for the period January 1, 1941 through December 31, 1988. The methodology and results of these evaluations are described in the following sections.

4.1 HISTORICAL RECORDED STREAM FLOW

Historically, the USGS has maintained three stream flow gaging stations on Onion Creek (Table 4.1-1). Onion Creek near Driftwood (USGS Station No. 08158700) commenced continuous operation in June 1979. This station, which is still active today, has a drainage area of 124 sq mi and is about 4.8 creek mi above the Recharge Zone. Also, the USGS maintained a daily gaging station on Onion Creek near Buda (USGS Station No. 08158800), during the period July 1979 through September 1983. This latter gage has a drainage area of 166 sq mi and is located about 0.5 creek mi below the Recharge Zone. Monthly stream flow data for these two stations are shown in Table 4.1-2. A monthly flow-duration graph for the short period of record of the Buda gage is shown in Figure 4.1-1.

Flow in Onion Creek above and below the Recharge Zone is very erratic and has varied from months of very little or no flow to days of major flooding. Examination of records for

TABLE 4.1-1
ONION CREEK USGS GAGE DESCRIPTIONS

GAGE NUMBER	LOCATION	DRAINAGE AREA	PERIOD OF RECORD	EXTREMES FOR PERIOD OF RECORD
08158700	**Onion Creek near Driftwood.**			
	Lat: 30 04'59" Long: 98 00'29" Hays County, Hydrologic Unit 12090205 on left bank at upstream side of low-water crossing on Fram Road 150, 3.2 mi southeast of Driftwood, and 10 mi west of Buda.	124 mi^2	April 1958, November 1961 to June 1979 (periodic discharge measurements only), July 1979 to current Year	Max. discharge: 8,990 ft^3/s (June 6, 1985) Min. discharge: no flow for several days in August and September 1984 and October 1-10, 1984 Flood of March 20,1979 reached at stage of 11.48 ft. (discharge, 4,980 ft^3/s)
08158800	**Onion Creek at Buda.**			
	Lat: 30 05'09" Long: 97 50'52" Hays County, Hydrologic Unit 12090205 on left bank at downstream side of bridge on Fram Road 967, 0.4 mi north-west of Buda.	166 mi^2	November 1961 to September 1973 January 1978 to July 1979 (periodic discharge measurements only), July 1979 to September 1983 (discontinued)	Max. discharge: 17,4000 ft^3/s (06/13/81) Flood of May 28, 1929, reached a stage of about 36.2 ft (discharge, 53,200 ft^3/s)
08159000	**Onion Creek at U.S. Highway 183 near Austin, TX.**			
	Lat": 30 10'40" Long: 97 41'18" Travis County, Hydrologic Unit 12090205 on right bank at downstream side of downstream bridge on U.S. Highway 183, 2.4 mi downstream from Williamson Creek, 3.2 mi southwest of Del Valle, and 7.5 mi southeast of the State Capitol Building in Austin	321 mi^2	May 1924 to March 1930, March 1976 to current year	Max. discharge: 76,000 ft^3/s May 28, 1929 no flow at times

Source: USGS Water Resources Data, Texas, Volume 3

TABLE 4.1-2
MONTHLY DISCHARGE OF ONION CREEK NEAR DRIFTWOOD AND ONION CREEK AT BUDA (ACRE-FEET)

ONION CREEK NEAR DRIFTWOOD
U.S.G.S. GAGE # 08158700

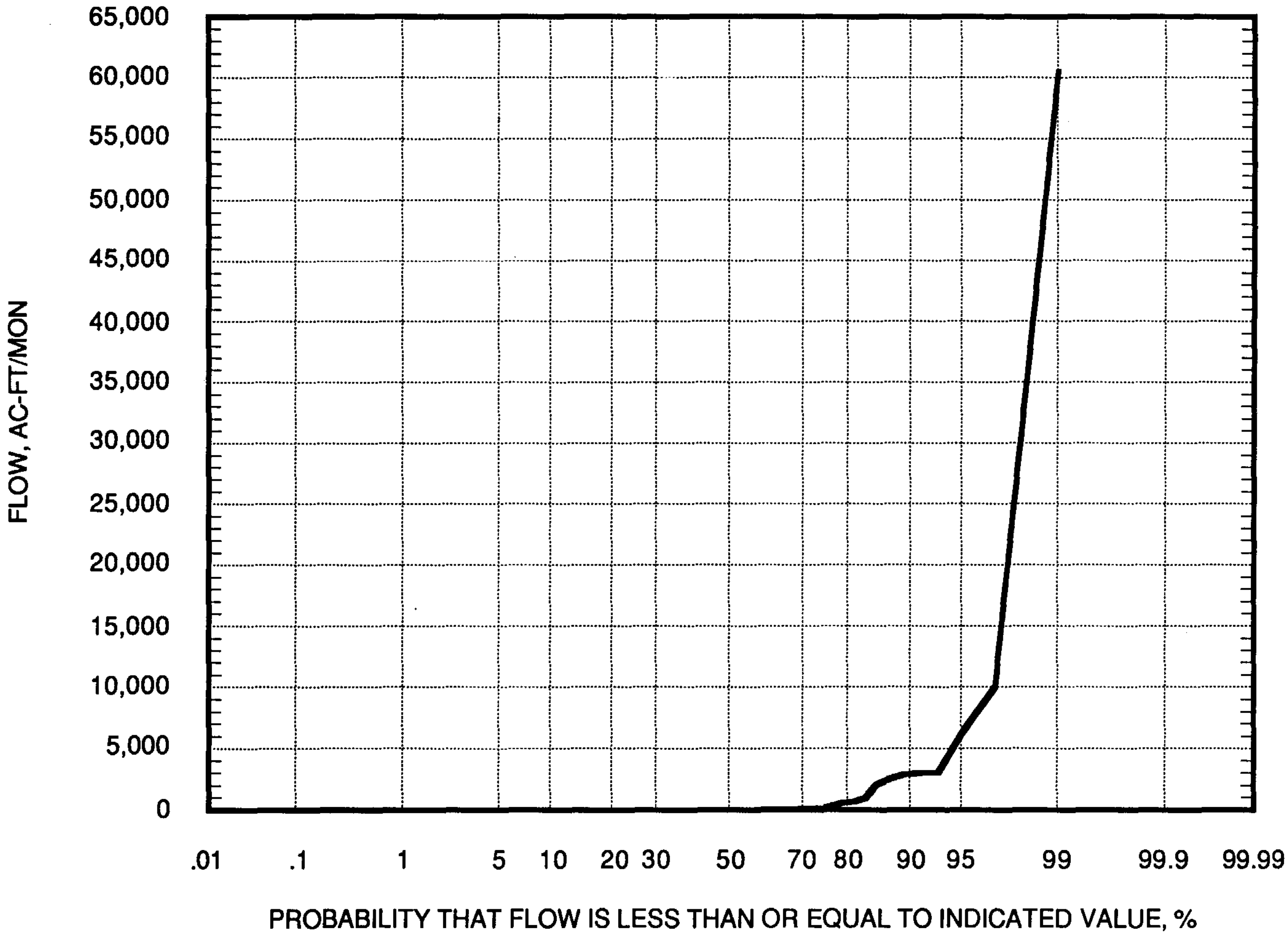
MONTH/YEAR	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
JANUARY	-----	126	1538	576	510	306	10282	2265	9128	543	55
FEBRUARY	-----	160	1784	399	1583	246	9759	4383	4742	401	128
MARCH	-----	222	7247	296	6186	354	11035	2009	9591	449	141
APRIL	-----	598	2919	434	3752	186	4803	679	3513	326	287
MAY	-----	4653	1909	7308	2954	164	1394	9476	3008	288	8187
JUNE	-----	1873	26488	1255	2998	275	11047	7252	47055	177	1711
JULY	1213	141	5011	398	2026	59	3025	1575	5988	104	463
AUGUST	475	59	715	78	760	6	422	381	1353	79	128
SEPTEMBER	241	680	588	94	685	3	214	316	393	20	17
OCTOBER	172	1599	4090	61	657	2198	1481	6709	42	15	14
NOVEMBER	101	1027	1490	105	351	1194	5104	4047	1190	6	15
DECEMBER	109	2034	826	156	329	4798	9698	19125	439	6	19

ONION CREEK AT BUDA
U.S.G.S. GAGE # 08158800

MONTH/YEAR	1979	1980	1981	1982	1983
JANUARY	-----	19	1	72	0
FEBRUARY	-----	31	8	53	0
MARCH	-----	27	6229	30	2067
APRIL	-----	23	134	4	674
MAY	-----	3006	601	10004	3053
JUNE	-----	4	60520	6	394
JULY	963	0	2535	0	11
AUGUST	149	0	0	0	0
SEPTEMBER	112	0	0	0	8
OCTOBER	0	208	2908	0	-----
NOVEMBER	8	2	0	0	-----
DECEMBER	35	3	0	0	-----

Source: USGS Water Resouces Data, Texas, Volume 3

FIGURE 4.1-1 MONTHLY FLOW-DURATION FOR ONION CREEK AT BUDA, 1979-1983



Onion Creek near Driftwood, since installation of its gaging station in July 1979, indicates that flows entering the recharge zone ranged from zero on many consecutive days to a maximumpeak of 8,990 cfs on June 6, 1985. Most of the flow volume consists of surface runoff resulting from storm rainfall. However, the USGS reports (personal communication with Mr. Raymond Slade) that some stream flow originating above and below the Driftwood gage comes from springs issuing from the Glen Rose Formation, especially after heavy rainfall events.

Since June 1979, the average recorded discharge at Onion Creek near Driftwood was 31,590 af per yr. This indirectly compares to an average discharge recorded at Onion Creek near Buda of approximately 21,417 af per yr. A direct comparison of annual average discharges of these two stations cannot be made since the Buda gage has an extremely short period of record. In addition, the average annual flow for the Buda gage is highly biased, due to the extremely high runoff event which occurred in June 1981 (see Table 4.1-2). During this month, the recorded flow at Buda was 60,520 af. The measured flow at the Driftwood gage was 26,488 af for the same month. This difference indicates that a very large storm centered over the Recharge Zone below the Driftwood gage and above the Buda gage.

4.2 GENERATION OF STREAM FLOW DATA FOR ONION CREEK

In order to develop a long term period of record for Onion Creek near Driftwood, numerous statistical analyses were performed. These analyses included correlation of measured daily and monthly stream flows for Onion Creek near Driftwood to distributed rainfall and to other area stream flow gages. Daily correlations of stream flow with most area stations and rainfall records produced nonsignificant statistical correlations. However, a strong correlation was found between monthly recorded flows of Onion Creek at Driftwood and the Blanco River at Wimberley. Monthly stream flows for these two gages and the resultant least squares correlation are shown in Table 4.2-1. As can be seen in Table 4.2-1, monthly stream flows for these two gaging stations have a correlation coefficient (r-squared) of 0.905.

TABLE 4.2-1
MONTHLY STREAMFLOWS OF BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
FOR THE COMMON PERIOD OF RECORD JULY 1979 THROUGH DECEMBER 1988
AND LEAST SQUARES CORRELATION STATISTICS

YEAR	MONTH	WIMBERLEY (Ac-Ft)	DRIFTWOOD (Ac-Ft)
1979	JUL	9524	1220
	AUG	5850	476
	SEP	4582	241
	OCT	3784	173
	NOV	3005	102
	DEC	2775	109
1980	JAN	2496	126
	FEB	2416	161
	MAR	2636	223
	APR	3574	599
	MAY	8286	4660
	JUN	4582	1880
	JUL	2556	142
	AUG	1448	59
	SEP	2466	681
	OCT	4622	1610
	NOV	2685	1030
	DEC	2895	2040
1981	JAN	2616	1550
	FEB	2935	1790
	MAR	11520	7260
	APR	5521	2920
	MAY	4193	1910
	JUN	57272	26540
	JUL	11740	5020
	AUG	4822	718
	SEP	3195	592
	OCT	21124	4100
	NOV	8515	1500
	DEC	5151	827
1982	JAN	3913	577
	FEB	3145	400
	MAR	3045	297
	APR	2805	435
	MAY	20665	7320
	JUN	5840	1260
	JUL	3125	399
	AUG	2955	78
	SEP	1697	95
	OCT	1757	61
	NOV	2166	105
	DEC	2076	156
1983	JAN	1837	511
	FEB	2785	1590
	MAR	8486	6200
	APR	7657	3760
	MAY	9723	2960
	JUN	10322	3000
	JUL	5590	2030
	AUG	3454	762
	SEP	2895	686
	OCT	4393	658
	NOV	3015	351
	DEC	2626	329
1984	JAN	2755	306
	FEB	2356	246
	MAR	2196	354
	APR	1527	186
	MAY	1418	164
	JUN	1947	276
	JUL	962	59
	AUG	810	6

TABLE 4.2-1(Cont.)
MONTHLY STREAMFLOWS OF BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
FOR THE COMMON PERIOD OF RECORD JULY 1979 THROUGH DECEMBER 1988
AND LEAST SQUARES CORRELATION STATISTICS

YEAR	MONTH	WIMBERLEY (Ac-Ft)	DRIFTWOOD (Ac-Ft)
	SEP	780	2
	OCT	3764	2200
	NOV	2556	1200
	DEC	7188	4810
1985	JAN	17141	10300
	FEB	16781	9780
	MAR	22092	11050
	APR	11610	4810
	MAY	5800	1400
	JUN	49625	11070
	JUL	14405	3030
	AUG	4932	422
	SEP	3474	215
	OCT	5860	1480
	NOV	10043	5110
	DEC	16861	9720
1986	JAN	8256	2260
	FEB	11960	4390
	MAR	6609	2010
	APR	4393	677
	MAY	19058	9490
	JUN	13896	7270
	JUL	5181	1580
	AUG	3284	381
	SEP	21903	317
	OCT	30778	6720
	NOV	15753	4050
	DEC	51622	19160
1987	JAN	24189	9140
	FEB	13537	4750
	MAR	19996	9610
	APR	9454	3520
	MAY	12409	3010
	JUN	115803	47140
	JUL	25906	6000
	AUG	7527	1350
	SEP	4842	394
	OCT	4203	42
	NOV	6339	1190
	DEC	5071	439
1988	JAN	4932	543
	FEB	3624	402
	MAR	3604	450
	APR	3025	326
	MAY	7417	289
	JUN	5660	178
	JUL	4273	104
	AUG	4652	98
	SEP	2116	21
	OCT	1817	15
	NOV	1527	6
	DEC	1428	6

LEAST SQUARE CORRELATION STATISTICS	
CONSTANT	-620.927
STD ERR OF Y EST	1783.433
R SQUARED	0.905
No. OF OBSERVATIONS	114
DEGREES OF FREEDOM	112
X COEFFICIENT(S)	0.393
STD ERROR OF COEFFICIENT	0.012

Using the least squares equation relating monthly stream flows of the Blanco River at Wimberley and Onion Creek near Driftwood, monthly stream flows for Onion Creek near Driftwood was generated for the period January 1941 through June 1979. These generated monthly flow values are presented in Appendix C. Daily stream flow for Onion Creek near Driftwood for the period January 1, 1941 through June 30, 1979, was estimated by applying the corresponding percent daily distribution, i.e. daily discharge divided by monthly flow times 100, observed at the Blanco River near Wimberley. Generated and measured daily discharges for Onion Creek near Driftwood for the respective periods January 1, 1941 through June 30, 1979, and July 1, 1979 through December 31, 1988 respectively, are shown in Appendix D.

To test the validity of developing generated daily, monthly, and annual stream flow for the Driftwood gage for the period January 1, 1941 through June 30, 1979, several comparisons were performed. For the period July 1, 1979 through December 31, 1988, the average percent daily flow at the Driftwood gage was 0.032843. The average percent daily flow at the Wimberley gage for the same period of record was 0.032834. The percentage of flow on an average daily basis between the two gages is almost identical. Likewise, the monthly flow-duration graphs for Onion Creek near Driftwood for the generated data period, January 1941 through June 1979 (Figure 4.2-1), and the measured period, July 1979 through December 1988 (Figure 4.2-2), are very similar, especially below the 98% probability level. In addition, the average annual flow for Onion Creek near Driftwood was estimated to be 32,188 af per yr for the period January 1941 through June 1979. The average annual flow for this gage measured by the USGS for the approximate 11-yr period July 1979 through September 1990 was 31,590 af per yr. This represents an annual percentage difference of about 2 percent between measured and generated annual flows. These three data tests indicate that the generated data for Onion Creek near Driftwood is representative and tracks expected flow magnitudes and fluctuations of the "measured" flow records. A composite monthly flow duration graph for Onion Creek near Driftwood for the period January 1941 through December 1988 is shown in Figure 4.2-3.

FIGURE 4.2-1 MONTHLY FLOW-DURATION FOR ONION CREEK AT DRIFTWOOD, 1941-1979

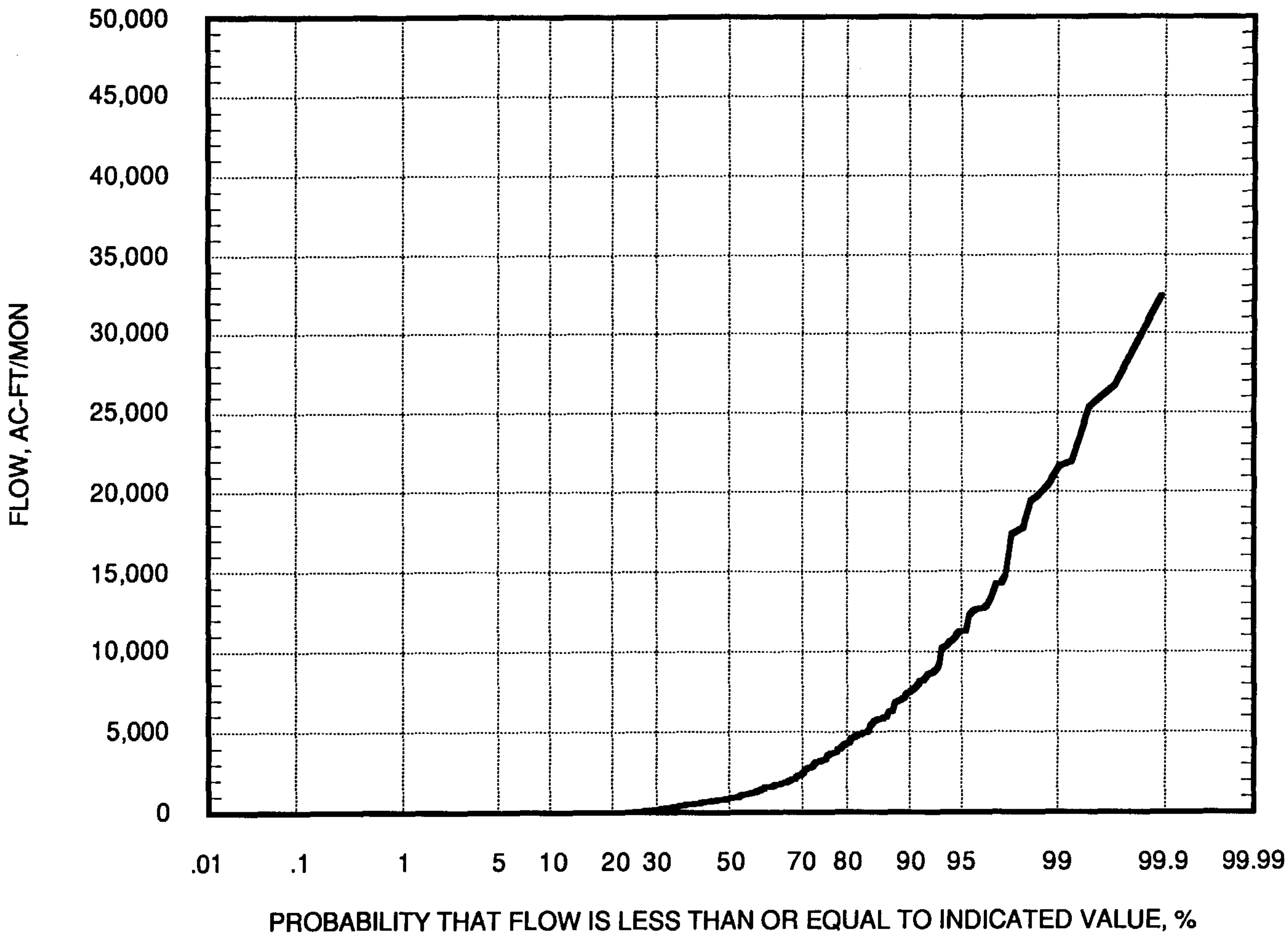


FIGURE 4.2-2 MONTHLY FLOW-DURATION FOR ONION CREEK AT DRIFTWOOD, 1979-1988

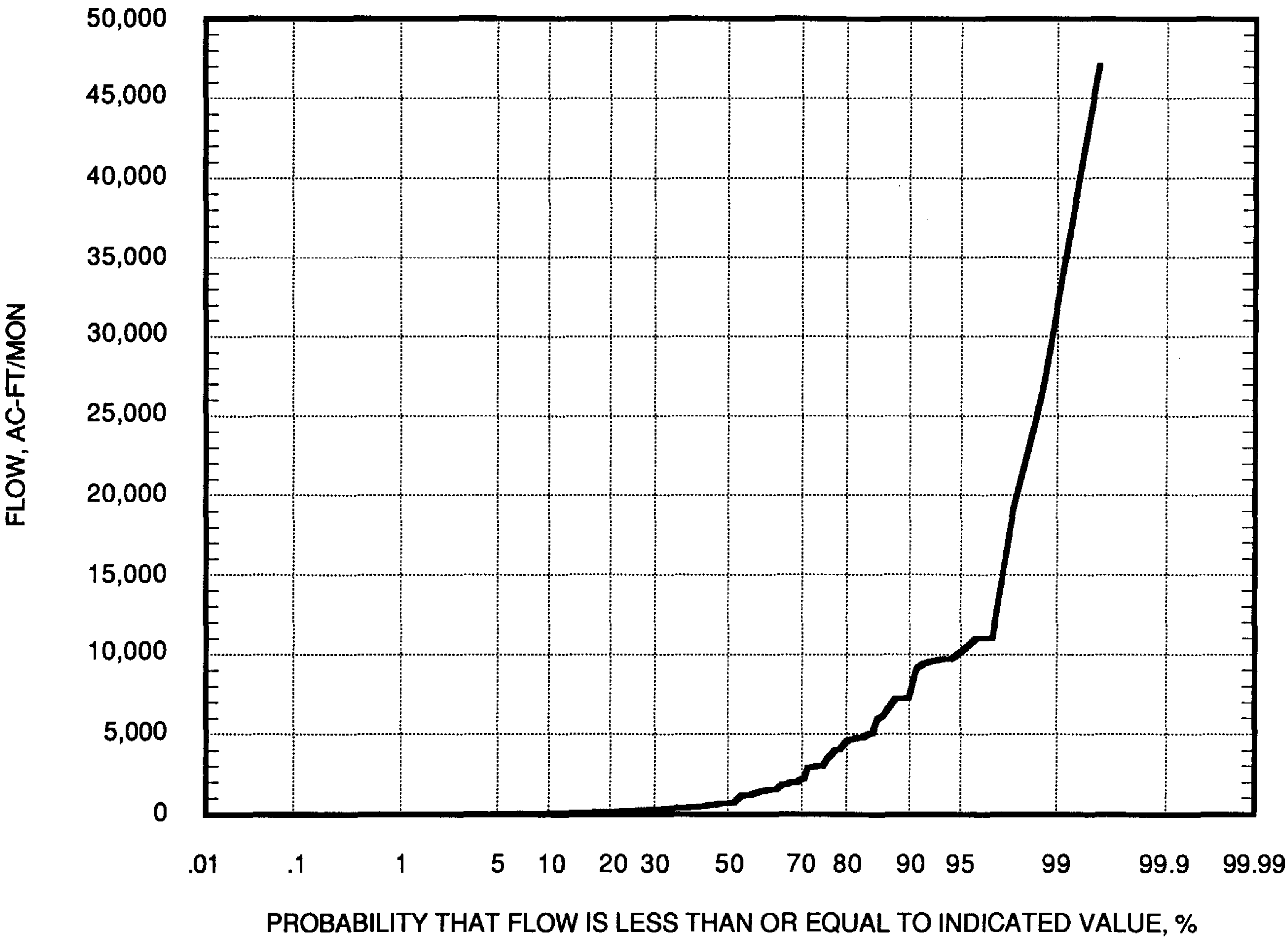
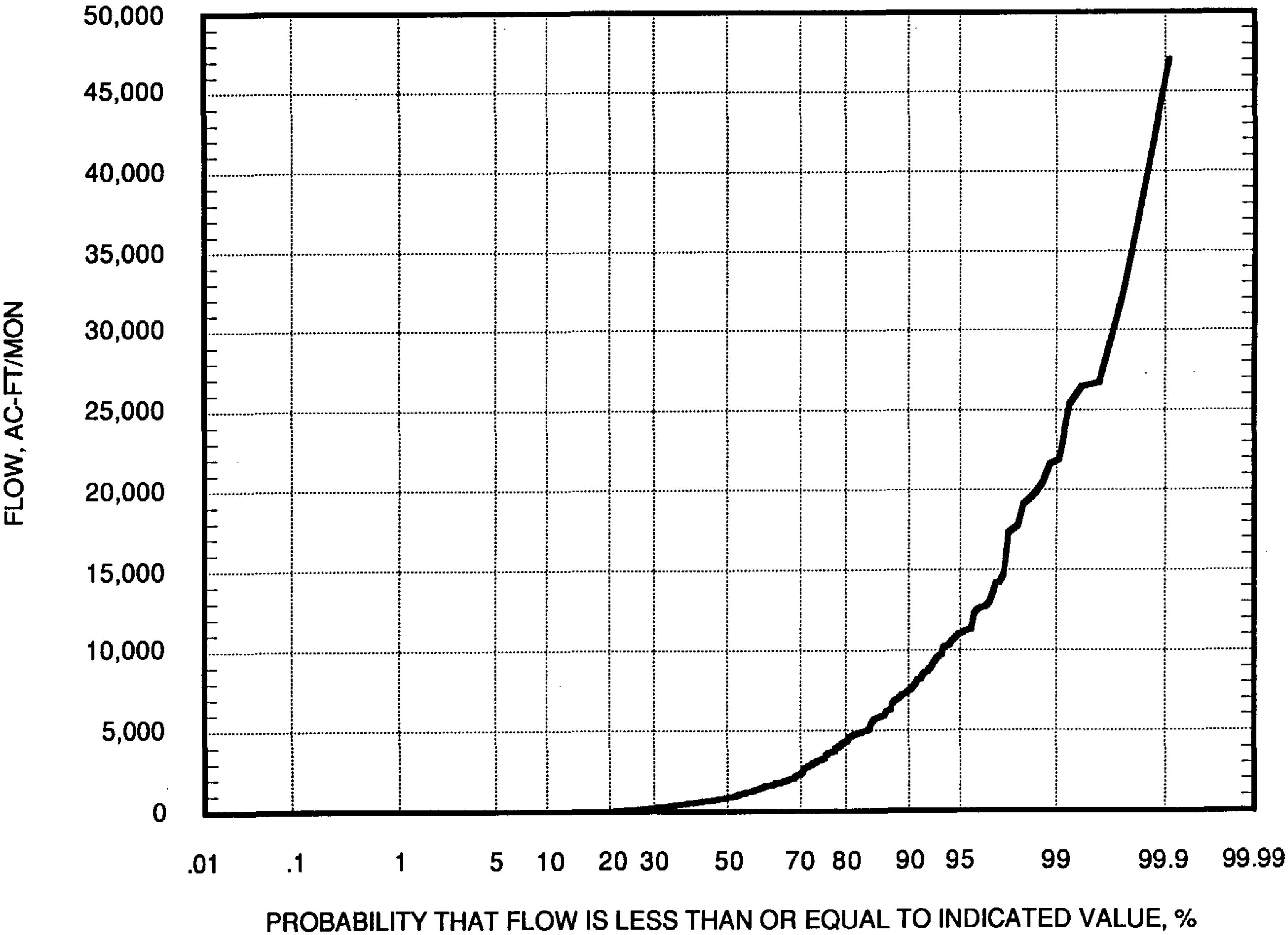


FIGURE 4.2-3 MONTHLY FLOW-DURATION FOR ONION CREEK AT DRIFTWOOD, 1941-1988



4.3 ESTIMATION OF STREAM FLOW ENTERING THE RECHARGE ZONE

The total flow from the Onion Creek watershed entering the Recharge Zone was estimated by using measured and generated stream flows for Onion Creek near Driftwood and unit runoff for the intervening drainage area below the Driftwood gage and above the bottom of the Recharge Zone.

Within Hays County, Onion Creek traverses a portion of the Recharge Zone of the Barton Springs segment of the Edwards aquifer. Onion Creek enters the Recharge Zone approximate 10 mi west of Buda, and leaves the zone 0.5 mi west of Buda (see Figure 1.4-1). Onion Creek has a drainage area above the Driftwood gaging station of 124 sq mi and a total drainage area of approximately 138.8 sq mi above the Recharge Zone. The Onion Creek watershed located within the Recharge Zone has a drainage area of approximately 26.2 sq mi, as shown in Table 4.3-1. This yields a total drainage area of 165.0 sq mi for the Onion Creek watershed above the bottom of the Recharge Zone. Applying the unit runoff method to the Driftwood streamgage results in a drainage area ratio factor of 1.35 (165/124). Therefore, daily and monthly flows from the Onion Creek watershed that are available for recharge were calculated by multiplying Driftwood flows times a factor of 1.35.

The monthly flows available for recharge, i.e., flows entering the Recharge Zone, from the Onion Creek watershed are shown in Table 4.3-2. For the 1941 through 1988 period the total annual flows available for recharge averaged 43,116 af. This ranged from a minimum annual flow of 406 af in 1956 to a maximum available flow of 122,259 af in 1973.

TABLE 4.3-1
DRAINAGE AREAS

SECTION	AREA (mi^2)
Driftwood Gage	124.0
Rutherford Reservoir	129.3
Top of Recharge Zone	138.8
Ruby Reservoir	144.1
Bottom of Recharge Zone	165.0
Buda Gage	166.0

TABLE 4.3-2
MONTHLY FLOWS AVAILABLE FOR RECHARGE

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1941	3304	14332	17344	16924	23247	18068	4903	1046	407	2436	534	306	102851
1942	93	63	93	5790	1666	574	73	1178	11085	7466	4248	2639	34968
1943	1900	1033	1481	2137	1061	622	1204	0	686	0	0	0	10124
1944	1937	6481	10522	5343	9324	6215	1771	3722	4719	675	770	7332	58811
1945	10001	10958	15153	7944	3210	2160	1146	254	222	832	226	2358	54464
1946	2455	4905	7822	3612	3087	1827	670	296	973	1651	15098	9801	52197
1947	11975	6249	4124	2762	1845	894	253	64	0	0	0	0	28166
1948	0	0	0	0	1251	0	0	0	0	170	0	0	1421
1949	0	477	718	8360	4986	913	169	0	0	0	0	0	15623
1950	0	37	0	587	1191	515	0	0	0	0	0	0	2330
1951	0	0	0	0	0	852	0	0	0	0	0	0	852
1952	0	0	0	424	2416	1661	0	0	43405	1184	628	1684	51402
1953	3179	1242	1083	1895	871	0	0	1067	5864	1127	1185	1497	19010
1954	646	287	62	0	0	0	0	0	0	0	0	0	995
1955	0	0	0	0	2139	0	0	0	0	0	0	0	2139
1956	0	0	0	0	0	0	0	0	0	302	89	15	406
1957	0	0	5215	28993	9983	10696	1061	59	6622	14529	11582	7276	96016
1958	6807	13781	14205	6673	33994	9004	2555	909	4267	4340	6623	2753	105911
1959	1827	2727	2628	6022	3062	2759	1128	1109	524	11317	1573	2367	37043
1960	4392	5788	4187	3564	2218	1209	2125	2252	859	23831	9191	13681	73297
1961	11577	26547	9504	3661	1872	11515	4233	1950	1409	1176	965	922	75331
1962	796	456	555	603	583	4461	717	0	523	75	0	649	9418
1963	366	174	146	2499	478	0	0	0	0	0	0	0	3663
1964	0	0	549	75	0	0	0	0	384	133	1071	0	2212
1965	963	10368	3095	6453	23520	17075	2469	1263	1601	3736	2358	10953	83854
1966	5006	4998	5296	6594	6473	2257	1307	743	1678	875	395	293	35915
1967	160	0	0	0	49	0	0	0	737	1469	3713	1757	7885
1968	35858	9529	7800	6619	9234	4460	2150	943	966	717	408	982	79666
1969	503	974	2109	4429	8408	4313	1543	880	663	2135	1153	3256	30366
1970	2641	5240	11854	4910	14898	7805	2135	1022	779	882	348	303	52817
1971	62	0	0	0	0	0	0	0	0	1211	1623	4886	7782
1972	2224	1117	816	341	7706	3731	1565	1193	432	1206	2158	1621	24110
1973	2988	5538	6319	6485	5694	17002	29440	5658	3383	27393	8473	3886	122259
1974	2831	2366	1964	1408	1457	756	266	1479	3039	2459	6224	3835	28084
1975	4766	19104	5702	4042	16774	16418	8411	3825	2353	2518	2329	1568	87810
1976	1387	985	1459	12474	15122	7645	9313	4284	2346	5032	7677	7974	75698
1977	6800	7926	5449	26049	10198	4370	2180	1030	652	1343	862	656	67515
1978	534	525	430	409	179	1426	0	305	2774	661	929	1067	9239
1979	7776	10166	19798	19083	13892	6376	1588	632	327	224	114	122	80098
1980	141	200	287	801	6240	2509	175	63	907	2142	1373	2716	17554
1981	2047	2388	9708	3911	2554	35523	6711	954	784	5473	1989	1111	73153
1982	769	539	404	574	9796	1682	530	78	105	63	129	190	14859
1983	678	2124	8286	5030	3960	4018	2709	1021	909	875	472	435	30517
1984	408	335	471	240	206	358	61	0	0	2947	1598	6426	13050
1985	13791	13085	14805	6429	1862	14810	4051	571	281	1992	6830	13002	91509
1986	3038	5869	2696	912	12702	9719	2107	507	429	8991	5418	25651	78039
1987	12238	6352	12859	4699	4032	63102	8023	1811	517	45	1593	586	115857
1988	733	531	600	521	396	227	119	113	16	16	0	0	3272

4.4 ESTIMATION OF HISTORICAL RECHARGE

Not all the stream flow that enters the Recharge Zone of the Onion Creek watershed is available for recharge. Onion Creek, like other creeks providing recharge to the Barton Springs segment of the Edwards aquifer, has a maximum infiltration rate that can transmit water from the creek bed to the water table. The USGS (Slade et al 1986) performed a flow-loss study on Onion Creek and used stream gaging records to determine a maximum infiltration rate for Onion Creek. From the 1986 study, the USGS estimated a maximum recharge rate for Onion Creek of "about 120 cfs". In addition, the USGS reported that the maximum recharge rate during floods is probably greater than the 120 cfs rate, because larger areas of streambed containing faults or other openings to the aquifer are inundated by floodwater.

A summary of the flow-loss study performed by the USGS (Slade et al 1986) on Onion Creek is shown in Table 4.4-1. The USGS found that between the upper part of the Recharge Zone (Station No. 481+00) and somewhere upstream of the YO Ranch/CenTex fence line (Station No. 116+79) that Onion Creek's stream flow diminished from 92.5 cfs to 0.0 cfs. The USGS probably pro-rated the loss of 92.5 cfs over approximately 36,420 ft of Onion Creek (between Station Nos. 481+00 and 116+79) and applied the pro-rated loss to the remaining portion of Onion Creek Recharge Zone of about 11,679 ft (between Station Nos. 116+00 and 0+00) to arrive at the estimated 120 cfs maximum recharge rate.

However, field and analytical investigations performed as part of this study indicate that the maximum recharge rate of Onion Creek is about 160 cfs. This higher recharge rate is supported by field observations. Downstream of the USGS's observed zero flow point (YO Ranch/CenTex fence line - Station No. 116+79) are located numerous significant recharge features. These include Barber Falls, Antioch Cave and several other moderate and high recharge areas (see Plate 2, Sheet 1 of 2).

TABLE 4.4-1
RESULTS OF USGS FLOW-LOSS STUDY OF ONION CREEK

USGS FLOW MEASUREMENTS[1] (cfs)	BS/EACD STATION No[2]	GENERAL STATION DESCRIPTION
92.5	481+00	Near top of recharge zone
91.5	434+45.2	Low-water crossing on Rutherford Ranch
57.0	356+00	2300 ft upstream from Searcy's East fence line
35.2	300+00	4300 ft upstream from YO ranch low-water crossing
0.0[3]	116+77	Centex Materials, Inc. and YO Ranch fence line

1 Source: Slade 1986

2 Approximate station location

3 Zero streamflow probably ocurred on the YO ranch upstram from the YO ranch Centex Materials, Inc. fence line. Exact location of zero flow location is unknown since USGS did not have access to the YO ranch during the course of their field investigations.

During observed flood flow events that occurred during the course of this study, significant recharge was observed to occur through the Barber Falls reach between Station Nos. 102+85 and 116+80, and at Antioch Cave between Station Nos. 20+00 and 39+00. Stream flow losses (recharge) occurring during these flood events were in excess of 60 cfs, based on flow and calculated measurements. This results in a total maximum recharge loss estimate of 160 cfs (approximately 100 cfs upstream of the YO Ranch/CenTex Materials fence line and 60 cfs downstream of this point) over the entire recharge reach of Onion Creek.

To support this maximum estimated recharge rate, an analysis of daily-lagged (one-day lag) stream flow measured at the Driftwood gage and the Buda gage for their common period of record was performed. This analyses indicated that stream flow losses of approximately 160 cfs are highly probable. Therefore, for the purposes of this study a maximum recharge rate of 160 cfs was used.

Applying a maximum recharge rate of 160 cfs to the 1941 through 1988 historical period may over- or under-estimate the volume of recharge that actually occurred. As discussed in Section 3.0 of this report, the openings of significant recharge features, such as Antioch Cave and Crippled Crawfish Cave, were known to be intermittently filled or clogged with debris and sediment. It is possible major floods would open-up these features, while minor floods would tend to close such features due to low velocities. Such closing and opening tendencies may apply to other recharge features such as faults, sinkholes and minor solution cavities. In addition, downstream migration of sediment deposition "cells" may tend to limit or restrict recharge within a given area. However, evidence and analyses performed as part of this investigation and by other researchers (Slade et al 1986) supports using a fixed maximum recharge rate.

Using a maximum recharge rate of 160 cfs, available daily stream flow, i.e., stream flow entering and occurring over the Recharge Zone was evaluated. For this analysis, daily estimated available stream flow rates of less than or equal to 160 cfs entering and occurring over the Recharge Zone were "recharged". Likewise, only 160 cfs was recharged when available estimated stream flow was greater than 160 cfs. Using this methodology, daily estimates of recharge were made.

For purposes of presentation, daily recharge estimates were summed monthly and annually and compared to available stream flow. For the period 1941 through 1988, the average annual stream flow available for recharge was calculated to be 43,116 af. This resulted, using the procedure described above, in an annual average recharge of 28,686 af, with a resulting average annual flow downstream of the Recharge Zone (at Buda) of 14,430 af. A graph illustrating annual available stream flow, recharge and flows at Buda, downstream of the Recharge Zone, is shown in Figure 4.4-1. Monthly bar charts illustrating these parameters are presented in Appendix E.

A comparison of monthly generated Onion Creek flows at Buda and measured (monthly) stream flow at Buda (USGS Station No. 08158800) for the period July 1979 through September 1983 is shown in Table 4.4-2. As shown on this table, the average monthly USGS measured flow at Buda was 1,841 af. The average monthly generated flow at this location was 799 af or about 43% of the measured stream flow. This might indicate that generated flows available for recharge from the Onion Creek watershed above Buda were underestimated and/or recharge volumes were over projected. Also, this may indicate that major recharge features, such as Antioch Cave and Crippled Crawfish Cave were covered with debris during the historical measured streamflow period, thereby, not providing for maximum recharge potential.

Annual rainfall recorded by the National Weather Service (NWS) at Blanco and Fisher, located west and near the upper end of the Onion Creek watershed, average 33.86 inches per yr and 33.41 inches per yr for the period 1979 through 1983, respectively. Similarly, NWS

FIGURE 4.4-1 PLOT OF ANNUAL FLOW AVAILABLE FOR RECHARGE, ESTIMATED RECHARGE VOLUME, AND FLOW AT BUDA, TEXAS ONION CREEK WATERSHED 1941-1988

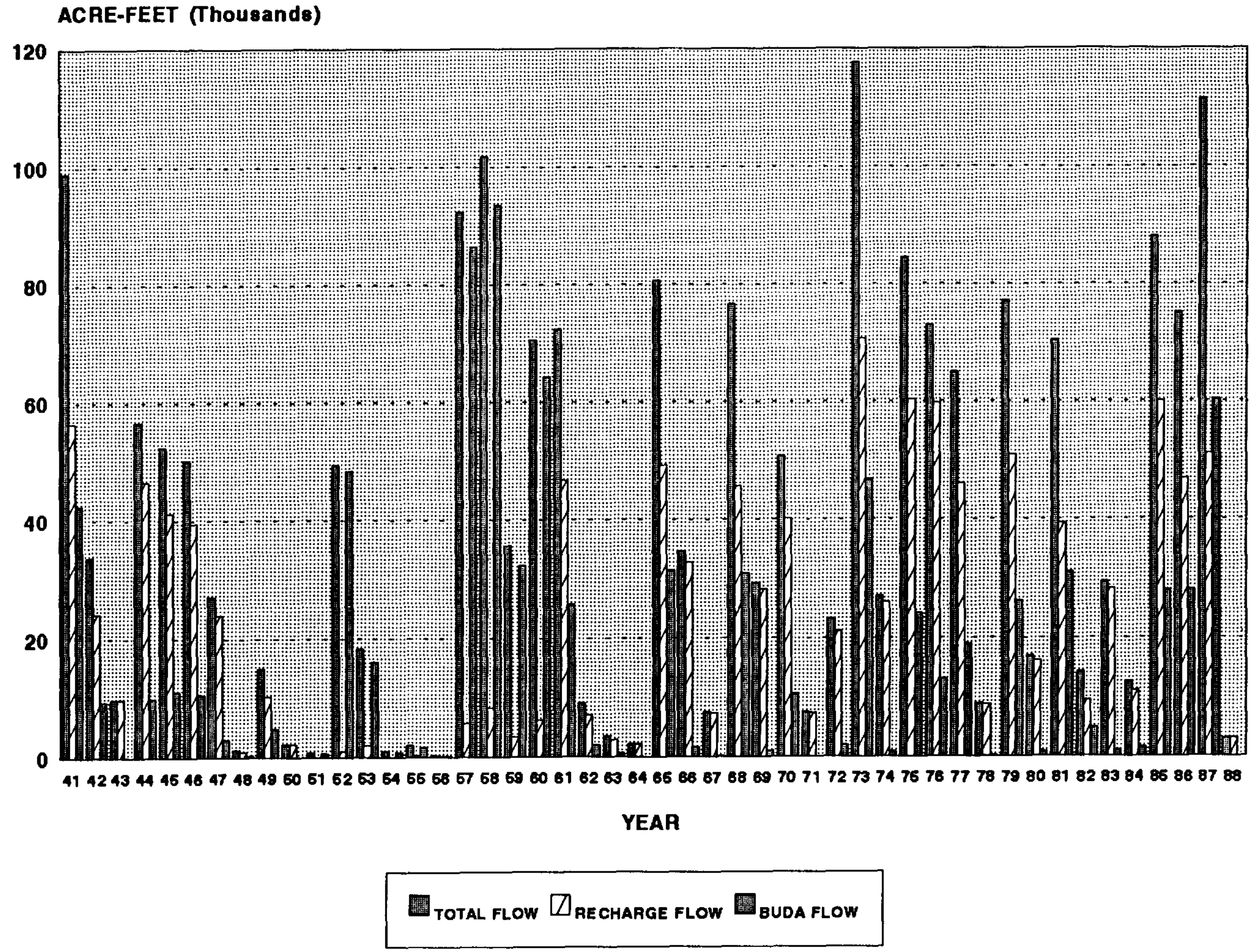


TABLE 4.4-2
COMPARISON BETWEEN MEASURED AND SIMULATED FLOWS AT BUDA, TEXAS

YEAR	MTH	MEASURED FLOW AT BUDA (AF)	SIMULATED FLOW AT BUDA (AF)
1979	JUL	963	256
1979	AUG	149	0
1979	SEP	112	0
1979	OCT	0	0
1979	NOV	8	0
1979	DEC	35	0
1980	JAN	19	0
1980	FEB	31	0
1980	MAR	27	0
1980	APR	23	1
1980	MAY	3006	738
1980	JUN	4	11
1980	JUL	0	0
1980	AUG	0	0
1980	SEP	0	3
1980	OCT	208	212
1980	NOV	2	5
1980	DEC	3	18
1981	JAN	1	0
1981	FEB	8	19
1981	MAR	6229	1869
1981	APR	134	28
1981	MAY	601	66
1981	JUN	60520	27547
1981	JUL	2535	594
1981	AUG	0	1
1981	SEP	0	0
1981	OCT	2908	2794
1981	NOV	0	3
1981	DEC	0	0
1982	JAN	72	0
1982	FEB	53	0
1982	MAR	30	0
1982	APR	4	0
1982	MAY	10004	5158
1982	JUN	6	4
1982	JUL	0	0
1982	AUG	0	0
1982	SEP	0	0
1982	OCT	0	0
1982	NOV	0	0
1982	DEC	0	0
1983	JAN	0	0
1983	FEB	0	14
1983	MAR	2067	893
1983	APR	674	34
1983	MAY	3053	404
1983	JUN	394	42
1983	JUL	11	12
1983	AUG	0	0
1983	SEP	8	2
AVERAGE MONTHLY		1841	799

annual rainfall recorded for the same period at San Marcos and Austin, located near and east of the Onion Creek watershed average 38.72 inches per yr and 34.28 inches per yr, respectively. This indicates that more rainfall occurred along and near the Interstate Highway 35 corridor, i.e., along the eastern portion of the Onion Creek watershed (near Buda), than on the western portion of the watershed during the 1979 through 1983 period. Distributing rainfall over the Onion Creek watershed for these four NWS rainfall stations, by using a Thiessen Network, results in an average annual rainfall of 37.08 inches for the period 1979 through 1983. This indicates that there was more rainfall occurring over the Onion Creek watershed, and that the stream flow projection methodology described earlier in this Section underprojected the quantity of runoff for this period. Therefore, projected stream flow underestimated actual stream flow resulting in conservative estimates of projected recharge quantities, i.e. tending to be underestimated.

As previously discussed, the openings to Antioch Cave and Crippled Crawfish Cave could have been clogged with debris and sediment during this period. Flow calculations indicate that if these two major recharge features were clogged, as much as, 30 to 50 af of water per day would not be recharged during "average" Onion Creek flood events.

Given the above considerations, the difference between generated and measured stream flow at Buda for the 1979 through 1983 period is not unexpected.

5.0 PROJECT ALTERNATIVES

There were five project alternatives evaluated in detail for this study. These alternatives, designed to maximize the artificial recharge potential of Onion Creek, are listed below:

1. Alternative No. 1 - CenTex Reservoir;
2. Alternative No. 2 - Ruby Reservoir;
3. Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation;
4. Alternative No. 4 - Rutherford Dam and Reservoir; and
5. Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry

The CenTex Reservoir (Alternative No. 1) and Ruby Reservoir (Alternative No. 2) involve the construction and operation of "on-channel" reservoirs situated directly on Onion Creek's Recharge Zone. These alternatives would temporarily impound water over known zones of moderate and high recharge potential in Onion Creek (see Plate 3). The CenTex Reservoir (Alternative No. 1) and Ruby Reservoir (Alternative No. 2) were evaluated as individual projects and as tandem reservoirs (Alternative No. 3), assuming both reservoirs were constructed.

The fourth alternative (No. 4), Rutherford Dam and Reservoir (see Plate 3), involves the construction of a dam and reservoir on Onion Creek located immediately above the Recharge Zone. This impoundment would store water during and after flood events. Water would be released after a flood subsides at a rate less than the maximum recharge rate (approximately 160 cfs) of Onion Creek.

A fifth alternative (No. 5), CenTex Diversion Dam and Recharge Quarry, involves the construction of a diversion dam on Onion Creek above Barber Falls (see Plate 3). Flood water would be diverted through a diversion channel to an existing CenTex Materials, Inc., quarry (pit). Water stored in the quarry would be recharged to the Edwards aquifer via a series of recharge wells.

5.1 HYDROLOGICAL METHODOLOGY FOR ALTERNATIVE ANALYSES

Hydrological analyses of the various project alternatives were performed using a modified version of the computer model SIMYLD. The SIMYLD model, originally developed by the Texas Water Development Board (TWDB 1969), mathematically simulates storage responses for a reservoir or series of reservoirs under a given set of hydrologic, climatologic, economic, and operational conditions. The original SIMYLD model performed reservoir(s) simulations on a monthly time step.

For this project, monthly simulation time steps were too long to adequately evaluate small recharge facilities and hydrologic responses, i.e. stream flow and recharge, which occur almost instantaneously. Therefore, a modified version was used which employs a daily time increment (time step).

The fundamental concept in applying the modified SIMYLD model is that the physical reservoir system can be transformed into a capacitated network flow problem. In making these transformations, the real system's physical elements are represented as a combination of two possible network components -- nodes and links. Given the proper parametric description of these two network components, it becomes a straight-forward task to develop the necessary network. Once properly developed, the network system can be analyzed as a direct analog of the real system.

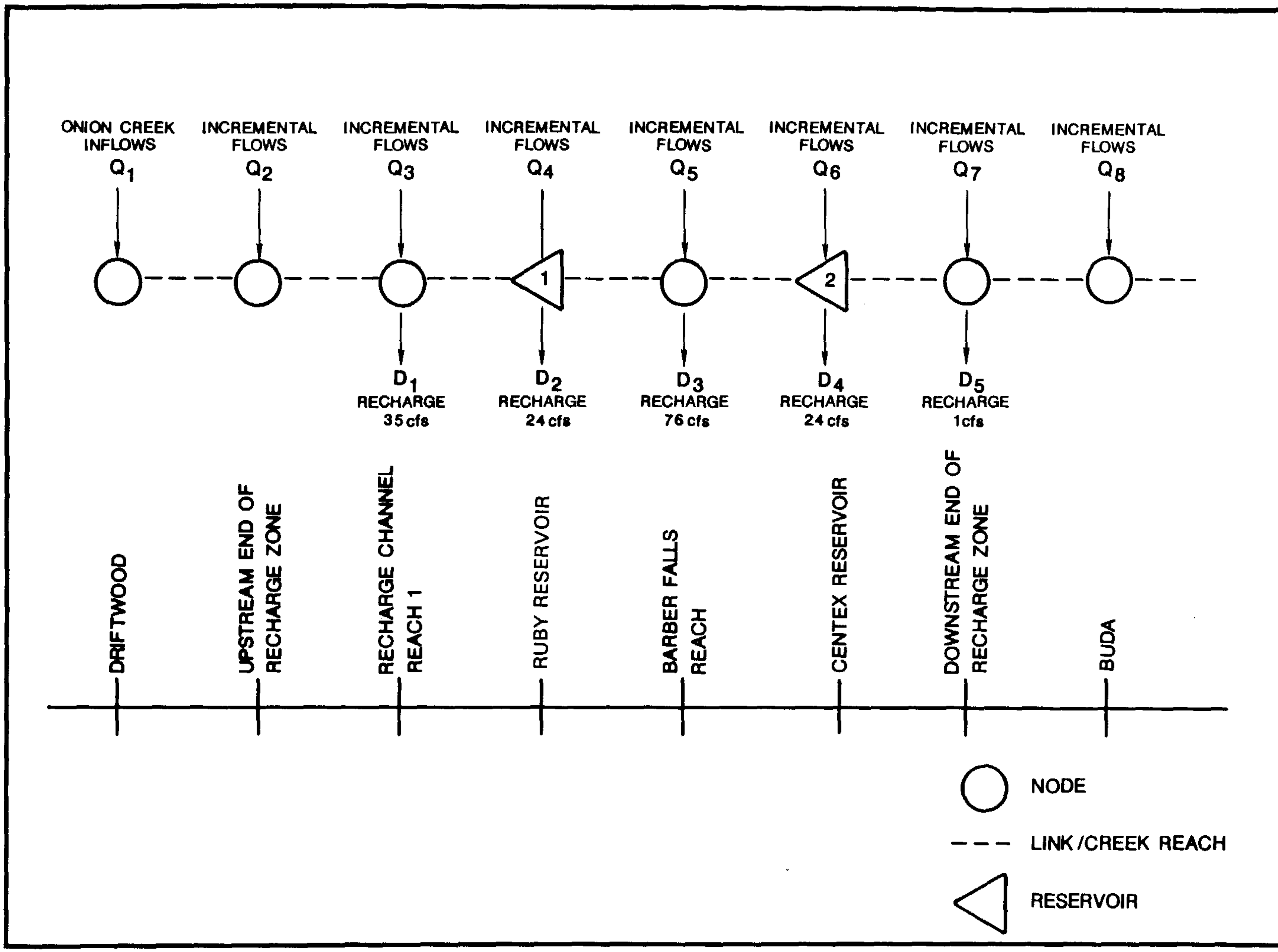
As the nomenclature implies, a node is a connection and/or branching point within the network. Therefore, a node is analogous to a reservoir or non-storage junction (i.e., canal junction, major river/creek confluence, etc.) in the physical system. Additionally, a node is a network component which is considered to have the capacity to store a finite and bounded amount of water moving within the network. In the case of SIMYLD, reservoirs are represented by nodes which have storage capacity and the ability to serve as branching points. A non-storage capacitated junction is handled similarly to a capacitated junction (reservoirs) except that its storage capacity is zero. Demands placed on the system must be located at nodal points. Also, any water entering the system, such as might occur naturally from runoff or artificially through import, must be introduced at a nodal point.

The transfer of water among the various network nodes is accomplished by transfer components called links. Typically, a link is a river reach, canal or closed conduit with a specified direction of flow and fixed maximum and minimum capacity. The physical system and its basic time step operation, in this case a day, is formulated as the network flow problem. The set of solutions to this network flow problem provide the sequential operation of the system with the set of monthly operations becoming the operation of the system over the entire length of the desired hydrologic sequence.

The initial step in the application of the SIMYLD model is the construction of the node-link network describing the physical system. For example, Figure 5.1-1 illustrates the node-link used for evaluation of Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation. In designing this node-link network, the physical system elements are represented by network element in the following manner:

1. CenTex and Ruby Reservoirs are represented by triangles;

FIGURE 5.1-1 SIMYLD NODE-LINK NETWORK OF CENTEX/RUBY RESERVOIRS OPERATED IN TANDEM



2. Non-storage junctions, i.e., Driftwood, upstream end of Recharge Zone, recharge channel reach 1, Barber Falls reach, and downstream end of Recharge Zone reach are represented by circles; and

3. River reaches above Ruby Reservoir, between Ruby Reservoir and CenTex Reservoir and below CenTex Reservoir are represented by dashed lines.

Inflows to and diversion from, in this case recharge, the system are identified on the network diagram (see Figure 5.1-1) by the Q arrows and the D arrows, respectively. For example, the inflow to Ruby Reservoir, Q_4, includes the sum of the Onion Creek flow upstream of the reservoir, tributary inflows and/or direct runoff from all other contributing drainage areas. Recharge or diversions for each creek reach were assigned, based, in part, on the information presented in Table 4.4-1.

With the model network defined to approximate the real physical system, the solution procedure follows the next four steps in moving from a known set of state variables (i.e., nodal storage volumes and link flow values) at the beginning of a time step to the solution for the required set of state variables at the end of the time step. The four solution steps are summarized as follows:

1. The present status of the network is evaluated and all system elements are given an appropriate parametric description;

2. All specified hydraulic and hydrologic inputs and demands are accounted for and the mass balance for the entire network system is determined. Bounds are placed on system demands, spills and storage levels;

3. The flows necessary to meet the levels required by Step 2 and at the same time to minimize the system's total cost of water transport are determined through the application of an optimization procedure; and

4. All necessary state variables have now been determined and the status of the system at the conclusion of the current time step becomes the status at the beginning of the next time step.

This procedure is repeated in a stepwise fashion until a specified simulation period, in this case January 1, 1941 through December 31, 1988, has been spanned. The required data inputs to the SIMYLD program and its simulated results are summarized in Table 5.1-1. Using the procedures described above a SIMYLD model (modified daily version) was coded and operated for a baseline condition (without projects) and for each of the project alternatives. The "without" project condition was run to establish historical recharge and flows at Buda (below the Recharge Zone) on a daily, monthly and annual basis. Subsequent runs for "with" project conditions were made to determine total recharge resulting from each alternative and resulting flow at Buda. The difference in recharge for with and without project conditions is the additional recharge attributable to each respective project.

5.2 WITH AND WITHOUT PROJECT ANALYSES

As described in the previous section, a daily SIMYLD model was coded and operated on a daily basis for the simulation period of January 1, 1941 through December 31, 1988. The following cases were evaluated:

1. Historical Baseline - "Without" Project Condition
2. Alternative No. 1 - CenTex Reservoir;
3. Alternative No. 2 - Ruby Reservoir;

TABLE 5.1-1
DAILY SIMYLD INPUT DATA AND SIMULATED OUTPUTS

INPUT DATA:

- Description of System Node-Link Network Configuration
- Identification of Yield Node (Optional)
- Number of Years to be Simulated
- Order of Preference for System Spill Nodes
- Area-Capacity Description for Reservoirs
- Daily Demands and Distributions for Nodes (Optional)
- Average, Wet and Dry Condition Priorities for Satisfying Nodal Demands
- Definition of Average, Wet and Dry Conditions in Terms of Reservoir Storage
- Reservoir Operation Rules in Terms of Desired Monthly Percentage Storage for Average, Wet and Dry Conditions and Priorities for Maintaining These Storage Conditions
- Daily Input Amounts and Distributions for Nodes
- Daily Inflows for Nodes
- Daily Demands for Nodes
- Daily Net Evaporation for Reservoirs

SIMULATED OUTPUTS:

- For Each Reservoir Node, Daily Values of:
  - Beginning of Day Storage
  - End of Day Storage
  - Inflows from Upstream Reservoir Release or Spills
  - Average Surface Area
  - Net Evaporation Losses
  - Downstream Spills
  - Shortages in Meeting Specified Demands
  - System Spill Losses
- Daily Shortage in Meeting Demands at Non-Storage Junction Nodes
- Daily Flows in System Links
- Monthly/Annual Yield Values When Calculated
- Monthly/Yearly Summaries and Average Annual Values for the above Daily Outputs by Node and Link and for the System

4. Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation;
5. Alternative No. 4 - Rutherford Dam and Reservoir; and
6. Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry

The hydrological and meteorological data inputs were similar for each simulation. Onion Creek and tributary inflows for each alternative were estimated by applying appropriate unit runoff ratios to the calculated or measured daily stream flows for Onion Creek near Driftwood (see Appendix D). Daily net evaporation data for quadrangles segmented along one degree parallels of latitude and medians of longitude was obtained from the Texas Water Development Board (TWDB 1967 and TWDB 1991). Daily net reservoir evaporation for the study area was computed by applying a weighted average to the appropriate quadrangle evaporation rates reported by the TWDB.

Baseline recharge rates were assigned to each creek reach based on actual flow-loss studies performed by the USGS and on investigations performed as part of this study. The maximum recharge rate of 160 cfs (see Section 4.4) was distributed over the Recharge Zone of Onion Creek (immediate creek channel), as shown in Figure 5.1-1.

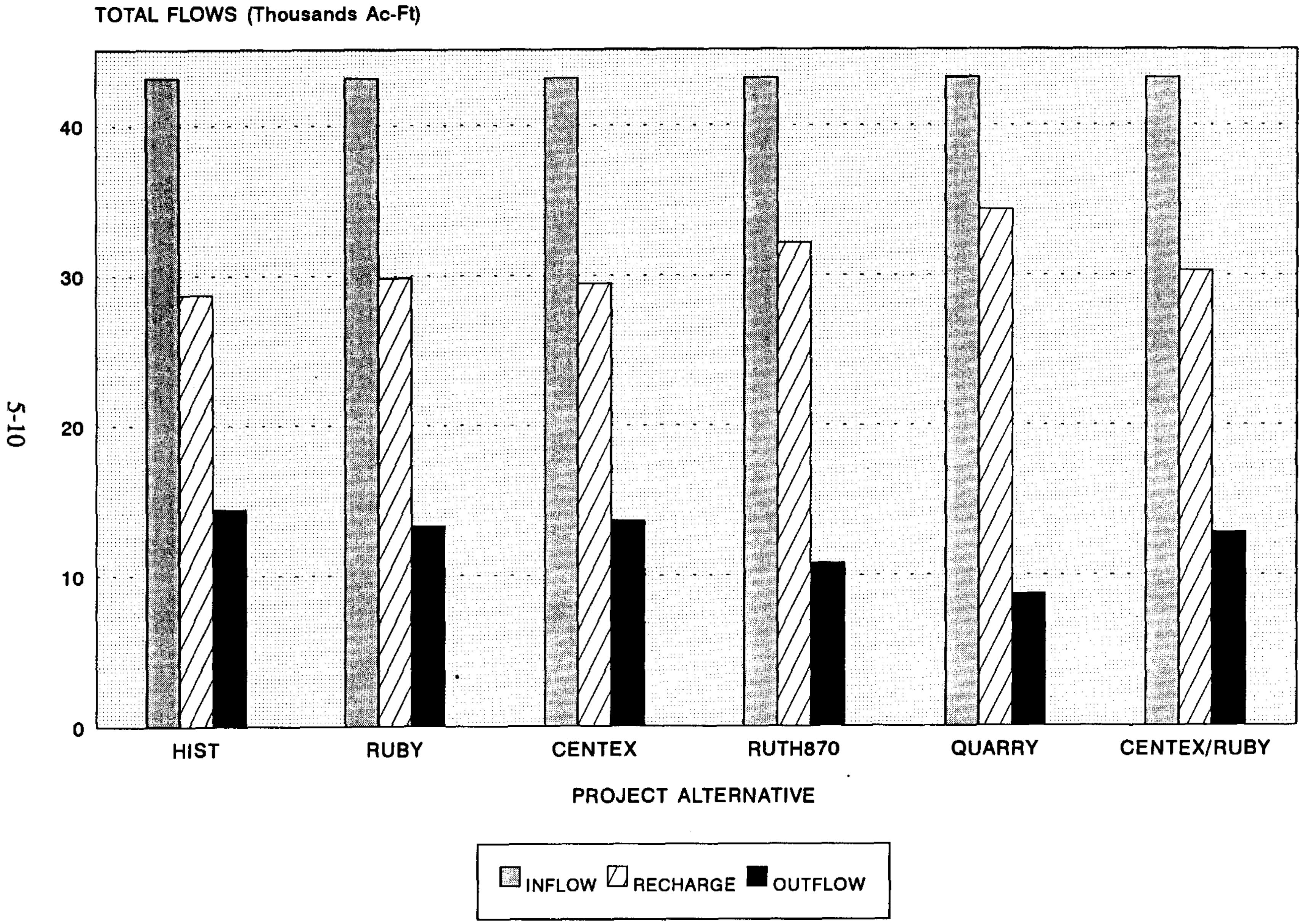
Reservoir area-elevation-capacity relationships for each alternative were developed from field survey information and USGS 7.5 minute topographic quadrangles. The physical descriptions of each project alternative, including area-elevation-capacity relationships, are presented in Sections 5.2.1 through 5.2.5.

The results from the SIMYLD simulations are summarized in Table 5.2-1. Values of total and incremental increase in the recharge and resulting outflow below the Recharge Zone (at Buda) for each project alternative are presented in this table and are illustrated graphically in Figure 5.2-1. The annual increase in recharge for each project alternative is shown in

TABLE 5.2-1
SUMMARY OF TOTAL AND INCREMENTAL INCREASE IN RECHARGE AND RESULTING FLOWS AT BUDA FOR EACH PROJECT ALTERNATIVE

ALTERNATIVE	AVERAGE ANNUAL INFLOW (AF)	AVERAGE ANNUAL RECHARGE (AF)	AVERAGE ANNUAL RECHARGE INCREASE (AF)	AVERAGE ANNUAL OUTFLOW (AF)
HISTORICAL-BASE CONDITION	43116	28686	—	14430
CENTEX RESERVOIR	43116	29447	762	13674
RUBY RESERVOIR	43121	29829	1143	13298
CENTEX RESERVOIR AND RUBY RESERVOIR TANDEM OPERATION	43116	30261	1576	12851
RUTHERFORD DAM AND RESERVOIR	43116	32201	3515	10810
CENTEX DIVERSION DAM AND RECHARGE QUARRY	43139	34404	5718	8736

FIGURE 5.2-1
AVERAGE ANNUAL FLOWS FOR EACH PROJECT ALTERNATIVE



INFLOW = TOTAL INFLOW AT RECHARGE ZONE
RECHARGE = TOTAL RECHARGE FOR PROJECT ALTERNATIVE
OUTFLOW = TOTAL FLOW AT BUDA

Table 5.2-2 and in Figures 5.2-2 through 5.2-6. The resulting annual outflow, i.e. estimated stream flow at Buda, for each project alternative is shown in Table 5.2-3.

The total stream flow from Onion Creek above the Recharge Zone was estimated to be about 43,116 af per yr. Of this quantity, an average of 28,686 af per yr was recharged, resulting in an average outflow below the Recharge Zone at Buda of 14,430 af per yr. Annual recharge was greater than 28,686 af in 24 of the 48 yr period (1941 through 1988). There were no years during the simulation period that recharge did not occur. Historical recharge ranged from a low of 404 af in 1956 to a high of 72,096 af in 1973.

The CenTex Reservoir alternative (No. 1) would provide an additional recharge of 762 af per yr. During the 48 yr simulation period, the increase in recharge for this alternative ranged from zero in seven years to a maximum of 2,477 af in 1957. Therefore, this project alternative would have not provided any additional recharge than occurred historically about 15% of the time. For 20 of the 48 years simulated, Centex Reservoir would have provided recharge in excess of 762 af per yr. A daily reservoir stage-duration relationship for the CenTex Reservoir alternative is shown in Figure 5.2-7. This reservoir would be at or near full capacity about 8% of the time and at zero capacity about 85% of the time.

Alternative No. 2 - Ruby Reservoir would provide an additional recharge of 1,143 af per yr. For the simulation period 1941 through 1988, annual recharge (additional) range from zero in 7 years (15% of the time) to a maximum of 3,854 ac ft in 1957. For 20 of the 48 years simulated, this alternative would have provided recharge in excess of 1,143 af per yr. This reservoir would be at or near full capacity about 8% of the time and at zero capacity about 87% of the time (Figure 5.2-8).

Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation would have provided 1,576 af of additional recharge per yr during the simulation period.

TABLE 5.2-2
HISTORICAL ANNUAL RECHARGE AND ANNUAL INCREASE IN RECHARGE FOR EACH PROJECT ALTERNATIVE

YEAR	HISTORICAL ANNUAL RECHARGE (AF)	CENTEX ANNUAL RECHARGE INCREASE (AF)	RUBY ANNUAL RECHARGE INCREASE (AF)	CENTEX/RUBY ANNUAL RECHARGE INCREASE (AF)	RUTHERFORD ANNUAL RECHARGE INCREASE (AF)	QUARRY ANNUAL RECHARGE INCREASE
1941	57347	2063	3146	3604	5693	19064
1942	24783	1825	2577	3442	6885	4865
1943	10111	0	0	0	0	0
1944	47705	1526	2406	3542	7746	8385
1945	42068	848	1394	1968	4251	10376
1946	40608	1324	2095	3093	4893	7806
1947	24754	274	443	710	4481	3243
1948	1080	271	317	335	0	335
1949	10432	558	761	987	2748	2142
1950	2328	0	0	0	0	0
1951	849	0	0	0	0	0
1952	11833	569	925	1293	3128	2336
1953	15763	331	487	761	1602	2092
1954	995	0	0	0	0	0
1955	1524	313	603	604	0	604
1956	404	0	0	0	0	0
1957	46547	2477	3854	5289	12682	17056
1958	63451	2128	3333	4500	11859	14292
1959	28474	957	1336	1619	3973	2340
1960	47053	1005	1494	2021	4332	8599
1961	47823	795	1302	2033	7344	10397
1962	7325	273	422	706	920	1401
1963	2978	272	435	674	0	657
1964	2208	0	0	0	0	0
1965	50272	1778	2864	4217	7029	14462
1966	33870	521	785	1078	3067	1841
1967	7634	222	257	222	0	233
1968	46809	906	1201	1776	5106	6468
1969	29054	502	679	937	137	1198
1970	41062	676	985	1580	4771	7179
1971	7722	22	32	22	0	35
1972	21746	481	604	916	0	2214
1973	72096	1002	1329	1837	6689	16377
1974	26932	628	790	1019	0	1043
1975	61457	977	1506	2016	7227	15620
1976	60969	1233	1736	2437	4733	10444
1977	47097	583	784	1000	3555	5759
1978	9049	175	207	175	0	179
1979	51647	1459	2012	2769	4360	15413
1980	16566	669	966	909	0	927
1981	40232	949	1463	2227	6189	7996
1982	9697	271	475	706	3328	1443
1983	29116	708	997	1237	0	1275
1984	11379	624	783	775	0	986
1985	60887	1347	2210	3342	9575	19231
1986	47997	1612	2617	3951	11226	11456
1987	51916	1402	2240	3299	10650	16666
1988	3271	0	0	0	0	0
MAX YEAR	72096	2477	3854	5289	12682	19231
MIN YEAR	404	0	0	0	0	0
AVG	28686	762	1143	1576	3515	5718

FIGURE 5.2-2
ANNUAL INCREASE IN RECHARGE RESULTING FROM
ALTERNATIVE No. 1 - CENTEX RESERVOIR

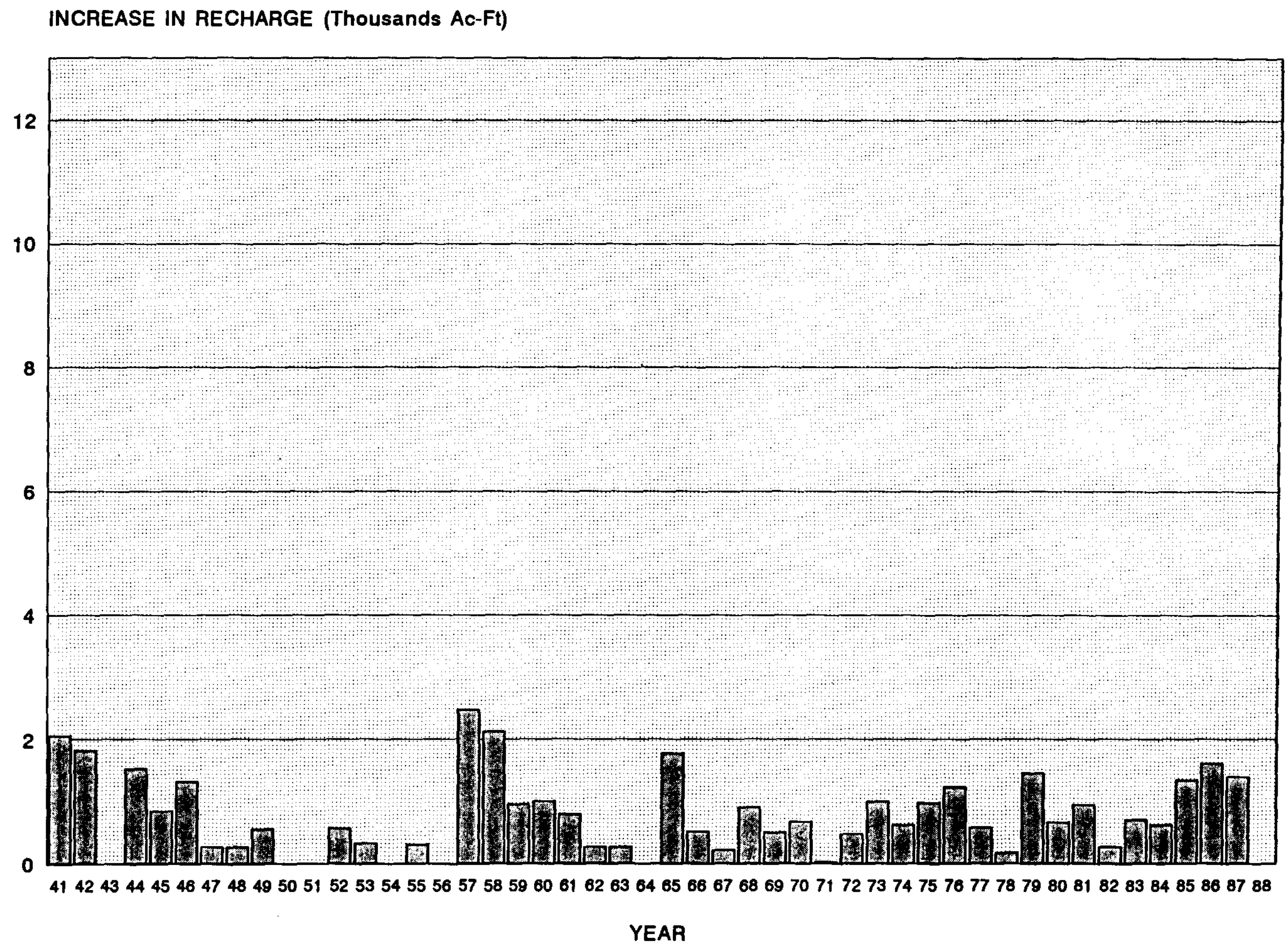


FIGURE 5.2-3
ANNUAL INCREASE IN RECHARGE RESULTING FROM
ALTERNATIVE No. 2 - RUBY RESERVOIR

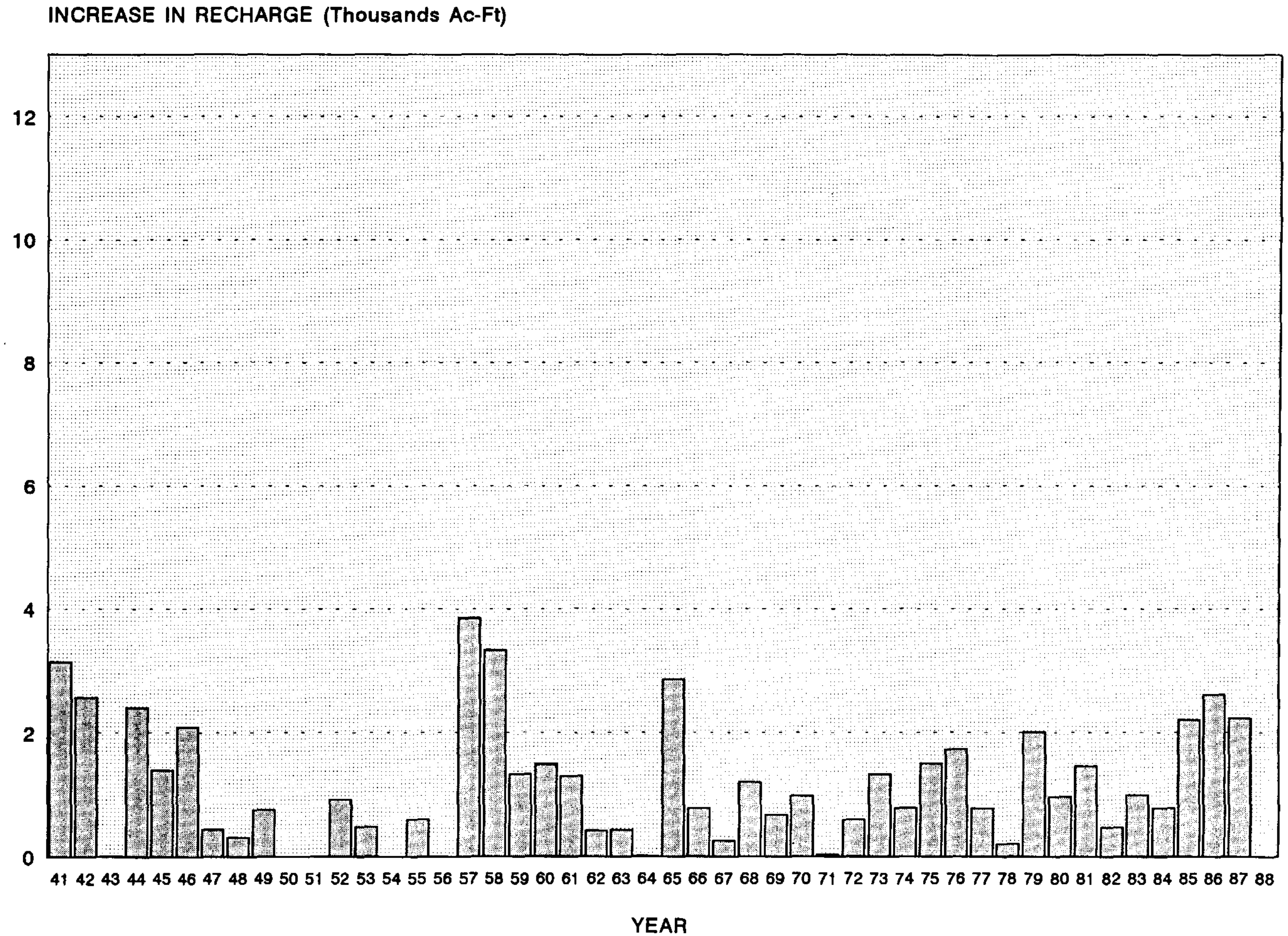


FIGURE 5.2-4
ANNUAL INCREASE IN RECHARGE RESULTING FROM
ALTERNATIVE No. 3 - CENTEX RESERVOIR AND RUBY RESERVOIR TANDEM OPERATION

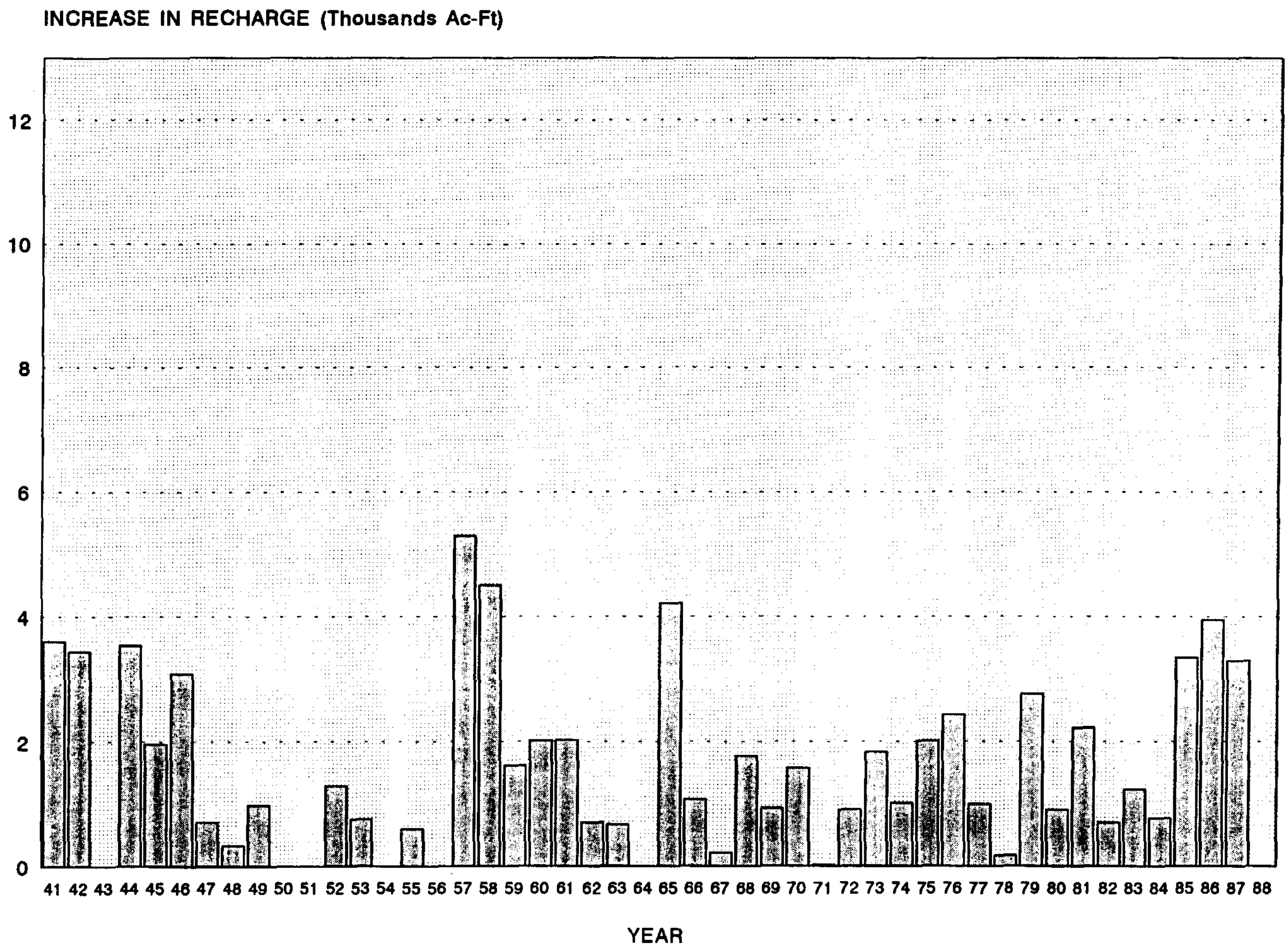


FIGURE 5.2-5
ANNUAL INCREASE IN RECHARGE RESULTING FROM ALTERNATIVE No. 4 - RUTHERFORD RESERVOIR

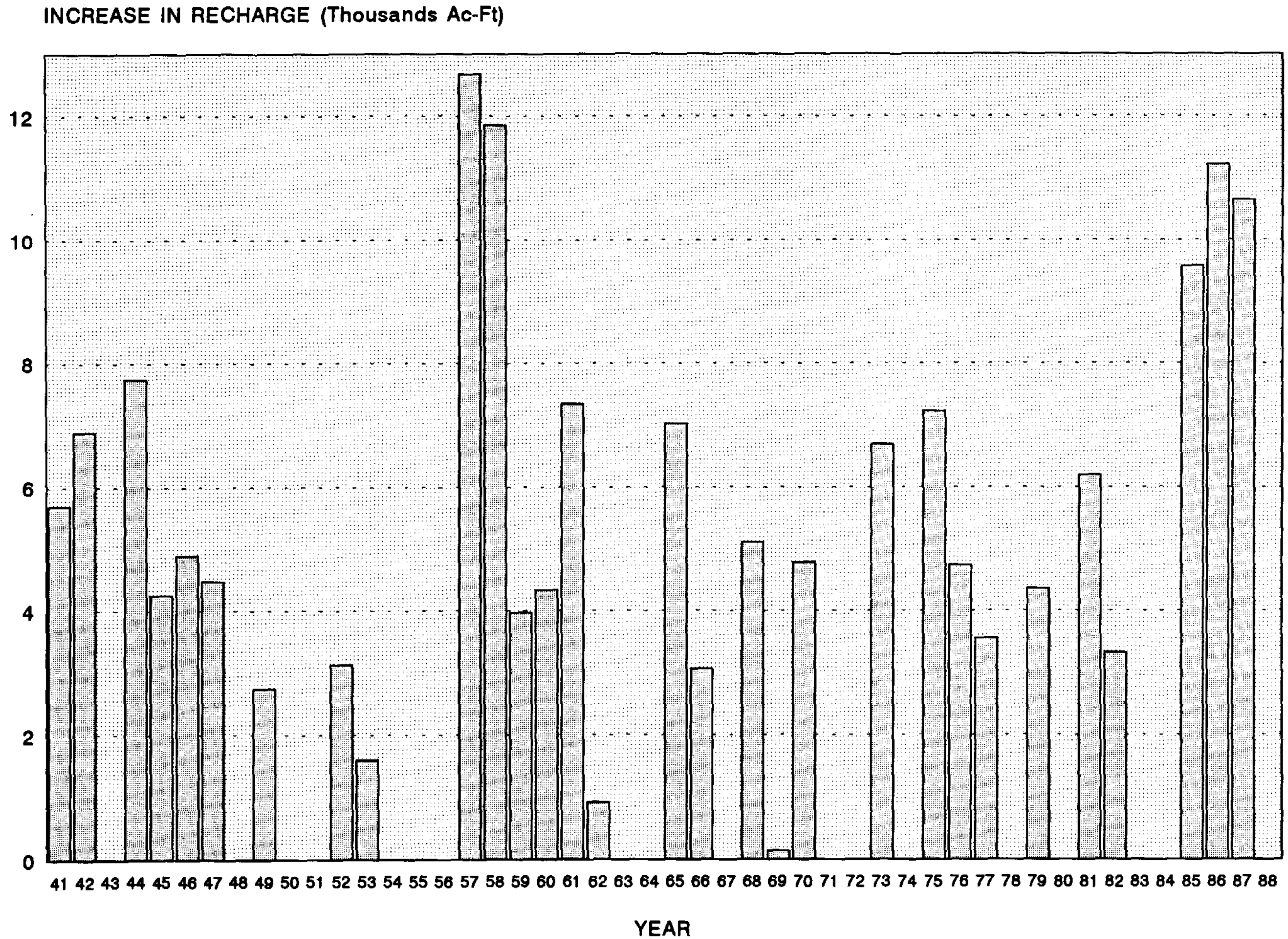


FIGURE 5.2-6
ANNUAL INCREASE IN RECHARGE RESULTING FROM ALTERNATIVE No. 5 - CENTEX DIVERSION DAM AND RECHARGE QUARRY

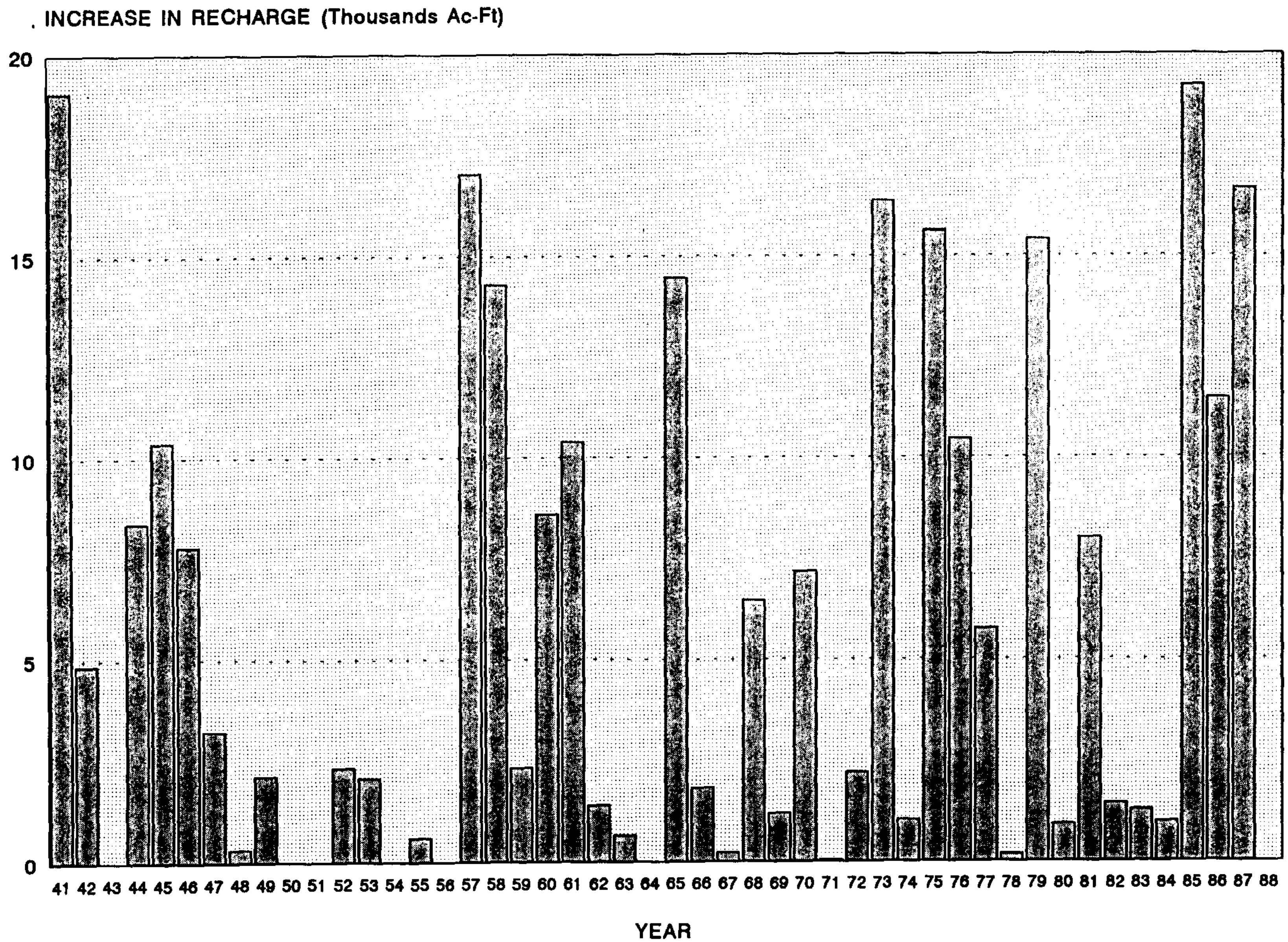


TABLE 5.2-3
HISTORICAL AND ESTIMATED ANNUAL OUTFLOW AT BUDA FOR EACH PROJECT ALTERNATIVE

YEAR	HISTORICAL ANNUAL OUTFLOW (AF)	CENTEX ANNUAL OUTFLOW (AF)	RUBY ANNUAL OUTFLOW (AF)	CENTEX/RUBY ANNUAL OUTFLOW (AF)	RUTHERFORD ANNUAL OUTFLOW (AF)	QUARRY ANNUAL OUTFLOW (AF)
1941	45504	43712	42757	41900	39495	26468
1942	10185	8360	7637	6743	3316	5336
1943	13	13	13	13	13	13
1944	11106	9577	8688	7540	3222	2764
1945	12396	11548	11039	10428	8032	2047
1946	11589	10265	9495	8496	4153	3816
1947	3412	3138	2972	2702	1304	195
1948	341	70	6	6	348	6
1949	5191	4633	4469	4204	2409	3058
1950	2	2	2	2	2	2
1951	3	3	3	3	3	3
1952	39569	39000	38672	38276	36242	37243
1953	3247	2916	2745	2480	1501	1179
1954	0	0	0	0	0	0
1955	615	302	21	11	617	12
1956	2	2	2	2	2	2
1957	49469	47000	45642	44197	36219	32451
1958	42460	40332	39129	37960	31080	28220
1959	8569	7612	7251	6950	4621	6260
1960	26244	24968	24317	23517	18430	17663
1961	27508	26984	26630	26181	23549	17173
1962	2093	1820	1657	1387	1126	696
1963	685	413	249	11	699	28
1964	4	4	4	4	4	4
1965	33582	31804	30680	29342	25084	19167
1966	2045	1524	1235	967	212	237
1967	251	29	29	29	249	29
1968	32857	31951	31627	31081	27693	26433
1969	1312	810	645	375	1152	149
1970	11755	11069	10691	10150	6778	4611
1971	60	38	38	38	88	38
1972	2364	1883	1718	1448	2382	163
1973	50163	49155	48796	48280	43190	33837
1974	1152	524	355	133	1170	139
1975	26353	25376	24831	24320	18919	10767
1976	14729	13496	12993	12291	9826	4335
1977	20418	19835	19673	19418	16713	14710
1978	190	15	15	15	188	15
1979	28451	26992	26470	25682	23912	13059
1980	988	319	79	79	1016	79
1981	32921	31963	31473	30671	26622	24965
1982	5162	4891	4727	4456	1726	3732
1983	1401	693	420	161	1402	161
1984	1671	776	461	190	1680	81
1985	30622	29493	28845	27765	17837	12040
1986	30042	28212	26965	25606	18149	17625
1987	63941	62810	62142	61331	56482	48311
1988	1	1	1	1	1	1
MAX	63941	62810	62142	61331	56482	48311
MIN	0	0	0	0	0	0
AVG	14430	13674	13298	12851	10810	8736

FIGURE 5.2-7 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP CENTEX RESERVOIR (ALTERNATIVE NO.1), 1941-1988

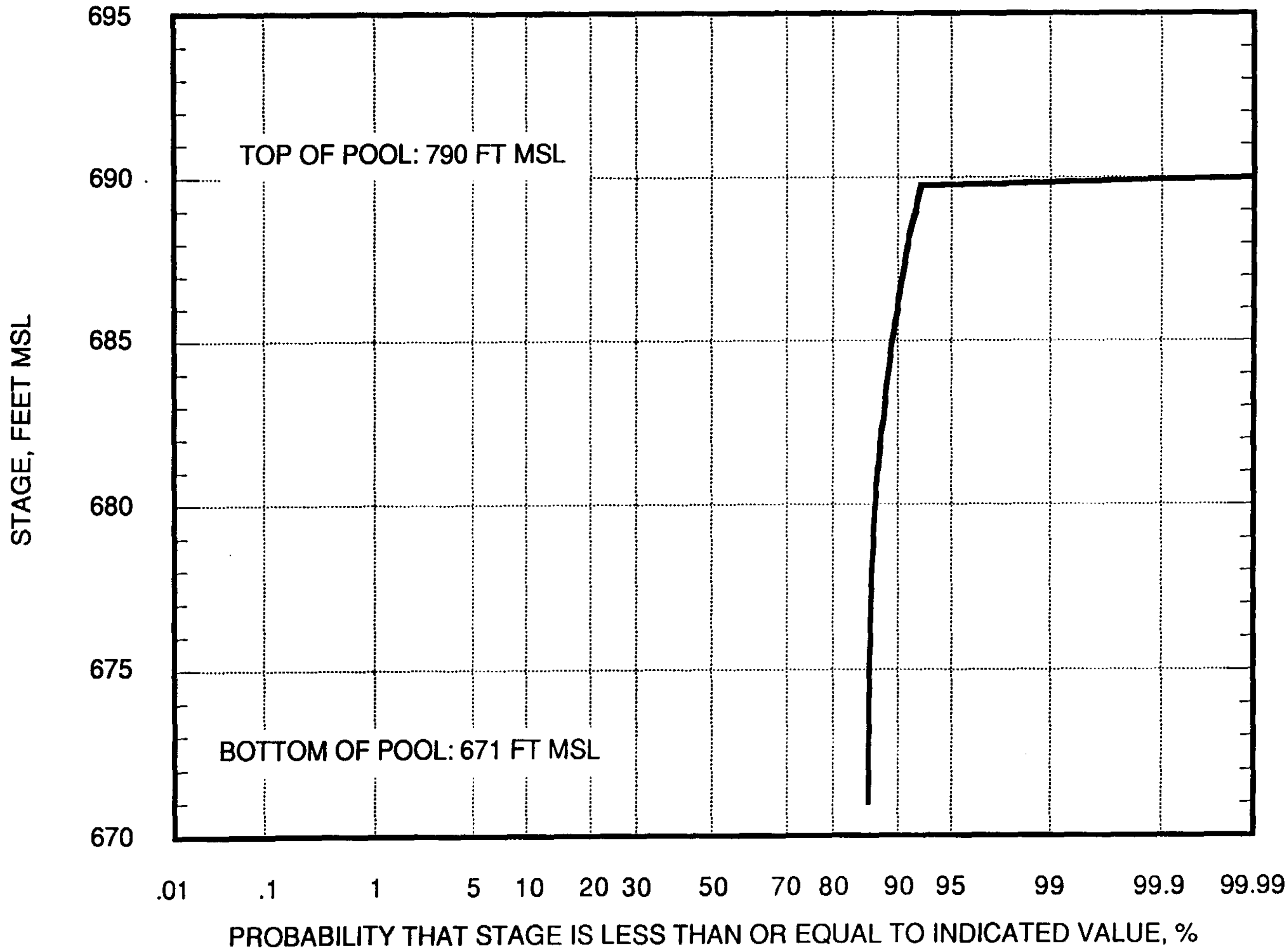
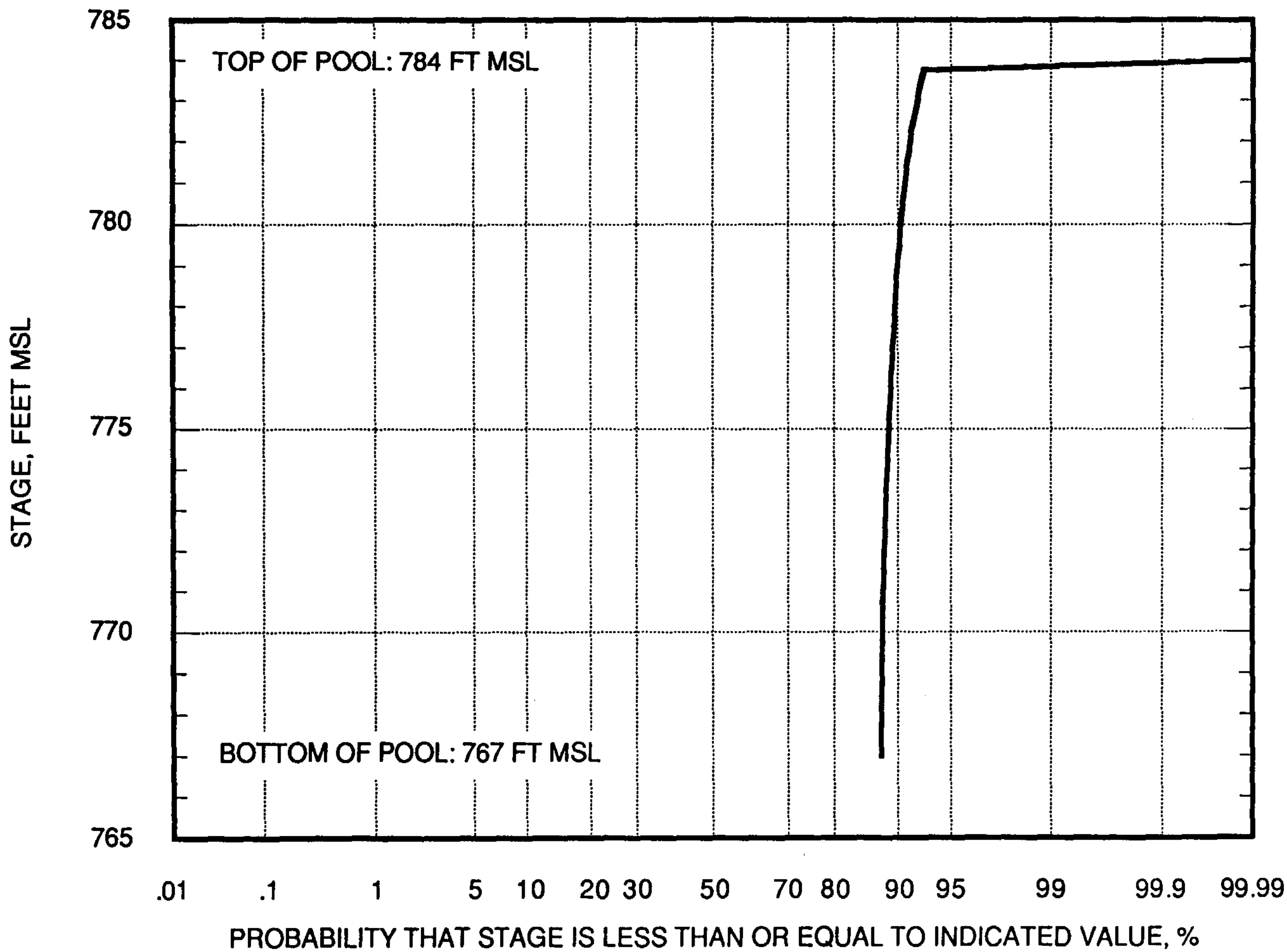


FIGURE 5.2-8 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP FOR RUBY RESERVOIR (ALTERNATIVE No. 2), 1941-1988



Additional recharge would not have occurred in 7 years of the 48 yr period. However, recharge in excess of the average annual quantity (1,576 af) would have occurred in 44% of the years (21 years out of 48 yr). Under this alternative, CenTex Reservoir and Ruby Reservoir would have been at full capacity about 7% of the time and at zero capacity about 88% of the time, as shown in Figures 5.2-9 and 5.2-10.

Alternative No. 4 - Rutherford Dam and Reservoir would provide an additional recharge of 3,515 af per yr. For 18 yr of the 48 yr simulation period, this alternative would have provided zero additional recharge. In fact, historical recharge for these 18 individual years was slightly decreased due to the capture and maintenance of a minimum 200 af storage capacity in Rutherford Reservoir (see Section 5.2.3), which is located upstream from the Recharge Zone. However, during "normal" and above normal stream flow years this alternative would provide for a substantial increase in recharge over historical conditions. Annual recharge exceeded the average annual recharge of 3,515 af in 26 years (54%) of the 48 year simulation period. The maximum recharge simulated for this alternative was 12,682 af, which occurred in year 1957. A daily reservoir stage-duration relationship for this alternative is shown in Figure 5.2-11. Rutherford Reservoir would be at maximum capacity approximately 6% of the time and would have a capacity of 200 af or more 85% of the time.

Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry provides the greatest potential for recharge enhancement of any other alternative evaluated. This alternative would provide an additional 5,718 af of recharge per yr, based on the 1941 through 1988 simulation period. As shown in Figure 5.2-12, the recharge quarry would contain about 1,000 af of water approximately 3% of the time and contain some water about 7% of the time. Annual recharge for this alternative ranges from a minimum of zero in 7 yr to a maximum of 19,231 af in the year 1985. Annual recharge was in excess of 5,718 af for 20 yr of the 48 yr simulated.

FIGURE 5.2-9 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP FOR CENTEX RESERVOIR IN TANDEM OPERATION WITH RUBY RESERVOIR (ALTERNATIVE No. 3), 1941-1988

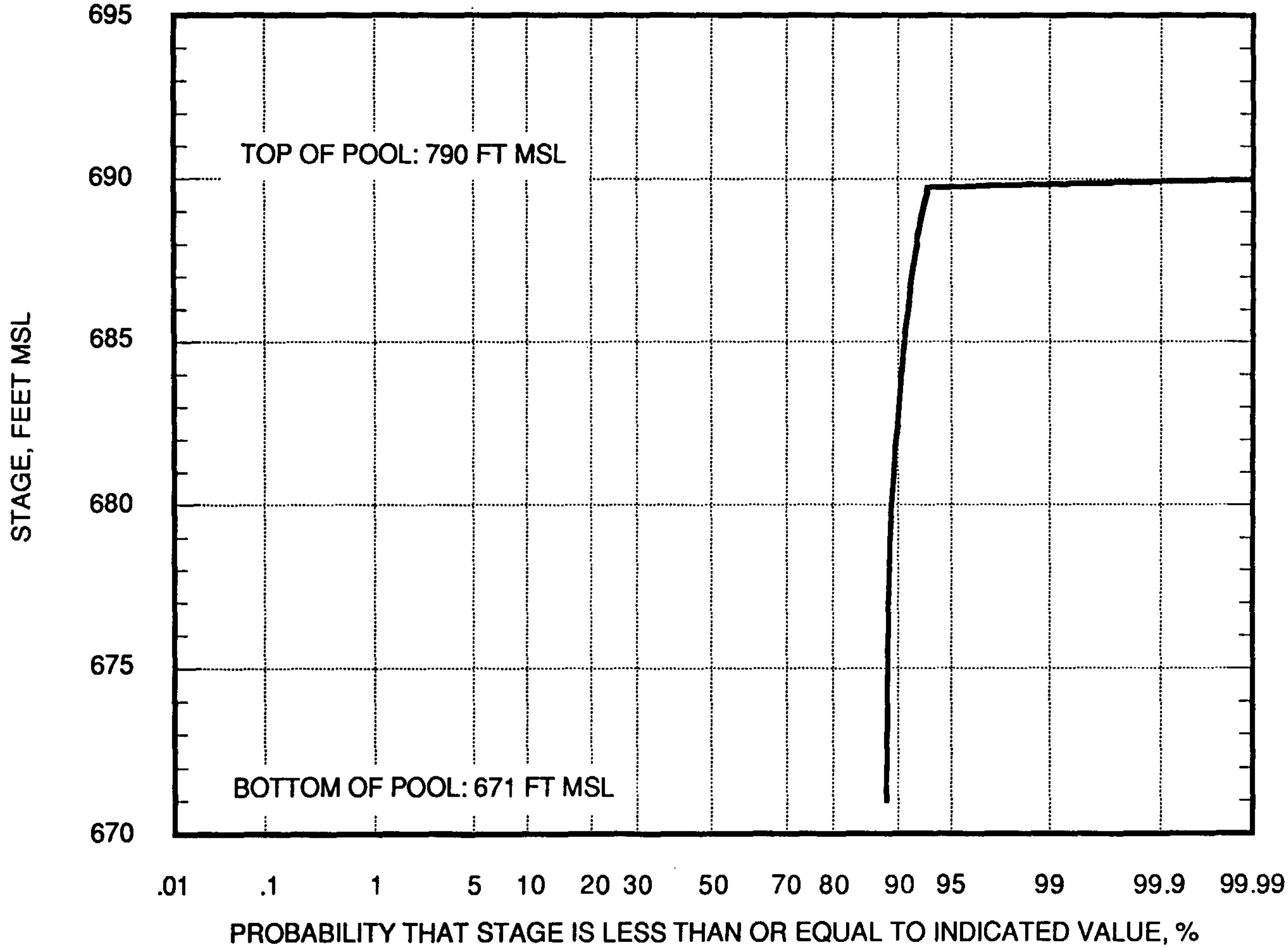


FIGURE 5.2-10 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP FOR RUBY RESERVOIR IN TANDEM OPERATION WITH CENTEX RESERVOIR (ALTERNATIVE No. 3), 1941-1988

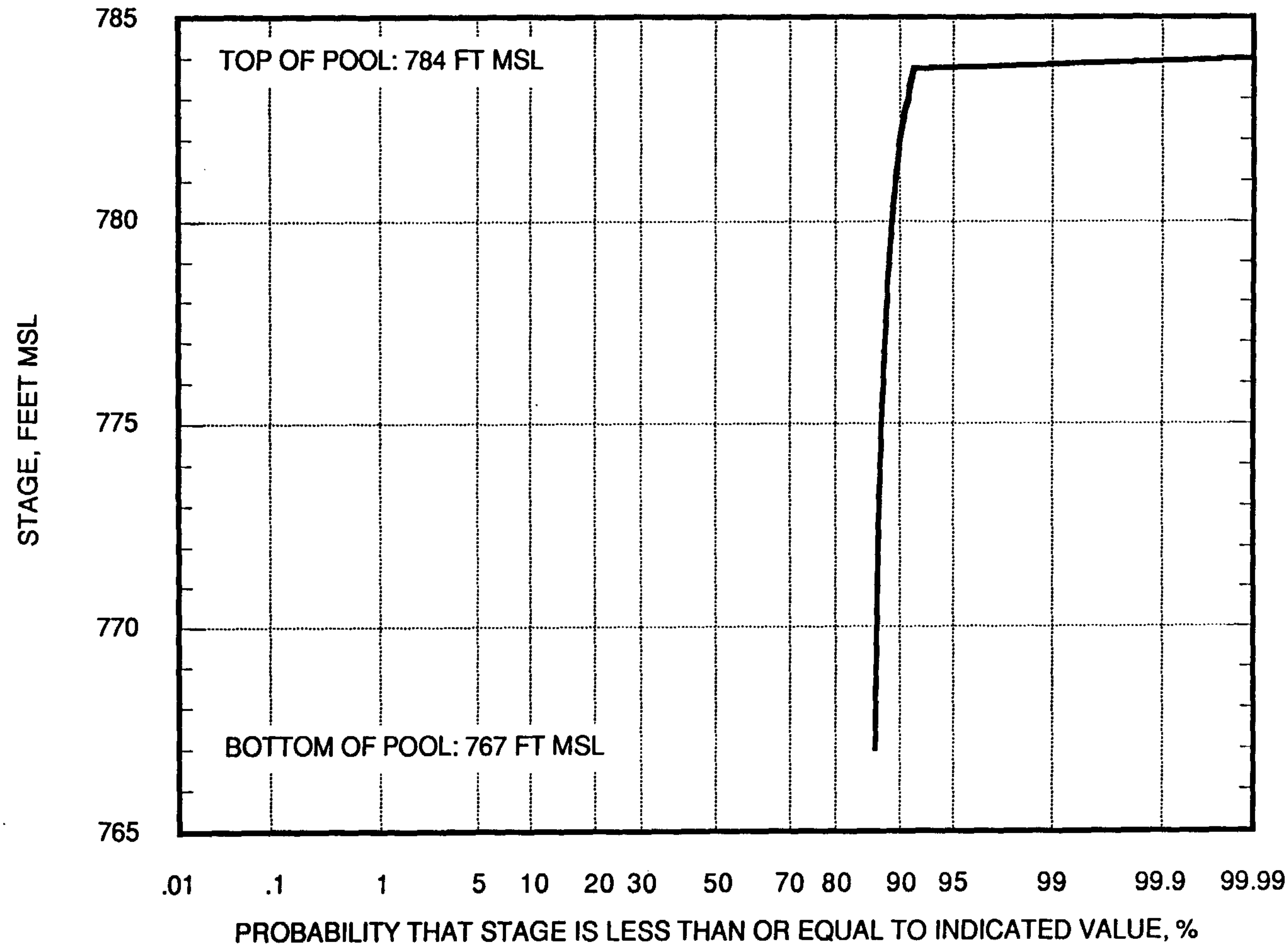


FIGURE 5.2-11 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP RUTHERFORD DAM AND RESERVOIR (ALTERNATIVE NO.4), 1941-1988

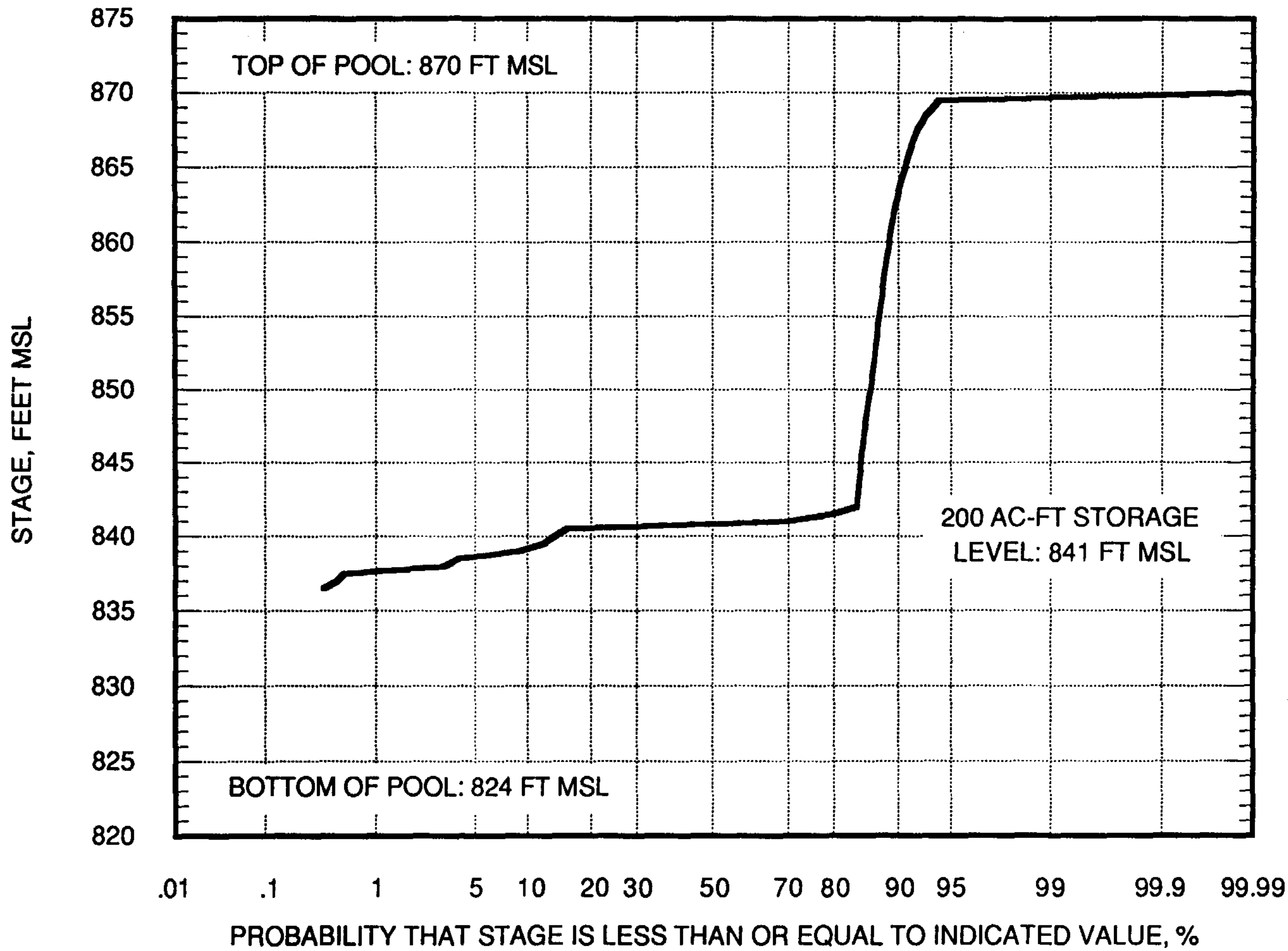
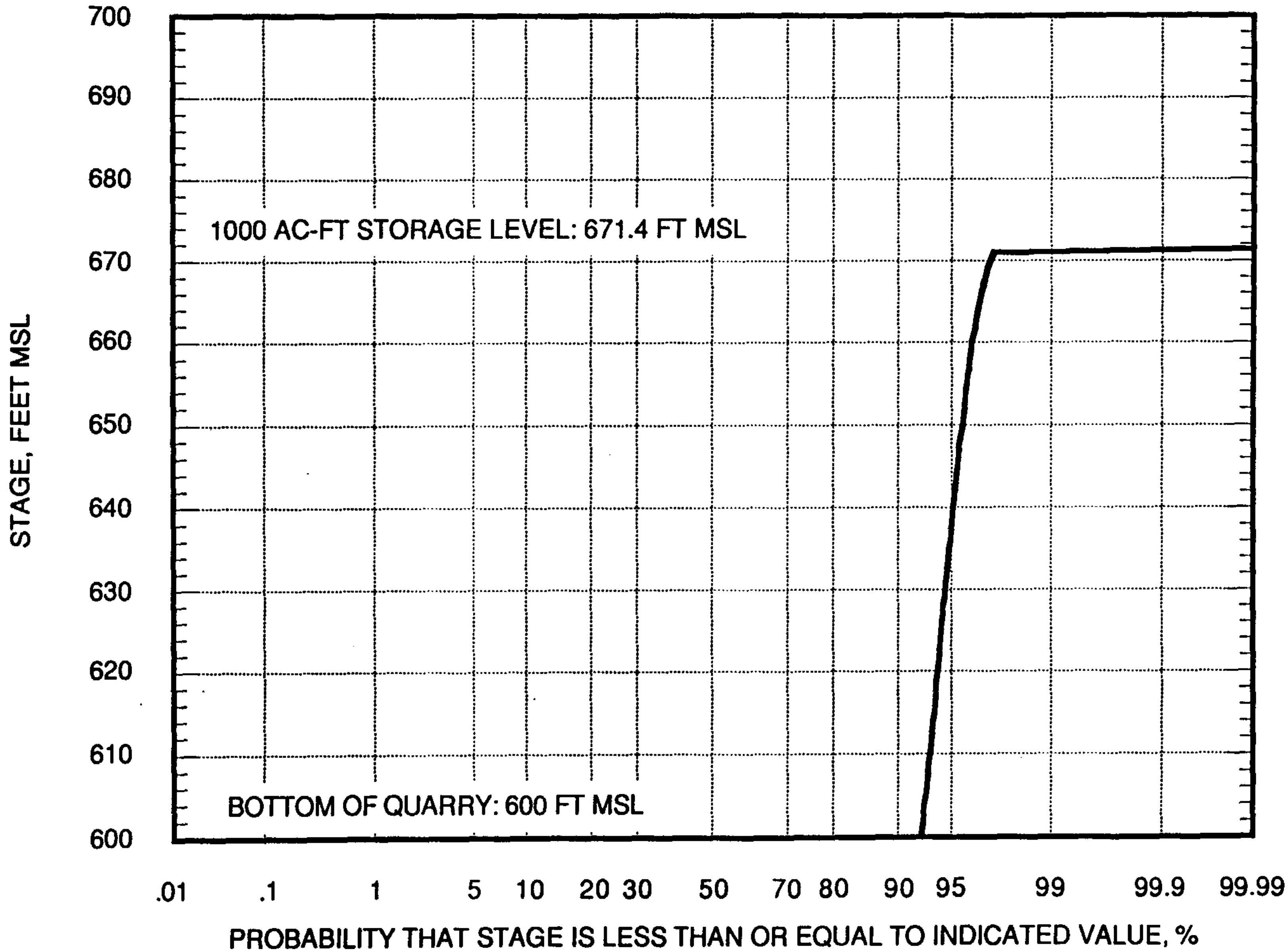


FIGURE 5.2-12 DAILY RESERVOIR STAGE-DURATION RELATIONSHIP FOR THE CENTEX DIVERSION DAM AND RECHARGE QUARRY (ALTERNATIVE NO.5), 1941-1988



5.2.1 Physical and Economic Description: Alternative No. 1 - CenTex Reservoir

CenTex Reservoir is a single purpose water resources development, which will provide additional water for recharge to the Barton Creek segment of the Edwards aquifer. This alternative entails the construction of a dam on Onion Creek at Station No. 20+00 (see Plate 3), located about 1.0 mi west of Buda, Texas. The dam, 19 ft high and 400 ft long, would be a rolled earth structure with a reinforced concrete cap. The dam, with side slopes of 2:1, would have a crest width of 14 ft at elevation 690 ft msl, which will serve as a spillway and access road. The dam would have a base width of 90 ft, with a downstream stilling basin. The entire length of the dam would serve as a spillway. The dam would be equipped with a low flow outlet to provide releases of up to 50 cfs. This outlet would aid in passing sediment laden water through this reservoir.

Preliminary designs indicate that about 14,630 cubic yards (cu yd) of earth material would be required to construct the dam embankment. Reinforced concrete riprap will provide upstream and downstream slope protection for the main dam embankment. Downstream, a stilling basin would be constructed to provide energy dissipation and flow regulation. Crushed rock riprap would be placed upstream and downstream on each creek bank to provide for soil/bank stabilization. The dam and stilling basin would require approximately 1.5 ac of land. In addition, a 5 ac temporary construction easement would be required during the construction phase of CenTex Dam. The dam, stilling basin and construction easement would be the only areas cleared of brush and small trees for this project alternative.

CenTex Reservoir, at its maximum level of 690 ft msl, would temporary impound about 270.5 af of water. At 690 ft msl, the impoundment would have a surface area of 33.4 ac, average width of 181 ft, and a total length of 7,600 ft. The elevation-area-capacity relationship for CenTex Reservoir is shown in Table 5.2-4. Typical channel cross-sections of CenTex Reservoir are shown in Figures 5.2-13 through 5.2-16.

Relocations required for the project include the moving of an existing 8-in diameter high pressure natural gas main crossing Onion Creek near Station No. 25+00, and the reinforcement of an existing property fence located underneath FM 1626 bridge near Station No. 100+00. The natural gas line would be relocated downstream of CenTex Dam and would cross Onion Creek near Station No. 18+00. This relocation would require the clearing of a strip of land, 100 ft wide and 1700 ft long (about 3.9 ac). Reinforcement of the existing fence at Station No. 100+00 would not require any additional clearing.

CenTex Reservoir, at maximum water level, would provide enhanced recharge on Onion Creek over a linear distance of about 7,600 ft. As part of this project, it is proposed that the existing Antioch Cave, located at Station No. 29+50, be modified to provide for additional recharge. Modification of Antioch Cave should be performed whether or not CenTex Reservoir is constructed. The opening to this cave would be enlarged by removing the promontory (see Figure 3.4-3). Filtration and cave protection devices would be installed around the modified cave opening. This modification would require the excavation and clearing of about 0.5 ac of land. The estimated cost for modification and protection of Antioch Cave is $50,000.

The principal project features for this alternative are shown in Table 5.2-5. The projected cost of CenTex Dam and Reservoir is approximately $602,000. Annual operation and maintenance costs for this alternative are estimated to be $15,000. It is estimated that this project would provide for an additional 762 ac ft per yr average recharge to the Barton Springs segment of the Edwards aquifer. This results in a projected cost per 1,000 gallons of water recharged of $0.29 (Table 5.2-6).

TABLE 5.2-4
CENTEX RESERVOIR
ELEVATION-AREA-CAPACITY RELATIONSHIP

ELEVATION (MSL)	AREA (AC)	CAPACITY (AF)
671	0.00	0.00
672	1.39	2.42
673	1.92	4.07
674	2.45	6.26
675	2.98	8.97
676	3.51	12.21
677	4.04	15.98
678	5.87	20.93
679	9.53	28.63
680	16.41	41.60
681	17.54	58.68
682	18.87	77.03
683	20.20	96.56
684	21.53	117.20
685	22.87	139.20
686	24.20	162.30
687	25.53	186.60
688	29.38	212.70
689	31.40	240.90
690	33.43	270.50

FIGURE 5.2-13 CENTEX RESERVOIR
CROSS-SECTION AT DAM LOCATION (20+00)

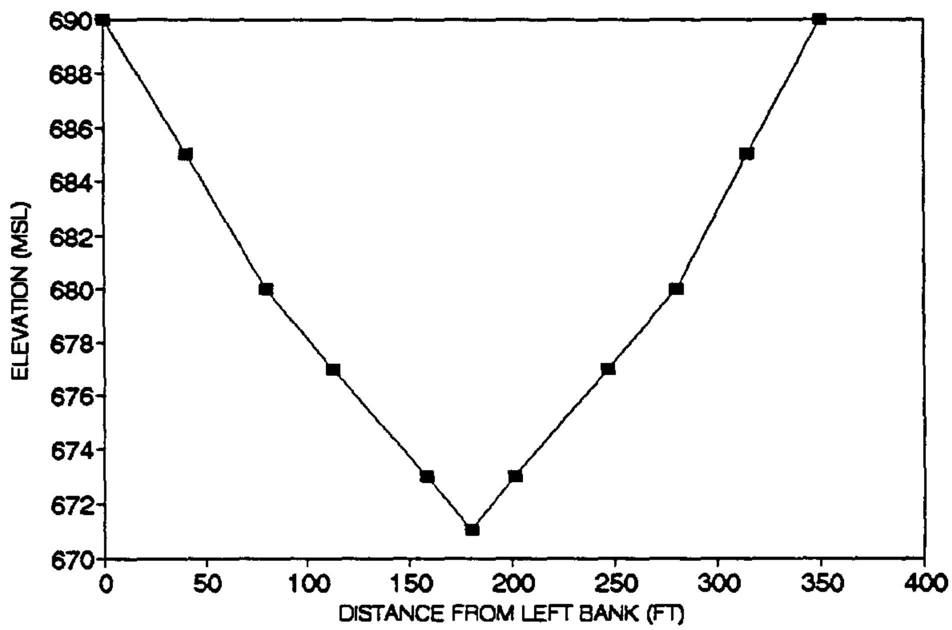


FIGURE 5.2-14 CENTEX RESERVOIR
CROSS-SECTION AT STATION 40+00

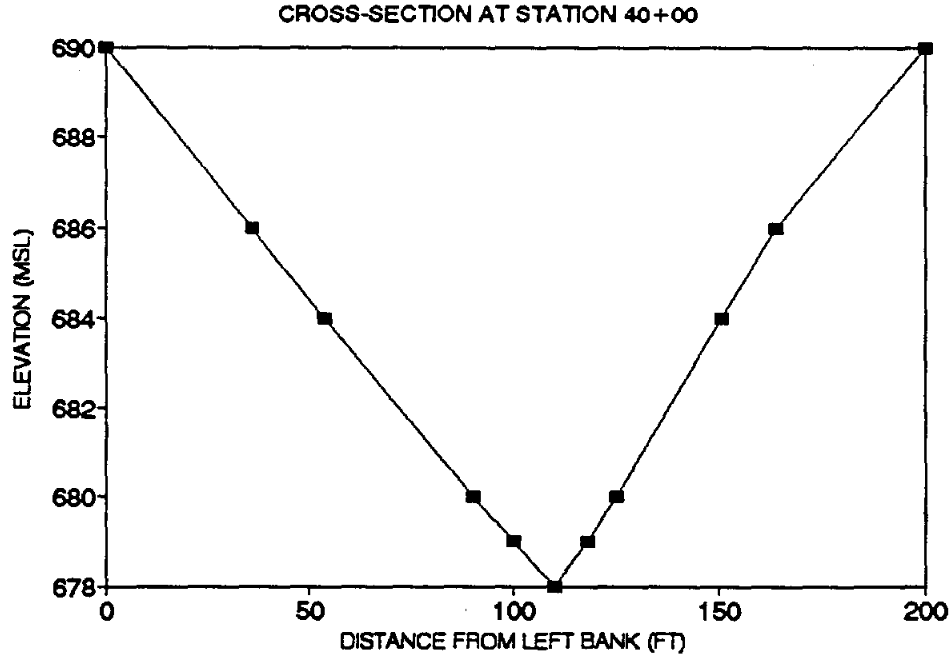


FIGURE 5.2-15 CENTEX RESERVOIR
CROSS-SECTION AT STATION 60+00

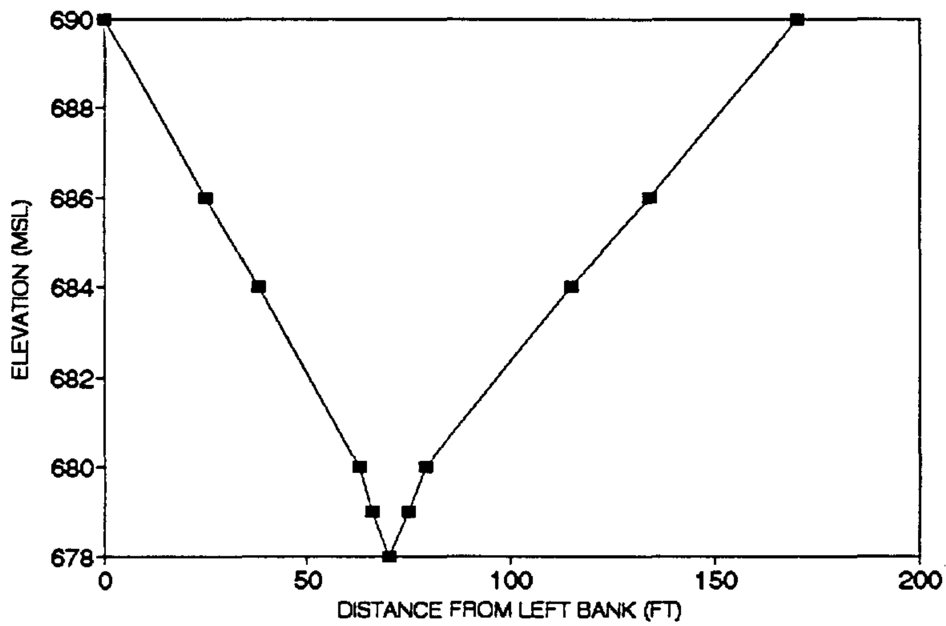


FIGURE 5.2-16 CENTEX RESERVOIR
CROSS-SECTION AT STATION 80+00

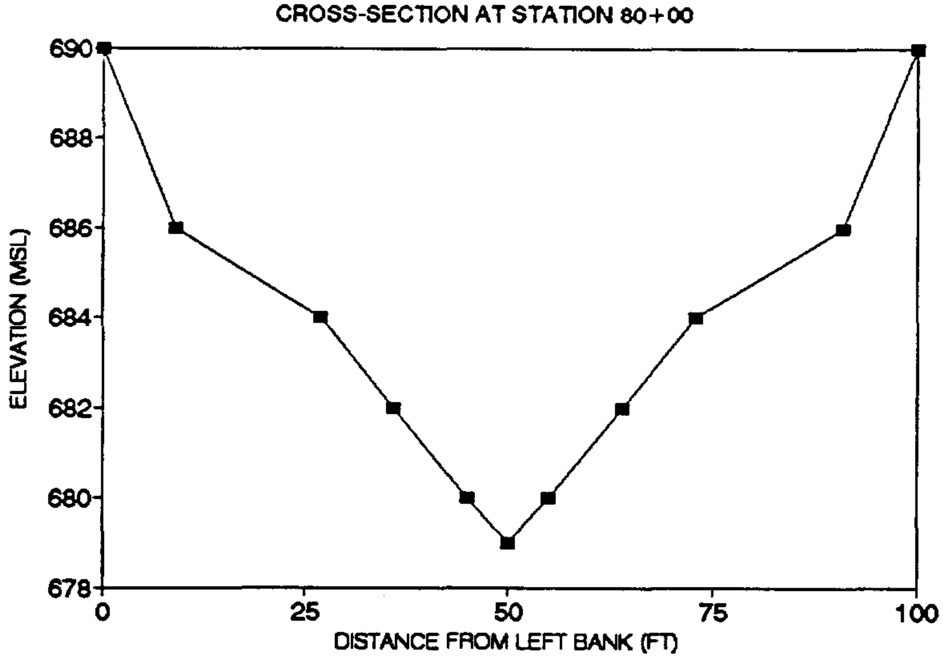


TABLE 5.2-5
CENTEX RESERVOIR PROJECTED COSTS

ITEM NO.	DESCRIPTION:	QUANTITY	UNIT	UNIT COST	AMOUNT
1	CLEARING AND SCARIFYING	1.5	AC	$1,000	$1,500
2	SITE PREPARATION	1	LS	$12,000	$12,000
3	COMPACTING EMBANKMENT	14630	CY	$4	$58,520
4	EMBANKMENT HAULING	14630	CY	$3	$36,575
5	REINFORCE CONCRETE CAP	733	CY	$250	$183,250
6	STILLING BASIN	330	CY	$350	$115,500
7	LOW FLOW OUTLET	100	LF	$30	$3,000
8	RETAINING WALLS	20	CY	$400	$8,000
9	UPSTREAM RIP RAP	35	T	$45	$1,575
10	DOWNSTREAM RIP RAP	35	T	$45	$1,575
11	ACCESS ROAD	300	LF	$20	$6,000
12	CENTEX CAVE IMP. & PROT.	1	LS	$30,000	$30,000
	SUBTOTAL				**$457,495**
	CONSTRUCTION CONTINGENCIES (10%)	--	--	--	$45,750
	R-O-W DAM SITE	1.5	AC	$3,000	$4,500
	R-O-W ACCESS ROAD	1	AC	$3,000	$3,300
	CONSTRUCTION EASEMENT	5	AC	$1,000	$5,000
	FLOOD EASEMENT	34	AC	$500	$17,000
	SURVEYING (3% OF CONST.)	--	--	--	$13,725
	ENGIN., LEGAL & FIN. (12% OF CONST.)	--	--	--	$54,899
	TOTAL ESTIMATED CONSTRUCTION COST				**$601,669**

TABLE 5.2-6
PRELIMINARY PROJECTED COSTS FOR PROJECT ALTERNATIVES

ALTERNATIVE	CAPITAL COSTS	ANNUAL DEBT SERVICE[1]	ESTIMATED ANNUAL O & M COST	ESTIMATED TOTAL ANNUAL COSTS (AF)	ESTIMATED ANNUAL RECHARGE POTENTIAL	PROJECTED COST PER 1000 GAL[2]
CENTEX RESERVOIR	$601,670	$56,360	$15,000	$71,360	768	$0.29
RUBY RESERVOIR	$952,080	$89,190	$15,000	$104,190	1152	$0.28
CENTEX RESERVOIR AND RUBY RESERVOIR TANDEM OPERATION	$1,553,750	$14,550	$30,000	$175,550	1576	$0.34
RUTHERFORD DAM & RESERVOIR	$2,856,150	$267,560	$50,000	$337,560	4000	$0.28
CENTEX QUARRY	$1,317,890	$123,460	$60,000	$183,460	5718	$0.10

[1] 8% FOR 25 YEARS

[2] (Annual Debt Service + Annual O&M)/(Estimated Annual Recharge Potential)

5.2.2 Physical and Economic Description: Alternative No. 2 - Ruby Reservoir

Ruby Reservoir is a single purpose water resource development, which would provide additional water for recharge. This alternative entails the construction of a dam on Onion Creek at Station No. 260+00 (see Plate 3), located about 4.8 mi west of Buda, Texas. The dam, 17 ft high and 700 ft long, would be a rolled earth structure with a reinforced concrete cap. The dam, with side slopes of 2:1, would have a crest width of 14 ft at elevation 784.0 ft msl, which would serve as a spillway and access road. It would have a base width of 82 ft and a downstream stilling basin. The entire length of the dam would serve as a spillway. The dam would be equipped with a low flow outlet to provide releases of up to 100 cfs, and to provide a means to pass sediment laden water through this impoundment.

Preliminary designs indicate that about 19,080 cu yd of earth material would be required to construct the dam embankment. Reinforced concrete riprap would provide upstream and downstream slope protection for the main dam embankment. Downstream, a stilling basin would be constructed to provide energy dissipation and flow regulation. Crushed rock riprap would be placed upstream and downstream on each creek bank to provide for soil/bank stabilization. The dam and stilling basin would require approximately 2.0 ac of land. In addition, a five ac temporary construction easement would be required during the construction phase of Ruby Dam. The dam, stilling basin and construction easement would be the only areas cleared of brush and small trees for this project alternative.

Ruby Reservoir, at its maximum level of 784 ft msl, would impound about 435 af of water. At 784 ft msl, the impoundment would have a surface area of 44.2 ac, average width of 283 ft and a total length of 10,200 ft. The elevation-area-capacity relationship for Ruby Reservoir is shown in Table 5.2-7. Typical channel cross-sections of Ruby Reservoir are shown in Figures 5.2-17 through 5.2-20. No relocations of utilities or facilities are required for this

TABLE 5.2-7
RUBY RESERVOIR
ELEVATION-AREA-CAPACITY RELATIONSHIP

ELEVATION (MSL)	AREA (AC)	CAPACITY (AF)
767	0.00	0.00
768	3.25	9.00
769	5.52	15.00
770	7.79	23.00
771	9.21	34.00
772	12.20	49.00
773	14.16	65.00
774	16.13	83.00
775	18.69	104.00
776	21.02	128.00
777	23.62	156.00
778	25.68	185.00
779	28.19	217.00
780	30.55	252.00
781	34.50	300.00
782	37.23	345.00
783	40.79	401.00
784	44.17	435.00

FIGURE 5.2-17 RUBY RESERVOIR

CROSS-SECTION AT DAM LOCATION (260+00)

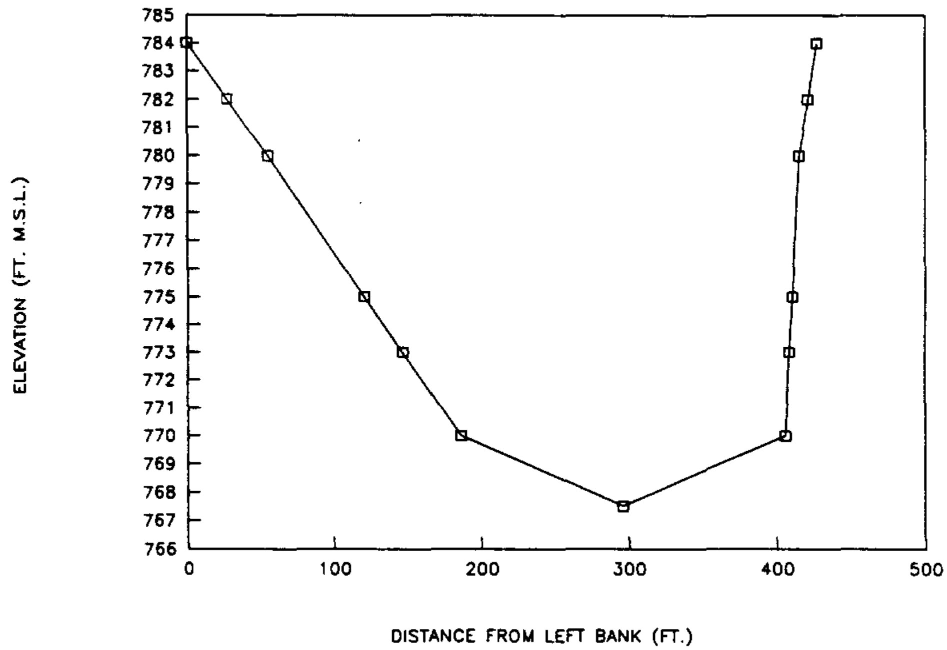


FIGURE 5.2-18 RUBY RESERVOIR

CROSS-SECTION AT STATION 280+00

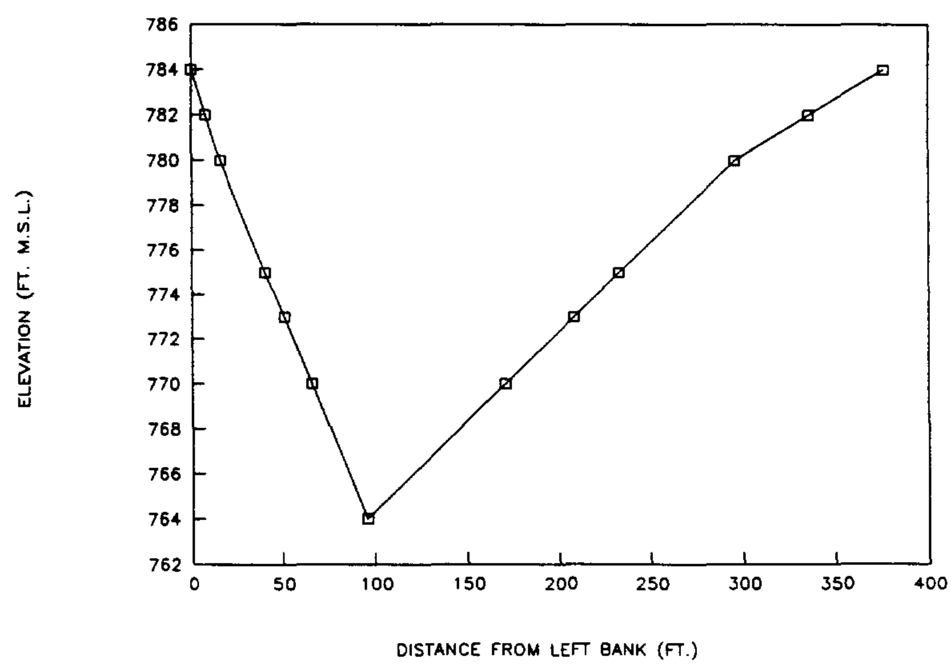


FIGURE 5.2-19 RUBY RESERVOIR

CROSS-SECTION AT STATION 310+00

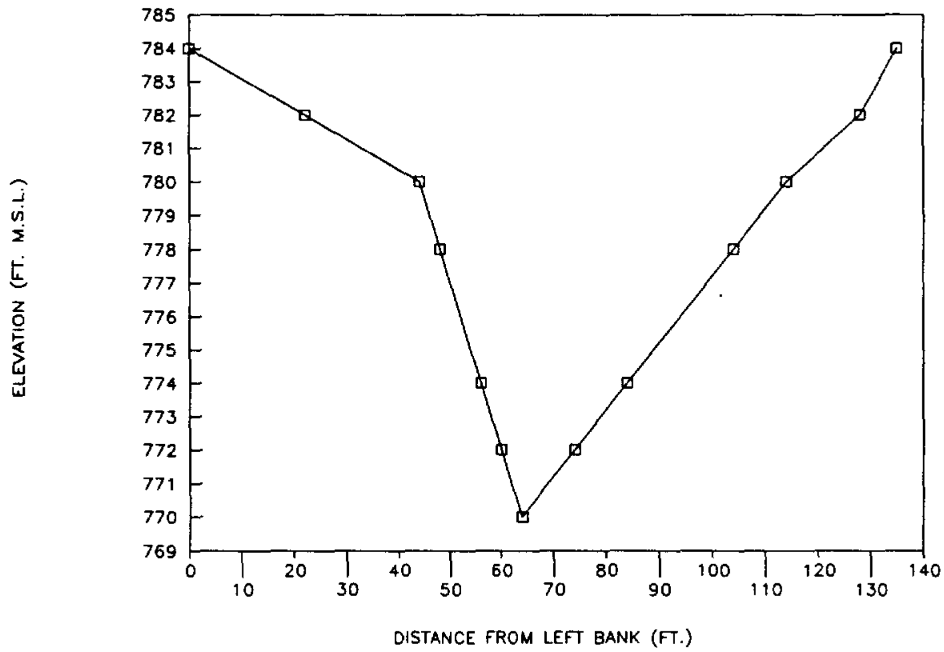
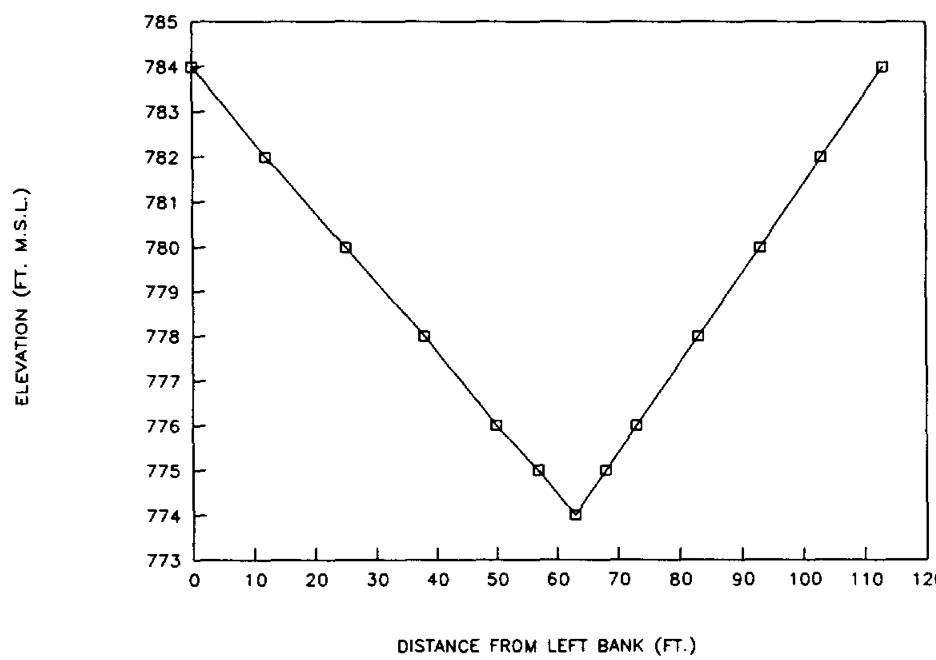


FIGURE 5.2-20 RUBY RESERVOIR

CROSS-SECTION AT STATION 340+00



project. Ruby Reservoir, at maximum water level, would provide enhanced recharge on Onion Creek over a linear distance of about 10,100 ft.

As part of this project, it is proposed that the existing Crippled Crawfish Cave, located at Station No. 320+00, be modified to provide for additional recharge. The opening to this cave would be enlarged by excavating existing overburden material. Filtration and cave protection devices would be installed around the modified cave opening. This modification would require the excavation and clearing of about 0.5 ac of land. Modification of Crippled Crawfish Cave should be performed whether or not Ruby Reservoir is constructed. The estimated cost for modification and protection of Crippled Crawfish Cave is $50,000.

The principal project features and projected cost of Ruby Dam and Reservoir of approximately $952,000 are itemized in Table 5.2-8. Annual operation and maintenance costs for this alternative are estimated to be $15,000. It is estimated that this project would provide for an additional 1,152 ac ft per yr average recharge to the Barton Springs segment of the Edwards aquifer. This results in a projected cost per 1,000 gallons of water recharged of $0.28 (see Table 5.2-6).

5.2.3 Physical and Economic Description: Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation

Under this alternative, it is proposed that both CenTex Reservoir and Ruby Reservoir be constructed and operated together for recharge enhancement. These reservoirs would have the same physical characteristics as presented above. The projected cost for this alternative is $1,553,750, with an annual operation and maintenance costs of $30,000. It is estimated that this project would provide an additional 1,576 af of recharge per yr. This results in a projected cost per 1,000 gallons of water recharged of $0.34 (see Table 5.2-6).

TABLE 5.2-8
RUBY RESERVOIR PROJECTED COSTS

ITEM NO.	DESCRIPTION:	QUANTITY	UNIT	UNIT COST	AMOUNT
1	CLEARING AND SCARIFYING	2	AC	$1,000	$1,500
2	SITE PREPARATION	1	LS	$12,000	$12,000
3	COMPACTING EMBANKMENT	19080	CY	$4	$76,320
4	EMBANKMENT HAULING	19080	CY	$3	$47,700
5	REINFORCE CONCRETE CAP	1115	CY	$250	$278,750
6	STILLING BASIN	740	CY	$350	$259,000
7	LOW FLOW OUTLET	100	LF	$30	$3,000
8	RETAINING WALLS	20	CY	$400	$8,000
9	UPSTREAM RIP RAP	35	T	$45	$1,575
10	DOWNSTREAM RIP RAP	35	T	$45	$1,575
11	ACCESS ROAD	700	LF	$20	$14,000
12	CRIPPLE CRAWFISH CAVE IMP. & PROT.	1	LS	$30,000	$30,000
	SUBTOTAL				**$733,420**
	CONSTRUCTION CONTINGENCIES (10%)	--	--	--	$73,342
	R-O-W DAM SITE	2	AC	$3,000	$4,500
	R-O-W ACCESS ROAD	1	AC	$3,000	$3,300
	CONSTRUCTION EASEMENT	5	AC	$1,000	$5,000
	FLOOD EASEMENT	45	AC	$500	$22,500
	SURVEYING (3% OF CONST.)	--	--	--	$22,003
	ENGIN., LEGAL & FIN. (12% OF CONST.)	--	--	--	$88,010
	TOTAL ESTIMATED CONSTRUCTION COST				**$952,075**

5.2.4 Physical and Economic Description: Alternative No. 4 - Rutherford Dam and Reservoir

The Rutherford Dam and Reservoir would involve the construction of a rolled earthfill dam, with a side spillway. The dam and reservoir would be located on Onion Creek, approximately 2,500 ft upstream of the Recharge Zone on Onion Creek or about 8.4 mi west of Buda, Texas.

The primary purpose of this project would be the impoundment of flood water, which would be released from storage after floods subside. The release would be made in a manner to provide for maximum recharge over Onion Creek's Recharge Zone. A minimum pool of 200 ac ft in the reservoir would be maintained to provide for private recreation and fish and wildlife habitat.

Rutherford Dam is planned to be 46 ft high and 900 ft long, at a maximum crest elevation of 880 ft msl. This rolled earthen structure would contain an estimated 160,600 cu yd of material. Very preliminary designs indicated that a side spillway of approximately 200 ft in width would be located on the east end of the dam. The top width of the dam, with side slopes of 2:1, would be 20 ft wide. Crushed rock riprap would be placed on the upstream slope of the dam to provide for slope protection. The dam would have a low flow outlet capable of releasing up to 300 cfs and provide a means of passing sediment laden water through the reservoir. The dam and spillway would require the clearing and excavation/filling of approximately 6 ac of land. In addition, a 10 ac temporary construction easement would be needed for construction purposes.

Rutherford Reservoir would have a maximum water surface elevation of 870 ft msl. At this elevation, the reservoir would have a maximum conservation pool of about 3,670 ac ft of water (Table 5.2-9), and a surface area of 252.2 ac. The reservoir would extend backwater for

TABLE 5.2-9
RUTHERFORD RESERVOIR
ELEVATION-AREA-CAPACITY RELATIONSHIP

ELEV. (MSL)	AREA (AC)	CAPAC. (AF)	ELEV. (MSL)	AREA (AC)	CAPAC. (AF)
824	0.00	0.00	847	57.30	488.00
825	0.29	0.14	848	62.38	559.00
826	0.57	1.00	849	68.65	653.00
827	1.55	2.00	850	76.67	756.00
828	2.53	4.00	851	81.73	838.00
829	4.65	7.00	852	87.25	923.00
830	6.77	13.00	853	92.55	1011.00
831	7.94	20.00	854	98.48	1106.00
832	9.11	29.00	855	104.38	1203.00
833	10.63	39.00	856	110.29	1302.00
834	12.14	50.00	857	117.27	1407.00
835	14.15	63.00	858	124.25	1513.00
836	16.16	78.00	859	131.23	1620.00
837	19.10	96.00	860	140.65	1729.00
838	21.96	116.00	861	150.95	1874.00
839	27.31	141.00	862	161.27	2029.00
840	32.59	171.00	863	171.49	2200.00
841	35.12	205.00	864	181.96	2376.00
842	37.64	242.00	865	191.43	2559.00
843	40.89	281.00	866	203.78	2763.00
844	44.13	323.00	867	214.87	2972.00
845	48.18	369.00	868	226.87	3192.00
846	52.22	420.00	869	239.35	3425.00
			870	252.23	3670.00

a linear creek distance of about 19,600 ft along Onion Creek. The reservoir would be cleared of trees and brush up to elevation 841 msl. At this elevation, the reservoir would have a capacity of 200 ac ft, covering about 35 ac of land. Typical reservoir cross-sections for Rutherford Reservoir are shown in Figures 5.2-21 through 5.2-24.

No utility relocations would be necessary for this project. However, three small concrete dams each less than 5 ft high would be inundated by the reservoir.

The principal project features and projected cost of Rutherford Dam and Reservoir is approximately $2,856,150 (Table 5.2-10). Annual operation and maintenance costs for this alternative are estimated to be $50,000. It is estimated that this project would provide an additional 3,515 ac ft per yr average recharge to the Barton Springs segment of the Edwards aquifer. This results in a projected cost per 1,000 gallons of water recharged of $0.28 (see Table 5.2-6).

5.2.5 Physical and Economic Description: Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry

The CenTex Quarry alternative has the potential of providing many times the recharge volume than any other alternative investigated in this project. However, this alternative involves the use of a currently active quarry pit being mined by CenTex Materials, Inc. CenTex Materials, Inc. has expressed a willingness to cooperate with the District on providing enhanced recharge capabilities via use of their quarries. However, such a recharge enhancement plan would take years to develop and implement. It is envisioned that quarry pits could be used for recharge upon completion of mining activities. As deep pits are abandoned, water from Onion Creek could be diverted into them and recharged via wells. CenTex Materials, Inc. is currently examining the institutional, legal and mechanical constraints involved with utilization

FIGURE 5.2-21 RUTHERFORD RESERVOIR
CROSS-SECTION AT DAM LOCATION (0+00)

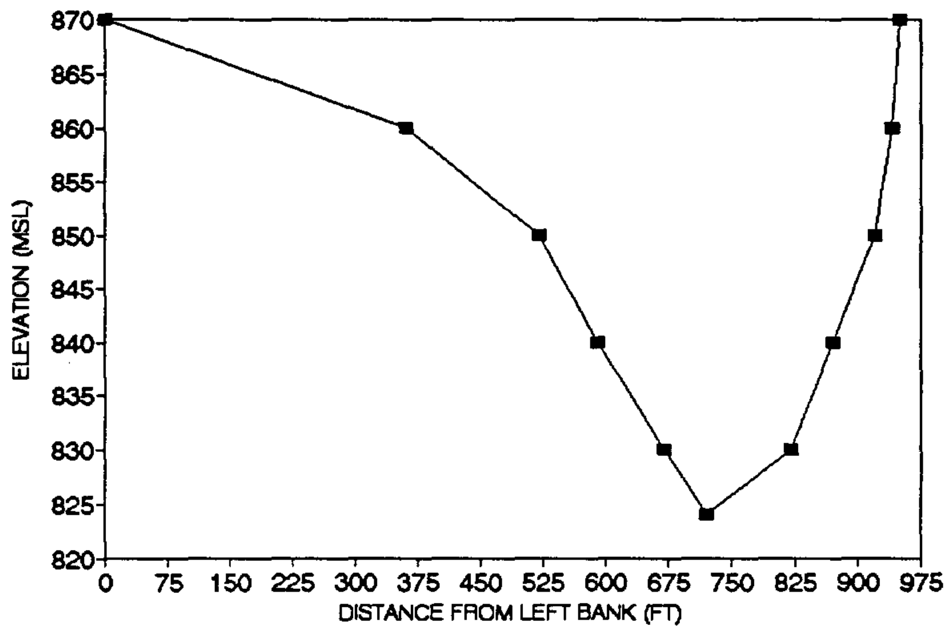


FIGURE 5.2-22 RUTHERFORD RESERVOIR
CROSS-SECTION AT STATION 500+00

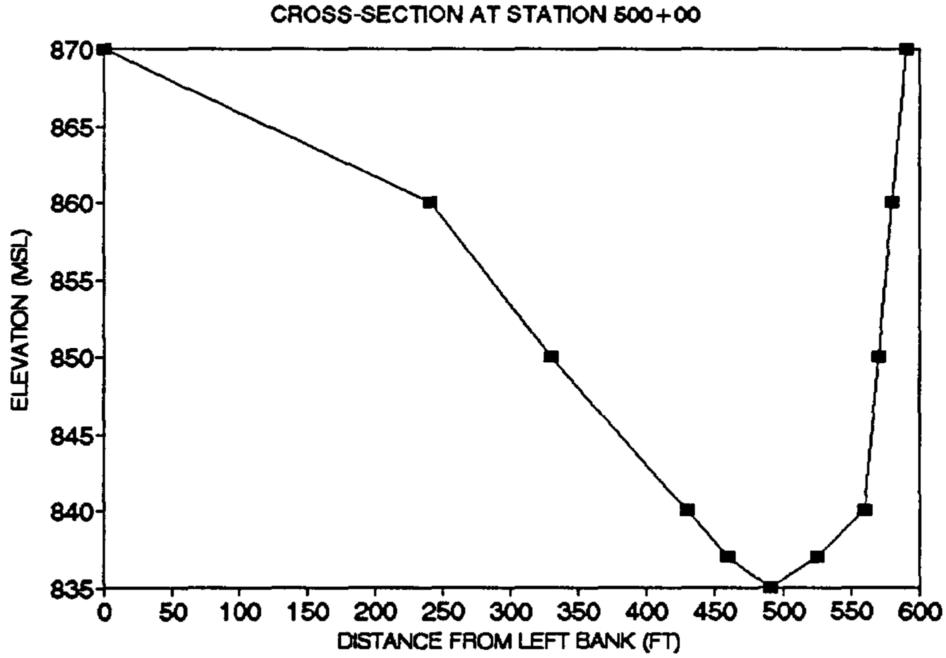


FIGURE 5.2-23 RUTHERFORD RESERVOIR
CROSS-SECTION AT STATION 1000+00

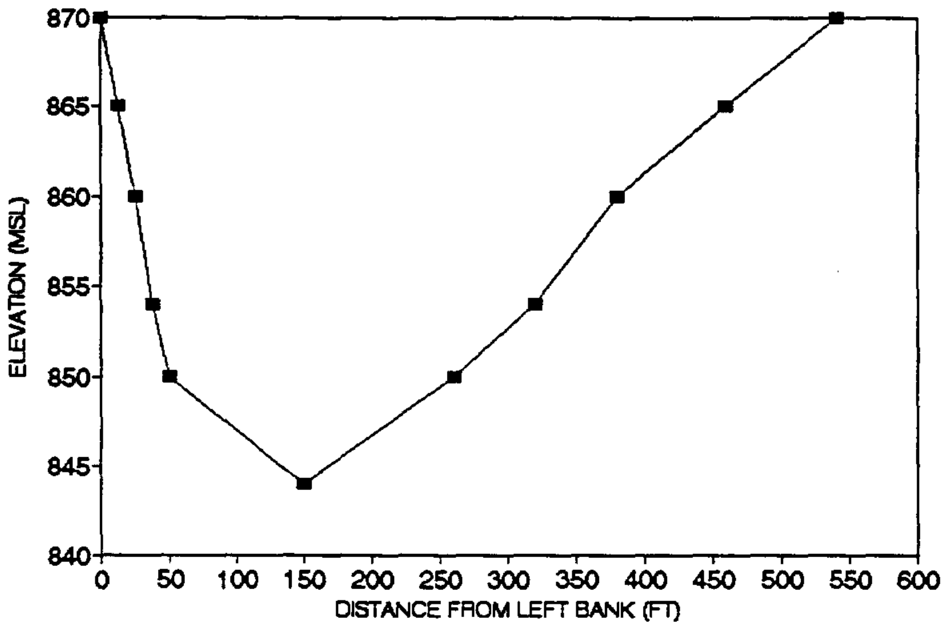


FIGURE 5.2-24 RUTHERFORD RESERVOIR
CROSS-SECTION AT STATION 1500+00

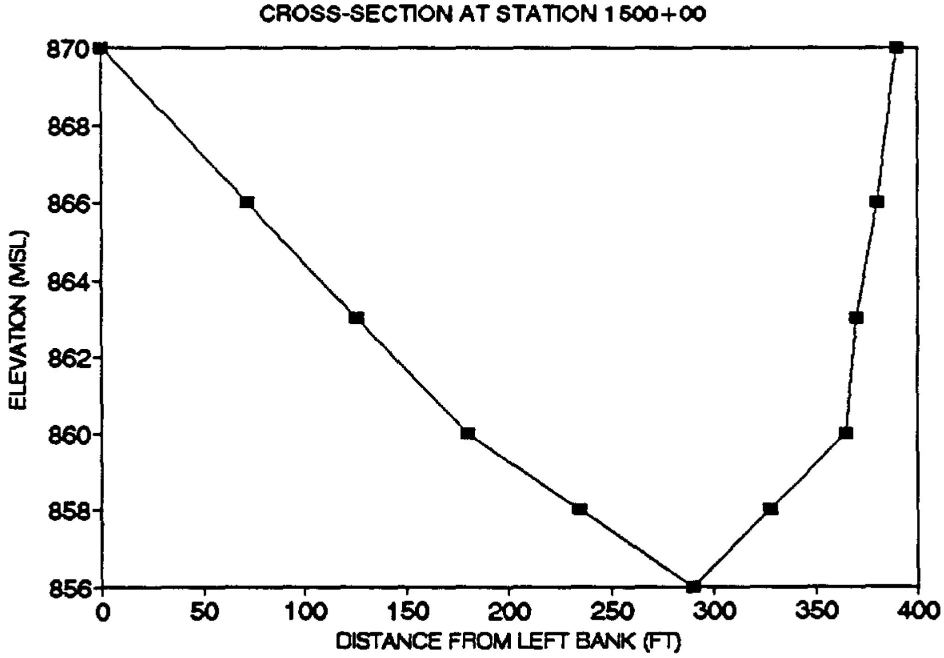


TABLE 5.2-10
RUTHERFORD DAM AND RESERVOIR PROJECTED COSTS

ITEM NO.	DESCRIPTION:	QUANTITY	UNIT	UNIT COST	AMOUNT
1	CLEARING AND SCARIFYING	6		$1,000	$6,200
2	SITE PREPARATION	1	LS	$15,000	$15,000
3	COMPACTING EMBANKMENT	160600	CY	$4	$642,400
4	EMBANKMENT HAULING	160600	CY	$3	$481,800
5	EMERGENCY SPILLWAY	1	LS	$100,000	$100,000
6	RADIAL GATE 20'x30' - IN PLACE	2	LS	$225,000	$450,000
7	ELECT. WORKS INCLUDE MOTOR & CONTROL	2	LS	$60,000	$120,000
8	ELECTRICAL POWER LINE	5000	LF	$10	$50,000
9	STILLING BASIN	560	CY	$350	$196,000
10	LOW FLOW OUTLET	200	LF	$30	$6,000
11	RETAINING WALLS	100	CY	$400	$40,000
12	UPSTREAM RIP RAP	70	T	$45	$3,150
13	DOWNSTREAM RIP RAP	70	T	$45	$3,150
14	ACCESS ROAD	4000	LF	$20	$80,000
	SUBTOTAL				$2,193,700
	CONSTRUCTION CONTINGENCIES (10%)	--	--	--	$219,370
	R-O-W DAM SITE	6	AC	$3,000	$18,600
	R-O-W ACCESS ROAD	1	AC	$3,000	$3,300
	CONSTRUCTION EASEMENT	10	AC	$1,000	$10,000
	FLOOD EASEMENT	252	AC	$500	$126,000
	SURVEYING (3% OF CONST.)	--	--	--	$65,811
	ENGIN., LEGAL & FIN. (10% OF CONST.)	--	--	--	$219,370
	TOTAL ESTIMATED CONSTRUCTION COST				$2,856,151

of the quarry pits for recharge purposes. A thorough and complete investigation of quarry utilization for recharge purposes will require months and possibly years to complete.

For purposes of this study and for comparing project alternatives, it was assumed that the CenTex Materials, Inc. current quarry could be utilized for recharge purposes. This quarry (see Plate 3) covers an area of about 100 ac and has an average depth of approximately 130 ft below existing grade. The current bottom of the pit is about 80 ft below Onion Creek at its nearest point. CenTex Materials, Inc., proposes to excavated another 100 vertically, resulting in a pit that would be about 230 ft deep and 100 surface ac in size. This pit could provide at least 1,000 ac ft of temporary storage for recharge purposes.

Under this proposal, flood waters from Onion Creek would be "scalped" and diverted via a concrete lined canal or through large concrete box culverts from the creek to the recharge pit. A series of settling basins would be constructed to settle out suspended sediment before entering a recharge basin. A series of wells would be drilled in the bottom of the pit to provide a recharge rate of approximately 100 cfs.

This alternative involves the construction of a dam (CenTex Diversion Dam) on Onion Creek at Station No. 125+00 (see Plate 3), located about 3 mi west of Buda. The dam, 14 ft high and 400 ft long, would be a rolled earth structure with reinforced concrete riprap. The dam, with side slopes of 2:1, would have a crest width of 14 ft at elevation 736.0 ft msl, which will serve as a spillway and access road. The dam would have a base width of 70 ft and a downstream stilling basin. The dam would be equipped with a low flow outlet to provide releases of up to 80 cfs, which would pass sediment laden water.

Preliminary designs indicate that about 8,700 cu yd of earth material would be required to construct the dam embankment. Reinforced concrete riprap would provide upstream and downstream slope protection for the main dam embankment. Downstream, a stilling basin would be constructed to provide energy dissipation and flow regulation. Crushed rock riprap would be placed upstream and downstream on each creek bank to provide for soil/bank stabilization. A trapezoidal shaped-concrete lined diversion channel would be constructed from just upstream of the diversion dam to the quarry (recharge) pit. This channel would be about 250 ft in length and have a bottom width of 50 ft and a top width of 160 ft. Energy dissipation facilities would be constructed in the recharge pit at the end of the diversion channel.

The dam, stilling basin and diversion channel would require approximately 1.5 ac of land. In addition, a five ac temporary construction easement would be required, during the construction phase of the CenTex Diversion Dam and Recharge Quarry. The dam, stilling basin, diversion channel, and construction easement would be the only areas cleared of brush and small trees for this project alternative.

CenTex Diversion Dam would only temporarily store water along Onion Creek. It is expected that water would remain in storage less than 24-hours after flood recession. The diversion dam would have a maximum operating level at 736 ft msl.

The principal project features for this alternative are shown in Table 5.2-11. The projected cost of the CenTex Diversion Dam and Recharge Facilities is estimated to be $1,317,894. Annual operation and maintenance costs for this alternative are estimated to be $60,000. It is estimated that this project would provide an additional 5,718 ac ft per yr average recharge to the Barton Springs segment of the Edwards aquifer. This results in a projected cost per 1,000 gallons of water recharged of $0.10 (see Table 5.2-6).

5.3 GROUNDWATER RESPONSE TO ONION CREEK RECHARGE

Water level elevations in the Barton Springs segment of the Edwards aquifer fluctuate in response to changes in the amounts of water recharged to and discharged from the aquifer

TABLE 5.2-11
CENTEX DIVERSION DAM AND RECHARGE FACILITIES PROJECTED COSTS

ITEM NO.	DESCRIPTION:	QUANTITY	UNIT	UNIT COST	AMOUNT
A	EARTHEN DAM				
1	CLEARING AND SCARIFYING	1.5	AC	$1,000	$1,500
2	SITE PREPARATION	1	LS	$12,000	$12,000
3	COMPACTING EMBANKMENT	8700	CY	$4	$34,800
4	EMBANKMENT HAULING	8700	CY	$3	$21,750
5	REINFORCE CONCRETE CAP	570	CY	$250	$142,500
6	STILLING BASIN	330	CY	$350	$115,500
7	LOW FLOW OUTLET	100	LF	$30	$3,000
8	RETAINING WALLS	20	CY	$400	$8,000
9	UPSTREAM RIP RAP	35	T	$45	$1,575
10	DOWNSTREAM RIP RAP	35	T	$45	$1,575
11	ACCESS ROAD	1500	LF	$20	$30,000
	SUBTOTAL				$372,200
B	DIVERSION CHANNEL AND STORAGE				
1	EXCAVATING AND SHAPING	13750	CY	$4	$55,000
2	CONCRETE LINING	815	CY	$250	$203,750
3	RECEIVING BASIN	200	CY	$350	$70,000
4	TRANSMISSION CHANNEL	325	CY	$300	$97,500
5	RECHARGE WELLS AND FACILITIES	1	LS	$200,000	$200,000
6	LAND EASEMENTS	100	AC	$500	$50,000
					$676,250
	CONSTRUCTION CONTINGENCIES (10%)	--	--	--	$104,845
	R-O-W DAM SITE	1.5	AC	$3,000	$4,500
	R-O-W ACCESS ROAD	1.1	AC	$3,000	$3,300
	CONSTRUCTION EASEMENT	5	AC	$1,000	$5,000
	FLOOD EASEMENT	31	AC	$500	$15,500
	SURVEYING (3% OF CONST.)	--	--	--	$31,454
	ENGIN., LEGAL & FIN. (10% OF CONST.)	--	--	--	$104,845
	TOTAL ESTIMATED CONSTRUCTION COST				$1,317,894

(TWDB 1986). In relatively "wet" years, i.e., periods of high stream flow, recharge exceeds discharge, causing net water level elevation rises. During dry or below normal stream flow years discharge from the aquifer, via pumpage and spring discharge, exceeds recharge, and causes the quantity of groundwater stored in the aquifer to decrease. This results in a net decline in aquifer water level elevations.

The cause and effect relationship between Onion Creek recharge and water level elevation variations at Well No. 58-58-101 (Buda well) is shown in Figure 5.3-1 through 5.3-10. These figures present plots of estimated monthly recharge for Onion Creek and measured water level elevations at the Buda well for the period 1941 through 1988. As can be seen in these graphs, water level elevation at the Buda well decline during low recharge periods and rise during high recharge periods. For example, Figure 5.3-6 presents a plot of monthly Onion Creek recharge and water level elevations at the Buda well for the period January 1966 through December 1970. As can be seen in this figure, water level elevations at the Buda well response directly to the quantity of recharge. Water level elevations at this well tend to increase very rapidly after recharge events and tend to decrease slowly in non-recharge periods.

The average rate of water level elevation decline during periods of little to no recharge for the 1941 through 1988 period was about 0.08 ft per day. Whereas, the average rate of water level elevation rise during and immediately following recharge events was approximately 0.2 ft per day. The rate of water level elevation decline at the Buda well in the 1970s and 1980s decade is probably much higher than that observed for the 48-yr period of analysis. The average rate of water level elevation decline in the last two decades averaged about 0.20 ft per day during no recharge periods. This higher rate is reflective of increased groundwater pumping demands that center in the Buda - San Leanna area. The District estimates that annual pumping requirements have risen from 70,000,000 gallons per year in 1970 to over 1 billion gallons per year in 1990. Very little is known about precise flow patterns in karst formations, therefore, it is quite possible that a cone of groundwater depression forms in the Buda - San Leanna area

FIGURE 5.3-1
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1941 - 1945

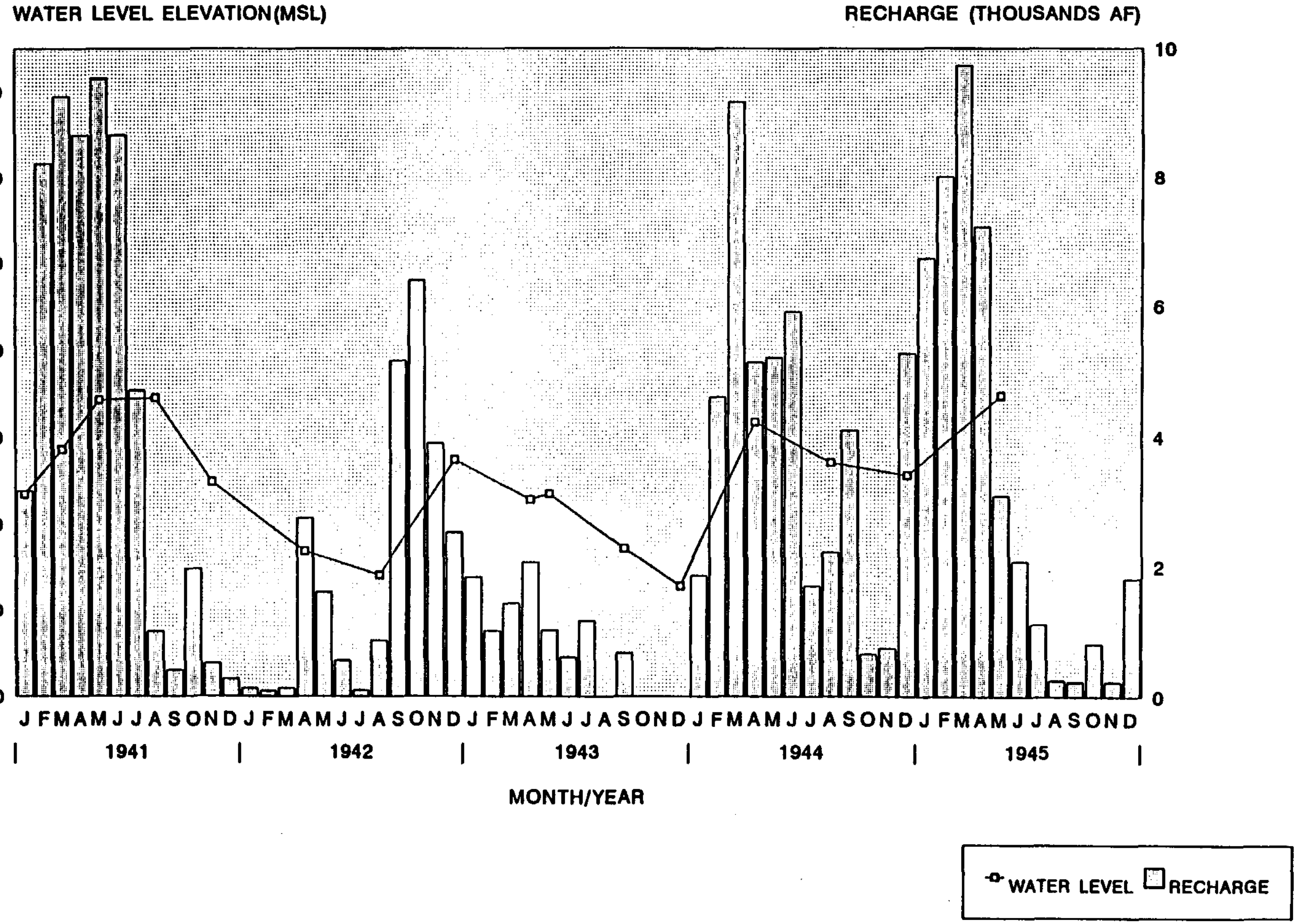


FIGURE 5.3-2
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1946 - 1950

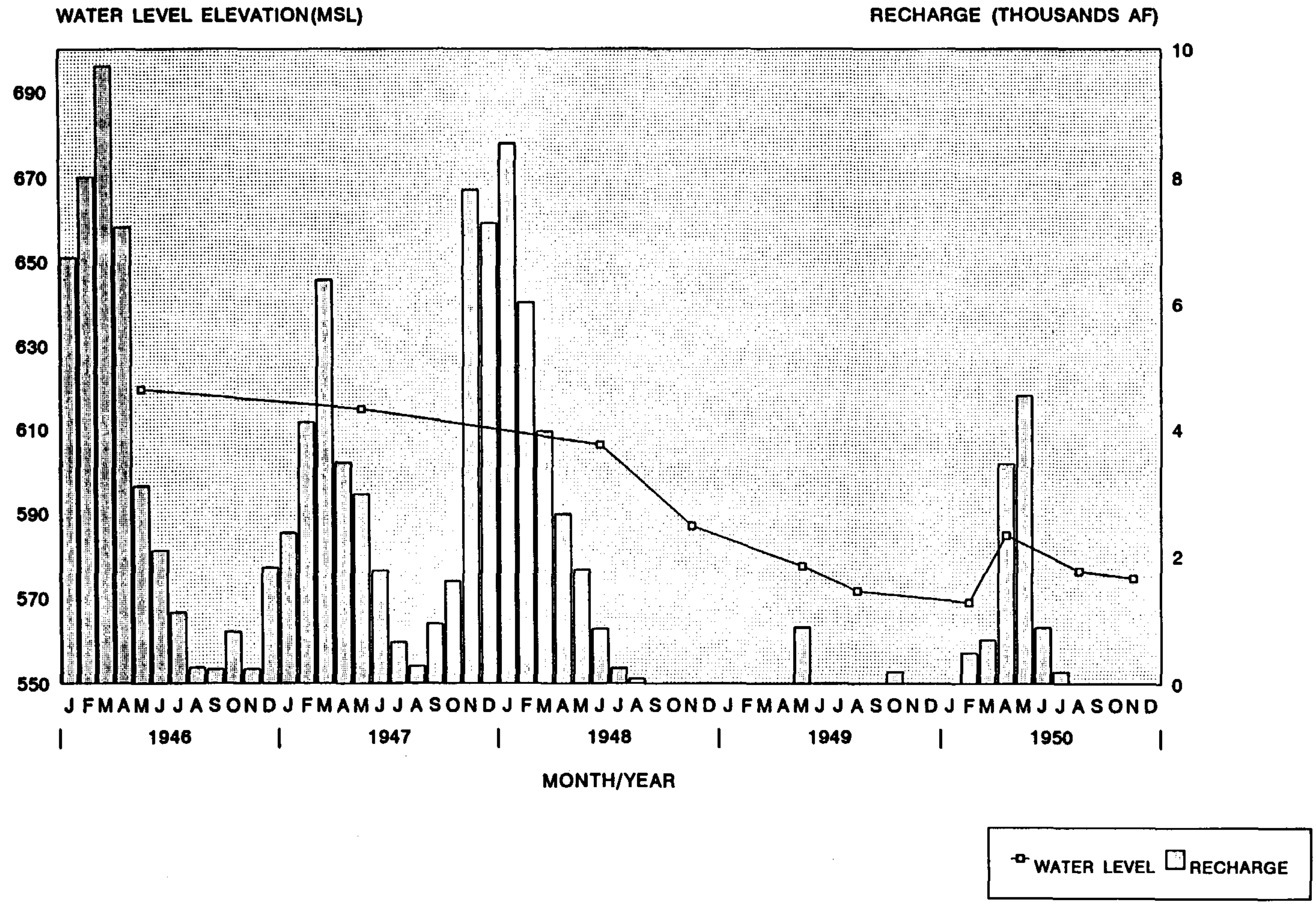


FIGURE 5.3-3
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1951 - 1955

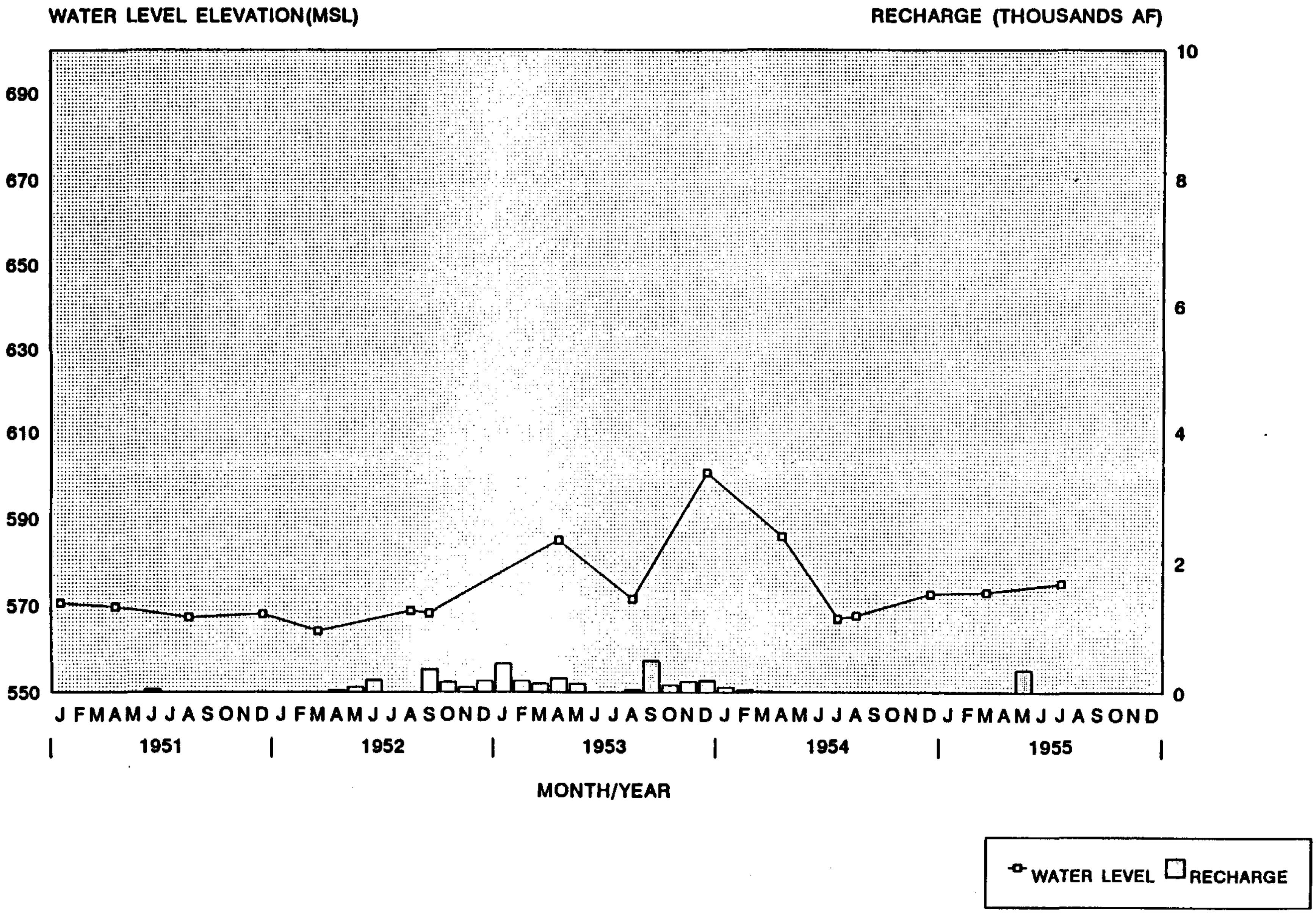


FIGURE 5.3-4
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE
FOR THE PERIOD 1956 - 1960

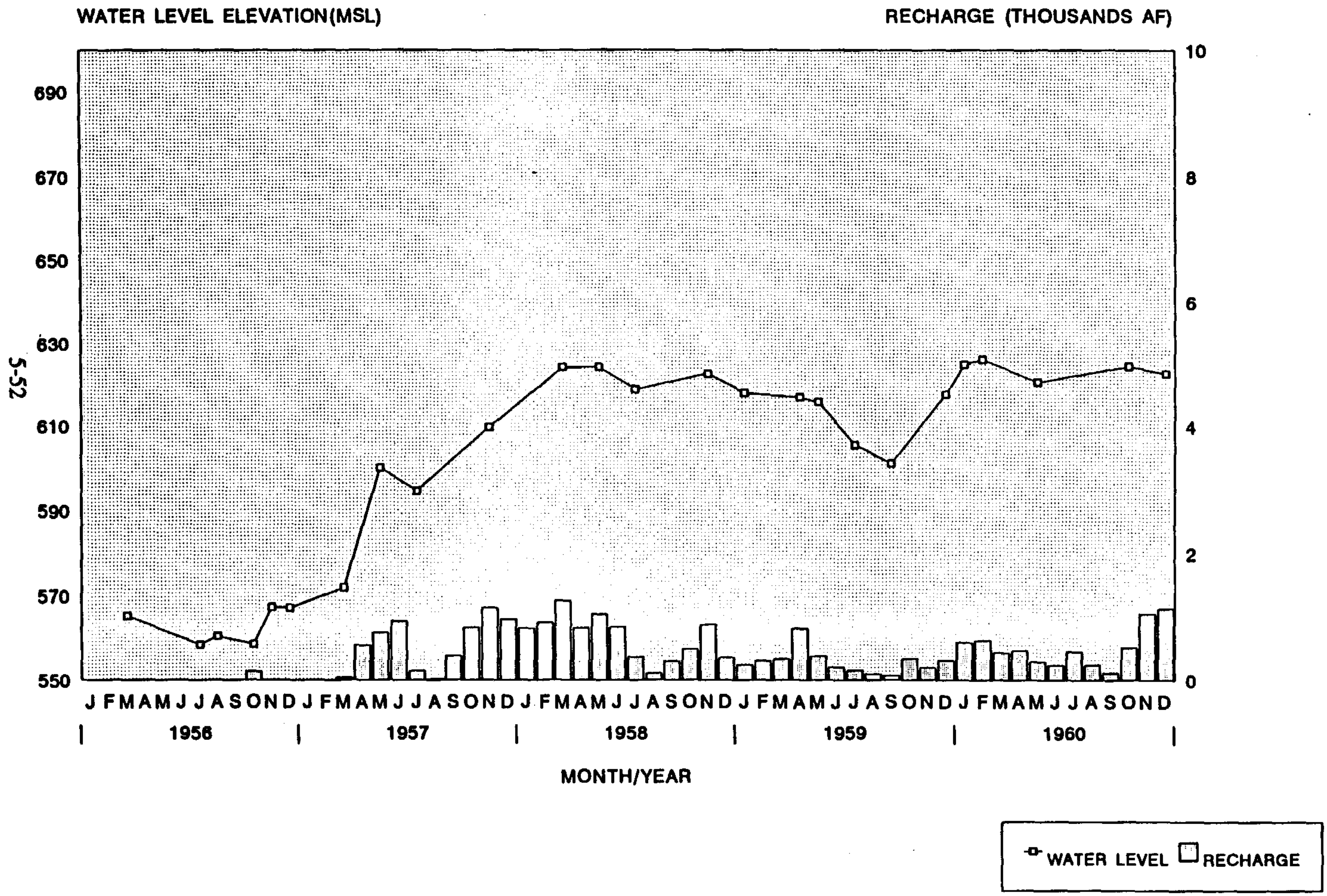


FIGURE 5.3-5
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1961 - 1965

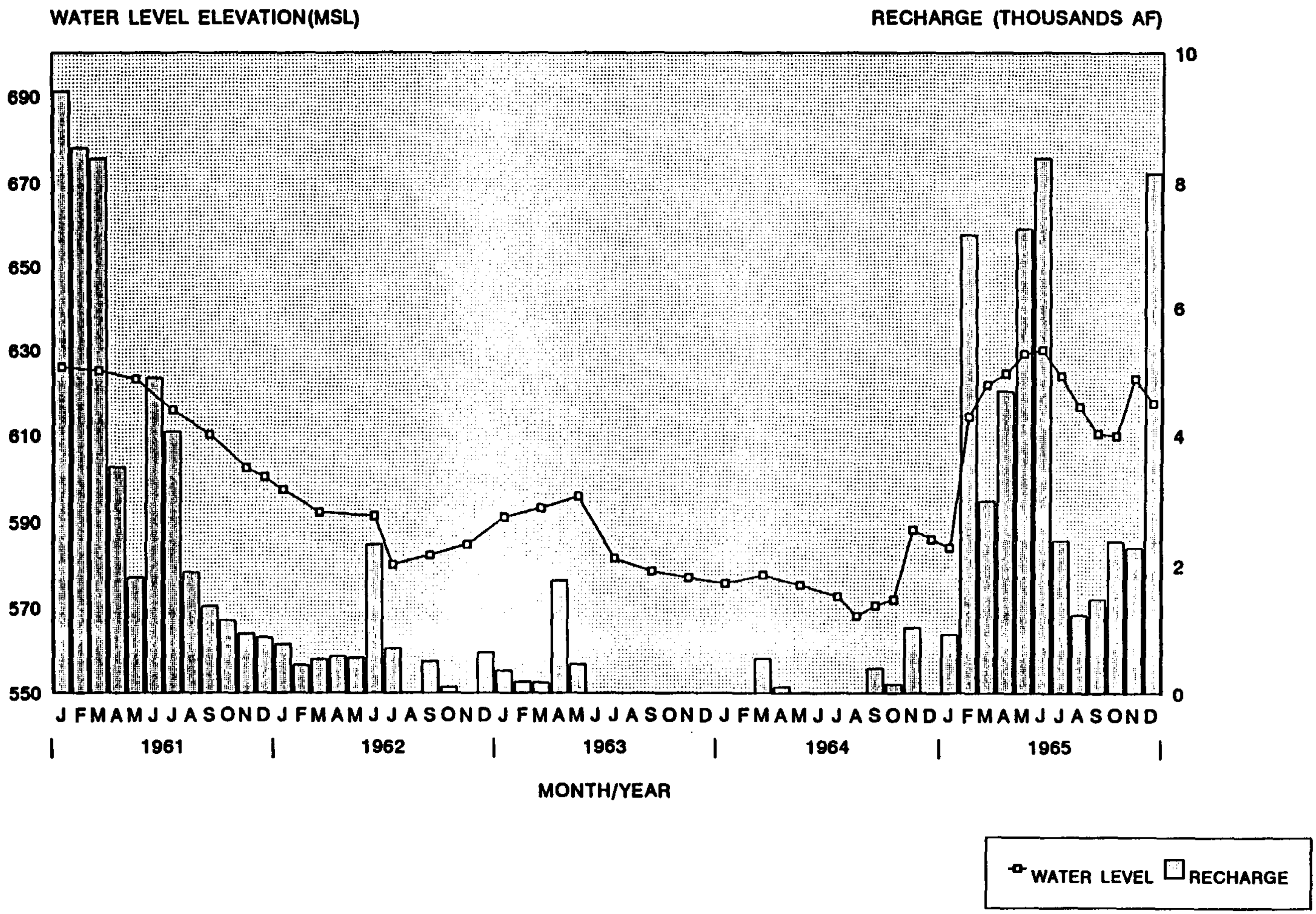


FIGURE 5.3-6
PLOT OF WATER LEVEL AT BUDA (58-58-101) AND RECHARGE FOR THE PERIOD 1966 - 1970

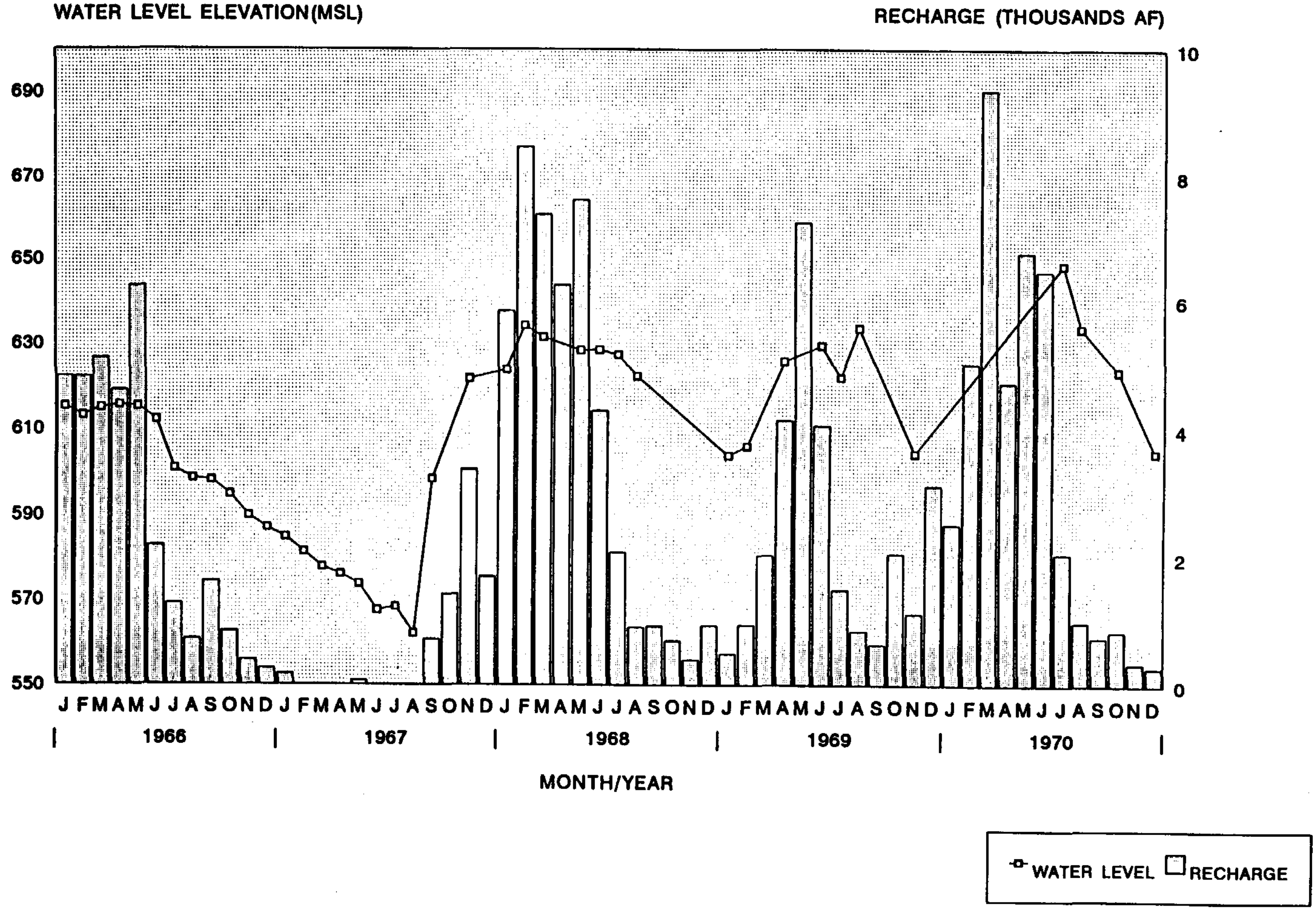


FIGURE 5.3-7
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1971 - 1975

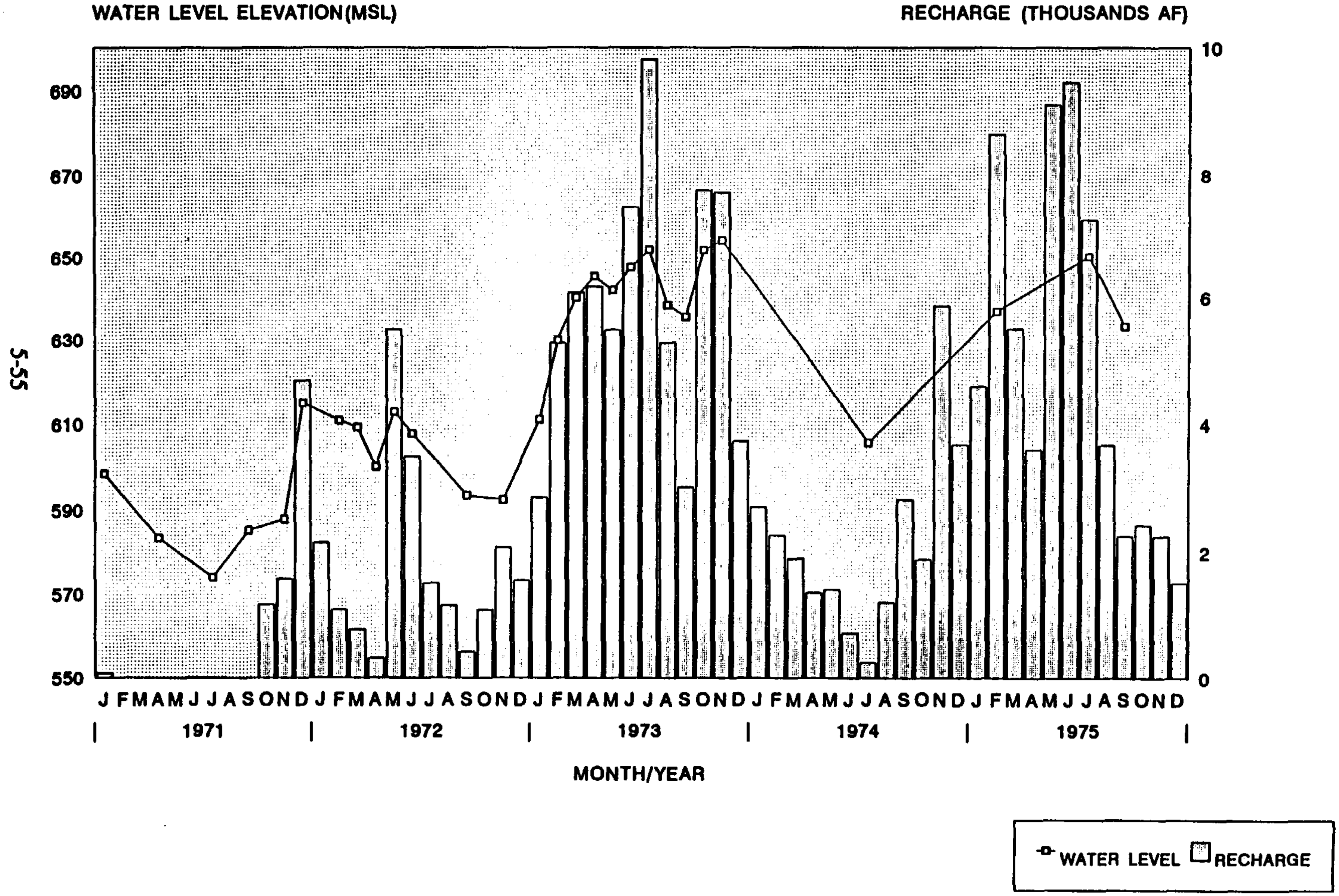


FIGURE 5.3-8
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1976 - 1980

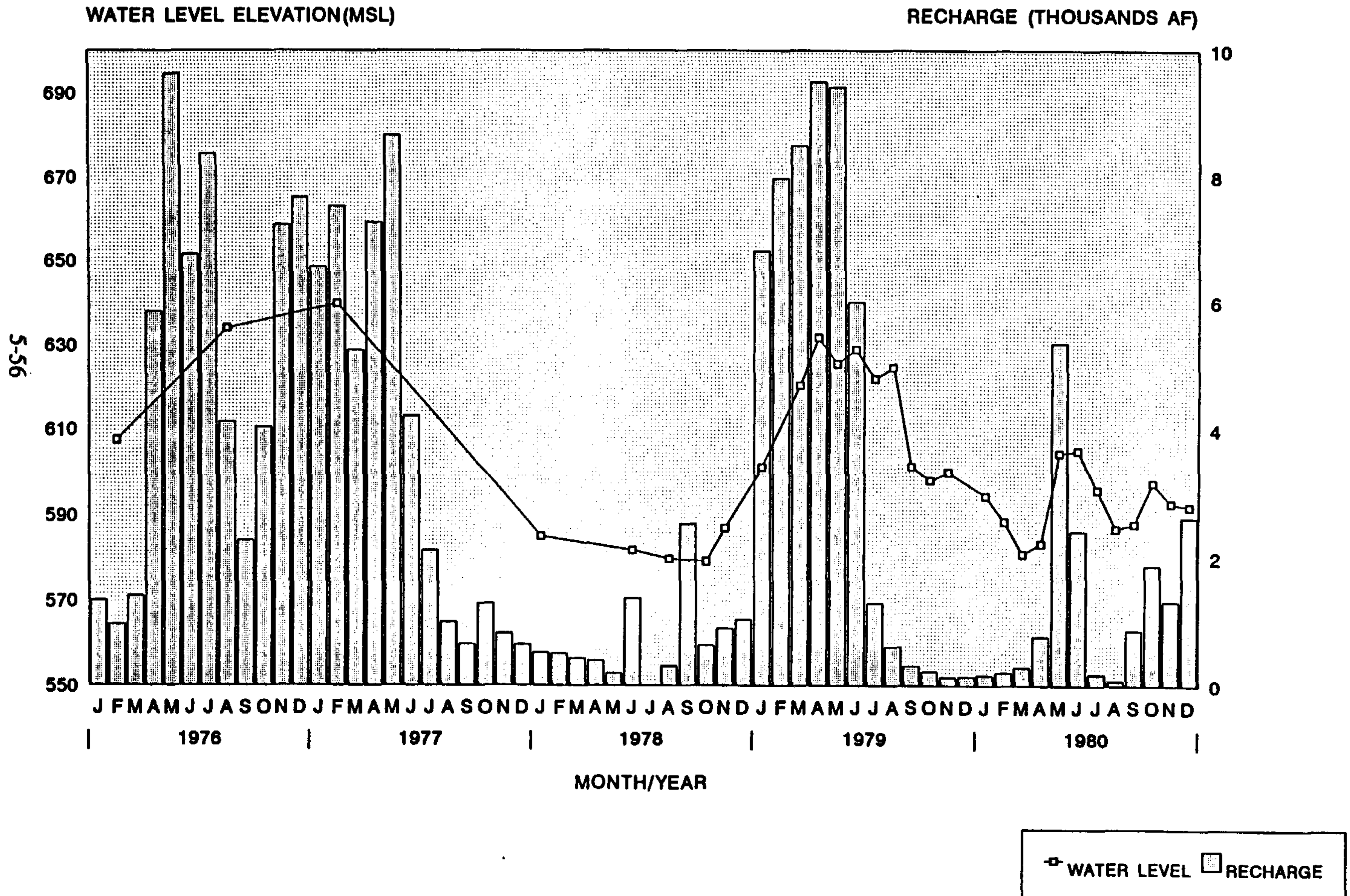


FIGURE 5.3-9
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1981 - 1985

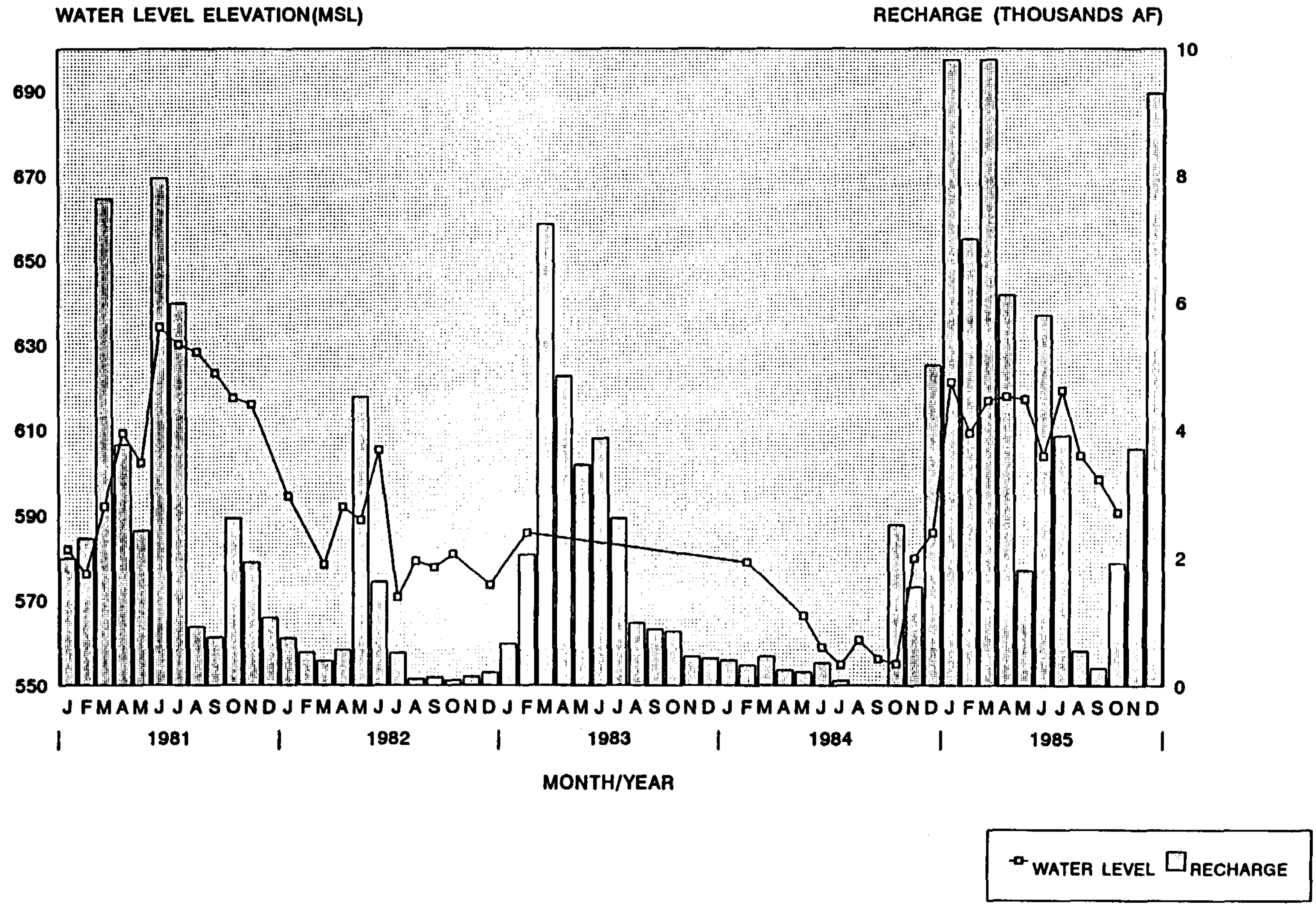
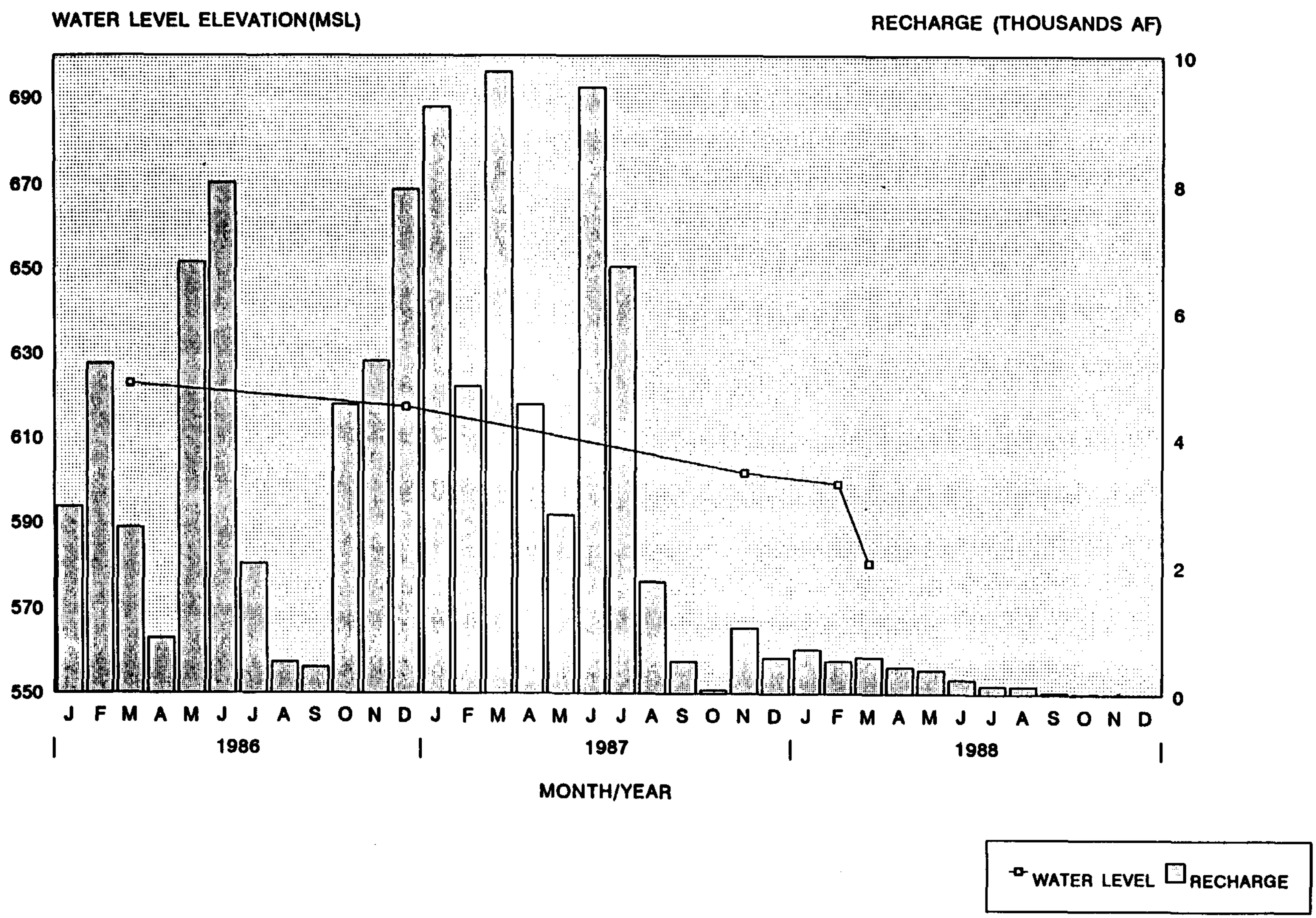


FIGURE 5.3-10
PLOT OF WATER LEVEL AT BUDA WELL (58-58-101) AND RECHARGE FOR THE PERIOD 1986 - 1988



during extended no-recharge periods and/or during high seasonal pumping periods. If this is the case, additional recharge from Onion Creek resulting from implementation of one or more of the recharge alternatives may tend to flow towards and remain longer within the Buda - San Leanna area, thereby becoming more directly useable for beneficial purposes.

Numerous attempts were made to develop quantitative relationships between Onion Creek recharge and water level elevation changes measured in the Buda well. For the most part, statistically significant correlations (simple and multivariant) could not be developed. These efforts included attempted correlations of recharge volume and water level elevation in ft msl; recharge volume and net change in water level elevation; and recharge rate and rate of change in water level elevations. The highest correlation obtained, $r^2 = 0.59$, involved relating the summation of 90-day antecedent Onion Creek recharge to observed water level elevations at Buda. Based on this relationship, it was estimated that for every 570 af of recharge originating from Onion Creek an average 1.0 ft rise in the Buda well resulted. Using this relationship, it is projected that each project alternative described in Section 5.2 could potentially result in the water level elevation increases shown in Table 5.3-1 during "average" conditions. Measured water level elevations at the Buda well are strongly correlated to other observation wells located in the Barton Springs segment of the Edwards aquifer and to flows at Barton Springs. Table 5.3-2 list water level elevation measurements for the Buda well and water level elevation measurement taken on or near the same date for a well located near San Leanna (Well No. 58-50-801). Water level elevation measurements for these two wells are highly correlated ($r^2 = 0.86$) as shown at the bottom of Table 5.3-2. A plot of water level elevation measurements for the Buda well and San Leanna well and "best" fit least squares regression line are shown in Figure 5.3-11. Likewise, data of water level elevation measurements at the Buda well and corresponding daily Barton Springs discharges are shown in Table 5.3-3 and are plotted in Figure 5.3-12. As can be seen from these tables and figures, there is a strong positive (slope) correlation between water level elevations at the Buda well and water level elevations at the San

TABLE 5.3-1
PROJECTED INCREASE IN POTENTIAL WATER ELEVATION LEVEL RISE IN THE BUDA WELL (NO. 58-58-101) RESULTING FROM RECHARGE ENHANCEMENT PROJECTS

PROJECT ALTERNATIVE	POTENTIAL WATER LEVEL INCREASE IN THE BUDA WELL RESULTING FROM AVERAGE ANNUAL INCREASE IN RECHARGE	POTENTIAL WATER LEVEL INCREASE IN THE BUDA WELL RESULTING FROM MAXIMUM AVERAGE RECHARGE
CENTEX RESERVOIR	1.3 ft	4.3 ft
RUBY RESERVOIR	2.0 ft	6.7 ft
RUBY AND CENTEX RESERVOIRS TANDEM OPERATION	2.7 ft	9.3 ft
RUTHERFORD RESERVOIR	6.2 ft	22.4 ft
CENTEX DIVERSION DAM AND RECHARGE QUARRY	10.0 ft	15.3 ft

TABLE 5.3-2
LISTING OF WATER LEVEL ELEVATION MEASUREMENTS FOR
THE BUDA WELL AND SAN LEANA WELL

BUDA
WELL No. 58-58-101
ELEVATION= 707.20 (FT MSL)

SAN LEANA
WELL No. 58-50-801
ELEVATION= 662.00 (FT MSL)

BUDA OBSERVATION DATE	BUDA WATER LEVEL (FT)[1]	BUDA SURFACE LEVEL (FT MSL)	SAN LEANA OBSERVATION DATE	SAN LEANA WATER LEVEL (FT)[1]	SAN LEANA SURFACE LEVEL (FT MSL)
18-Nov-41	107.36	599.84	18-Nov-41	74.72	587.28
10-Apr-42	123.53	583.67	11-Apr-42	99.01	562.99
04-Dec-42	102.25	604.95	04-Dec-42	73.12	588.88
13-Apr-43	110.15	597.05	16-Apr-43	83.31	578.69
09-Sep-43	122.91	584.29	09-Sep-43	96.91	565.09
28-Apr-44	93.63	613.57	28-Apr-44	62.79	599.21
23-Aug-44	103.00	604.20	23-Aug-44	69.25	592.75
22-May-45	87.62	619.58	22-May-45	52.41	609.59
10-Feb-49	138.11	569.09	10-Feb-49	114.92	547.08
22-Apr-49	122.29	584.91	22-Apr-49	109.05	552.95
10-Nov-49	132.45	574.75	10-Nov-49	108.35	553.65
12-Apr-50	129.71	577.49	12-Apr-50	110.96	551.04
03-Aug-50	129.67	577.53	03-Aug-50	110.91	551.09
06-Dec-50	135.79	571.41	07-Dec-50	111.73	550.27
02-Jan-51	136.60	570.60	04-Jan-51	113.45	548.55
21-Jul-54	140.13	567.07	21-Jul-54	118.87	543.13
23-Aug-54	139.41	567.79	20-Aug-54	122.42	539.58
28-Aug-56	146.64	560.56	29-Aug-56	132.68	529.32
07-Jan-57	139.96	567.24	08-Jan-57	121.32	540.68
18-Nov-57	97.42	609.78	14-Nov-57	74.98	587.02
12-Nov-58	84.49	622.71	17-Nov-58	64.89	597.11
16-Dec-59	89.43	617.77	16-Dec-59	66.11	595.89
28-Jan-60	82.23	624.97	28-Jan-60	60.42	601.58
22-Feb-60	80.97	626.23	22-Feb-60	58.86	603.14
26-May-60	86.50	620.70	26-May-60	65.63	596.37
15-Sep-62	124.78	582.42	19-Sep-62	111.15	550.85
04-Nov-69	102.73	604.47	04-Nov-69	82.14	579.86
26-Apr-73	61.80	645.40	27-Apr-73	42.60	619.40
17-Aug-78	127.47	579.73	14-Aug-78	125.80	536.20
26-Oct-78	128.05	579.15	26-Oct-78	120.45	541.55
28-Nov-78	118.93	588.27	28-Nov-78	102.28	559.72
02-Jan-79	133.80	573.40	02-Jan-79	106.16	555.84
30-Jan-79	91.88	615.32	30-Jan-79	72.40	589.60
27-Mar-79	78.40	628.80	28-Mar-79	57.54	604.46
26-Apr-79	73.20	634.00	27-Apr-79	53.12	608.88
31-May-79	71.38	635.82	30-May-79	54.09	607.91
26-Jun-79	81.68	625.52	26-Jun-79	65.95	596.05
09-Aug-79	82.65	624.55	09-Aug-79	59.33	602.67
30-Aug-79	83.90	623.30	30-Aug-79	72.27	589.73
26-Sep-79	112.40	594.80	27-Sep-79	73.40	588.60
30-Nov-79	103.70	603.50	29-Nov-79	92.60	569.40
02-Nov-79	110.65	596.55	02-Nov-79	84.40	577.60
21-Jan-80	112.70	594.50	21-Jan-80	92.65	569.35
29-Feb-80	118.70	588.50	29-Feb-80	108.25	553.75
04-Apr-80	123.20	584.00	04-Apr-80	100.40	561.60
29-Apr-80	124.60	582.60	29-Apr-80	105.43	556.57
29-Jul-80	111.00	596.20	29-Jul-80	114.29	547.71
29-Aug-80	121.34	585.86	28-Aug-80	119.50	542.50
25-Sep-80	119.21	587.99	30-Sep-80	114.55	547.45
23-Oct-80	109.58	597.62	23-Oct-80	102.35	559.65
20-Nov-80	118.80	588.40	20-Nov-80	103.00	559.00
28-Nov-80	110.00	597.20	28-Dec-80	95.80	566.20
26-Jan-81	131.11	576.09	23-Jan-81	94.40	567.60
23-Feb-81	131.07	576.13	27-Feb-81	99.40	562.60
25-Mar-81	98.00	609.20	25-Mar-81	79.30	582.70
23-Apr-81	94.95	612.25	23-Apr-81	77.85	584.15

1 Feet Below Land Surface Datum

TABLE 5.3-2 (Continued)
LISTING OF WATER LEVEL ELEVATION MEASUREMENTS FOR
THE BUDA WELL AND SAN LEANA WELL

BUDA
WELL No. 58-58-101
ELEVATION= 707.20 (FT MSL)

SAN LEANA
WELL No. 58-50-801
ELEVATION= 662.00 (FT MSL)

OBSERVATION DATE	WATER LEVEL (FT)[1]	SURFACE LEVEL (FT MSL)	OBSERVATION DATE	WATER LEVEL (FT)[1]	SURFACE LEVEL (FT MSL)
21-May-81	101.25	605.95	21-May-81	82.50	579.50
25-Jun-81	77.55	629.65	25-Jun-81	52.85	609.15
29-Jul-81	77.12	630.08	25-Jul-81	66.90	595.10
31-Aug-81	78.93	628.27	25-Aug-81	69.65	592.35
28-Sep-81	83.83	623.37	25-Sep-81	68.95	593.05
26-Oct-81	89.74	617.46	25-Oct-81	66.80	595.20
30-Nov-81	91.20	616.00	25-Nov-81	68.10	593.90
29-Jan-82	106.77	600.43	25-Jan-82	83.00	579.00
28-Jun-82	101.94	605.26	25-Jun-82	96.00	566.00
26-Jul-82	136.46	570.74	25-Jul-82	121.25	540.75
25-Aug-82	128.02	579.18	25-Aug-82	131.20	530.80
27-Sep-82	129.48	577.72	25-Sep-82	131.95	530.05
27-Oct-82	126.47	580.73	26-Oct-82	132.40	529.60
14-May-84	140.75	566.45	14-May-84	140.62	521.38
06-Jun-84	148.82	558.38	06-Jun-84	141.02	520.98
14-Jun-84	155.40	551.80	14-Jun-84	130.18	531.82
29-Jun-84	140.33	566.87	29-Jun-84	145.68	516.32
16-Jul-84	151.06	556.14	16-Jul-84	147.83	514.17
31-Jul-84	153.59	553.61	31-Jul-84	150.78	511.22
15-Aug-84	143.40	563.80	15-Aug-84	153.04	508.96
14-Sep-84	156.54	550.66	14-Sep-84	155.90	506.10
28-Sep-84	145.30	561.90	28-Sep-84	152.56	509.44
12-Oct-84	152.08	555.12	12-Oct-84	136.78	525.22
14-Nov-84	127.42	579.78	14-Nov-84	135.65	526.35
09-Jan-85	83.87	623.33	09-Jan-85	91.00	571.00
13-Feb-85	101.17	606.03	13-Feb-85	78.12	583.88
18-Mar-85	83.87	623.33	18-Mar-85	65.47	596.53
18-Apr-85	92.34	614.86	18-Apr-85	62.01	599.99
10-May-85	86.60	620.60	10-May-85	70.25	591.75
12-Jun-85	103.38	603.82	12-Jun-85	65.93	596.07
17-Jul-85	90.10	617.10	17-Jul-85	58.52	603.48
11-Sep-85	108.90	598.30	11-Sep-85	101.30	560.70

Regression Output:

Constant	-32.8311
Std Err of Y Est	10.93684
R Squared	0.86189
No. of Observations	88
Degrees of Freedom	86
X Coefficient(s)	1.145492
Std Err of Coef.	0.049446

1 Feet Below Land Surface Datum

FIGURE 5.3-11
GRAPH OF WATER LEVEL ELEVATION AT BUDA WELL VERSUS WATER LEVEL ELEVATION AT SAN LEANA WELL WITH BEST FIT LEAST SQUARES REGRESSION LINE

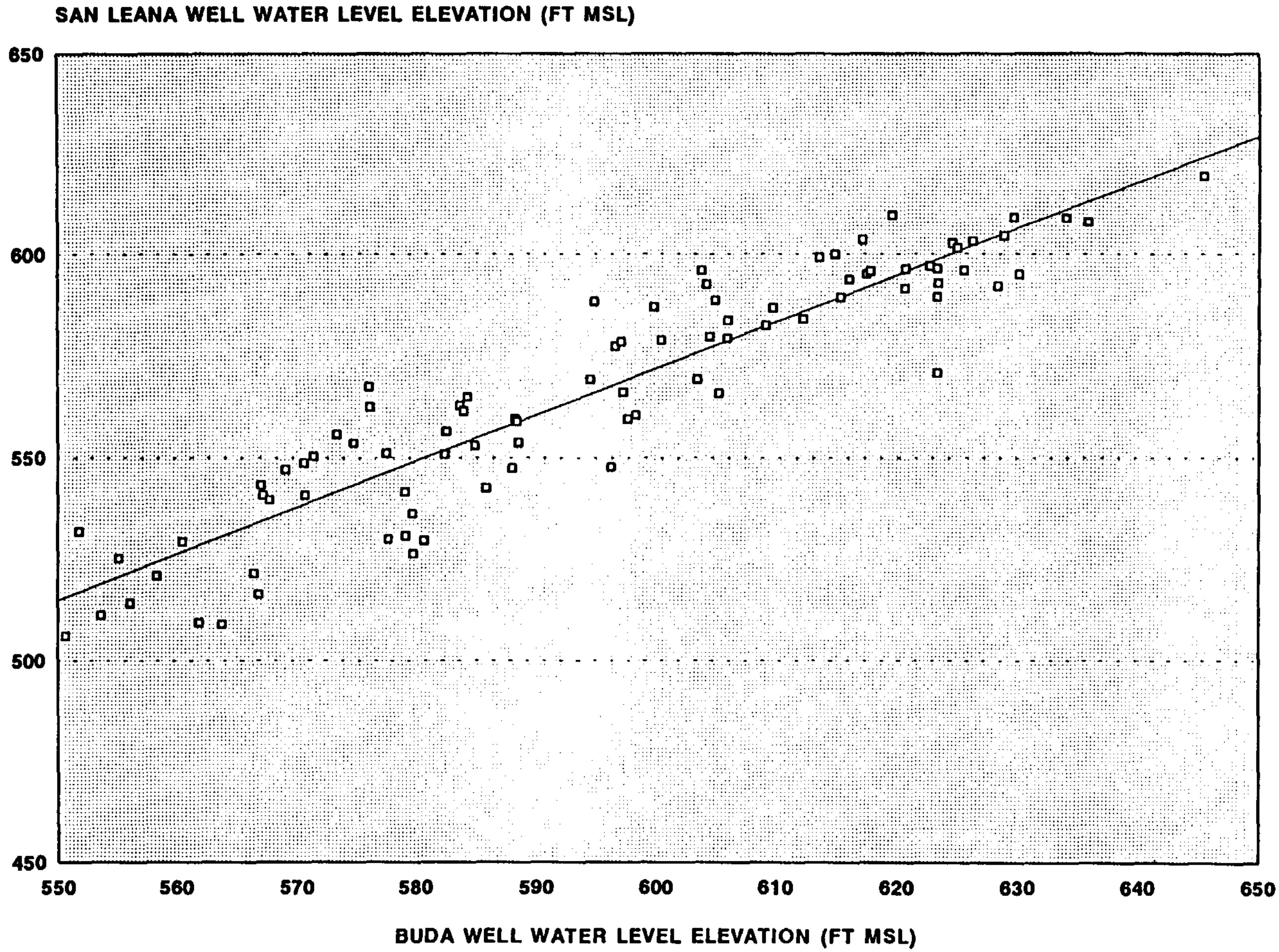


TABLE 5.3-3
LISTING OF CORRESPONDING WATER LEVEL ELEVATION MEASUREMENTS
AT BUDA WELL AND DISCHARGES AT BARTON SPRINGS

DATE	FLOW OF BARTON SPRINGS AT AUSTIN (AF)	BUDA WELL No. 58-58-101 WATER LEVEL (FT)[1]	BUDA WELL No. 58-58-101 ELEVATION (FT MSL)
01-Jun-78	63.36	125.45	581.75
18-Aug-78	41.58	127.47	579.73
26-Oct-78	45.54	128.05	579.15
27-Nov-78	79.20	121.63	585.57
28-Nov-78	77.22	118.93	588.27
02-Jan-79	100.98	133.80	573.40
26-Jan-79	138.60	92.42	614.78
30-Jan-79	136.62	91.88	615.32
01-Mar-79	166.32	83.60	623.60
09-Mar-79	164.34	89.28	617.92
26-Mar-79	170.28	95.78	611.42
27-Mar-79	170.28	78.40	628.80
24-Apr-79	194.04	77.80	629.40
26-Apr-79	194.04	73.20	634.00
29-May-79	209.88	91.86	615.34
31-May-79	209.88	71.38	635.82
26-Jun-79	207.90	81.68	625.52
27-Jun-79	207.90	74.85	632.35
25-Jul-79	188.10	85.17	622.03
09-Aug-79	188.10	82.65	624.55
29-Aug-79	178.20	80.94	626.26
30-Aug-79	178.20	83.90	623.30
25-Sep-79	158.40	105.87	601.33
25-Oct-79	126.72	109.03	598.17
26-Oct-79	126.72	112.40	594.80
02-Nov-79	116.82	110.65	596.55
30-Nov-79	99.00	103.70	603.50
21-Jan-80	73.26	112.70	594.50
29-Feb-80	69.30	118.70	588.50
24-Mar-80	67.32	126.29	580.91
04-Apr-80	83.16	123.20	584.00
29-Apr-80	87.12	124.60	582.60
17-May-80	144.54	102.70	604.50
05-Jun-80	152.46	113.85	593.35
09-Jun-80	144.54	95.96	611.24
23-Jun-80	136.62	96.24	610.96
26-Jun-80	132.66	102.30	604.90
28-Jul-80	100.98	111.46	595.74
29-Jul-80	100.98	111.00	596.20
25-Aug-80	79.20	119.36	587.84
29-Aug-80	75.24	121.34	585.86
25-Sep-80	73.26	119.21	587.99
23-Oct-80	93.06	109.58	597.62
20-Nov-80	83.16	118.80	588.40
28-Nov-80	91.08	110.00	597.20
23-Dec-80	100.98	114.50	592.70
29-Dec-80	99.00	115.87	591.33
26-Jan-81	97.02	131.11	576.09
29-Jan-81	97.02	119.45	587.75
23-Feb-81	106.92	131.07	576.13
05-Mar-81	124.74	123.40	583.80
25-Mar-81	130.68	98.00	609.20
27-Mar-81	132.66	124.05	583.15
23-Apr-81	122.76	94.95	612.25
27-Apr-81	120.78	101.06	606.14
21-May-81	104.94	101.25	605.95
26-May-81	112.86	108.60	598.60

1 Feet Below Land Surface Datum

TABLE 5.3-3 (Continued)
LISTING OF CORRESPONDING WATER LEVEL ELEVATION MEASUREMENTS AT BUDA WELL AND DISCHARGES AT BARTON SPRINGS

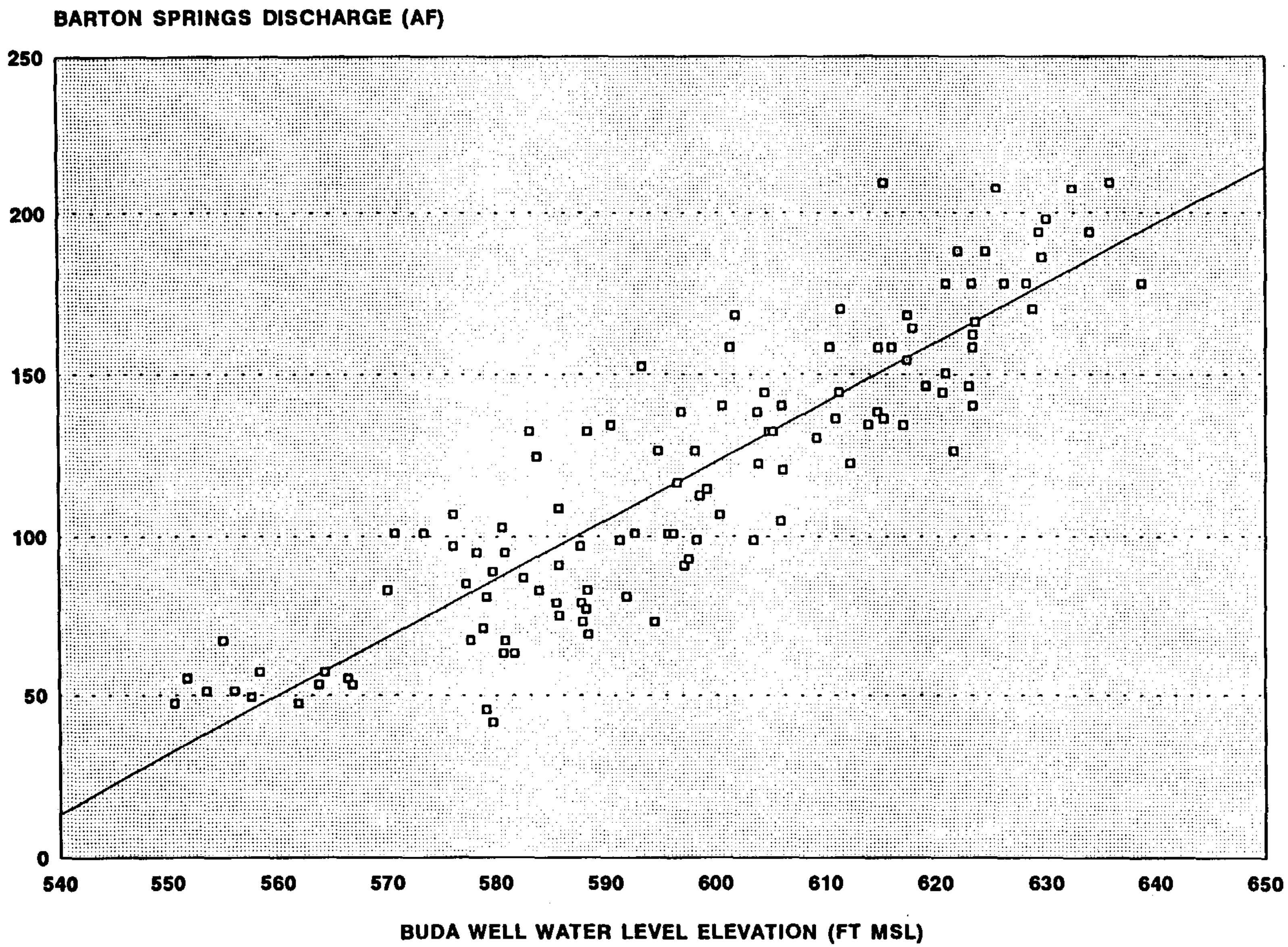
DATE	FLOW OF BARTON SPRINGS AT AUSTIN (AF)	BUDA WELL No. 58-58-101 WATER LEVEL (FT)[1]	BUDA WELL No. 58-58-101 ELEVATION (FT MSL)
18-Feb-83	91.08	121.37	585.83
16-Feb-84	71.28	128.31	578.89
14-May-84	55.44	140.75	566.45
06-Jun-84	57.42	148.82	558.38
14-Jun-84	55.44	155.40	551.80
29-Jun-84	53.46	140.33	566.87
16-Jul-84	51.48	151.06	556.14
31-Jul-84	51.48	153.59	553.61
15-Aug-84	53.46	143.40	563.80
30-Aug-84	49.50	149.53	557.67
14-Sep-84	47.52	156.54	550.66
28-Sep-84	47.52	145.30	561.90
12-Oct-84	67.32	152.08	555.12
14-Nov-84	89.10	127.42	579.78
17-Dec-84	108.90	121.42	585.78
09-Jan-85	140.58	83.87	623.33
28-Jan-85	146.52	88.10	619.10
13-Feb-85	140.58	101.17	606.03
14-Feb-85	140.58	106.57	600.63
25-Feb-85	178.20	86.25	620.95
18-Mar-85	158.40	83.87	623.33
25-Mar-85	158.40	96.83	610.37
18-Apr-85	158.40	92.34	614.86
29-Apr-85	150.48	86.29	620.91
10-May-85	144.54	86.60	620.60
28-May-85	134.64	93.28	613.92
12-Jun-85	138.60	103.38	603.82
17-Jul-85	134.64	90.10	617.10
30-Jul-85	126.72	85.58	621.62
08-Aug-85	122.76	103.27	603.93
11-Sep-85	99.00	108.90	598.30
17-Oct-85	134.64	116.65	590.55
05-Mar-86	146.52	84.20	623.00
16-Dec-86	154.44	89.77	617.43
04-Nov-87	168.30	105.34	601.86
29-Feb-88	114.84	107.92	599.28
15-Apr-88	102.96	126.57	580.63
07-Feb-89	57.42	142.90	564.30

Regression Output:

Constant	546.3168
Std Err of Y Est	9.899196
R Squared	0.791031
No. of Observations	115
Degrees of Freedom	113
X Coefficient(s)	0.431664
Std Err of Coef.	0.020871

1 Feet Below Land Surface Datum

FIGURE 5.3-12
GRAPH OF WATER LEVEL ELEVATION AT BUDA WELL AND CORRESPONDING DAILY DISCHARGE AT BARTON SPRINGS WITH BEST FIT LEAST SQUARES REGRESSION LINE



Leanna well and Barton Springs discharges. This indicates that any increase in water level elevation at the Buda well, due to recharge enhancement, would tend to increase water level elevations (or piezometric surface) in the San Leanna well and eventually increase discharges through Barton Springs.

5.4 WATER RIGHTS

A major consideration in the planning and development of recharge enhancement projects on Onion Creek will be the appropriation or assignment of surface water rights. As explained in Section 7.0, the District and/or other project sponsors will have to apply to the TWC for a water rights appropriation permit to construct, impound and divert (recharge) water from the proposed projects.

There are at least three possible scenarios by which water rights for the selected alternative(s) could be secured. First, the District could submit an application to the TWC for a surface water appropriation. An application for water appropriation would have to include permitting of the diversion (recharge) facility(ies) and a request for appropriation of surface water in an amount to satisfy both the historical recharge volumes and the increased recharge quantity associated with each project to be permitted (personal communication with Mr. Jack Chitwood, TWC).

Secondly, the District could possibly enter into a cooperative agreement with the Lower Colorado River Authority (LCRA) and/or the City of Austin to assign part of their existing water right appropriations to the selected recharge enhancement project(s). The reasoning behind this approach is that LCRA and the City of Austin would be direct benefactors of the recharge project(s). According to Slade (1986), approximately 85% of all water recharged to the Barton Springs segment of the Edwards aquifer eventually discharges through Barton and other associated springs into Town Lake.

Thirdly, the District may elect to use a combination of the previous two scenarios to secure water rights for the project(s).

The quantity of water rights that are authorized or appropriated for diversion and use in the Onion Creek watershed was 622 af per yr, as of November 20, 1991 (Table 5.4-1). All of these water rights are assigned for irrigation purposes. The irrigation water rights upstream from the Onion Creek Recharge Zone total 506 af per yr, while 116 af per yr are situated downstream of the Recharge Zone.

Existing water rights in the Colorado River watershed total over 9.0 million af per yr, of which, approximately 6.8 million af per yr are dedicated for hydropower generation. Irrigation use has the second largest appropriation of about 1.3 million af per yr. Municipal and industrial appropriations total approximately 0.37 million af per yr and 0.58 million af per yr, respectively. The balance of the remaining water rights, approximately 0.014 million af per yr, are for mining and recreational purposes.

LCRA's water rights in the Highland Lakes total approximately 2.26 million af per yr. Austin maintains an annual water rights appropriation for municipal and industrial purposes of almost 0.275 million af. The largest appropriative use of water in the Colorado River watershed downstream of the Highland Lakes is for irrigation. Lakeside[3], Garwood, Pierce, and Gulf Coast Irrigation Districts hold water right allocations or assignment totalling approximately 0.56 million af per yr.

[3] Water rights held by the LCRA.

TABLE 5-4.1
EXISTING WATER RIGHTS IN THE ONION CREEK WATERSHED AS OF NOVEMBER 20,1991

APPLICATION NUMBER	PERMIT NUMBER	OWNER	DATE OF PERMIT	AMOUNT OF WATER (AF/YR)	TYPE	USE	MAXIMUM DIVERSION RATE	LOCATION FROM BUDA GAGE
A-3638	3344	ONION CREEK C. C.	12-Oct-76	12	IMPOUNDMENT	IRRIGATION	2.20 CFS	DOWNSTREAM
A-4338	4027	RICHARD NIELSCHER	07-Mar-83	15	IMPOUNDMENT	IRRIGATION	0.70 CFS	DOWNSTREAM
A-4408	4087	DANIEL C. PITTS	31-Oct-83	12	DIRECT DIVERSION	IRRIGATION	0.20 CFS	DOWNSTREAM
A-4457	4143	H.G. & C.J. MOORE	28-Aug-84	81	DIRECT DIVERSION	IRRIGATION	1.10 CFS	UPSTREAM
A-5086		G. MCALISTER	15-Aug-86	145	IMPOUNDMENT	IRRIGATION	1.96 CFS	UPSTREAM
A-5273	5273	M.K. HAGE JR.	04-Apr-90	60	IMPOUNDMENT	IRRIGATION	0.66 CFS	UPSTREAM
14-5387		TONNET BYRD	13-Jan-65	182	IMPOUNDMENT	IRRIGATION	2.89 CFS	UPSTREAM
14-5388		RICHARD JORDAN	31-Jul-65	15	DIRECT DIVERSION	IRRIGATION	0.53 CFS	UPSTREAM
14-5389		LOUISE WIDEN	31-Dec-39	5	DIRECT DIVERSION	IRRIGATION	0.44 CFS	UPSTREAM
14-5390		BETTY SLAUGHTER	31-Dec-54	6	IMPOUNDMENT	IRRIGATION	0.56 CFS	UPSTREAM
14-5391		C. W. NAGEL	31-May-55	12	IMPOUNDMENT	IRRIGATION	0.56 CFS	UPSTREAM
14-5392		O. V. GRUBERT	15-Jan-73	2	IMPOUNDMENT	IRRIGATION	0.05 CFS	DOWNSTREAM
14-5393		JOINT VENTURE	30-Jun-63	75	DIRECT DIVERSION	IRRIGATION		DOWNSTREAM
			TOTAL	622				

The recharge enhancement alternatives discussed in Section 5.2 of this report will require a TWC appropriation in at least the amount of the maximum recharge to be expected in any given year[4]. The quantity of maximum appropriation for each project is shown below:

PROJECT ALTERNATIVE	REQUIRED TWC APPROPRIATION (AF/YR)
Centex Reservoir	2,477
Ruby Reservoir	3,854
Ruby/CenTex Tandem Operation	5,289
Rutherford Dam and Reservoir	12,682
CenTex Diversion and Dam Recharge Quarry	19,231

As described above, the District could elect to seek a TWC appropriation "outside" of any agreement with LCRA and/or the City of Austin. In this case, the District would have to apply to the TWC for an appropriation in at least the amounts presented above for each project alternative. If the District elects to secure an agreement with LCRA and/or the City of Austin, a surface water rights appropriation request (application) could be for quantities substantially less than those shown above. For example, if 85% of the water recharged by the project alternatives eventually discharges to Town Lake via Barton and other associated springs and, subsequently, used under either or both LCRA's or City of Austin's existing water rights appropriations, then the request for new appropriation could be in the following amounts:

[4] An additional appropriation in the amount of the historical natural recharge (without project conditions) may also be required. For presentation purposes herein, only the amount of maximum annual recharge expected from each alternative is considered for appropriation, since all existing and senior water rights are appropriated based on historical streamflow and recharge conditions.

PROJECT ALTERNATIVE	REQUIRED TWC APPROPRIATION (A-F/YR)
CenTex Reservoir	372
Ruby Reservoir	578
Ruby/CenTex Tandem Operation	793
Rutherford Dam and Reservoir	1,902
CenTex Diversion Dam and Recharge Quarry	2,884

The LCRA has agreed to perform an assessment of water rights and the impact the selected recharge enhancement project(s) would have on LCRA's existing water rights, upon receipt of this investigation. This will require a daily assessment of water availability and use for "with" and "without" recharge project conditions. Upon completion of the LCRA's water rights impact assessment, the District should take appropriate action to secure the necessary water rights for the selected alternative(s).

5.5 SEDIMENT TRANSPORT AND SEDIMENTATION

Estimates of erosion and sedimentation rates for the Onion Creek watershed above Buda were made to determine the average annual expected sediment load entering the Recharge Zone, and the quantity of sediment that may be captured by the proposed recharge enhancement projects.

Sedimentation is the end result of the erosion process. There are two major types of erosion: erosion by water and erosion by wind. For this project, only water erosion is considered, since water is the main transport vehicle of sediment into the study area. Erosion is further categorized into two broad categories: (1) sheet and rill erosion and (2) gully and streambank erosion.

Sheet erosion, including rilling, is the detachment and movement of soil particles by the forces of surface runoff. It can occur on all types of land, but is most active on sloping, cultivated land whose runoff consists primarily of overland flow. It is also very active on bare, sloping uncultivated areas (geologic erosion). The principal factors influencing the rate of sheet and rill erosion on a given piece of land are soil erodibility, slope gradient, slope length, type of vegetative cover, and rainfall energy.

Gully and streambank erosion occur on steeply sloping banks and bottoms of gullies and streams. Some of this erosion takes place by sheet erosion of the banks, but it is differentiated from sheet and rill erosion because it occurs within the confines of a gully or stream. A large part of this erosion occurs as the result of undermining of the banks by water flowing in the gully or stream, which causes the soil in the bank to cave or slough into the flowing watercourse (TDWR 1982).

An important difference between sheet and rill erosion and gully and streambank erosion is the eroded soils from the latter are immediately available to the transport system and the ratio of amounts delivered to amounts eroded are very high.

In order to determine sheet and rill erosion and gully and streambank erosion for the Onion Creek watershed above Buda, data and procedures described by the Texas Department of Water Resources (TDWR) were utilized. These procedures are presented in TDWR Report No. 268 titled "Erosion and Sedimentation By Water in Texas", 1982. Sheet and rill erosion was computed by using the universal soil loss equation. Gully and streambank erosion was estimated by applying TDWR computed percentages of gully and streambank erosion to the sheet and rill erosion estimate (TDWR 1982).

Using this methodology, the average annual sediment yield (sheet and rill erosion and gully and streambank erosion) for the Onion Creek watershed above Buda was estimated to be

0.66 tons per ac. This compares to a TDWR (1982) computed sediment yield of 0.69 tons per ac for the Colorado River at Austin and 0.64 tons per ac for the Blanco River at San Marcos.

For the study area, a sediment yield of 0.66 tons per ac is equivalent to 69,700 tons[5] of sediment per yr or an average of 46 af[6] of sediment per yr. Field observations of floods within the study area indicate that the initial flood surge probably transports an estimated 95 to 98 percent of the sediment load (District field studies in 1991). Following initial flood surges, floodwater (stream flow) entering the study area transports very little sediment load, as evidenced by observing extremely clear, clean water.

If provisions are not made to pass initial sediment laden flood surges in the recharge project alternatives, then a portion of the inflowing sediment will be retained or recharged in the recharge reservoirs. The amount of sediment retained a reservoir is commonly referred to as "trap efficiency". Using commonly accepted engineering techniques (Linsley and Franzini 1964), it is estimated that each project alternative will have trap efficiencies and sediment retention as follows:

PROJECT ALTERNATIVE	TRAP EFFICIENCY (PERCENT)	ESTIMATED VOLUME OF SEDIMENT RETAINED (AF PER YR)
CenTex Reservoir	25	11
Ruby Reservoir	45	20
Ruby/CenTex Tandem Operation	50	23
Rutherford Dam and Reservoir	80	36
CenTex Diversion Dam and Recharge Quarry	68	31

[5] 0.66 Tons per ac times 165 sq mi times 640 ac per sq mi.

[6] 1-af of sediment equals 1,524.6 tons.

Sediment deposition in the recharge reservoirs could be mitigated by providing structural and operational mechanisms to allow initial storm-runoff surges to pass through the impoundment(s) and dam(s). The dam(s) could be equipped with large diameter outflow pipes or gates that would remain open until sediment laden stream flow passes the structure. The gates would be subsequently closed to impound and recharge low sediment content water. In any event, there will be some sediment deposition in the bottom of the reservoirs, and particularly, near upstream dam abutments. Sediment accumulation should be continually monitored and should be mechanically removed, if deposition occurs to the point to prevent or restrict recharge.

5.6 WATER QUALITY OF ONION CREEK OVER THE RECHARGE ZONE

The USGS has measured water quality constituents, using grab sampling techniques, at the Driftwood gage (No. 08158700) since 1974, and at the Buda gage (No. 08158800) for the period January 1978 through September 1983. Tables 5.6-1 and 5.6-2 contains a statistical summary of important water quality constituents for these gages for their respective periods of records.

Water quality analyses (USGS) for Onion Creek near Driftwood and at Buda include nutrients (ammonia nitrogen, organic nitrogen, nitrite nitrogen, nitrate nitrogen, and phosphorus); physical organics and inorganics (specific conductance, pH, temperature, turbidity, dissolved oxygen, suspended and dissolved solids, biochemical oxygen demand, and total organic carbon); indicator bacteria (fecal coliform, and fecal streptococci); inorganic chemical constituents (calcium, magnesium, sodium, alkalinity, sulfate, chloride, and fluoride); and selected trace elements (arsenic, barium, beryllium, cadmium, cobalt, lithium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, and zinc).

TABLE 5.6-1
AVERAGE CONCENTRATION FOR SELECTED WATER QUALITY CONSTITUENTS
AT THE DRIFTWOOD GAGE
(SOURCE: USGS, JANUARY 1974 THROUGH SEPTEMBER 1990)

CONSTITUENT	UNITS	No. OF OBSERVATIONS	AVERAGE CONCENTRATION	MAXIMUM OBSERVED CONCENTRATION	MINIMUM OBSERVED CONCENTRATION
FLOW	cfs	101	177.65	8800.00	0.04
SPECIFIC CONDUCTANCE	µS/CM	101	456.95	584.00	142.00
TEMPERATURE	DEG C	100	19.80	29.00	6.00
TURBIDITY	NTU	100	15.90	550.00	0.00
OXIGEN DISSOLVED	MG/L	101	8.74	11.50	5.50
5 DAY BOD	MG/L	100	0.80	6.50	0.00
FECAL COLIFORM	COLS/100ML	19	7707.89	49000.00	150.00
FECAL COLIFORM .7 UM-MF	COLS/100ML	56	2152.39	27000.00	6.00
FECAL STREPTOCOCCI	COLS/100ML	56	7528.18	280000.00	16.00
HARDNESS TOTAL	MG/L CaCO3	88	227.51	270.00	71.00
HARDNESS DISSOLVED	MG/L CaCO3	88	30.27	63.00	2.00
CALCIUM DISSOLVED	MG/L Ca	88	65.14	84.00	23.00
MAGNESSIUM DISSOLVED	MG/L Mg	88	15.74	21.00	3.30
SODIUM DISSOLVED	MG/L Na	88	7.59	16.00	1.60
POTASIUM DISSOLVED	MG/L K	88	1.31	3.70	0.90
ALKALINITY	MG/L CaCO3	29	186.97	231.00	62.00
SULFATE DISSOLVED	MG/L SO4	88	27.17	48.00	1.00
CHLORIDE DISSOLVED	MG/L Cl	88	12.03	18.00	2.60
FLUORIDE DISSOLVED	MG/L F	43	0.20	0.60	0.10
SOLIDS SUM OF CONSTITUENTS	MG/L	88	257.20	302.00	86.00
NITORGEN NITRITE	MG/L N	100	0.03	1.00	0.00
NITROGEN NO2+NO3 TOTAL	MG/L N	101	0.17	1.50	0.00
NITROGEN AMMONIA	MG/L N	101	0.03	0.16	0.00
NITROGEN ORGANIC TOTAL	MG/L N	86	0.33	3.00	0.00
PHOSPHORUS TOTAL	MG/L P	101	0.03	0.21	0.00
ORGANIC CARBON TOTAL	MG/L C	101	3.37	38.00	0.00
ARSENIC DISSOLVED	µG/L As	52	0.81	4.00	0.00
BARIUM DISSOLVED	µG/L Ba	38	30.79	200.00	0.00
BERILIUM DISSOLVED	µG/L Be	2	0.50	0.50	0.50
CADMIUM DISSOLVED	µG/L Cd	50	1.06	14.00	0.00
CHROMIUM DISSOLVED	µG/L Cr	50	5.60	60.00	0.00
COBALT DISSOLVED	µG/L Co	12	0.25	1.00	0.00
COPPER DISSOLVED	µG/L Cu	50	1.80	10.00	0.00
IRON DISSOLVED	µG/L Fe	50	12.90	50.00	0.00
LEAD DISSOLVED	µG/L Pb	50	2.98	10.00	0.00
LITHIUM DISSOLVED	µG/L Li	14	3.21	10.00	0.00
MANGANESE DISSOLVED	µG/L Mn	50	3.36	20.00	0.00
MERCURY DISSOLVED	µG/L Hg	50	0.07	0.30	0.00
MOLYBDENUM DISSOLVED	µG/L Mo	2	10.00	10.00	10.00
NICKEL DISSOLVED	µG/L Ni	14	2.79	10.00	0.00
SELENIUM DISSOLVED	µG/L Se	38	0.68	2.00	0.00
SILVER DISSOLVED	µG/L Ag	38	0.63	2.00	0.00
STRONTIUM DISSOLVED	µG/L Sr	2	6.00	6.00	6.00
ZINC DISSOLVED	µG/L Zn	50	6.48	70.00	0.00

TABLE 5.6-2
AVERAGE CONCENTRATION FOR SELECTED WATER QUALITY CONSTITUENTS
AT THE BUDA GAGE
(SOURCE: USGS, JANUARY 1978 THROUGH MARCH 1983)

CONSTITUENT	UNITS	No. OF OBSERVATIONS	AVERAGE CONCENTRATION	MAXIMUM OBSERVED CONCENTRATION	MINIMUM OBSERVED CONCENTRATION
FLOW	cfs	25	967.72	8320.00	0.13
SPECIFIC CONDUCTANCE	US/CM	25	360.96	545.00	115.00
TEMPERATURE	DEG C	25	19.90	31.50	6.00
TURBIDITY	NTU	23	169.45	1200.00	0.00
OXIGEN DISSOLVED	MG/L	21	8.70	11.20	5.60
5 DAY BOD	MG/L	23	2.48	12.00	0.10
FECAL COLIFORM	COLS/100ML	19	17976.32	130000.00	0.00
FECAL COLIFORM .7 UM-MF	COLS/100ML	23	9118.17	46000.00	2.00
FECAL STREPTOCOCCI	COLS/100ML	23	21362.35	84000.00	14.00
HARDNESS TOTAL	MG/L CaCO3	20	155.70	250.00	0.00
HARDNESS DISSOLVED	MG/L CaCO3	20	20.45	44.00	0.00
CALCIUM DISSOLVED	MG/L Ca	20	49.55	79.00	0.00
MAGNESSIUM DISSOLVED	MG/L Mg	20	7.83	16.00	0.00
SODIUM DISSOLVED	MG/L Na	20	5.97	15.00	0.00
POTASIUM DISSOLVED	MG/L K	20	2.09	4.00	0.00
ALKALINITY	MG/L CaCO3	5	101.20	190.00	41.00
SULFATE DISOLVED	MG/L SO4	20	20.84	44.00	0.00
CHLORIDE DISSOLVED	MG/L Cl	20	9.95	22.00	0.00
FLUORIDE DISSOLVED	MG/L F	19	0.15	0.20	0.10
SOLIDS SUM OF CONSTITUENT	MG/L	20	184.60	304.00	0.00
NITORGEN NITRITE	MG/L N	24	0.03	0.25	0.00
NITROGEN NO2+NO3 TOTAL	MG/L N	24	0.27	1.50	0.00
NITROGEN AMMONIA	MG/L N	24	0.06	0.29	0.00
NITROGEN ORGANIC TOTAL	MG/L N	24	0.97	6.50	0.07
PHOSPHORUS TOTAL	MG/L P	24	0.07	0.30	0.01
ORGANIC CARBON TOTAL	MG/L C	23	12.71	77.00	1.30
ARSENIC DISSOLVED	µG/L As	19	0.89	3.00	0.00
BARIUM DISSOLVED	µG/L Ba	17	26.94	200.00	0.00
CADMIUM DISSOLVED	µG/L Cd	17	0.82	3.00	0.00
CHROMIUM DISSOLVED	µG/L Cr	17	1.76	10.00	0.00
COBALT DISSOLVED	µG/L Co	4	0.00	0.00	0.00
COPPER DISSOLVED	µG/L Cu	17	1.29	5.00	0.00
IRON DISSOLVED	µG/L Fe	17	29.47	190.00	0.00
LEAD DISSOLVED	µG/L Pb	17	1.65	15.00	0.00
MANGANESE DISSOLVED	µG/L Mn	17	9.53	80.00	0.00
MERCURY DISSOLVED	µG/L Hg	17	0.01	0.10	0.00
NICKEL DISSOLVED	µG/L Ni	4	0.00	0.00	0.00
SELENIUM DISSOLVED	µG/L sE	17	0.24	1.00	0.00
SILVER DISSOLVED	µG/L Ag	17	0.12	1.00	0.00
STRONTIUM DISSOLVED	µG/L Sr	4	0.00	0.00	0.00
ZINC DISSOLVED	µG/L Zn	17	5.24	18.00	0.00

For the period of record at the Driftwood gage (see Table 5.6-1), specific conductance averaged 457 μs/cm with an average water temperature of 19.8 degrees C. Turbidity, dissolved oxygen, biochemical oxygen demand (5-day) and total hardness averaged 15.9 ntu, 8.74 mg/l, 0.8 mg/l and 228 mg/l, respectively. Likewise, sulfates, chlorides and total dissolved solids averaged 27.2 mg/l, 12.0 mg/l and 257 mg/l respectively. Average concentrations of heavy metals, such as, copper, iron, lead, manganese, and mercury averaged 1.8 μg/l, 12.9 μg/l, 2.98 μg/l, 3.36 μg/l, and 0.07 μg/l, respectively.

At the Buda gage (see Table 5.6-2), for the period January 12, 1978 through March 23, 1983, specific conductance averaged 361 μs/cm with an average water temperature of 19.9 degrees C. Turbidity, dissolved oxygen, biochemical oxygen demand (5-day) and total hardness averaged 169 ntu, 8.70 mg/l, 2.48 mg/l and 156 mg/l, respectively. Sulfates, chlorides and total dissolved solids averaged 20.8 mg/l, 10.0 mg/l and 185 mg/l respectively. Average concentrations of heavy metals, such as, copper, iron, lead, manganese, and mercury averaged 1.3 μg/l, 29.5 μg/l, 1.65 μg/l, 9.53 μg/l, and 0.01 μg/l, respectively.

In comparing the Driftwood and Buda gages, water quality constituent concentrations at each gage are similar with the exception of turbidity, iron and manganese. Average turbidity, iron and manganese concentrations at the Buda gage averaged several hundreds of percent higher than at the Driftwood gage. The high increases for these water quality constituents may be a result of quarry operations located between the Buda and Driftwood gages. However, current and proposed new state and Federal regulations will limit and require partial treatment of runoff from quarry operations, which should result in better water quality for these constituents at the Buda gage.

Fecal coliform (colonies per 100 ml) and fecal streptococci (colonies per 100 ml) exhibit high to extremely high concentrations at both the Driftwood and Buda gages. Average concentrations for these indicator bacteria at the Driftwood gage were 2,152 colonies per 100 ml (fecal coliform) and 7,528 colonies per 100 ml (fecal streptococci). At the Buda gage, these indicator bacteria averaged 9,118 colonies per 100 ml and 21,362 colonies per 100 ml, respectively. These average concentrations greatly exceed Texas Department of Health drinking water and contact recreation standards of 100 colonies per 100 ml and 200 colonies per 100 ml, respectively.

The ratio of fecal coliform to fecal streptococci is often used to identify the origin of bacterial contamination. Ratios of greater than 4 generally indicate contamination predominantly from human sources, while ratios less than 0.7 generally indicate predominantly animal sources (Slade et al 1986). Using average colony counts as a basis, the ratio of fecal coliform to fecal streptococci at the Driftwood and Buda gages are 0.28 and 0.43, respectively. Examination of individual grab samples collected by the USGS yields similar ratios, which indicates that the contamination source is predominately from animal populations.

The Onion Creek watershed above the Driftwood gage is predominately ranching country. Large herds of cattle, goats and sheep graze within this area. In addition, extensive populations of deer and other wildlife reside within this watershed. These animal populations are probably the source of fecal coliform and fecal streptococci contamination.

Fecal coliform and fecal streptococci concentrations at the Buda gage average about 3 to 4 times higher than at the Driftwood gage. Like the watershed above the Driftwood gage, the drainage area between the Driftwood gage and Buda gage is predominately used for ranching operations. There is one residential subdivision located within this area on the banks of Onion Creek. Wastewater treatment within this subdivision is provided by individual on-site septic systems. In addition, there is an exotic game preserve and ranch located within this area. This preserve and hunting facility may have a higher population and density of imported deer and other animals. Ranching operations downstream of the Driftwood gage are also possibly larger in scale, with more large livestock per acre, than operations upstream from Driftwood. Higher density of animal populations and the subdivision could account for the observed increase in fecal coliform and fecal streptococci concentrations at the Buda gage.

District staff (personal communication with Mr. Ron Fieseler) indicate that monitor wells located in the vicinity of Onion Creek have not historically exhibited fecal coliform and fecal streptococci concentrations in excess of drinking water standards. The USGS (Slade et al 1986) also found fecal densities in water samples from the Edwards aquifer were low and diminish with time of travel from recharge source to water supplies (wells) and spring discharge points. Therefore, recharge (natural and enhanced) of Onion Creek water containing high concentrations of fecal coliform and fecal streptococci indicator bacteria should not pose significant water quality problems. However, the presence of high densities of indicator bacteria in recharge water should be monitored closely and further study of the mechanisms that reduce indicator bacteria densities upon entering the Edwards aquifer system should be investigated.

In general, the water quality of Onion Creek as it enters and leaves the Recharge Zone exhibits good water quality. Although relatively high concentrations for a few constituents (cadmium, iron, manganese, zinc, and indicator bacteria) have been detected, no organic, inorganic or trace element water quality contamination problems have been identified from the USGS data. A summary of Texas Department of Health and U.S. Environmental Protection Agency drinking water standards for selected water quality constituents is presented in Table 5.6-3. Using these drinking water standards in comparison with water quality data collected by the USGS at the Driftwood and Buda gages, the data indicates that Onion Creek water is suitable as a public drinking water supply source. Monitoring and continual evaluation of indicator bacteria densities should be undertaken.

Table 5.6-3
SUMMARY OF STANDARDS FOR SELECTED WATER-QUALITY CONSTITUENTS AND PROPERTIES FOR PUBLIC WATER SYSTEMS

ORGANIC AND INORGANIC CHEMICALS AND RELATED PROPERTIES

Contaminant	Contaminant Level	
	Maximum (μg/L)	Secondary Maximum mg/L
Arsenic (As)	50	---
Barium (Ba)	1,000	---
Cadmium (Cd)	10	---
Chlorine (Cl)	---	300
Chromium (Cr)	50	---
Copper (Cu)	---	1
Fluoride (F)	4,000	---
Iron (Fe)	---	0.3
Lead (Pb)	50	---
Manganese (Mn)	---	0.05
Mercury (Hg)	2	---
Nitrate (as N)	10,000	---
pH	---	>= 7.0
Selenium (Se)	10	---
Silver (Ag)	50	---
Sulfate (SO4)	---	300
Zinc (Zn)	---	5
Dissolved Solids	---	1,000

Source: TDH, Drinking Water Standards Governing Drinking Water Quality and Reporting Requirements for Public Water Supply Systems, January 1991

DEFINITIONS:

Contaminant.-Any physical, chemical, biological, or radiological substance or matter in water.

Public Water System.-A system for the provision of piped water to the public for human consumption, if such system has at least 15 service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

Maximum contaminant level.-The maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system. Maximum contaminant levels are those levels set by the U.S. Environmental Protection Agency (1976) in the National Interim Primary Drinking Water Regulations. These regulations deal with contaminants that may have a significant impact on the health of the consumer and are enforceable by the Environmental Protection Agency.

Secondary maximum contaminant level.-The advisable maximum level of contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system. Secondary maximum contaminant levels are those proposed by the Environmental Protection Agency. These regulations deal with contaminants that may not have a significant direct impact on the health of the consumer, but their presence in excessive quantities may affect the aesthetic qualities and discourage the use of a drinking-water supply by the public.

6.0 ENVIRONMENTAL INVENTORY AND ISSUES REPORT

This Environmental Inventory and Issues Report provides a preliminary analysis of each of the five project alternatives with respect to environmental issues and concerns. This section generally follows the Texas Water Development Board's (TWDB's) "Guidelines for the Preparation of Environmental Assessments". Note, however, that this planning report is not intended to provide a comprehensive evaluation of the impacts or mitigation requirements associated with each of the proposed alternatives. Instead, it is intended to provide a preliminary inventory of baseline environmental conditions in the study area and a relative ranking of each of the alternatives with respect to potential environmental impacts.

This preliminary assessment begins with a description of the Baseline Environmental setting in the project area including Geological Elements, Hydrological Elements, Climate, Wetlands and Floodplains, Biological Elements, Historic/Archaeological Resources, Land Use, Socioeconomics, and Recreation. The baseline description is followed by a general description of the potential impacts of each of the alternatives with respect to each of the disciplines identified above.

6.1 BASELINE ENVIRONMENTAL SETTING

A three step process was utilized to obtain a preliminary assessment of baseline environmental conditions in the study area. These steps include a literature review, review of remote sensing data, and a field reconnaissance.

A thorough review of previous environmental studies conducted in the project area was the initial step in assessing baseline environmental conditions. The following agencies/ institutions were contacted and/or visited in an initial effort to develop a comprehensive set of baseline data.

- Texas Natural Heritage Program (TNHP)
- City of Austin - Environmental and Conservation Services
- University of Texas - Life Sciences Library
- Southwest Texas State University - Edwards Aquifer Research and Data Center
- Dr. Kent Butler - University of Texas - Department of Community and Regional Planning

The detailed literature review did not prove to be very fruitful, as apparently a minimal amount of environmental study (especially biological) had previously been conducted in the project area. This very likely could be due to the lack of access as a result of private ownership by a few landowners holding large parcels in the project area. Literature analyzed and used in this analysis is presented in the bibliography.

The literature review was followed by a review of remote sensing information black and white (scale 1:24,000) and color (scale 1:24,000) aerial photography and topographic maps) to identify significant features prior to the field reconnaissance. Significant features identified from the remote sensing information were noted and ground verified in the field.

Finally, a field reconnaissance was conducted by biologists from Mariah (in conjunction with the BS/EACD geologist and engineers from DGRA) at various times throughout the summer and early autumn as land owner access allowed. The field reconnaissance consisted of a pedestrian survey of the creek channel and adjacent areas beginning immediately east of the downstream edge of the Edwards aquifer Recharge Zone. The field reconnaissance concluded just upstream of the western edge of the recharge zones at the site of the proposed Rutherford

Reservoir. Note that due to the time frame of the field reconnaissance (mid-summer months) the creek was dry during the major portion of the field effort. This field effort was conducted prior to siting of the project alternatives and, in fact, was designed to aid in the siting of the potential alternatives. Therefore no exhaustive effort was conducted at any one site.

Finally, the Regional Project location and Locations of the Proposed Project Alternatives within the Onion Creek Watershed are presented in Figures 6.1-1 and 6.1-2 to provide an orientation to the project alternatives.

6.1.1 Geology and Soils

6.1.1.1 Geology

The geology of the Onion Creek Recharge Zone is discussed in detail in Section 3.0 of this report.

6.1.1.2 Soils

The following discussion of the edaphic resources of the Onion creek watershed begins with general soil descriptions in relation to the vegetational region where they occur. A characterization of the individual soil associations within the watershed will follow.

The Onion Creek watershed crosses two vegetational regions as described by Gould (1975). The portion of the creek in Blanco and Hays Counties lies within the Edwards Plateau vegetational region of Texas. The Travis County stretch of Onion Creek is found within the Blackland Prairie vegetational region. On a gross scale, the soils of these two vegetational

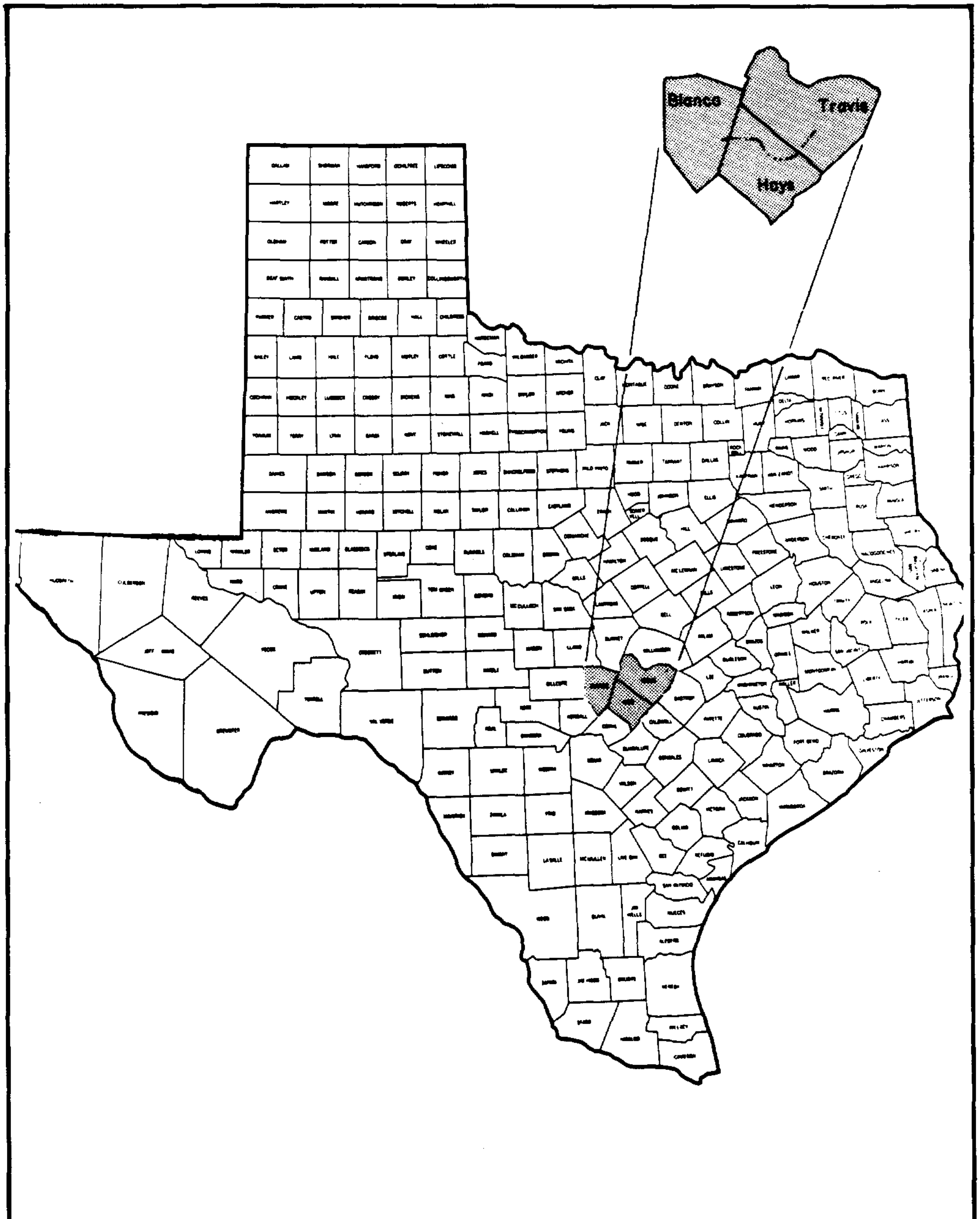


Figure 6.1-1

PROJECT LOCATION MAP

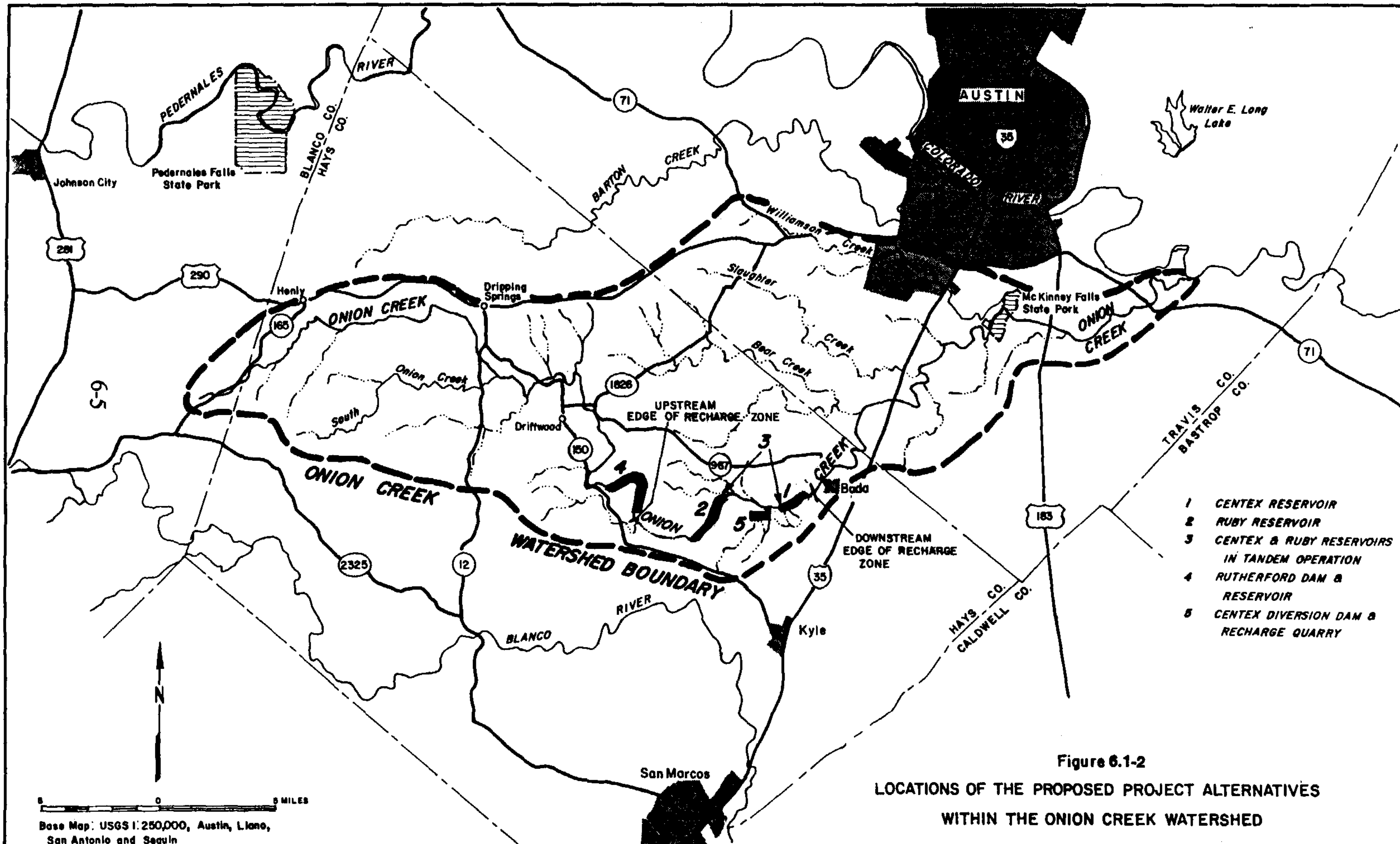


Figure 6.1-2
LOCATIONS OF THE PROPOSED PROJECT ALTERNATIVES WITHIN THE ONION CREEK WATERSHED

regions differ considerably. The soils of the Edwards Plateau are mostly shallow stoney clays and clay loams, whereas Blackland Prairie soils are mainly deep clays (SCS 1984).

The thin, stoney clays and clay loams of the Edwards Plateau are best suited to use as rangeland provided that the resource is managed properly. Important grasses that may occur on moderately grazed range sites include switchgrass (*Panicum vigatum*), *Tridens* sp., *Aristida* sp., indiangrass (*Sorghastrum nutans*), several species of gramas (*Bouteloua* sp.) and bluestems, buffalograss (*Buchloe dactyloides*), and tall dropseed (*Sporobolus asper*) along with several other species (Gould 1975; Amos and Gehlbach 1988; Hatch et al 1990).

The deep clays of the Blackland Prairie are well suited for improved pasture and field crops. Blackland soils that occur in this region are so named due to the uniform dark-colored calcareous clay component of the typical alfisols. These soils are interspersed with gray acid sandy loams. Little bluestem (*Schizachyrium scoparium* var. *frequens*) represents a climax dominant species of the true prairie vegetation of this region (Thomas 1975). Big bluestem (*Andropogon gerardi*), indiangrass, switchgrass, hairy grama (*Bouteloua hirsuta*), sideoats grama (*B. curtipendula*), tall dropseed, silver bluestem (*Bothriochloa saccharoides*), and Texas wintergrass (*Stipa leucotricha*) represent other important grasses in the region. Improved pastures with such introduced grass species as dallisgrass (*Paspalum dilatatum*), King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*), Kleingrass (*Panicum coloratum*) and bermudagrass (*Cynodon dactylon*) are common in the area (Thomas 1975; SCS 1984). Common crops include grain sorghum, cotton, corn, wheat, and oats.

Soil Associations

Soil associations can be useful in assessing natural landscapes, as they are contrived in accordance with their distinctive patterns of soils, relief, and drainage (SCS 1984). These characteristics, in turn, often determine native vegetation composition and the use of these lands by man. What follows is a brief discussion of the soil associations that occur in the Onion Creek drainage basin. Figure 6.1-3 provides a map of these associations, using county specific nomenclature for the soil groups. All soil association information provided below issues from the Soil Conservation Service's (SCS) soil surveys for Travis County, and Comal and Hays Counties (SCS 1974 & SCS 1984, respectively).

Brackett-Comfort-Real

The Brackett-Comfort-Real soil association is described by the SCS (1984) as shallow, undulating to steep soils over limestone or strongly cemented chalk, found on uplands of the Edwards Plateau. When these soils occur on hills and ridges, the topography often exhibits a stepped appearance due to differential weathering of alternate layers of the marl and indurated limestone underburden.

This association is made up of Brackett soils (23%), Comfort soils (17%), and Real soils (up to 9%). Bolar, Denton, Doss, Eckrant, Krum, Lewisville, Orif, Purvis, Sunev, and Tarpley soils and Rock outcrop make up the remaining 51 percent of the surface cover.

Being generally shallow and stoney, the soils of the Brackett-Comfort-Real association are best suited for rangeland. Some alluvial soils are used as pastureland or hayland. The soils of this association provide food and cover for deer, turkey, and quail.

Brackett

The Brackett soil association of Travis County is homologous to the Brackett-Comfort-Real association of Comal and Hays counties.

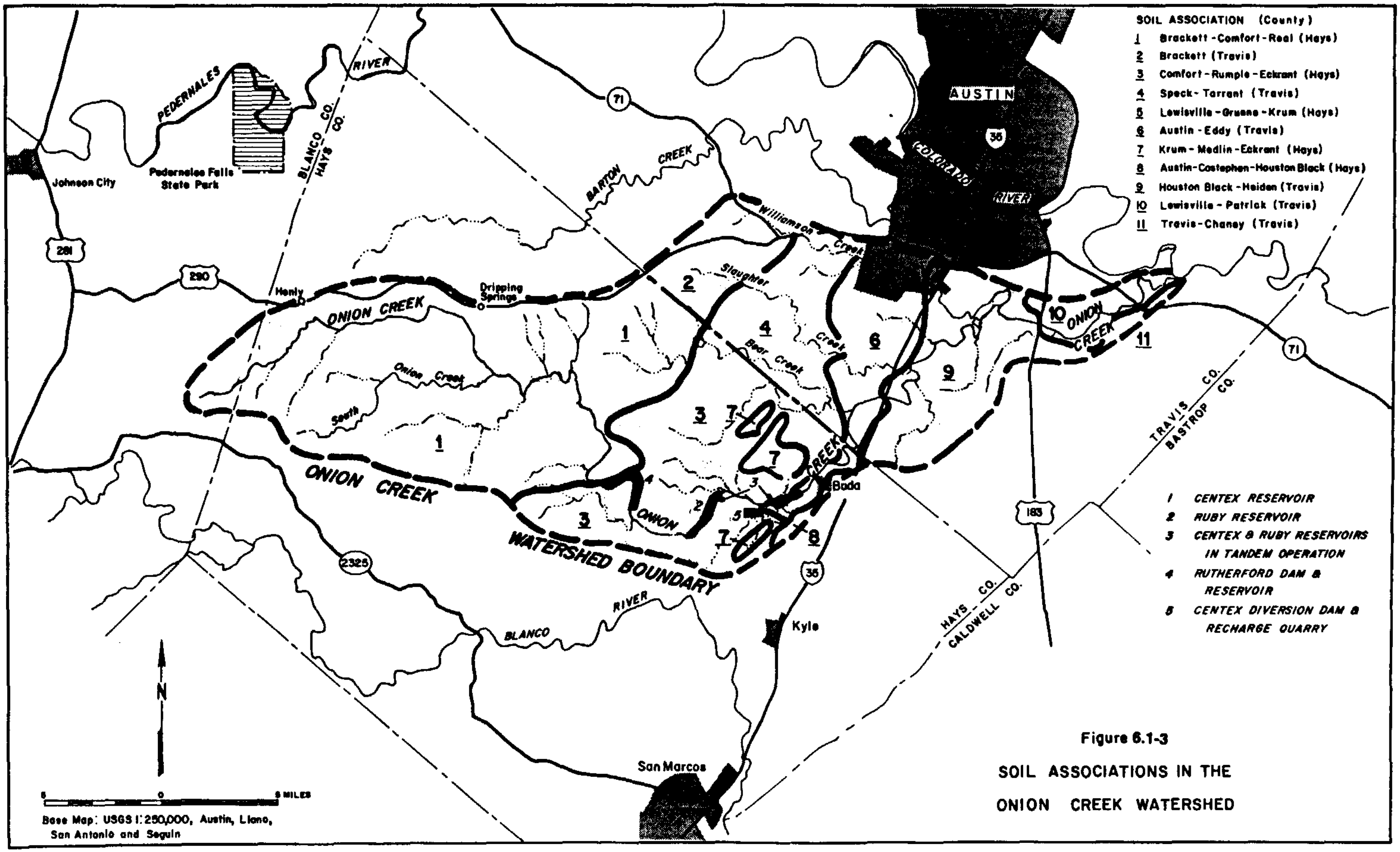


Figure 6.1-3

SOIL ASSOCIATIONS IN THE ONION CREEK WATERSHED

Comfort-Rumple-Eckrant

The Comfort-Rumple-Eckrant soil association is described by the SCS (1984) as very shallow to moderately deep, undulating to steep and hilly soils over indurated limestone, found on uplands of the Edwards Plateau. These well drained soils occur on broad divides that are widely intersected by small divides. Sinks are often associated with these soils.

This association is made up of Comfort soils (36%), Rumple soils (26%), and Eckrant soils (8%). Anhalt, Denton, Krum, Orif, Purves, Real, Sunev, and Tarpley soils make up the remaining 30 percent.

Urban and recreation uses of this soil association is limited by slope, stoniness and shallowness to rock. The soils facilitate good habitat for deer, turkey, and quail.

Speck-Tarrant

The Speck-Tarrant soil association of Travis County is homologous to the Comfort-Rumple-Eckrant association of Comal and Hays counties.

Lewisville-Gruene-Krum

The Lewisville-Gruene-Krum soil association is described by the SCS (1984) as deep, shallow and very shallow, nearly level to gently sloping soils over loamy, clayey, and gravelly sediments, found on stream terraces and valley fills of the Blackland Prairie and Edwards Plateau.

This association is made up of Lewisville soils (27%), Gruene soils (14%), and Krum soils (13%). Boerne, Branyon, Oakalla, Orif, Seawillow, Sunev soils and Pits make up the remaining 46 percent.

The Lewisville and Krum soils of this association are well suited for crops and pasture. Some areas are used as rangeland. The clayey texture, high shrink-swell potential, and low soil strength of these soils are limitations to urban development. These soils facilitate habitat for openland wildlife, including rabbits and small birds.

Austin-Eddy

The Austin-Eddy soil association of Travis County is homologous to the Lewisville-Gruene-Krum association of Comal and Hays counties.

Krum-Medlin-Eckrant

The Krum-Medlin-Eckrant soil association is described by the SCS (1984) as deep, very shallow and shallow, undulating to steep and hilly soils over clay, shaly clay, and limestone, found on stream terraces, valley fills, and uplands of the Edwards Plateau.

This association is made up of Krum soils (30%), Medlin soils (15%), and Eckrant soils (15%). Bolar, Denton, Doss, Purves, Rumple, and Tarpley soils make up the remaining 40 percent.

The Medlin and Eckrant soils of this association are mainly used for rangeland, while Krum soils are used mainly for crops and pasture. The shallowness to rock, slope, stoniness, clayey texture, and shrink-swell potential of these soils are limitations to urban development. These soils facilitate habitat for deer, turkey, dove, and quail.

Austin-Castephen-Houston Black

The Austin-Castephen-Houston Black soil association is described by the SCS (1984) as deep, gently sloping soils over chalk or marly clay, found on uplands of the Blackland Prairie.

This association is made up of Austin soils (21%), Castephen soils (20%), and Houston Black soils (18%). Heiden, Real, and Tinn soils make up the remaining 41 percent.

The soils of this association are used mainly as rangeland and pasture. Limitations for urban development for the Austin and Houston Black soils include high shrink-swell potential, very slow permeability, clayey texture, and low soil strength. Limitations for Castephen soils include shallowness to rock and clayey texture. The soils of this association facilitate habitat for openland wildlife, including rabbits and small birds.

Houston Black-Heiden

The Houston Black-Heiden soil association is described by the SCS (1974) as deep, nearly level and gently sloping calcareous, clayey soils overlying marl, found along drainages of the Blackland Prairie.

This association is made up of Houston Black (70%) and Heiden (20%) soils. Ferris and Trinity soils make up the remaining 10 percent.

The soils of this association are used mainly for farming. There are some limitations to these soils for urban development and recreation due to expanding soils.

Lewisville-Patrick

The Lewisville-Patrick soil association is described by the SCS (1974) as deep and moderately deep, calcareous, clayey soils overlying old gravelly alluvium, found along drainages of the Blackland Prairie.

This association is made up of Lewisville soils (56%) and Patrick soils (10%). Altoga, Houston Black, Trinity, and Frio soils make up the remaining 34 percent.

Lewisville soils are used mainly for farming, and Patrick soils are used for pasture and as a source of sand and gravel.

Travis-Chaney

The Travis-Chaney soil association is described by the SCS (1974) as deep, acid, and loamy soils overlying old alluvium, found along drainages of the Blackland Prairie.

This association is made up of Travis soils (28%) and Chaney soils (14%). Altoga, Dougherty, Houston Black, Wilson, Burleson, Lewisville, and Hornsby soils make up the remaining 58 percent.

This association is used mainly for pasture and wooded range.

6.1.2 Hydrology

The hydrology of the project area is discussed in detail in Sections 2.0 and 4.0 of this report.

6.1.3 Climate

The following climatic information issues from the Soil Conservation Service's (SCS) soil surveys of Travis County and Comal and Hays Counties (Orton 1974 & NCC 1984, respectively).

The climate of the Onion Creek watershed is humid subtropical, with hot summers and mild winters. Below freezing temperatures, associated with usually short duration cold fronts, occur on an average of less than 25 days a year. In winter the average temperature is 52 degrees F, and the average minimum daily temperature is 40 degrees. Daytime temperatures in summer average 84 degrees, with average lows in the low seventies.

The total annual precipitation for this area averages about 33 inches. The majority of this precipitation (57%), falls during the months of April through September. On the average, usually in the spring, thunderstorms occur. Severe thunderstorms with extremely heavy rainfall events are common in the area. Dissipating tropical storms, on rare occasions, can bring strong winds and heavy rains to the area. A strong or orographic effect is induced by the Balcones Escarpment. Precipitation during the winter falls as light rain, and snowfall is rare.

Throughout the year prevailing winds are from the south-southeast, with strong northerly winds occurring in the winter associated with cold fronts. The relative humidity averages about 60 percent in mid afternoon.

6.1.4 Wetlands and Floodplains

6.1.4.1 Wetlands

Overview

Wetlands represent some of the most productive natural systems in the world. As vegetated aquatic ecosystems, they provide excellent quality habitat for fish, shellfish, waterfowl and wading birds and many other rare or commercially valuable species of plants and wildlife. Functionally, wetlands contribute to flood control, erosion control and water quality maintenance. Wetland systems absorb and hold flood surges and rainfall. This allows for settling out of suspended materials such as nutrients and/or pollutants. This slowing process enables aquatic vegetation to buffer otherwise erosional flows.

In response to the alarming rate of loss of wetlands to agriculture and development, federal mandates have been issued which call for project review and mitigation (when necessary) when wetlands are impacted. Until fairly recently, several agencies produced their own guidelines and enforced them independently. The traditional lead agency for wetland-related regulation is the U.S. Army Corps of Engineers (USCE). Beginning with the Rivers and Harbors Act of 1899 (33 USC 403) the USCE has developed policy which operated essentially under a directive of navigational servitude. Under this navigational focus, the main concerns were with obstructions of waterways and disposal of refuse within navigable waters of the U.S. In the late 1960's, wetlands policy began to derive justification and direction from an environmental basis, as well as a navigational basis. Lawsuits filed in the late 1960's led to the drafting and passage of the Federal Water Pollution Control Act (33 USC 403) of 1972. This act included provisions for the permitting of dredge and fill activities in navigable waters (Section -)4, which now corresponds to Section 1344 of the Clean Water Act). Under this permitting process, the Secretary of the Army, through the Chief of Engineers, issues permits for the discharge of dredged or fill materials into waters of the U.S., including wetlands. The USCE also issues permits under Section 10 of the Rivers and Harbors Act (33 USC 403), for filling, dredging and construction in certain wetlands.

When the Section 404 permitting process is involved, several other federal agencies automatically become involved. First of all, the Environmental Protection Agency (EPA) maintains program oversight (over the USCE) and makes final determinations as to the extent of Clean Water Act jurisdiction. Secondly, the Fish and Wildlife Coordination Act (48 Stat. 401 as amended 16 USC 661 et seq.) mandates review of 404 Permits by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) (Wetland Training Institute 1989).

Prior to 1989, each agency responsible for wetland permitting review and oversight (USCE, EPA, USFWS and Soil Conservation Service [SCS]) established their own wetland delineation manuals and procedures. In early 1989, after a series of meetings, the USCE, EPA, USFWS and SCS formally adopted an interagency manual recommended for identifying and delineating wetlands in the U.S. This is known as the Unified Federal Method for wetland delineation. This method establishes mandatory technical criteria for vegetation, soils, and hydrology which must be met in order to delineate an area as a jurisdictional wetland. This method hinges upon the definition which describes wetlands as areas which under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology (Wetlands Training Institute 1989).

As of late summer (mid to late August) in 1991, the 1989 Federal Manual for identifying and Delineating Jurisdictional Wetlands came under official revision. Until this revision process is complete, the U.S.C.E. will apply the 1987 Corps of Engineers Wetlands Delineation Manual toward the identification and delineation of jurisdictional wetlands under Section 404 of the

Clean Water Act. The mandate to use the 1987 manual, in the interim, arises partially from the 1991 Energy and Water Development Appropriations Act signed by George Bush, August 17, 1991 (U.S.C.E. 1991).

Classifications

The following wetland classification discussion focuses upon approximately a one-mile band of land on either side of Onion creek. For the purpose of this general planning study, wetlands will be classified and discussed based upon the USFWS Systems as proposed by Cowardin et al. (1979). Approximate wetland boundaries and locations are illustrated in Plate 4 (in attached map pocket). The sources for the mapping include the Mountain City and Buda sheets of the National Wetlands Inventory (1980).

In general, the Cowardin (1979) system differentiates between wetland resources upon the basis of ecological systems, subsystems and classes. Ecological systems are broad groupings of wetland habitats which share similar hydrology, geomorphology, chemistry, and biological characteristics. The major ecological systems include marine, estuarine, riverine, lacustrine, and palustrine. Within the area of the proposed project alternatives, only riverine, lacustrine and palustrine systems occur.

In preparing this report, the different mapping units found on the NWI sheets have been tabulated. This provides general information as to the types and extent of wetland ecosystems in the study area. The following paragraphs describe the major ecological systems, subsystems and classes present in the study area. The goal of this approach is to characterize the general ecological trend within wetland ecosystems in the study area. This description will be divided by the three major systems present: riverine, lacustrine and palustrine. Table 6.1-1 lists and describes all the mapping units in the study area. The location of these mapping units are illustrated in Plate 4 (in the attached map pocket).

Table 6.1-1 Wetland Mapping Units Found Within the Onion Creek Project Area.

Mapping Unit	Ecological System	Ecological Subsystem	Class	Subclass	Water Regime	Special Modifier
R2OWH	Riverine	Lower Perennial	Open Water	Unknown Bottom		
R4SBA	Riverine	Intermittent	Streambed		Temporary	
R4SBC	Riverine	Intermittent	Streambed		Seasonal	
L1OWHh	Lacustrine	Limnetic	Open Water	Unknown Bottom	Permanent	Diked/ Impounded
L1OWHx	Lacustrine	Limnetic	Open Water	Unknown Bottom	Permanent	Excavated
PEM1Ah	Palustrine	None	Emergent	Persistent	Temporary	Diked/ Impounded
PEM1A	Palustrine	None	Emergent	Persistent	Temporary	
PEM1C	Palustrine	None	Emergent	Persistent	Seasonal	
PEM1Ch	Palustrine	None	Emergent	Persistent	Seasonal	Diked/ Impounded
PEM1/AB3Fh	Palustrine	None	Emergent / Aquatic Bed	Persistent / Submerged Moss	Semi-permanent	Diked/ Impounded
PFO1A	Palustrine	None	Forested	Broad-leafed Deciduous	Temporary	
PF01C	Palustrine	None	Forested	Broad-leafed Deciduous	Seasonal	
POWH	Palustrine	None	Open Water	Unknown Bottom	Permanent	
POWHh	Palustrine	None	Open Water	Unknown Bottom	Permanent	Diked/ Impounded
POWHx	Palustrine	None	Open Water	Unknown Bottom	Permanent	Excavated
PUSAh	Palustrine	None	Unconsolidated Shore	Unknown Bottom	Temporary	Diked/ Impounded
PUSCh	Palustrine	None	Unconsolidated Shore	Unknown Bottom	Seasonal	Diked/ Impounded

Source: NWI, 1980.

Riverine Ecological System

The prominent riverine feature in the study area is the main channel and tributaries of Onion Creek. Portions of the main channel of Onion Creek have been designated as lower perennial which implies a permanent nature in terms of flow regime. Field investigations on this project indicate that this designation is in error since Onion Creek dries up periodically. The remainder of the main channel and tributaries are designated as intermittent with water regimes of a temporary or seasonal nature. The creek appears to carry high volume flushing or scouring flows off and on through the course of the year. After the initial flood flows, some isolated pools remain. However, there is not evidence that the pools located within the Recharge Zone are perennial. No perennial springs were observed during field visits.

Lacustrine Ecological System

Lacustrine ecological systems include large open bodies of water. Three characteristics must be met for a wetland ecosystem to be defined lacustrine. These include: 1) location in a topographic depression or a dammed river channel; 2) absence of trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; 3) and a surface area of 20 acres or more. Smaller impoundments may be deemed lacustrine if an active wave-formed or bedrock shoreline forms all or part of the boundary, or if the deepest part of the basin exceeds 6 m at low water.

All of the lacustrine mapping units in the study area consist of limnetic, open water lakes which are diked/impounded or excavated. The excavated lakes are mainly clustered southwest of Buda and are probably old quarry sites.

Palustrine Ecological System

The palustrine ecological system derives it name from the Latin word for marsh - *palus*. All non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens are grouped into the palustrine category. Tidal wetlands with the above characteristics with ocean-derived salinities of less than 0.5‰ are also palustrine. Wetlands lacking the above characteristics but possessing all of the following four are also palustrine: 1) area less than 20 acres; 2) active wave-formed or bedrock shoreline features lacking; 3) water depth at the deepest part of less than 2 m at low water; 4) ocean derived salinity of less than 0.5‰.

Palustrine systems have no subsystems and are further divided only by class. Classes are delineated by substrate material and flooding regime or by vegetation life forms. The palustrine wetlands classes in the project vicinity include: emergent, forested, aquatic bed, open water and unconsolidated shore. Brief discussions of these classes follow.

Emergent Class

Palustrine wetlands of the emergent class tend to be dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). These wetlands typically support such perennial vegetation throughout the growing season in most years. All palustrine wetlands of the emergent class mapped in the study area are of the persistent subclass. The most common erect, rooted herbaceous dominant observed in the Onion Creek Watershed is waterwillow (*Justicia* sp.).

Forested Class

Forested wetlands may exist in all water regimes (except subtidal) but, by definition, are dominated by woody vegetation of 6 m in height or greater. These wetlands usually contain a tree overstory, an understory of young trees or shrubs and a herbaceous level. All mapped forested wetlands in the study area fall into the broad-leaved deciduous subclass. A common broad-leaved deciduous tree observed in wetland ecosystems in the Onion Creek Watershed is Sycamore (*Platanus occidentalis*).

Open Water and Unconsolidated Shore Classes

The remainder of the palustrine mapping units within the study area are designated as belonging to the open water or unconsolidated shore classes. All of the open water class wetlands contain permanent water regimes and two out of three are diked/impounded or excavated. The unconsolidated shore class members are either temporary or seasonally flooded and are diked/impounded.

In conclusion, the vast majority of the wetlands mapped are man-made stock tanks, old limestone quarries or the main channel and tributaries of Onion Creek itself.

6.1.4.2 Floodplains

Floodplains in the Onion Creek Watershed which are in close proximity to the proposed action alternatives are mapped in Plate 4 (in attached map pocket). These floodplain delineations refer to the 100 year floodplain as identified by the Federal Emergency Management Agency's (FEMA 1978 and 1987) Flood Insurance Rate Map.

6.1.5 Biological Elements

6.1.5.1 Vegetation

This section initially provides a regional overview of Central Texas, characterizing the vegetational areas in the region according to Gould (1975). The major plant communities occurring within these vegetational areas will also be discussed. Secondly, an assessment of important vegetation and unique or sensitive habitats will be provided. Finally, the vegetation of the five project alternative sites will be characterized and important vegetation and unique and/or sensitive areas will be identified and discussed.

Regional Overview

The total drainage area of Onion Creek occurs in three counties and encompasses approximately 343 square miles. The head of the basin is in Blanco County, with the creek flowing through Hays County and into Travis County to its confluence with the Colorado River. The Onion Creek watershed crosses two vegetational regions as described by Gould (1975). The project area in relationship to the vegetational areas of Texas is presented in Figure 6.1-4. The portion of the creek in Blanco and Hays Counties lies within the Edwards Plateau vegetational region of Texas. The Travis County stretch of Onion Creek is found within the Blackland Prairie vegetational region. The Onion Creek Recharge Zone and the proposed recharge enhancement facility alternatives lie within the Edwards Plateau vegetational region. The following discussion characterizes the two vegetational regions within which the Onion Creek drainage basin occurs.

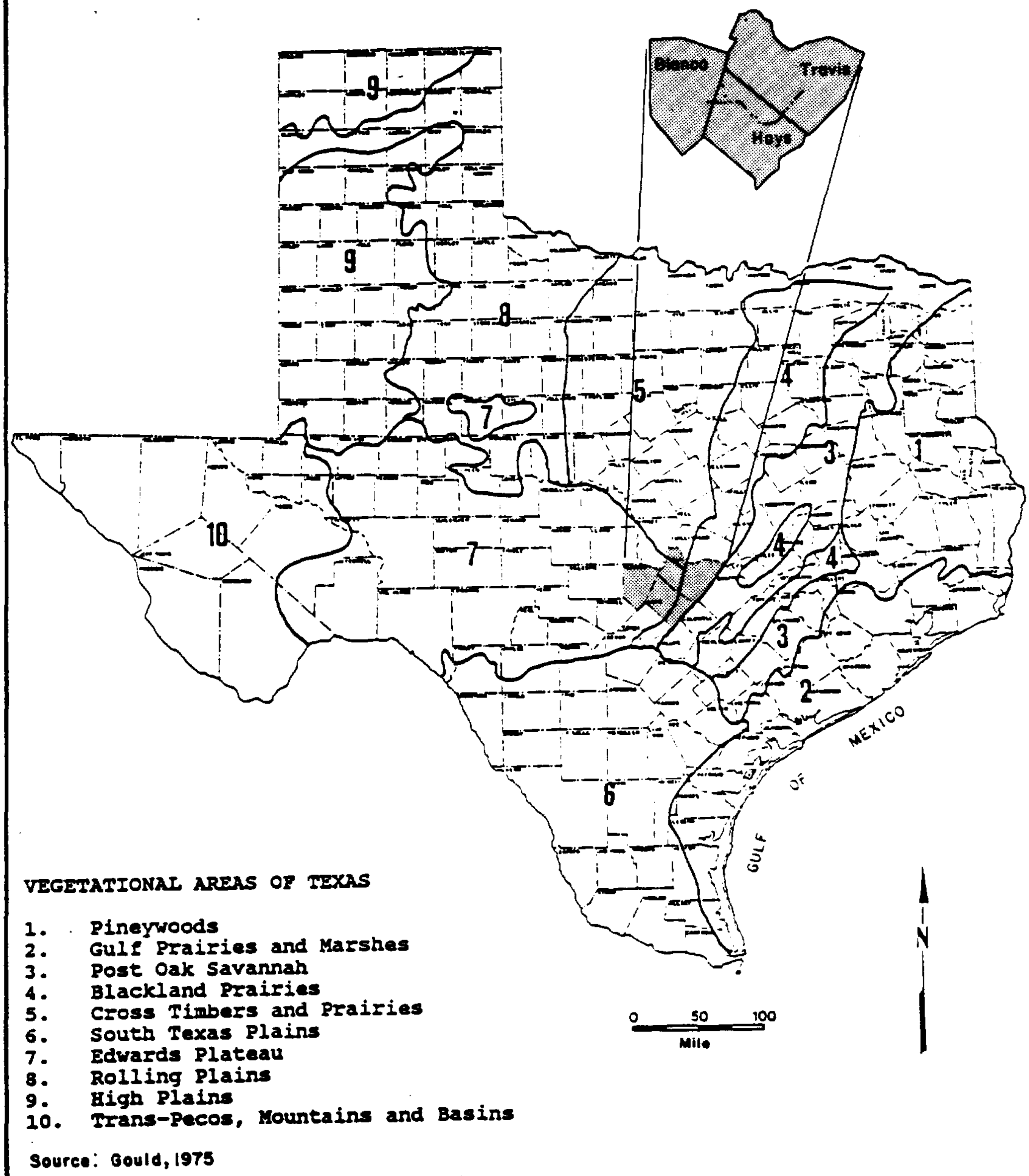


Figure 6.1-4

PROJECT LOCATION IN RELATION TO THE VEGETATIONAL AREAS OF TEXAS

Vegetational Regions and Community Types

Edwards Plateau

The Edwards Plateau vegetational region, which encompasses approximately 24 million acres (ac) of the Texas "Hill Country", consists of moderately to deeply dissected limestone hills and plains, with elevations ranging from about 100 feet to more than 3,000 feet. Typically the shallow soils of this region are underlain by limestone or caliche, with granitic formations constituting the bedrock in the Llano uplift area of Mason and Llano counties. These soils are mostly stony clays and gravelly clay loams (SCS 1984). The eastern and southern portions of this region, bounded by the Balcones Escarpment, are marked by topography of high relief and are well drained by several river systems. The area is characterized by vegetation communities that include grassland/savannah, oak-juniper woodlands, and bottomland/riparian forests. Numerous endemics, species at the limit of their ranges, and disjunct, relictual populations form a unique component of the Edwards Plateau flora.

The grassland/savannah vegetation type predominates in the Edwards Plateau region of Texas. These grassland areas are often scattered with live oak motts or individuals. Livestock grazing is the major land use employed in the region. The species composition of the grassland/savannah can vary dramatically due to differing land management practices of ranchers. Important grasses that may occur on moderately grazed range sites include switchgrass (*Panicum vigatum*), *Tridens* sp., *Aristida* sp., indiangrass (*Sorghastrum nutans*), several species of gramas (*Bouteloua* sp.) and bluestems, buffalograss (*Buchloe dactyloides*), and tall dropseed (*Sporobolus asper*) along with several other species (Gould 1975; Amos and Gehlbach 1988; Hatch et al 1990). Pricklypear (*Opuntia* spp.), agarita, twistleaf yucca (*Yucca rupicola*), *Gaillardia* spp., western bitterweed (*Hymenoxys odorata*), white pricklypoppy (*Argemone albaflora* ssp. *texana*) and *Verbena* spp. comprise frequent nongrass species occurring in grassland areas. Common woody species associated with oak motts include plateau live oak, Ashe juniper, agarita, and other species that can depend on the mott's proximity to a contiguous woodland.

The oak-juniper woodland typically occurs on relatively steep, rocky slopes and ridges of the Edwards Plateau (Correll and Johnston 1979). The dominant tree species of this vegetative community include plateau live oak (*Quercus fusiformis*), Texas oak (*Q. buckleyi*), shin oak (*Q. durandii* var. *breviloba*), Ashe juniper (*Juniperus ashei*), cedar elm (*Ulmus crassifolia*) and other smaller, woody species such as fragrant sumac (*Rhus aromatica*), evergreen sumac (*R. virens*), Texas persimmon (*Diospyros texana*), Texas mountain laurel (*Sophora secundiflora*), agarita (*Berberis trifoliolata*), kidneywood (*Eysenhardtia texana*), elbow-bush (*Forestiera pubescens*) and Texas redbud (*Cercis canadensis* var. *texensis*). The herbaceous component of the oak juniper woodlands often include bush croton (*Croton fruticulosus*), mat euphorbia (*Euphorbia serpens*), greenbriar (*Smilax* spp.), Lindheimer globeberry (*Ibervillea lindheimeri*), mustang grape (*Vitis mustangensis*), and wood-sorrels (*Oxalis* spp.) (McMahan et al 1984; Amos and Gehlbach 1988). The species composition of these woodlands can differ locally depending on the geology, soils, and orientation of the site. Along drier south or west facing, marly slopes, virtually monotypic stands of Ashe juniper may form what is referred to locally as cedar breaks.

Bottomland/riparian forest associations occur along drainages throughout the Edward Plateau. Although bottomland and riparian forests are similar in terms of species composition and certain hydrologic and edaphic factors, these two communities are differentiated by floodplain characteristics. Bottomland forests are found on wide floodplains and are distinguished by distinct vegetative stratification. Riparian forest communities are restricted to narrow creeks and streams, and its weakly stratified vegetation rapidly intergrades with adjacent, less mesic vegetative communities.

Common overstory tree species bottomland/riparian forests include pecan (*Carya illinoiensis*), black willow (*Salix nigra*), sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and baldcypress (*Taxodium distichum*). The understory and shrub layer may contain such species as roughleaf dogwood (*Cornus drummondii*), sugar hackberry (*Celtis laevigata*), river walnut (*Juglans microcarpa*) boxelder (*Acer negundo*), common buttonbush (*Cephalanthus occidentalis*), Mexican buckeye (*Ungnadia speciosa*), Texas ash (*Fraxinus texensis*), Turk's cap (*Malvaviscus arboreus* var. *drummondii*), and Amerian beautyberry (*Callicarpa americana*).

The Edwards Plateau is a refuge of numerous endemics (Correll and Johnston 1979). As Amos and Rowell (1988) have pointed out, there are four hypotheses that may account for the high occurrence of endemism in the region. The first hypothesis, put forth by Palmer (1920), suggests that these endemic species inhabit relictual refugia created by late Tertiary or early Pleistocene isolation. Another explanation is that the limestone canyons, cliffs and seeps of the region harbored unique species long before floral isolation from eastern and western forests (Amos and Rowell 1988). A third hypothesis maintains that the Edwards Plateau is an area where eastern forest, western desert, and Mexican subtropical floristic regions overlap, providing an arena for hybridization of many diverse species (Amos and Rowell 1988). A fourth hypothesis is that because none of the first three hypotheses satisfactorily explains all of the endemic occurrences, it is possible that a combination of these factors could be involved (Amos and Rowell 1988).

The southeastern Balcones Canyonlands of the Edwards Plateau is home to many of the endemic plant species found in the region. A partial list of these species includes plateau milkvine (*Matelea edwardsensis*), bracted twist-flower (*Steptanthus bracteatus*), canyon mock-orange (*Philadelphus ernestii*), big red sage (*Salva penstemonoides*), wand butterfly-bush (*Buddleja racemosa*), and Roemer euphorbia (*Euphorbia roemeriana*) (Correll and Johnston 1979; Amos and Rowell 1988).

The above characterization of the Edwards Plateau vegetation is important as baseline information, as all of the proposed project alternatives are located within this region. The vegetation, any unique and sensitive areas, and potential threatened or endangered species habitat of these specific sites will be discussed in more detail below.

Blackland Prairies

The Blackland Prairies vegetational region of Texas consists of nearly level to gently rolling topography. This area covers approximately 11.5 million acres from Grayson and Red River Counties in northeast Texas to Bexar County in the south-central region of the state. Elevations range from 300 to 800 feet above sea level. Blackland soils that occur in the region are so named due to the uniform dark-colored calcareous clay component of the typical alfisols. These soils are interspersed with gray acid sandy loams. This highly fertile region is now largely cultivated, although there remains some ranches and small, native hay meadows in the area (Thomas 1975).

Studies have shown that the native vegetation of the Blackland Prairie should be classified as true prairie with little bluestem (*Schizachyrium scoparium* var. *frequens*) being a climax dominant (Thomas 1975). Big bluestem (*Andropogon gerardi*), indiangrass, switchgrass, hairy grama (*Bouteloua hirsuta*), sideoats grama (*B. curtipendula*), tall dropseed, silver bluestem (*Bothriochloa saccharoides*), and Texas wintergrass (*Stipa leucotricha*) represent other important grasses in the vegetational region. With heavy grazing practices, invading or increasing species such as buffalograss (*Buchloe dactyloides*), Texas grama (*Boutaloua rigidiseta*), smutgrass (*Sporobolus indicus*), along with other annuals may become prevalent (Thomas 1975; Correll and Johnston 1979). Improved pastures with the introduced grass species such as dallisgrass (*Paspalum dilatatum*) and bermudagrass (*Cynodon dactylon*) are common in the area. Asters (*Aster* spp.), prairie bluet (*Hedyotis nigricans* var. *nigricans*), prairie clover (*Dalea* spp.), and late coneflower (*Rudbeckia serotina*) are common forbs of these prairies (Hatch et al 1990).

Wooded areas along riparian strips in the Blackland Prairie include such species as black willow, oaks (*Quercus* spp.), pecan, osage orange (*Maclura pomifera*), elms (*Ulmus* spp.), and cottonwood (Hatch et al 1990). Woody invasive species that are commonly found in the vegetational area include post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) in the north, with honey mesquite (*Prosopis glandulosa*) being a common invader in the southern portion of the region (Thomas 1975).

The characterization provided above of the Blackland Prairies vegetation is important as baseline information, as potential downstream effects of the proposed project alternatives would occur within this region. The potential downstream effects of each proposed alternative will be discussed in more detail in Section 6.2. The important vegetation and unique and/or sensitive areas will be discussed in the following section according to the vegetational region in which they may be found.

Important Species and Habitats

This section provides a description of the important species and habitats that may occur in the study area. These species and habitats often present important policy issues and bear identification and discussion.

Important vegetation includes any rare, threatened or endangered species, vegetation that is important commercially or recreationally, any species that if removed or seriously impacted would threaten the fitness of species in the first two categories, or species that are a dominant component, or are an important biological indicator of an ecological system.

There are no federally listed threatened or endangered plant species known to be present in the Onion Creek watershed. Three rare and potentially threatened species of plants that may occur in the watershed are designated Category 2 under the Endangered Species Act of 1973.

These plants include the canyon mock-orange (*Philadelphis ernestii*), bracted twistflower (*Streptanthus bracteatus*), and Texas amorpha (*Amorpha texana*). The Category 2 designation indicates that these species, pending further study, may be listed in the future.

Plant species, as components of a vegetative community, provide habitat for wildlife species considered rare or are listed as threatened or endangered. These communities also provide refuge and food for commercially or recreationally important wildlife species (i.e. wild game).

Vegetative assemblages are important as a unit, and as a component of the larger ecological system. Native upland vegetation (i.e. woodlands and grasslands) provides groundcover that inhibits erosion, as well as habitat for wildlife. Mesic woodlands and riparian forests impede erosional forces of runoff and concurrently, tend to filter nutrients from overland flow destined for aquatic systems. Additionally, riparian forest are important for their high species diversity.

Two shelter caves, associated with limestone seep activities, occur in the vicinity of the proposed Ruby Reservoir. These seep areas provide a unique niche for mesic species such as southern maidenhair fern (*Adiantum capillus-veneris*), western bracken fern (*Pteridium aquilinum*), *Pellaea* sp., milkvine (*Matelea gonocarpa*), and Drummond Wax-mallow (*Malvaviscus arboreus* var. *drummondii*).

Project Alternative Site Descriptions

A biological field reconnaissance of the Onion Creek study area was performed during the summer and early autumn of 1991 by Mariah personnel. The field reconnaissance consisted of a pedestrian survey of the creek channel, beginning east of the Onion Creek Recharge Zone. The crew walked approximately ten miles westward through the entire Recharge Zone of the creek. This field survey was beneficial in characterizing the general vegetation communities occurring in the proposed reservoir sites. A summary of general vegetative information collected during the field survey for each proposed alternative is presented below.

CenTex Reservoir

The dam site for the proposed CenTex reservoir is located approximately one mile west of Buda, Texas on Onion Creek. This facility would create a reservoir pool that is intermittently filled extending about 1.4 miles upstream. The general vegetation community types in the area include riparian forest, mixed deciduous woodlands, a savannah/shrub association, improved pasture, along with a highly disturbed industrial site.

The riparian vegetation of this site consists of a narrow creekside strip with sycamore, black willow, green ash, sugar hackberry, and occasional baldcypress as the common arboreal components. This band of vegetation intergrades rapidly with the less mesic mixed deciduous woodlands adjacent to it. Understory woody species include boxelder, roughleaf dogwood, greenbriar (*Smilax* sp.), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), river walnut and common buttonbush. Common herbaceous understory species found were Drummond wax-mallow (*Malvaviscus arboreus* var. *drummondii*), inland seaoats (*Chasmanthium latifolium*), aster (*Aster* sp.), giant ragweed (*Ambrosia trifida*), *Ruellia* sp., *Dicliptera brachiata*, and frostweed (*Verbesina virginica*) in areas with a more open canopy.

For the most part, the creek bed in this area is dry during the summer, as it traverses a highly fractured part of the Recharge Zone. Waterwillow (*Justicia* sp.) is a clear dominant within the creek bed proper, growing extremely dense in places. Dodder (*Cuscuta* sp.) is often parasitic on the waterwillow along the creek. Other herbaceous species found in the creek bed include Abrojo (*Xanthium strumarium*), umbrella water-pennywort (*Hydrocotyle umbellata*), pepperwort (*Marsilea* sp.) and devil's claw (*Proboscidea louisianica*).

The mixed deciduous woodlands that occur adjacent to the riparian strip in this area consists of dominant tree species such as plateau live oak, sugar hackberry, and cedar elm. Ashe juniper, Mexican persimmon, yaupon (*Ilex vomitoria*), mustang grape (*Vitis mustangensis*), and Virginia creeper are common shrub and vine components in this segment of Onion Creek. A second type of mixed deciduous woodland occurs in this area along limestone bluffs on the south bank of the creek. In these areas, the evergreen component (plateau live oak and Ashe juniper) is more dominant than in the woodlands on more gradual slopes.

In upland areas of this section of the Onion creek watershed a plateau live oak-grassland savannah association predominates. These grassland areas are often scattered with rather dense and closely spaced live oak motts. Livestock grazing is the major land use employed in these areas. The species composition of the grassland/savannah can vary dramatically due to differing land management practices of ranchers. Although a survey of these rangeland sites was not undertaken, common grasses that may occur on moderately grazed range sites include switchgrass, *Tridens* sp., *Aristida* sp., indiangrass, several species of gramas and bluestems, buffalograss, and tall dropseed along with several other species (Gould 1975; Amos and Gehlbach 1988; Hatch et al 1990). Pricklypear, agarita, twistleaf yucca, *Gaillardia* spp., western bitterweed, white pricklypoppy and *Verbena* spp. comprise frequent nongrass species occurring in grassland areas.

Common woody species associated with oak motts include plateau live oak, Ashe juniper, Mexican persimmon, and agarita. Honey mesquite is a common invader in this area, often forming small motts with agarita and pricklypear as associates.

Some fairly large tracts of improved pasture occur in this area, and as with rangeland far removed from the project area, these tracts were not surveyed. Common grasses cultivated in improved pastures include King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*), Kleberg bluestem (*Dichanthium annulatum*), and coastal bermudagrass (SCS, 1984).

South of Onion Creek, adjacent to this proposed project, is a large industrial complex comprised of the Centex limestone quarry and the Texas-Lehigh Cement Co. The land occupied by these concerns are mostly separated from Onion Creek by a strip of mixed deciduous woodland or a shrub/oldfield association. Most of the land utilized by these industries is completely denuded of vegetation, excavated, or covered by buildings, road base, or stockpiled materials. The few highly disturbed, vegetated parcels found in this area are dominated by honey mesquite, *Baccharis* sp., and invasive grasses and forbs.

Ruby Reservoir

The dam site for the proposed Ruby Reservoir is located approximately 4.8 miles west of Buda, Texas on Onion Creek. This facility would create a reservoir pool that is intermittently filled extending about 1.9 miles upstream. The general vegetation community types in the area include riparian forest, mixed deciduous woodlands, grassland savannah, and improved pasture.

The riparian vegetation of this site consists of a narrow creekside strip with sycamore, black willow, green ash, sugar hackberry, and frequent stands of baldcypress as the common tree species. This band of vegetation intergrades rapidly with the less mesic mixed deciduous woodlands adjacent to it. Understory woody species include Texas ash, boxelder, roughleaf dogwood, greenbriar, trumpet creeper, Virginia creeper, river walnut and common buttonbush. Common herbaceous understory species found were Drummond wax-mallow, inland seaoats, *Aster* sp., giant ragweed, *Ruellia* sp., and frostweed.

The creek bed in this stretch of Onion Creek is mostly dry during the summer, as it traverses a highly fractured part of the Recharge Zone. In areas of channel bifurcation, islands are formed that support riparian vegetation. Most of these islands are rather narrow (up to 10 meters wide) inhabited by sycamore, baldcypress, osage orange, green ash, switchgrass, buffalobur (*Solanum rostratum*) and occasionally dwarf palmetto (*Sabal minor*). One large island located at station 280+00, is approximately 20 meters wide and supports large American elms (*Ulmus americana*), as well as species found on the smaller islands listed above. In keeping with the Recharge Zone as a whole, waterwillow is a clear dominant within the creek bed proper. Other herbaceous species found in the creek bed include umbrella water-pennywort, and pepperwort.

The mixed deciduous woodlands that occur adjacent to the riparian strip in this area consists of dominant tree species such as plateau live oak, Ashe juniper, Texas oak, and cedar elm. In some areas, the Ashe Juniper occurring in these woodlands were mature, suggesting potential golden-cheeked warbler habitat. Mexican persimmon, deciduous yaupon (*Ilex decidua*), mustang grape, winter grape (*Vitis berlandieri*) and Virginia creeper are common shrub and vine components along this segment of Onion Creek. A second type of mixed deciduous woodland occurs in this area on limestone bluffs along the creek. In these areas, the evergreen component (plateau live oak and Ashe juniper) is more dominant than in the woodlands on more gradual slopes.

The majority of the grassland savannah occurring in the vicinity of the proposed Ruby Reservoir site is moderately to lightly grazed by cattle and is essentially the same as that found near the Centex Reservoir project. An exception to this is the range condition of the YO Ranch property. The proposed dam site and a portion of the lower end of the impoundment (0.5 miles) would be located on this property. The vegetation on this ranch is considerably different than the adjacent properties. There is a marked increase of species considered indicators of overgrazing, such as snow-on-the-mountain (*Euphorbia marginata*), Roosevelt weed (*Baccharis neglecta*), buffalograss and sideoats grama. The range condition may be due to overgrazing by exotic game species. The ranch provides commercial exotic game hunting, with axis deer and blackbuck antelope stocked on the property. These exotic ungulates have been implicated in the degradation of rangesites, as they will utilize a wide range of forbs, browse, and grasses for food (TPWD 1991).

Improved pastures, typical of this part of the Edwards Plateau are present in this area, with species composition similar to the pastures found near the proposed Centex reservoir site.

Centex Reservoir and Ruby Reservoir in Tandem

These two areas are discussed in detail above.

Rutherford Reservoir

The dam site for the proposed Rutherford reservoir is located immediately above Onion Creek's Recharge Zone. This facility would create a reservoir pool extending a maximum of 3.7 miles upstream. The general vegetation community types in the area include riparian forest, mixed deciduous woodlands, grassland savannah, and improved pasture.

The riparian vegetation of this site is similar to that found associated with the Ruby Reservoir site, though differing somewhat in dominance and composition of arboreal species. Much of the creek is impounded and holds water throughout the year due to the impermeability of the geology of this area. Pecan, American elm, and baldcypress are more frequent in this segment of Onion Creek, and the occurrence of black willow and green ash decreases.

The mixed deciduous woodlands that occur in this area is much like that found on the proposed Ruby Reservoir site, except that blackcherry (*Prunus serotina*) is a prevalent component of the woodland flora.

The grassland savannah and improved pasture vegetation occurring in the vicinity of the proposed Rutherford Reservoir site is typical of other moderately to lightly grazed rangeland discussed above.

Centex Diversion Dam and Recharge Facilities

The land to be utilized by the proposed Centex Diversion Dam and Recharge Facilities borders the south bank of Onion Creek above Barber Falls (see Plate 3). This property is currently being used as a limestone quarry. The Centex recharge facility is a 130 foot deep, excavated pit that is in hydrologic contact with the Barton Springs segment of the Edwards Aquifer. Under this proposal, flood waters from Onion Creek would be diverted via a canal from the creek to the recharge pit. The pit and surrounding areas are essentially denuded of vegetation except for highly disturbed, vegetated parcels dominated by honey mesquite, *Baccharis* sp., and invasive grasses and forbs. Separating this site from Onion Creek is a strip of mixed deciduous woodland. A concrete lined diversion channel is proposed that would require an excavated corridor through this woodland strip. This woodland strip consists of plateau live oak, sugar hackberry, and cedar elm. Ashe juniper, Mexican persimmon, yaupon, mustang grape, and Virginia creeper are common shrub and vine components of the understory.

6.1.5.2 Wildlife

This section describes wildlife resources and the context within which they are found in the project vicinity. This section consists of four divisions beginning with a regional overview which narrows, in the second division, to a more site-specific discussion regarding wildlife communities and habitat types in the Onion Creek watershed. The third division discusses important, unique and/or sensitive species and habitats. The final division describes specific baseline conditions found in the vicinity of each proposed alternative.

The proposed project offers five potential action alternatives. Each of these alternatives entail impoundments or diversions of water in different locations; however, all alternatives are currently proposed to be placed within a 13 mile stretch of Onion Creek west of the community of Buda.

The Onion Creek drainage basin begins in southeastern Blanco County and terminates in eastern Travis County at its confluence with the Colorado River. This particular east-west location of the watershed places it in two very different biogeographic zones. A line may be drawn roughly from north to south immediately west of the communities of Buda and San Marcos in southeastern Hays County which separates the Edwards Plateau ecological region, to the west, from the Blackland Prairie ecological region to the east (Gould 1975 and Hatch et al 1990). As previously mentioned, all action alternatives (potential direct impacts) are proposed west of Buda; or, in the Edwards Plateau region. Discussion regarding the Blackland Prairie region is provided to establish context for evaluation of potential downstream (indirect) impacts if any of the proposed alternatives are implemented. Brief characterizations of these two regions follow, beginning with the Edwards Plateau. Figure 6.1-5 illustrates the project location in relation to the ecological areas of Texas.

Edwards Plateau Ecological Region

The Edwards Plateau, or Texas Hill Country, is comprised of approximately 25 counties in Central and Southwest Texas. Physiographically, the region is a rocky plain, deeply incised by drainages. Originally, the Edwards Plateau might have been characterized as a grassland or open savannah with wooded slopes and drainages. With the advent of increased grazing pressure and the cessation of naturally occurring fires, thicketization by woody species such as ashe juniper (*Juniperus ashei*), mesquite (*Prosopis glandulosa*) and shin oak (*Quercus durandii* var. *breviloba*) has occurred. Tallgrasses, previously dominant in the region, are now restricted to rocky outcrops or other protected places and have largely been replaced by mid and short grasses. Almost all undeveloped land within the Edwards Plateau is used as rangeland for livestock with a very important secondary use being wildlife production. Arable soil is limited to riparian strips and is generally quite shallow. Sorghum, peanuts, plums and peaches are raised in limited amounts on these soils (Gould 1975 and Hatch et al 1990).

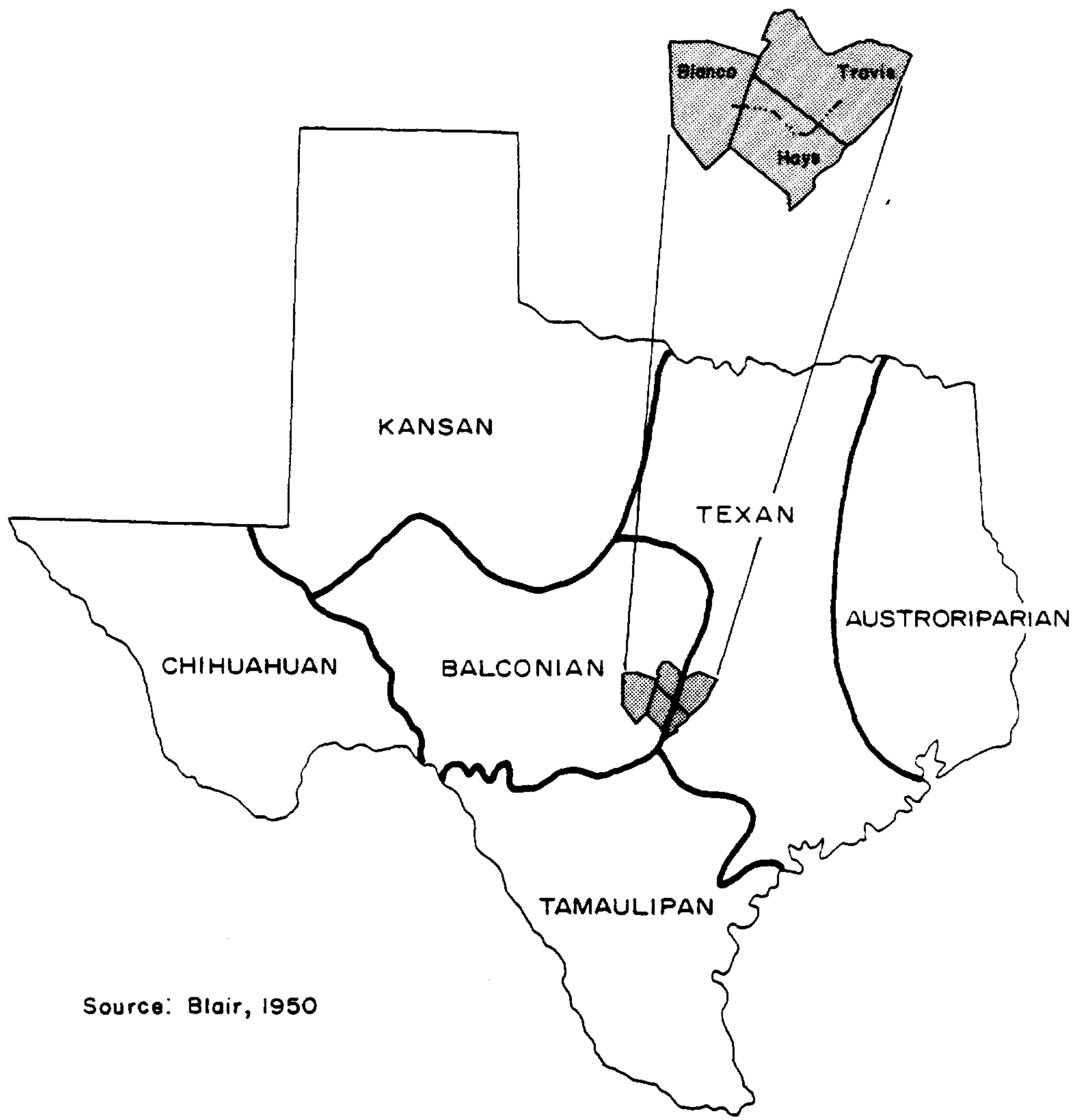


Figure 6.1-5

PROJECT LOCATION IN RELATION TO THE BIOTIC PROVINCES OF TEXAS

The Edwards Plateau east of the Pecos River is grouped into a biotic province by Blair (1950) known as the Balconian. With the exception of a few endemic species of salamander and other adapted cave fauna, the fauna of the Balconian biotic province is a mixture derived from adjacent provinces. Specifically, faunal influences come from the Austroriparian (eastern forests) to the east, the Tamaulipan (subtropical and tropical plains and scrub) to the south, Chihuahuan (desert) to the west, and Kansan (plains) to the north.

The physiography of the Balconian province offers a diversity of wildlife habitat types. The terrain and climate varies from less dissected and drier to deeply dissected and wetter from west to east. Drainage through limestone strata from the Colorado, Nueces, Concho, Blanco, Llano, Frio, Pedernales, Sabinal, Medina, Guadalupe, Devil's and San Saba Rivers and their tributaries cuts rugged canyons through southern and eastern portions of the Balconian. Features typical of karst topography, such as caverns and springs, are common throughout the area (Blair 1950).

The Balconian Province is home, or has been home, to 57 species of mammals, none of which occur solely in this province. As previously mentioned, the mammals of the Balconian receive distributional influence from the Austroriparian, Kansan, Chihuahuan and Tamaulipan provinces. Mammalian population densities are lower in the Balconian for the most part, than those in the Tamaulipan province to the south. Blair (1950) attributes this to the transitional nature of the habitat and overgrazing. Both of these factors work to lower potential carrying capacities for species already at the periphery of preferred ranges.

The reptilian fauna is represented by one species of land turtle, the ornate box turtle (*Terrapene ornata*), 16 lizard species and 36 species of snakes. None of the reptilian species are restricted to the Balconian province. Most are either widely occurring western or Chihuahuan species with a smattering of Austroriparian representatives as well.

Amphibian representatives of the Balconian province include 15 species of frogs and toads. Two of these frogs are essentially Balconian endemics with western range extensions into the Chihuahuan. These include the cliff frog (*Syrrhophus marnochi*) and barking frog (*Hylactophryne augusti latrans*) which inhabit the cliffs and crevices of the rugged Balconian Canyonlands. The only true endemic vertebrate species are eight neotenic salamanders which inhabit subterranean water courses and springs of the Edwards Plateau. These include the Texas blind salamander (*Typhlomolge rathbuni*), the Blanco blind salamander(*Typhlomolge robusta*), the San Marcos salamander (*Eurycea nana*), the Texas salamander (*Eurycea neotenes*), the Cascade Caverns salamander (*Eurycea latitans*), the Comal blind salamander (*Eurycea tridentifera*), the Valdina Farms salamander (*Eurycea troglodytes*), and the Barton Spring Salamander (*Eurycea sp*) currently under investigation (Dixon 1987).

Bird life of the Balconian biotic province also reflects a general trend toward biogeographic overlap in terms of species distribution. Pedernales Falls State Park, immediately northwest of the study area, posts a list of nearly 180 species of birds. Many of these species have eastern (e.g., Great Crested Flycatcher, Eastern Phoebe, Red-eyed Vireo), western (e.g., Scrub Jay, Ash-throated Flycatcher, Canyon Wren, Rufous-crowned Sparrow), and neotropical (e.g., Green Kingfisher) affinities. This park is also home to the endangered Edwards Plateau endemic, the Golden-cheeked Warbler (Lasley et al 1981). As previously mentioned, this discussion offers context for the evaluation of direct impacts since all alternatives proposed are in the Edwards Plateau region. A discussion of unique/sensitive and/or important habitats and species (including threatened and endangered species) will be provided following a discussion of the Blackland Prairie region (area of potential downstream impacts).

Blackland Prairie Ecological Region

East of the Edwards Plateau Ecological Region lies the Blackland Prairie. Formerly a tallgrass prairie, nearly all of the Blackland Prairie has been cultivated at one time. Current land use is dominated by livestock operations. Most of the native grassland is either far from a climax condition due to invasion by species stimulated by overgrazing or has been physically replaced for tame grass or cereal production. Remnant patches of climax tallgrass areas contain little bluestem, big bluestem, indiangrass, tall dropseed and silveous dropseeds as dominant grasses. Common forbs and legumes include asters, prairie bluet, prairie-clover, late clover, snoutbeans and vetch. Invading woody species include mesquite, huisache, oak and elm. Drainages support cottonwood, elm, sycamore and native pecan (Thomas 1975). As discussed previously regarding the Edwards Plateau, Blair (1950) distinguishes between the two areas in terms of biotic provinces.

Blair (1950) includes the Blackland Prairie, Post Oak Savannah and portions of the Gulf Prairies and Marshes, Cross Timbers and Prairies ecological areas into a biotic province called the Texan. This is an ecotonal area between the southeastern forests to the east and arid grasslands to the west. The Texan biotic province has no endemic vertebrate species. Drainages of the Texas rivers passing through the Texan (i.e., Red, Trinity, Brazos, Colorado, and Guadalupe) support riparian forests important to the western dispersal of Austroriparian species. A pattern of Austroriparian species occurring in lowland forests and Chihuahuan or Kansan grassland species occurring on the prairies of the Balconian and Texan biotic provinces holds true.

Some 49 species of mammals currently occur or have historically occurred in the Texan province. Of these, only eight are grassland species encroaching from the west, southwest or north. The remainder of these species have Austroriparian affinities.

Two species of land turtles, three-toed (a forest species) and ornate box turtle (a grassland species), occur in the Texan and slightly more than half (9 of 16) of the lizard species are eastern forest species. The remaining seven are western grassland fauna. Of the 39 species of snakes documented by Blair (1950), 27 are eastern forest species and 12 are western.

For amphibians, the Texan province serves as a barrier between most Austroriparian and Balconian endemics. Five salamanders (all Austroriparian) and 18 species of frogs and toads (13 of which are Austroriparian species) are documented by Blair (1950) in the Texan.

Bird life in the Texan province also exhibits an ecotonal influence. The major difference between the eastern and western ends of the watershed is the availability of semipermanent to permanent water sources. McKinney Falls State Park, located near the confluence of Onion Creek and the Colorado River boasts a species list of 224, as opposed to 178 at Pedernales State Park northwest of the Onion Creek watershed (Kutac 1989). The main difference may be attributed to greater numbers of waterfowl and migrant wading birds documented in the east. More species of migratory passerines are documented at McKinney Falls in fall and spring as well.

The previous discussions of the Edwards Plateau and Blackland Prairie ecological regions simply provide regional context for direct and indirect impact analysis. The discussion of both ecological regions is necessary since the Onion Creek watershed occupies such an ecotonal location.

Habitat Types and Wildlife Communities Within the Onion Creek Watershed

The location of the Onion Creek watershed places it exactly on the edge of a rolling prairie region and a hilly, rocky, wooded region. Very dramatic climatic, edaphic, and geologic changes also occur here. These changes create a variety of vegetative communities which, in turn, provide wildlife with differing habitat types. For the purposes of this report, an important distinction must be made between areas in the Recharge Zone which would receive direct impacts and downstream areas which would receive indirect impacts from any of the proposed alternatives. Since the entire watershed is located in an ecotone between the Blackland Prairie and Edwards Plateau, there is an observable east to west gradient of ecological transition.

Within the watershed, three zones of transition may be delineated according to primary geologic, topographic and vegetative influences. These include: 1) an Edwards plateau influenced zone; 2) a Blackland prairie/Edwards plateau transition Zone; and 3) a Blackland influenced zone. Brief descriptions of these zones follow.

Zone 1 - Edwards Plateau Influenced Zone. From the York Creek confluence to the western end of the study area lies the zone of Edwards influence. Here, more true Edwards Plateau land forms begin to occur. The topography becomes more incised and larger canyons have been created. This change in topography results in some vegetative changes from Zone 2 described below; however, the same basic wildlife habitat types occur here as in Zone 2. These habitat types include: 1) riparian wetlands; 2) narrow creek woodlands; 3) xeric upland brush and savannah; and 4) cleared areas where cereal grains have been planted for livestock and wildlife. The only exception might be taller, more vegetatively diverse woodlands occurring in some canyons. Although these canyons in the western portion of the study area have not been visited by field personnel on this project, it is possible that some Edwards Plateau endemics, such as the golden-cheeked warbler could be found there.

Zone 2 - The Edwards Plateau/Blackland Prairies Transition Zone. The Edwards/Blackland Transition Zone stretches from the eastern boundary of the Recharge Zone (at the western edge of the community of Buda), to Onion Creek's confluence with Yorks Creek (the upstream edge of the Recharge Zone). This stretch of Onion Creek flows through the Recharge Zone of the Edwards aquifer where runoff flows across fairly shallow soils over compacted limestone. Much runoff is lost into fractures and other openings in this limestone. The result is a fairly xeric-adapted plant community where the only wildlife habitat types are: 1) spottily occurring riparian wetlands (areas of low recharge); 2) narrow creek woodlands; 3) xeric upland brush and savannah; 4) a few cleared areas along the creek where cereal grains (oats, rye or winter wheat) have been planted for livestock and wildlife to utilize.

Zone 3 - Blackland Prairie Influenced Zone. The Blackland influenced section is the zone of potential indirect impacts which stretches downstream from the eastern end of the Recharge Zone (just west of Buda) to Onion Creek's confluence with the Colorado River. In the Blackland influenced section of the watershed, roughly six habitat types may be delineated. These include riparian wetlands, fairly dense but narrow creek woodlands, upland brush and savannah, relictual prairie/old fields, tame pasture and agricultural fields. Deeper soils and more level topography lend this area to agricultural land uses. Wooded drainages through this area are important for dispersal of Austroriparian species into analogous habitats farther to the west.

A summary of the wildlife habitat types for each of these zones is presented in Table 6.1-2. Mammals, reptiles and amphibians and birds of potential occurrence are presented by habitat type in Appendix F.

Table 6.1-2 Wildlife Habitat Types by Zone.

Wildlife Habitat Type	Ecological Zone		
	Zone 1 (Edwards Influenced)	Zone 2 (Blackland/Edwards Transition)	Zone 3 (Blackland Influenced)
Riparian Wetland (RW)	X	X	X
Creek Woodland (CW)	X	X	X
Upland Brush & Savannah (UBS)	X	X	X
Relictual Prairie/Old Field (RPO)			X
Tame Pasture (TP)			X
Agricultural Fields (AF)	X	X	X
Steep Canyon (SC)	X		

Important Species and Habitats

The goal of this portion of the report is to focus a bit more closely upon elements of wildlife resources which often present important policy issues. For the purposes of this report, this discussion will be limited to commercially and/or recreationally important species, threatened and endangered species, and unique and sensitive habitats.

Commercially and Recreationally Important Species

Furbearing Species

In the Blackland Prairie and Edwards Plateau regions of Texas hunting and trapping are activities of significant commercial and recreational significance. A brief synopsis of fur harvest activities and furbearer population status follows. After the fur havest/furbearer discussions, data and trends regarding hunting in the Project Area East Texas will be discussed by species.

The TPWD evaluates fur harvest for the State of Texas on an annual basis. Brownlee (1991), TPWD furbearer program leader, estimates the Edwards Plateau region leads the state in terms of average annual fur harvest. The Blackland Prairie region has significantly lower harvests. On a state-wide basis, fur harvests have declined dramatically. The 1989-90 fur season suffered a 52% harvest decrease from the 9 year average posted between 1979-1987 (Perkins 1990). This drop was undoubtedly linked to a considerable reduction in fur prices in the 1988-89 and 1989-90 seasons. Numbers of trapper's licenses sold have decreased dramatically over the years as well. Between 1979 and 1980, 46,245 were sold as compared to 14,157 sold in 1989-1990.

The TPWD collects incidental data on furbearer abundance between July and October through spotlight surveys primarily conducted to assess white-tailed deer populations. The following table (Table 6.1-3) summarizes this data for the Edwards Plateau and Blackland Prairie ecological areas.

Table 6.1-3 Selected Deer Herd Data for Blanco, Hays and Travis Counties, 1989.

County	Acres of Deer Range	Estimated Population	Herd Composition		
			% Bucks	% Does	% Fawns
Blanco	453,616	59,686	26.6	58.9	14.5
Hays	345,874	28,120	20.9	65.2	13.9
Travis	228,334	9,025	14.3	60.7	25.0

Source: TPWD, 1989

In general, furbearer harvests have declined over the last decade for a number of reasons. It would be safe to assume this activity will increase when and if fur prices rise again. Hunting activities contribute significantly to the Central Texas economy. Brief population and harvest summaries of the more commonly hunted species of waterfowl, upland game birds, and mammals in Central Texas follow.

Waterfowl

Several species of waterfowl winter in the study area. Available data from the TPWD consists of mid-winter waterfowl surveys and hunter harvest data from nearby reservoirs. Harvest data was unavailable when requested.

The surveys are conducted in January on an annual basis by airplane. The state is partitioned into five zones which are flown by TPWD and USFWS personnel. Our study area lies in the north-central zone which roughly corresponds to portions of the Post Oak Savannah, Blackland Prairies, Cross Timbers and Prairies and Edwards Plateau as mapped by Gould (1975). Since these areas are large, the surveyors tend to focus upon large bodies of water where the birds are readily identifiable. Although they fly the individual zones, the overall goal is to provide population summaries on a state-wide basis. Five zones were surveyed, but large portions of south and west Texas were omitted as they are generally considered to be areas harboring lower wintering waterfowl densities. The zones surveyed include the upper coast (Orange County to Aransas County), the lower coast (Nueces to Cameron Counties), the northeast (portions of the pineywoods, post oak savannah, and blackland prairie), the northwest (the panhandle and portions of the Rolling Plains) and the north-central (as previously described). Table 6.1-4 summarizes these mid-winter survey results from the north-central zone. The only waterfowl species documented during the summer field work were several wood ducks observed flying east over the main channel of Onion Creek.

Table 6.1-4 Mid-winter Waterfowl Survey Results for the North-central Zone, January, 1989.

Species	Number Observed	% Relative to State Total (By Species)
Mallard	12,611	6.1
Godwall	2,859	5.8
Wigeon	467	2.3
Shoveler	315	0.8
Pintail	203	0.07
Wood Duck	47	4.4
Canvasback	686	4.8
Scarp	385	2.2
Ringneck	64	0.3
Goldeneye	107	58.5
Bufflehead	210	6.3
Ruddy Duck	100	2.2
Mergansers	245	6.9
Canada Geese	39,423	76.5

Species	Number Observed	% Relative to State Total (By Species)
Snow/Blue Geese	135	5.9
White-fronted Geese	1	0.06
Whistling Swan	3	0.75

Source: Lobpries, 1990.

Upland Game Birds

Information regarding populations and harvest of bobwhite quail and mourning dove in or near the study area follows. The Rio Grande strain of wild turkey occurs in the study area but no population or harvest data was available.

A state-wide quail census was initiated by TPWD in 1976. Data was collected by ecological region, in all ecological regions until 1988. After 1988, the census was discontinued in the Pineywoods, Post Oak Savannah, Blackland Prairie regions in Travis County. The median count was six birds per route through the period of 1977 through 1987. Two out of those 11 years posted yields of zero birds per route. The closest Edwards Plateau county surveyed was Blanco. Of the ten years surveyed (1978-1987) the number of quail per route ranged from 0 to 53 with a median count of two and an average of 20.3. As a region, the Edwards Plateau yielded 10 quail per route in 1990 compared to a long-term median of 10 quail per route (Wilson 1990).

The mourning dove is considered the most important game bird in the U.S. and Texas in terms of hunter recreation. The TPWD collects data regarding dove density and distribution in order to make harvest recommendations. A total of 133 randomly selected 15-mile call-count surveys are conducted in late May throughout all ecological regions of the state. Call counts yield data expressed as birds heard per route. Between 1967 and 1990, regional means for call counts ranged from 11.2 to 26.7 and 11.2 to 26.1 birds heard per route in the Blackland Prairie and Edwards Plateau, respectively. Mourning dove hunter days per 1,000 acres ranged from 7-12 in Blanco County, to 13-20 in Hays County, and to greater than 20 in Travis County.

Mammals

Fox squirrels offer some hunting in the Blackland Prairies and Edwards Plateau ecological regions; however, no data regarding their population or harvest was available. This species was observed in the Onion Creek watershed and should be fairly common in the more heavily wooded areas.

Rabbits constitute the fifth most often hunted species in Texas. Eastern cottontails and black-tailed jackrabbits (actually hares) occur in relatively high densities in the Edwards Plateau ecological region where population data has been collected concurrently with quail data for several years. An average of 4.81 cottontails and 9.48 jackrabbits per route was observed in 1990 in the Edwards Plateau region; whereas, the state-wide averages were 2.03 and 2.47, respectively. The 1990 survey was the first year rabbit data was systematically collected in the Blackland Prairie region. Only one cottontail was observed on four routes totalling 54 miles (0.019 rabbits per miles). No jackrabbits were observed (Wilson 1990).

The white-tailed deer is the most important game animal, in terms of economic impact, in the state of Texas. Although nearly decimated in the early 1900's due to commercial and illegal hunting, the species has made a remarkable recovery. The TPWD does not census white-tailed deer in the Blackland Prairies ecological region due to low numbers. White-tailed densities in the Edwards Plateau ecological region have averaged 75.4 deer per 1,000 acres or 13.3 acres per deer over the past 10 years. In that same time span densities have ranged from 11.7 acres per deer to 16.0 acres per deer. Productivity and fawn survival has averaged .57 fawns per doe, ranging from .35 to .80 fawns per doe from 1980 through 1989. An adequate adult sex ratio, in terms of production needs, of 3.03 does per buck has been the average over the past 10 years in the Edwards Plateau ecological region (Gore and Reagan 1990). Table 6.1-5 lists selected 1989 deer herd data for Blanco, Hays and Travis Counties. In addition to the white-tailed deer, the Y.O. ranch has introduced blackbuck antelope and axis deer to the region (Reagan 1991). Although the ranch strives to contain these animals, they have spread to surrounding properties and appear to be thriving. Seeing the animals themselves, as well as signs of their grazing/browsing and antler rubs are common. These animals provide another huntable resource of significant value to landowners.

Table 6.1-5 1989 Furbearer Abundance By Ecological Area (Expressed as animals/100 linear miles).

Ecological Area	Raccoon	Ringtail	Opossum	Skunk	Red Fox	Gray Fox	Coyote	Bobcat
Blackland Prairie	53.13	1.56	4.69	18.75	0.00	0.00	6.25	0.00
Edwards Plateau	39.58	5.10	0.50	7.62	0.17	6.78	0.33	0.25

Source: Sorola 1990.

Threatened and Endangered Species

Overall, the most important species to be concerned with are federally listed threatened and endangered species. There are five endangered invertebrates and seven endangered vertebrates potentially occurring in the region. Three threatened vertebrates could potentially occur as well. Several invertebrate, vertebrate and plant species are federal category two (C2) species which may warrant a threatened or endangered listing in the near future. A more comprehensive list and discussion of these species may be found in Section 6.1.5.4 - Threatened and Endangered species.

Unique and Sensitive Habitats

The most important wildlife habitats in the study area are the creek and all associated karst features, woodlands and wetlands. Onion Creek is an ephemeral stream which remains dry for extensive periods. However, wildlife species depend upon persistent pools for watering and for the protection and nutrition which the associated wetland vegetation offers. Numerous shelter caves have been encountered along the creek bank which provide roosting and nesting habitat for species such as bats and vultures; as well as potential den or lair sites for larger mammals. The caves found within the main channel of the creek appear to be so frequently and violently inundated that they may not provide reliable habitat for troglobitic species in the vicinity of the openings. However, since caves are important recharge features, they contribute to spring flow downgradient. This spring flow could be important to species known to depend upon perennial spring flow, such as the *Eurycea* salamanders. Mesic woodlands and wetlands associated with Onion Creek provide the highest areas of vegetative diversity in the watershed. These creekside woodlands and wetland areas constitute a sort of western expression of Austroriparian (eastern) riparian forest. These habitat types allow for east to west dispersal for Austroriparian species of wildlife. In the Edwards influenced zone, woodlands on the larger canyons and rocky slopes could provide suitable habitat for Edwards Plateau endemics such as the golden-cheeked warbler.

Baseline Conditions for Each Alternative

Based upon a field reconnaissance conducted by Mariah Associates, Inc. personnel in July and August of 1991, a brief summary discussion of baseline conditions in the vicinity of each proposed alternative follows. The vegetation at each site has been described in Section 6.1.5.1.

Since no quantitative field work was conducted, specific baseline conditions for wildlife communities are difficult to assess. Some of the most important information, from a wildlife habitat standpoint, is discussed in the last portion of Section 6.1.5.1, where the baseline vegetation at each proposed alternative site is described. There is a trend in potential occurrence of threatened and endangered species and sensitive karst features which increases from east to west. Species such as the golden-cheeked warbler, black-capped vireo and the cave invertebrates are Balconian species. Therefore, the western alternative - the Rutherford Dam and Reservoir is sited in what could potentially be (at least as for as the birds are concerned) the most sensitive stretch of Onion Creek in the study area. Impacts to wildlife resources from the proposed actions will be discussed in Section 6.2.5.2. Impacts to threatened and endangered species will be discussed in Section 6.2.5.4.

6.1.5.3 Aquatic Resources

This discussion of aquatic habitats and resources within the Onion Creek watershed is based upon a physical description of the watershed and its habitats, and historical water quantity and quality data. A detailed literature review (University of Texas at Austin; Southwest Texas State University; City of Austin Environmental and Conservation Services Department) indicated very little biological sampling had been conducted within the Onion Creek Watershed. In light of the paucity of biological data, this section will focus upon a habitat characterization based upon physical and chemical data collected in the watershed.

Regional Overview

This section initially presents a regional overview of the aquatic habitats in the study area followed by a discussion of historical base flows and water quality conditions (and their relationships to aquatic habitat) in Onion Creek. Finally a habitat characterization based upon the aforementioned flow and water quality data is provided for each of the project alternatives.

The Onion Creek watershed spans three counties (Blanco, Hays and Travis Counties) and encompasses approximately 343 square miles. Approximately 48% (166 square miles) of the drainage basin lie above the City of Buda. The watershed ranges in elevation from approximately 1,650 ft in the upper reaches to approximately 400 ft near its confluence with the Colorado River (USCE 1987). Onion Creek heads in Blanco County and flows approximately 78 miles in an easterly direction through Hays County to its confluence with the Colorado River in Travis county. The Creek has an average slope of approximately 12 feet per mile (.23%) slope over its 78 mile length (USCE 1987). Major tributaries in the Onion Creek Watershed include Little Bear Creek, Bear Creek, Slaughter Creek and Williamson Creek. Each of these tributaries are intermittent and typically only experience flows following significant precipitation events.

As previously discussed in the vegetation and wildlife sections, the Onion Creek watershed spans two ecological regions (the Edwards Plateau and Blackland Prairie) and a variety of geological features. This unique alignment of the watershed across an ecotone and varying geological features has created three rather distinct zones of aquatic habitat. For the purposes of this report these zones are delineated as follows:

Zone 1 - Zone 1 encompasses the area from the headwaters to the upstream edge of the Edwards aquifer Recharge Zone. Review of topographic information and discussions with local experts indicate this zone of Onion Creek is perennial with some spring flow, except in cases of severe drought during which the creek and associated springs have been known to become intermittent. The Proposed Rutherford Dam and Reservoir) is located within this zone.

Zone 2 - Zone 2 is synonymous with the Recharge Zone described in the Geological discussion. This zone is approximately 9.6 miles in length and typically flows only after significant precipitation events. As noted in the discussion on recharge, this zone is capable of recharging at a rate of 120-160 cfs, thus leaving any quantity greater than this as flow through the Recharge Zone. Four of the five proposed project alternatives (Centex Reservoir; Centex Diversion Dam; Ruby Reservoir; and Centex and Ruby Reservoirs in Tandem) are located within this zone.

Zone 3 - Zone 3 encompasses the area from the downstream edge of the Recharge Zone (near Buda) to the creek's confluence with the Colorado River. This zone is influenced by discharge from the City of Buda Wastewater Treatment Plant (.39 MGD). The area below McKinney Falls is influenced by inflows from Williamson Creek and backwater effects of the Colorado River. None of the proposed project alternatives are located within this zone. This zone is included to provide a context to evaluate potential downstream impacts.

Habitat Assessments

Habitat quality is a function of a number of physical, chemical, and biological parameters including flow rate, duration and periodicity; water quality (among others, dissolved oxygen, temperature, and pH); channel width and depth; substrate; macrophytes and algae; detritus; bank height and slope; canopy closure; adjacent land use; and channel modifications. The following paragraphs provide an overview of historical flows and water quality data on Onion Creek. Site specific descriptions of substrate characteristics and vegetative communities at each of the sites of the proposed alternatives are presented in Sections 3.0 and 6.1.5.1. Cross sectional profiles of each of the alternatives are presented in Section 5.0.

Historical Flow Data

The average, maximum, minimum and standard deviation of baseflows (in cfs) roughly corresponding to each of the three zones described above are presented in Table 6.1-6. The

Table 6.1-6 Inflow, Recharge and Outflow Estimates for Onion Creek[1] (Cubic Feet Per Second) (Based on 1941-1988 Data)[2].

Inflow to Recharge	January	February	March	April	May	June	July	August	September	October	November	December
Average	60	72	76	81	100	105	38	15	38	51	39	51
Maximum	604	447	333	488	572	1062	496	95	731	461	254	432
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Standard	101	96	90	106	122	181	77	21	107	94	57	81

Recharge Within the Recharge Zone	January	February	March	April	May	June	July	August	September	October	November	December
Average	43	51	59	52	62	54	30	14	19	28	33	40
Maximum	166	147	166	159	164	159	166	92	89	131	150	158
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Standard	49	52	61	106	122	181	77	21	107	94	57	81

Outflow From Recharge Zone (from Buda)	January	February	March	April	May	June	July	August	September	October	November	December
Average	16	22	18	29	38	51	8	1	19	24	6	12
Maximum	504	302	188	417	420	903	340	25	656	332	121	297
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Standard	73	54	38	80	80	147	47	4	95	70	20	45

Source: DGRA, 1991

[1] Inflow denotes flow into the recharge zone; Outflow denotes flow out of the recharge zone.

information in Table 6.1-6 corresponds to the three zones as follows: Zone 1 - Inflow; Zone 2 - Recharge; and Zone 3 - Outflow. This data is based on historical flow data from 1941-1988. The inflow data presented in Table 6.1-6 includes all flow draining from Zone 1 as well as all surface drainage (via tributaries and/or sheet flow) into the Recharge Zone below Zone 1. The recharge data is indicative of the flow recharged into the aquifer over the entire stretch of the Recharge Zone. As noted in the recharge and geology sections, this recharge is not occurring uniformly throughout the Recharge Zone, but rather in varying degrees depending upon the recharge potential of the recharge features in any localized area. However, it can be generally stated that, due to the surface area of the drainage basin in Zone 1, and the potential for recharge in the upper reaches of Zone 2, Zone 2 will become dry (over time) from the downstream edge of the Recharge Zone towards the upstream edge of the Recharge Zone. More simply stated, unless the inflow exceeds 120 to 160 cfs, most of the flow will be recharged into the aquifer prior to reaching the downstream edge of the Recharge Zone. Thus, the upstream portion of Zone 2 typically has a longer period of inundation and, therefore more useable aquatic habitat.

The outflow data presented in Table 6.1-6 is simply the difference between the inflow data and the recharge data. Note that the minimum flow for all three measurements (inflow, recharge and outflow) has historically been zero for any given month, exemplifying the intermittent nature of Zone 2. Note, as would be expected, the summer months (July, August, and September) have the lowest flow average monthly flows with average inflows of 38, 15, and 38 cfs respectively.

Water Quality

Water quality data is another parameter (in addition to flow) that aids in describing the aquatic habitats in the project area. Two separate studies by the Texas Water Commission and Southwest Texas State University (SWTSU)(TWC 1990 and Short 1988) have been conducted on Onion Creek to evaluate water quality. Due to the intermittent flow in Zones 1 and 2, all sampling in these two efforts was conducted in Zone 3. A summary of each of these efforts is presented below.

TWC Water Quality Inventory

The TWC has designated Onion Creek as Segment 1427 of the Colorado River Basin. Designated water uses for this segment include contact recreation, high quality aquatic habitat, public water supply and aquifer protection. Water quality data for this segment is generally good with some periodic exceedance of dissolved oxygen (DO) sulfates, total dissolved solids (TDS) and fecal coliform criteria. However, it should be noted that these intensive surveys by the TWC were conducted in 1981 and 1982 and several wastewater discharges on the creek have been eliminated since these surveys. Water quality data for Onion Creek is presented in Table 6.1-7.

Table 6.1-7 Water Quality Status of Segment 1427 (Onion Creek) of the Colorado River Basin.

Parameter	Criteria	Number of Samples	Minimum	Maximum	Mean	Number of Values Outside Criteria	Mean Values Outside Criteria
Dissolved oxygen (mg/L)	5.0	148	1.7	16.4	8.7	8	3.7
Temperature (F)	90.0	149	42.3	90.1	72.1	1	90.1
pH	6.5-9.0	143	6.6	8.9	7.9	0	0
Chloride (mg/L)	50	54	7	56	20	1	56
Sulfate (mg/L)	50	54	13	90	35	10	59
Total Dissolved Solids (mg/L)	300	149	137	367	247	14	327
Fecal Coliforms (#/100 ml)	200	47	1	1589	20	7	399

Source: TWC, 1990.

SWTSU Phosphorus Study

In 1988 SWTSU conducted a study for the TWC to determine:

1) The existing physico-chemical conditions of several tributaries of the Colorado River (including Onion Creek) and;

2)The potential for phosphorus to be a limiting nutrient to algal growth in these streams (including Onion Creek)

The water quality data collected in this study is presented in Table 6.1-8. In short, the study indicated that phosphorus was limiting at the Bluff Springs site on Onion Creek and the remainder of the water quality parameters measured were all within the range expected from discharge impacted Hill Country streams.

A description of the geology and vegetation in the vicinity of the project alternatives is presented in Sections 3.0 and 6.1.5.1 respectively. Descriptions of the channel width and lengths of the proposed alternatives are presented in Section 6.2. Finally, cross sectional profiles of each of the locations of the project alternatives are presented in Section 5.0.

The physical and chemical parameters described above (and in the sections noted) provide the baseline information necessary to generally evaluate aquatic habitat in the project vicinity. Brief habitat descriptions are presented below in the order in which the zones were previously described.

Zone 1 - This zone, as previously noted, is perennial with some spring flow during seasons with high precipitation. This zone provides a variety of fishery habitats, depending upon seasonal conditions, including runs, riffles and pools. Benthic

Table 6.1-8 Water Quality Data for Two Sample Sites Located on Onion Creek.

	Buda			Bluff Springs		
Parameter	Average	Minimum	Maximum	Average	Minimum	Maximum
Turbidity (NTU)	nd			0.1		
Alkalinity (mg/L)	202	161	243	198	182	236
Hardness (mg/L)	214	172	253	214	144	259
Total phosphorus (ug/L)	22.3	<1	137.4	4.6	<1	12.6
Ortho phosphorus (ug/L)	<1			2.5	<1	6.3
Ammonia-nitrogen (mg/L)	0.28	0.03	0.80	0.35	0.06	1.18
Nitrate-nitrogen (mg/L)	0.38	0.05	1.07	0.45	0.08	0.93
Temperature (°C)	25.1	15.6	30.5	23.2	14.1	27.7
pH	7.8	7.5	8.6	7.5	7.0	7.7
Dissolved oxygen (mg/L)	7.2	3.9	8.5	8.6	7.2	9.5
Conductivity (umho/cm)	440	367	591	461	397	607
Discharge (m^3/s)	0.13	0	0.52	0.93	0.07	2.00

Source: Short, R. 1988.

communities in this area are expected to be limited due to the limestone substrate. However, the actual species composition and diversity of both fish and macroinvertebrates is unknown due to the lack of any extensive sampling efforts in this zone.

Zone 2 - As previously discussed, Zone 2 is characterized by intermittent flow which typically follows significant precipitation events. Habitat for both fish and invertebrates in this zone is very limited and only seasonal at best. Various species of fish obviously pass through this zone during wet periods but it does not provide any significant amount of quality habitat.

Zone 3 - This zone, as previously discussed, is intermittent although it does pool for significantly longer periods than Zone 2 and receiving inflows from Slaughter Creek above McKinney Falls. Inflow from Williamson Creek and backwater effects from the Colorado River result in perennial pools, riffles and runs in the area below McKinney Falls. This zone is very likely the most highly productive (with respect to aquatic biota) of the three zones. The substrate in this zone typically has a higher incidence of organic matter, thus providing higher quality habitat for benthic invertebrates. In addition, due to its proximity to the Colorado River, the area below McKinney Falls could be expected to have a similar species composition and provide refuge during extreme flow conditions. Again, detailed biological studies have not been conducted in support of this project.

6.1.5.4 Threatened and Endangered Species

The purpose of this section is to provide a brief introduction to the listing and monitoring processes employed by federal, state and private entities; to provide a listing of threatened and endangered species potentially occurring in the study area and to give brief life history descriptions of federally listed threatened and endangered species in the study area. The listing/monitoring description will be presented by entity.

Listing and Monitoring Process

Federal - U.S. Fish and Wildlife Service

The USFWS has legislative authority to list and monitor the status of species whose populations are considered to be imperiled. This federal legislative authority for the protection of threatened and endangered species issues from the Endangered Species Act of 1973, and its subsequent amendments. Regulations supporting this act are codified and regularly updated in Sections 17.11 and 17.12 of Title 50 of the Code of Federal Regulations. The federal process stratifies potential candidates based upon the species' biological vulnerability. The vulnerability decision is based upon many factors affecting the species within its range and is always linked to the best scientific data available to the USFWS at this time. Species listed as Endangered (E) or Threatened (T) by the USFWS are provided full protection. This protection includes a prohibition of indirect take such as destruction of critical habitat. The Endangered Species Act and accompanying regulations provide the necessary authority and incentive for the individual states to establish their own regulatory vehicle for the management and protection of threatened and endangered species.

State - Texas Parks and Wildlife Department

Endangered species legislation passed in Texas in 1973 (amended in 1981, 1985, and 1987) (TPWD 1991). Subsequently, 1975 and 1981 revisions to the TPWD Code established a state regulatory vehicle for the management and protection of threatened and endangered species. Chapters 67 and 68 (the 1975 revisions) of the code authorizes TPWD to formulate lists of threatened and endangered fish and wildlife species and to regulate the taking or possession of the species. A 1981 revision (and 1985 amendment) to the code provides authority for TPWD to designate plant species as threatened or endangered and to prohibit commercial collection or sale of these species without permits.

The ensuing department regulations are Sections 65.171 - 65.177, 65.181-65.184, and 69.01-69.14 of the Texas Administrative Code for (for Chapters 67, 68, and 88 of the TPWD Code, respectively). These sections regulate the taking, possessing, transporting, exporting, processing, selling or offering for sale, or shipping of endangered or threatened species of fish, wildlife and plants. Neither specific criteria for the listing of plant and animal species, nor protection from indirect take (i.e., destruction of habitat or unfavorable management practices) are found in either of the above mentioned statutes or regulations (TPWD 1991).

Functionally, the TPWD oversees endangered resources through the Resource Protection Division. The Division is further divided into branches, with the Endangered Resources Branch consisting of the Endangered Species Program and the Natural Heritage Program. The Endangered Species Program lists, regulates and plans for recovery of threatened and endangered species. The Natural Heritage Program catalogs, monitors, and provides information on rare species and communities of concern (TPWD 1991).

Private - Texas Organization for Endangered Species (TOES)

Lastly, a private group of biologists, conservationists and natural resource managers formed the Texas Organization for Endangered Species (TOES) in 1972 to study vanishing plants and animals in Texas and to educate the public regarding their conservation. The TOES group publishes lists which provide status reports of their own as well as federal and state listings on a periodic basis. The status of the given species and brief descriptions of preferred habitats and possible reasons for their listing appear in these reports (TOES 1987).

List of Threatened and Endangered Species

The list of threatened and endangered species potentially occurring in the Onion Creek vicinity issues from the above mentioned federal and state regulations (lists), and supplementary information comes from the Texas Natural Heritage Program and the Texas Organization for Endangered Species. Table 6.1-9 presents the current status of those threatened and endangered species and footnotes below the table explain the rationale for the various classifications.

Habitat Requirements and Texas Status of Federally Protected Species

As mentioned in the first paragraph of this section, brief life histories of federally listed threatened or endangered species will be presented. No species of plants or fish which are federally listed as threatened or endangered are documented in the study area. Endangered species potentially occurring in the study area include five invertebrates, one amphibian, and six birds. Threatened species in the area include one amphibian, one reptile and one bird. Endangered and threatened species information shall be presented by major taxonomic groups.

Invertebrates

Five species of troglobitic (cave dwelling) invertebrates have been listed by the USFWS as endangered. These include the Tooth Cave pseudoscorpion, the Tooth cave spider, the Bee Creek cave harvestman, the Tooth Cave Ground Beetle and the Kretschmarr cave mold beetle. Two other invertebrates recently discovered are thought to be distinct species but have yet to be described in a published format. It is thought that these two will be listed as endangered after their descriptions are published. These are the Coffin Cave mold beetle (originally thought to be synonymous with the Kretschmarr Cave mold beetle) and the Bone Cave harvestman

Table 6.1-9 Federally Listed Species of Potential Occurrence in the Onion Creek Vicinity.

Common Name	Scientific Name	Status			
		USFWS	TPWD	TNHP	TOES
Invertebrates					
Balcones Cave Amphipod	*Stygobromus balconis*	C2	NL	G1S1	NL
Bifurcated Cave Amphipod	*Stygobromus bifurcatus*	C2	NL	G1S1	NL
Tooth Cave Pseudoscorpion	*Microcreagris texana*	E	NL	G1S1	NL
Tooth Cave Spider	*Neoleptoneta myopica*	E	NL	G1S1	NL
Bee Creek Cave Harvestman	*Texella reddellii*	E	NL	G1S1	NL
Tooth Cave Ground Beetle	*Rhadine persephone*	E	NL	G1S1	NL
Kretschmarr Cave Mold Beetle	*Texamaurops reddelli*	E	NL	G1S1	NL
Vertebrates					
Blue Sucker	*Cycleptus elongatus*	C2	T	G4S3	WL
Guadalupe Bass	*Micropterus treculi*	C2	NL	G3S3	T
Cascade Caverns Salamander	*Eurycea latitans*	3B	T	NL	T
San Marcos Salamander	*Eurycea nana*	T	T	G1S1	NL
Texas Salamander	*Eurycea neotenes*	C2	NL	G3S3	NL
Barton Springs Salamander	*Eurycea sp.*	C2	NL	G1S1	NL
Comal Blind Salamander	*Eurycea tridentifera*	C2	T	G1S1	T
Texas Blind Salamander	*Typhlomolge rathbuni*	E	E	G1S1	T
Blanco Blind Salamander	*Typhlomolge robusta*	C2	E	G1S1	T
American Alligator	*Alligator mississippiensis*	T(S/A)	NL	NA	WL
Texas Horned Lizard	*Phrynosoma cornutum*	C2	T	G5S5	T
Texas Garter Snake	*Thamnophis sirtalis annectans*	C2	NL	G5S3	NL
White-faced Ibis	*Plegadis chihi*	C2	T	G5S3	T
American Swallow-tailed Kite	*Elavoides forficatus*	3C	T	G5S2	T
Bald Eagle	*Haliaeetus leucocephalus*	E	E	G3S2	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	E	E	G3T2 S1	T
Whooping Crane	*Grus americana*	E	E	G1S1	E
Piping Plover	*Charadrius melodus*	T	T	G2S2	T
Interior Least Tern	*Stevna antillarum athalassos*	E	E	G4T2 S2	E
Black-capped Vireo	*Vireo atricapillus*	E	E	G2S2	T
Golden-cheeked Warbler	*Dendroica chrysoparia*	E	E	G2S2	T
Plants					
Bracted Twist-flower	*Streptanthus bracteatus*	C2	NL	G2S2	III
Canyon Mock-orange	*Philadelphus ernestii*	C2	NL	G2S2	V
Texas Amorpha	*Amorpha roemerana*	C2	NL	G3S3	NL
Correll's False Dragon Head	*Physostegia correllii*	C2	NL	G2S2	NL

USFWS: United States Fish and Wildlife Service

E:	Endangered (in danger of extinction throughout all or a significant portion of its range)
T:	Threatened (likely to become endangered within the foreseeable future)
T S/A:	Threatened for similarity of appearance
Proposed:	Proposed for listing as Threatened and Endangered and under consideration by the Secretary of the Interior
Category 1:	Substantial information on hand to support listing as Threatened or Endangered
Category 2:	Substantial information to support listing is currently in hand, yet conclusive data are needed on biological vulnerability and threats to the species
Category 3:	Rejected for listing, yet held in consideration pending changes in biological status owing to factors not yet anticipated
3A:	Previously under consideration for listing, but are currently presumed to be extinct
3B:	Previously under consideration for listing, but currently presumed not to be a valid species or subspecies
3C:	Previously under consideration for listing, but currently presumed to be more abundant and/or widespread than previously though, and not subject to substantial threats to their continued existence

TPWD: Texas Parks and Wildlife Department

E:	Listed as Endangered in the State of Texas
T:	Listed as Threatened in the State of Texas
NL:	Not listed

TNHP: Texas Natural Heritage Program

S1:	Fewer than 6 occurrences statewide
S2:	Six to 20 occurrences statewide

Table 6.1-9 (continued)

S3:	Twenty-one to 100 known Texas occurrences
S4:	Apparently secure in Texas
S5:	Demonstrably secure in Texas
SX:	Apparently extirpated from state
G1:	Critically imperiled globally, 5 or fewer occurrences
G2:	Imperiled globally, 6-20 occurrences
G3:	Very rare and/or local throughout range, 21-100 occurrences
G4:	Apparently secure globally
G5:	Demonstrably secure globally
GX:	Believed to be extinct throughout range.

Texas Organization for Endangered Species (TOES)

Plants

Category I — The term "endangered species" means any species which is in danger of extinction throughout all or significant portion of its range other than a species of the Class Insecta determined by the Secretary of Interior to constitute a pest whose protection under the provision of the Endangered Species Act of 1973, P.L. 93-205, as amended (Dec. 1978), would present an overwhelming and overriding risk to man.

Category II — The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion its range.

Category III — The term "state endangered species" means any species which is in danger of extinction or of extirpation in Texas or in addition to I and II above.

Category IV — The term "state threatened species" means any species which is likely to become a state endangered species within the foreseeable future.

Category V — The term "TOES watch list" means any species which at present has either low population or restricted range in Texas and is not declining or being restricted in its range but requires attentions to insure that the species does not become endangered or threatened (state or federal).

Animals

E	In danger of extinction in all of most of the species' range in the United States, particularly in Texas
T	Depleted or impacted by man so as likely to become endangered in the near future
WL	Potentially endangered or threatened in the United States, especially in Texas, although not necessarily in its range as a whole.

Sources

50 CFR Part 17. January 6, 1989. Endangered and Threatened Wildlife and Plants; Animal Notice of Review. Dept. of Interior. Fish and Wildlife Service.

50 CFR Part 17.11 & 17.12 April 15, 1990. Endangered and Threatened Wildlife and Plants; Animal Notice of Review. Dept. of Interior. Fish and Wildlife Service.

31 T.A.C. 65.171-177. December 28, 1987. Regulation for Taking, Possessing, Transporting, Exporting, Processing, Selling, or Offering for Sale, or Shipping Endangered Species.

31 T.A.C. 65.181-65. February 10, 1988. Regulation for Taking, Possessing, Transporting, Exporting, Processing, Selling, or Offering for Sale, or Shipping Endangered Species.

Texas Organization for Endangered Species (TOES). 1987. Endangered, Threatened and Watch Lists of Plants of Texas. TOES Publications 6. Austin, Texas. 9pp.

Texas Organization for Endangered Species (TOES). 1987. Endangered, Threatened and Watch Lists of Vertebrates of Texas. TOES Publications 6. Austin, Texas. 16pp.

Texas Parks and Wildlife Department. Texas Natural Heritage Program. Computerized Special Species and Natural Community Occurrences, Hays, Blanco, and Travis, Counties.

Texas Parks and Wildlife Department. Texas Natural Heritage Program. April, 1991. Special Plant and Animal Lists.

(originally thought to be synonymous with the Bee Cave harvesterman (The Butler/EH&A Team, 1990). The following table (Table 6.1-10) describes the endangered invertebrates' appearance, distribution and abundance.

Table 6.1-10 Appearance, Distribution and Abundance of Endangered Invertebrates in the Edwards Plateau.

Species	Description	Distribution & Abundance
Tooth Cave Pseudoscorpion	4 mm long; tiny, tailless scorpion, no eyes; no stinger; captures small insects with pinchers.	Known only from Tooth and Amber Caves in W. Travis County (Four Points area).
Tooth Cave Spider	1.6 mm long (smallest of listed invertebrates); pale, long-legged with rudimentary eyes.	Known only from Tooth and New Comanche Trail Caves in W. Travis County
Bee Creek Cave Harvestman	2-3 mm long; "daddy-longlegs"; yellowish-brown, eyeless and feeds on small insects.	Known only from Bee Creek, Bandit, and Jester Estates Cave and Cave Y, all in Travis County
Tooth Cave Ground Beetle	7-8 mm long; a reddish-brown, predatory beetle with reduced eyes	Known from Tooth, Kretschmarr, and Root Caves - Travis County; and Marigold, Lakeline (cave and anicrokarst), Raccon, Good Friday and T.W.A.S.A. Caves - Williamson County
Kretschmarr Cave Mold Beetle	3 mm long; short-winged, long-legged beetle which is dark-colored and eyeless. May be predatory.	Known only from Tooth, Kretschmarr and Amber Caves in Travis County

Source: The Butler/E.H. & A Team, 1990.

Little or nothing is known about these creatures' reproductive biology. It is thought that, although surface congeners possess distinct seasonal life cycles, the cave invertebrates have lost this seasonality through adaptation to a fairly steady-state environment. Therefore, adults of each species may be found throughout the year.

A cursory investigation of two of the caves found in the Onion Creek watershed (Section 3.0) yielded very little invertebrate life. The endangered invertebrate species are generally found in caves, sinks and associated karst features of Edwards Limestone.

These species depend upon a fairly intricate environment where humidity, light and nutrient-input systems select for a very specialized organism. Densities of these species tend to be highest near openings where energy transfer from leaf litter, decomposing bodies (of trapped animals) and feces is at a maximum. During unfavorable outside conditions, the organisms can move further in through the cracks and other passages to a more advantageous site (The Butler/E.H. & A Team, 1990).

Amphibians and Reptiles

This discussion is limited to the San Marcos Salamander (Threatened) and Texas Blind Salamander (Endangered); however, two other *Eurycea* salamanders will be briefly mentioned as well.

Although five species of *Eurycea* salamanders are listed in Table 6.1-9, the number of species in this genus will likely increase in the near future. Within the *E. neotenes* complex, two genetically distinct species (one on the Jollyville Plateau and one known only from Barton Springs in Zilker Park, Austin, Texas) will likely be separated. Both are probable candidates for a threatened or endangered listing by the USFWS if they attain specific status (Price, personal communication, and the Butler/E.H. & A Team 1990).

The San Marcos salamander is a very small (1 1/2 - 2 inch), brown neotenic (retains external gills throughout life) aquatic salamander with a row of yellowish spots down each side of its back, and a whitish/yellowish venter. This species is known only from the algal mats on the bottom of the spring pool which feeds the San Marcos River in San Marcos, Texas (Conant 1986). This species is very unlikely to occur in the Onion Creek watershed; however, the threatened and endangered species list compiled was purposefully over-comprehensive due to the unique nature of the Edward's Aquifer. Although the Barton Springs portion of the aquifer is considered to be hydrologically distinct from that in the San Marcos River watershed, if permanent springs were found in the Onion Creek watershed, similarly unique species might also be found in such an isolated habitat.

The endangered Texas Blind Salamander is another San Marcos resident. This cave dwelling species is also neotenic and possesses very thin legs, remnant eyes and a strongly flattened snout (Conant 1986). Again, this particular species is not expected to occur in the Onion Creek watershed, but it serves as an example of the extremes to which the urodele fauna has adapted to environments along the Balcones Escarpment in Texas. Although no permanent springs were observed along Onion Creek, the potential for unique species to occur in the watershed cannot be totally dismissed.

American Alligator

The American Alligator has recovered dramatically in Texas and therefore has been removed from state lists. It remains listed as T/SA (threatened due to this similarity in appearance to the American crocodile [Crocodylus acutus], which is endangered on the federal level). Insufficient flows in Onion Creek throughout the majority of the year preclude it from being considered optimal alligator habitat. Only between Onion Creek's confluence with the Colorado River and McKinney Falls could one even rarely expect to find an alligator.

Bald Eagle

The bald eagle ranges over much of the U.S. Canada, British Columbia and Labrador. This eagle is primarily a fishing species and prefers habitat associated with large bodies of water. In Texas, wintering and nesting activity occurs mainly near large, freshwater impoundments with standing timber located in or around the water (Mabie 1989). Bald eagle research conducted by the TPWD focuses upon nest survey, management and post-fledgling survival and dispersal. Mid-winter counts by 117 observers yielded 199 bald eagle sightings at

15 standard survey locations in 1989. No bald eagles have been documented by TPWD in Hays, Travis or Blanco Counties; however, wintering birds are consistently observed on Lake Buchanan (Burnet County) and successful nesting has been documented in Bastrop County since 1984.

Arctic Peregrine Falcon

The arctic peregrine falcon is a medium to large cosmopolitan falcon which inhabits a variety of habitats. In Texas, this species rarely breeds and only a few migrants and winter residents are found. This falcon primarily feeds on birds and is often found near seabird colonies (Oberholser 1971). Winter and summer sightings have been historically documented in Travis and Hays Counties, but no nesting has been observed (Oberholser 1971).

Whooping Crane

The whooping crane is North America's tallest bird with a standing height of 5 ft. or more. The bird is a large, white crane with a daggerlike, yellow bill, and with reddish skin on the crown which is darker on the face and lower jaw of adult birds. The whooping crane's tail plumes form a sort of bustle. In flight, the long extended neck and black legs and black-tipped wings are characteristic. The whooping crane ranges from Wood Buffalo National Park and northern Alberta south to North Dakota, Iowa and the central coastal prairie in Texas and southwest Louisiana. In Texas, whooping cranes winter at Aransas National Wildlife Refuge and Matagorda and St. Joseph's Islands in Aransas, Calhoun and Matagorda Counties. Travis, Blanco and Hays counties are generally in the path of migration for the whoopers during their 2,600 mile flight each spring (late March to late April) and fall (mid-October to late November) (Oberholser 1971). The recent killing of a whooping crane near Lampasas serves as a remainder that these birds are very vulnerable during migration. Site records in Travis and Comal counties are reported by Oberholser.

Piping Plover

The piping plover (threatened) is a small, ringed (has a dark, narrow breast band) plover which ranges from south-central Canada, the Great Lakes region, and coastally from Newfoundland to Virginia. This species winters coastally from South Carolina to Texas. The piping plover tends to inhabit lake and sea shores where it breeds and nests on sparsely vegetated expanses between dunes and high water lines. The majority of Texas specimens and sightings documented by (Oberholser 1974) come from coastal counties from Chambers to Cameron. One isolated fall sight record for Travis county is documented.

Interior Least Tern

The interior least tern is a colonial nesting species adapted to lacustrine and riverine habitats. Active nesting colonies may be found in the Texas panhandle on the Red and Canadian river systems and in south Texas along the Rio Grande River (Locknane 1988). Oberholser (1974) cites a handful of summer and fall sight records in Central Texas, but no nesting has been documented.

Black-Capped Vireo

The Black-Capped Vireo is an insectivorous migrating songbird which nests from late March through July in mid-successional, brushy habitat. These birds have olive green backs, a blackish tail with yellow-green edges, a white breast and belly and two pale yellow wing bars. Males of this species have a black head with conspicuous white eye-rings with a white connecting band (spectacles). Females have a grayish head. The present active breeding range in Texas extends from Dallas County southeast to Bexar County, west to Brewster and Pecos counties and northwest to Taylor and Coke Counties. This species has been well studied in

Central Texas and is documented in Hays, Travis, and Blanco Counties (Oberholser 1974 and the Butler/E.H. & A. Team 1990). Marginal habitat for the Black-capped vireo was observed in the Onion Creek watershed during field investigations. A complete survey of upland areas has not taken place to determine whether suitable habitat exists.

Golden-Cheeked Warbler

The golden-cheeked warbler nests on the Edwards Plateau in mixed mature Oak/Ashe Juniper woodlands. This insectivorous species winters in southern Mexico, east-central Guatemala, Honduras and Nicaragua (Pulich 1976). Its nesting range extends in an arc south from Palo Pinto County to northwestern Bexar County and west to Edwards and Kinney Counties. Physically, this warbler has white underparts with black streaks on its flanks. Males have bright yellow cheeks with a distinctive black eyeline and black on the crown, nape, back, throat and upper breast. Females have a duller, greenish crown, nape and back and much duller cheek patches and eyeline than the male (Oberholser 1974). These birds are very active and spend much time in the upper canopy gleaning insects.

Suitable habitat for the golden-cheeked warbler occurs sparingly in the upper portions of Onion Creek. Canyons on the Rutherford property especially warrant formal habitat assessment.

6.1.6 Historic/Archaeological Resources

6.1.6.1 Regional Overview

Onion Creek drains a catchment along the margin of the Edwards Plateau, dropping down the Balcones escarpment and traversing a segment of the Blackland Prairie south of Austin before joining the Colorado River. The portion of the creek west of Buda, along which the proposed recharge enhancement facilities are being considered, is ecologically interesting from a human point of view, because of its proximity to two major biogeographical zones. Hunter-gatherers, who occupied this part of central Texas throughout prehistory, would find such a setting advantageous, because it would allow them to exploit two nearby areas with different sets of floral and faunal resources. Onion Creek also possesses a developed terrace system (REF), a depositional setting which favors the burial and preservation of prehistoric sites.

The study area thus possesses the potential for containing preserved archeological remains which may be of considerable importance in addressing research issues concerned with questions of human ecology as well as human history. Before a cultural resource permit is issued, it may be necessary, under Section 106 of the Historic Preservation Act of 1966, to identify all archeological and historical sites subject to impact under the finalized construction plan, to assess their significance and if it is determined that construction plans will entail adverse impacts to significant cultural resources, it will be necessary to mitigate any information loss. The effort to identify, assess, and preserve or mitigate cultural resources must conform to guidelines set forth by the State Historic Preservation Officer and the U.S. Army Corps of Engineers, assuming that the Corps will be the lead federal agency involved in the project.

In order to aid in the selection among the proposed recharge enhancement alternatives, and to facilitate understanding of the steps required to obtain a Cultural Resources permit, the following sections provide a brief overview of central Texas archeology, focusing on research issues and their relevance to the determination of site significance, and address more specifically the cultural resources of the Onion Creek watershed and the potential impacts of each of the proposed construction alternatives.

6.1.6.2 Archeological Background

A considerable amount of research has been performed over the last fifty years into the archeological remains along the margin of Edwards Plateau. Cultural Resources Management (CRM) projects have ranged from large lignite mine and reservoir studies along the region's major rivers to small scale studies attendant on highway construction and municipal improvements largely centered in Austin and San Antonio. Research has also been conducted under the auspices of the University of Texas and other institutions. The body of resulting information has been synthesized into a historical framework which provides the background against which research questions into prehistoric human development and behavior may be formulated.

Four very broad stages of human history in the central Texas area are recognized (Black 1989). The earliest groups yet identified in North America inhabited the region ca. 12,000-9,000 years ago. This time span is referred to as the Paleo-Indian period; it occurred during the retreat of the last glaciers. Paleo-Indian groups have been best studied on the Great Plains, where they appear to have pursued a lifeway centered on the hunting of large game animals, such as mammoth and an ancient form of bison, which became extinct during the climatic upheavals at the end of the Pleistocene.

Paleo-Indian artifacts have been found repeatedly at sites on either side of the Balcones Fault but are most commonly isolated occurrences in sites dating primarily to later time periods; very few well-preserved remains of extensive Paleo-Indian encampments have been identified or excavated in central Texas. Exceptions include rockshelter sites, Horn Shelter (Watt 1978, Forrester 1985) on the Brazos, Kincaid Shelter in Uvalde County (Collins 1990) and Levi Shelter on the Pedernales (Alexander 1963). Two open camps, at 41BX52 near San Antonio and the Wilson-Leonard site in Williamson County have been excavated but are not yet published.

Due to the lack of information about Paleo-Indian habitation of central Texas, the identification of a possible Paleo-Indian component in the study area would be of high significance, and such a site would have to be avoided or its destruction mitigated through excavation. The potential of encountering a well preserved Paleo-Indian deposit along Onion Creek is probably low, but in such an alluvial setting it is always a possibility. Artifacts dating to the end of the Paleo-Indian period were recovered from a shallowly buried Pleistocene surface at 41HY209 near Mustang Branch, evidence of Paleo-Indian use of the immediate study area; the results of the excavations at this site and at 41HY202 are currently in preparation.

At the end of the Pleistocene, hunter-gatherer lifeways appear to have changed considerably throughout the continent. The extinction of the large game animals probably led to a broadening of the human resource base, with a variety of smaller animal species providing meat and with an increased reliance on wild plant foods. An apparent increase in human population density led to restricted territories, and hunter-gatherer groups became increasingly specialized in utilizing the resources available in their particular region, resulting in differences in cultural traits and adaptations from territory to territory. This trend towards regionalization characterizes the long span of prehistory known as the Archaic period, which in central Texas is dated roughly from 7000 B.C. to A.D. 700. The time span is normally subdivided into Early, Middle and Late Archaic periods, each with a recognizable set of artifacts and range of site types and common features.

Archaic sites are abundant in central Texas and have been extensively studied. A detailed chronology has been worked out which allows a rough identification of the dates of site occupation, within ca. 500 years in most cases, based on changing styles of projectile points. A sketchy historical outline of population growth and decline, and changes in adaptation and technology during the Archaic period has also been established, allowing the formation of specific research questions pertinent to defined time periods and geographic locality. Current interest is therefore aimed at refining knowledge of human ecology and customs during specific time periods, in order to create a broad and thorough data base for understanding cultural change and development in this part of the continent.

Significant Archaic sites are thus those with the potential to contribute detail to what is already known about this period in central Texas. In most cases, significant sites would either possess outstanding preservation, particularly of floral and faunal remains, or good stratigraphic resolution of remains from discrete historical time periods. Although both of these circumstances are comparatively rare in central Texas sites, they are both favored in alluvial settings such as the terrace systems along Onion Creek. Rapid burial may enhance preservation of organic remains, depending on soil chemistry, and aggrading alluvium is probably the optimum setting for isolating discrete, short-term occupation debris.

The Archaic period is considered to have ended in central Texas with the adoption of the bow and arrow as a primary weapon, replacing darts and atlatls, and with the slightly later adoption of the use and manufacture of pottery. It is estimated that these artifacts came into common use in the region some time about A.D. 700, and the time span which saw their advent is designated the Late Prehistoric period. Elsewhere, in east Texas and the Panhandle, for instance, these technological changes accompanied large scale social and settlement changes associated with the establishment of horticulture, sedentary villages and complex political and social systems, but in the central Texas region, hunting and gathering persisted as the primary adaptation throughout the Late Prehistoric Period. Significant Late Prehistoric components, therefore, will meet essentially the same criteria as Archaic sites; that is, they will contribute detail towards the general outline of cultural adaptation and change already established for this time period.

The beginning of the Historic period is open for debate; most archaeologists consider the designation to refer to that time when written historical records became available. The earliest written records from Texas are the journals of Cabeza de Vaca, shipwrecked on the coast of south Texas in the sixteenth century. Subsequent Spanish expeditions, and, in the seventeenth and eighteenth centuries, missions and presidios, left piecemeal records of events, descriptions of the countryside, and ethnographic observations of the native Indians. Except for the missions, however, Historic settlement of central Texas did not begin until the arrival of Anglo- and Afro-Americans in the early nineteenth century, and it is likely that historic archeological sites in the Onion Creek basin will date primarily to after the beginning of substantial settlement, although a mission was established near Barton Springs in the 1730's, and there is some possibility that activities dating to this era may have left some remains in the Onion Creek watershed.

Significance of historic era sites can be determined on the basis of potential contribution to knowledge of a specific historical epoch, in much the same way as significance is applied to prehistoric sites. Examples of early ranching sites, or railroad construction camps, or schoolhouses, for example, may be considered significant if they are well preserved, even though the history they encapsulate is rather mundane. Sites which can be connected with important historic personalities or events may also be considered significant, as may examples of architectural styles. Cemeteries are always significant and require avoidance or relocation. Because the variety of Historic sites is greater, criteria of significance are more varied.

6.1.6.3 Site Significance Criteria

Explicit in the Section 106 compliance process is the determination of the significance of a site by its potential to contribute substantially to defined research questions which are agreed upon by the regional archeological community and are formalized by the SHPO. In Texas, regional research designs have recently been adopted and are outlined in summary sections of the Corps of Engineers Southwestern Division Archeological Overview. The review of archeological research in central Texas (Black 1989) proposes the following major prehistoric research themes:

1) Paleo-Indian adaptations. This topic seeks to understand Paleo-Indian lifeways in central Texas, and how they might have differed from the mobile, big-game hunting adaptations known from the Plains.

2) Environmental Relationships. This topic stresses the need to recover information which would aid in the reconstruction of paleo-climates and landscapes. An enhanced understanding of prehistoric resource communities, and changes in the communities is necessary to fully comprehend the behavior of prehistoric hunter-gatherers. Geomorphology, the study of the evolution of landscapes, is currently used extensively to analyze the depositional context of archeological remains, which greatly improves site interpretation. Sites with preserved pollen columns, the analysis of which can indicate prehistoric plant communities, and sites with complex depositional histories may thus be considered significant even if their archeological remains are not particularly outstanding.

3) Social Organization. This research avenue seeks information on population density, group size, leadership, trade and external relations, and ultimately kinship structure and political organization. Much data in this regard can be

obtained from careful analysis of cemetery populations, but inferences can also be made from spatial analysis of remains at well-preserved, single component sites. The layout of a short term campsite may provide clues, for instance, to the numbers of families in residence, the presence or absence of community centers, or evidence of differences in status among individuals occupying the site, while artifact distributions at such sites may indicate male/female activity areas, or even, through non-local items, the presence of individuals from external groups.

4) Burned Rock Middens. Burned rock middens are large, prominent piles of limestone rocks which have been cracked and fractured by fire. They are believed to date primarily to the Middle Archaic period in central Texas, though an example of a later such midden was recently excavated at 41HY202, just adjacent to the study area. These features are common across the Edwards Plateau and have excited interest for years, but have never been adequately explained, although they are generally considered to be the remains of intensive cooking activities. This research topic seeks data on the formation, function, and temporal affiliation of middens, as well as information pertaining to their function within the context of a general campsite.

5) Subsistence. This research area seeks to better understand hunter-gatherer economies by an improved knowledge of the species they exploited for food, and ultimately their yearly scheduling of resource procurement. Sites with well preserved bone or macrobotanical assemblages could be considered significant because of their potential to contribute to this research topic.

6) Technology. Technological change often accompanies social or economic change. Frequently, stone, shell and bone tools, and ceramics, are the only remains left at archeological sites. Analysis of tools and of changes in tools through time may

enable inferences about activities performed and net changes in economic orientation. Much of what is known about central Texas prehistory today has been inferred from analysis of prehistoric technology, and such analysis has become increasingly sophisticated. Studies of residues and wear patterns on tool edges have enabled better assessments of activities performed. Inclusion of this research topic leaves the door open for such basic research to continue.

These research topics span prehistory and in a broad way allow for inquiry into almost every aspect of prehistoric life. It should be appreciated that almost any site might be considered significant to one or more of these stated research goals. In practice, however, only a small percentage of sites are actually determined to be significant, and of these, many have been excavated which are now seen to be of minimal research value. Black's overview (1989:35) states explicitly the need to focus on the admittedly rare sites with good preservation and excellent temporal control, and calls for the abandonment of excavation of large, multi-component sites which produce many and varied artifacts but little information of interpretive use. However, as will be discussed below, the Onion Creek Watershed has already demonstrated its potential for the preservation of significant archeological sites.

Specific research questions have not yet been formulated for Historic sites in central Texas. In general, the determination of significance of historic properties involves an assessment of their age, context, associations, and rarity. Context includes the relationship of artifact scatters and standing structures to the surrounding historic remains. Rarity is a function not only of the unusualness of site itself, but also of the amount of research that has been conducted into that particular site type, or the era that it represents, in the region in question. For example, if a number of late nineteenth century German farmhouses have been recorded and studied in the area, then one more German farmhouse may not be particularly significant. If, however, all German farmhouses in the region have been destroyed by later development, then a site of this type may be very significant indeed.

6.1.6.4 Known Archaeological Resources in the Onion Creek Watershed

A total of 27 historic and prehistoric sites have been recorded along the segment of Onion Creek where the four alternative recharge impoundment are proposed (Texas Archeological Research Laboratory Files 1991). The locations of these sites are presented on Plate 4. Twenty of these sites were recorded during a systematic survey of the upstream area currently being considered for construction of Rutherford Reservoir conducted in the early 1970's (TARL Files). They include seventeen historic sites, some of which also include prehistoric artifact scatters, associated with the Mayes/Hay family homestead, elements of which may date as early as 1859, the Butler family homestead, probably also as early, and a cluster of structures known locally as "Smokestack Holler" around the headwaters of a small, side tributary entering Onion Creek from the north. Three prehistoric lithic scatters, including one with a possible tipi ring, were also recorded.

The other seven sites were six prehistoric and one historic site recorded within the right-of-way of the proposed FM 1626 by the State Department of Highways and Public Transportation. This road crosses the study area in the vicinity of the proposed Centex Reservoir construction alternative. Two of the sites, 41HY202 and 41HY209, located north and south of Mustang Branch, were subsequently tested, found to be significant, and their destruction was mitigated through extensive excavation (M. Quigg, personal communication). 41HY209, on the south side of the creek, included a burned rock midden on the bluff top, and a buried, stratified Late Prehistoric campsite in the low terrace adjacent to the creek. Preservation of faunal remains and component separation at this site was excellent and illustrates the area's potential for containing significant sites. 41HY202, on the north side of the creek, was a shallowly buried, multi-component site lying on an old Pleistocene terrace. It contained remains dating to the late Paleo-Indian and Early Archaic as well as Late Prehistoric periods. Preservation and stratification at this site were not as good as at 41HY209, but the site was nevertheless informative. The previously recorded sites in the study area are summarized in Table 6.1-11.

Smith Rockshelter, 41TV27, located upstream on Onion Creek near McKinney Falls, contained stratified deposits dating from the Late Archaic and Late Prehistoric periods. It was excavated by the University of Texas field school in the early 1960's (Johnson 1967), and helped to define the chronological sequence of these periods for the central Texas region. This site illustrates the watershed's potential for significant rockshelters and open campsites.

6.1.6.5 Permitting Issues

Cultural resources present in the specific area selected for inundation by any recharge enhancement facility along Onion Creek must be evaluated and planned for in compliance with the National Historic Preservation Act of 1966 (Public Law 89-655) as amended (Public Law). Compliance will be monitored by the State Historic Preservation Officer, for projects involving Federal funds, and by the Texas Antiquities Committee, for projects involving State funds. Regulations proscribed by the above Federal Laws are interpreted and implemented by the concerned Federal agencies, in this case the Army Corps of Engineers.

A permit for construction of the selected facility will require that both the regulatory agencies (SHPO or TAC) and the lead Federal agency (COE) be satisfied that the laws governing the protection of cultural resources have been complied with. This will essentially involve negotiation of a cultural resources management plan between the contractors and the concerned agencies, and implementation of the agreed on plan by the contractors.

The language of the cultural resources protection act is vague. Procedures of compliance have been established by major funding agencies, such as the Corps. These procedures have entered the realm of custom and are generally accepted as adequate by the State regulatory

Table 6.1-11 Recorded Archeological Sites in the Areas to be Affected by the Proposed Onion Creek Recharge Enhancement Facilities.

Site	Estimated Age	Description
41HY42	Unknown historic	**Hoskins** family cemetery on knoll-top. Moderate scatter of prehistoric materials.
41HY55	Unknown historic	**"Hoskins House"** site. Limestone and mortar structure with "flat"-arched windows. Two story w/ staircase in middle. Associated outbuildings.
41HY66	Unknown historic	Possible house remains, ceramic and nail scatter. Prehistoric lithic scatter also noted.
41HY67	Unknown historic	Two laid-stone cisterns, 4 ft. above ground, ca. 20 ft deep. Both historic and prehistoric artifact scatter associated.
41HY43	1860-1870	**Mayes/Hay Complex.** Historic ceramic scatter.
41HY45	1871+	**Mayes/Hay Complex.** Dry rock wall structure, 3 rooms, 2 chimneys, 7 outbuildings. "Hay House" stagecoach stop. Prehistoric artifact scatter also noted.
41HY63	1859-1871	**Mayes/Hay Complex.** Historic and prehistoric artifact scatter. Possibly remains of Mayes family settlement.
41HY68	1855+	**Butler Complex.** Butler house. Foundations stones scattered. Possibly 2 rooms. Historic artifact scatter.
41HY69	1855+	**Butler Complex.** Historic & prehistoric artifact scatter.
41HY70	1855+	**Butler Complex.** Historic & prehistoric artifact scatter.
41HY44	1853	**Butler Complex.** Limestone block and mortar house. 2 rooms, separated by hallway; 2 fireplaces. Historic and prehistoric artifact scatter.
41HY64	Unknown historic	**Butler Complex?** Limestone block and mortar wall 50 ft long, 2.5-3 ft wide, running E-W.
41HY65	Unknown historic - Middle Archaic	Historic and prehistoric artifact scatter. Middle Archaic projectile point.
41HY46	Unknown historic	**Smokestack Holler.** Structure foundation and circular chimney w/ fireplace. Historic artifact scatter.
41HY47	Unknown historic	**Smokestack Holler.** Rectangular structure ca. 4x5 m, w/ chimney of coursed gray limestone blocks. Historic artifact scatter.
41HY48	Unknown historic	**Smokestack Holler.** Limestone and mortar structure. 2 rooms, 3x3 m each. 1 chimney. Historic artifact scatter.
41HY49	Unknown prehistoric	**Smokestack Holler.** Prehistoric lithic scatter.
41HY50	Unknown historic	**Smokestack Holler.** Structural remains; limestone pile with stone fence
41HY62	Unknown prehistoric	**Smokestack Holler.** Dense prehistoric lithic scatter.
41HY54	Late Prehistoric	Stone circle (tipi ring) with associated prehistoric artifact scatter in level, cultivated field.
41HY199	Unknown prehistoric	Prehistoric artifact scatter on upland flats associated with small outcrop of limestone and chert.
41HY200	Unknown prehistoric	Thin prehistoric artifact scatter on high terrace of Onion Creek, located in plowed field. Recommended for testing by SDHPT.

Table 6.1-11 (continued)

Site	Estimated Age	Description
41HY201	Unknown prehistoric	Moderately dense scatter of prehistoric artifacts located within gravel quarry. Site removed by quarrying along southern edge. Shallow deposits. Recommended for testing by SDHPT.
41HY202	Early Archaic, Late Prehistoric	Prehistoric campsite on north bank of Mustang Branch. Mitigated by University of Texas 1989-1990. Publication in preparation.
41HY209	Late Archaic, Late Prehistoric	Burned rock midden and Late Prehistoric campsite on south bank of Mustang Branch. Mitigated by University of Texas 1989-1990. Publication in preparation.
41HY210	1850-1860	Cistern, house rubble, ceramic, glass and metal scatter. "Marlowe" or "Marlove" Hill, possibly pre-Civil War. On slight rise in cleared field.
41HY219	Unknown prehistoric	Thin scatter of flakes and burned rock on crest of gently sloping rounded hill in an open, cultivated field.

Source: TARL Files

agencies. Specific procedural guidelines differ depending on the lead agency involved, but the general outline of the responsibilities of the contractor is consistent.

Vastly simplified, obtaining a cultural resources permit is a two-step process, which involves 1) identification of all cultural resources in the proposed construction area and 2) design and implementation of a plan for managing those resources. These procedures must be performed by qualified archaeologists familiar with site identification and assessment.

Step 1 is generally accomplished by funding a pedestrian survey of the construction area by trained personnel who undertake to physically locate all archeological sites in the area. This step is referred to as Phase I, or simply as survey, and should result in a documented inventory of all existing prehistoric and historic sites in the construction area.

Step 2 primarily involves a) an assessment of the impact of the proposed construction on the inventory of cultural resources; and b) an assessment of the significance, or historical importance, of the resources involved. Where significance is not apparent from survey-level data, subsurface testing, or, in the case of historic-age sites, archival background research may be required to further assess site importance. Significant cultural resources are those judged to be eligible for the National Register of Historic Places. If significant cultural resources are determined to exist, and if they will be adversely impacted by the proposed construction, the contractor is responsible for their management. Sites may be avoided or protected. If neither of these alternatives is possible, their loss must be mitigated.

6.1.6.6 Potential Site Occurrence and Significance by Alternative

All four of the proposed construction alternatives involve small areas of land. Surveys of each parcel should be comparatively simple and straightforward. Potential site density in three of the four alternative construction zones is likely to be high, based on the existing survey data for the area.

CenTex Reservoir

The CenTex Reservoir would inundate stretches of Onion Creek and Mustang Branch. A cross-section of the reservoir was surveyed prior to construction of FM 1626, resulting in the identification of seven sites just along the linear highway right-of-way, including two well-preserved and important prehistoric sites which were judged eligible for the National Register and were mitigated. The area impounded by this reservoir must be completely evaluated and potentially may have a high site density, and some of the sites encountered may be significant.

CenTex Diversion Dam

The CenTex Diversion Dam would undoubtedly have the least adverse impact on any existing cultural resources, largely because the quarries where the diverted water would be stored have already eradicated most landforms young enough to contain archeological deposits. The only remaining area with archeological potential subject to impact under this alternative is the immediate area along the creek where the dam and diversion channel are to be constructed.

Ruby Reservoir

The Ruby Reservoir alternative will inundate an area where no previous archeological work has been done. Based on the work in the surrounding areas, however, site density may potentially be high.

Rutherford Reservoir

A large portion of the area which would be inundated by construction of the Rutherford Reservoir has already been surveyed. Resurvey would probably not be necessary, except in those specific areas which were not previously examined. Further evaluation of the historic sites in the area would undoubtedly be required. Some of the structures at these sites may be remnants of the earliest Anglo settlement of the creek basin, and are likely to be determined significant. Archival research into their history, as well as more extensive on-site assessments by a qualified historical archeologist will probably be requested. All the recorded sites in this area appear to lie below or at the edge of the proposed floodpool and would probably be adversely impacted.

Step 1, identification of affected cultural resources in the selected construction area(s), should be a small scale effort, regardless of the alternative chosen. Mitigation efforts at historical sites of probable significance, unless something extraordinary is found requiring excavation, will probably be limited to archival research and additional surface level investigation and would most likely not prove time consuming or expensive. Identification of significant prehistoric resources, an unknown at this point and, until survey and possibly testing are completed, could potentially entail a considerable effort to mitigate the resource loss if adverse impacts can not be avoided.

6.1.7 Land Use

The portion of Onion Creek in the vicinity of the proposed alternatives is completely held in private ownership. As illustrated on Figure 1.5-1, 8 property owners control the portions of Onion Creek in the project area. In fact, three property owners, CenTex Materials Inc.; Ruby Ranch; and Rutherford Ranch control approximately 85% of the creek within the study area. With the exception of CenTex Materials Inc.'s industrial land use, land use in the project area is dominated by various types of ranching activity, ranging from cattle (Rutherford Ranch) to exotic wildlife (YO Ranch). Land use/land cover within a one mile corridor (either side of the creek) is illustrated on Plate 5. Land use/land cover categories include industrial, improved pasture, residential, savannah, wooded areas (and subsets based on species composition), and stock tanks. This information is presented to provide an overview of the land uses/land cover that may be impacted by each of the proposed alternatives. Dominant land use/land cover categories include savannah, improved pasture and wooded areas. A description of the land use/land cover for each of the alternatives is presented below.

CenTex Reservoir

Land use/land cover adjacent to the proposed CenTex Reservoir include industrial (CenTex Materials Inc.), Woodland (Live Oak, Cedar Elm, Juniper, Hackberry), Improved Pasture and Savannah.

CenTex Diversion Dam

The CenTex Diversion Dam, by design is immediately adjacent and part of the industrial area currently being utilized by CenTex Materials Inc. Other land use/land cover categories include savannah, woodlands (Live Oak, Cedar Elm, Juniper, Hackberry) and improved pasture.

Ruby Reservoir

The proposed Ruby Reservoir is bordered by savannah and woodland (Live Oak, Mature Juniper, Texas Oak, Cedar Elm). The only other land use/land cover category in the immediate area is improved pasture.

CenTex and Ruby Reservoir in Tandem - (see above)

Rutherford Reservoir

The border of the proposed Rutherford Reservoir is dominated by Savannah land cover category. Other dominant land use/land cover categories include woodland (Live Oak, Juniper, Texas Oak, Black Cherry) and improved pasture.

Local land use controls are discussed in detail in Section 7.0

6.1.8 Demographics

This brief discussion of demographics initially presents a summary of population and ethnic origin for each of the 5 precincts within the District's boundaries. This will be followed by a brief discussion of projected population growth for entities utilizing the aquifer.

The Barton Springs Edwards Aquifer Conservation District encompasses approximately 255 square miles. Approximately 133,300 persons reside (Table 6.1-12) in 5 precincts within the District's boundaries, 66% (19,900) of these individuals obtain their water via any of the 37 independent water supplies. This water supply dependent population is projected to increase to approximately 28,000 by the year 2010. Projected populations for the 37 independent water suppliers is presented in Table 6.1-13.

6.1.9 Recreation

The proposed project alternatives are located in Region 12 as designated by the Texas Outdoor Recreation Plan (TPWD 1990). This region is currently in need of additional

Table 6.1-12 Barton Springs Edwards Aquifer Districts 1990 Total Population and Ethnic Origin by Precincts.

Precinct	Persons	Hispanic Origin	Black	Asian	Anglo/Other
1st	10,029	947 9.44%	232 2.31%	121 1.21%	8,729 87.04%
2nd	10,087	1,766 17.51%	468 4.64%	251 2.49%	7,602 75.36%
3rd	10,449	3,126 29.92%	361 3.45%	94 0.90%	6,868 65.73%
4th	52,573	16,930 32.20%	3003 5.71%	616 1.17%	32,024 60.91%
5th	50,173	8,182 16.31%	1773 3.53%	1027 2.05%	39,191 78.11%
Totals	133,311	30,951 23.22%	5,837 4.38%	2,109 1.58%	94,414 70.82%

Source: BSEACD, 1991.

Table 6.1-13 Estimated and Projected Populations for Water Supply Systems Within the District Boundaries.

Number of Suppliers	Estimated 1990 Population	Projected 200 Population	Projected 2010 Population
37	19,919	23,874	27,885

Source: DGRA, 1990

recreational facilities in virtually all facility/resource categories. As noted in Section 6.1.7 Land Use - all of the project alternatives are located in areas held in private ownership, thus restricting access and recreational opportunities in those areas. However, one facility, the YO Ranch, does deserve mention here. The YO Ranch is a private ranch providing hunting opportunities for exotic game including axis deer and blackbuck antelope. Other than the fee recreational opportunities associated with the YO Ranch access is limited due to the private ownership.

Regional facilities/resources in the vicinity of Onion creek include McKinney Falls State Park; the segment of Onion Creek from Highway 71 to the Colorado River (4.6 miles) which has been deemed permanently floatable by the TPWD and the segment of Onion Creek stretching, from IH-35 to Highway 71 (1.9 miles) which has been deemed seasonally floatable by the TPWD.

6.2 POTENTIAL ENVIRONMENTAL IMPACTS

This section is intended to generally identify the range of potential environmental impacts associated with each of the proposed alternatives. Discussion of the potential impacts with respect to each discipline described in the baseline section is provided. Note that this description of potential impacts is not intended to be comprehensive, but rather is intended to provide a relative ranking of each of the alternatives with respect to potential environmental impacts. A more exhaustive discussion of impacts will be necessary in support of the various State and Federal permits which may be required.

This analysis of potential impacts is based upon the baseline description previously provided and the summaries of the various alternatives provided in Tables 6.2-1, 6.2-2 and 6.2-3. These tables provide a Physical Description of the Proposed Project Alternatives; the Maximum Operating Data for the Proposed Alternatives; and the Daily Reservoir-Stage Duration

Table 6.2-1 Physical Description of Proposed Project Alternatives.

Alternative	Structure	Dam Height (ft)	Dam Length (ft)	Dam Width (ft)	Other
CenTex Reservoir	Rolled earth structure with reinforced concrete cap	19	400	90	Entire length will serve as spillway
Ruby Reservoir	Rolled earth structure with reinforced concrete cap	17	700	82	Entire length will serve as spillway
CenTex Reservoir and Ruby Reservoir	See above				
Rutherford Reservoir	Rolled earth structure	46	900	200 ft 20 ft at top	200 ft side spillway
Centex Diversion Dam and Recharge Quarry	Rolled earth structure with reinforced concrete riprap	14	400	70	Entire dam would serve as spillway; low flow outlet to provide releases up to 80 cfs

Source: DGRA, 1991.

Table 6.2-2 Maximum Operating Data for the Proposed Alternatives.

Alternative	Maximum Elevation (msl)	Maximum Impoundment (Acre-feet)	Percent of Time at Maximum Elevation	Maximum Surface Acres	Average Width (ft)	Length (ft)
CenTex Reservoir	690	270.5	7%	33.4	181	7600
Ruby Reservoir	784	435	7%	44.2	283	10,200
CenTex Reservoir & Ruby Reservoir in Tandem	See above	705.5	7%	77.6	464	17,800
Rutherford Dam & Reservoir	870	3,670	6%	252.2	113.4	19,600
(Rutherford Reservoir-Normal Operating Pool)	841	200		35		

CenTex Diversion Dam & Quarry	Maximum Elevation	Channel Description				
		<u>Length</u>	<u>Bottom Width</u>	<u>Top Width</u>	<u>Total Acreage</u>	
	736 ft.	250 ft.	50 ft.	160 ft.	92 ac.	

Source: DGRA, 1991

Table 6.2-3 Daily Reservoir Stage-Duration Relationship for Each Alternative.

	Percent of the Time		
Alternatives	Full Capacity	Zero Capacity	Other Capacity
Alternative 1--- Centex Reservoir	7% (≈25.5 days 1)	85% (≈310 days)	
Alternative 2--- Ruby Reservoir	7% (≈25.5 days 1)	87% (≈310 days)	
Alternative 3--- Centex Reservoir and Ruby Reservoir Tandem Operation	7% (≈25.5 days 1)	86% (≈310 days)	
Alternative 4--- Rutherford Dam and Reservoir	6% (≈21.9 days 1)		85% of the time at a capacity of 200 acre-feet (≈ 35 surface arces
Alternative 5--- Centex Diversion Dam and Recharge Quarry			

1 Expected to occur during 4 to 8 flood events annually.

Relationship for each alternative, respectively. Detailed descriptions of the proposed alternatives are provided in Section 5.0.

6.2.1 Potential Impacts to Geological Elements

The detailed geological description of the Onion Creek Recharge Zone presented in Section 3.0 provides the context to evaluate the potential impacts of the proposed alternatives on sensitive geological features. As noted in that section, the Recharge Zone is characterized by a series of potential recharge features including faults, fractures zones, solution cavities, sinkholes and caves. Potential impacts to these features are expected as a result of 1) a possible increase in sediment retention and 2) an alteration in the flow regime.

Each of the proposed projects is expected to result in an increase in sediment retention which may cause recharge of sediment and accumulation of sediment over sensitive recharge features. This increase in sediment may cause some deterioration of water quality and over time sediment deposition is expected to decrease recharge potential as recharge features become less penetrable. The impacts to the recharge features is a function of the number of potential recharge features, (presented on Plate 1) and the volume of sediment retained. A summary of the estimated volumes of sediment which may be retained is presented below:

Project Alternative:		Estimated Volume of Sediment Retained (AF per year)
Alternative No. 1	Centex Reservoir	11
Alternative No. 2	Ruby Reservoir	20
Alternative No. 3	Centex Reservoir and Ruby Reservoir in Tandem Operation	23

Alternative No. 4	Rutherford Dam and Reservoir	36
Alternative No. 5	Centex Diversion Dam and Recharge Quarry	31

Sediment accumulation will be closely monitored and, if necessary, any number of structural, operational and/or mechanical means can be implemented to reduce the impact on these sensitive geological features. Examples of methods which may be implemented include large diameter outflow pipes or gates which would allow sediment rich flows to bypass the dams and/or mechanical removal via equipment (as currently practiced by the Edwards Underground Water District in San Antonio).

The alteration of the flow regime may reduce the number of significant flood events which result in scouring of the Recharge Zone and removal of long term sediment deposition. Flow which will be impeded by the proposed dams is far less likely than unimpeded storm event flow to remove sediment which has accumulated in these significant recharge features. For example, floodwater in January 1991 resulted in the removal of sediment which had accumulated at Antioch Cave. This cave entrance was cleared as a result of the flooding and identified as a significant recharge feature which had been plugged with sediment and debris since the 1960's. The mitigation measures discussed above for removing accumulated sediment are also appropriate for reducing these potential impacts.

6.2.2 Potential Impacts to Hydrological Elements

Descriptions of surface water and groundwater hydrology and the potential effects of the proposed alternatives on these are presented in Section 2.0. In addition, the physical and operations data related to the surface water hydrology of each of the alternatives is presented in Tables 6.2-1 through 6.2-3. The changes in the flow regime associated with each of the proposed projects is presented in Tables 6.2-4 through 6.2-8.

Table 6.2-4 CenTex Reservoir Average Historical Flow (Values in cfs)

Month	Inflow (Zone 1)	Percent of Baseline	Recharge (Zone 2)	Percent of Baseline	Outflow (Zone 3)	Percent of Baseline
January	59.48	100.0%	43.62	101.1%	15.90	97.3%
February	72.18	100.0%	51.49	102.0%	20.17	93.0%
March	76.32	100.0%	60.08	102.1%	16.38	93.8%
April	80.77	100.0%	53.35	103.0%	27.40	94.6%
May	99.55	100.0%	63.77	103.5%	35.74	94.3%
June	105.05	100.0%	55.54	102.8%	49.74	97.5%
July	38.18	100.0%	30.76	102.8%	7.87	95.4%
August	14.83	100.0%	14.08	101.6%	0.59	61.1%
September	37.75	100.0%	19.94	105.0%	17.99	95.9%
October	51.08	100.0%	28.74	104.1%	21.75	92.6%
November	39.26	100.0%	34.57	103.3%	5.19	89.4%
December	51.40	100.0%	39.83	101.9%	11.47	93.3%
Sum	725.86	100.0%	495.75	102.7%	230.20	94.8%

Source: DGRA, 1991.

Table 6.2-5 Ruby Reservoir Average Historical Flow (Values in cfs)

Month	Inflow (Zone 1)	Percent of Baseline	Recharge (Zone 2)	Percent of Baseline	Outflow (Zone 3)	Percent of Baseline
January	59.49	100.0%	43.82	101.6%	15.67	95.9%
February	72.19	100.0%	52.07	103.1%	19.32	89.1%
March	76.34	100.0%	60.75	103.2%	15.84	90.7%
April	80.77	100.0%	54.05	104.3%	26.75	92.4%
May	99.55	100.0%	64.96	105.4%	34.47	90.9%
June	105.07	100.0%	56.47	104.5%	49.03	96.1%
July	38.20	100.0%	31.06	103.8%	7.72	93.6%
August	14.83	100.0%	14.14	102.0%	.47	49.0%
September	37.76	100.0%	20.44	107.6%	17.71	94.4%
October	51.08	100.0%	29.08	105.4%	20.94	89.1%
November	39.27	100.0%	35.10	104.9%	4.93	84.8%
December	51.39	100.0%	40.22	102.9%	11.01	89.6%
Sum	725.93	100.0%	502.17	104.0%	223.87	92.2%

Source: DGRA, 1991

Table 6.2-6 CenTex and Ruby Reservoir Tandem Option Average Historical Flow (Values in cfs)

Month	Inflow (Zone 1)	Percent of Baseline	Recharge (Zone 2)	Percent of Baseline	Outflow (Zone 3)	Percent of Baseline
January	59.48	100.0%	43.88	101.7%	15.29	93.6%
February	72.18	100.0%	52.61	104.2%	18.30	84.4%
March	76.32	100.0%	61.52	104.5%	15.20	87.1%
April	80.77	100.0%	55.1	106.3%	25.87	89.4%
May	99.55	100.0%	65.93	107.0%	33.24	87.7%
June	105.05	100.0%	57.58	106.6%	48.27	94.6%
July	38.18	100.0%	31.61	105.6%	7.58	91.9%
August	14.83	100.0%	14.29	103.1%	.38	38.9%
September	37.75	100.0%	20.87	109.9%	17.31	92.3%
October	51.08	100.0%	29.64	107.4%	19.90	84.7%
November	39.26	100.0%	35.77	106.9%	4.58	78.9%
December	51.40	100.0%	40.66	104.0%	10.42	84.8%
Sum	725.86	100.0%	509.45	105.5%	216.34	89.1%

Source: DGRA, 1991

Table 6.2-7 Rutherford Reservoir Average Historical Flow (Values in cfs)

Month	Inflow (Zone 1)	Percent of Baseline	Recharge (Zone 2)	Percent of Baseline	Outflow (Zone 3)	Percent of Baseline
January	59.50	100.0%	45.59	105.7%	12.14	74.3%
February	72.18	100.0%	54.30	107.5%	16.18	74.6%
March	76.33	100.0%	62.95	106.9%	12.64	72.4%
April	80.77	100.0%	59.74	115.3%	21.80	75.3%
May	99.54	100.0%	66.85	108.5%	27.16	71.6%
June	105.07	100.0%	64.78	119.9%	42.81	83.9%
July	38.18	100.0%	38.64	129.1%	7.98	96.7%
August	14.82	100.0%	15.32	110.5%	0.76	78.9%
September	37.75	100.0%	21.87	115.1%	14.37	76.6%
October	51.08	100.0%	32.27	117.0%	15.19	64.7%
November	39.26	100.0%	36.85	110.2%	3.30	56.7%
December	51.39	100.0%	42.97	109.9%	7.65	62.2%
Sum	725.85	100.0%	542.11	112.3%	181.98	74.9%

Source: DGRA, 1991

Table 6.2-8 Quarry Option Average Historical Flow (Values in cfs)

Month	Inflow (Zone 1)	Percent of Baseline	Recharge (Zone 2)	Percent of Baseline	Outflow (Zone 3)	Percent of Baseline
January	59.52	100.1%	49.63	115.0%	9.96	61.0%
February	72.22	100.1%	60.48	119.7%	10.64	49.1%
March	76.36	100.1%	71.48	121.4%	5.80	33.2%
April	80.81	100.1%	60.47	116.7%	19.07	65.9%
May	99.59	100.0%	78.08	126.7%	21.28	56.1%
June	105.09	100.0%	69.66	128.9%	36.32	71.2%
July	38.21	100.1%	34.20	114.3%	5.12	62.1%
August	14.85	100.1%	14.66	105.8%	0.06	5.9%
September	37.76	100.0%	22.28	117.3%	15.80	84.2%
October	51.11	100.0%	34.47	125.0%	15.47	65.9%
November	39.29	100.1%	38.13	114.0%	1.84	31.6%
December	51.44	100.1%	45.64	116.7%	5.71	46.5%
Sum	726.25	100.1%	579.18	119.9%	147.07	60.5%

Source: DGRA, 1991

A brief recap of the discussion of the three biogeographic zones presented in Section 6.1.5.3 Aquatic Resources provides the context to evaluate the effects of the proposed alternatives on hydrological resources. As previously noted, Onion Creek can be roughly separated into three biogeographic zones which have been identified for this study as:

Zone 1 - This zone encompasses the area from the headwaters to the upstream edge of the Edwards aquifer recharge zone. Review of topographic information and discussions with local experts indicate this zone of Onion Creek is perennial with some spring flow, except in cases of severe drought during which the creek and associated springs have been known to become intermittent. The proposed Rutherford Reservoir is located within this zone.

Zone 2 - This zone is synonymous with the Recharge Zone described in the Geological discussion. This zone is approximately 9.6 miles in length and typically only flows after significant precipitation events. As noted in the discussion on recharge, this zone is capable of recharging at a rate of 120-160 cfs, thus leaving any quantity greater than this as flow through the Recharge Zone. Four of the five proposed project alternatives (Centex Reservoir; Centex Diversion Dam; Ruby Reservoir; and Centex and Ruby Reservoirs in Tandem) are located within this zone.

Zone 3 - This zone encompasses the area from the downstream edge of the Recharge Zone (near Buda) to the creek's confluence with the Colorado River. This zone is influenced by discharge from the City of Buda Wastewater Treatment Plant (.39 MGD) and by inflows from Williamson Creek, Slaughter Creek, and backwater effects of the Colorado River. None of the proposed project alternatives are located within this zone. This zone is included to provide a context to evaluate potential downstream impacts.

These zones correspond as follows to Tables 6.2-4 through 6.2-8. Zone 1 (inflow); Zone 2 - (recharge); Zone 3 - (outflow).

CenTex Reservoir

CenTex Reservoir is located in the lower one-third of Zone 2 (Recharge Zone) of Onion Creek. The development of this facility is expected to increase recharge from approximately 1% to 5% (on a monthly basis). This loss to recharge is expected to have a corresponding effect on Zone 3 (outflow) and decrease outflow by 3% to 40% (on a monthly basis) for an overall average annual decrease of approximately 5.4%.

Ruby Reservoir

The proposed Ruby Reservoir is projected to remain at full capacity for approximately 26 days annually (typically over 4 to 8 separate periods) and at zero capacity for roughly 87% of the time. The development and operation of this reservoir is expected to increase recharge from 1.6% to 7.6 % on a monthly basis for a projected annual average increase of approximately 4%. Due to its location in Zone 2 (Recharge Zone) the Ruby Reservoir is not expected to impact Zone 1; outflow (Zone 3), however, is expected to decrease from 4.1% to 51% on a monthly basis with a projected annual average decrease of approximately 7.8%.

CenTex and Ruby Reservoirs in Tandem

The CenTex and Ruby Reservoirs in Tandem operation increase in recharge is less than the cumulative recharge of both projects. The tandem operation of both facilities is expected to increase recharge by approximately 5.5% annually while decreasing outflow by about 11.9% on an annual basis.

Rutherford Reservoir

The proposed Rutherford Reservoir is located in Zone 1, immediately upstream of the Edwards aquifer Recharge Zone. This alternative, by far the largest of the proposed alternatives, is expected to be at full capacity approximately 22 days a year (on the average) and inundate approximately 252 acres. The remainder of the year this reservoir is expected to inundate about 35 acres and provide an average increase in recharge potential of approximately 4% annually. Outflow is expected to decrease by about 7.8% if the project is constructed. Hydrological changes in this zone which can be expected include extended retention times and increased sedimentation.

6.2.3 Potential Impacts to Climate

None of the proposed project alternatives are expected to impact climatic conditions.

6.2.4 Potential Impacts to Wetlands and Floodplains

The following impacts discussion will address all in-channel alternatives (CenTex, Ruby and Rutherford Reservoirs) collectively since they involve essentially the same construction methods, pattern and period of inundation and wetland resource. The out-of-channel alternative (CenTex diversion dam) will be discussed separately.

As mentioned in Section 6.1.4 (Wetlands and Floodplains), the channel of Onion Creek is an ephemeral riverine system. Substrates vary from cobbles and boulders in high recharge zones to mud in persistent pools. The construction and placement of dams will obviously impact areas identified as wetlands (by NWI) and floodplains (by FEMA).

Changes in surface hydrology such as those proposed result in an overall reduced and slower rate of flow during flood events. This results in increased siltation and sedimentation behind the newly constructed dam and a reduced scouring affect downstream of the dam. Increased mud substrates and reduced scouring will be favorable to the growth of submerged and emergent hydrophytic vegetation. The general ecological trend will be toward a more palustrine ecosystem upstream from the dam and to a more vegetated stream bank downstream.

An off-channel alternative, such as the proposed CenTex diversion dam, will affect wetlands and floodplains less dramatically. The main impact will be the construction of the dam and diversion canal. The inundation behind the dam should only last for a 24 hour period. Similar downstream impacts as those from the in-channel alternatives may be realized. The quarry site possesses potential lacustrine wetland habitat which will be altered if recharge potentials are enhanced by the drilling of wells.

As previously mentioned, all of the proposed alternatives will require fill of varying amounts into waters of the U.S. and adjacent wetlands. This activity brings the project within the regulatory confines of Section 404 of the Clean Water Act. The proposed project will be coordinated with the Fort Worth District of the U.S. Corps of Engineers. All necessary mitigative measures will be taken to avoid, minimize and/or rectify impacts occurring as a result of the construction and/or operation of any chosen alternative. Based on preliminary designs, the following table (Table 6.2-9) lists expected fill amounts for each alternative.

Table 6.2-9 Potential Impacts to Wetlands and Floodplains.

Alternative	Fill Amount Necessary for Dam Construction (Cubic Yards)
CenTex Reservoir	14,630
Ruby Reservoir	19,080
CenTex & Ruby Reservoir (Tandem)	33,710
Rutherford Reservoir	160,600
CenTex Diversion	8,700

6.2.5 Potential Impacts to Biological Elements

6.2.5.1 Vegetation

Reservoir projects invariably impact some portion of the vegetation present in the project area. The extent of impact is directly proportional to the magnitude of the project. These effects can be separated into impacts due to the construction phase of the project, and those related to the operation of the facility.

The most obvious direct impact to vegetation communities during dam construction is the removal of all plant life from the area where the dam structure is to be installed (the dam footprint). Immediately downstream of the dam, a stilling basin will be constructed to dissipate the energy of the facility's discharge flow. The stilling basin is usually comprised of boulders and/or riprap, and would require total removal of vegetation at the site. Easements are obtained in order to facilitate transportation of materials to the construction site. The amount of vegetation removed from the construction easement can be variable.

Impacts due to the operation of the reservoir facility include the direct impact of inundation of vegetation communities in the pool area and indirect impacts to vegetation downstream of the project resulting from altered stream flow.

The operation of the reservoir facility results in direct and indirect impacts on vegetation associated with the drainage basin. The project will directly affect vegetation that is present in the reservoir pool above the dam. Often, in the case of large water storage reservoirs, much of the vegetation is removed from the pool area. With smaller retention dam projects, the vegetation is often left intact, especially when short periods of inundation is expected. Indirect downstream effects include disruption of normal flow and flooding events, and decrease of sediment load (and associated nutrients) to downstream areas. A decrease in stream flow can adversely affect bottomland and wetland communities dependent on the existing flow. Many of these communities depend on nutrient input from normal flow and flood events.

CenTex Reservoir

The proposed CenTex Reservoir dam site is located approximately one mile west of Buda, Texas. The dam, 90 feet wide and 400 feet long, would have a footprint of 0.83 acres (ac). A 0.67 ac stilling basin is planned downstream of the dam. In addition, a five acre temporary construction easement will be required during the construction phase of the project. At maximum capacity, the dam would impound a 270.5 acre-feet reservoir pool extending about 1.4 miles upstream. The impoundment would have a maximum surface area of 33.4 ac, and average 181 feet in width. This reservoir is expected to be at full capacity approximately 26 days a year (over 4 to 8 occasions) and at zero capacity approximately 310 days a year. The remainder of the time the reservoir will be at some intermediate stage.

The construction phase of the dam would result in the removal of approximately 6.5 acres of vegetative cover. The majority of the vegetation removed would be part of a live oak-hackberry-cedar elm, mixed deciduous woodland. A narrow band of riparian vegetation (sycamore, black willow, and sugar hackberry) adjacent to the stream channel would also be removed. Because of the ephemeral nature of the creek over the Recharge Zone, the vegetation in the area of perturbation consists of invasive species such as waterwillow and abrojo. Much of the construction easement will be revegetated save for the permanent road traversing the dam.

Upstream of the dam, maximum impoundment will, occur on average, 26 days a year, over 4 to 8 occasions. This projects that, on average, the reservoir pool would be at maximum capacity for 3.25 to 6.5 days per maximum impoundment event. Mortality of some flood-intolerant tree and shrub species (live oak, Ashe juniper, and Mexican persimmon) may occur where inundation periods are the longest (i.e. at low elevations, immediately upstream of the dam). Flood-tolerant species (American sycamore, green ash, black willow, and common buttonbush) should persist, given the projected periods of inundation.

Downstream effects of the proposed CenTex Reservoir would include disruption of normal flow and flooding events, and decrease of sediment load (and associated nutrients) to downstream areas.

Ruby Reservoir

The proposed Ruby Reservoir dam site is located approximately 4.8 miles west of Buda, Texas. The dam, 82 feet wide and 700 feet long, would have a footprint of 1.32 acres (ac). A 0.68 ac stilling basin is planned downstream of the dam. In addition, a five acre temporary construction easement will be required during the construction phase of the project. At maximum capacity, the dam would impound a 435 acre-feet reservoir pool extending about 1.9 miles upstream. The impoundment would have a maximum surface area of 44.2 ac, and average 283 feet in width. This reservoir is expected to be at full capacity approximately 26 days a year (over 4 to 8 occasions) and at zero capacity approximately 310 days a year. The remainder of the time the reservoir will be at some intermediate stage.

The construction phase of the dam would result in the removal of approximately 6.5 acres of vegetative cover. The majority of the vegetation removed would be part of a live oak-juniper-Texas oak, mixed deciduous woodland. A narrow band of riparian vegetation (sycamore, black willow, band sugar hackberry) adjacent to the stream channel would also be removed. Frequent stands of baldcypress occur along the stream channel. Because of the ephemeral nature of the creek over the Recharge Zone, the vegetation in the area of perturbation consists of invasive species such as waterwillow and abrojo. Much of the construction easement will be revegetated save for the permanent road traversing the dam.

Upstream of the dam, maximum impoundment will occur on average, 26 days a year, over 4 to 8 occasions. This projects that, on average, the reservoir pool would be at maximum capacity for 3.25 to 6.5 days per maximum impoundment event. Mortality of some flood-intolerant tree and shrub species (oaks, Ashe juniper, and Mexican persimmon) may occur where inundation periods are the longest (i.e. at low elevations, immediately upstream of the dam). Flood-tolerant species (American sycamore, American elm, green ash, bold cypress, black willow, and common buttonbush) should persist, given the projected periods of inundation.

Downstream effects of the proposed CenTex Reservoir would include disruption of normal flow and flooding events, and decrease of sediment load (and associated nutrients) to downstream areas.

CenTex and Ruby Reservoir in Tandem

The proposed CenTex and Ruby Reservoir in Tandem alternative would implement both alternatives as described above. The potential impacts will be similar in nature to those elucidated above. However, due to the greater volume of water retained, a significantly higher decrease in outflows is expected.

Rutherford Reservoir

The proposed Rutherford Reservoir dam site is located immediately above Onion Creek's Recharge Zone. The dam, 200 feet wide and 900 feet long, and spillway would have a footprint of approximately 6 acres (ac). In addition, a 10 acre temporary construction easement will be required during the construction phase of the project. At maximum capacity, the dam would impound a 3,670 acre-feet reservoir pool extending about 3.7 miles upstream. The impoundment would have a maximum surface area of 252.2 ac, and average 113.4 feet in width. This reservoir is expected to be at full capacity approximately 22 days a year and at normal operating capacity (200 acre-feet) most of the remaining time.

The construction phase of the dam would result in the removal of approximately 16 acres of vegetative cover. The majority of the vegetation removed would be part of a live oak-grassland savannah. On the western bank, some bluff associated woodland (live oak, Ashe juniper, and Texas oak) would require removal. A narrow band of riparian vegetation (sycamore, black willow, and pecan) adjacent to the stream channel would also be removed. Frequent stands of baldcypress occur along the stream channel. Much of the construction easement will be revegetated save for the permanent road traversing the dam.

Upstream of the dam, maximum impoundment will, occur on average, 22 days a year. Normal operating capacity would be no less than 200 acre-feet. Mortality of some flood-intolerant tree and shrub species (oaks, Ashe juniper, and Mexican persimmon) would occur in areas below the normal operating capacity elevation (841 ft. msl) and may occur where inundation periods are the longest (i.e. at intermediate pool level elevations, immediately upstream of the dam). Flood-tolerant species (American sycamore, American elm, green ash, black willow, baldcypress, and common buttonbush) should persist in the drawdown zone, given the projected periods of inundation.

Downstream effects of the proposed CenTex Reservoir would include disruption of normal flow and flooding events, and decrease of sediment load (and associated nutrients) to downstream areas.

CenTex Diversion Dam and Recharge Facilities

The proposed CenTex Diversion Dam site is located upstream of Barber Falls, approximately 2.5 miles west of Buda, Texas. The dam, 70 feet wide and 400 feet long, the stilling basin, and diversion channel will require approximately 1.5 ac of land. CenTex Diversion Dam will only store water temporarily. It is expected that water will remain in storage less than 24-hours. The dam is designed to divert water to an existing quarry pit for storage.

The construction phase of the dam would result in the removal of approximately 6.5 acres of vegetative cover. The majority of the vegetation removed would be part of a live oak-hackberry-cedar elm, mixed deciduous woodland. A narrow band of riparian vegetation (sycamore, black willow, and sugar hackberry) adjacent to the stream channel would also be removed. Because of the ephemeral nature of the creek over the Recharge Zone, the vegetation in the area of perturbation consists of invasive species such as waterwillow and abrojo. Much of the construction easement will be revegetated save for the permanent road traversing the dam and the diversion channel.

No sensitive vegetation communities are present in the quarry area.

Downstream effects of the proposed CenTex Reservoir would include disruption of normal flow and flooding events, and decrease of sediment load (and associated nutrients) to downstream areas.

6.2.5.2 Terrestrial Wildlife

Direct impacts to wildlife species from the proposed set of alternatives consist of construction disturbance, the actual inundation, and the presence of permanent structures such as dams, spillways and roadways. Indirect impacts include downstream effects and subterranean effects of the diversion. The following paragraphs will briefly explain anticipated impacts on an alternative by alternative basis starting downstream and working up.

CenTex Reservoir

The proposed CenTex Reservoir will inundate about 33 surface acres within the channel of Onion Creek at maximum operation. The dam will be sited immediately west of Buda and extend past Mustang Branch and the FM 1626 bridge. Construction activities will center around the dam and stilling basin sites. As mentioned in Section 6.2.5.1 (Vegetative Impacts), roughly six and a half acres of creek woodland habitat will be lost. This creekside woodland offers good habitat for many wildlife species with eastern affinities. Although no threatened or endangered species would be expected in this stretch, it provides wetland and mesic woodland habitat in a fairly xeric region. If the area is not rigorously maintained (routinely cleared) the areas not occupied by structures should become revegetated over time. During actual periods of inundation, the flooding will approximate that of natural conditions. Given the natural flow regime of Onion Creek, most resident wildlife species in close proximity to the channel will escape. Those few sessile species which might be in the channel will be lost. Indirect impacts downstream will include the potential alteration of creek floodlands and wetlands which could negatively affect wildlife dependant upon those particular stretches of the creek. When water is diverted in greater than usual amounts into recharge features, subterranean environments will undergo hydrological changes. It is not known whether cave invertebrates utilize the karst features in the vicinity of the proposed CenTex Reservoir; however, the existing Antioch Cave will receive a considerable volume of floodwater after rain events.

Ruby Reservoir

The next proposed reservoir, beginning about five miles upstream from Buda, is the Ruby Reservoir which will inundate approximately 44 acres during full capacity operation. The principle vegetation lost will be the six and a half acres during the construction phase. The portion of Onion Creek flowing through the YO Ranch has been impacted by heavy grazing by cattle, axis deer, black buck antelope and native white-tailed deer. These species may be expected to be impacted favorably by increased inundation. Since the average width of the proposed Ruby Reservoir will be nearly 100 yards (283 feet), some of the more xeric adapted vegetation may be drowned during longer inundation periods. Although this property might, under less intensive land use practices, produce vegetation suitable for golden-cheeked warbler or black-capped vireo habitat, these species are not likely to occur here. Potentially negative effects might occur, as mentioned in the previous alternative discussion, to downstream wetlands and creek woodlands. Similar subterranean impacts are expected due to the inundation of Crippled Crawfish Cave.

Combined CenTex and Ruby Reservoirs

The two reservoirs mentioned above would be constructed and operate simultaneously under this scenario. The combined impacts listed above may be expected with the addition of further reduced downstream flows since a theoretical maximum impoundment of approximately 700 acre-feet (as opposed to 270 or 435 acre feet) could be reached.

Rutherford Reservoir

This proposed reservoir site is the largest at a maximum of 3,670 acre-feet with 252 surface acres extending 3.7 miles upstream. This alternative is sited at the more environmentally sensitive end of the watershed, with respect to Federally protected birds, and its dam and stilling basin construction will cause clearing of 16 acres of mixed live oak/grassland and live oak/Texas oak/Ashe Juniper woodland. The canyons along this entire stretch may need to be evaluated for potential endangered species habitat. Since this alternative is located immediately upstream from the Recharge Zone, impacts to subterranean environments will be restricted to previously mentioned downstream recharge features (such as Crippled Crawfish and Antioch Caves). Similar downstream impacts as those with the previously mentioned projects, may be expected.

CenTex Diversion Dam and Recharge Facilities

This alternative proposes off-channel recharge augmentation by diversion to an existing limestone quarry (CenTex). This option offers similar vegetation and downstream impacts; but inundation impacts and impacts to surface karst features in Onion Creek are reduced since the diversion dam and pool will only be at capacity for 24 hour periods following flood-events.

6.2.5.3 Aquatic Resources

This section provides a general discussion of the potential impacts of the proposed alternatives upon the aquatic resources in the project area. This discussion is intended to generally describe the range and types of impacts that may occur and is not intended to provide a comprehensive evaluation of impacts. A comprehensive baseline is needed for such an evaluation, and as stated in Section 6.1, this study was not intended to provide such a baseline set, but rather provides a general overview of the baseline environmental setting and a relative ranking of the proposed project alternatives. With this goal in mind this discussion of potential impacts to aquatic resources begins with a general description of the types of impacts associated with the construction of the proposed alternatives followed by a discussion of the operational impacts of each of the proposed alternatives.

Construction of any of the proposed alternatives will have similar impacts relative to the size of the proposed structure, period of construction and construction and erosion control methods implemented. The primary impact associated with construction is an increase in erosion potential and subsequent increases in sediment and silt loadings. This increase in turbidity can have immediate impact upon both fish and benthic populations. As noted in Section 7.0, the City of Austin has recently amended its Comprehensive Watershed Ordinance (CWO) which provides potential guidance as to the control of erosion. Prior to construction of the selected alternative, the CWO, and other accepted erosion control methods should be evaluated as to their appropriateness. Other impacts associated with construction include an increase in pollutants in runoff from materials (including oil/grease, chemicals, and other construction materials) used at the construction site. Again, strict adherence to accepted erosion control measures will minimize these impacts.

The operations of the various alternatives will have varying impacts on aquatic resources directly related to their individual impacts on water quality, flow (quantity and seasonal distribution) and unique and sensitive habitats. These impacts include direct effects (within the proposed pool) and indirect effects (both upstream and downstream). This discussion of operational impacts will focus upon the changes in the flow regime and the sediment load associated with each of the proposed alternatives. Again, detailed baseline studies have not been conducted to date and these measures can only be considered as a proxy of potential impacts of each of the proposed alternatives. The percent change in baseline flows for Zone 1 (inflow), Zone 2 (recharge), Zone 3 (outflow) for each of the alternatives is presented in Tables 6.2-4 through 6.2-8. The estimated sediment loadings associated with each of the alternatives is presented in Table 6.2-10. The daily reservoir stage duration relationship for each alternatives is presented in Table 6.2-3. A description of the potential impacts of each of the alternatives relative to the data presented on these three tables is presented below.

Table 6.2-10 Estimated Sediment Volumes Retained (Acre-Feet Per Year)

Alternative	Estimated Volume of Sediment Retained (Acre-Feet per/year)
CenTex Reservoir	11
Ruby Reservoir	20
Ruby/Centex Tandem	23
Rutherford Dam & Reservoir	36
Centex Diversion Dam & Recharge Quarry	31

Source: DGRA, 1991

CenTex Reservoir

The proposed CenTex Reservoir is expected to be at full capacity approximately 26 days (over 4 to 8 occasions) and at zero capacity approximately 310 days a year. The remainder of the time the reservoir will be at some intermediate stage. As indicated in Table 6.2-4, this reservoir is expected to increase recharge (on a monthly basis) by 1% to 5% and decrease outflows (on a monthly basis) by 3% to 39%. These changes in flow volume and duration (based average values) do not appear to be significant and would not be expected to notably alter the aquatic biota of Onion Creek in Zones 1, 2 or 3. However, as previously stated, more detailed information on the selected alternatives will be required to more accurately assess the impacts of the project.

Ruby Reservoir

As previously noted in the baseline section, both the CenTex and Ruby Reservoirs are in Zone 2, which flows only periodically following significant precipitation events which limits the available habitat in the area of direct impacts. The Ruby Reservoir is expected to generally have similar impacts to CenTex with a 2% to 8% increase in recharge (on a monthly basis) and a 4% to 11% decrease in outflows (on a monthly basis).

CenTex and Ruby Reservoir In Tandem

The proposed CenTex and Ruby Reservoir In Tandem alternative will have basically the same structures as each independently. However a significantly higher decrease in outflows is expected due to the overall retention of a greater volume of water.

All three of the previously discussed options can be expected to have a minor positive impact on aquatic habitat in Zone 2 due to a increased retention time, thus more available habitat. However, as discussed in the baseline section, this aquatic habitat currently has limited value and an increase in the period of inundation is not expected to cause any significant alterations in the aquatic biota in Zone 2. Generally all three of these alternatives are expected to have a minor negative impact on Zone 3 due to decreased outflows and increase in sediment retention and decrease in nutrient transport. For the purposes of this study, this negative impact can generally be considered to be directly related to the percent decrease in flow.

Rutherford Dam and Reservoir

The proposed Rutherford Reservoir is significantly different than the three alternatives discussed above due to its location is Zone 3 and its associated perennial pool. This reservoir is expected to be at full capacity (252 surface acres) approximately 22 days annually and occupy approximately 35 surface acres the remainder of the time. This increase in area of inundation is expected to create an overall increase in aquatic habitats in Zone 3 and have minimal impact on aquatic habitats in Zone 2 and 1. Some change in habitat composition (% runs, % riffles, % pools) may occur as a result of this project but it is not expected to have a significant effect on species composition or diversity.

CenTex Diversion Dam

The proposed CenTex Diversion Dam is expected to have minimal impact on Zone 2, due to the off-channel storage. Zone 3 is expected to experience some decrease in useable habitat due to a 39.5% decrease in outflow. Finally, as mentioned several times previously, more detailed investigations in the selected alternative(s) will be required to thoroughly assess the potential impacts. The discussion provides a background to each the alternatives relative to their potential impacts. The ranking of the alternatives with respect to environmental issues is presented in Section 8.0

6.2.5.4 Potential Impacts to Threatened and Endangered Species

A thorough literature search (including coordination with TPWD) - Natural Heritage Program staff and files) has revealed no known occurrences of threatened or endangered species in the Onion Creek watershed.

The vast majority of the federally protected species documented regionally are Edwards Plateau endemics (i.e., cave invertebrates, salamanders, black-capped vireo and golden-cheeked warbler) or are migrant species which are not known to depend on any habitat in the Onion Creek watershed for breeding or wintering purposes (i.e., bald eagle, arctic peregrine falcon, whooping crane, and interior least tern).

Given the current level of study, the potential for federally protected species to occur in the Onion Creek watershed cannot be dismissed. When and if specific alternatives are chosen, habitat assessments and/or surveys for the cave invertebrates and birds may need to be initiated. Further groundwater and karst investigations may need to take place to determine whether suitable habitat for any of the troglobitic salamanders exists. Communications with TPWD personnel (Price 1991) indicate there is a low probability for these species to be encountered.

However, given the nature of the proposed actions (i.e., modification and diversion into Crippled Crawfish and/or Antioch Caves), a careful analysis of these features is warranted.

6.2.6 Potential Impacts on Historic/Archaeological Resources

The potential impacts on historical/archaeological resources are addressed in Section 6.1.6.

6.2.7 Land Use

Land use/land cover in the project area is dominated by rural ranching activities with a significant influences from the CenTex Materials, Inc. and Lehigh Cement Co. industrial complex. As noted in the baseline section, all of the property in the project area is privately owned. Due to the unique ownership situation most of the land uses in the project area are not expected to undergo any significant changes as a result of any of the alternatives being constructed. The one exception would be the CenTex Diversion Dam which would potentially combine the existing industrial use of the quarries and a water supply recharge facility. However, as previously noted, this facility is expected to remain in private ownership and no public access for recreation or other activities is expected.

6.2.8 Demographics

The proposed recharge structures are designed to enhance water availability in the Edwards aquifer to satisfy projected future demands.

6.2.9 Recreation

As noted in the baseline section, all of the land in the immediate project area is privately owned and used primarily for ranching and/or industrial purposes. The one recreational facility, the YO Ranch, in the immediate project vicinity is not expected to experience any changes in operational procedures as a result of the proposed project.

Downstream impacts may be somewhat more significant. As discussed in the baseline, McKinney Falls State Park is downstream of the proposed alternatives as are two stretches of Onion Creek identified as seasonally and permanently floatable by TORP. The impacts to these downstream recreational resources can be considered to be directly proportional to the decrease in outflows presented in Tables 6.2-4 through 6.2-8.

7.0 INSTITUTIONAL AND LEGAL ISSUES

7.1 REGULATORY OVERVIEW

Federal, state and local regulations will affect the development of recharge projects on Onion Creek. This section reviews Federal regulations, including U. S. Army Corps of Engineers (USCE) Section 404 and Section 10 permits for stream crossings and/or dredge and fill operations; U.S. Fish and Wildlife Service (FWS) Section 7 consultation for threatened and endangered species; the Environmental Protection Agency (EPA) - National Pollutant Discharge Elimination Systems (NPDES) permit for wastewater discharges; and the National Historic Preservation Act for cultural resources. State environmental regulations expected to be of concern include the Texas Antiquities Code, which applies to all action taken by political subdivisions of the State of Texas, Texas Water Commission (TWC) rules on appropriation of surface water rights and the TWC Edwards aquifer rules. Local regulation and environmental regulations expected to be of particular concern possibly include City of Buda and the City of Austin ordinances and Hays County permitting requirements. Table 7.1-1 provides a synopsis of environmental and regulatory considerations which may be of concern in the development of the proposed recharge enhancement projects investigated in this study.

7.2 FEDERAL REGULATORY CONSIDERATIONS

7.2.1 U.S. Army Corps of Engineers

The USCE has been regulating activities in the nation's waters since 1890. Until the 1960's the primary purpose of the regulatory program was to protect navigation. Since then, as a result of laws and court decisions, the program has been broadened so that it now considers the full public interest for both the protection and utilization of water resources (USCE 1985).

TABLE 7-1
SYNOPSIS OF ENVIRONMENTAL REGULATORY PROGRAMS

PROGRAM	CONSIDERATIONS
Federal	
Corps of Engineers Section 10 and Section 404 Permit Requirements	1) A permit is required for dredge and fill in surface water tributaries and waterways. 2) A "general permit" exists which significantly reduces the time and paperwork for pipeline construction authorizations. 3) Should have information on potential impacts to cultural resources and threatened or endangered species prior to involvement of Corps.
Section 7 of the Endangered Species Act of 1973, as amended	1) Formal section 7 consultation with FWS and USCE. 2) It will be the responsibility of the applicant to prove whether or not Federally-listed species occur in the project. 3) If formal Section 7 consultation is required, schedule delays of 90 days or more can be expected.
EPA-NPDES Discharge Permit	1) Establishes criteria for treatment and discharge of wastewater, including pollutant limitations, prohibitions, and monitoring and reporting criteria. 2) Administered by Texas Historic Commission and State Historic Preservation Officer. 3) Generally requires archaeological survey of affected areas, and, occasionally, testing of more important sites; in some cases, indirect impact areas must be considered. 4) Sites which are determined to be eligible for the National Register of historic Places may need preservation and/or mitigation.
State	
Texas Antiquities Code	1) Applies to actions taken by political subdivisions of the State of Texas. 2) Administered by Texas Antiquities Committee. 3) Generally requires archaeological survey of area of primary impact, and, occasionally, testing of potential important sites.
TWC - State Water Rights Permit	1) Texas water Law requires a permit be acquired to divert, use or store State waters 2) Typical components of water rights application include conservation plan, an Environmental Assessment (or, possibly, an Environmental Impact Statement) and detail engineering information.

TABLE 7-1 (continued)
SYNOPSIS OF ENVIRONMENTAL REGULATORY PROGRAMS

PROGRAM	CONSIDERATIONS
TWC - Edwards Aquifer Rule	1) Applies to facilities constructed over the recharge zone of the Edwards aquifer.
	2) Requires a pollution abatement plan.
<u>Local</u>	
Hays County	1) Requires permits for construction in County rights-of-ways and easements.
City of Buda	2) May require approval for construction within ETJ.

The regulatory authorities and responsibilities of the USCE that may affect the proposed Onion Creek recharge projects are based on the following laws:

1. Section 10 of the Rivers and Harbors Act of 1899 prohibits the obstruction or alteration of navigable waters of the United States (U.S.), without a permit from the USCE.

2. Section 404 of the Clean Water Act prohibits the discharge of dredged or fill material into waters of the U.S., without a permit from the USCE.

The Rivers and Harbors Act of 1899 contains several sections (Section 9, Section 10 and Section 13) relevant to the regulation of works and structures in navigable waters of the U.S. The USCE regulations define navigable waters as those subject to the ebb and flow of the tide (to the mean high water line), including all bays, estuaries, tidal creeks, and wetlands inundated up to the mean high water line. The definition of navigable waters also includes waters presently or formerly used to transport interstate and foreign commerce, and waters that may potentially be used to transport such commerce. In non-tidal waters, such as many rivers, streams and bayous, USCE jurisdiction extends to the ordinary high water mark.

Section 9 of the Rivers and Harbors Act requires a USCE permit to construct a dam or dike in navigable waters. Most USCE permits are issued under Section 10 of the Rivers and Harbors Act of 1899. This section requires a permit for structures and works in navigable waters. Examples of activities requiring a permit include piers, bulkheads, breakwaters, pipelines, dredging, filling, stream excavation, channelization, and similar works.

The Clean Water Act (CWA) prohibits the discharge of pollutants from any discernible point source into the waters of the U.S., with the exception of those discharges that are permitted in compliance with the CWA. Permits authorized under the CWA that may be of concern to the artificial recharge enhancement projects presented in this report, include Section 404 permits for dredge and fill, as issued by the USCE and the NPDES for the discharge of water as issued by the EPA.

Section 404 of the CWA, as administered by the USCE, regulates the placement of dredge (excavated) or fill material in "Waters of the U.S." Waters of the U.S. are broadly defined in Section 404, as any body of surface water (such as oceans, bays, rivers, etc.), all surface tributary streams with a defined channel (including intermittent waterways), any in-stream impoundments, i.e., lakes and ponds, many off-channel impoundments, and wetlands. "Dredged or fill material" has also been given a rather broad definition to include almost any material or object used for construction, such as dirt, rocks, concrete, piles, etc. In regards to construction of a water intake structure or pipeline where a crossing or direct involvement with a surface tributary stream, impoundment, or wetland may be required, placement of the pipeline itself, regardless of construction materials, and any trench backfill material within the area or jurisdiction is subject to permit requirements under 404 regulations.

In addition, the River and Harbor Act of 1899 provides regulatory responsibility to the USCE for protection of wetlands. Federal regulations define wetlands as those areas that are inundated or saturated often enough to support a prevalence of vegetation adapted for life in saturated soil.

The USCE Fort Worth District has Section 10, Section 404 and wetlands regulatory responsibility for Hays County. This District maintains a "general permit" covering some construction projects in navigable waters. A general permit is a pre-authorized permit for a specifically identified activity which is conducted under certain specified conditions. General permits are issued on either a nationwide or regional basis. The purpose of general permits is to provide paperwork and time expenditure relief for permitting actions which are determined to be routine and resulting in little or no impacts to waters of the U.S. However, the construction of the recharge enhancement projects presented in this report may require a Section 10 and/or Section 404 permit from the Fort Worth District of the USCE. In addition, there are other Federal laws, overseen by the USCE and other Federal agencies, that may affect the construction and implementation of the proposed projects. Among these are the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Endangered Species Act, the National Historic Preservation Act, and the Wild and Scenic Rivers Act.

In order to determine Federal jurisdiction, a written request must be submitted to the USCE Fort Worth District. The USCE will provide written determination as to the necessity for Federal permits and approvals upon receipt of the request.

7.2.2 U. S.Fish and Wildlife Service Section 7 Consultation for Threatened and Endangered Species

It is possible that formal Section 7 (CWA) consultation will be required between the FWS, USCE and project sponsor(s), before a USCE permit is issued, due to perceived direct and indirect impacts to Federally-listed threatened and endangered species. Additionally, environmental groups or other entities may petition the FWS and/or the USCE to initiate Section 7 consultation, if it is not initiated by the project sponsor(s). It is the responsibility of the project sponsor to prove whether or not Federally-listed threatened or endangered species occur in the project area. If Section 7 consultation is required, project implementation schedules are inevitably delayed to allow for the FWS to conduct biological assessments and form its "biological opinions" concerning the project. The need for Section 7 consultation is determined by the FWS upon the formal submission of a Section 10 and/or Section 404 application to the USCE.

7.2.3 National Historic Preservation Act

Protection of cultural resource sites may be invoked, through application for a Section 404 or Section 10 permit from the USCE, should structures or lines be located in waters of the U.S. Should the USCE become involved, it may request the opinion of the State Historic Preservation Officer (SHPO) concerning the effect of the project on cultural resources. Because of the potential for cultural resources in the general area, it is certainly possible that the SHPO could, like the Texas Antiquities Committee (TAC), require an archaeological survey, site evaluation, and protection and/or mitigation measures for important sites located during the initial survey. In such cases where the TAC and SHPO have jurisdiction, one agency will operate as the lead agency. Cultural resources studies may be coordinated through the TWDB, when TWDB funds are utilized, or coordinated directly through the TAC.

7.2.4 EPA-NPDES Permit

All point source discharges of wastewater into the waters of the U.S. are regulated under the CWA and require a NPDES permit from the EPA. Recent new interpretations of the CWA may give the EPA broader powers in requiring NPDES permits for surface water and groundwater projects, such as those proposed in this study. The EPA expanded NPDES permit requirements in 1990 to include construction site runoff that may impact surface water and groundwater resources. The treatment and discharge conditions described in the NPDES permit are typically designed to maintain ambient stream standards and require evaluation of the cumulative impacts of all point sources discharged into receiving streams. Upon project(s) formalization, the EPA should be contacted to determine the applicability of NPDES permit requirements.

7.3 STATE REGULATORY CONSIDERATIONS

7.3.1 Texas Antiquities Code

All municipalities, water districts, etc. are considered to be political subdivisions of the state under the provisions of the Texas Antiquities Code, and, therefore, must consider the effects of its actions upon possible archaeological sites. Under the code, all archaeological sites, either historic or prehistoric, and significant historic structures on lands belonging to or controlled by political subdivisions of the state are automatically considered to be State Archaeological Landmarks (SALs) and may be eligible for protection. Construction projects, like those proposed in this study, will require a Texas Antiquities Permit and coordination with the TAC. In practice, this often necessitates an archaeological and historical survey of previously unsurveyed areas, prior to any potentially destructive action. Sites recorded during this survey must be evaluated; those which are of significant historical or scientific value will be formally designated for SAL status and measures of protection or mitigation of the adverse impact negotiated between the political subdivision and the TAC.

7.3.2 TWC - State Water Rights Permit

The development of this plan requires a thorough analysis of the water demand, supply and uses of existing water. In order to construct and divert water from any of the proposed projects investigated in this study, a water appropriation permit must be obtained from the TWC.

The TWC, as a regulatory agency with broad discretionary powers, is charged with the administration of rights to the surface water resources of the state. The TWC consists of three members appointed by the Governor for six-year terms, with the consent of the Senate. The Chairman is designated by the Governor. The Rules, Regulations, and Modes of Procedure of the TWC prescribe the procedures for applying for a water permit. The TWC will consider an application for approval, if the application is in proper form, complies with statutory provisions, contemplates an authorized use of water, does not impair existing water rights or vested riparian rights, and is not detrimental to the public welfare and environment.

After approval of an application, the TWC issues a permit giving the applicant the right to take and use water only to the extent stated. Permits may be "regular," "seasonal," "temporary," or "contract" in nature. A regular permit is permanent in nature and does not limit the appropriator to the taking of water during a particular season or between certain dates. A seasonal permit is also permanent in nature, but the taking of water is limited to certain months or days during the year. A temporary permit is granted for a period of time not exceeding three years and does not vest in the holder any permanent right to the use of water. A contract permit is granted for a stated duration and governs the use of water to be obtained from the storage facilities and/or existing water rights owned by another person or entity. This latter type of permit requires a written consent agreement or a contract with the owner of the facilities or rights to be used.

The TWC may also grant permits for the impoundment and storage of water with the use of the impounded water to be determined at a later date by the TWC.

Once the right to the use of water has been perfected by issuance of a permit from the TWC and subsequent beneficial use of the water by the permittee, the water authorized to be appropriated under the terms of the particular permit is not subject to further appropriation until the permit is canceled. Formal cancellation of unused permits and certified filings is possible by administrative action initiated by the TWC or by judicial proceedings to adjudicate water rights between claimants (TWDB 1977).

7.3.3 TWC - Edwards Aquifer Rules

Chapter 313 of the TWC's permanent rules regulates activities having the potential for causing pollution of the Edwards aquifer. Activities addressed under this rule apply to those that pose direct threats to water quality, such as, construction of buildings, utility stations, roads, highways, or railroads, clearing, excavation or any other activities which may pose a potential for contaminating the Edwards aquifer. These rules apply to the proposed projects presented in this investigation, to the extent that the proposed projects are constructed over the Edwards aquifer Recharge Zone. TWC will most likely extend the Edwards Rules and Requirements for a Water Pollution Abatement Plan (WPAP) into the Contributing Zone during 1992.

Under this rule, a WPAP must be prepared and submitted to the TWC for approval. The WPAP must contain a detailed project description, location data and map(s), site plan, assessment of area geology, and a technical report. The technical report must provide a detailed assessment of the impact of the proposed project on water quality and plans for measures that will be undertaken to prevent pollution. WPAPs are provided to local affected entities for comments prior to TWC approval.

7.4 LOCAL PERMIT REQUIREMENTS AND REGULATIONS

Local permit requirements and regulations that may be applicable to the proposed projects include those propagated by Hays County, the City of Buda and the City of Austin. Permits for construction of any facilities to be located in county rights-of-ways and/or easements must be obtained from the Hays County Commissioners Court. This would include facilities such as pipelines, structures and electrical/communication transmission lines. The proposed projects located within the City of Buda's extra territorial jurisdiction may fall under Buda's regulatory review and regulatory ordinances (i.e., subdivision, building codes, engineering, etc.). A written application for project construction should be submitted to Hays County and the City of Buda to determine respective regulations that may apply to individual projects.

One or more of the recharge enhancement alternatives may be subject to approval and review by the City of Austin under their Comprehensive Watershed Ordinance (CWO). Austin's current 5-mi extra-territorial jurisdiction may encompass the CenTex Reservoir Alternative, including proposed improvements to Antioch Cave. As Austin extends its city limits, other project alternatives may become subject to the CWO.

In 1986, the City of Austin adopted the CWO to protect the quality of water resources in the Austin area. The primary measures of this protection were through development setbacks from creeks, impervious cover limitations, and partial treatment of urbanized storm water runoff by filtration through sand media. This ordinance was subsequently amended in 1991 to include stricter development regulations. The CWO currently has provisions providing for the establishment of critical water quality zones, water quality buffer zones, impervious cover limitations based on net site area, and storm water treatment requirements.

Upon of selection of project alternative(s), the District should formally contact the City of Austin to determine their jurisdiction regarding the CWO.

7.5 FINANCING CONSIDERATIONS

The District was created by the 70th Texas Legislature under Senate Bill 988 and Chapter 52 of the Texas Water Code with a mandate to conserve, protect and enhance the ground water resources of the Barton Springs segment of the Edwards aquifer and other ground water resources located within its boundaries. Senate Bill 988 and Chapter 52 of the Texas Water Code gives the District the power and authority to undertake various studies and to implement structural facilities and non-structural programs to achieve its statutory mandate. The District has the authority to issue debt and/or to undertake financing programs, allowed by law, to finance and construct any of the recharge enhancement alternatives set forth in this investigation.

Construction of public works projects, like those described in this report, is frequently financed by the selling of bonds. Entities such as the District, cities, river authorities and other political subdivisions can issue bonds and use the proceeds to construct capital improvement projects. In general, entities repay the bonds, with interest, from taxes, revenues and/or fees collected in the service area. Because bonds issued by public entities are for the purpose of providing services, they are classified under federal law as "tax exempt", and the interest paid to bond holders does not have to be declared as ordinary income. Consequently, bond holders are generally willing to lend their financial resources to public entities at a lower rate of interest than the going market rate.

The District has two primary sources from which it could possibly secure bonds for the purpose of constructing any of the recharge enhancement projects: the Texas Water Development Board and the open market. The TWDB administers the Water Development Fund. This fund is used to provide loans to political subdivisions for the construction of water supply, wastewater treatment, flood control, regional water and wastewater facilities, and other related projects. Open market funds can be used for a variety of public improvement projects and are available through financing institutions. The District would have to retain the services of a financial advisory and legal bond counsel in order to secure project financing from the TWDB or from open market sources.

Since the District does not currently have taxing authority, the repayment of debt (bonds) for the construction of recharge enhancement projects would be derived from fees and other revenue sources the District has the power to assess. Likewise, operation and maintenance costs associated with the operation of recharge enhancement projects would be derived from District fees and other revenue sources.

The District could undertake these projects on a sole-sponsorship basis or could potentially co-sponsor this effort with other political subdivisions. Recharge enhancement on Onion Creek would benefit Edwards groundwater users, Barton Springs, Town Lake, and the Colorado River downstream of its confluence with Barton Creek. As such, benefactors of these projects would include the District, municipalities including Buda, San Leanna, Sunset Valley, and Austin, individuals and private/public water companies deriving their water supply from the Barton Springs segment of the Edwards aquifer, and the Lower Colorado River Authority. The District could pursue joint project sponsorship with any or all of these entities. However, the Lower Colorado River Authority and the City of Austin probably offer the best financial ability to assist the District in financing and participation in recurring operation and maintenance costs.

8.0 CONCLUSIONS AND RECOMMENDATIONS

For the purposes of assessing each project alternative on a equal basis, a ranking process was used to evaluate the relative rank of each alternative with respect to various project parameters. These project parameters included recharge potential (af per yr), annual cost (dollars), unit cost (per 1,000 gallons), engineering factors, legal/institutional factors, and environmental factors. A ranking for each parameter ranging from 1 to 5 (1 being the best and 5 the worst) was assigned by key project participants. This scoring process is based on the assumption that each of the project parameters were equal in weight (obviously not an absolute statement) and no fatal flaws were present. This scoring corresponds with a general ranking, conducted by key project participants. A review of Table 8.0-1 provides the data used to assess these rankings. A summary of conclusions and recommendations based on this ranking process and the detailed investigations performed in this study is presented below. Ranking of these projects decreases with an increase in the score. This scoring process results in the following project ranking:

PROJECT ALTERNATIVE	SCORE
CenTex Reservoir	14
Ruby Reservoir	16
CenTex Reservoir and Ruby Reservoir Tandem Operation	25
Rutherford Reservoir	19
CenTex Diversion Dam and Recharge Quarry	15

As shown above, CenTex Reservoir has the best ranking of all the project alternatives with a rank of 14. The second "best" project is CenTex Diversion Dam and Recharge Quarry. However, it should be pointed out that this latter alternative is entirely dependent upon the

Table 8.0-1 PROJECT ALTERNATIVE RANKING.

PROJECT ALTERNATIVE	RECHARGE POTENTIAL (AF/YR)	ANNUAL COST ($)	UNIT COST ($/1000 GAL)	ENGINEERING FACTORS	LEGAL/INSTITUTIONAL	ENVIRONMENTAL
Alternative No. 1 CenTex Reservoir	768	71,360	0.29	Located lower end of recharge zone Inundates Antioch Cave Move natural gas line and fence Easy/ready access	Requires local, state and federal permit Land possibly available immediately Good cooperation from CenTex Materials, Inc.	33.4 AC Inundation within existing channel No significant resources identified Inundates Antioch Cave Could retain 11 af/yr of sediment
Rank Value	5	1	4	1	1	2
Alternative No. 2 Ruby Reservoir	1,152	104,190	0.28	Located on upper end of recharge zone Inundates Crippled Crawfish Cave No relocations Moderate access problems	Requires local, state and federal permits Multipel land owners Potential land acquisation problems	44.2 AC Inundation within existing channel Could retain 20 AF/YR of sediment
Rank Values	4	2	2	2	3	3
Alternative No. 3 Ruby Reservoir/Centex Reservoir Tandem Operation	1,576	175,550	0.34	Located on upper and lower portions of recharge zone Multiple land owners Relocate natural gas line and fence Moderate access problems Proportionate recharge potential decreases	Requires local, state, and fedeal permits Potential land acquisition problems	77.6 AC Impacts shown above are additive Inundates Crippled Crawfish Cave Potential to retain 23 AF/YR sediment
Rank Values	3	3	5	5	5	4

Table 8.0-1 PROJECT ALTERNATIVE RANKING. (Continued)

PROJECT ALTERNATIVE	RECHARGE POTENTIAL (AF/YR)	ANNUAL COST ($)	UNIT COST ($/1000 GAL)	ENGINEERING FACTORS	LEGAL/INSTITUTIONAL	ENVIRONMENTAL
Alternative No. 4 Rutherford Reservoir	3,515	337,560	0.28	Located above the recharge zone Potential conflict with FM 150 Requires construction of large dam Moderate access problems	Requires local, state, and federal permits Multiple land owner Potential land acquisation problems	252 AC (6% of the time) 35 AC (94% of the time) Inundates outside of channel banks Inundates savannah and wooded areas Area of inundation characterized by steep canyons Potential to retain Could retain 36 af/yr sediment
Rank Value	2	5	2	2	3	5
Alternative No. 5 CenTex Reservoir and Recharge Quarry	5,718	183,460	0.10	Located in lower third of recahrge zone Potential conflicts with existing quarry operations Moderate access problems long term project	Requires local, state and federal permits Multiple land owners	Less than 1 AC other than existing quarries Off-channel storage Potential of retain 31AF/YR sediment but has potential sediment removal prior to recharge
Rank Value	1	4	1	4	4	1

willingness of CenTex Materials, Inc. to cooperate in using their active quarry pit as a recharge facility, and that this alternative could require twenty to thirty years to be fully developed. Ruby Reservoir was third in the ranking process primary due to limited access and multiple land ownership. Rutherford Dam and Reservoir ranked fourth due to more severe environmental problems. The lowest ranked project was CenTex Reservoir and Ruby Reservoir Tandem Operation. Its ranking was influenced mainly by having the highest unit cost, multiple land ownership problems, and moderate access problems.

8.1 CONCLUSIONS

Based on the results and findings presented in this investigation the following conclusions are offered:

1. Artificial recharge enhancement on Onion Creek's Recharge Zone is feasible from an engineering, geologic, economic, and environmental viewpoint.

2. Recharge occurs in "pockets" or identifiable areas along Onion Creek over the Recharge Zone that can be classified as moderate or high recharge potential areas. Recharge enhancement activities should focus on these areas.

3. Recharge enhancement could range from an annual average of about 760 af per yr for Alternative No. 1 - CenTex Reservoir to over 5,700 af per yr for Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry.

4. The cost per 1,000 gallons of water recharged ranges from $0.10 for Alternative No. 5 - CenTex Diversion Dam and Recharge Quarry to $0.34 for Alternative No. 3 - CenTex Reservoir and Ruby Reservoir Tandem Operation.

5. The recharge impoundments will be subject to some sediment deposition and accumulation, but can be mitigated through structural, operational, and maintenance mechanisms.

6. A Texas Water Rights Permit will be required to constructed any of the recharge enhancement projects.

7. Currently, all the recharge enhancement projects, except for Rutherford Dam and Reservoir will be subject to the Texas Water Commission's Edwards Aquifer Rules. Rutherford Dam and Reservoir may be subject to new rules proposed for 1992.

8. Implementation of the recharge enhancement projects may require permits from the U.S. Army Corps of Engineers and from other regulatory agencies and be subject to the City of Austin's Comprehensive Watersheds Ordinance.

8.2 RECOMMENDATIONS

The following recommendations are offered as a result of this investigation:

1. The District should immediately determine the interest of the City of Austin and the Lower Colorado River Authority as potential co-sponsors of recharge enhancement on Onion Creek.

2. The District should avail itself to all opportunities to purchase or secure easements on lands located within project areas.

3. The District should immediately undertake activities to acquire Antioch Cave and Crippled Crawfish Cave.

4. The District should immediately commence permitting and modification/protection activities on Antioch Cave and Crippled Crawfish Cave.

5. The District should continue hydrologic, hydraulic and geologic investigations on Antioch Cave and Crippled Crawfish Cave to determine recharge potential before and after acquisition and modification.

6. The District should continue investigations with CenTex Materials, Inc. to determine the ultimate feasibility of using quarries for recharge enhancement.

7. The District should pursue the implementation of CenTex Reservoir in a timely manner.

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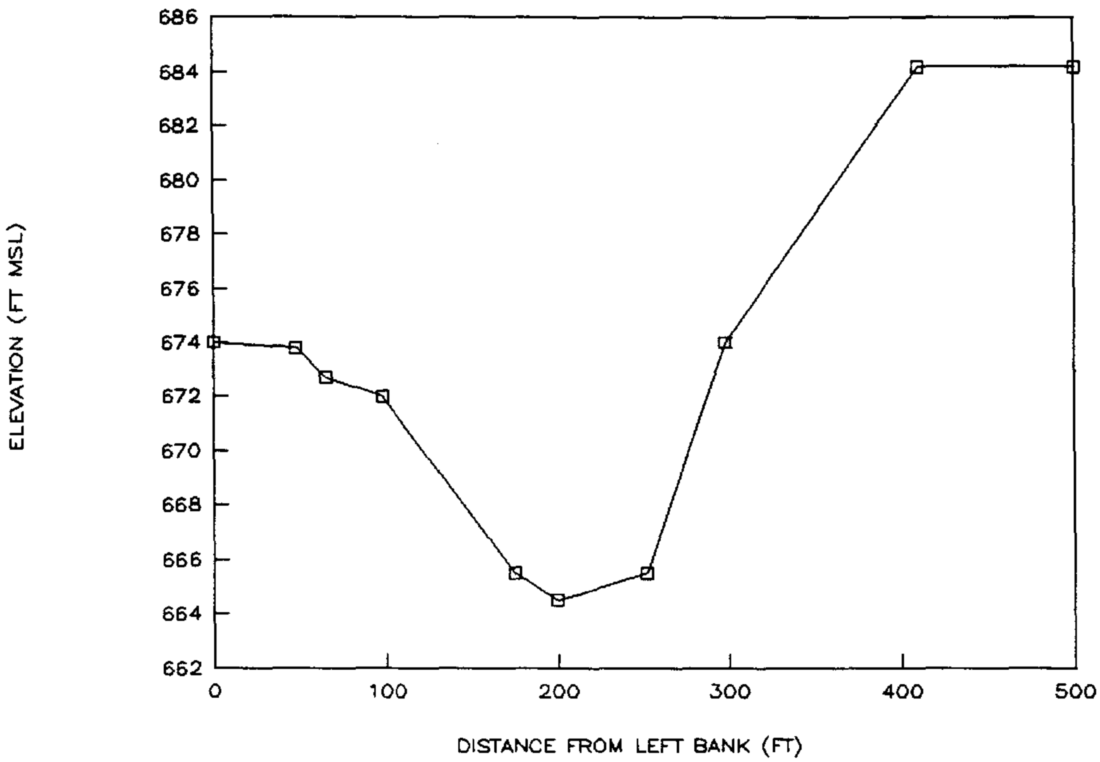
APPENDIX A:

SURVEYED CROSS-SECTION OF ONION CREEK

ONION CR. CROSS SECTION @ STA. 01+77.1

NEAR MARY LEE SCHOOL



ONION CR. CROSS SECTION @ STA. 126+85.7

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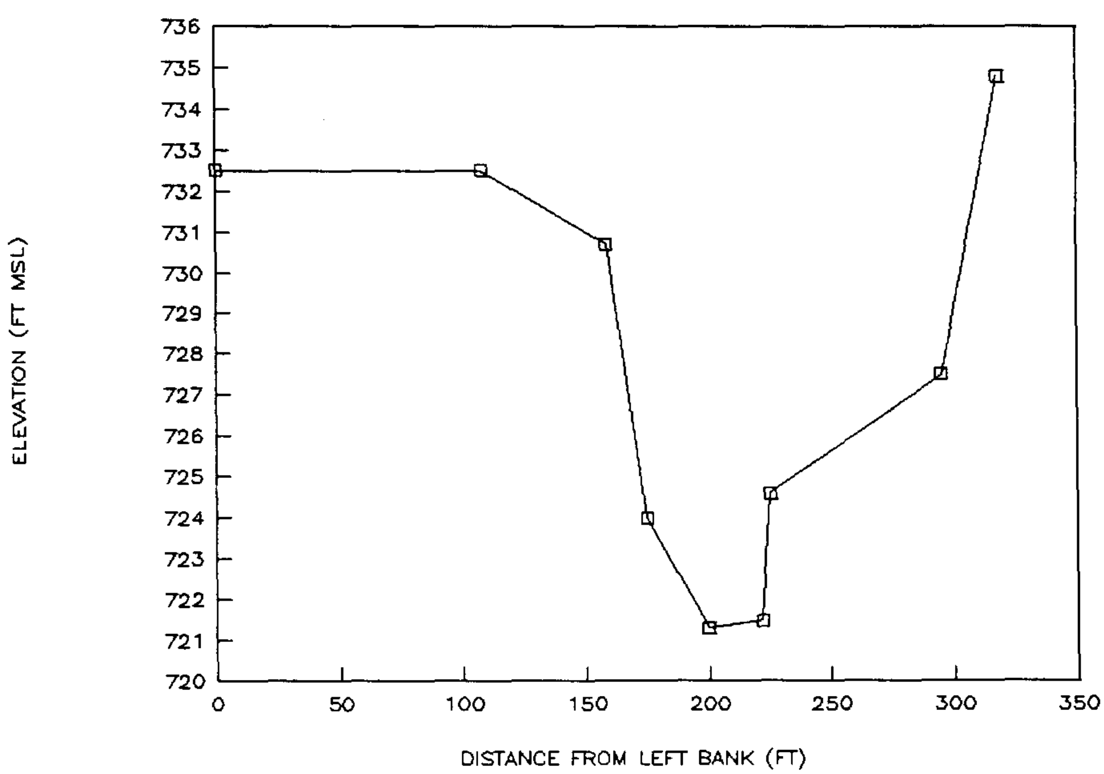

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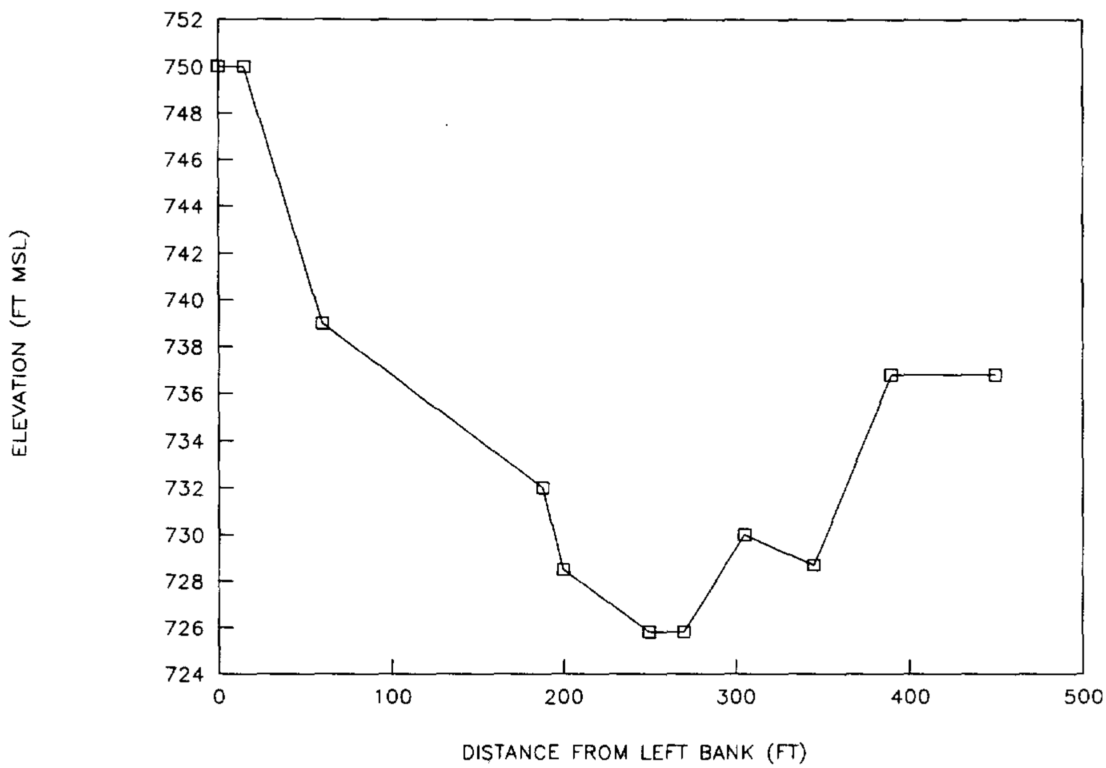

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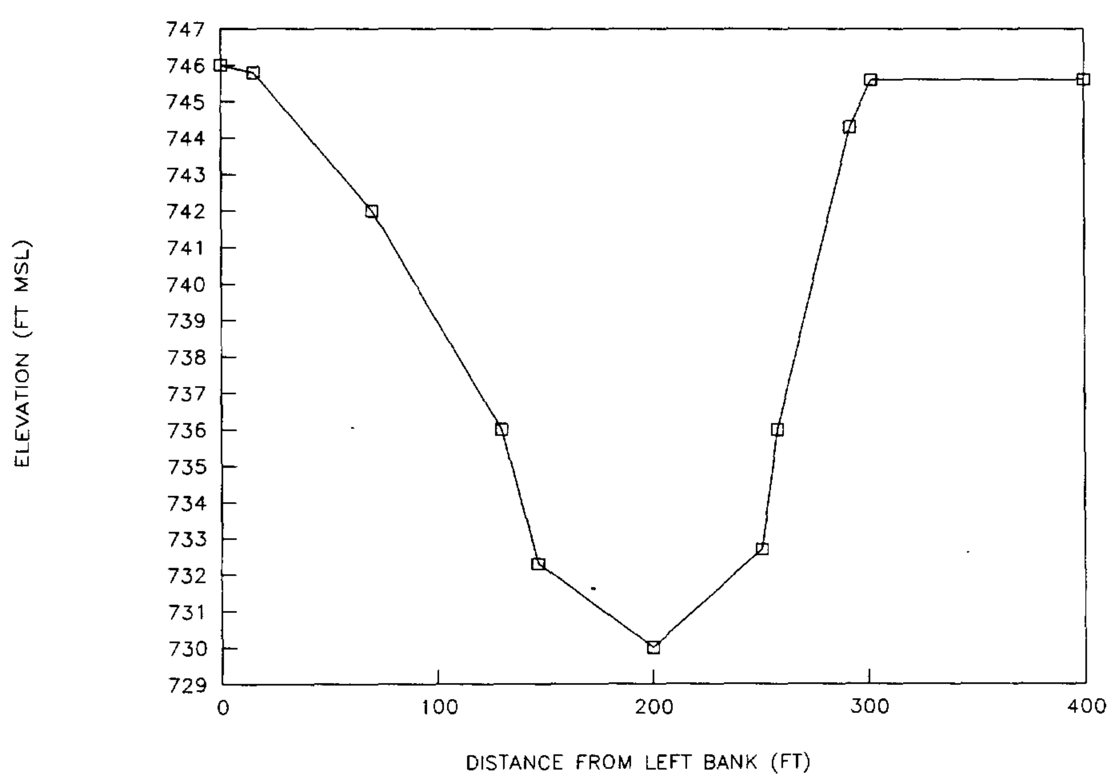

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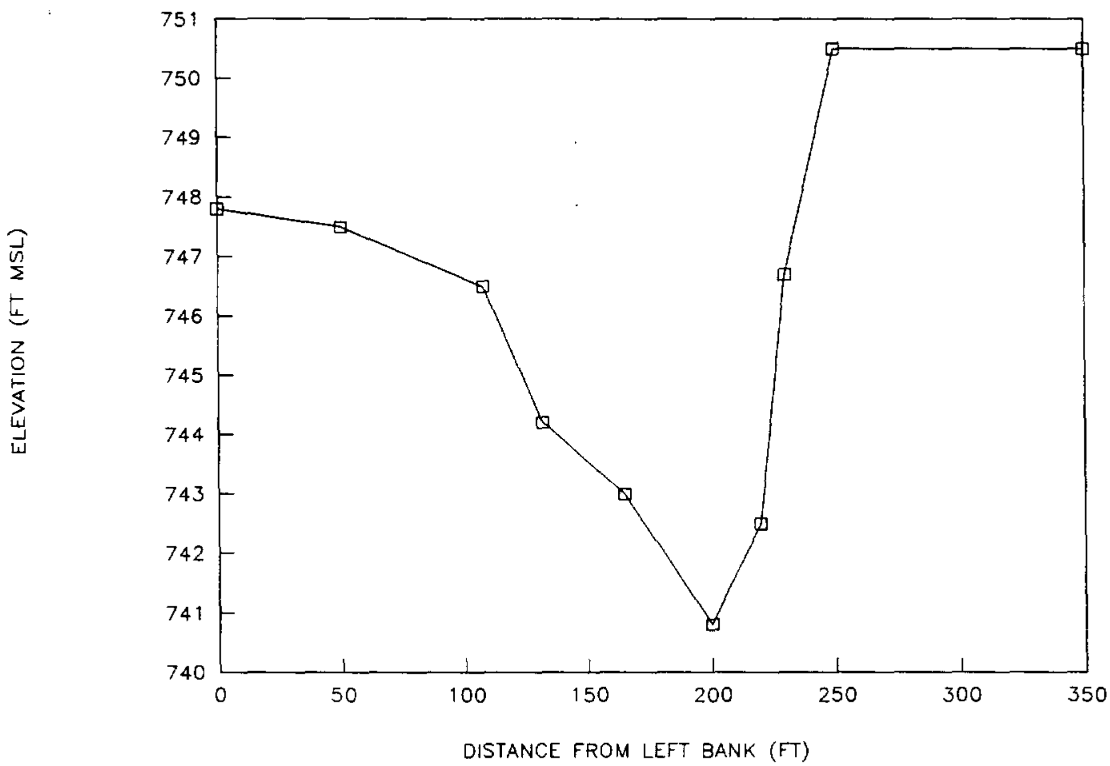

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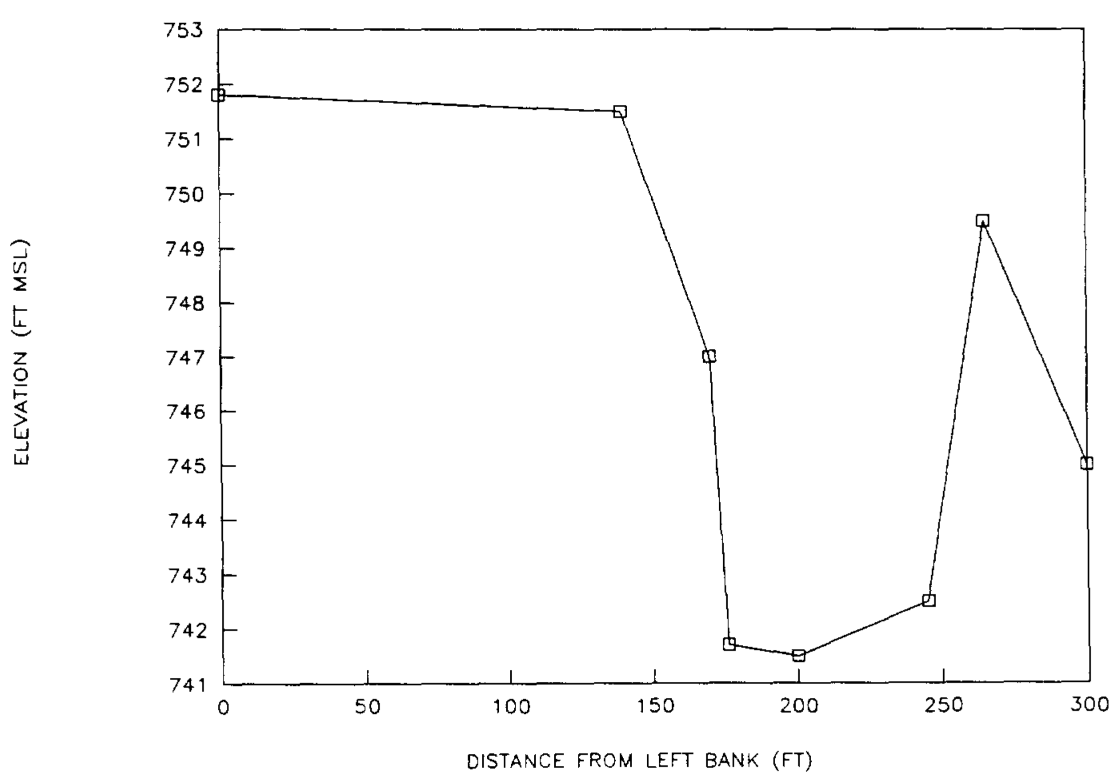

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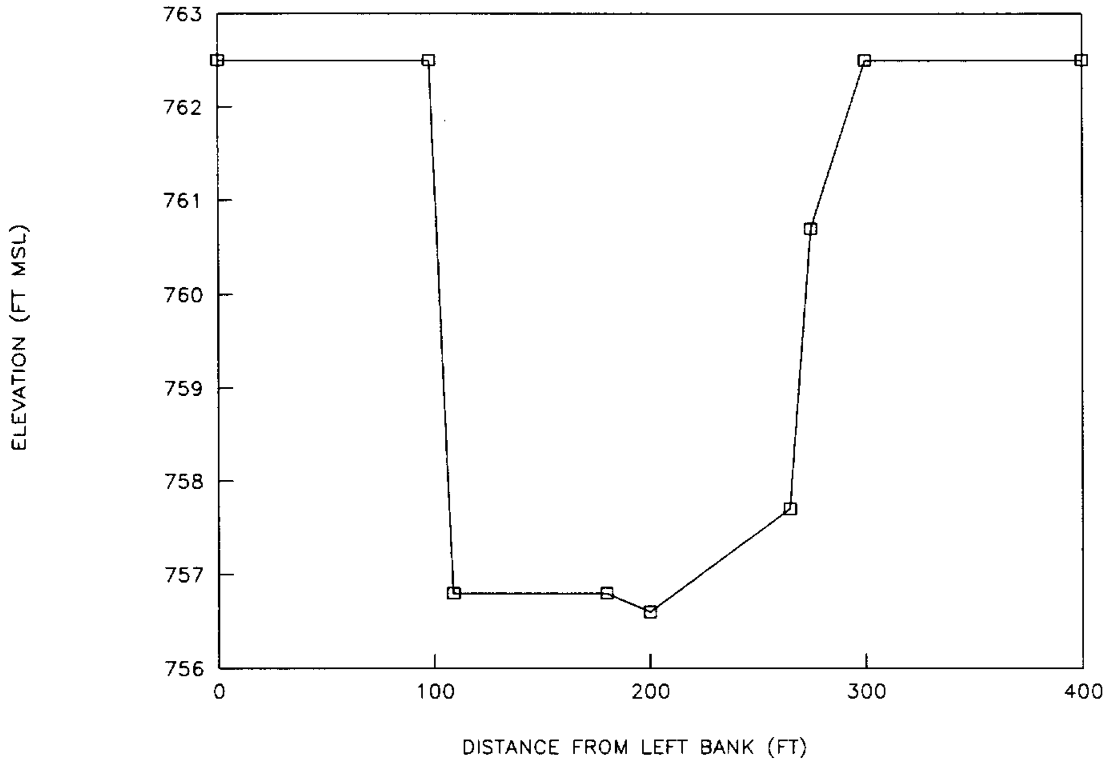

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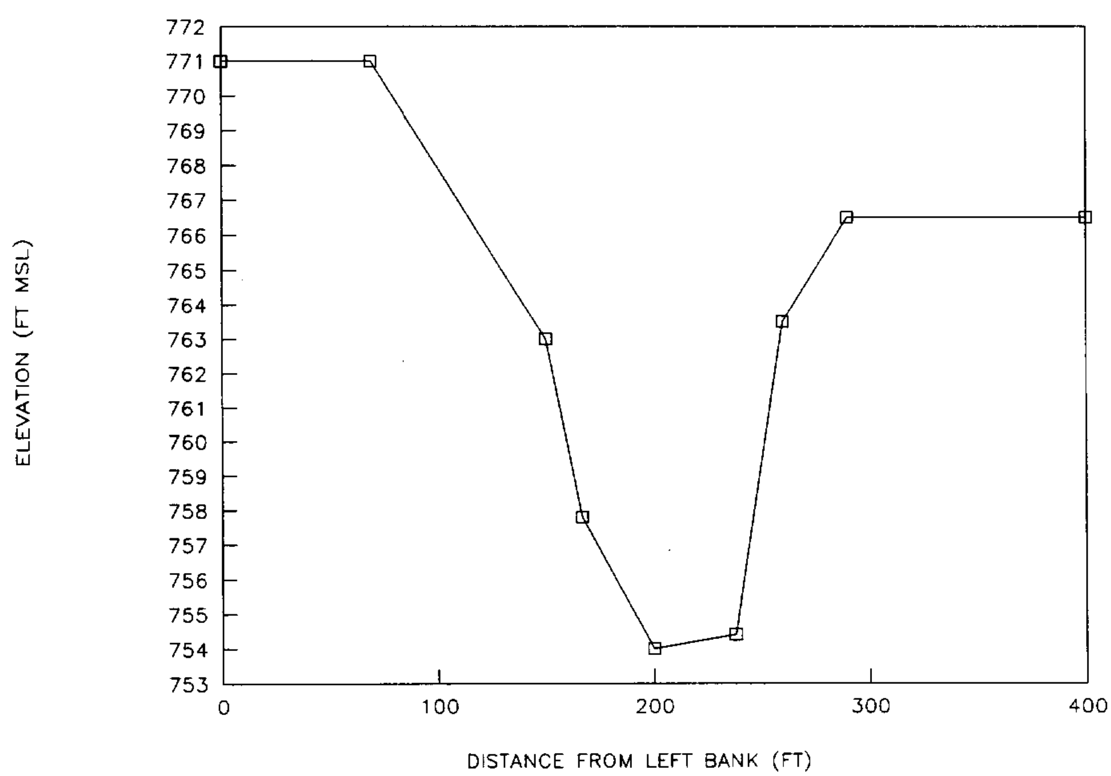
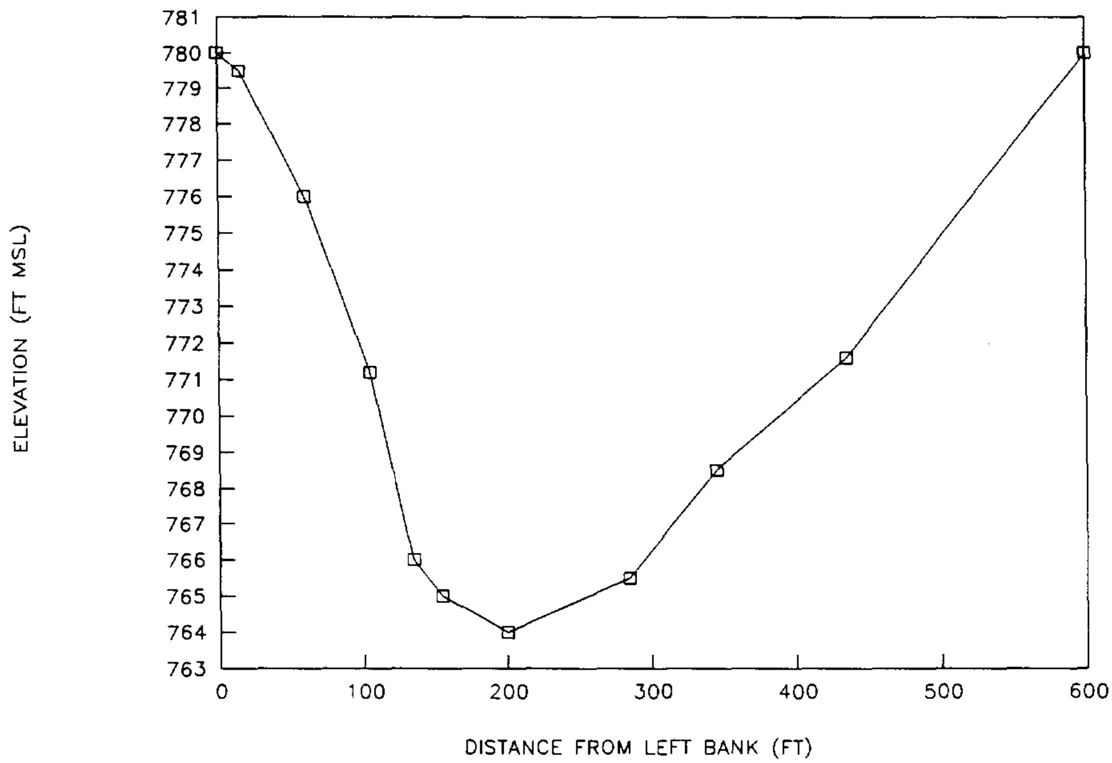


ONION CR. CROSS SECTION @ STA. 252+02.3

AT YO RANCH — LOW WATER CROSSING



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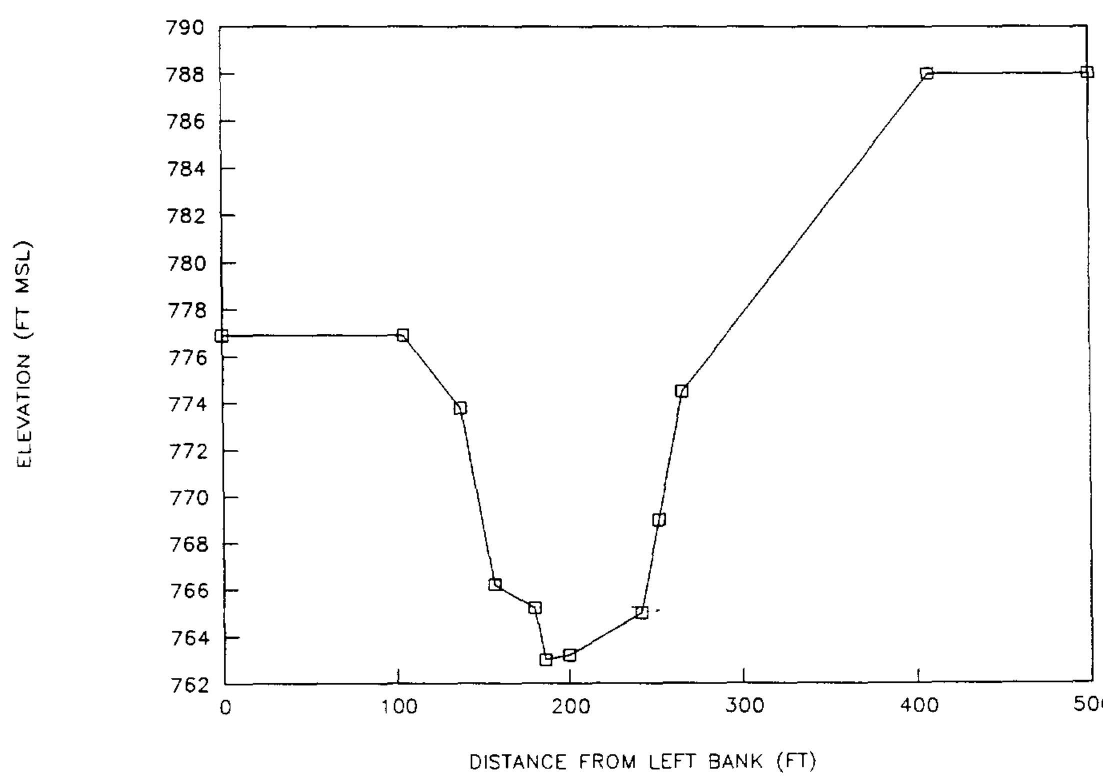

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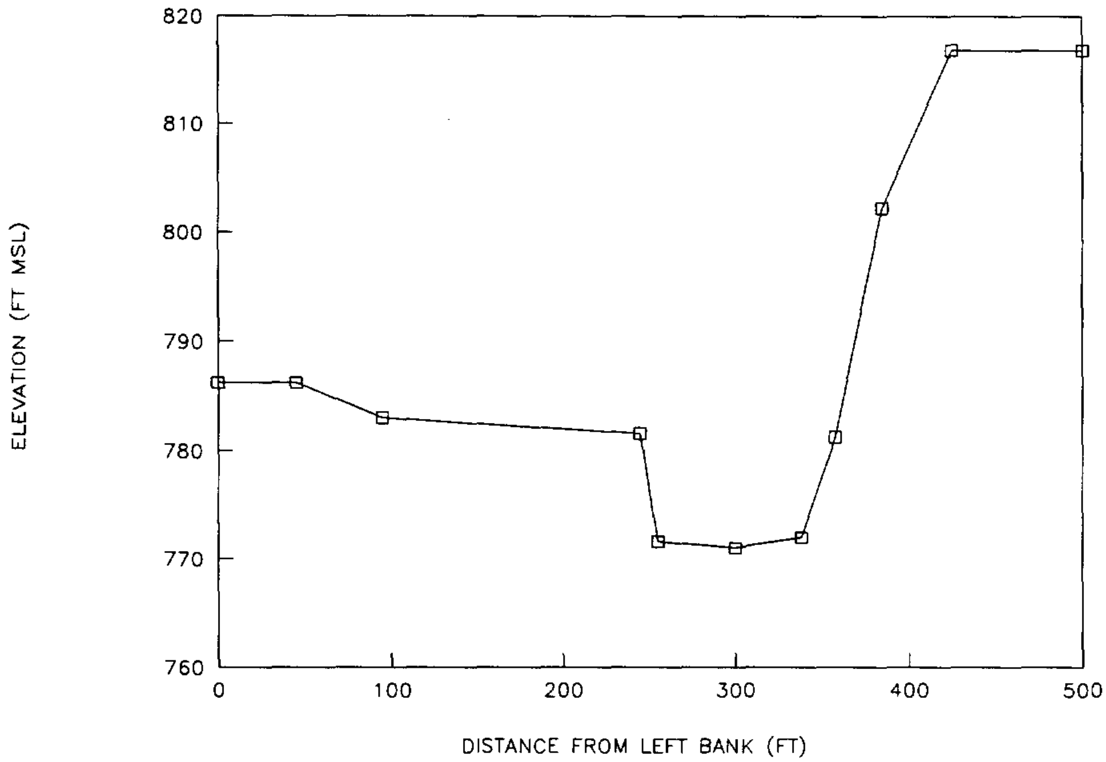

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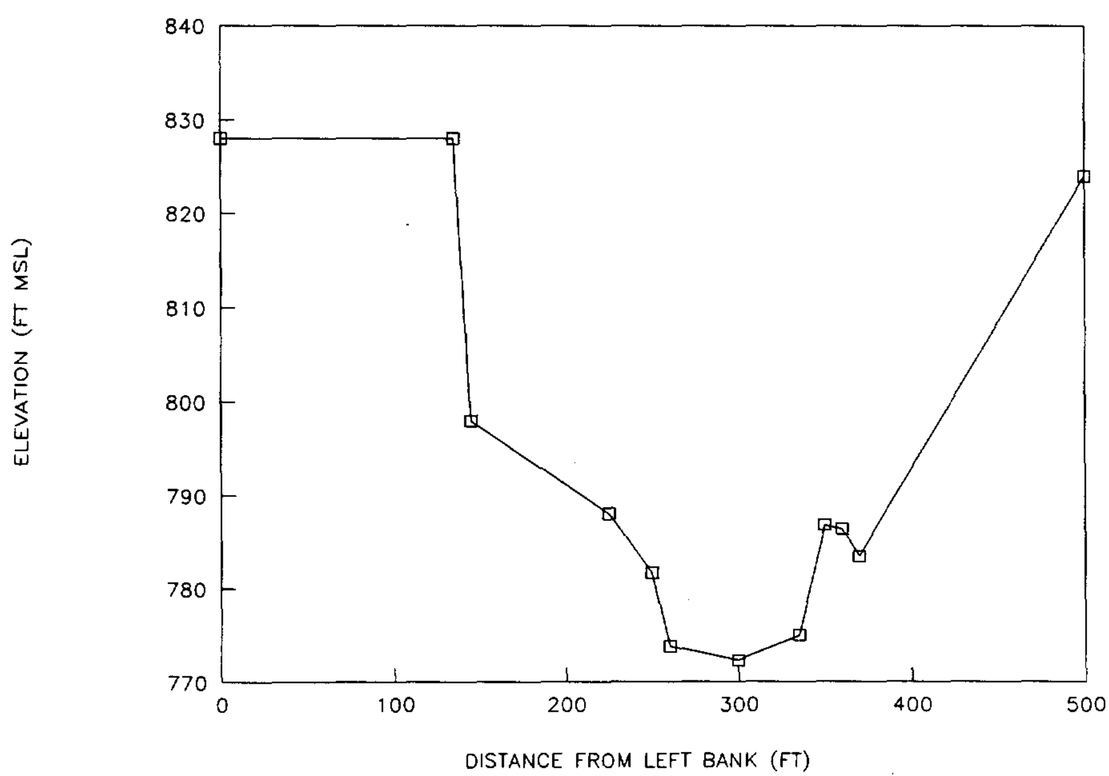
AT SEARCY RANCH



ONION CR. CROSS SECTION @ STA. 372+99.7

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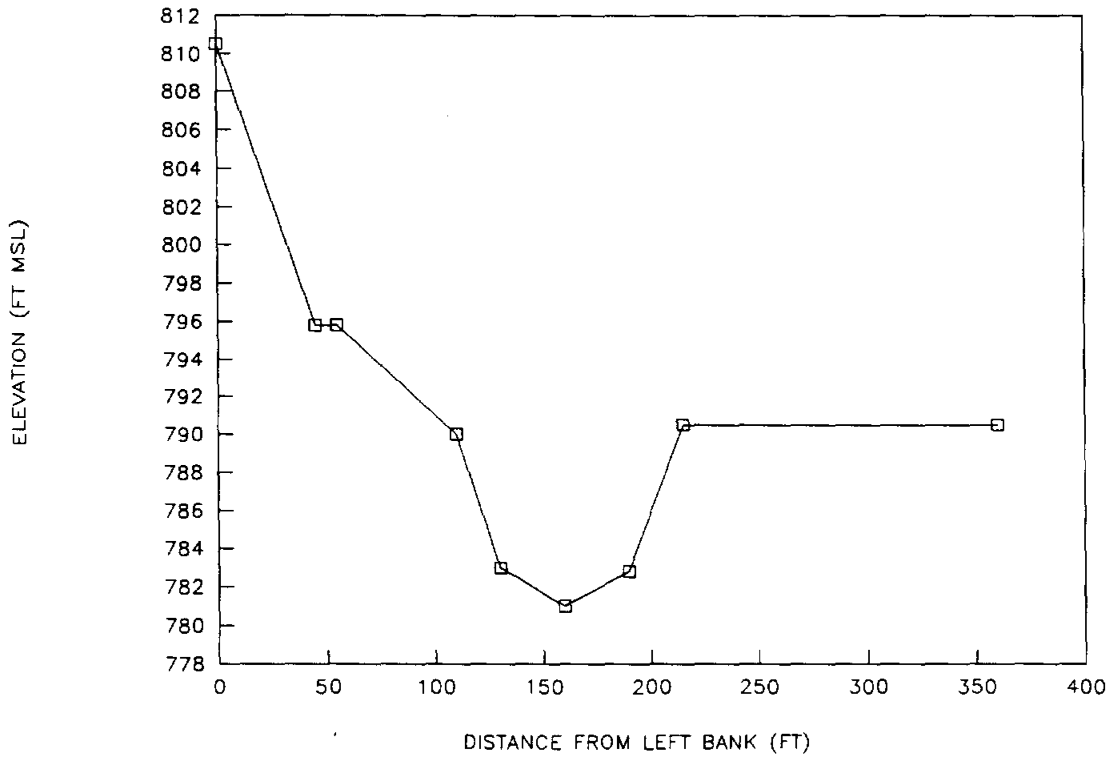
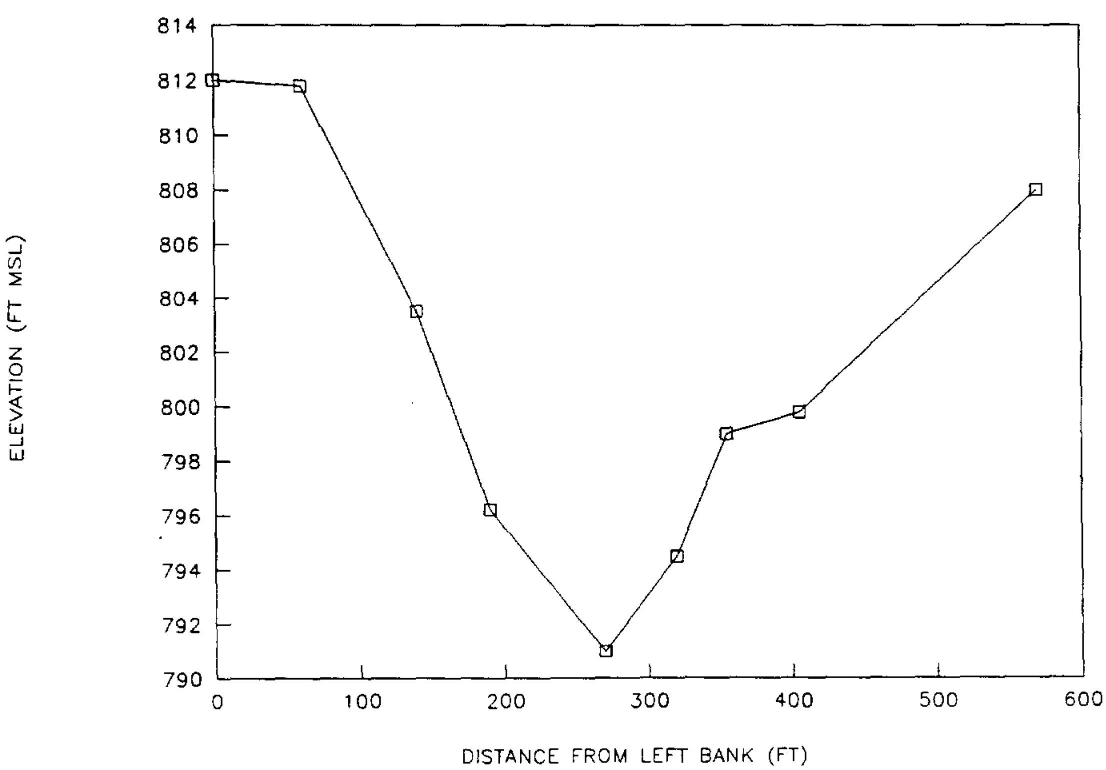


ONION CR. CROSS SECTION @ STA. 395+15.4

AT RUTHERFORD RANCH



ONION CR. CROSS SECTION @ STA. 425+31.1

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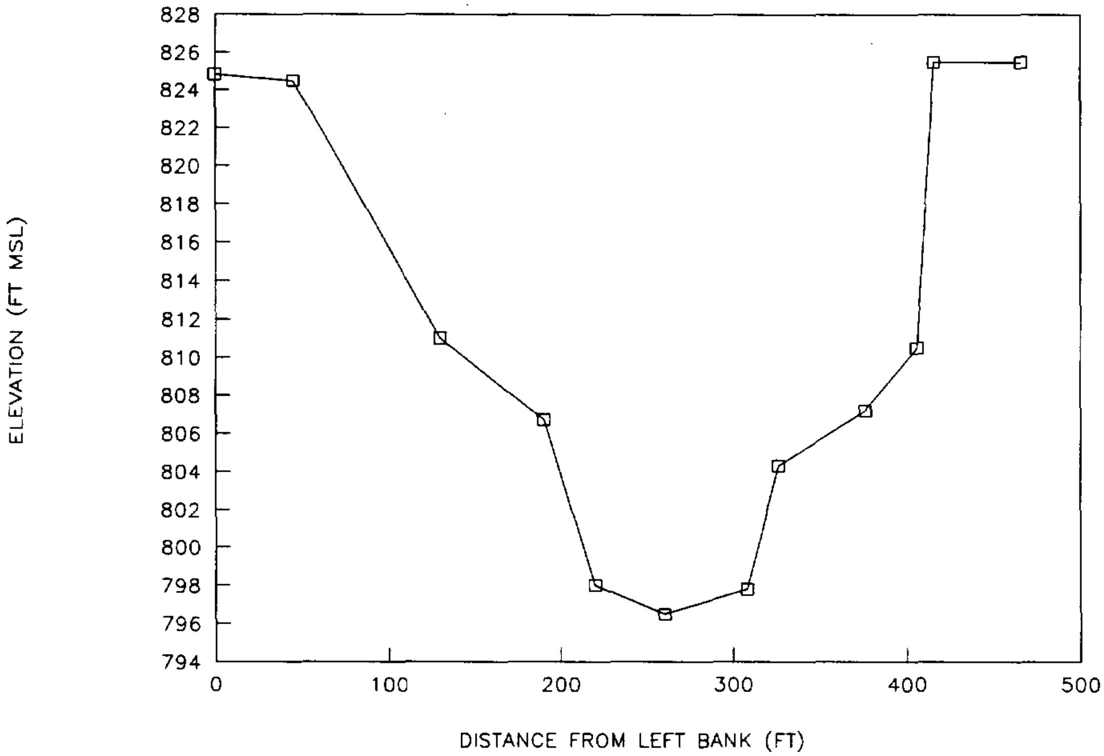

ONION CR. CROSS SECTION @ STA. 458+27.0

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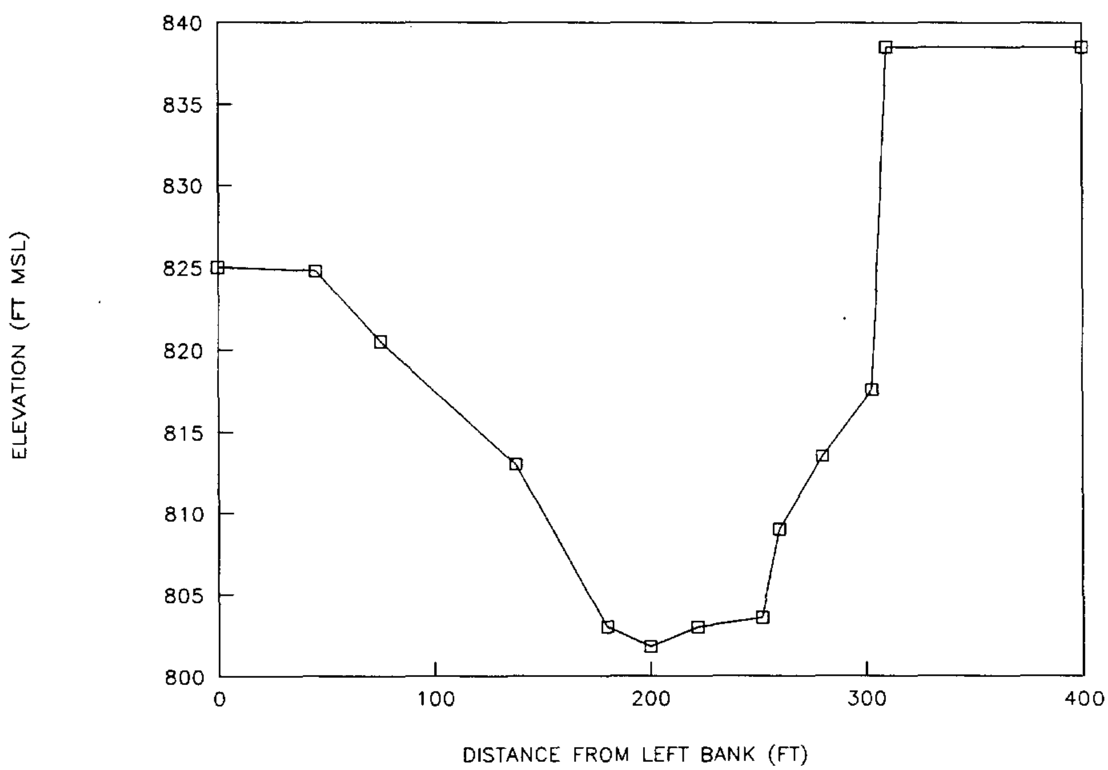

APPENDIX B:

STANDARD CAVE MAP SYMBOLS

ASSOCIATION FOR MEXICAN CAVE STUDIES
STANDARD CAVE MAP SYMBOLS, 1980

PASSAGE SYMBOLS	SIMBOLOS DE PASAJES
Passage walls	Pared del pasaje
Lower level passage	Pared de nivel inferior
Upper level passage	Pared de nivel superior
Unsurveyed passage; indefinite walls	Pasaje que no está levantado
Breakdown walls	Paredes de cantos rodados
Sharp drop in floor, down in hatchured direction	Tiro en el pasaje
Pit; if so indicated, entrance pit	Tiro, tiro de entrada
Cross section of passage, viewed in direction shown by half barbed arrow, and rotated to horizontal	Sección
Depth below entrance (or datum)	Profundidad bajo la entrada
Height above entrance (or datum)	Elevación arriba de la entrada
WATER SYMBOLS	**SIMBOLOS DE AGUA**
Direction and course of flowing stream	Chorro de agua corriendo
Direction and course of intermittent stream	Chorro seco
Standing water, lake or pool	Agua estancada
Intermittent or relict pool	Laguna seca
Sump (cross hatched)	Sifón
Large stream, rapids	Río, rápido
STAL SYMBOLS	**SIMBOLOS DE FORMACIONES**
Flowstone on floor; may indicate slope contours, with bulged side downslope	Piso de travertino
Rimstone dams, drawn to scale and shape when possible	Gours
Flowstone on walls	Paredes de travertino
Stalactite	Estalactita

CEILING SYMBOLS	SIMBOLOS DEL TECHO
Sharp drop in ceiling, hatchures point toward low ceiling	Techo bajo
Dome	Domo
FLOOR SYMBOLS	**SIMBOLOS DEL PISO**
Bedrock floor	Piso de piedra
Mud or clay	Lodo, barro
Sand or silt	Arena
Gravel	Grava
Rounded stream cobbles	Guijarros
Talus	Piedras
Breakdown	Rocas
Large breakdown, drawn to shape and scale	Cantos rodados
Guano	Guano
Pottery or other archeological material	Materia arqueológica
Slope, down in splayed direction	Pendiente
Organic debris	Materia orgánica
Trail	Vereda
Survey station, survey datum point	Estación topográfica
GEOLOGY SYMBOLS	**SIMBOLOS DE GEOLOGIA**
Strike and dip of strata; dip in degrees	Estratos
Vertical joint	Fractura
Dipping joint	Fractura inclinada
Fault, D side moved down relative to U side	Falla

BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
1941	JAN	7851	----	2468
	FEB	28761	----	10700
	MAR	34471	----	12948
	APR	33673	----	12634
	MAY	45662	----	17353
	JUN	35859	----	13494
	JUL	10891	----	3666
	AUG	3564	----	782
	SEP	2376	----	314
	OCT	6210	----	1824
	NOV	2585	----	396
	DEC	2106	----	208
1942	JAN	1815	----	93
	FEB	1747	----	67
	MAR	1823	----	97
	APR	12579	----	4330
	MAY	4757	----	1252
	JUN	2668	----	429
	JUL	1761	----	72
	AUG	3804	----	876
	SEP	22611	----	8280
	OCT	15743	----	5576
	NOV	9624	----	3167
	DEC	6576	----	1968
1943	JAN	5211	----	1430
	FEB	3574	----	786
	MAR	4403	----	1112
	APR	5652	----	1604
	MAY	3584	----	790
	JUN	2765	----	467
	JUL	3881	----	907
	AUG	1480	----	0
	SEP	2885	----	515
	OCT	1547	----	0
	NOV	1225	----	0
	DEC	1176	----	0
1944	JAN	5261	----	1450
	FEB	13876	----	4841
	MAR	21553	----	7863
	APR	11720	----	3992
	MAY	19247	----	6955
	JUN	13367	----	4641
	JUL	4942	----	1324
	AUG	8665	----	2790
	SEP	10552	----	3533
	OCT	2858	----	504
	NOV	3034	----	573
	DEC	15494	----	5478
1945	JAN	20555	----	7470
	FEB	22362	----	8181
	MAR	30328	----	11317
	APR	16652	----	5934
	MAY	7684	----	2404
	JUN	5682	----	1616
	JUL	3772	----	864
	AUG	2066	----	192
	SEP	2019	----	174

Common period of records for Blanco River at Wimberley and Onion Creek at Driftwood is July 1979 to December 1988. Driftwood generated streamflows based on Blanco River at Wimberley - Generated flows of less than zero for the Driftwood Gage were set to zero.

BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	OCT	3172	----	628
	NOV	2019	----	174
	DEC	6090	----	1776
1946	JAN	6229	----	1831
	FEB	10869	----	3657
	MAR	16435	----	5849
	APR	8430	----	2698
	MAY	7429	----	2303
	JUN	5058	----	1370
	JUL	2848	----	500
	AUG	2118	----	213
	SEP	3424	----	727
	OCT	4730	----	1241
	NOV	30217	----	11273
	DEC	20180	----	7322
1947	JAN	24294	----	8942
	FEB	13453	----	4675
	MAR	9396	----	3078
	APR	6810	----	2060
	MAY	5088	----	1382
	JUN	3273	----	668
	JUL	2048	----	185
	AUG	1728	----	59
	SEP	1310	----	0
	OCT	1308	----	0
	NOV	1225	----	0
	DEC	1271	----	0
1948	JAN	1179	----	0
	FEB	1152	----	0
	MAR	970	----	0
	APR	978	----	0
	MAY	3934	----	928
	JUN	1364	----	0
	JUL	1216	----	0
	AUG	697	----	0
	SEP	611	----	0
	OCT	1939	----	142
	NOV	786	----	0
	DEC	792	----	0
1949	JAN	928	----	0
	FEB	2525	----	373
	MAR	2933	----	534
	APR	17445	----	6246
	MAY	11033	----	3722
	JUN	3317	----	685
	JUL	1937	----	142
	AUG	1352	----	0
	SEP	859	----	0
	OCT	988	----	0
	NOV	867	----	0
	DEC	976	----	0
1950	JAN	906	----	0
	FEB	1660	----	33
	MAR	1082	----	0
	APR	2695	----	440
	MAY	3841	----	891
	JUN	2559	----	386

Common period of records for Blanco River at Wimberley and Onion Creek at Driftwood is July 1979 to December 1988. Driftwood generated streamflows based on Blanco River at Wimberley - Generated flows of less than zero for the Driftwood Gage were set to zero.

BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	JUL	1453	----	0
	AUG	936	----	0
	SEP	842	----	0
	OCT	722	----	0
	NOV	682	----	0
	DEC	660	----	0
1951	JAN	623	----	0
	FEB	612	----	0
	MAR	826	----	0
	APR	826	----	0
	MAY	1147	----	0
	JUN	3188	----	634
	JUL	498	----	0
	AUG	358	----	0
	SEP	782	----	0
	OCT	436	----	0
	NOV	524	----	0
	DEC	533	----	0
1952	JAN	475	----	0
	FEB	492	----	0
	MAR	551	----	0
	APR	2412	----	329
	MAY	6166	----	1806
	JUN	4744	----	1246
	JUL	1459	----	0
	AUG	664	----	0
	SEP	83896	----	32403
	OCT	3825	----	885
	NOV	2767	----	468
	DEC	4801	----	1269
1953	JAN	7595	----	2369
	FEB	3950	----	934
	MAR	3649	----	816
	APR	5203	----	1427
	MAY	3234	----	652
	JUN	1540	----	0
	JUL	1148	----	0
	AUG	3594	----	794
	SEP	12709	----	4382
	OCT	3734	----	849
	NOV	3835	----	889
	DEC	4437	----	1126
1954	JAN	2826	----	491
	FEB	2106	----	208
	MAR	1757	----	71
	APR	1334	----	0
	MAY	1049	----	0
	JUN	678	----	0
	JUL	530	----	0
	AUG	471	----	0
	SEP	439	----	0
	OCT	667	----	0
	NOV	465	----	0
	DEC	594	----	0
1955	JAN	701	----	0
	FEB	823	----	0
	MAR	570	----	0

Common period of records for Blanco River at Wimberley and Onion Creek at Driftwood is July 1979 to December 1988. Driftwood generated streamflows based on Blanco River at Wimberley - Generated flows of less than zero for the Driftwood Gage were set to zero.

BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	APR	498	----	0
	MAY	5660	----	1607
	JUN	1031	----	0
	JUL	602	----	0
	AUG	609	----	0
	SEP	447	----	0
	OCT	398	----	0
	NOV	440	----	0
	DEC	483	----	0
1956	JAN	408	----	0
	FEB	467	----	0
	MAR	364	----	0
	APR	308	----	0
	MAY	768	----	0
	JUN	204	----	0
	JUL	104	----	0
	AUG	177	----	0
	SEP	548	----	0
	OCT	2172	----	234
	NOV	1751	----	68
	DEC	1623	----	18
1957	JAN	562	----	0
	FEB	1404	----	0
	MAR	11495	----	3904
	APR	56569	----	21646
	MAY	20524	----	7458
	JUN	21868	----	7987
	JUL	3602	----	797
	AUG	1714	----	54
	SEP	14142	----	4946
	OCT	29119	----	10841
	NOV	23546	----	8647
	DEC	15392	----	5438
1958	JAN	14502	----	5087
	FEB	27729	----	10294
	MAR	28531	----	10610
	APR	14253	----	4989
	MAY	66040	----	25375
	JUN	18674	----	6730
	JUL	6422	----	1907
	AUG	3285	----	672
	SEP	9673	----	3187
	OCT	9798	----	3236
	NOV	14156	----	4951
	DEC	6790	----	2052
1959	JAN	5062	----	1372
	FEB	6746	----	2035
	MAR	6568	----	1965
	APR	13006	----	4499
	MAY	7388	----	2287
	JUN	6814	----	2061
	JUL	3746	----	854
	AUG	3685	----	830
	SEP	2573	----	392
	OCT	23057	----	8455
	NOV	4583	----	1183
	DEC	6097	----	1779

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
1960	JAN	9903	----	3277
	FEB	12572	----	4328
	MAR	9515	----	3124
	APR	8322	----	2655
	MAY	5804	----	1664
	JUN	3883	----	907
	JUL	5632	----	1596
	AUG	5866	----	1688
	SEP	3214	----	644
	OCT	46787	----	17796
	NOV	19020	----	6866
	DEC	27530	----	10216
1961	JAN	23540	----	8645
	FEB	51926	----	19819
	MAR	19616	----	7100
	APR	8508	----	2728
	MAY	5149	----	1406
	JUN	23445	----	8608
	JUL	9582	----	3151
	AUG	5302	----	1466
	SEP	4269	----	1059
	OCT	3831	----	887
	NOV	3420	----	725
	DEC	3299	----	678
1962	JAN	3087	----	594
	FEB	2446	----	342
	MAR	2628	----	414
	APR	2715	----	448
	MAY	2680	----	434
	JUN	10061	----	3339
	JUL	2957	----	543
	AUG	1553	----	0
	SEP	2563	----	388
	OCT	1759	----	72
	NOV	1490	----	0
	DEC	2830	----	493
1963	JAN	2258	----	268
	FEB	1922	----	135
	MAR	1908	----	130
	APR	6321	----	1867
	MAY	2474	----	353
	JUN	1267	----	0
	JUL	843	----	0
	AUG	732	----	0
	SEP	699	----	0
	OCT	727	----	0
	NOV	725	----	0
	DEC	823	----	0
1964	JAN	737	----	0
	FEB	1134	----	0
	MAR	2632	----	415
	APR	1767	----	75
	MAY	1223	----	0
	JUN	1213	----	0
	JUL	570	----	0
	AUG	533	----	0
	SEP	2332	----	297

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	OCT	1856	----	110
	NOV	3612	----	801
	DEC	1559	----	0
1965	JAN	3394	----	715
	FEB	21254	----	7745
	MAR	7471	----	2320
	APR	13831	----	4823
	MAY	46181	----	17557
	JUN	33971	----	12751
	JUL	6277	----	1850
	AUG	4005	----	956
	SEP	4629	----	1201
	OCT	8674	----	2793
	NOV	6062	----	1765
	DEC	22376	----	8187
1966	JAN	11086	----	3743
	FEB	11070	----	3737
	MAR	11646	----	3963
	APR	14078	----	4921
	MAY	13875	----	4841
	JUN	5878	----	1693
	JUL	4095	----	991
	AUG	2994	----	558
	SEP	4769	----	1256
	OCT	3232	----	651
	NOV	2345	----	302
	DEC	2090	----	202
1967	JAN	1920	----	135
	FEB	1546	----	0
	MAR	1569	----	0
	APR	1538	----	0
	MAY	1702	----	49
	JUN	1088	----	0
	JUL	699	----	0
	AUG	558	----	0
	SEP	2992	----	557
	OCT	4381	----	1104
	NOV	8628	----	2775
	DEC	4920	----	1316
1968	JAN	69593	----	26773
	FEB	19659	----	7117
	MAR	16394	----	5832
	APR	14171	----	4957
	MAY	19101	----	6898
	JUN	10041	----	3332
	JUL	5680	----	1615
	AUG	3366	----	704
	SEP	3404	----	719
	OCT	2953	----	541
	NOV	2365	----	310
	DEC	3428	----	728
1969	JAN	2553	----	384
	FEB	3443	----	735
	MAR	5599	----	1583
	APR	9984	----	3309
	MAY	17536	----	6282
	JUN	9758	----	3220

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	JUL	4522	----	1159
	AUG	3251	----	659
	SEP	2846	----	499
	OCT	5646	----	1602
	NOV	3796	----	873
	DEC	7742	----	2426
1970	JAN	6550	----	1958
	FEB	11530	----	3917
	MAR	24058	----	8849
	APR	10906	----	3672
	MAY	29839	----	11125
	JUN	16382	----	5827
	JUL	5654	----	1605
	AUG	3532	----	770
	SEP	3063	----	585
	OCT	3253	----	660
	NOV	2252	----	266
	DEC	2121	----	214
1971	JAN	1734	----	61
	FEB	1411	----	0
	MAR	1464	----	0
	APR	1330	----	0
	MAY	1156	----	0
	JUN	883	----	0
	JUL	732	----	0
	AUG	1162	----	0
	SEP	1051	----	0
	OCT	3891	----	911
	NOV	4686	----	1224
	DEC	10847	----	3649
1972	JAN	5820	----	1670
	FEB	3734	----	849
	MAR	3115	----	605
	APR	2209	----	248
	MAY	16196	----	5754
	JUN	8630	----	2776
	JUL	4560	----	1174
	AUG	3873	----	904
	SEP	2408	----	327
	OCT	3887	----	909
	NOV	5688	----	1618
	DEC	4651	----	1210
1973	JAN	7237	----	2228
	FEB	12095	----	4140
	MAR	13584	----	4726
	APR	13884	----	4844
	MAY	12402	----	4261
	JUN	33825	----	12693
	JUL	57384	----	21967
	AUG	12311	----	4225
	SEP	8001	----	2529
	OCT	53525	----	20448
	NOV	17656	----	6329
	DEC	8945	----	2900
1974	JAN	6928	----	2106
	FEB	6048	----	1760
	MAR	5327	----	1476

Common period of records for Blanco River at Wimberley and Onion Creek at Driftwood is July 1979 to December 1988. Driftwood generated streamflows based on Blanco River at Wimberley - Generated flows of less than zero for the Driftwood Gage were set to zero.

BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	APR	4267	----	1059
	MAY	4360	----	1095
	JUN	3010	----	564
	JUL	2068	----	193
	AUG	4395	----	1109
	SEP	7358	----	2275
	OCT	6258	----	1842
	NOV	13396	----	4652
	DEC	8842	----	2860
1975	JAN	10631	----	3564
	FEB	37814	----	14264
	MAR	12420	----	4268
	APR	9230	----	3012
	MAY	33369	----	12514
	JUN	32716	----	12257
	JUL	17544	----	6285
	AUG	8820	----	2851
	SEP	6024	----	1750
	OCT	6358	----	1882
	NOV	6014	----	1746
	DEC	4562	----	1175
1976	JAN	4217	----	1039
	FEB	3487	----	752
	MAR	4358	----	1094
	APR	25236	----	9313
	MAY	30270	----	11294
	JUN	16093	----	5714
	JUL	19251	----	6957
	AUG	9703	----	3198
	SEP	6048	----	1760
	OCT	11110	----	3752
	NOV	16170	----	5744
	DEC	16710	----	5957
1977	JAN	14512	----	5091
	FEB	16613	----	5919
	MAR	11929	----	4075
	APR	50980	----	19446
	MAY	20926	----	7616
	JUN	9881	----	3269
	JUL	5735	----	1637
	AUG	3550	----	777
	SEP	2858	----	504
	OCT	4128	----	1004
	NOV	3204	----	640
	DEC	2848	----	500
1978	JAN	2598	----	402
	FEB	2569	----	390
	MAR	2424	----	333
	APR	2349	----	304
	MAY	1957	----	149
	JUN	4277	----	1062
	JUL	1320	----	0
	AUG	2179	----	237
	SEP	6857	----	2078
	OCT	2828	----	492
	NOV	3356	----	700
	DEC	3624	----	805

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
1979	JAN	16334	----	5809
	FEB	20874	----	7596
	MAR	39128	----	14781
	APR	37753	----	14240
	MAY	27923	----	10371
	JUN	13683	----	4765
	JUL	9524	1220	----
	AUG	5850	476	----
	SEP	4582	241	----
	OCT	3784	173	----
	NOV	3005	102	----
	DEC	2775	109	----
1980	JAN	2496	126	----
	FEB	2416	161	----
	MAR	2636	223	----
	APR	3574	599	----
	MAY	8286	4660	----
	JUN	4582	1880	----
	JUL	2556	142	----
	AUG	1448	59	----
	SEP	2466	681	----
	OCT	4622	1610	----
	NOV	2685	1030	----
	DEC	2895	2040	----
1981	JAN	2616	1550	----
	FEB	2935	1790	----
	MAR	11520	7260	----
	APR	5521	2920	----
	MAY	4193	1910	----
	JUN	57272	26540	----
	JUL	11740	5020	----
	AUG	4822	718	----
	SEP	3195	592	----
	OCT	21124	4100	----
	NOV	8515	1500	----
	DEC	5151	827	----
1982	JAN	3913	577	----
	FEB	3145	400	----
	MAR	3045	297	----
	APR	2805	435	----
	MAY	20665	7320	----
	JUN	5840	1260	----
	JUL	3125	399	----
	AUG	2955	78	----
	SEP	1697	95	----
	OCT	1757	61	----
	NOV	2166	105	----
	DEC	2076	156	----
1983	JAN	1837	511	----
	FEB	2785	1590	----
	MAR	8486	6200	----
	APR	7657	3760	----
	MAY	9723	2960	----
	JUN	10322	3000	----
	JUL	5590	2030	----
	AUG	3454	762	----
	SEP	2895	686	----

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	OCT	4393	658	----
	NOV	3015	351	----
	DEC	2626	329	----
1984	JAN	2755	306	----
	FEB	2356	246	----
	MAR	2196	354	----
	APR	1527	186	----
	MAY	1418	164	----
	JUN	1947	276	----
	JUL	962	59	----
	AUG	810	6.3	----
	SEP	780	2.8	----
	OCT	3764	2200	----
	NOV	2556	1200	----
	DEC	7188	4810	----
1985	JAN	17141	10300	----
	FEB	16781	9780	----
	MAR	22092	11050	----
	APR	11610	4810	----
	MAY	5800	1400	----
	JUN	49625	11070	----
	JUL	14405	3030	----
	AUG	4932	422	----
	SEP	3474	215	----
	OCT	5860	1480	----
	NOV	10043	5110	----
	DEC	16861	9720	----
1986	JAN	8256	2260	----
	FEB	11960	4390	----
	MAR	6609	2010	----
	APR	4393	677	----
	MAY	19058	9490	----
	JUN	13896	7270	----
	JUL	5181	1580	----
	AUG	3284	381	----
	SEP	21903	317	----
	OCT	30778	6720	----
	NOV	15753	4050	----
	DEC	51622	19160	----
1987	JAN	24189	9140	----
	FEB	13537	4750	----
	MAR	19996	9610	----
	APR	9454	3520	----
	MAY	12409	3010	----
	JUN	115803	47140	----
	JUL	25906	6000	----
	AUG	7527	1350	----
	SEP	4842	394	----
	OCT	4203	42	----
	NOV	6339	1190	----
	DEC	5071	439	----
1988	JAN	4932	543	----
	FEB	3624	402	----
	MAR	3604	450	----
	APR	3025	326	----
	MAY	7417	289	----
	JUN	5660	178	----

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BLANCO RIVER AT WIMBERLEY AND ONION CREEK AT DRIFTWOOD
MONTHLY STREAMFLOWS

YEAR	MONTH	WIMBERLEY ACTUAL (AF)	DRIFTWOOD ACTUAL (AF)	DRIFTWOOD GENERATED (AF)
	JUL	4273	104	----
	AUG	4652	98	----
	SEP	2116	21	----
	OCT	1817	15	----
	NOV	1527	6	----
	DEC	1428	6.3	----

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APPENDIX D:

GENERATED DAILY STREAMFLOWS FOR
ONION CREEK NEAR DRIFTWOOD

GENERATED DAILY STREAMFLOWS FOR ONION CREEK NEAR DRIFTWOOD
PERIOD OF RECORD JANUARY 1, 1941 THROUGH JUNE 30, 1979
AND RECORDED STREAMFLOWS FOR ONION CREEK NEAR DRIFTWOOD
FOR JULY 1, 1979 THROUGH DECEMBER 31, 1988

YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1941	1	1	63.4	60.3	57.1	54.9	52.7	49.9	47.7	45.8	
1941	1	2	43.6	41.8	40.8	39.6	39.6	47.7	43.6	39.6	
1941	1	3	36.7	35.2	34.2	35.2	34.2	33.3	31.4	31.4	
1941	1	4	29.8	29.8	29.8	29.8	29.8	27.9	27.9		1245
1941	2	1	1311.7	460.8	267.2	221.1	194.7	189.1	166.5	164.6	
1941	2	2	170.2	147.9	135.6	127.1	123.7	110.7	106.3	101.8	
1941	2	3	100.3	97.4	92.9	91.8	87.3	87.3	158.3	179.5	
1941	2	4	139.0	130.4	120.4	114.1					5398
1941	3	1	111.8	108.8	108.8	104.3	98.3	274.6	185.0	131.7	
1941	3	2	124.9	121.6	110.3	107.3	104.3	99.8	98.3	96.8	
1941	3	3	162.1	1054.2	446.4	361.3	304.3	279.5	251.7	227.7	
1941	3	4	213.1	238.6	251.7	204.8	191.0	183.1	175.6		6532
1941	4	1	167.9	162.3	194.5	152.9	142.0	142.0	167.9	130.0	
1941	4	2	121.4	115.0	110.2	107.2	110.2	108.7	107.2	101.2	
1941	4	3	101.2	95.2	93.7	91.1	98.2	116.5	105.7	105.7	
1941	4	4	93.7	539.6	1165.5	697.0	513.4	416.0			6373
1941	5	1	353.8	535.2	1146.3	497.2	493.5	573.2	365.5	318.1	
1941	5	2	285.1	257.0	584.5	394.8	261.5	232.3	211.0	197.0	
1941	5	3	189.0	179.5	171.9	160.6	153.0	154.9	145.4	135.1	
1941	5	4	124.9	118.0	111.6	107.0	102.5	99.4	94.9		8754
1941	6	1	88.3	85.7	84.2	85.7	78.9	78.9	1789.1	217.2	
1941	6	2	172.1	230.0	207.1	160.9	240.9	131.9	125.2	815.6	
1941	6	3	240.6	175.9	153.4	139.1	128.5	121.8	118.8	107.5	
1941	6	4	101.5	272.1	315.7	128.5	110.5	101.5			6807
1941	7	1	84.1	80.4	87.1	110.0	76.7	70.6	66.9	64.6	
1941	7	2	61.2	58.8	59.9	59.9	65.2	114.7	81.0	112.6	
1941	7	3	64.6	51.1	47.7	44.7	42.4	41.4	39.3	38.3	
1941	7	4	36.7	35.6	33.6	31.9	30.9	29.3	28.2		1849
1941	8	1	17.3	16.6	16.2	16.2	16.2	16.2	16.2	15.5	
1941	8	2	15.1	14.4	14.0	13.6	13.1	12.5	12.5	12.0	
1941	8	3	11.6	11.6	11.2	11.2	10.7	10.7	10.7	10.7	
1941	8	4	10.7	10.3	9.6	9.4	9.4	9.4	9.4		394
1941	9	1	5.7	5.7	5.4	5.4	5.4	5.2	5.2	5.2	
1941	9	2	5.8	5.7	5.4	5.4	5.4	5.4	5.4	5.4	
1941	9	3	5.8	5.4	5.4	5.4	5.4	5.2	5.2	5.2	
1941	9	4	4.9	4.9	4.9	4.6	4.6	4.6			159
1941	10	1	20.5	15.0	12.9	272.3	115.8	39.0	27.8	23.2	
1941	10	2	21.7	22.3	20.8	18.8	18.2	17.6	16.7	16.7	
1941	10	3	16.1	16.1	16.1	16.7	16.7	16.1	16.1	16.1	
1941	10	4	16.7	16.1	16.1	16.1	15.5	15.0	15.0		920
1941	11	1	7.8	7.8	7.5	7.5	7.2	7.2	6.7	6.6	
1941	11	2	6.6	6.7	6.6	6.6	6.6	6.6	6.6	6.6	
1941	11	3	6.3	6.3	6.3	6.6	6.6	6.6	6.6	6.4	
1941	11	4	6.4	6.3	6.3	6.1	6.1	6.0			200
1941	12	1	3.9	3.8	3.8	3.7	3.7	3.7	3.5	3.5	
1941	12	2	3.3	3.5	3.9	3.5	3.3	3.3	3.3	3.3	
1941	12	3	3.3	3.3	3.1	3.1	3.3	3.3	3.5	3.5	
1941	12	4	3.5	3.5	3.3	3.3	3.3	3.1	2.9		105
1942	1	1	1.6	1.7	1.7	1.7	1.6	1.6	1.6	1.5	
1942	1	2	1.5	1.5	1.4	1.3	1.3	1.3	1.3	1.3	
1942	1	3	1.3	1.5	1.6	1.6	1.6	1.6	1.5	1.5	
1942	1	4	1.5	1.5	1.7	1.6	1.5	1.6	1.6		47
1942	2	1	1.3	1.3	1.2	1.2	1.2	1.3	1.3	1.2	
1942	2	2	1.2	1.2	1.2	1.1	1.1	1.4	1.3	1.3	
1942	2	3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	
1942	2	4	1.1	1.1	1.1	1.1					34
1942	3	1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
1942	3	2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
1942	3	3	1.5	1.5	1.5	1.6	1.6	1.6	1.5	1.6	
1942	3	4	1.7	1.7	1.6	1.5	1.4	1.4	1.5		49
1942	4	1	9.3	9.3	9.3	9.3	9.3	10.0	29.2	959.5	
1942	4	2	86.3	51.2	41.3	35.4	31.6	28.2	26.1	24.4	
1942	4	3	23.7	22.7	22.0	22.0	21.3	20.6	22.0	26.1	
1942	4	4	392.0	89.8	47.8	39.2	33.7	31.6			2184
1942	5	1	22.1	21.5	20.8	21.5	20.8	19.4	20.0	23.4	
1942	5	2	27.1	22.9	21.5	22.1	21.5	20.8	19.4	18.1	
1942	5	3	18.6	18.6	20.8	19.4	18.1	16.8	16.3	16.3	
1942	5	4	44.9	22.9	16.8	15.8	15.0	14.4	13.9		631

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1942	6	1	8.2	8.2	8.2	8.2	8.0	8.0	7.9	7.9	
1942	6	2	7.7	7.7	7.5	7.5	7.4	7.4	7.2	7.2	
1942	6	3	7.1	7.1	6.9	6.9	6.7	6.7	6.6	6.6	
1942	6	4	6.4	6.4	6.3	6.3	6.1	6.1			216
1942	7	1	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	
1942	7	2	1.4	1.4	1.3	1.2	1.2	1.2	1.1	1.1	
1942	7	3	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	
1942	7	4	1.0	1.0	0.9	0.9	0.9	0.9	0.9		37
1942	8	1	4.8	4.6	4.6	4.4	4.4	4.1	4.1	4.1	
1942	8	2	4.1	4.1	4.1	3.7	3.7	3.7	3.7	4.4	
1942	8	3	4.8	4.8	6.9	7.1	5.1	227.7	44.2	17.0	
1942	8	4	10.8	8.5	7.6	7.1	6.7	8.0	9.0		442
1942	9	1	11.3	10.6	35.5	17.9	15.7	19.4	66.6	1821.5	
1942	9	2	501.1	194.2	131.7	106.1	91.4	101.7	80.5	71.7	
1942	9	3	65.1	60.4	58.2	122.9	116.7	71.7	61.4	56.7	
1942	9	4	53.4	51.9	48.6	46.1	43.9	42.8			4177
1942	10	1	40.3	46.0	44.6	271.0	167.0	102.6	84.5	76.4	
1942	10	2	70.4	66.5	63.0	60.8	57.3	54.8	78.9	106.8	
1942	10	3	79.2	224.3	140.8	108.6	99.8	91.3	86.0	80.7	
1942	10	4	80.7	76.4	71.5	72.9	70.4	69.3	70.4		2813
1942	11	1	58.5	56.6	54.3	53.3	53.3	52.3	49.0	48.0	
1942	11	2	46.7	45.7	42.8	41.4	41.4	41.4	40.5	40.5	
1942	11	3	38.5	37.5	36.8	36.8	103.9	189.1	64.5	55.3	
1942	11	4	52.3	44.7	43.7	44.7	43.7	40.5			1598
1942	12	1	36.7	35.8	35.8	34.9	34.1	32.6	32.3	32.3	
1942	12	2	32.0	31.7	30.8	29.9	29.3	28.4	27.5	27.5	
1942	12	3	26.6	26.6	26.6	26.0	27.5	63.3	37.6	33.5	
1942	12	4	31.7	32.6	30.8	30.8	29.3	29.3	29.3		993
1943	1	1	26.1	26.1	25.2	24.4	23.0	25.2	26.9	26.1	
1943	1	2	24.4	24.4	23.9	24.4	26.1	25.2	23.9	24.4	
1943	1	3	23.0	22.5	22.2	22.2	21.9	21.7	21.7	21.4	
1943	1	4	21.1	21.1	20.9	20.9	20.6	20.3	20.3		722
1943	2	1	16.1	15.8	15.8	15.6	15.4	15.4	15.2	15.0	
1943	2	2	15.0	14.7	14.7	14.5	14.3	14.3	14.1	13.9	
1943	2	3	13.9	13.6	13.6	13.6	13.2	13.2	13.2	13.2	
1943	2	4	12.5	12.1	12.1	12.5					396
1943	3	1	14.4	14.4	13.9	13.4	13.9	13.9	13.9	13.9	
1943	3	2	13.4	13.4	13.4	13.4	12.9	12.9	12.9	12.9	
1943	3	3	12.9	12.4	12.4	12.4	12.4	11.9	11.9	12.9	
1943	3	4	118.2	35.8	18.7	18.7	18.7	17.9	17.4		561
1943	4	1	19.5	19.5	19.5	18.7	18.1	18.1	18.1	95.2	
1943	4	2	63.7	38.5	34.0	30.9	28.3	26.9	26.1	26.9	
1943	4	3	26.9	26.1	24.6	23.8	23.2	23.2	22.4	21.5	
1943	4	4	21.0	20.1	19.5	18.7	18.1	17.6			809
1943	5	1	13.7	12.6	12.1	11.7	11.2	11.2	11.2	11.2	
1943	5	2	10.8	40.5	24.0	15.6	12.6	12.1	11.7	11.2	
1943	5	3	10.8	10.4	10.4	10.4	10.4	12.1	12.1	12.1	
1943	5	4	11.9	11.5	11.2	10.8	10.6	10.4	9.9		398
1943	6	1	7.4	7.1	6.9	24.3	9.3	8.6	8.4	8.4	
1943	6	2	8.3	8.1	7.9	7.9	7.9	7.8	7.8	7.6	
1943	6	3	7.4	7.3	7.1	7.1	6.9	6.9	6.6	6.6	
1943	6	4	6.2	6.2	6.2	5.9	5.9	5.6			236
1943	7	1	7.7	7.7	7.2	6.8	6.8	6.3	6.3	6.3	
1943	7	2	6.1	6.1	9.8	111.0	85.4	28.7	16.1	12.4	
1943	7	3	11.4	10.3	10.0	9.6	9.1	8.6	8.2	7.7	
1943	7	4	7.7	7.7	7.7	7.2	7.7	7.2	6.8		457
1943	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1943	9	1	5.0	7.8	10.2	14.4	7.3	6.6	6.2	6.2	
1943	9	2	5.9	6.2	6.2	5.9	5.5	5.5	4.8	5.2	
1943	9	3	51.3	18.5	9.8	7.8	7.7	6.9	6.9	6.6	
1943	9	4	6.6	6.6	6.9	5.5	4.3	5.2			260
1943	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1943	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1943	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1943	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1943	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1944	1	1	11.3	17.1	14.6	12.1	12.1	11.8	11.3	10.7	
1944	1	2	11.3	11.3	10.2	11.3	12.1	12.9	12.9	12.9	
1944	1	3	14.1	14.6	14.6	14.1	13.5	12.9	12.9	51.2	
1944	1	4	105.8	56.8	49.0	41.9	45.5	44.6	43.8		731
1944	2	1	51.9	51.9	50.8	49.5	47.4	46.3	43.9	47.4	
1944	2	2	46.3	48.4	48.4	45.3	45.3	52.9	52.9	52.9	
1944	2	3	52.9	50.8	49.5	49.5	49.5	50.8	50.8	51.9	
1944	2	4	525.9	235.1	157.8	180.1	156.0				2442
1944	3	1	139.6	129.8	123.2	123.2	108.6	108.6	102.8	92.6	
1944	3	2	91.1	111.9	116.6	102.8	98.4	91.1	113.4	163.3	
1944	3	3	129.8	121.4	131.2	124.6	115.2	231.1	195.0	166.9	
1944	3	4	156.0	145.1	139.6	131.2	127.9	118.1	116.6		3967
1944	4	1	102.8	100.0	97.3	90.5	89.1	85.1	81.3	80.0	
1944	4	2	78.6	77.6	73.5	70.1	67.7	67.7	66.7	62.9	
1944	4	3	59.5	59.5	56.1	55.1	54.1	51.7	51.7	50.7	
1944	4	4	48.3	47.3	46.3	44.2	44.2	54.1			2014
1944	5	1	59.6	54.9	51.3	56.0	60.7	54.9	49.1	44.4	
1944	5	2	69.3	78.0	56.0	50.2	48.0	46.9	45.5	43.3	
1944	5	3	42.2	41.2	42.2	42.2	45.5	62.1	56.0	46.9	
1944	5	4	52.7	877.3	179.8	588.5	214.8	183.8	165.4		3509
1944	6	1	143.2	129.7	121.7	114.1	104.7	124.8	109.6	100.6	
1944	6	2	93.6	86.7	88.1	92.2	84.3	80.1	74.9	71.4	
1944	6	3	66.6	63.1	60.7	58.3	56.2	52.7	50.6	49.2	
1944	6	4	48.2	47.2	43.7	42.7	41.6	40.6			2341
1944	7	1	33.7	32.1	30.5	30.0	29.2	27.6	26.2	24.6	
1944	7	2	24.6	23.8	22.5	22.5	21.9	21.1	20.3	20.3	
1944	7	3	20.3	19.0	19.0	18.5	17.7	17.1	17.1	16.6	
1944	7	4	16.6	16.6	16.1	16.1	16.1	15.2	15.2		668
1944	8	1	17.7	17.1	16.4	16.4	16.4	15.8	15.8	15.1	
1944	8	2	14.2	14.2	14.2	14.2	14.2	13.8	13.8	13.2	
1944	8	3	13.2	13.2	11.9	11.3	10.6	10.6	10.0	10.0	
1944	8	4	9.3	9.3	22.5	334.6	239.1	186.0	273.5		1407
1944	9	1	208.7	146.5	107.0	90.3	81.3	79.9	152.5	163.2	
1944	9	2	114.4	93.0	77.2	65.5	55.2	47.5	39.1	34.4	
1944	9	3	28.1	23.7	20.7	17.7	15.7	14.7	13.7	13.7	
1944	9	4	13.0	13.0	13.0	13.0	13.0	13.0			1782
1944	10	1	6.9	6.9	10.9	10.7	10.6	10.4	10.2	10.0	
1944	10	2	9.9	9.5	9.3	9.2	9.0	8.8	8.6	8.5	
1944	10	3	8.3	8.1	7.9	7.7	7.6	7.2	7.0	6.9	
1944	10	4	6.7	6.5	6.3	6.2	6.2	6.2	6.2		254
1944	11	1	6.6	6.6	7.0	7.0	7.0	7.0	7.0	7.0	
1944	11	2	6.6	6.6	7.0	6.6	6.6	6.6	6.6	8.1	
1944	11	3	7.7	8.9	10.0	8.3	8.1	7.7	7.7	9.6	
1944	11	4	33.6	21.5	15.5	14.3	13.4	13.0			289
1944	12	1	23.3	23.3	22.6	112.7	769.8	174.1	124.0	99.6	
1944	12	2	88.3	80.5	72.7	69.2	66.4	62.9	60.7	58.3	
1944	12	3	56.1	53.7	51.6	49.1	49.1	48.0	47.0	47.0	
1944	12	4	49.1	51.6	76.6	70.3	70.3	67.8	67.8		2763
1945	1	1	66.1	63.5	62.4	61.0	58.8	59.9	58.8	56.3	
1945	1	2	54.1	53.0	53.0	51.6	51.6	53.0	51.6	49.4	
1945	1	3	56.3	827.8	289.4	209.9	192.4	166.3	153.6	144.5	
1945	1	4	137.6	127.4	120.9	117.6	111.5	106.7	102.4		3768
1945	2	1	100.1	98.7	97.2	98.7	108.9	95.8	91.4	85.9	
1945	2	2	84.4	84.4	80.4	438.6	209.4	169.2	154.6	147.3	
1945	2	3	165.6	163.7	174.7	172.9	197.4	172.9	161.9	158.3	
1945	2	4	158.3	154.6	156.4	145.5					4127
1945	3	1	144.6	142.8	592.6	243.4	209.5	191.6	174.4	170.7	
1945	3	2	165.1	159.5	155.8	148.3	150.2	148.3	626.2	203.5	
1945	3	3	176.3	176.3	167.0	155.8	148.3	141.3	139.4	137.9	
1945	3	4	129.3	122.6	119.3	115.9	114.4	114.4	124.1		5709
1945	4	1	262.3	152.3	126.7	120.3	112.5	112.5	110.7	107.5	
1945	4	2	106.1	104.6	101.8	100.4	97.5	93.2	94.7	94.7	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1945	4	3	89.0	85.1	81.1	82.2	89.0	86.5	81.1	79.7	
1945	4	4	78.3	74.7	70.8	69.8	65.8	62.3			2993
1945	5	1	53.7	52.5	53.7	58.7	50.6	48.4	47.5	46.5	
1945	5	2	44.3	45.6	45.6	43.4	41.5	39.3	38.4	36.5	
1945	5	3	35.6	35.0	34.0	34.0	34.0	34.0	34.0	32.2	
1945	5	4	30.6	28.7	28.7	27.2	26.2	26.2	25.6		1213
1945	6	1	23.3	23.3	22.4	26.1	26.1	25.3	22.4	21.6	
1945	6	2	21.0	29.2	56.8	43.1	50.5	32.4	26.1	23.8	
1945	6	3	23.3	29.2	44.0	31.8	27.0	25.3	23.3	22.4	
1945	6	4	21.0	20.2	19.6	18.7	18.2	17.6			815
1945	7	1	13.7	14.2	13.7	13.7	13.0	13.0	13.0	12.6	
1945	7	2	12.6	12.6	14.6	19.2	19.9	17.4	19.2	35.9	
1945	7	3	21.7	14.6	13.0	11.7	11.7	11.7	11.2	11.2	
1945	7	4	10.7	10.1	10.1	10.1	10.1	9.8	9.8		436
1945	8	1	4.0	3.6	3.6	3.4	3.4	3.4	3.3	3.4	
1945	8	2	3.3	3.1	3.1	3.1	2.9	2.9	2.9	2.7	
1945	8	3	2.9	2.7	2.7	2.7	2.7	2.5	2.5	2.5	
1945	8	4	2.5	2.7	2.9	2.7	2.7	6.2	4.1		97
1945	9	1	3.7	3.5	3.5	3.2	3.2	3.2	3.0	3.0	
1945	9	2	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	
1945	9	3	2.7	2.7	2.5	2.5	2.5	2.3	2.5	2.7	
1945	9	4	2.3	2.3	2.3	2.5	4.9	4.7			88
1945	10	1	8.7	8.5	7.7	7.3	10.1	14.0	9.3	8.5	
1945	10	2	11.3	22.5	17.2	14.6	13.0	12.2	10.9	10.5	
1945	10	3	10.1	9.7	9.7	9.3	8.7	8.5	8.5	8.7	
1945	10	4	8.7	8.5	8.5	8.5	7.7	7.7	7.7		317
1945	11	1	3.3	3.3	3.2	3.2	3.2	3.2	3.0	3.0	
1945	11	2	3.0	3.7	3.2	3.0	3.2	3.0	3.0	2.8	
1945	11	3	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	
1945	11	4	2.7	2.7	2.7	2.5	2.5	2.5			88
1945	12	1	8.5	294.5	139.4	41.4	27.7	22.2	19.2	18.1	
1945	12	2	16.6	15.5	15.5	15.5	16.0	15.5	15.5	14.9	
1945	12	3	14.3	14.3	13.7	13.7	13.7	13.7	13.7	13.7	
1945	12	4	12.8	12.8	12.8	12.8	12.8	12.8	12.5		896
1946	1	1	12.9	12.9	12.9	14.4	15.0	15.0	14.4	15.0	
1946	1	2	14.4	15.6	18.2	23.2	21.7	22.3	44.4	62.6	
1946	1	3	53.5	48.5	45.5	43.8	41.7	39.1	38.2	37.0	
1946	1	4	35.2	35.2	33.5	32.0	35.2	36.1	34.4		924
1946	2	1	36.6	35.6	35.6	37.6	37.6	36.6	34.6	35.6	
1946	2	2	35.6	39.3	38.3	37.6	37.6	35.6	34.6	34.6	
1946	2	3	36.6	342.6	142.1	104.5	96.1	90.7	84.0	77.6	
1946	2	4	75.2	73.9	71.6	66.8					1845
1946	3	1	68.2	64.7	63.2	63.2	62.2	59.7	57.5	54.0	
1946	3	2	52.9	51.9	51.9	426.3	237.3	137.8	113.7	100.2	
1946	3	3	90.2	83.5	81.0	78.2	75.7	74.6	71.8	70.7	
1946	3	4	90.2	148.8	101.2	86.3	82.1	78.2	73.2		2950
1946	4	1	63.6	60.1	59.1	56.9	54.9	52.7	50.8	49.5	
1946	4	2	47.6	47.6	44.4	47.6	43.4	42.5	40.2	40.2	
1946	4	3	39.3	37.4	35.8	34.8	37.4	45.4	56.9	49.5	
1946	4	4	41.5	38.3	36.4	34.8	33.9	38.3			1361
1946	5	1	40.2	38.1	35.3	32.8	31.9	32.8	31.9	31.9	
1946	5	2	31.0	29.4	28.5	27.5	28.5	28.5	44.3	52.6	
1946	5	3	75.5	58.2	42.1	37.1	34.7	32.8	31.9	31.0	
1946	5	4	35.3	69.6	41.2	35.3	31.9	31.0	29.4		1162
1946	6	1	29.2	41.9	30.3	24.1	22.7	22.7	22.2	21.4	
1946	6	2	27.9	28.7	26.5	22.2	20.6	19.2	18.7	17.8	
1946	6	3	17.3	17.3	17.3	37.3	20.6	23.5	23.5	23.5	
1946	6	4	22.2	20.6	19.2	17.8	17.8	17.3			691
1946	7	1	10.9	11.6	10.9	10.5	10.0	9.6	9.3	8.9	
1946	7	2	8.9	8.6	8.6	8.2	7.7	7.7	7.7	7.5	
1946	7	3	7.5	7.2	7.2	7.2	7.5	7.5	7.2	6.8	
1946	7	4	7.7	7.2	6.8	6.5	6.5	6.5	6.1		252
1946	8	1	4.1	3.9	3.7	3.5	3.3	3.3	3.5	3.5	
1946	8	2	3.3	3.3	3.3	3.1	3.1	2.9	2.9	2.9	
1946	8	3	2.9	2.9	2.9	2.9	3.1	2.9	2.9	2.9	
1946	8	4	3.1	2.9	3.5	3.7	5.7	6.4	4.7		107
1946	9	1	55.1	15.0	11.2	10.0	8.7	8.3	7.8	7.8	
1946	9	2	7.8	7.0	6.6	7.4	6.6	7.8	9.1	8.3	
1946	9	3	7.8	7.8	7.4	7.4	7.4	7.0	6.6	6.6	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1946	9	4	6.6	8.7	35.2	26.1	23.7	23.7			367
1946	10	1	22.8	20.7	19.4	32.5	33.0	29.3	27.0	26.2	
1946	10	2	25.7	24.9	22.8	21.5	20.7	19.4	19.4	19.9	
1946	10	3	19.4	18.6	18.1	17.3	16.8	16.2	16.2	16.2	
1946	10	4	15.7	14.9	14.9	14.4	14.4	13.9	13.9		626
1946	11	1	19.7	27.6	1411.6	454.4	148.2	114.3	99.1	89.0	
1946	11	2	227.6	320.7	159.4	130.7	114.3	103.5	97.6	644.3	
1946	11	3	197.4	159.4	141.2	125.9	115.8	105.0	99.1	94.6	
1946	11	4	90.5	84.9	83.4	79.3	75.2	73.0			5687
1946	12	1	67.0	64.5	63.4	60.9	59.8	58.7	56.1	55.1	
1946	12	2	52.9	127.5	623.1	286.5	197.8	171.3	156.9	144.2	
1946	12	3	130.4	119.2	117.4	114.5	105.1	99.3	96.4	93.5	
1946	12	4	90.6	88.0	85.1	79.7	77.2	76.1	76.1		3694
1947	1	1	74.2	74.2	74.2	72.0	72.0	72.0	70.5	70.5	
1947	1	2	89.3	122.4	119.1	116.1	116.1	112.8	109.5	109.5	
1947	1	3	177.5	303.1	313.1	273.7	235.5	218.6	210.5	200.6	
1947	1	4	183.0	172.0	162.8	155.4	151.8	144.4	134.1		4511
1947	2	1	121.8	115.5	114.1	111.0	104.8	104.8	102.0	96.4	
1947	2	2	93.7	89.5	89.5	88.1	84.3	81.5	79.1	76.3	
1947	2	3	74.9	73.9	72.8	71.5	69.0	68.0	65.2	64.2	
1947	2	4	61.7	60.7	60.7	63.1					2358
1947	3	1	58.2	54.0	53.0	53.0	52.0	49.7	54.9	54.0	
1947	3	2	50.7	48.7	47.7	48.7	46.4	44.5	43.5	43.5	
1947	3	3	42.5	54.0	69.6	59.5	53.0	50.7	50.7	49.7	
1947	3	4	47.7	45.5	45.5	45.5	45.5	45.5	45.5		1553
1947	4	1	41.1	42.0	41.1	40.2	39.3	38.0	38.0	38.0	
1947	4	2	38.0	38.0	37.1	36.2	35.3	35.3	35.3	34.4	
1947	4	3	33.8	32.9	32.9	32.0	32.0	31.1	30.2	29.6	
1947	4	4	28.7	28.7	29.6	30.2	30.2	29.6			1039
1947	5	1	26.6	24.1	23.6	22.2	21.4	21.4	20.6	20.6	
1947	5	2	20.6	21.4	21.4	20.6	20.6	20.6	20.1	29.6	
1947	5	3	24.1	24.9	24.1	24.1	21.4	20.6	23.6	26.8	
1947	5	4	22.8	23.6	22.2	21.4	20.6	20.6	20.6		697
1947	6	1	15.1	14.5	14.5	13.4	13.4	13.0	13.0	12.6	
1947	6	2	12.6	11.6	11.6	11.2	11.2	10.4	10.8	12.2	
1947	6	3	11.2	10.8	10.8	11.2	10.8	10.4	9.6	9.6	
1947	6	4	9.0	9.0	8.8	8.8	7.9	7.9			337
1947	7	1	3.5	3.3	3.2	3.3	3.3	3.2	3.2	3.2	
1947	7	2	3.2	3.2	3.2	3.5	3.5	3.3	3.2	3.0	
1947	7	3	2.8	3.0	4.9	3.0	2.8	2.6	2.6	2.6	
1947	7	4	2.4	2.4	2.4	2.4	2.4	2.4	2.3		93
1947	8	1	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	
1947	8	2	0.8	1.1	1.1	1.8	1.1	0.9	0.9	0.8	
1947	8	3	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
1947	8	4	0.9	1.1	1.1	1.1	1.1	1.1	1.0		30
1947	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1947	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1947	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1947	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1947	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1948	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1948	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	2	4	0.0	0.0	0.0	0.0	0.0				0

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1948	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1948	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1948	5	1	3.5	3.5	3.5	4.2	3.5	4.2	3.5	3.3	
1948	5	2	3.3	3.3	247.2	75.1	19.3	10.4	6.8	5.9	
1948	5	3	5.4	5.2	6.4	5.9	5.2	4.7	4.2	4.2	
1948	5	4	4.2	4.2	3.5	3.5	3.5	3.5	3.5		468
1948	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1948	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1948	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1948	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1948	10	1	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.6	
1948	10	2	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	
1948	10	3	38.0	7.6	2.6	1.5	1.2	1.2	1.1	1.0	
1948	10	4	1.0	1.0	1.0	1.0	1.0	1.0	0.9		72
1948	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1948	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1948	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1949	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1949	2	1	2.2	2.2	2.2	2.4	2.4	2.2	2.2	2.1	
1949	2	2	2.1	2.1	1.9	1.9	1.9	1.8	1.8	1.8	
1949	2	3	1.8	1.8	1.8	1.8	1.8	2.2	2.1	2.1	
1949	2	4	31.0	81.0	18.0	10.0					188
1949	3	1	8.5	6.9	5.8	5.1	5.1	4.9	4.5	4.5	
1949	3	2	4.4	4.0	4.0	3.6	4.4	4.5	3.6	3.6	
1949	3	3	3.6	3.5	3.5	3.5	4.4	4.5	6.5	5.8	
1949	3	4	5.4	64.7	38.3	16.9	12.0	10.2	8.9		269
1949	4	1	16.8	16.8	16.1	20.7	20.7	21.8	19.3	18.6	
1949	4	2	17.5	17.5	16.1	16.1	15.0	14.3	13.6	13.6	
1949	4	3	13.6	13.6	18.6	97.9	61.8	41.5	39.0	45.8	
1949	4	4	1658.5	237.7	171.2	198.7	153.7	124.7			3151
1949	5	1	106.1	93.6	83.2	77.5	71.7	67.4	63.3	61.0	
1949	5	2	56.9	207.8	86.2	58.3	51.9	48.5	45.8	42.4	
1949	5	3	42.4	42.4	39.1	36.7	35.7	34.7	32.3	30.3	
1949	5	4	29.3	41.4	32.3	139.8	58.3	33.7	27.6		1878
1949	6	1	15.2	14.0	13.6	12.6	12.0	12.0	12.0	12.0	
1949	6	2	11.1	10.7	10.1	10.7	12.6	11.1	11.1	18.5	
1949	6	3	12.6	10.1	9.3	8.7	8.2	7.8	7.4	7.0	
1949	6	4	8.2	22.0	16.9	10.7	9.3	7.8			345
1949	7	1	2.6	2.8	2.8	3.1	3.3	2.8	2.5	2.5	
1949	7	2	2.5	2.3	2.3	2.2	2.2	2.5	2.6	2.5	
1949	7	3	2.5	2.3	2.3	2.2	2.0	2.0	2.0	1.8	
1949	7	4	2.0	2.0	1.8	1.8	1.8	1.8	1.6		71
1949	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1949	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1949	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1949	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1949	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1949	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1949	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	2	1	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	
1950	2	2	0.3	0.3	0.4	2.5	1.5	1.0	0.8	0.7	
1950	2	3	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5	
1950	2	4	0.5	0.5	0.4	0.4					16
1950	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	4	1	2.6	5.4	7.7	8.0	4.4	3.9	3.6	3.3	
1950	4	2	3.3	3.1	3.1	2.6	2.8	3.6	2.8	4.1	
1950	4	3	23.6	15.6	8.8	6.8	6.5	6.8	18.9	16.8	
1950	4	4	10.8	9.5	9.1	8.5	8.5	7.7			222
1950	5	1	10.9	10.4	10.4	9.7	9.3	8.8	8.3	7.9	
1950	5	2	7.4	6.9	13.9	71.3	31.5	23.9	23.9	19.0	
1950	5	3	15.7	14.6	13.4	13.4	13.0	8.8	11.3	11.3	
1950	5	4	10.9	10.9	10.9	10.4	10.4	10.4	10.4		450
1950	6	1	7.4	7.4	7.8	7.1	7.8	9.9	17.5	11.2	
1950	6	2	9.2	7.8	7.4	7.1	6.8	5.7	6.0	6.3	
1950	6	3	5.7	5.4	5.4	5.1	4.8	4.2	4.2	4.2	
1950	6	4	4.2	4.1	3.8	3.8	3.6	3.8			195
1950	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1950	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1950	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1950	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1950	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1951	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	2	4	0.0	0.0	0.0	0.0					0
1951	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1951	5	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	6	1	3.2	3.0	43.1	8.1	5.6	4.4	3.8	3.6	
1951	6	2	3.2	3.0	3.0	19.9	117.3	23.6	13.3	8.1	
1951	6	3	6.7	5.6	4.8	4.4	4.0	3.8	3.4	3.4	
1951	6	4	3.6	3.2	3.0	2.8	2.8	2.6			320
1951	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1951	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1951	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1951	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1951	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1952	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1952	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	2	4	0.0	0.0	0.0	0.0	0.0				0
1952	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1952	4	1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	
1952	4	2	1.6	2.2	1.8	4.1	3.8	3.0	2.6	2.2	
1952	4	3	2.0	2.0	2.2	2.7	2.4	2.9	70.0	14.3	
1952	4	4	8.4	6.7	6.0	5.3	4.9	4.4			166
1952	5	1	10.5	10.8	9.1	8.8	8.8	8.8	8.8	8.8	
1952	5	2	8.2	7.3	7.0	6.4	6.4	6.1	5.8	5.8	
1952	5	3	5.8	9.1	8.2	7.3	9.4	9.4	9.1	8.8	
1952	5	4	8.8	116.1	231.0	223.7	66.1	40.4	30.7		911
1952	6	1	22.6	19.7	17.6	16.8	19.4	108.3	60.3	51.4	
1952	6	2	29.6	23.9	22.6	21.5	19.7	17.6	16.8	15.2	
1952	6	3	14.2	13.4	12.9	12.9	12.1	11.0	10.2	9.4	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1952	6	4	8.9	8.4	8.1	8.1	8.1	8.1			629
1952	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1952	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1952	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1952	9	1	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
1952	9	2	2.9	64.8	14227.6	485.8	253.7	164.6	127.2	102.6	
1952	9	3	85.6	128.0	107.6	75.6	70.2	62.5	53.6	51.3	
1952	9	4	48.2	47.0	44.7	41.6	39.7	37.8			16346
1952	10	1	21.9	21.5	20.3	19.2	18.7	17.5	16.6	15.9	
1952	10	2	15.9	15.5	15.5	15.5	15.0	14.5	13.9	12.9	
1952	10	3	12.9	12.5	12.5	12.0	12.0	12.0	12.0	11.5	
1952	10	4	11.5	11.5	11.5	11.1	11.1	11.1	10.6		446
1952	11	1	7.8	7.8	7.8	7.4	7.4	7.4	7.4	7.1	
1952	11	2	7.1	7.4	7.1	7.1	7.1	7.1	7.1	6.8	
1952	11	3	6.4	8.1	6.4	6.4	6.4	6.4	8.1	8.4	
1952	11	4	8.4	8.1	8.1	9.8	14.4	13.7			236
1952	12	1	21.9	19.5	19.5	18.2	17.7	17.2	16.6	16.6	
1952	12	2	15.8	15.3	14.8	14.8	14.8	14.8	14.2	14.2	
1952	12	3	14.2	14.2	17.7	25.3	25.1	20.1	19.0	17.7	
1952	12	4	17.2	16.6	17.2	17.2	17.7	53.8	81.3		640
1953	1	1	67.6	61.0	54.5	51.4	49.2	48.3	47.3	44.2	
1953	1	2	41.4	39.9	38.9	38.0	37.1	37.1	36.1	37.1	
1953	1	3	37.1	37.1	36.1	35.2	33.0	32.1	31.1	29.6	
1953	1	4	29.0	28.0	28.0	28.0	27.4	26.5	28.0		1195
1953	2	1	21.2	20.1	19.6	19.1	18.4	18.4	17.9	17.5	
1953	2	2	17.5	17.5	17.5	17.0	17.0	17.0	16.3	16.3	
1953	2	3	15.8	15.8	15.8	15.8	15.3	14.2	14.9	14.9	
1953	2	4	15.3	15.3	14.9	14.9					471
1953	3	1	14.1	14.1	14.1	13.4	12.9	12.5	12.5	12.9	
1953	3	2	12.5	12.9	12.5	14.1	14.5	21.2	17.4	14.9	
1953	3	3	14.5	13.4	13.4	12.9	12.9	12.5	12.0	12.0	
1953	3	4	11.6	11.6	11.6	11.6	11.6	11.6	11.6		411
1953	4	1	18.3	22.2	17.3	16.4	15.3	14.8	14.8	14.2	
1953	4	2	14.2	20.0	17.8	15.3	14.2	13.7	13.7	13.1	
1953	4	3	13.1	13.1	12.0	12.0	12.0	12.0	12.0	95.6	
1953	4	4	38.9	20.3	15.9	14.8	140.5	52.0			720
1953	5	1	18.7	14.5	12.7	11.7	10.9	10.5	10.1	9.7	
1953	5	2	9.3	9.3	9.3	10.7	12.7	10.1	10.5	12.9	
1953	5	3	16.7	12.7	10.9	10.5	10.1	9.7	9.7	9.3	
1953	5	4	8.9	8.5	8.5	8.1	7.6	7.6	7.2		329
1953	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1953	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1953	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1953	8	1	4.0	3.5	3.5	3.5	3.3	3.3	3.1	3.1	
1953	8	2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	
1953	8	3	3.1	3.1	3.1	3.3	3.3	4.4	4.0	5.5	
1953	8	4	6.6	4.6	4.6	5.1	4.6	8.6	284.4		400
1953	9	1	244.7	321.8	228.9	691.8	130.8	62.6	45.8	37.2	
1953	9	2	32.0	28.6	26.2	24.8	23.7	23.1	22.4	21.7	
1953	9	3	20.7	20.7	20.0	19.3	18.6	17.9	17.2	16.5	
1953	9	4	16.5	16.5	15.8	15.1	15.1	14.5			2210
1953	10	1	9.1	9.1	10.4	17.2	18.4	13.2	12.7	11.8	
1953	10	2	11.3	10.9	10.4	10.0	9.5	9.1	9.1	8.6	
1953	10	3	8.6	8.6	8.6	8.2	8.2	12.3	11.3	9.5	
1953	10	4	16.1	62.4	19.3	18.4	18.4	14.8	22.7		428
1953	11	1	25.0	20.8	21.5	19.7	18.7	18.0	17.6	17.1	
1953	11	2	16.0	16.0	15.5	15.0	14.6	13.9	13.9	13.4	
1953	11	3	13.4	13.0	13.0	12.5	12.5	12.5	13.4	12.0	
1953	11	4	12.0	11.6	11.6	11.6	11.6	11.1			448

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1953	12	1	23.0	66.6	24.8	23.6	21.5	20.5	19.2	19.2	
1953	12	2	18.2	18.2	18.2	18.2	18.7	17.0	16.5	16.5	
1953	12	3	16.0	15.2	16.0	15.2	15.2	13.7	13.2	13.2	
1953	12	4	13.2	13.2	13.7	13.2	12.7	12.2	12.2		568
1954	1	1	8.0	8.0	8.0	7.6	7.6	7.3	7.3	7.3	
1954	1	2	7.6	9.7	7.6	7.6	8.3	8.7	8.7	8.3	
1954	1	3	8.3	8.0	8.3	8.3	8.0	7.6	7.6	7.6	
1954	1	4	8.0	8.0	8.0	8.0	8.3	8.0	8.0		248
1954	2	1	4.5	4.5	4.3	4.1	4.1	4.1	3.9	3.9	
1954	2	2	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	
1954	2	3	3.5	3.5	3.7	3.5	3.5	3.5	3.7	3.4	
1954	2	4	3.4	3.2	3.2	3.0					105
1954	3	1	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.2	
1954	3	2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	
1954	3	3	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.2	
1954	3	4	1.1	1.0	1.0	1.0	1.0	1.0	1.0		36
1954	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1954	5	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1954	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1954	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1954	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1954	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1954	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1954	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1954	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1954	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	2	4	0.0	0.0	0.0	0.0					0
1955	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1955	5	1	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	

GENERATED DAILY STREAMFLOWS FOR ONION CREEK NEAR DRIFTWOOD
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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1955	5	2	1.9	1.9	3.1	11.9	4.0	3.1	74.8	22.7	
1955	5	3	289.1	48.5	181.1	52.7	19.6	13.0	10.2	8.5	
1955	5	4	7.4	6.5	6.0	4.5	13.0	6.0	6.0		811
1955	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1955	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1955	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1955	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1955	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1955	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	2	4	0.0	0.0	0.0	0.0	0.0				0
1956	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1956	5	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1956	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1956	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1956	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1956	10	1	0.5	0.4	0.4	1.8	0.6	0.5	0.5	0.5	
1956	10	2	0.4	0.4	0.4	0.4	0.5	0.5	0.5	37.5	

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FOR JULY 1, 1979 THROUGH DECEMBER 31, 1988

YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1956	10	3	53.8	7.1	2.7	1.3	0.8	0.8	0.7	0.6	
1956	10	4	0.6	0.6	0.6	0.6	0.6	0.6	0.6		118
1956	11	1	0.2	0.2	0.3	13.1	4.6	4.6	2.4	1.1	
1956	11	2	0.7	0.5	0.4	0.4	0.4	0.4	0.3	0.3	
1956	11	3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
1956	11	4	0.4	0.4	0.3	0.3	0.3	0.3			34
1956	12	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
1956	12	2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
1956	12	3	0.1	0.6	3.7	1.1	0.5	0.3	0.2	0.2	
1956	12	4	0.2	0.1	0.1	0.1	0.2	0.1	0.1		9
1957	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1957	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1957	2	4	0.0	0.0	0.0	0.0					0
1957	3	1	4.7	3.7	3.7	3.4	3.1	3.1	2.8	2.6	
1957	3	2	2.6	2.6	2.4	2.4	2.2	2.2	2.0	2.0	
1957	3	3	3.1	3.1	2.4	266.1	1203.6	41.0	15.6	8.8	
1957	3	4	6.1	4.7	5.1	283.8	39.3	18.3	22.4		1969
1957	4	1	78.7	25.6	16.8	13.0	10.7	9.9	9.6	9.6	
1957	4	2	8.0	8.0	8.0	8.0	7.6	6.9	6.9	8.8	
1957	4	3	8.0	6.9	94.7	139.0	54.2	1264.4	155.9	3934.6	
1957	4	4	997.0	458.4	1837.4	764.0	737.3	231.5			10920
1957	5	1	160.0	124.8	99.4	90.7	82.7	69.6	63.5	59.9	
1957	5	2	56.2	106.3	58.8	48.2	128.8	129.1	66.0	72.2	
1957	5	3	63.5	180.7	248.1	97.9	72.6	61.7	58.0	58.0	
1957	5	4	54.4	65.3	243.0	315.6	145.1	123.3	558.6		3762
1957	6	1	441.2	448.5	306.3	266.2	251.6	266.2	207.8	131.3	
1957	6	2	113.0	105.7	98.4	105.7	196.9	113.0	98.4	83.9	
1957	6	3	80.2	76.6	69.3	65.6	62.0	58.3	58.3	54.7	
1957	6	4	51.0	47.4	43.8	43.8	43.8	40.1			4029
1957	7	1	22.1	22.1	19.9	19.4	17.9	17.2	16.3	15.2	
1957	7	2	14.8	13.9	13.3	13.3	11.9	11.5	11.0	11.0	
1957	7	3	10.6	10.2	9.7	9.3	11.5	13.9	12.4	11.0	
1957	7	4	9.7	9.7	9.3	8.8	8.8	8.4	7.7		402
1957	8	1	1.0	0.9	0.9	0.9	0.9	1.0	1.0	1.0	
1957	8	2	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.8	
1957	8	3	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
1957	8	4	0.8	0.8	0.7	0.7	0.7	1.1	0.9		27
1957	9	1	8.7	8.0	8.7	8.0	9.1	9.1	14.0	11.9	
1957	9	2	10.5	10.5	9.8	11.2	11.9	11.2	9.8	8.7	
1957	9	3	8.7	8.0	8.0	7.3	7.3	1256.9	394.5	130.9	
1957	9	4	125.7	126.4	84.8	67.0	57.6	50.6			2495
1957	10	1	48.3	44.2	41.3	40.1	37.2	36.4	35.3	34.6	
1957	10	2	32.7	31.6	30.8	30.1	33.8	490.6	657.9	382.8	
1957	10	3	178.4	141.2	121.2	107.8	109.3	929.2	405.1	279.5	
1957	10	4	234.2	200.7	176.2	162.0	150.5	137.9	127.9		5469
1957	11	1	116.2	107.8	109.6	104.9	101.9	96.1	96.1	94.6	
1957	11	2	86.2	85.1	125.4	220.0	185.9	163.5	146.7	135.7	
1957	11	3	128.3	135.7	124.7	117.3	117.3	128.3	154.0	264.0	
1957	11	4	256.6	231.0	209.0	187.0	172.3	161.3			4362
1957	12	1	144.6	141.1	137.5	127.0	119.9	116.4	116.4	109.3	
1957	12	2	98.8	95.2	95.2	88.2	84.6	81.1	77.6	74.1	
1957	12	3	74.1	70.5	70.5	67.7	65.2	62.8	62.8	61.7	
1957	12	4	82.9	81.8	71.2	72.7	66.3	64.2	61.7		2743
1958	1	1	56.7	54.3	53.2	54.3	64.8	91.8	76.0	72.1	
1958	1	2	70.7	69.7	68.6	81.3	81.3	76.0	74.6	72.1	
1958	1	3	72.1	70.7	70.7	73.5	74.6	70.7	90.0	162.2	
1958	1	4	128.2	119.1	112.8	107.9	101.6	98.8	96.0		2566
1958	2	1	94.3	91.3	88.7	87.2	87.2	84.6	80.5	76.4	
1958	2	2	76.4	80.5	80.5	79.0	76.4	75.0	71.2	66.1	
1958	2	3	64.9	63.5	62.3	63.5	131.0	697.6	909.2	519.5	
1958	2	4	423.0	378.5	313.6	270.9					5193
1958	3	1	252.8	247.6	222.7	211.6	308.1	250.2	247.6	218.3	
1958	3	2	193.0	185.6	178.2	174.5	167.1	155.9	148.5	144.8	
1958	3	3	144.8	167.1	204.2	155.9	141.1	137.4	163.3	141.1	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1958	3	4	129.9	122.5	115.1	111.4	107.7	103.9	100.2		5352
1958	4	1	90.9	125.8	104.8	97.9	90.9	87.4	83.9	80.4	
1958	4	2	97.9	83.9	76.9	73.4	139.8	188.7	104.8	87.4	
1958	4	3	76.9	73.4	69.9	66.4	64.7	62.9	62.2	60.8	
1958	4	4	59.4	59.4	62.9	64.7	61.2	57.7			2517
1958	5	1	61.4	4564.5	2454.9	909.1	521.7	391.2	335.6	295.4	
1958	5	2	263.1	236.3	215.6	197.2	191.0	184.9	174.1	165.7	
1958	5	3	151.5	143.8	140.0	129.6	125.8	120.8	113.9	107.0	
1958	5	4	102.0	95.1	91.3	84.8	80.2	78.6	74.0		12800
1958	6	1	66.6	64.0	61.5	60.1	58.6	56.1	53.6	52.5	
1958	6	2	51.1	48.9	47.5	46.4	44.3	44.3	42.8	41.7	
1958	6	3	906.6	156.1	76.6	60.1	53.6	510.9	245.4	116.6	
1958	6	4	90.7	76.6	69.4	66.6	64.0	61.5			3395
1958	7	1	48.3	45.4	44.2	42.1	41.2	39.1	42.1	44.2	
1958	7	2	45.4	37.4	34.4	33.5	31.7	29.9	29.1	28.2	
1958	7	3	27.3	26.4	25.5	25.5	24.0	23.1	23.1	24.0	
1958	7	4	24.0	23.1	22.5	20.8	20.2	18.7	17.8		962
1958	8	1	11.8	11.8	11.4	11.8	11.4	11.8	11.4	11.4	
1958	8	2	10.8	10.8	10.8	10.8	10.4	10.4	10.4	10.4	
1958	8	3	10.4	10.8	10.4	10.8	11.4	11.4	10.8	11.4	
1958	8	4	10.8	10.8	10.8	10.4	10.4	10.0	10.0		339
1958	9	1	16.8	15.5	15.5	14.8	14.8	17.4	315.7	116.4	
1958	9	2	42.4	32.2	26.6	23.0	19.7	19.1	19.1	19.7	
1958	9	3	18.4	18.4	105.2	243.7	77.0	92.4	53.6	44.7	
1958	9	4	40.5	38.1	37.2	37.2	36.2	36.2			1608
1958	10	1	98.2	39.2	35.3	33.3	32.3	31.3	30.3	29.3	
1958	10	2	28.4	28.4	42.5	52.8	42.5	37.3	36.3	35.3	
1958	10	3	34.3	33.3	32.3	31.3	30.3	37.3	48.1	34.3	
1958	10	4	32.3	34.3	33.3	49.1	159.6	232.4	177.4		1632
1958	11	1	158.5	141.4	129.2	129.2	129.2	114.5	103.7	99.2	
1958	11	2	94.3	89.4	83.1	80.3	86.6	83.1	78.6	75.8	
1958	11	3	73.0	68.8	64.6	63.2	60.8	59.7	58.3	56.9	
1958	11	4	55.9	53.4	52.0	53.4	52.0	49.6			2498
1958	12	1	41.9	41.9	41.0	39.8	39.8	37.1	35.9	35.9	
1958	12	2	35.9	34.1	34.1	34.1	33.2	33.2	32.3	32.3	
1958	12	3	32.3	32.3	32.3	31.4	30.5	29.6	29.6	28.7	
1958	12	4	28.7	27.8	27.8	27.8	28.7	32.3	33.2		1035
1959	1	1	27.3	25.7	24.9	24.9	24.1	24.1	24.1	24.1	
1959	1	2	24.1	23.3	23.3	23.3	23.3	23.3	23.3	22.5	
1959	1	3	22.5	21.9	21.9	21.9	21.1	20.6	19.7	19.7	
1959	1	4	19.7	19.7	19.7	19.7	19.7	19.7	18.9		692
1959	2	1	22.0	22.9	22.9	22.9	22.0	21.1	20.5	20.5	
1959	2	2	21.1	20.5	20.5	20.5	20.5	158.4	82.5	48.2	
1959	2	3	42.8	39.7	37.0	34.9	35.8	37.9	37.9	37.0	
1959	2	4	34.9	37.9	41.8	41.8					1026
1959	3	1	38.5	37.6	37.6	36.7	36.7	35.5	34.6	34.6	
1959	3	2	34.6	34.6	34.6	33.7	32.8	32.8	31.9	31.1	
1959	3	3	30.2	30.2	30.2	30.2	29.3	28.4	28.4	28.4	
1959	3	4	29.3	30.2	29.3	28.4	27.5	26.6	26.6		991
1959	4	1	31.8	30.7	29.7	28.0	28.0	28.0	28.0	151.6	
1959	4	2	144.7	56.3	129.1	183.0	105.7	91.8	87.0	90.1	
1959	4	3	99.4	100.8	87.0	82.2	76.3	73.5	69.4	68.0	
1959	4	4	66.6	63.9	62.5	62.2	58.7	55.2			2269
1959	5	1	47.9	49.4	55.6	51.0	46.4	44.8	44.8	42.0	
1959	5	2	39.9	46.0	55.0	46.0	39.9	36.8	35.9	34.9	
1959	5	3	33.1	32.1	31.2	30.3	32.1	30.3	31.2	31.2	
1959	5	4	29.4	27.5	27.5	26.6	25.7	25.0	24.1		1154
1959	6	1	23.0	22.0	21.1	21.1	27.2	34.1	27.8	23.6	
1959	6	2	22.0	20.5	19.6	19.6	19.0	18.1	18.1	17.5	
1959	6	3	17.5	17.5	16.9	16.0	16.0	16.0	15.4	16.9	
1959	6	4	18.1	284.5	131.4	50.4	38.1	30.5			1040
1959	7	1	20.9	17.7	17.3	16.6	15.5	14.8	14.3	13.6	
1959	7	2	13.2	13.2	12.7	12.7	12.7	12.7	12.1	12.1	
1959	7	3	11.6	11.6	11.6	11.6	28.4	13.6	13.2	12.7	
1959	7	4	12.7	12.7	12.1	12.1	11.6	11.6	11.1		431
1959	8	1	10.6	10.6	10.1	10.1	10.1	9.4	9.4	9.0	
1959	8	2	9.4	9.0	8.5	8.5	8.5	9.0	9.0	8.5	
1959	8	3	8.1	7.6	7.6	7.6	7.6	7.6	10.6	10.1	
1959	8	4	9.4	9.0	100.9	33.7	18.7	15.7	14.2		418

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1959	9	1	8.8	8.1	7.4	7.4	6.8	6.4	6.4	6.4	
1959	9	2	6.4	5.8	5.8	5.8	5.8	5.8	5.8	5.8	
1959	9	3	5.5	5.5	5.3	5.3	5.3	5.3	7.6	10.6	
1959	9	4	7.6	7.6	6.8	6.1	7.6	6.8			198
1959	10	1	14.6	14.6	14.6	2745.6	329.5	117.1	73.2	51.3	
1959	10	2	43.9	36.6	32.9	31.1	47.6	109.8	65.9	54.9	
1959	10	3	43.9	40.3	36.6	36.6	34.8	32.9	32.9	31.1	
1959	10	4	30.4	28.6	26.7	26.7	26.7	26.7	26.7		4265
1959	11	1	18.0	19.6	19.6	22.2	21.4	19.6	19.6	18.8	
1959	11	2	18.0	18.0	18.0	18.0	18.0	21.4	21.4	23.7	
1959	11	3	22.9	22.2	21.4	21.4	20.9	20.9	20.1	19.6	
1959	11	4	18.8	18.8	18.8	18.8	18.8	18.0			597
1959	12	1	20.4	20.4	19.8	19.8	18.9	18.9	18.9	18.9	
1959	12	2	18.9	18.9	18.9	18.9	18.9	18.9	32.0	72.8	
1959	12	3	52.4	46.6	40.8	35.0	33.5	32.0	32.0	32.0	
1959	12	4	30.6	30.6	30.6	30.6	29.1	29.1	37.9		897
1960	1	1	79.3	66.1	56.2	49.6	51.2	52.9	54.5	52.9	
1960	1	2	51.5	50.5	50.5	50.5	58.5	87.2	57.5	53.8	
1960	1	3	56.5	56.5	51.5	50.5	49.2	49.2	49.2	48.2	
1960	1	4	48.2	48.2	48.2	46.9	43.6	42.6	41.6		1653
1960	2	1	43.3	43.3	250.5	143.3	99.0	88.0	83.5	81.8	
1960	2	2	81.8	79.0	73.2	70.4	70.4	70.4	69.1	66.3	
1960	2	3	65.0	63.6	62.2	61.2	61.2	61.2	59.8	59.8	
1960	2	4	58.8	56.0	55.0	53.6	52.6				2183
1960	3	1	50.2	51.1	50.2	47.9	46.5	46.5	46.5	46.5	
1960	3	2	46.5	46.5	44.6	42.3	41.3	41.3	42.3	41.3	
1960	3	3	40.3	39.0	38.0	38.0	37.0	36.1	36.1	35.1	
1960	3	4	37.0	149.2	95.1	73.8	68.5	62.0	59.3		1576
1960	4	1	56.7	54.5	53.2	51.9	49.7	48.7	48.7	48.7	
1960	4	2	47.5	42.0	44.3	44.3	44.3	44.3	43.3	42.0	
1960	4	3	39.2	37.9	36.9	36.9	36.9	39.2	36.0	39.2	
1960	4	4	41.1	39.2	54.5	41.1	51.9	45.2			1339
1960	5	1	38.9	37.8	36.9	36.1	36.1	35.2	31.5	31.5	
1960	5	2	29.8	29.8	28.9	28.0	27.2	27.2	26.3	26.3	
1960	5	3	25.5	24.6	24.6	24.6	23.2	22.3	21.7	20.9	
1960	5	4	21.7	21.7	20.9	20.0	20.0	20.0	20.0		839
1960	6	1	15.2	15.2	15.2	14.7	14.7	14.0	14.0	14.0	
1960	6	2	13.5	13.5	13.1	12.4	12.4	11.9	11.4	11.0	
1960	6	3	11.0	11.0	10.5	9.8	9.8	9.8	9.3	15.2	
1960	6	4	54.4	25.0	21.5	19.4	18.2	17.0			458
1960	7	1	18.4	17.8	17.0	16.4	16.4	15.8	15.0	14.4	
1960	7	2	13.9	13.9	13.3	13.3	12.7	11.9	11.9	60.5	
1960	7	3	130.7	72.7	34.8	32.0	34.8	30.3	25.2	22.9	
1960	7	4	21.5	20.7	19.8	19.8	19.8	19.2	18.4		805
1960	8	1	18.7	18.7	18.1	18.1	18.1	17.2	17.2	17.2	
1960	8	2	17.2	17.2	17.2	16.7	16.7	21.8	55.4	39.9	
1960	8	3	34.2	32.5	42.8	124.7	34.2	28.2	26.4	24.7	
1960	8	4	23.3	22.4	21.0	25.6	23.3	21.8	21.0		852
1960	9	1	14.0	13.6	13.0	13.0	13.6	12.6	13.0	12.6	
1960	9	2	12.0	12.0	12.0	11.6	11.2	11.2	10.6	10.6	
1960	9	3	10.2	10.2	9.8	9.4	9.4	9.0	9.0	9.0	
1960	9	4	9.0	9.0	9.0	8.4	8.4	8.4			325
1960	10	1	15.2	15.2	15.2	15.2	15.2	14.4	15.2	15.9	
1960	10	2	15.9	15.9	15.2	14.4	14.4	21.6	17.8	1112.6	
1960	10	3	129.1	1196.1	235.4	83.9	55.4	52.8	49.0	47.8	
1960	10	4	47.8	46.7	45.2	45.2	4214.8	937.9	440.5		8977
1960	11	1	300.5	231.4	186.7	161.4	145.9	133.3	124.7	118.2	
1960	11	2	113.5	108.8	103.8	100.5	97.3	92.3	87.6	82.9	
1960	11	3	82.9	82.9	81.1	81.1	112.4	116.8	102.3	95.9	
1960	11	4	94.1	90.8	89.4	85.8	81.1	78.2			3464
1960	12	1	78.9	77.4	77.4	77.4	75.9	74.5	150.4	489.0	
1960	12	2	304.5	287.8	263.8	221.5	208.2	206.0	206.0	176.3	
1960	12	3	170.4	160.0	151.9	144.5	133.4	131.9	126.7	123.4	
1960	12	4	118.5	114.8	111.9	110.0	208.9	170.4	201.5		5153
1961	1	1	176.7	162.4	152.5	146.7	144.8	152.5	192.8	188.4	
1961	1	2	180.4	174.5	172.3	168.6	166.4	158.4	148.5	143.0	
1961	1	3	137.5	133.8	132.0	123.9	120.3	118.8	117.3	115.5	
1961	1	4	110.7	112.2	108.9	105.6	102.3	97.5	95.7		4361
1961	2	1	99.4	95.3	89.5	85.7	392.5	449.6	258.7	221.0	

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FOR JULY 1, 1979 THROUGH DECEMBER 31, 1988

YEAR	MTH	CARD				DAILY FLOW				MONTHLY
		#	1	2	3	4	5	6	7	8	TOTAL (cfs)
1961	2	2	207.3	195.8	185.6	177.2	173.0	166.9	158.5	2857.7	
1961	2	3	746.8	499.1	419.1	388.6	355.1	322.7	293.4	266.0	
1961	2	4	241.6	230.1	218.7	202.7					9998
1961	3	1	182.1	176.0	169.8	168.0	160.1	150.3	144.5	135.5	
1961	3	2	126.8	125.0	123.6	122.1	117.1	115.6	113.8	110.6	
1961	3	3	109.1	100.8	99.0	97.6	96.1	94.3	92.5	89.6	
1961	3	4	86.0	86.0	84.6	81.3	78.4	72.6	72.6		3582
1961	4	1	60.5	59.2	57.9	57.0	55.7	54.7	53.5	53.5	
1961	4	2	52.2	51.2	49.0	47.7	46.7	45.5	44.5	42.3	
1961	4	3	42.3	42.3	42.3	41.3	41.3	40.3	39.4	38.1	
1961	4	4	37.1	37.1	37.1	36.2	35.2	35.2			1376
1961	5	1	30.0	29.2	29.2	28.3	28.3	27.5	26.7	26.7	
1961	5	2	25.9	25.1	24.3	23.4	22.6	22.6	22.6	22.1	
1961	5	3	22.1	21.3	20.7	20.7	19.9	19.1	19.9	19.9	
1961	5	4	19.9	19.1	19.1	19.1	18.5	17.7	17.7		709
1961	6	1	23.8	23.1	23.1	23.1	23.1	22.0	22.0	23.1	
1961	6	2	33.0	24.9	23.8	24.9	25.7	24.9	25.7	105.9	
1961	6	3	153.9	2056.2	461.8	210.4	156.1	131.9	115.5	102.3	
1961	6	4	93.8	89.1	82.5	76.6	72.2	67.8			4342
1961	7	1	57.1	54.8	52.5	51.2	48.9	46.6	45.6	43.3	
1961	7	2	44.6	116.2	69.9	53.5	58.4	48.9	45.6	43.3	
1961	7	3	44.6	43.3	42.3	39.1	37.1	38.1	49.2	112.3	
1961	7	4	54.8	46.6	43.3	41.4	40.4	39.1	37.1		1589
1961	8	1	30.4	29.5	29.5	28.7	28.7	27.9	27.9	27.1	
1961	8	2	27.1	25.4	25.4	24.6	24.6	23.7	23.7	22.9	
1961	8	3	22.9	22.9	22.9	22.4	21.5	21.5	21.0	21.0	
1961	8	4	20.2	20.2	19.3	19.3	19.3	19.3	18.8		740
1961	9	1	16.8	16.1	16.1	16.8	16.1	15.6	15.6	15.6	
1961	9	2	14.9	14.9	18.8	25.0	22.8	20.6	20.1	19.3	
1961	9	3	19.3	19.3	18.8	18.8	18.1	18.1	18.1	17.3	
1961	9	4	17.3	17.3	16.8	16.8	16.8	16.1			534
1961	10	1	15.0	15.7	15.0	15.0	15.0	15.0	15.0	15.0	
1961	10	2	15.0	19.2	16.2	15.7	15.0	14.6	14.6	13.9	
1961	10	3	13.9	13.9	13.9	13.4	12.9	12.9	12.9	12.9	
1961	10	4	13.4	13.9	13.4	13.9	13.9	13.9	13.4		448
1961	11	1	12.3	12.7	12.3	11.9	11.2	11.2	11.2	11.2	
1961	11	2	11.2	11.2	11.2	11.2	17.6	12.7	13.8	13.8	
1961	11	3	13.3	13.3	12.7	12.3	12.3	12.3	11.9	11.9	
1961	11	4	11.9	11.9	11.9	11.2	11.2	11.2			366
1961	12	1	10.9	10.9	10.9	10.9	10.9	10.5	10.5	10.5	
1961	12	2	10.9	10.9	10.5	10.5	10.5	10.5	10.5	10.5	
1961	12	3	13.3	12.9	12.3	11.9	11.9	11.9	11.5	11.5	
1961	12	4	10.9	10.9	10.9	10.5	10.5	10.5	10.5		342
1962	1	1	9.8	9.4	9.4	9.4	9.4	9.0	9.0	9.4	
1962	1	2	9.4	9.4	9.4	9.4	9.4	10.2	9.8	9.8	
1962	1	3	9.8	9.8	9.8	9.8	9.8	10.8	9.8	9.8	
1962	1	4	9.8	10.2	10.2	9.8	9.8	9.4	9.4		300
1962	2	1	6.8	6.8	6.6	6.6	6.6	6.3	6.3	6.3	
1962	2	2	6.3	6.3	5.9	5.9	5.9	5.9	6.3	6.3	
1962	2	3	6.3	6.3	6.3	5.9	5.9	5.9	6.3	5.9	
1962	2	4	5.9	5.9	5.9	5.6					172
1962	3	1	6.3	6.3	6.6	6.6	6.6	6.6	6.6	6.6	
1962	3	2	7.1	7.1	7.4	6.6	6.6	7.7	7.4	7.1	
1962	3	3	7.1	7.1	7.1	7.1	7.1	7.1	6.6	6.6	
1962	3	4	6.3	6.3	6.3	6.3	6.3	6.3	6.3		209
1962	4	1	6.9	6.9	6.9	7.4	8.1	7.7	8.1	8.1	
1962	4	2	8.1	8.1	8.1	7.7	7.4	6.9	7.4	6.9	
1962	4	3	6.9	6.9	6.6	5.9	6.3	6.6	7.7	6.9	
1962	4	4	6.9	6.9	10.4	8.7	9.2	9.2			226
1962	5	1	9.1	8.2	7.9	7.9	7.6	7.3	7.3	7.3	
1962	5	2	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	
1962	5	3	6.8	6.8	6.8	6.5	6.5	6.5	6.5	6.5	
1962	5	4	6.5	6.5	6.1	6.1	9.1	6.8	8.2		219
1962	6	1	17.6	21.5	344.6	679.3	71.6	39.4	30.5	26.8	
1962	6	2	25.2	24.2	23.2	22.5	23.2	21.5	19.2	18.6	
1962	6	3	17.6	16.2	15.6	14.9	14.9	14.9	13.9	13.3	
1962	6	4	13.3	13.3	49.7	25.2	21.5	31.5			1685
1962	7	1	18.0	16.3	15.2	13.9	12.8	11.9	11.5	10.6	
1962	7	2	10.3	9.7	9.3	9.0	8.6	8.2	7.7	7.7	

GENERATED DAILY STREAMFLOWS FOR ONION CREEK NEAR DRIFTWOOD
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FOR JULY 1, 1979 THROUGH DECEMBER 31, 1988

YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1962	7	3	7.3	7.0	7.0	6.6	6.2	6.2	6.2	6.2	
1962	7	4	6.0	6.0	5.7	5.7	5.7	5.7	5.3		274
1962	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1962	9	1	3.8	4.1	3.9	3.6	3.3	3.3	3.9	10.1	
1962	9	2	11.5	9.1	8.0	7.4	6.8	6.0	5.7	5.1	
1962	9	3	5.0	5.0	4.7	4.4	4.4	4.4	4.1	3.8	
1962	9	4	3.8	27.8	12.2	8.0	6.3	6.0			196
1962	10	1	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	
1962	10	2	1.3	1.2	1.2	1.1	1.0	1.0	1.0	1.1	
1962	10	3	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	
1962	10	4	1.0	1.0	1.0	1.3	1.4	1.3	1.3		36
1962	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1962	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1962	12	1	5.0	5.9	5.7	5.7	5.7	5.4	5.4	5.4	
1962	12	2	5.4	5.4	5.4	5.0	4.7	4.7	4.7	4.7	
1962	12	3	4.7	4.7	4.7	20.2	16.5	12.7	11.3	13.2	
1962	12	4	13.2	12.7	11.3	11.0	10.1	9.2	8.9		249
1963	1	1	5.8	5.6	5.6	5.6	5.6	5.3	5.0	4.7	
1963	1	2	4.7	4.7	4.5	4.5	4.3	4.3	4.3	4.3	
1963	1	3	4.3	4.3	4.7	4.3	3.9	3.9	3.7	3.4	
1963	1	4	3.4	3.4	3.4	3.4	3.4	3.4	3.4		135
1963	2	1	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	
1963	2	2	1.8	1.9	1.9	1.8	1.8	1.8	1.8	1.8	
1963	2	3	1.8	3.5	4.2	3.9	3.6	3.4	3.3	3.3	
1963	2	4	3.2	3.2	3.0	3.0					68
1963	3	1	2.9	2.7	2.7	2.6	2.4	2.3	2.2	2.2	
1963	3	2	2.2	2.2	2.3	2.3	2.4	2.2	2.2	2.2	
1963	3	3	2.1	2.1	2.0	1.8	1.8	1.8	1.8	1.8	
1963	3	4	1.8	1.8	1.7	1.6	1.6	1.6	1.5		66
1963	4	1	6.8	6.8	6.8	7.7	374.5	61.3	41.9	35.1	
1963	4	2	32.4	28.9	26.2	23.9	22.4	21.5	20.6	19.2	
1963	4	3	18.6	17.7	17.1	16.5	16.5	15.6	15.0	14.4	
1963	4	4	13.9	13.3	12.4	11.8	11.8	11.2			942
1963	5	1	5.4	5.4	5.4	5.0	5.7	6.0	5.4	5.0	
1963	5	2	4.7	4.4	4.4	4.4	4.3	4.3	4.0	3.7	
1963	5	3	3.4	3.4	3.3	5.0	4.0	3.7	3.4	3.4	
1963	5	4	3.3	3.4	3.4	35.0	13.1	7.0	5.7		178
1963	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1963	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1963	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1963	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1963	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	10	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	10	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	10	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1963	11	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	11	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	11	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	11	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1963	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1963	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1963	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1964	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	1	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1964	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	2	4	0.0	0.0	0.0	0.0	0.0				0
1964	3	1	2.2	2.5	3.1	2.8	2.2	2.5	2.8	3.5	
1964	3	2	3.1	2.8	2.5	2.2	2.8	3.8	3.5	3.1	
1964	3	3	2.5	2.2	15.7	39.4	23.6	11.0	11.0	9.4	
1964	3	4	7.9	7.1	7.1	7.1	7.1	6.3	6.3		209
1964	4	1	1.7	1.7	1.7	1.5	1.5	1.5	1.4	1.4	
1964	4	2	1.3	1.3	1.3	1.3	1.3	1.2	1.1	1.1	
1964	4	3	1.3	1.2	1.0	1.0	1.0	1.0	1.1	1.1	
1964	4	4	1.1	1.4	1.1	1.1	1.1	1.1			38
1964	5	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1964	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1964	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1964	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1964	9	1	1.2	1.2	1.2	1.0	1.0	1.0	1.0	1.0	
1964	9	2	1.3	1.3	1.2	1.1	1.1	1.1	1.0	6.4	
1964	9	3	7.6	3.8	2.5	1.8	1.3	3.2	3.8	2.5	
1964	9	4	1.9	1.5	76.3	10.2	6.4	3.8			150
1964	10	1	1.5	1.2	1.2	1.1	1.1	0.9	0.9	0.9	
1964	10	2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	
1964	10	3	1.0	1.1	0.8	0.8	0.8	0.8	0.8	0.9	
1964	10	4	1.0	16.2	5.0	3.4	2.7	2.4	2.1		55
1964	11	1	6.6	6.2	5.8	85.7	37.8	22.4	19.0	15.5	
1964	11	2	12.8	10.0	8.0	7.7	6.9	7.3	17.3	11.7	
1964	11	3	12.4	12.4	10.8	10.0	9.3	8.9	8.4	8.4	
1964	11	4	8.0	7.3	6.9	6.9	6.9	6.9	0.0		404
1964	12	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	12	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1964	12	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1965	1	1	4.2	4.4	5.5	4.2	4.2	4.2	3.8	3.8	
1965	1	2	4.2	3.8	3.8	3.8	3.8	3.8	3.8	3.6	
1965	1	3	3.6	3.6	3.6	3.6	20.6	93.2	30.7	23.8	
1965	1	4	21.2	18.1	17.0	16.0	14.7	13.7	12.6		361
1965	2	1	20.0	18.2	16.4	29.1	90.9	127.3	109.1	90.9	
1965	2	2	363.8	218.3	145.5	127.3	109.1	98.2	90.9	181.9	
1965	2	3	254.7	327.4	254.7	218.3	181.9	163.7	145.5	127.3	
1965	2	4	109.1	101.9	94.6	90.9					3907
1965	3	1	71.3	65.1	58.9	55.8	49.6	46.5	43.4	43.4	
1965	3	2	40.3	40.3	37.2	37.2	34.1	34.1	31.0	31.0	
1965	3	3	37.2	31.0	37.2	31.0	27.9	27.9	26.3	26.3	
1965	3	4	26.3	24.8	24.8	24.8	24.8	34.1	46.5		1170
1965	4	1	38.3	34.8	31.3	27.9	27.9	696.3	155.3	112.8	
1965	4	2	97.1	90.9	82.9	76.9	72.8	68.6	64.4	60.6	
1965	4	3	56.7	55.7	53.3	50.8	47.3	44.9	43.9	40.4	
1965	4	4	40.4	46.0	58.1	65.8	48.4	42.8			2433
1965	5	1	42.9	40.6	40.6	39.5	39.5	38.3	37.2	36.1	
1965	5	2	55.8	41.7	246.7	113.9	75.9	68.3	64.5	379.5	
1965	5	3	1707.9	948.8	948.8	569.3	455.4	379.5	341.6	303.6	
1965	5	4	265.7	227.7	208.7	189.8	341.6	265.7	341.6		8857

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1965	6	1	224.8	187.4	168.6	149.9	1611.3	659.5	363.5	306.9	
1965	6	2	259.3	224.1	201.6	184.4	167.9	153.6	138.6	131.5	
1965	6	3	122.9	118.0	111.3	107.9	101.2	97.8	101.2	102.7	
1965	6	4	84.3	78.3	73.8	69.3	66.7	64.1			6432
1965	7	1	47.1	45.0	43.8	40.9	40.0	38.8	37.1	35.0	
1965	7	2	34.1	33.2	31.5	30.6	29.7	28.8	29.7	29.7	
1965	7	3	28.8	28.0	26.2	25.3	25.3	24.4	24.4	23.8	
1965	7	4	23.8	22.9	22.4	21.5	21.5	20.6	19.1		933
1965	8	1	15.5	15.5	15.0	15.5	15.0	15.0	14.3	14.3	
1965	8	2	13.8	51.5	22.6	18.1	16.7	16.2	16.2	15.5	
1965	8	3	15.0	15.0	14.3	13.8	13.8	13.8	13.3	13.3	
1965	8	4	13.3	12.6	11.7	11.2	10.7	10.0	9.5		482
1965	9	1	10.9	10.9	10.9	10.4	10.4	12.2	13.2	12.7	
1965	9	2	13.7	13.2	12.7	12.2	12.2	12.2	12.7	13.2	
1965	9	3	12.7	12.2	12.7	12.7	11.7	48.4	152.1	33.7	
1965	9	4	23.1	21.0	19.7	18.1	17.6	16.8			606
1965	10	1	20.3	18.6	20.9	25.1	25.1	22.5	21.9	20.9	
1965	10	2	20.3	18.6	20.3	19.3	18.6	18.0	17.0	17.0	
1965	10	3	16.4	594.8	136.0	52.1	37.3	28.6	26.7	26.0	
1965	10	4	25.1	24.4	24.4	23.5	23.5	23.5	22.5		1409
1965	11	1	20.3	20.3	22.1	22.1	22.1	21.2	21.2	38.7	
1965	11	2	78.5	49.7	39.5	36.6	34.6	32.0	31.1	29.4	
1965	11	3	28.5	28.5	27.6	27.6	27.6	27.6	27.6	27.6	
1965	11	4	26.2	26.2	24.7	24.7	23.3	23.3			890
1965	12	1	29.2	73.1	730.5	365.3	164.4	146.1	127.8	116.9	
1965	12	2	109.6	105.9	102.3	98.6	95.0	91.3	109.6	102.3	
1965	12	3	91.3	146.1	127.8	120.5	113.2	109.6	105.9	102.3	
1965	12	4	98.6	95.0	93.5	92.0	90.6	88.8	86.9		4130
1966	1	1	77.5	74.5	70.4	69.1	73.1	73.1	67.7	65.1	
1966	1	2	63.7	62.4	61.0	61.0	60.0	61.0	61.0	57.6	
1966	1	3	54.9	53.9	56.3	58.6	58.6	58.6	57.6	56.3	
1966	1	4	56.3	54.9	53.9	53.9	52.6	51.6	51.6		1888
1966	2	1	51.6	50.2	49.2	47.8	47.8	47.8	47.8	47.8	
1966	2	2	116.9	84.9	67.7	67.7	75.8	70.4	67.7	70.4	
1966	2	3	69.1	67.7	67.7	65.0	63.7	62.3	63.7	66.4	
1966	2	4	66.4	71.8	112.2	97.0					1885
1966	3	1	87.0	85.6	85.6	80.9	71.0	62.9	66.9	71.0	
1966	3	2	71.0	71.0	71.0	72.4	75.1	69.6	66.9	64.2	
1966	3	3	62.9	61.5	60.5	59.1	59.1	58.1	55.4	54.4	
1966	3	4	52.0	52.0	50.6	53.0	52.0	50.6	46.2		1999
1966	4	1	48.5	45.0	45.0	42.9	41.5	40.5	38.4	42.9	
1966	4	2	40.5	39.4	38.4	37.3	37.3	36.3	35.2	35.2	
1966	4	3	37.7	260.3	66.6	48.5	40.5	39.4	38.4	44.0	
1966	4	4	544.3	219.5	148.6	127.4	114.4	108.2			2482
1966	5	1	101.7	97.2	94.0	90.9	92.6	98.9	97.2	90.9	
1966	5	2	86.4	82.9	81.5	81.5	81.5	80.1	80.1	77.0	
1966	5	3	72.8	71.4	118.4	78.4	71.4	68.6	65.8	64.4	
1966	5	4	62.0	59.6	60.6	60.6	59.6	59.6	54.3		2442
1966	6	1	42.0	39.1	37.1	36.2	35.4	34.2	33.3	32.5	
1966	6	2	30.8	29.9	29.0	27.3	25.6	26.4	26.4	23.9	
1966	6	3	23.9	28.2	23.9	23.9	24.7	24.7	24.7	24.7	
1966	6	4	24.7	24.7	24.7	24.7	23.9	23.3			854
1966	7	1	19.6	19.6	19.6	19.6	19.6	20.1	18.8	18.4	
1966	7	2	18.4	17.6	17.6	17.6	16.9	16.9	16.4	15.2	
1966	7	3	14.5	14.0	13.5	14.0	14.0	14.0	14.0	14.0	
1966	7	4	14.0	14.0	14.0	14.0	13.5	13.5	12.8		500
1966	8	1	9.9	9.5	10.4	9.9	9.5	9.5	10.8	11.7	
1966	8	2	9.9	9.5	11.2	9.9	9.1	9.5	9.1	9.1	
1966	8	3	8.7	8.7	8.7	8.4	8.4	7.8	7.8	7.8	
1966	8	4	7.8	7.8	8.7	8.4	7.8	7.8	8.4		281
1966	9	1	11.8	11.8	11.0	12.4	14.7	17.9	15.3	16.6	
1966	9	2	17.9	20.0	18.4	17.9	17.1	16.6	15.8	15.3	
1966	9	3	75.0	50.8	48.4	28.1	23.4	20.5	19.2	17.9	
1966	9	4	17.1	16.6	17.1	17.1	16.6	15.8			634
1966	10	1	11.7	11.7	12.1	12.1	11.7	11.7	11.7	11.7	
1966	10	2	11.7	11.7	11.3	11.3	11.3	11.3	10.3	10.3	
1966	10	3	10.3	10.3	10.3	9.9	9.9	9.9	9.9	9.9	
1966	10	4	9.5	9.5	9.5	9.5	9.5	9.1	9.1		328
1966	11	1	5.4	5.4	5.1	5.4	5.7	5.4	5.4	5.4	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1966	11	2	5.4	5.4	5.4	5.1	5.1	5.1	5.1	5.1	
1966	11	3	5.1	4.9	5.1	4.9	4.9	4.9	4.9	4.9	
1966	11	4	4.9	4.6	4.6	4.5	4.5	4.5			152
1966	12	1	3.2	3.2	3.4	3.5	3.5	3.5	3.5	3.5	
1966	12	2	3.4	3.2	3.2	3.2	3.2	3.2	3.4	3.4	
1966	12	3	3.4	3.4	3.4	3.2	3.2	3.2	3.2	3.2	
1966	12	4	3.2	3.2	3.2	3.2	3.2	3.4	3.4		102
1967	1	1	2.5	2.3	2.3	2.3	2.3	2.3	2.3	2.3	
1967	1	2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	
1967	1	3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	
1967	1	4	2.2	2.2	2.2	2.2	2.0	2.0	2.0		68
1967	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	2	4	0.0	0.0	0.0	0.0					0
1967	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1967	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1967	5	1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
1967	5	2	0.6	0.6	0.6	0.6	0.5	0.5	0.6	0.5	
1967	5	3	0.5	0.5	0.5	0.7	1.2	0.8	1.0	1.0	
1967	5	4	0.9	0.9	0.7	0.7	3.4	1.5	1.1		25
1967	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1967	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1967	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1967	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1967	9	1	1.7	1.7	31.6	7.4	26.0	7.4	6.5	5.6	
1967	9	2	4.6	3.7	2.8	1.9	1.9	1.9	2.8	1.9	
1967	9	3	1.9	1.9	3.9	5.2	16.5	32.3	21.6	17.1	
1967	9	4	15.0	13.6	12.6	11.1	9.5	9.5			281
1967	10	1	12.3	11.3	11.3	10.6	10.1	9.6	11.1	18.9	
1967	10	2	11.8	11.3	10.1	10.1	9.6	9.1	92.3	41.5	
1967	10	3	28.4	23.9	20.9	20.4	19.1	17.6	17.1	16.3	
1967	10	4	15.1	14.6	14.1	14.1	14.1	16.3	14.1		557
1967	11	1	17.0	17.0	16.4	15.7	15.7	15.7	15.7	18.6	
1967	11	2	45.0	203.6	117.2	89.6	76.4	67.1	60.7	57.2	
1967	11	3	53.6	50.1	46.9	44.6	42.4	40.5	39.5	37.2	
1967	11	4	35.3	33.4	32.4	32.4	31.5	31.5			1400
1967	12	1	24.6	24.3	23.8	23.8	24.6	24.6	24.6	23.8	
1967	12	2	22.2	20.3	20.3	20.3	20.3	19.5	23.0	21.6	
1967	12	3	23.0	22.2	21.6	21.6	21.6	20.3	19.5	19.5	
1967	12	4	19.5	19.5	19.5	18.7	18.7	18.7	18.7		664
1968	1	1	26.9	26.9	26.9	26.9	28.0	28.0	26.9	29.2	
1968	1	2	33.0	36.5	37.6	38.8	37.6	37.6	37.6	36.5	
1968	1	3	36.5	1605.3	572.2	4263.0	2296.6	967.8	645.2	507.0	
1968	1	4	414.8	343.0	297.6	295.0	283.4	242.0	221.2		13506
1968	2	1	199.5	181.4	167.3	161.2	150.0	141.0	132.3	125.8	
1968	2	2	122.9	117.8	124.3	119.3	111.3	108.1	109.9	103.4	
1968	2	3	103.4	109.9	116.4	130.8	121.1	114.6	111.3	108.1	
1968	2	4	106.3	101.9	99.0	97.6	94.7				3590
1968	3	1	88.8	88.8	84.9	81.0	81.0	82.4	82.4	78.1	
1968	3	2	78.1	78.1	147.4	154.8	119.0	110.8	109.4	106.2	
1968	3	3	103.0	101.6	101.6	104.4	104.4	97.3	91.6	90.2	
1968	3	4	87.4	84.9	83.5	82.4	81.0	79.6	78.1		2942
1968	4	1	75.8	75.8	76.8	73.3	67.1	65.7	64.6	64.6	
1968	4	2	64.6	81.4	87.3	118.4	177.4	106.2	91.5	87.3	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1968	4	3	87.3	87.3	85.9	90.1	88.7	87.3	84.9	81.0	
1968	4	4	76.8	75.8	73.3	70.5	68.4	65.7			2501
1968	5	1	66.7	65.6	65.6	71.7	72.8	80.8	86.2	71.7	
1968	5	2	66.7	65.6	312.9	285.2	174.8	149.6	138.8	129.1	
1968	5	3	130.5	165.1	125.5	114.3	107.8	103.1	100.2	95.9	
1968	5	4	93.0	88.7	94.5	109.6	88.7	80.8	78.2		3480
1968	6	1	69.6	91.4	108.6	93.4	77.8	74.2	69.6	64.9	
1968	6	2	61.3	58.0	55.6	53.7	51.3	50.3	48.0	46.0	
1968	6	3	45.0	46.0	47.0	45.0	44.1	43.1	48.0	49.0	
1968	6	4	44.1	42.4	40.4	39.4	37.4	35.8			1681
1968	7	1	30.1	29.2	29.2	28.4	27.8	27.0	26.4	26.4	
1968	7	2	29.2	37.7	35.5	30.7	26.4	57.6	38.0	27.8	
1968	7	3	24.1	23.0	22.1	21.6	21.0	21.6	21.0	19.6	
1968	7	4	19.0	19.0	19.0	18.4	19.0	19.6	19.0		815
1968	8	1	14.0	14.0	13.2	13.2	13.2	13.2	13.2	12.5	
1968	8	2	12.1	12.1	11.7	11.3	11.3	11.3	11.3	11.3	
1968	8	3	11.3	11.3	10.9	10.9	10.4	10.0	10.0	10.0	
1968	8	4	10.9	10.4	10.4	10.0	10.0	10.0	10.0		355
1968	9	1	10.5	11.0	11.0	11.4	16.4	12.2	11.8	11.8	
1968	9	2	11.4	11.0	10.5	10.5	10.5	11.4	11.4	11.8	
1968	9	3	16.2	16.0	14.5	13.7	13.3	12.7	12.2	12.2	
1968	9	4	11.8	11.4	11.4	11.0	11.0	10.5			363
1968	10	1	9.2	9.2	9.2	9.9	10.2	10.2	9.9	9.5	
1968	10	2	9.5	9.2	8.8	8.8	8.8	8.8	8.8	8.8	
1968	10	3	8.8	8.8	8.4	8.4	8.4	8.4	8.6	9.7	
1968	10	4	8.4	8.1	7.7	7.7	7.7	7.7	7.7		273
1968	11	1	5.5	5.5	5.2	5.0	5.0	5.0	5.0	5.2	
1968	11	2	5.5	5.2	5.0	4.7	4.7	4.7	5.2	4.7	
1968	11	3	4.7	4.7	4.4	4.4	4.4	4.4	4.4	4.4	
1968	11	4	4.2	5.0	7.1	6.5	5.8	10.6			156
1968	12	1	24.0	18.0	16.5	15.7	14.6	13.4	12.3	11.5	
1968	12	2	11.5	11.5	11.5	11.0	10.6	10.6	10.6	10.2	
1968	12	3	10.2	10.2	10.6	10.2	10.6	11.5	10.2	10.2	
1968	12	4	10.2	10.6	10.2	10.2	9.8	9.8	9.8		367
1969	1	1	6.6	6.6	6.6	6.6	6.3	6.3	6.6	6.6	
1969	1	2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.9	
1969	1	3	6.6	6.3	6.3	6.3	6.3	6.0	6.0	6.0	
1969	1	4	5.7	5.7	5.7	5.7	6.0	6.0	5.7		194
1969	2	1	8.1	8.1	8.1	7.7	7.7	7.7	8.1	8.1	
1969	2	2	7.7	7.7	7.2	7.2	8.9	20.9	20.9	19.2	
1969	2	3	17.2	15.8	15.8	15.3	18.1	18.7	18.7	18.1	
1969	2	4	17.7	17.7	17.7	16.6					371
1969	3	1	22.0	22.0	22.0	21.5	22.0	22.0	21.5	20.9	
1969	3	2	20.3	20.3	20.3	20.3	19.5	20.3	26.8	25.4	
1969	3	3	25.4	25.4	25.4	24.8	24.8	24.8	30.5	41.2	
1969	3	4	38.4	33.6	31.9	31.9	31.3	31.3	30.5		798
1969	4	1	35.1	35.1	34.1	34.1	33.1	32.4	31.4	31.4	
1969	4	2	30.8	30.8	37.4	76.1	169.1	82.7	69.5	63.5	
1969	4	3	66.8	65.8	60.2	55.6	53.6	51.3	49.0	47.0	
1969	4	4	46.0	45.0	79.7	93.3	68.2	61.2			1669
1969	5	1	63.7	62.6	98.0	99.4	90.8	84.0	104.1	96.6	
1969	5	2	85.5	80.1	73.7	75.1	72.2	68.7	163.1	224.2	
1969	5	3	267.9	157.7	137.7	124.4	115.2	106.9	99.4	92.3	
1969	5	4	88.0	83.0	78.7	73.7	70.1	67.2	65.1		3169
1969	6	1	57.7	54.4	76.8	157.5	82.4	72.5	65.9	62.6	
1969	6	2	59.3	56.0	54.4	52.7	51.1	49.4	47.8	46.1	
1969	6	3	44.5	42.8	41.2	39.5	37.9	36.2	34.6	34.6	
1969	6	4	72.5	49.4	41.2	36.2	34.6	32.9			1624
1969	7	1	24.3	23.0	22.5	21.7	21.7	21.7	21.2	20.7	
1969	7	2	20.7	20.7	20.7	20.0	19.4	19.4	19.4	19.4	
1969	7	3	18.9	18.9	18.4	18.4	17.1	16.6	16.1	16.1	
1969	7	4	15.4	15.4	15.4	15.4	15.4	15.4	14.8		585
1969	8	1	11.7	11.3	11.3	11.3	11.3	10.9	10.5	10.9	
1969	8	2	10.5	10.5	10.1	10.1	10.1	10.1	10.1	10.1	
1969	8	3	9.7	10.1	9.7	9.3	9.3	9.3	9.3	10.1	
1969	8	4	9.7	11.3	14.0	13.6	12.7	11.7	11.3		332
1969	9	1	9.5	9.1	9.5	9.8	9.1	9.1	9.1	8.8	
1969	9	2	9.1	8.4	8.4	8.4	8.4	8.4	8.4	8.8	
1969	9	3	8.4	8.4	8.4	8.4	8.1	8.1	8.1	8.1	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1969	9	4	7.7	7.7	7.4	7.0	7.0	7.0			252
1969	10	1	10.8	10.2	10.2	10.2	100.0	68.8	28.3	20.4	
1969	10	2	17.8	17.0	16.4	20.4	79.9	38.8	26.9	24.1	
1969	10	3	22.9	22.1	22.1	22.9	21.0	19.5	19.5	19.0	
1969	10	4	18.4	17.8	18.4	19.0	22.1	21.5	21.5		808
1969	11	1	17.0	16.5	15.8	15.8	15.4	15.4	15.4	15.4	
1969	11	2	14.9	14.5	14.5	14.9	14.5	13.3	13.3	13.3	
1969	11	3	13.8	15.4	14.5	13.8	13.8	13.8	13.8	13.8	
1969	11	4	13.8	14.5	14.9	14.9	14.9	14.9			440
1969	12	1	20.3	19.7	19.7	19.7	44.1	114.5	87.0	62.3	
1969	12	2	54.8	49.4	45.4	41.6	40.7	40.1	39.1	38.2	
1969	12	3	37.2	36.3	35.4	34.7	33.8	32.2	31.3	31.3	
1969	12	4	31.3	30.7	29.7	29.7	31.3	31.3	31.3		1224
1970	1	1	29.8	29.8	29.2	29.2	31.6	34.6	36.4	33.7	
1970	1	2	33.1	33.1	33.1	33.1	32.2	31.6	31.6	32.2	
1970	1	3	33.1	33.1	32.2	32.2	32.2	31.6	31.6	31.6	
1970	1	4	31.6	31.6	30.7	30.7	30.7	29.8	29.8		987
1970	2	1	33.9	33.9	33.9	34.9	34.9	61.1	111.3	88.9	
1970	2	2	76.0	71.2	69.9	67.5	66.5	65.1	71.2	67.5	
1970	2	3	63.8	61.7	59.4	56.0	54.9	54.9	62.1	110.9	
1970	2	4	133.0	113.6	107.5	110.6					1976
1970	3	1	118.2	116.4	127.8	126.3	124.8	183.6	330.5	225.5	
1970	3	2	198.3	182.1	170.7	161.6	150.5	139.5	134.4	132.9	
1970	3	3	206.0	152.4	139.5	131.5	131.5	129.6	119.7	118.2	
1970	3	4	114.6	106.5	102.1	102.1	99.1	94.7	93.3		4464
1970	4	1	81.7	76.6	72.9	70.6	66.9	65.2	62.2	60.5	
1970	4	2	63.9	67.2	63.9	60.5	55.5	52.1	50.4	52.1	
1970	4	3	52.1	50.4	100.8	84.0	67.2	60.5	57.1	55.5	
1970	4	4	53.8	52.1	50.4	50.4	48.7	47.1			1852
1970	5	1	52.1	52.1	50.2	48.4	46.5	44.7	42.8	40.9	
1970	5	2	39.1	39.1	37.2	37.2	37.2	39.1	260.5	317.5	
1970	5	3	160.0	124.7	109.4	102.0	96.0	145.2	228.5	483.8	
1970	5	4	260.5	744.4	595.5	409.4	335.0	297.7	335.0		5612
1970	6	1	248.6	213.1	195.3	177.6	159.8	142.0	134.9	127.8	
1970	6	2	120.7	113.6	106.5	99.4	92.3	85.2	78.1	74.6	
1970	6	3	71.0	67.5	63.9	60.4	56.8	53.3	49.7	53.3	
1970	6	4	53.3	51.5	49.7	47.9	46.2	45.5			2940
1970	7	1	35.4	34.6	32.9	32.0	31.4	30.0	28.3	28.3	
1970	7	2	27.8	26.9	26.3	26.3	25.5	26.3	27.8	26.9	
1970	7	3	26.3	24.9	24.1	24.1	23.5	24.1	22.9	22.9	
1970	7	4	22.9	22.1	22.1	21.5	21.0	20.4	19.5		809
1970	8	1	14.6	14.6	14.1	16.1	15.7	14.6	14.1	13.7	
1970	8	2	13.7	13.0	13.0	13.0	12.6	12.6	12.2	12.2	
1970	8	3	12.2	11.7	11.7	11.3	11.3	11.3	11.3	11.3	
1970	8	4	11.3	11.3	10.9	10.9	10.4	10.4	10.9		388
1970	9	1	9.9	9.5	9.5	9.1	8.8	8.8	8.4	8.0	
1970	9	2	8.4	8.0	9.5	8.8	9.9	9.5	8.8	9.9	
1970	9	3	9.9	9.1	8.8	8.4	8.4	8.0	9.1	8.4	
1970	9	4	11.1	18.3	14.1	12.8	12.4	11.4			295
1970	10	1	11.3	10.9	10.5	10.1	13.4	13.6	11.7	10.9	
1970	10	2	10.5	10.1	10.1	10.1	9.7	9.5	9.3	9.1	
1970	10	3	8.9	8.7	14.2	13.2	11.3	10.5	10.1	12.1	
1970	10	4	11.1	10.1	9.3	11.1	11.1	10.1	9.7		333
1970	11	1	5.4	5.2	4.9	4.9	4.7	4.7	4.7	4.7	
1970	11	2	4.7	4.5	4.5	4.5	4.5	4.2	4.2	4.2	
1970	11	3	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	
1970	11	4	4.2	4.2	4.2	4.2	4.2	4.2			134
1970	12	1	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	
1970	12	2	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.4	
1970	12	3	3.4	3.4	3.4	3.4	3.4	3.4	3.6	3.4	
1970	12	4	3.2	3.2	3.2	3.2	3.2	3.2	3.2		108
1971	1	1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	
1971	1	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
1971	1	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
1971	1	4	1.0	0.9	0.9	0.9	0.9	0.9	0.9		31
1971	2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	2	4	0.0	0.0	0.0	0.0					0

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1971	3	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	3	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	3	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	3	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1971	4	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	4	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	4	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	4	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1971	5	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	5	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	5	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	5	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1971	6	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	6	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	6	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	6	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1971	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1971	8	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	8	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	8	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	8	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1971	9	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	9	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1971	9	4	0.0	0.0	0.0	0.0	0.0	0.0			0
1971	10	1	4.7	4.7	4.2	5.4	5.4	5.4	4.9	4.9	
1971	10	2	5.4	5.4	5.4	4.9	5.4	5.4	5.4	8.4	
1971	10	3	9.3	7.0	16.4	118.0	54.7	25.9	20.6	17.8	
1971	10	4	16.1	15.2	14.7	14.7	15.2	14.7	14.0		459
1971	11	1	15.1	14.6	14.1	14.1	14.1	14.1	13.6	13.6	
1971	11	2	13.6	13.0	13.0	12.5	12.5	12.5	12.5	12.5	
1971	11	3	13.6	107.9	36.2	28.2	22.9	21.6	23.5	24.8	
1971	11	4	22.9	21.6	20.3	19.8	19.3	19.3			617
1971	12	1	24.2	36.3	39.0	37.9	129.0	98.7	78.9	72.9	
1971	12	2	73.9	82.6	82.6	78.9	71.5	69.2	65.8	62.1	
1971	12	3	58.8	57.1	55.4	53.7	52.1	50.4	50.4	48.7	
1971	12	4	47.0	47.0	45.3	43.7	43.7	42.0	42.0		1841
1972	1	1	34.4	34.4	34.4	32.9	32.9	32.9	31.5	31.5	
1972	1	2	31.5	30.1	29.5	29.5	29.5	28.1	26.6	25.8	
1972	1	3	25.2	25.2	25.2	24.3	24.3	23.8	23.2	23.2	
1972	1	4	22.3	21.8	21.8	21.2	21.2	21.8	22.3		842
1972	2	1	17.2	17.2	16.3	16.3	16.3	16.3	16.3	15.7	
1972	2	2	15.7	15.7	15.7	15.7	15.2	15.2	15.2	15.2	
1972	2	3	14.8	14.3	13.6	13.6	13.6	13.6	13.2	13.2	
1972	2	4	13.2	12.7	12.7	12.3	12.3				428
1972	3	1	10.5	10.1	10.1	10.1	10.9	10.9	10.9	10.5	
1972	3	2	9.7	9.7	10.1	10.1	10.1	10.5	10.5	9.7	
1972	3	3	9.7	9.7	9.3	9.3	9.7	9.7	9.7	9.7	
1972	3	4	9.7	9.3	9.3	9.3	8.9	8.9	8.9		305
1972	4	1	4.9	4.9	4.9	4.9	4.7	4.7	4.7	4.7	
1972	4	2	4.5	4.5	4.5	4.3	4.2	4.0	3.9	3.9	
1972	4	3	3.8	3.7	3.8	3.9	3.8	3.7	3.5	3.4	
1972	4	4	3.4	3.4	3.6	5.1	4.3	3.6			125
1972	5	1	12.1	11.7	9.9	9.6	9.6	14.2	21.3	21.3	
1972	5	2	21.3	23.1	63.8	159.6	141.9	159.6	141.9	354.7	
1972	5	3	425.6	212.8	145.4	124.1	106.4	95.8	88.7	81.6	
1972	5	4	74.5	70.9	67.4	63.8	60.3	56.7	53.2		2903
1972	6	1	45.0	43.4	41.7	41.1	40.1	38.2	37.3	36.3	
1972	6	2	37.3	38.2	40.1	37.3	36.3	36.3	35.6	37.3	
1972	6	3	141.6	135.2	69.7	53.0	48.8	44.6	41.1	38.2	
1972	6	4	37.3	36.3	35.6	34.0	32.1	31.5			1400
1972	7	1	24.4	24.4	23.1	25.2	24.4	23.1	22.6	21.3	
1972	7	2	20.0	20.0	19.0	18.5	18.5	18.5	18.5	20.0	
1972	7	3	19.0	17.7	17.7	17.7	17.7	17.7	17.2	16.2	
1972	7	4	16.2	16.2	16.2	15.4	15.4	14.9	14.9		592
1972	8	1	13.5	13.5	14.7	14.0	13.5	13.0	13.0	12.6	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1972	8	2	12.6	12.8	13.7	12.8	12.1	12.1	12.6	13.5	
1972	8	3	12.3	12.6	12.3	11.9	11.4	11.9	17.7	39.8	
1972	8	4	26.6	18.4	16.1	14.7	14.0	13.5	12.6		456
1972	9	1	6.9	6.8	6.5	6.4	6.4	6.4	6.1	5.8	
1972	9	2	5.8	5.7	5.6	5.6	5.4	5.4	5.3	5.2	
1972	9	3	5.2	5.0	4.9	4.7	4.7	4.7	4.9	5.4	
1972	9	4	5.2	5.3	5.0	5.0	5.0	4.7			165
1972	10	1	7.9	7.9	7.9	7.7	7.5	7.2	7.0	6.5	
1972	10	2	6.5	6.3	6.3	6.3	6.1	6.1	6.1	5.8	
1972	10	3	5.8	5.8	5.6	5.6	6.1	155.7	50.0	21.9	
1972	10	4	15.6	14.7	13.8	13.3	12.6	11.4	11.2		459
1972	11	1	126.1	57.9	29.5	24.7	22.4	21.3	20.2	19.6	
1972	11	2	19.3	18.7	18.5	18.2	21.6	23.9	26.7	23.9	
1972	11	3	23.0	22.7	22.1	21.6	21.0	20.4	20.4	24.4	
1972	11	4	25.3	24.7	25.0	24.7	24.1	24.1			816
1972	12	1	21.6	21.6	21.6	21.6	21.6	21.0	20.5	21.0	
1972	12	2	21.0	20.8	20.5	20.5	20.5	20.3	19.7	19.2	
1972	12	3	19.2	19.2	19.2	19.2	19.2	19.2	19.0	18.7	
1972	12	4	17.9	17.9	17.4	17.9	17.9	17.1	18.2		610
1973	1	1	23.4	24.6	25.2	25.8	26.4	26.4	27.7	28.3	
1973	1	2	28.9	30.1	31.3	30.7	31.3	31.3	31.7	31.7	
1973	1	3	31.7	31.7	31.7	32.0	31.7	32.0	31.0	30.4	
1973	1	4	36.6	77.1	71.0	61.8	56.2	56.5	57.8		1124
1973	2	1	63.6	59.8	57.1	55.4	55.4	54.0	53.0	55.7	
1973	2	2	58.1	59.8	59.1	60.5	61.2	57.7	54.0	52.6	
1973	2	3	57.1	66.3	69.0	66.6	73.1	107.3	139.4	129.2	
1973	2	4	123.4	117.5	112.8	110.0					2089
1973	3	1	110.4	108.0	103.2	100.7	96.9	95.9	91.0	87.2	
1973	3	2	85.8	85.1	83.7	78.5	76.4	75.4	74.0	73.6	
1973	3	3	69.8	66.0	65.3	62.5	59.7	58.7	59.7	73.3	
1973	3	4	81.6	66.3	61.1	59.7	60.4	58.4	55.6		2384
1973	4	1	53.3	51.6	51.2	51.6	49.1	51.9	60.6	63.4	
1973	4	2	54.0	50.5	49.8	49.1	49.1	49.8	111.1	88.8	
1973	4	3	108.3	126.1	112.9	103.1	97.9	95.8	96.5	98.6	
1973	4	4	98.6	143.9	123.7	103.8	100.7	99.3			2444
1973	5	1	97.1	96.4	96.0	86.4	85.7	92.9	125.5	98.8	
1973	5	2	87.8	83.0	80.9	79.6	75.8	71.3	68.9	66.9	
1973	5	3	64.8	62.8	60.0	56.9	54.2	52.1	50.1	49.4	
1973	5	4	48.0	47.3	46.6	43.9	41.5	39.4	39.1		2149
1973	6	1	42.7	41.2	40.5	94.8	80.2	52.4	46.5	42.7	
1973	6	2	42.7	39.3	50.2	1659.6	430.8	268.2	216.9	188.1	
1973	6	3	174.2	168.6	149.9	142.4	300.5	206.8	182.1	176.1	
1973	6	4	223.3	363.4	281.7	250.3	232.3	215.0			6403
1973	7	1	211.0	196.0	183.4	177.7	172.0	162.4	158.6	229.3	
1973	7	2	508.3	196.4	165.1	148.7	136.0	129.9	3171.9	1414.0	
1973	7	3	603.8	412.7	342.8	298.5	267.5	240.0	219.0	201.0	
1973	7	4	185.7	172.0	159.7	182.7	148.7	136.0	150.6		11081
1973	8	1	179.9	130.5	114.4	106.2	100.0	95.9	91.1	86.0	
1973	8	2	81.5	77.1	73.3	69.9	66.5	65.1	62.0	58.2	
1973	8	3	55.8	53.8	51.7	51.0	50.7	46.9	44.9	42.8	
1973	8	4	41.8	40.1	40.8	39.1	38.4	37.7	38.0		2131
1973	9	1	36.0	33.8	32.2	30.9	30.0	30.3	32.8	41.0	
1973	9	2	43.9	36.3	32.2	30.9	32.8	36.9	35.3	36.6	
1973	9	3	32.5	30.9	30.0	29.0	28.4	27.4	26.8	26.5	
1973	9	4	27.4	31.2	215.5	107.6	62.2	48.3			1276
1973	10	1	51.1	45.0	40.0	46.1	47.3	44.2	42.0	38.1	
1973	10	2	35.1	40.0	1006.8	267.3	255.5	258.6	2097.6	1239.5	
1973	10	3	686.5	533.9	450.0	392.8	345.1	308.9	281.1	260.1	
1973	10	4	241.4	226.2	220.4	211.3	190.3	188.0	224.6		10315
1973	11	1	175.0	160.7	151.7	146.0	139.2	132.4	131.3	128.5	
1973	11	2	122.0	115.6	112.4	109.5	107.0	104.5	100.9	95.9	
1973	11	3	93.8	93.4	91.3	96.3	90.5	85.5	84.5	84.1	
1973	11	4	80.5	78.4	75.5	70.9	68.0	67.6			3193
1973	12	1	60.5	59.9	59.2	57.6	55.7	53.7	52.4	51.8	
1973	12	2	51.1	50.2	49.5	49.5	48.9	47.9	46.3	45.0	
1973	12	3	44.3	44.3	46.6	44.7	42.7	42.1	43.0	42.4	
1973	12	4	41.1	40.1	39.2	38.5	38.8	38.2	37.5		1463
1974	1	1	33.7	33.7	33.7	33.7	33.7	33.7	32.8	32.8	
1974	1	2	32.8	32.8	31.9	31.0	30.3	30.0	30.0	30.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1974	1	3	30.0	30.3	31.3	32.8	31.3	29.7	31.3	35.2	
1974	1	4	40.4	45.2	48.0	43.4	40.4	38.8	37.9		1063
1974	2	1	36.0	36.0	35.4	33.7	33.7	34.0	33.4	32.5	
1974	2	2	32.0	31.4	31.7	31.7	32.2	32.2	32.2	31.1	
1974	2	3	30.2	31.4	30.2	29.6	29.9	32.0	32.8	30.5	
1974	2	4	28.8	27.9	27.6	27.6					888
1974	3	1	26.0	26.6	26.0	27.4	25.4	24.3	25.2	25.2	
1974	3	2	24.9	24.3	23.8	23.5	23.2	23.5	24.6	23.8	
1974	3	3	23.0	23.5	23.5	23.5	23.2	22.1	21.9	24.9	
1974	3	4	24.6	23.5	23.8	23.2	21.9	22.1	22.1		745
1974	4	1	19.8	19.3	19.6	19.1	18.8	18.6	18.6	18.6	
1974	4	2	17.8	18.3	19.1	18.1	18.3	17.8	18.1	17.6	
1974	4	3	17.3	17.3	17.6	17.6	17.3	19.1	16.6	16.3	
1974	4	4	16.3	16.3	16.1	16.1	15.9	16.6			534
1974	5	1	18.1	16.8	18.1	18.3	18.8	17.8	17.8	17.6	
1974	5	2	20.8	23.8	21.6	20.6	19.8	19.8	19.3	18.8	
1974	5	3	18.6	18.1	17.6	17.3	17.1	16.8	16.6	16.0	
1974	5	4	15.8	16.0	15.3	15.0	14.8	15.0	14.8		552
1974	6	1	11.0	11.0	11.2	11.0	10.7	10.7	10.5	10.5	
1974	6	2	10.3	10.3	10.1	10.3	11.0	9.9	9.7	9.5	
1974	6	3	9.2	9.2	9.0	8.8	8.8	8.6	8.4	8.2	
1974	6	4	8.0	7.9	7.9	7.7	7.7	7.5			284
1974	7	1	3.7	3.7	3.6	3.6	3.4	3.4	3.4	3.4	
1974	7	2	3.3	3.3	3.2	3.4	3.4	3.2	3.2	3.2	
1974	7	3	3.1	3.2	3.2	3.0	2.9	2.9	2.9	2.8	
1974	7	4	2.8	2.8	2.8	2.7	2.7	2.7	2.7		97
1974	8	1	7.6	7.6	7.6	7.6	7.6	10.3	9.3	11.8	
1974	8	2	9.3	8.6	8.6	8.1	7.8	7.8	7.3	7.1	
1974	8	3	7.1	7.1	7.1	7.1	6.8	6.6	6.6	6.3	
1974	8	4	6.6	6.8	7.3	7.6	8.8	178.1	156.2		560
1974	9	1	49.7	29.9	163.3	68.8	41.4	32.7	28.7	25.9	
1974	9	2	25.0	24.7	25.6	30.3	37.4	38.0	31.2	29.0	
1974	9	3	27.8	26.9	26.2	25.3	24.4	73.5	46.0	37.7	
1974	9	4	34.3	31.5	30.6	29.0	27.2	25.9			1148
1974	10	1	24.1	23.5	22.6	22.0	22.0	21.7	21.5	20.9	
1974	10	2	20.9	20.9	20.6	20.3	20.3	20.6	21.2	18.8	
1974	10	3	19.7	19.7	19.4	18.8	18.8	18.5	18.8	19.7	
1974	10	4	20.0	19.7	19.7	19.7	19.4	21.2	314.5		929
1974	11	1	174.4	74.2	55.8	61.4	60.0	53.0	61.7	99.8	
1974	11	2	100.5	99.5	103.3	91.5	86.3	82.9	78.7	76.6	
1974	11	3	75.2	71.8	70.0	66.9	63.1	61.0	62.1	106.1	
1974	11	4	77.7	71.4	68.0	66.6	65.2	62.1			2347
1974	12	1	54.6	52.9	51.3	49.7	49.7	48.8	47.8	44.9	
1974	12	2	42.3	46.8	51.7	56.2	49.4	45.5	44.2	42.9	
1974	12	3	41.6	41.3	41.0	40.0	39.1	39.1	39.1	38.4	
1974	12	4	38.7	44.2	54.9	52.0	51.0	51.0	52.3		1443
1975	1	1	55.2	57.6	60.9	60.6	60.2	60.9	60.9	60.6	
1975	1	2	59.6	58.9	57.6	66.6	73.3	66.3	64.9	63.6	
1975	1	3	62.2	62.2	60.9	57.6	56.2	56.2	52.9	52.9	
1975	1	4	52.9	52.2	49.5	49.5	48.5	48.2	48.2		1798
1975	2	1	57.2	538.5	591.2	907.5	500.8	410.5	355.1	326.9	
1975	2	2	291.1	268.1	251.9	226.3	210.9	203.0	193.9	184.9	
1975	2	3	173.2	165.7	155.9	151.0	146.5	143.1	134.1	128.8	
1975	2	4	125.8	121.6	117.5	114.5					7195
1975	3	1	102.2	96.7	92.3	89.9	89.5	88.2	85.8	78.9	
1975	3	2	77.2	78.9	76.2	74.8	72.4	78.9	70.3	66.6	
1975	3	3	64.8	64.5	63.8	60.0	58.3	56.9	58.0	58.3	
1975	3	4	51.5	51.8	51.5	51.8	49.1	46.7	47.3		2153
1975	4	1	45.3	43.7	42.7	40.7	39.7	42.0	44.0	64.2	
1975	4	2	52.5	46.9	43.3	40.4	40.7	41.7	41.1	42.4	
1975	4	3	39.7	37.8	34.5	32.9	33.6	34.2	34.5	34.9	
1975	4	4	33.6	32.6	31.6	185.4	171.4	71.7			1520
1975	5	1	81.2	68.9	63.3	62.9	196.9	182.0	109.7	114.2	
1975	5	2	112.7	271.4	192.4	159.1	142.6	172.6	159.5	134.4	
1975	5	3	122.8	114.9	114.9	162.9	181.6	139.3	167.0	1115.7	
1975	5	4	378.1	304.0	269.6	239.6	244.8	302.5	231.4		6313
1975	6	1	196.4	177.7	163.8	154.5	146.6	138.8	132.0	127.2	
1975	6	2	133.1	733.1	377.8	268.5	224.4	205.7	188.9	176.5	
1975	6	3	162.7	151.8	141.0	132.0	128.7	151.5	132.0	120.1	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1975	6	4	113.3	213.9	422.6	350.8	227.0	190.7			6183
1975	7	1	167.0	184.5	194.5	167.0	146.6	136.6	126.2	118.0	
1975	7	2	111.6	102.3	97.3	97.3	192.4	110.1	94.4	93.0	
1975	7	3	90.1	88.7	82.6	75.5	72.6	68.7	67.2	65.8	
1975	7	4	65.8	62.2	60.8	59.7	58.3	57.2	56.1		3170
1975	8	1	49.4	72.6	105.2	66.1	57.4	53.9	51.3	50.3	
1975	8	2	48.7	46.8	45.2	45.2	43.9	42.6	38.7	38.7	
1975	8	3	37.8	37.8	37.8	39.4	39.4	37.8	39.0	37.8	
1975	8	4	39.7	41.9	40.0	37.8	36.8	38.7	40.7		1438
1975	9	1	37.7	39.4	35.1	30.7	32.2	33.4	33.1	32.2	
1975	9	2	32.2	31.6	31.9	31.9	30.2	29.0	29.0	50.2	
1975	9	3	28.4	26.7	25.8	25.2	24.9	23.8	23.8	23.5	
1975	9	4	23.5	23.5	23.5	23.5	23.5	23.5			883
1975	10	1	23.0	23.0	22.5	22.8	23.0	22.8	23.0	22.5	
1975	10	2	22.5	22.8	21.6	22.5	22.5	22.5	22.5	21.9	
1975	10	3	21.9	21.6	21.6	21.0	21.3	21.6	22.5	27.8	
1975	10	4	99.3	75.1	63.5	49.0	42.8	40.2	39.3		949
1975	11	1	37.7	36.5	34.8	33.9	33.0	33.0	33.0	30.7	
1975	11	2	30.7	30.7	29.9	29.9	29.9	29.9	29.0	29.0	
1975	11	3	29.0	29.0	29.0	28.1	27.2	27.2	25.8	26.7	
1975	11	4	24.9	24.1	24.4	24.6	25.5	23.8			881
1975	12	1	20.1	20.1	20.1	20.3	20.8	20.1	19.5	19.5	
1975	12	2	19.5	19.5	19.5	19.5	19.8	19.5	19.3	18.8	
1975	12	3	18.3	18.3	18.3	17.5	17.5	17.5	17.5	21.6	
1975	12	4	19.8	18.8	18.8	18.8	18.5	17.5	18.3		593
1976	1	1	17.5	17.0	16.7	18.0	18.0	18.0	17.0	16.7	
1976	1	2	16.7	17.5	18.0	17.7	18.0	17.5	17.2	17.7	
1976	1	3	16.7	16.7	17.0	16.7	15.7	16.2	16.5	17.5	
1976	1	4	18.7	16.0	15.5	15.5	15.5	15.5	15.5		524
1976	2	1	13.1	13.1	13.3	13.6	13.6	12.7	12.7	12.3	
1976	2	2	12.7	12.9	13.1	12.9	13.3	12.7	12.7	12.7	
1976	2	3	13.6	12.3	12.9	13.1	15.1	13.1	12.9	12.9	
1976	2	4	13.6	13.3	12.5	13.1	13.3				379
1976	3	1	15.5	15.3	15.0	15.0	17.5	17.8	18.8	20.1	
1976	3	2	20.8	20.3	20.3	20.1	18.6	18.6	18.3	17.8	
1976	3	3	17.8	17.8	17.8	17.8	17.0	17.0	17.0	17.8	
1976	3	4	17.8	17.8	17.8	17.3	17.8	17.0	16.5		552
1976	4	1	25.1	26.2	26.2	30.2	36.8	37.6	41.6	51.2	
1976	4	2	49.7	46.8	45.3	43.1	40.9	39.8	40.5	51.6	
1976	4	3	48.3	1307.8	394.2	375.8	282.2	234.7	204.5	206.3	
1976	4	4	259.0	162.1	145.9	137.0	158.4	149.2			4698
1976	5	1	130.0	119.6	111.4	103.2	121.4	350.1	351.6	289.0	
1976	5	2	219.8	204.9	186.2	173.9	204.5	176.9	157.2	146.0	
1976	5	3	134.8	127.0	119.9	119.2	153.1	123.7	113.2	114.4	
1976	5	4	121.1	640.7	223.5	182.1	167.2	156.1	155.7		5697
1976	6	1	257.3	173.0	151.7	140.7	132.2	125.1	119.4	113.8	
1976	6	2	108.8	103.5	98.2	93.2	88.6	85.1	81.9	78.3	
1976	6	3	74.4	71.6	70.5	68.4	69.5	62.4	58.5	56.7	
1976	6	4	64.9	83.3	74.8	65.6	58.1	52.8			2882
1976	7	1	51.9	49.8	50.1	118.7	154.4	114.4	109.0	83.7	
1976	7	2	77.2	80.1	115.8	172.8	138.2	133.5	153.7	160.5	
1976	7	3	155.8	143.9	133.8	125.5	120.9	118.0	112.6	107.1	
1976	7	4	116.5	124.8	110.8	101.4	96.3	90.9	87.3		3509
1976	8	1	77.0	73.7	71.1	69.1	68.4	66.1	63.2	61.5	
1976	8	2	58.6	56.9	55.0	53.3	52.0	51.3	50.0	48.7	
1976	8	3	46.7	45.7	46.1	47.1	47.1	44.8	43.4	41.5	
1976	8	4	39.5	38.5	37.8	37.2	39.8	44.4	37.8		1613
1976	9	1	32.2	36.0	33.4	36.3	36.0	32.8	31.4	29.9	
1976	9	2	29.6	28.2	28.2	28.2	27.6	27.3	26.7	26.7	
1976	9	3	25.9	25.9	26.4	28.5	30.8	30.5	29.0	28.2	
1976	9	4	27.0	27.3	29.9	29.6	29.0	29.0			888
1976	10	1	33.7	32.7	31.0	32.4	194.2	43.8	38.4	35.7	
1976	10	2	33.7	32.7	31.7	31.0	31.0	31.0	33.7	42.5	
1976	10	3	44.8	40.5	41.5	43.8	42.5	42.5	40.5	57.3	
1976	10	4	56.3	55.0	51.6	52.3	183.4	253.9	177.7		1893
1976	11	1	159.9	145.4	133.7	123.8	115.6	111.0	103.6	98.2	
1976	11	2	94.7	90.4	87.6	84.8	91.1	92.2	81.9	80.5	
1976	11	3	79.1	79.4	94.0	99.6	90.8	84.0	81.9	81.2	
1976	11	4	81.2	94.7	91.1	84.8	82.3	79.1			2898

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1976	12	1	78.3	77.2	75.8	73.7	76.2	92.9	93.2	84.7	
1976	12	2	82.9	82.2	90.4	109.3	104.3	107.5	118.1	113.9	
1976	12	3	112.8	112.8	114.9	116.4	110.3	107.8	106.4	101.8	
1976	12	4	101.8	99.3	95.7	95.4	91.5	90.7	86.8		3005
1977	1	1	83.0	85.5	82.0	79.5	76.7	73.2	75.7	74.3	
1977	1	2	74.3	72.5	70.0	70.7	79.2	98.8	89.0	84.8	
1977	1	3	81.6	81.6	80.9	80.9	80.9	82.3	92.8	94.9	
1977	1	4	89.7	88.3	90.4	90.4	87.2	86.2	91.4		2568
1977	2	1	93.2	96.0	101.0	102.1	98.9	95.7	95.7	94.6	
1977	2	2	95.7	99.9	135.1	141.9	129.5	126.6	121.6	117.7	
1977	2	3	117.4	117.0	113.8	108.1	106.7	106.3	105.6	100.3	
1977	2	4	97.1	93.9	87.8	86.4					2986
1977	3	1	81.8	82.9	89.0	90.7	82.5	77.7	75.0	73.7	
1977	3	2	73.3	72.6	73.0	69.6	67.5	66.5	65.1	63.1	
1977	3	3	62.1	62.1	60.7	58.3	58.0	54.2	51.1	51.8	
1977	3	4	51.1	51.5	54.6	67.2	62.7	54.6	51.5		2056
1977	4	1	55.6	56.4	56.7	54.5	50.6	49.5	48.7	48.7	
1977	4	2	46.8	46.1	45.7	54.1	130.2	150.4	1054.8	1782.2	
1977	4	3	754.0	548.4	495.0	955.8	548.4	453.2	392.2	350.7	
1977	4	4	315.3	287.1	270.4	249.8	235.3	223.1			9810
1977	5	1	206.7	189.3	178.8	170.8	159.1	152.6	145.0	138.1	
1977	5	2	133.0	130.1	138.8	137.7	120.6	112.6	109.7	105.4	
1977	5	3	102.1	99.2	108.3	182.0	119.9	120.3	105.0	96.3	
1977	5	4	91.6	87.9	84.7	81.4	79.6	78.1	77.4		3842
1977	6	1	77.6	68.7	72.6	63.7	59.1	58.1	58.5	57.1	
1977	6	2	54.2	53.5	52.5	51.5	53.5	61.1	55.1	52.2	
1977	6	3	50.2	48.5	46.9	47.2	46.2	47.9	55.8	55.5	
1977	6	4	60.1	52.8	49.5	46.9	46.9	45.2			1649
1977	7	1	38.7	38.2	36.7	36.7	32.5	30.2	29.3	28.8	
1977	7	2	29.1	27.9	27.3	26.8	26.2	26.8	26.2	26.2	
1977	7	3	24.8	24.8	24.5	24.2	23.6	23.4	22.8	21.9	
1977	7	4	21.9	21.7	21.4	21.1	21.4	20.2	20.2		826
1977	8	1	14.8	14.6	14.6	14.6	14.4	13.5	13.5	13.3	
1977	8	2	13.1	13.3	13.5	13.5	12.7	12.4	12.4	12.2	
1977	8	3	12.2	11.8	12.9	11.8	11.8	11.8	11.4	11.4	
1977	8	4	11.8	11.8	11.4	11.4	12.2	10.7	10.7		392
1977	9	1	8.6	8.6	9.2	9.2	8.6	9.5	8.6	8.6	
1977	9	2	9.2	8.3	8.6	8.6	8.3	8.3	8.3	8.3	
1977	9	3	8.3	7.9	8.3	8.3	8.6	8.6	8.3	8.3	
1977	9	4	7.9	7.9	8.3	8.3	8.3	8.3			254
1977	10	1	10.9	11.4	10.9	11.2	10.7	10.9	10.7	10.2	
1977	10	2	10.0	9.5	9.5	8.7	9.0	9.2	9.0	8.5	
1977	10	3	8.0	8.3	8.5	8.3	8.3	106.8	69.2	25.3	
1977	10	4	18.7	16.8	16.0	14.8	13.1	12.4	11.9		506
1977	11	1	9.6	8.4	8.6	8.6	8.2	8.0	8.2	11.2	
1977	11	2	9.0	10.2	10.4	10.6	10.2	9.8	9.6	9.8	
1977	11	3	9.6	9.6	9.8	10.0	37.3	15.0	11.6	11.0	
1977	11	4	10.2	10.2	10.0	9.8	10.0	9.2			323
1977	12	1	8.1	8.1	8.4	8.6	8.4	7.9	7.5	7.7	
1977	12	2	7.5	7.5	7.5	7.7	8.2	8.1	8.1	8.2	
1977	12	3	8.4	8.1	8.2	8.1	10.3	8.4	8.2	8.2	
1977	12	4	8.1	7.9	7.9	8.1	8.2	8.2	8.2		252
1978	1	1	6.9	6.6	6.6	6.6	6.8	6.9	7.1	6.8	
1978	1	2	6.3	6.3	6.6	6.3	6.3	6.3	6.3	6.6	
1978	1	3	6.5	6.3	6.5	6.3	6.3	6.3	6.3	6.3	
1978	1	4	6.3	6.2	6.5	6.6	6.6	6.8	6.9		203
1978	2	1	6.8	6.5	6.5	6.5	6.5	6.5	6.5	6.2	
1978	2	2	6.2	6.2	6.5	7.9	6.8	6.8	7.4	7.1	
1978	2	3	7.9	7.9	8.2	8.2	7.9	7.1	7.1	7.1	
1978	2	4	7.1	7.1	7.1	6.8					197
1978	3	1	5.9	5.6	5.6	5.2	5.4	5.9	5.8	5.5	
1978	3	2	5.8	5.8	5.9	5.6	5.8	5.5	5.2	5.2	
1978	3	3	4.9	5.2	5.2	5.1	5.2	5.2	5.4	5.6	
1978	3	4	5.1	5.2	5.2	5.5	5.4	5.2	5.1		168
1978	4	1	4.8	4.8	4.6	4.3	4.3	4.4	4.5	4.5	
1978	4	2	4.5	9.9	5.9	6.5	6.6	6.3	6.1	5.7	
1978	4	3	5.6	5.6	5.2	4.9	4.9	4.9	4.8	4.9	
1978	4	4	4.5	3.9	4.3	4.1	4.0	4.1			153
1978	5	1	2.4	2.9	3.4	2.9	3.2	2.8	2.7	2.4	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1978	5	2	2.2	2.1	2.1	2.1	2.0	2.1	2.2	2.2	
1978	5	3	2.3	2.2	2.1	3.0	2.7	2.7	2.5	2.4	
1978	5	4	2.2	2.2	2.0	1.9	3.0	2.4	2.2		75
1978	6	1	7.7	13.4	15.1	12.2	10.2	10.7	75.6	41.7	
1978	6	2	37.2	31.7	27.3	23.1	21.1	17.9	15.9	15.6	
1978	6	3	14.9	14.4	13.4	12.6	11.9	11.7	10.9	11.2	
1978	6	4	11.7	10.9	10.7	9.7	8.7	7.2			536
1978	7	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1978	7	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1978	7	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1978	7	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0
1978	8	1	25.6	10.2	6.8	4.9	4.4	4.2	4.0	3.8	
1978	8	2	3.6	4.0	2.9	2.6	2.5	2.5	2.2	2.2	
1978	8	3	2.0	2.2	2.3	2.2	2.2	2.2	2.3	2.2	
1978	8	4	2.0	2.2	2.3	2.1	2.3	2.3	2.6		119
1978	9	1	14.5	10.6	17.9	19.1	17.5	13.9	13.3	106.2	
1978	9	2	185.5	61.1	45.1	38.1	39.3	34.5	31.8	30.9	
1978	9	3	29.3	29.3	28.4	27.5	26.9	26.0	27.5	26.9	
1978	9	4	26.9	25.1	25.1	24.5	22.7	22.7			1048
1978	10	1	12.7	11.8	11.8	11.5	10.6	10.1	9.7	9.4	
1978	10	2	9.0	9.0	8.5	8.0	7.6	7.3	7.1	7.3	
1978	10	3	7.0	7.0	6.6	6.6	6.6	6.4	6.4	6.3	
1978	10	4	6.6	6.4	6.3	6.3	6.3	6.1	6.1		248
1978	11	1	7.1	7.3	7.3	6.9	15.6	21.7	14.2	13.7	
1978	11	2	12.5	11.7	10.8	9.8	9.6	9.0	10.2	10.8	
1978	11	3	11.2	10.6	11.9	12.1	13.1	13.1	13.1	12.7	
1978	11	4	12.7	13.1	13.1	12.7	12.9	12.7			353
1978	12	1	13.8	13.8	14.0	13.8	14.0	14.0	13.5	12.9	
1978	12	2	12.4	12.6	12.6	12.4	12.4	12.9	13.3	12.9	
1978	12	3	12.9	12.9	12.9	12.9	12.4	12.0	12.0	12.0	
1978	12	4	11.8	12.2	12.0	11.5	11.5	11.5	24.6		406
1979	1	1	128.9	84.1	65.3	62.8	62.1	61.4	58.9	55.4	
1979	1	2	52.9	76.3	291.1	185.7	151.9	127.1	117.9	114.3	
1979	1	3	108.3	103.3	102.2	95.9	88.4	83.1	81.7	76.7	
1979	1	4	74.9	77.0	74.2	68.2	67.1	67.8	65.3		2930
1979	2	1	63.9	63.6	64.7	70.5	118.8	287.0	254.3	214.0	
1979	2	2	187.4	176.9	167.5	158.0	147.8	141.7	134.8	123.1	
1979	2	3	116.6	114.8	111.9	110.4	107.5	104.3	149.7	178.7	
1979	2	4	124.2	114.1	113.7	111.9					3832
1979	3	1	109.7	107.9	120.3	109.7	101.8	99.6	97.3	95.4	
1979	3	2	93.5	90.5	87.5	87.1	85.2	81.8	79.2	81.1	
1979	3	3	91.3	94.7	682.6	277.6	1161.5	633.6	486.5	407.3	
1979	3	4	353.7	308.9	284.3	270.8	261.7	308.9	305.5		7456
1979	4	1	283.2	387.8	315.2	293.3	272.6	259.4	243.2	249.6	
1979	4	2	223.7	210.9	204.1	181.5	171.7	163.4	161.2	154.0	
1979	4	3	159.7	198.1	160.0	161.5	617.5	313.7	264.3	231.2	
1979	4	4	211.6	192.0	181.5	169.1	299.7	248.5			7183
1979	5	1	407.8	345.5	277.0	249.5	218.4	205.4	193.2	185.4	
1979	5	2	182.8	178.0	169.1	172.4	152.0	143.9	138.7	132.7	
1979	5	3	132.0	126.4	120.5	117.2	112.3	250.3	159.4	127.9	
1979	5	4	115.3	109.0	105.7	104.9	102.3	100.5	96.0		5231
1979	6	1	89.0	145.7	139.1	116.1	123.4	140.8	117.5	108.8	
1979	6	2	104.6	96.6	96.3	87.6	83.1	81.0	76.1	72.7	
1979	6	3	68.5	65.0	60.5	58.1	55.3	53.9	51.8	49.4	
1979	6	4	48.0	44.8	43.8	43.5	42.4	40.3			2404
1979	7	1	14.0	14.0	14.0	13.0	14.0	18.0	16.0	13.0	
1979	7	2	13.0	14.0	13.0	13.0	12.0	12.0	12.0	12.0	
1979	7	3	12.0	11.0	11.0	12.0	13.0	12.0	11.0	11.0	
1979	7	4	11.0	216.0	42.0	7.8	9.3	3.7			600
1979	8	1	4.4	5.4	6.1	9.0	8.6	8.2	8.2	8.6	
1979	8	2	8.6	8.6	9.4	12.0	11.0	11.0	10.0	9.8	
1979	8	3	9.0	9.0	8.6	7.9	7.5	7.5	6.5	6.5	
1979	8	4	6.5	6.1	5.2	5.2	5.2	5.2	5.2		240
1979	9	1	5.2	5.2	5.6	5.2	5.2	5.2	5.2	5.2	
1979	9	2	4.8	4.3	3.8	3.8	3.7	3.2	2.3	2.5	
1979	9	3	4.3	4.3	4.0	3.5	3.2	3.8	3.8	3.8	
1979	9	4	3.8	3.8	3.8	3.2	3.2	2.7			122
1979	10	1	2.7	2.7	2.7	2.2	1.8	1.8	2.0	2.3	
1979	10	2	3.1	1.6	2.2	2.9	4.1	3.9	3.2	3.2	

GENERATED DAILY STREAMFLOWS FOR ONION CREEK NEAR DRIFTWOOD
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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1979	10	3	3.8	3.8	3.8	3.8	3.8	3.5	2.2	2.2	
1979	10	4	2.2	2.2	2.2	2.2	2.2	3.8	2.9		87
1979	11	1	1.4	1.1	1.1	1.1	1.1	1.1	1.1	1.2	
1979	11	2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.5	
1979	11	3	1.6	2.2	2.4	2.7	2.7	2.7	2.7	2.3	
1979	11	4	3.2	2.6	2.2	1.5	1.3	1.3			51
1979	12	1	1.3	1.3	1.3	1.3	1.3	1.3	1.6	1.3	
1979	12	2	1.3	1.3	1.3	2.4	3.7	1.7	1.6	1.6	
1979	12	3	1.6	1.6	1.6	1.6	1.6	1.6	1.8	2.2	
1979	12	4	2.1	1.8	1.8	2.6	4.0	1.8	1.8		55
1980	1	1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
1980	1	2	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
1980	1	3	2.2	2.6	2.2	2.2	3.0	3.2	3.2	2.9	
1980	1	4	2.7	2.7	2.4	2.2	2.2	2.2	2.2		64
1980	2	1	2.2	2.2	2.2	2.2	2.2	2.2	2.3	2.7	
1980	2	2	3.1	3.2	3.2	3.2	3.2	3.2	3.2	4.4	
1980	2	3	3.2	3.2	2.7	2.7	2.7	2.7	2.7	2.7	
1980	2	4	2.7	2.7	2.7	2.7	2.7				81
1980	3	1	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	
1980	3	2	2.7	2.7	2.7	3.4	3.3	3.2	3.2	3.2	
1980	3	3	3.2	3.2	3.2	3.2	2.8	2.7	3.0	2.8	
1980	3	4	2.7	2.7	7.0	8.3	7.5	7.0	7.0		112
1980	4	1	7.7	8.2	8.3	8.3	8.3	8.3	8.1	7.7	
1980	4	2	6.5	6.5	6.5	6.5	32.0	10.0	10.0	10.0	
1980	4	3	10.0	9.0	9.0	9.0	9.0	9.4	9.8	9.8	
1980	4	4	13.0	14.0	13.0	12.0	11.0	11.0			302
1980	5	1	11.0	11.0	11.0	11.0	11.0	11.0	11.0	12.0	
1980	5	2	13.0	13.0	13.0	91.0	88.0	225.0	115.0	101.0	
1980	5	3	87.0	77.0	82.0	74.0	255.0	145.0	124.0	114.0	
1980	5	4	107.0	101.0	97.0	90.0	83.0	72.0	94.0		2350
1980	6	1	91.0	72.0	69.0	61.0	53.0	44.0	42.0	39.0	
1980	6	2	37.0	35.0	32.0	29.0	28.0	26.0	26.0	26.0	
1980	6	3	24.0	23.0	23.0	22.0	21.0	20.0	18.0	17.0	
1980	6	4	15.0	14.0	12.0	10.0	9.0	7.9			946
1980	7	1	7.5	6.1	5.6	4.8	4.3	3.8	2.7	3.2	
1980	7	2	2.2	2.2	2.2	2.7	2.2	2.7	2.7	1.5	
1980	7	3	1.3	1.1	1.1	1.1	1.1	1.3	1.3	1.0	
1980	7	4	0.9	0.9	0.9	0.8	0.8	0.8	0.8		71
1980	8	1	0.8	0.8	0.9	1.1	1.1	1.0	1.0	1.1	
1980	8	2	1.1	1.8	2.5	1.5	1.3	1.2	1.1	1.3	
1980	8	3	0.9	1.0	1.1	1.0	0.9	0.9	0.8	0.7	
1980	8	4	0.6	0.5	0.5	0.4	0.4	0.4	0.4		30
1980	9	1	0.4	0.4	0.3	0.3	0.3	0.4	9.0	29.0	
1980	9	2	16.0	10.0	8.6	7.5	5.2	4.8	4.3	3.8	
1980	9	3	2.7	2.2	41.0	15.0	8.6	7.0	5.6	5.2	
1980	9	4	5.2	4.3	6.5	9.8	14.0	116.0			343
1980	10	1	51.0	37.0	30.0	26.0	22.0	14.0	18.0	18.0	
1980	10	2	17.0	15.0	15.0	13.0	12.0	12.0	12.0	198.0	
1980	10	3	37.9	26.7	27.8	23.9	21.6	20.6	19.0	16.0	
1980	10	4	13.9	13.9	15.0	15.0	15.0	15.5	16.0		808
1980	11	1	15.0	15.0	15.0	14.4	12.9	12.9	12.0	13.4	
1980	11	2	10.7	10.7	12.0	12.9	9.8	9.8	9.0	12.9	
1980	11	3	22.0	17.0	14.0	11.0	11.0	13.0	17.0	15.0	
1980	11	4	14.0	37.0	40.0	38.0	36.0	35.0			518
1980	12	1	37.0	37.0	37.0	37.0	39.0	38.0	37.0	39.0	
1980	12	2	45.0	41.0	39.2	38.5	38.5	37.9	37.9	36.6	
1980	12	3	35.4	34.2	31.2	28.9	28.3	27.2	26.7	27.2	
1980	12	4	26.7	26.7	25.0	23.9	23.9	23.4	22.8		1027
1981	1	1	23.4	22.8	23.4	23.9	24.5	25.0	26.1	25.6	
1981	1	2	27.2	26.7	26.1	25.6	26.1	26.7	27.2	26.1	
1981	1	3	26.1	25.6	26.1	26.1	26.4	25.6	25.0	25.6	
1981	1	4	24.5	24.5	23.9	23.4	23.9	22.8	21.0		777
1981	2	1	23.0	23.0	22.0	22.0	22.0	23.0	23.0	24.0	
1981	2	2	24.0	39.0	38.0	37.0	38.0	38.0	38.0	39.0	
1981	2	3	39.0	38.0	37.0	37.0	37.0	36.0	34.0	34.0	
1981	2	4	34.0	34.0	34.0	34.0					901
1981	3	1	38.0	38.0	57.0	765.0	139.0	117.0	116.0	112.0	
1981	3	2	103.0	100.0	102.0	114.0	142.0	122.0	120.0	113.0	
1981	3	3	111.0	106.0	99.0	98.0	96.0	91.0	87.0	85.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1981	3	4	84.0	83.0	81.0	80.0	97.0	85.0	79.0		3660
1981	4	1	77.0	74.0	73.0	69.0	63.0	61.0	61.0	60.0	
1981	4	2	58.0	57.0	50.0	53.0	50.0	49.0	48.0	47.0	
1981	4	3	46.0	44.0	41.0	38.0	37.0	36.0	43.0	43.0	
1981	4	4	38.0	35.0	32.0	32.0	30.0	29.0			1474
1981	5	1	28.0	27.0	28.0	28.0	27.0	25.0	23.0	22.0	
1981	5	2	21.0	20.0	20.0	20.0	19.0	18.0	17.0	21.0	
1981	5	3	21.0	19.0	17.0	16.0	14.0	15.0	15.0	139.0	
1981	5	4	124.0	46.0	34.0	31.0	30.0	34.0	45.0		964
1981	6	1	42.0	46.0	52.0	93.0	101.0	72.0	63.0	59.0	
1981	6	2	55.0	53.0	1990.0	1840.0	1730.0	1390.0	225.0	1810.0	
1981	6	3	238.0	551.0	486.0	352.0	307.0	276.0	238.0	204.0	
1981	6	4	203.0	198.0	193.0	176.0	164.0	171.0			13378
1981	7	1	173.0	163.0	154.0	148.0	154.0	139.0	123.0	119.0	
1981	7	2	114.0	105.0	97.0	91.0	87.0	81.0	76.0	71.0	
1981	7	3	65.0	62.0	58.0	54.0	50.0	47.0	42.0	39.0	
1981	7	4	37.0	38.0	35.0	33.0	29.0	25.0	22.0		2531
1981	8	1	20.0	19.0	17.0	15.0	13.0	11.0	8.4	7.0	
1981	8	2	6.2	6.1	6.2	6.7	8.0	6.5	6.5	6.1	
1981	8	3	7.9	13.9	38.5	22.8	16.0	13.4	11.5	9.8	
1981	8	4	8.6	8.6	8.3	7.9	8.6	9.8	12.9		361
1981	9	1	11.5	11.5	13.9	15.0	12.9	10.2	9.8	11.5	
1981	9	2	12.0	12.0	10.0	8.7	7.6	6.5	31.0	19.0	
1981	9	3	14.0	11.0	10.0	9.0	8.3	7.8	8.0	6.0	
1981	9	4	5.2	4.4	3.6	3.1	1.8	1.6			297
1981	10	1	1.8	1.8	1.8	1.8	1.8	1150.0	139.0	93.0	
1981	10	2	65.0	53.0	45.0	40.0	40.0	43.0	36.0	30.0	
1981	10	3	27.0	23.0	19.6	20.6	21.1	21.6	25.6	26.1	
1981	10	4	22.3	20.1	18.0	17.0	16.0	17.5	27.0		2065
1981	11	1	51.0	32.4	28.3	26.7	26.1	25.0	24.0	25.6	
1981	11	2	37.9	28.3	26.7	26.1	26.1	26.7	25.0	25.0	
1981	11	3	23.9	23.9	23.4	21.6	21.1	21.1	21.1	20.1	
1981	11	4	19.6	19.6	19.6	19.0	18.5	19.0			752
1981	12	1	18.0	17.0	16.0	15.0	15.0	16.0	15.0	15.0	
1981	12	2	15.0	15.0	15.0	15.0	14.0	14.0	13.0	14.0	
1981	12	3	13.0	13.0	12.0	12.0	12.0	12.0	12.0	12.0	
1981	12	4	11.0	11.0	11.0	11.0	11.0	11.0	11.0		417
1982	1	1	11.0	11.0	11.0	9.8	9.8	10.0	9.7	9.1	
1982	1	2	8.6	8.2	7.8	9.8	9.8	9.8	9.8	9.8	
1982	1	3	9.4	9.4	9.4	9.4	9.4	9.4	9.3	9.0	
1982	1	4	9.0	9.0	9.0	8.6	8.6	8.6	8.3		291
1982	2	1	8.3	8.5	8.6	8.6	8.6	8.0	7.9	7.5	
1982	2	2	7.4	7.0	7.0	7.0	7.0	7.0	7.0	7.0	
1982	2	3	7.0	7.0	6.5	6.5	6.6	6.5	6.5	6.3	
1982	2	4	6.1	7.2	6.5	6.5					202
1982	3	1	6.5	6.5	6.1	6.1	6.1	6.1	6.2	4.8	
1982	3	2	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	
1982	3	3	3.8	3.8	3.8	3.8	3.8	3.2	3.2	3.2	
1982	3	4	3.2	3.2	5.4	6.1	5.6	5.6	5.2		150
1982	4	1	5.2	5.2	5.2	4.8	4.8	3.8	3.4	4.0	
1982	4	2	3.4	3.3	2.6	2.2	2.2	1.7	2.0	2.2	
1982	4	3	2.0	1.4	2.0	6.2	4.3	8.4	14.0	20.0	
1982	4	4	23.0	19.0	17.0	16.0	15.0	15.0			219
1982	5	1	14.0	13.0	13.0	12.0	11.0	16.0	17.0	15.0	
1982	5	2	13.0	13.0	13.0	14.0	1960.0	201.0	133.0	115.0	
1982	5	3	117.0	109.0	102.0	96.0	85.0	78.0	72.0	74.0	
1982	5	4	71.0	62.0	58.0	55.0	51.0	46.0	42.0		3691
1982	6	1	38.0	36.0	34.0	32.0	30.0	27.0	26.0	24.0	
1982	6	2	23.0	20.0	18.0	22.0	25.0	21.0	19.0	21.0	
1982	6	3	21.0	17.0	15.0	14.0	13.0	16.0	19.0	18.0	
1982	6	4	15.0	15.0	16.0	14.0	12.0	13.0			634
1982	7	1	12.0	12.0	12.0	12.0	11.0	11.0	11.0	10.0	
1982	7	2	10.0	10.0	9.7	8.9	8.3	7.8	7.2	6.4	
1982	7	3	5.6	5.0	4.5	4.3	3.4	2.8	2.1	3.6	
1982	7	4	2.1	2.0	1.8	1.2	1.3	1.0	1.0		201
1982	8	1	1.0	1.1	0.9	1.0	0.8	0.8	0.8	1.0	
1982	8	2	0.9	1.2	1.5	1.8	1.9	1.6	1.6	1.5	
1982	8	3	1.0	0.8	0.7	0.7	0.7	1.1	1.6	1.3	
1982	8	4	1.2	1.7	1.6	1.6	1.7	2.1	2.2		39

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1982	9	1	2.2	2.1	4.1	4.1	2.4	1.9	1.5	1.6	
1982	9	2	1.6	1.5	1.3	1.3	1.0	1.2	1.4	1.6	
1982	9	3	1.5	1.2	1.2	3.2	2.8	1.1	1.1	1.1	
1982	9	4	1.0	0.7	0.6	0.5	0.5	0.5			48
1982	10	1	0.6	0.6	0.6	0.6	0.6	0.8	1.7	3.9	
1982	10	2	2.0	1.6	1.3	1.7	1.7	1.2	0.9	0.8	
1982	10	3	0.8	0.8	0.8	0.7	0.6	0.7	0.9	0.8	
1982	10	4	0.7	0.6	0.6	0.6	0.7	0.6	0.6		31
1982	11	1	0.6	0.9	3.2	0.8	0.6	0.6	0.8	0.9	
1982	11	2	0.8	1.3	2.8	1.2	0.6	0.6	0.7	0.8	
1982	11	3	0.8	0.9	1.5	1.3	1.0	0.9	1.0	2.0	
1982	11	4	1.4	4.7	6.8	5.5	4.3	3.8			53
1982	12	1	3.3	3.1	3.0	2.3	2.1	1.6	1.6	1.6	
1982	12	2	1.6	2.9	2.5	2.0	1.8	2.4	2.7	2.7	
1982	12	3	2.7	3.0	2.9	2.2	2.2	2.2	2.4	2.7	
1982	12	4	2.7	2.2	4.7	3.3	2.7	2.7	2.9		79
1983	1	1	5.2	5.2	5.6	6.1	7.3	8.0	8.4	8.6	
1983	1	2	8.6	8.6	8.3	8.2	7.9	7.9	7.6	7.5	
1983	1	3	7.5	8.4	8.4	8.3	8.9	9.0	9.0	9.2	
1983	1	4	9.4	9.7	10.0	10.0	10.0	10.0	11.0		258
1983	2	1	11.0	10.0	9.9	9.8	10.0	11.0	11.0	11.0	
1983	2	2	13.0	22.0	21.0	20.0	19.0	19.0	48.0	53.0	
1983	2	3	49.0	47.0	45.0	44.0	43.0	42.0	41.0	40.0	
1983	2	4	39.0	38.0	37.0	36.0					800
1983	3	1	36.0	35.0	34.0	163.0	136.0	104.0	90.0	83.0	
1983	3	2	81.0	76.0	75.0	75.0	75.0	74.0	76.0	89.0	
1983	3	3	93.0	85.0	82.0	81.0	79.0	76.0	114.0	116.0	
1983	3	4	110.0	223.0	156.0	129.0	137.0	206.0	135.0		3124
1983	4	1	114.0	101.0	99.0	96.0	90.0	85.0	81.0	78.0	
1983	4	2	74.0	72.0	68.0	67.0	65.0	60.0	59.0	56.0	
1983	4	3	54.0	53.0	51.0	50.0	49.0	49.0	45.0	43.0	
1983	4	4	42.0	40.0	40.0	38.0	38.0	38.0			1895
1983	5	1	37.0	34.0	32.0	30.0	28.0	28.0	26.0	24.0	
1983	5	2	23.0	23.0	45.0	34.0	28.0	24.0	27.0	24.0	
1983	5	3	24.0	24.0	22.0	94.0	265.0	118.0	79.0	66.0	
1983	5	4	59.0	54.0	49.0	47.0	44.0	41.0	39.0		1492
1983	6	1	39.0	38.0	37.0	36.0	45.0	50.0	49.0	42.0	
1983	6	2	38.0	36.0	34.0	33.0	31.0	71.0	124.0	85.0	
1983	6	3	86.0	62.0	56.0	52.0	49.0	46.0	45.0	42.0	
1983	6	4	64.0	60.0	49.0	42.0	38.0	35.0			1514
1983	7	1	34.0	31.0	27.0	26.0	29.0	51.0	41.0	27.0	
1983	7	2	25.0	23.0	23.0	23.0	23.0	30.0	34.0	42.0	
1983	7	3	90.0	64.0	52.0	45.0	40.0	36.0	33.0	28.0	
1983	7	4	25.0	24.0	22.0	20.0	20.0	18.0	17.0		1023
1983	8	1	16.0	16.0	15.0	15.0	15.0	14.0	16.0	17.0	
1983	8	2	16.0	19.0	16.0	14.0	14.0	13.0	14.0	12.0	
1983	8	3	11.0	11.0	11.0	10.0	11.0	11.0	9.6	9.5	
1983	8	4	9.8	9.4	8.6	7.9	8.5	7.3	6.4		384
1983	9	1	5.9	5.5	4.3	4.1	3.8	3.2	2.6	4.1	
1983	9	2	6.2	5.2	4.2	3.1	1.8	1.6	1.6	1.6	
1983	9	3	1.6	6.8	86.0	41.0	22.0	20.0	18.0	17.0	
1983	9	4	15.0	14.0	13.0	12.0	11.0	9.8			346
1983	10	1	9.2	8.7	8.6	8.2	7.8	7.5	7.5	7.8	
1983	10	2	26.0	21.0	14.0	14.0	13.0	12.0	11.0	11.0	
1983	10	3	10.0	9.8	9.0	13.0	12.0	10.0	10.0	10.0	
1983	10	4	9.1	9.0	9.0	8.6	8.6	8.3	8.2		332
1983	11	1	7.9	7.6	7.5	7.5	8.0	7.9	7.9	7.6	
1983	11	2	7.4	6.9	6.5	7.0	6.7	6.9	5.6	5.2	
1983	11	3	5.2	5.2	4.9	4.3	4.3	4.6	5.2	3.8	
1983	11	4	3.8	4.1	5.0	4.2	3.8	4.7			177
1983	12	1	4.3	4.6	8.4	7.9	7.6	6.5	6.1	5.6	
1983	12	2	5.9	6.1	5.9	5.1	5.5	5.2	5.2	5.2	
1983	12	3	5.2	5.2	5.2	5.2	5.2	5.0	4.8	4.5	
1983	12	4	4.3	4.3	4.8	5.1	4.2	3.8	4.1		166
1984	1	1	4.4	4.6	4.3	4.3	4.9	4.8	4.3	4.7	
1984	1	2	7.8	4.8	4.3	5.2	4.9	4.8	4.8	5.2	
1984	1	3	5.2	5.2	4.8	4.8	4.8	5.3	6.2	5.6	
1984	1	4	5.2	5.1	4.8	5.0	4.8	4.8	4.8		155
1984	2	1	4.8	5.1	4.9	4.8	4.6	4.3	4.3	4.4	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1984	2	2	5.2	4.9	5.0	4.8	4.1	3.8	4.2	4.2	
1984	2	3	4.0	4.5	4.2	3.8	3.8	3.8	4.3	3.8	
1984	2	4	3.2	6.1	3.2	2.7	3.2				124
1984	3	1	4.3	4.3	4.3	4.3	14.0	9.8	8.2	7.9	
1984	3	2	6.5	6.5	6.1	6.1	5.6	5.6	5.2	5.2	
1984	3	3	5.2	5.2	6.1	5.2	4.8	5.2	5.6	4.8	
1984	3	4	4.8	4.8	4.8	4.8	4.3	4.3	4.8		179
1984	4	1	4.8	4.8	4.3	3.2	3.2	3.8	4.7	4.7	
1984	4	2	3.8	4.3	3.8	3.2	2.7	2.6	2.7	2.2	
1984	4	3	2.2	2.8	3.8	4.0	3.7	2.7	2.2	2.6	
1984	4	4	2.7	1.7	1.8	1.7	2.0	1.0			94
1984	5	1	1.5	2.7	2.9	1.8	1.8	2.3	3.0	1.8	
1984	5	2	1.3	1.5	1.5	1.6	1.6	1.6	2.0	2.6	
1984	5	3	3.7	4.1	5.8	4.1	3.2	3.4	3.2	2.3	
1984	5	4	2.2	2.7	2.5	5.0	3.7	3.0	2.3		83
1984	6	1	2.6	2.2	2.8	3.8	7.5	5.9	7.8	11.0	
1984	6	2	10.0	9.2	7.9	8.2	7.4	6.0	5.6	5.0	
1984	6	3	4.5	4.6	3.7	3.1	2.4	2.5	2.2	2.3	
1984	6	4	1.5	1.3	1.6	1.7	2.1	2.7			139
1984	7	1	2.3	1.5	1.5	1.5	1.6	1.6	1.6	1.8	
1984	7	2	1.6	1.6	1.3	1.1	1.2	0.9	0.9	0.6	
1984	7	3	0.4	0.4	0.3	0.2	0.1	0.2	0.1	0.2	
1984	7	4	0.7	0.8	2.1	0.8	0.4	0.4	0.3		30
1984	8	1	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	
1984	8	2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	
1984	8	3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
1984	8	4	0.1	0.1	0.1	0.2	0.2	0.2	0.2		3
1984	9	1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	
1984	9	2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	
1984	9	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1984	9	4	0.0	0.0	0.0	0.0	0.0	0.0			1
1984	10	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1984	10	2	0.0	0.0	75.0	27.0	18.0	26.0	30.0	15.0	
1984	10	3	9.4	8.3	4.1	3.4	169.0	55.0	56.0	57.0	
1984	10	4	78.0	46.0	43.0	82.0	206.0	58.0	44.0		1110
1984	11	1	38.0	35.0	32.0	30.0	26.0	23.0	22.0	21.0	
1984	11	2	20.0	18.0	16.0	16.0	16.0	15.0	15.0	14.0	
1984	11	3	14.0	17.0	15.0	13.0	13.0	12.0	10.0	14.0	
1984	11	4	35.0	28.0	20.0	18.0	18.0	19.0			603
1984	12	1	19.0	18.0	18.0	18.0	19.0	20.0	19.0	19.0	
1984	12	2	19.0	19.0	20.0	20.0	31.0	42.0	30.0	209.0	
1984	12	3	148.0	149.0	134.0	123.0	112.0	101.0	97.0	94.0	
1984	12	4	83.0	78.0	81.0	86.0	78.0	79.0	440.0		2423
1985	1	1	220.0	198.0	193.0	197.0	187.0	177.0	162.0	149.0	
1985	1	2	146.0	142.0	138.0	140.0	145.0	147.0	177.0	208.0	
1985	1	3	225.0	209.0	198.0	183.0	173.0	173.0	169.0	161.0	
1985	1	4	148.0	143.0	144.0	140.0	137.0	137.0	127.0		5193
1985	2	1	121.0	120.0	115.0	115.0	120.0	112.0	104.0	99.0	
1985	2	2	97.0	98.0	93.0	85.0	83.0	79.0	75.0	74.0	
1985	2	3	70.0	69.0	67.0	66.0	67.0	67.0	1710.0	304.0	
1985	2	4	253.0	230.0	212.0	224.0					4929
1985	3	1	250.0	218.0	212.0	200.0	185.0	181.0	180.0	174.0	
1985	3	2	168.0	162.0	165.0	157.0	153.0	198.0	198.0	195.0	
1985	3	3	185.0	180.0	177.0	211.0	189.0	182.0	175.0	167.0	
1985	3	4	160.0	153.0	185.0	166.0	155.0	151.0	141.0		5573
1985	4	1	139.0	136.0	128.0	123.0	105.0	104.0	102.0	91.0	
1985	4	2	85.0	98.0	104.0	96.0	99.0	123.0	95.0	79.0	
1985	4	3	70.0	65.0	70.0	61.0	57.0	54.0	51.0	43.0	
1985	4	4	41.0	45.0	42.0	40.0	41.0	39.0			2426
1985	5	1	40.0	37.0	31.0	28.0	27.0	27.0	25.0	25.0	
1985	5	2	25.0	25.0	24.0	25.0	26.0	32.0	26.0	22.0	
1985	5	3	24.0	22.0	19.0	19.0	20.0	21.0	22.0	18.0	
1985	5	4	16.0	15.0	14.0	14.0	12.0	12.0	11.0		704
1985	6	1	10.0	10.0	9.3	9.2	14.0	2850.0	264.0	207.0	
1985	6	2	186.0	145.0	116.0	93.0	83.0	74.0	59.0	44.0	
1985	6	3	38.0	43.0	82.0	42.0	38.0	38.0	300.0	200.0	
1985	6	4	150.0	120.0	100.0	90.0	85.0	80.0			5579
1985	7	1	70.0	65.0	60.0	100.0	90.0	80.0	75.0	70.0	
1985	7	2	65.0	60.0	75.0	89.0	75.0	64.0	53.0	46.0	

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YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1985	7	3	41.0	36.0	35.0	33.0	33.0	31.0	29.0	26.0	
1985	7	4	24.0	21.0	19.0	17.0	16.0	15.0	15.0		1528
1985	8	1	13.0	12.0	11.0	10.0	11.0	11.0	10.0	9.6	
1985	8	2	9.8	8.7	8.2	7.6	8.6	11.0	9.2	8.0	
1985	8	3	5.7	4.5	3.5	3.0	3.6	4.1	3.7	3.7	
1985	8	4	3.3	3.1	3.1	2.9	3.2	3.4	3.5		213
1985	9	1	2.2	3.4	3.4	2.8	3.1	4.7	2.9	2.0	
1985	9	2	3.4	3.2	4.0	4.2	8.8	10.0	6.3	4.0	
1985	9	3	3.4	3.0	3.2	2.4	2.0	1.9	2.0	1.3	
1985	9	4	2.1	1.3	1.2	2.5	8.9	4.6			108
1985	10	1	3.6	3.7	3.6	3.3	3.0	3.3	3.5	3.4	
1985	10	2	3.5	3.7	3.5	3.3	2.9	3.2	20.6	31.3	
1985	10	3	20.3	18.0	122.6	120.2	48.9	41.2	38.7	34.6	
1985	10	4	29.6	28.9	29.8	26.1	25.0	34.3	30.4		748
1985	11	1	24.8	29.2	27.9	25.1	24.0	24.8	26.4	25.8	
1985	11	2	26.0	26.0	27.1	25.2	20.3	21.5	25.4	25.1	
1985	11	3	30.9	30.0	30.3	40.2	26.6	24.9	24.1	107.3	
1985	11	4	133.0	111.8	786.9	325.7	263.2	238.3			2578
1985	12	1	211.6	190.2	173.3	161.1	186.9	142.7	139.6	131.6	
1985	12	2	127.6	210.5	409.5	243.7	218.0	196.1	186.1	172.1	
1985	12	3	166.6	157.3	145.3	140.6	134.5	137.3	131.8	123.9	
1985	12	4	116.1	102.0	99.3	95.1	89.0	81.3	77.1		4898
1986	1	1	70.8	72.5	65.9	61.0	54.3	53.4	51.8	53.3	
1986	1	2	54.3	49.3	44.4	41.1	37.4	36.0	34.6	33.3	
1986	1	3	34.0	31.9	28.9	26.3	25.8	23.7	21.5	21.9	
1986	1	4	21.0	17.5	16.2	16.5	16.5	14.4	14.7		1144
1986	2	1	14.7	15.3	223.4	213.2	121.4	103.8	94.3	89.5	
1986	2	2	87.2	86.9	82.3	79.7	77.0	78.7	77.0	75.4	
1986	2	3	72.7	70.4	65.1	61.7	58.2	56.0	55.4	54.2	
1986	2	4	53.0	51.4	49.6	46.1					2214
1986	3	1	44.5	45.4	48.1	44.0	42.2	41.9	41.1	40.6	
1986	3	2	39.3	38.1	36.3	38.7	36.0	35.2	34.3	32.1	
1986	3	3	31.3	31.8	29.1	26.9	26.0	28.8	26.0	26.4	
1986	3	4	25.6	24.3	23.5	20.7	19.6	19.0	17.6		1015
1986	4	1	15.3	13.9	13.4	13.8	12.2	11.6	9.9	9.4	
1986	4	2	11.1	11.0	11.2	12.4	11.9	10.4	10.1	10.8	
1986	4	3	10.3	9.6	9.4	10.6	10.3	12.1	11.5	14.7	
1986	4	4	11.2	10.8	10.4	11.0	11.2	11.3			343
1986	5	1	26.3	38.3	21.4	17.4	16.4	15.4	15.0	14.3	
1986	5	2	242.0	1497.5	143.3	105.0	76.0	68.0	84.0	78.0	
1986	5	3	545.6	262.7	160.0	141.0	132.0	116.0	112.0	102.0	
1986	5	4	95.0	121.0	119.0	102.0	101.0	115.2	103.0		4786
1986	6	1	109.0	112.0	101.0	104.0	103.0	89.0	132.9	137.0	
1986	6	2	138.0	114.0	122.0	350.4	199.9	142.5	138.5	128.9	
1986	6	3	216.0	153.1	142.2	126.6	115.7	106.4	93.8	83.7	
1986	6	4	77.9	73.1	70.4	64.2	60.8	56.3			3663
1986	7	1	53.2	47.7	43.6	41.2	38.8	37.4	36.3	35.2	
1986	7	2	33.1	31.4	29.3	27.2	25.8	24.7	23.8	23.0	
1986	7	3	20.7	22.3	22.0	20.3	18.7	18.1	16.9	16.1	
1986	7	4	15.4	14.0	13.1	12.0	11.8	11.5	10.8		795
1986	8	1	10.1	9.5	9.5	8.8	8.6	8.5	7.8	8.2	
1986	8	2	8.4	6.9	7.9	8.8	7.5	6.8	6.2	5.6	
1986	8	3	5.6	4.9	4.2	3.9	4.4	4.4	4.7	5.3	
1986	8	4	5.8	4.3	3.6	3.4	3.3	2.8	2.7		193
1986	9	1	2.9	3.6	2.6	2.2	2.3	21.0	5.8	7.4	
1986	9	2	8.0	7.1	12.6	8.5	6.4	5.4	4.6	4.6	
1986	9	3	4.6	4.3	4.3	4.4	4.4	4.2	4.0	3.6	
1986	9	4	3.4	3.4	3.4	3.5	3.6	3.4			160
1986	10	1	3.4	4.1	3.5	3.4	3.6	4.3	4.5	4.1	
1986	10	2	3.4	3.4	7.7	394.0	156.0	83.0	57.0	45.0	
1986	10	3	38.0	34.0	31.0	28.0	28.0	35.0	1060.0	291.0	
1986	10	4	218.0	182.0	156.0	142.0	133.0	121.0	111.0		3388
1986	11	1	104.0	98.0	92.0	104.0	106.0	90.0	89.0	84.0	
1986	11	2	76.0	70.0	66.0	64.0	61.0	59.0	58.0	56.0	
1986	11	3	54.0	51.0	47.0	45.0	43.0	44.0	43.0	46.0	
1986	11	4	98.0	72.0	60.0	57.0	54.0	53.0			2044
1986	12	1	50.0	47.0	46.0	45.0	43.0	44.0	47.0	47.0	
1986	12	2	49.0	81.0	167.0	138.0	131.0	155.0	261.0	238.0	
1986	12	3	231.0	252.0	246.0	234.0	224.0	1860.0	1480.0	806.0	

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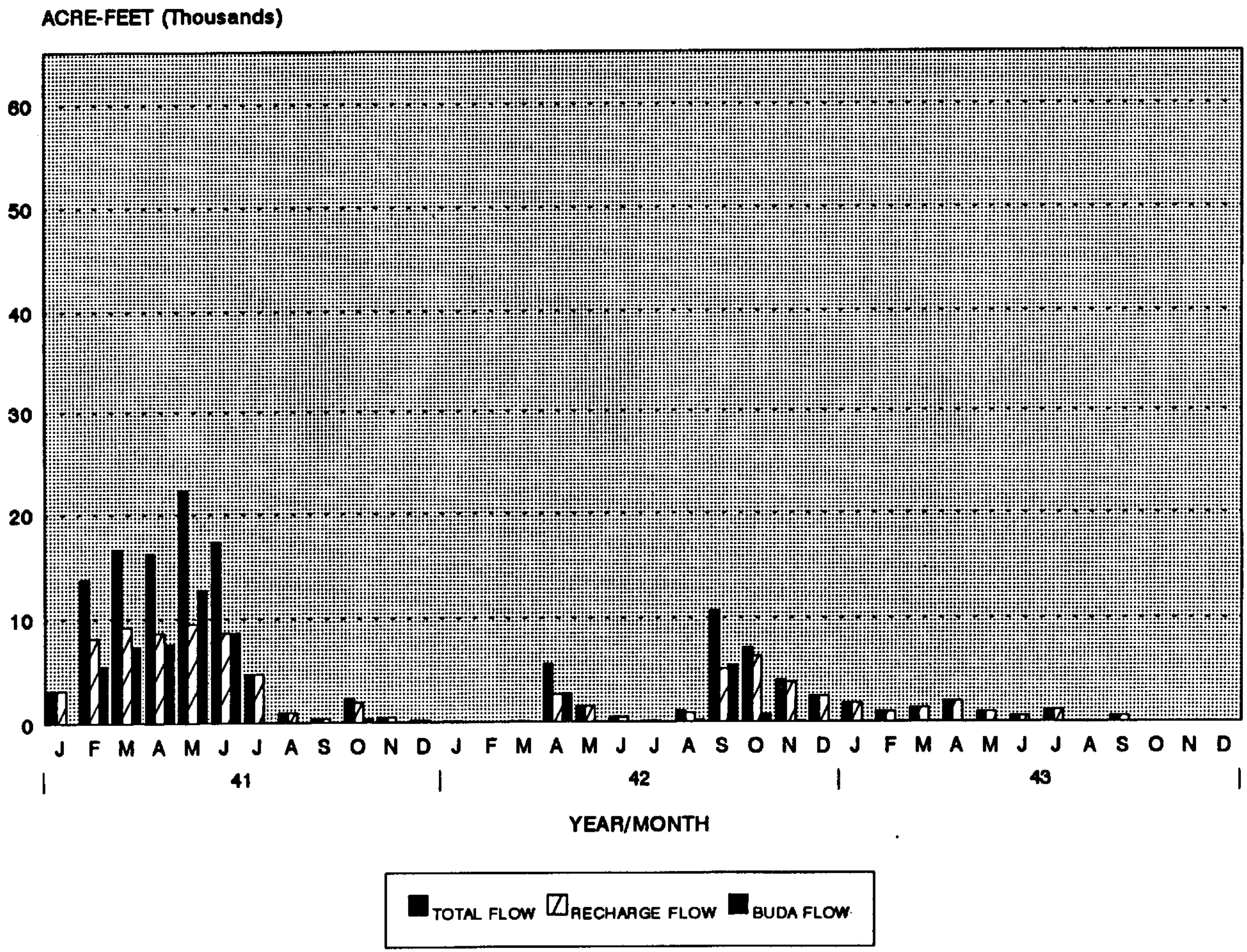
YEAR	MTH	CARD #	DAILY FLOW 1	2	3	4	5	6	7	8	MONTHLY TOTAL (cfs)
1986	12	4	615.0	505.0	410.0	338.0	311.0	285.0	273.0		9659
1987	1	1	260.0	250.0	236.0	217.0	206.0	198.0	189.0	181.0	
1987	1	2	179.0	164.0	152.0	147.0	144.0	143.0	140.0	137.0	
1987	1	3	144.0	142.0	135.0	127.0	125.0	121.0	114.0	111.0	
1987	1	4	104.0	99.0	96.0	94.0	91.0	84.0	80.0		4610
1987	2	1	81.0	76.0	73.0	71.0	68.0	70.0	66.0	62.0	
1987	2	2	58.0	56.0	56.0	54.0	52.0	51.0	53.0	47.0	
1987	2	3	44.0	43.0	43.0	64.0	63.0	52.0	47.0	76.0	
1987	2	4	92.0	350.0	268.0	259.0					2395
1987	3	1	233.0	219.0	204.0	188.0	173.0	164.0	155.0	148.0	
1987	3	2	145.0	143.0	155.0	144.0	140.0	138.0	135.0	132.0	
1987	3	3	247.0	187.0	165.0	158.0	152.0	148.0	146.0	142.0	
1987	3	4	140.0	138.0	133.0	129.0	119.0	114.0	110.0		4844
1987	4	1	106.0	101.0	95.0	91.0	88.0	92.0	85.0	78.0	
1987	4	2	73.0	71.0	70.0	65.0	62.0	55.0	52.0	50.0	
1987	4	3	48.0	48.0	46.0	43.0	41.0	40.0	40.0	39.0	
1987	4	4	37.0	35.0	33.0	31.0	30.0	29.0			1774
1987	5	1	28.0	28.0	28.0	30.0	30.0	28.0	26.0	28.0	
1987	5	2	29.0	25.0	25.0	24.0	21.0	20.0	21.0	22.0	
1987	5	3	38.0	30.0	32.0	35.0	30.0	28.0	23.0	20.0	
1987	5	4	19.0	18.0	17.0	16.0	208.0	200.0	392.0		1519
1987	6	1	386.0	1430.0	1380.0	2510.0	1100.0	740.0	568.0	506.0	
1987	6	2	849.0	1170.0	2140.0	1580.0	2610.0	1320.0	866.0	661.0	
1987	6	3	524.0	530.0	376.0	317.0	286.0	273.0	259.0	245.0	
1987	6	4	228.0	212.0	195.0	181.0	168.0	155.0			23765
1987	7	1	148.0	220.0	145.0	135.0	122.0	111.0	102.0	96.0	
1987	7	2	101.0	128.0	93.0	83.0	73.0	70.0	71.0	67.0	
1987	7	3	336.0	153.0	96.0	73.0	67.0	70.0	56.0	50.0	
1987	7	4	67.0	60.0	53.0	49.0	45.0	43.0	41.0		3024
1987	8	1	40.0	43.0	35.0	32.0	30.0	30.0	36.0	34.0	
1987	8	2	34.0	33.0	30.0	29.0	28.0	26.0	24.0	23.0	
1987	8	3	21.0	20.0	18.0	14.0	11.0	9.1	8.3	7.8	
1987	8	4	7.4	7.2	6.2	7.6	7.5	12.0	19.0		683
1987	9	1	19.0	15.0	13.0	10.0	7.3	5.2	6.2	6.0	
1987	9	2	6.7	7.2	18.0	12.0	10.0	8.6	8.3	9.0	
1987	9	3	7.0	5.0	3.7	3.0	2.6	2.7	2.7	2.9	
1987	9	4	2.0	1.0	1.5	1.7	0.8	0.5			199
1987	10	1	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	
1987	10	2	0.6	0.4	0.1	0.1	0.1	0.2	0.2	0.2	
1987	10	3	0.3	0.3	0.5	0.3	0.2	0.8	0.9	1.0	
1987	10	4	1.1	1.0	0.7	1.0	1.9	2.3	3.1		21
1987	11	1	3.2	3.3	3.3	3.3	2.7	2.5	3.3	18.0	
1987	11	2	9.2	6.3	9.0	10.0	9.7	9.1	12.0	7.6	
1987	11	3	9.0	11.0	11.0	10.0	13.0	5.6	8.9	9.0	
1987	11	4	316.0	28.0	20.0	17.0	15.0	12.0			598
1987	12	1	9.6	8.2	6.4	5.6	5.3	5.1	4.5	4.1	
1987	12	2	3.1	2.9	2.9	2.2	2.3	2.5	1.3	1.0	
1987	12	3	1.2	1.9	9.4	11.0	14.0	13.0	13.0	13.0	
1987	12	4	12.0	11.0	11.0	11.0	11.0	11.0	11.0		221
1988	1	1	10.0	10.0	11.0	10.0	9.6	11.0	11.0	9.5	
1988	1	2	9.5	9.7	10.0	10.0	9.1	9.6	9.8	9.8	
1988	1	3	9.4	9.2	8.8	8.0	7.9	7.9	6.8	6.7	
1988	1	4	6.5	6.8	6.8	7.1	7.5	7.5	7.5		274
1988	2	1	8.1	7.6	6.8	6.3	7.1	7.3	6.8	7.1	
1988	2	2	7.5	7.5	7.1	6.5	6.8	6.8	6.0	6.3	
1988	2	3	7.7	8.6	7.8	7.9	8.5	8.4	7.7	5.8	
1988	2	4	5.1	5.1	6.0	6.0	6.3				202
1988	3	1	6.2	7.8	6.7	6.2	5.9	5.3	5.4	6.5	
1988	3	2	4.6	4.5	5.0	4.6	4.1	4.5	4.2	4.2	
1988	3	3	8.1	13.0	16.0	13.0	11.0	10.0	9.6	9.0	
1988	3	4	8.4	8.0	7.8	7.6	7.4	6.1	6.2		227
1988	4	1	5.9	5.7	7.6	7.7	7.1	6.2	5.6	5.2	
1988	4	2	5.7	7.4	5.5	6.2	5.6	5.9	6.2	6.2	
1988	4	3	6.2	5.1	3.9	4.2	4.3	4.6	4.6	3.8	
1988	4	4	4.1	3.6	3.5	3.6	5.4	7.8			164
1988	5	1	4.7	3.8	4.0	3.4	3.3	3.8	4.2	4.4	
1988	5	2	3.9	3.9	5.5	6.1	3.2	3.1	3.2	6.4	
1988	5	3	4.4	3.7	3.3	3.5	18.0	7.1	5.6	5.1	
1988	5	4	5.1	3.9	1.2	3.5	4.0	6.9	3.4		146

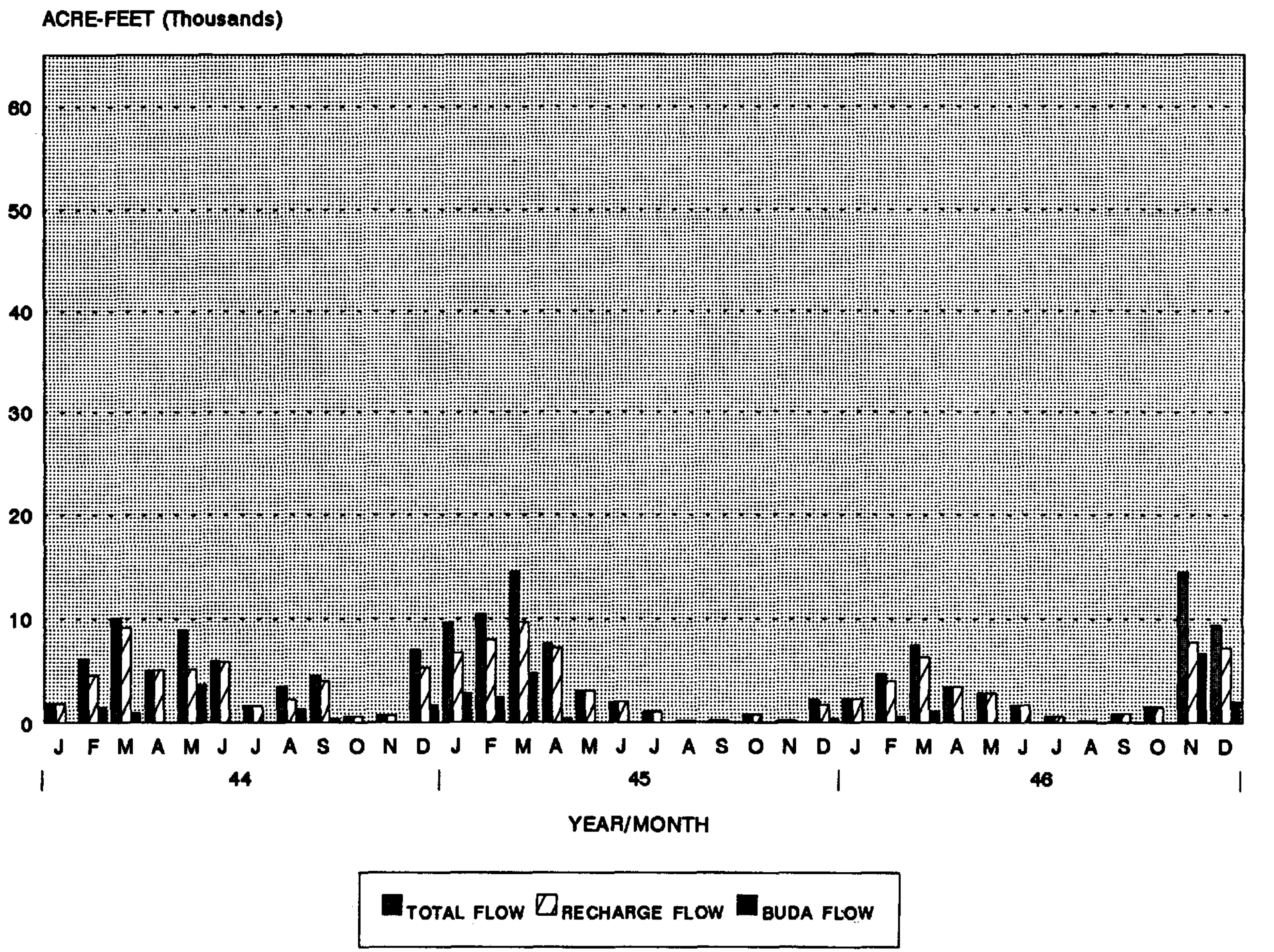
APPENDIX E:

PLOTS OF MONTHLY FLOW AVAILABLE FOR RECHARGE,
ESTIMATED RECHARGE VOLUME, AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED
ONION CREEK NEAR DRIFTWOOD

PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



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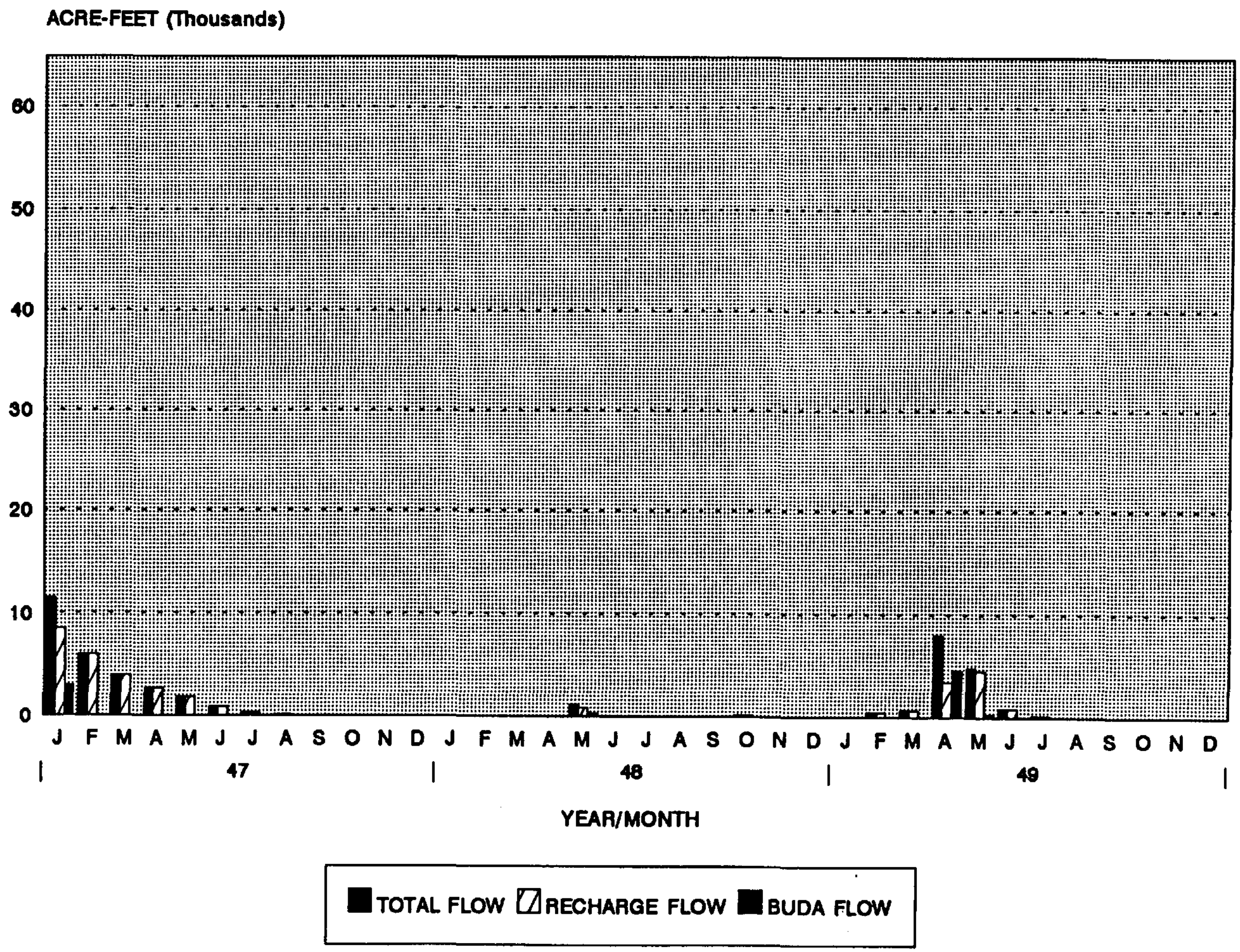
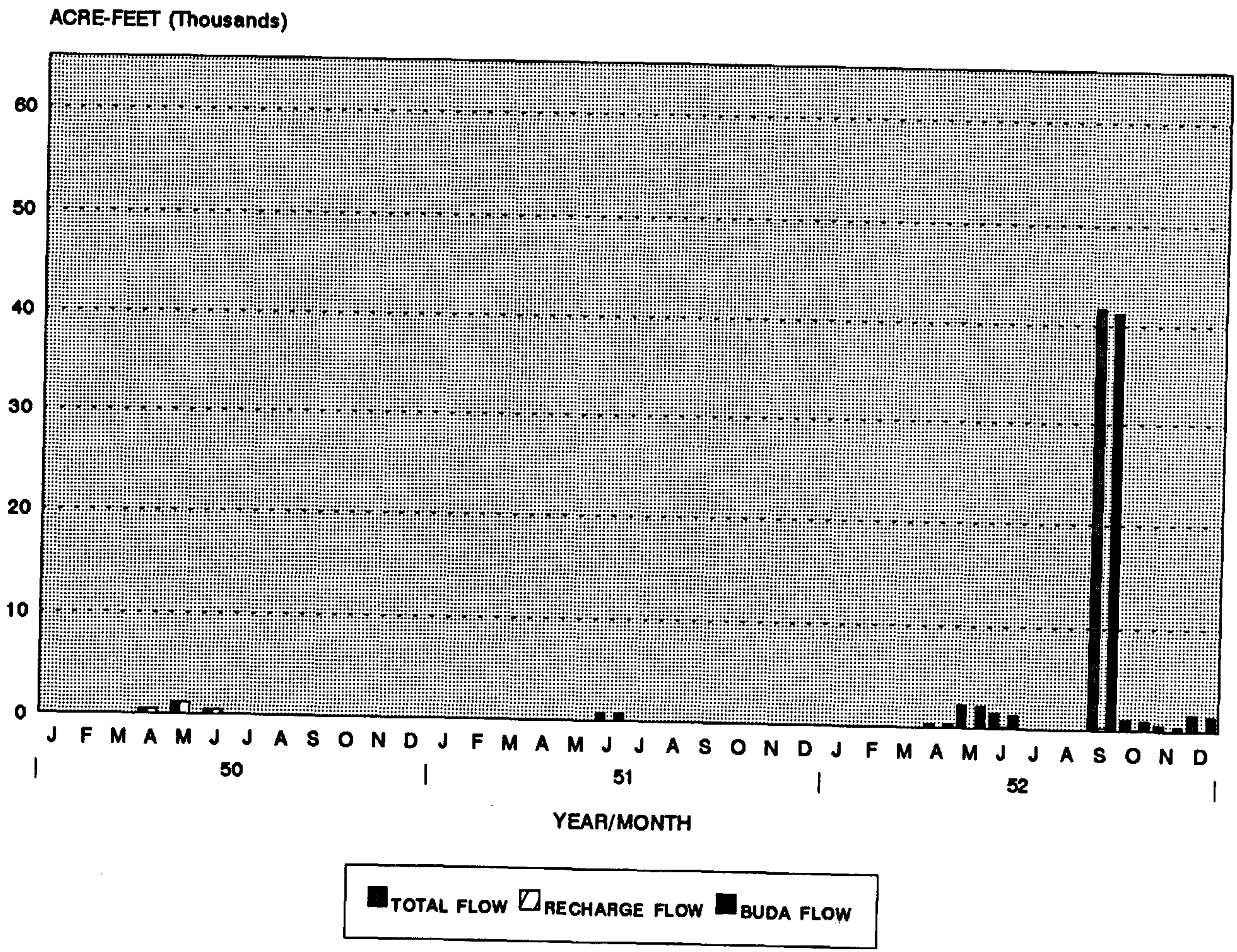
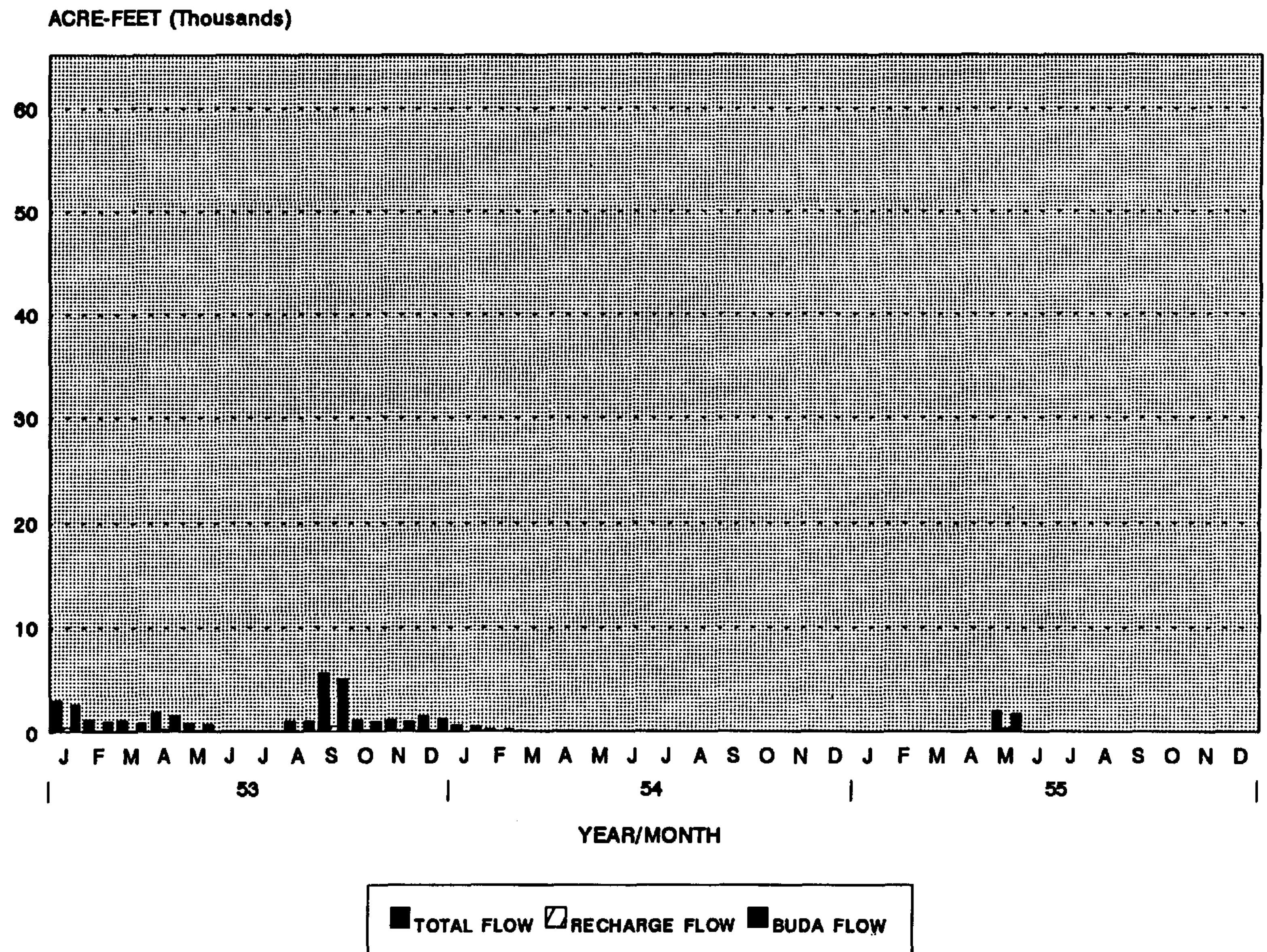
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



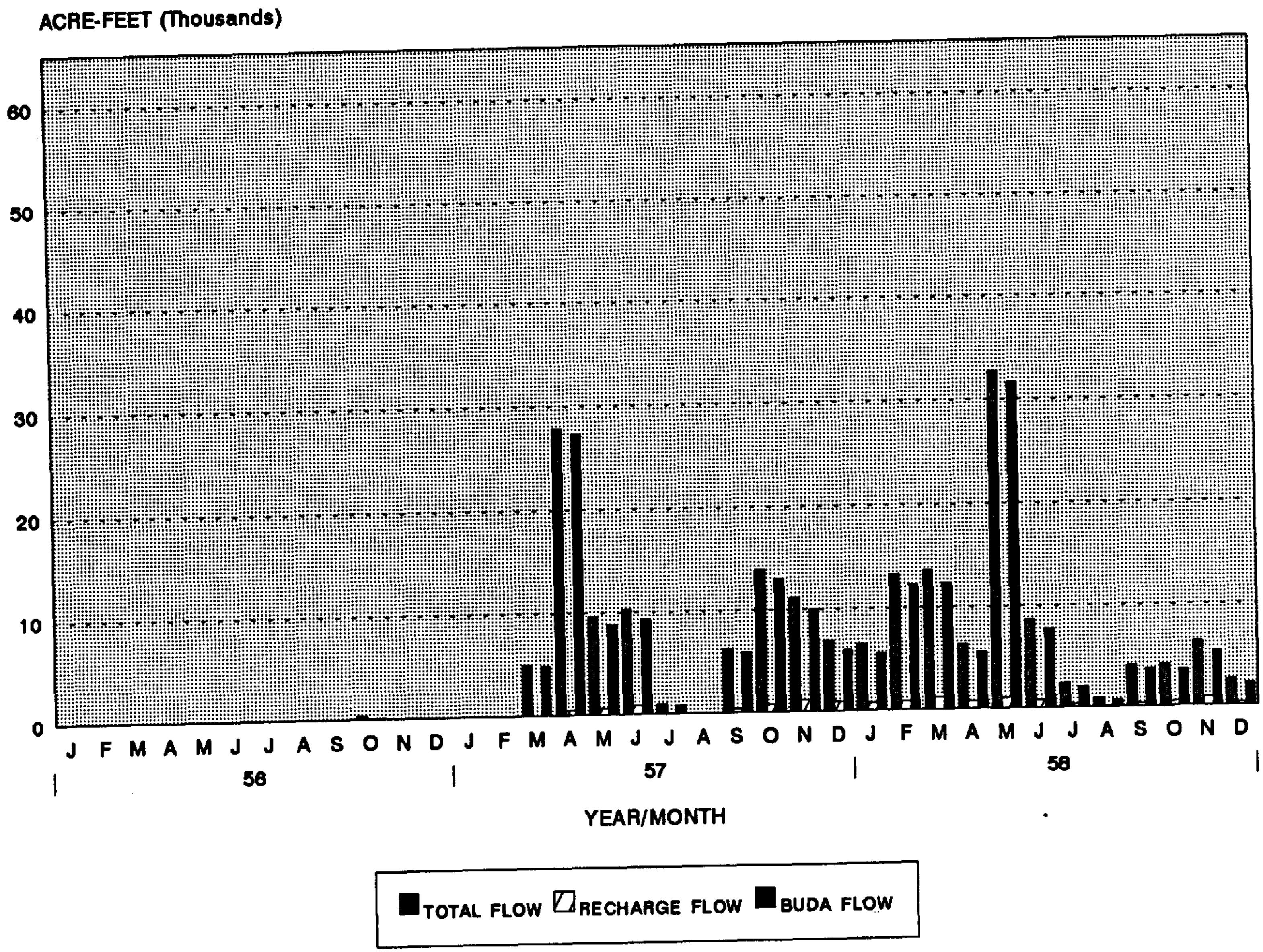
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



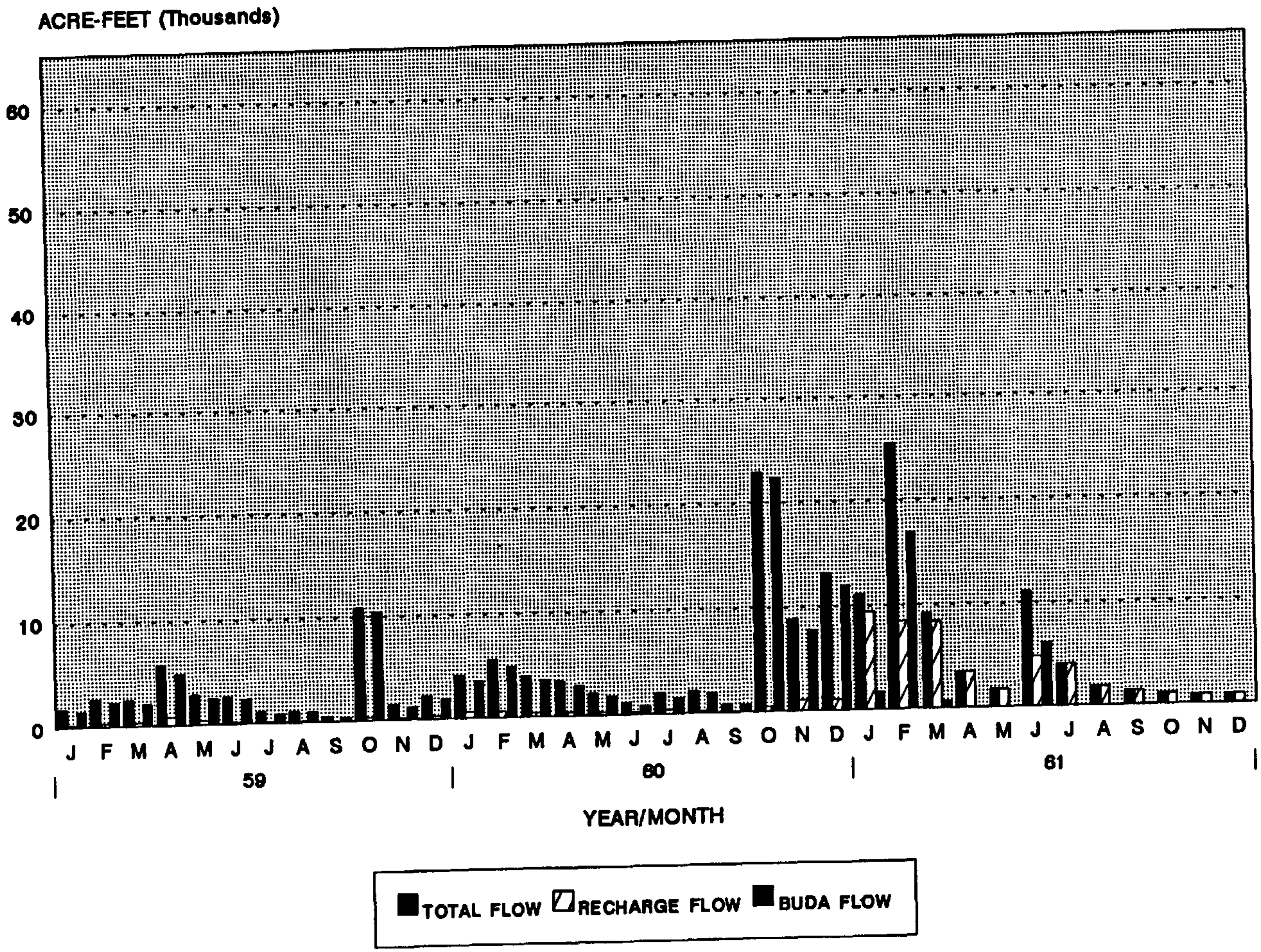
PLOT OF MONHTLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



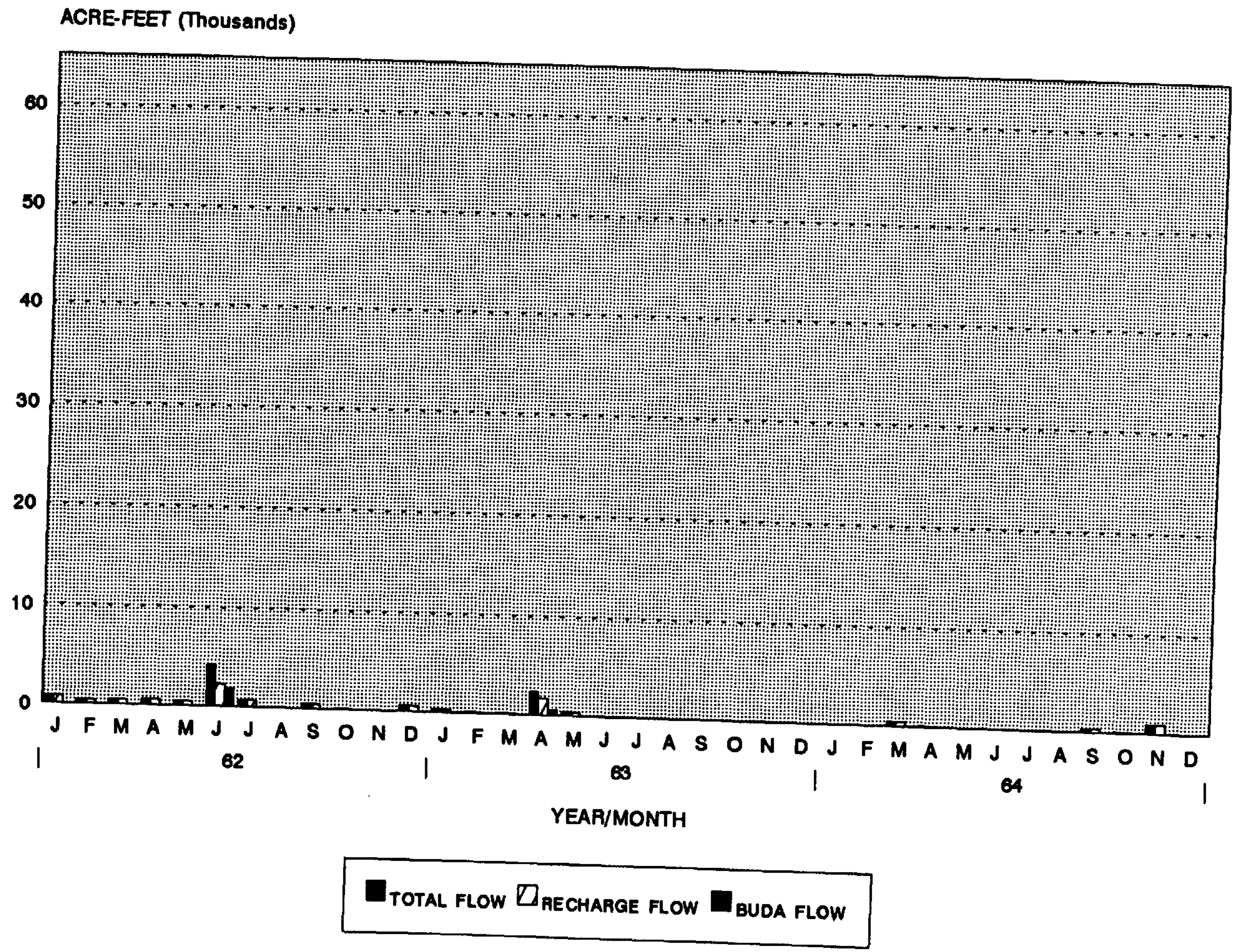
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



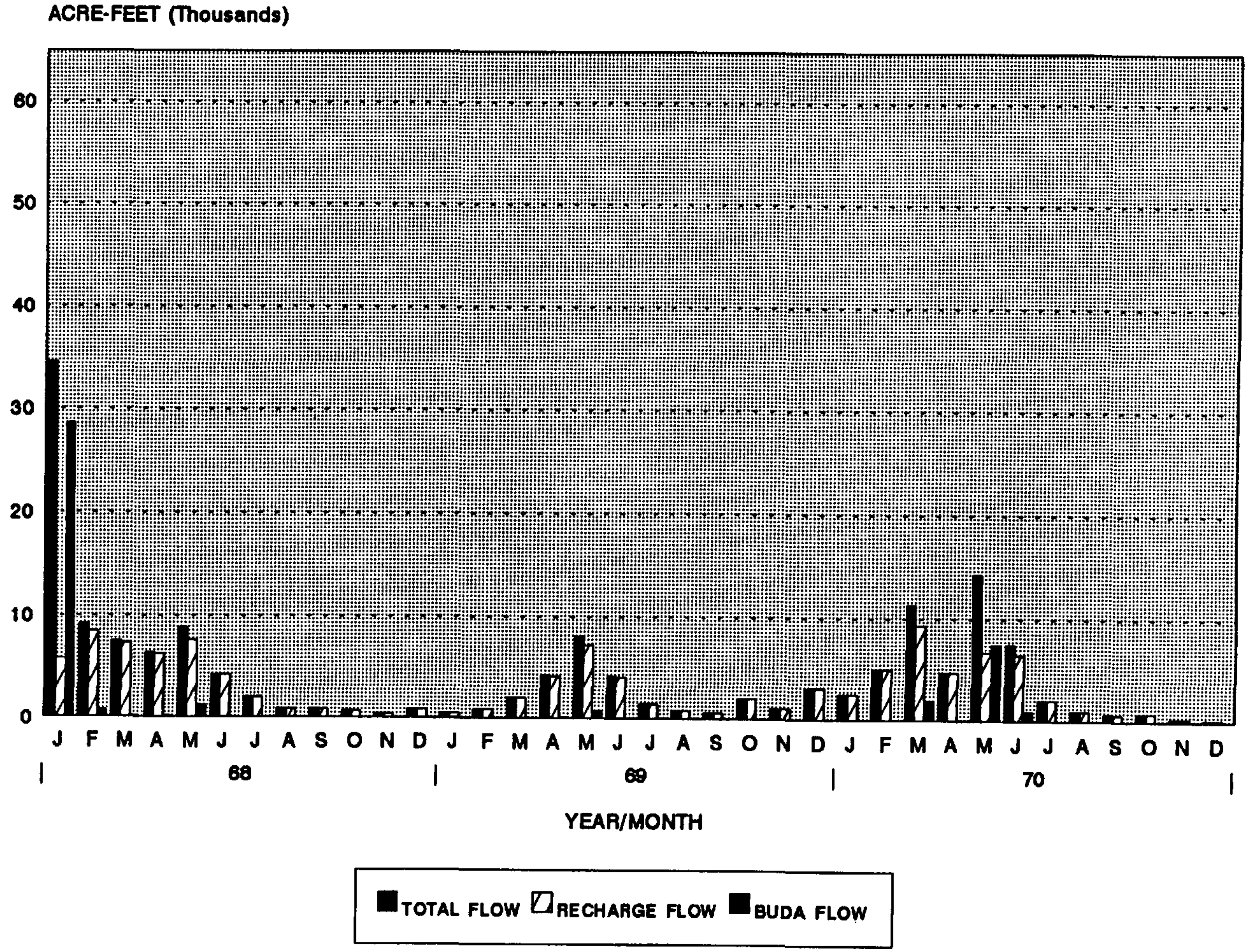
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED RECHARGE VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



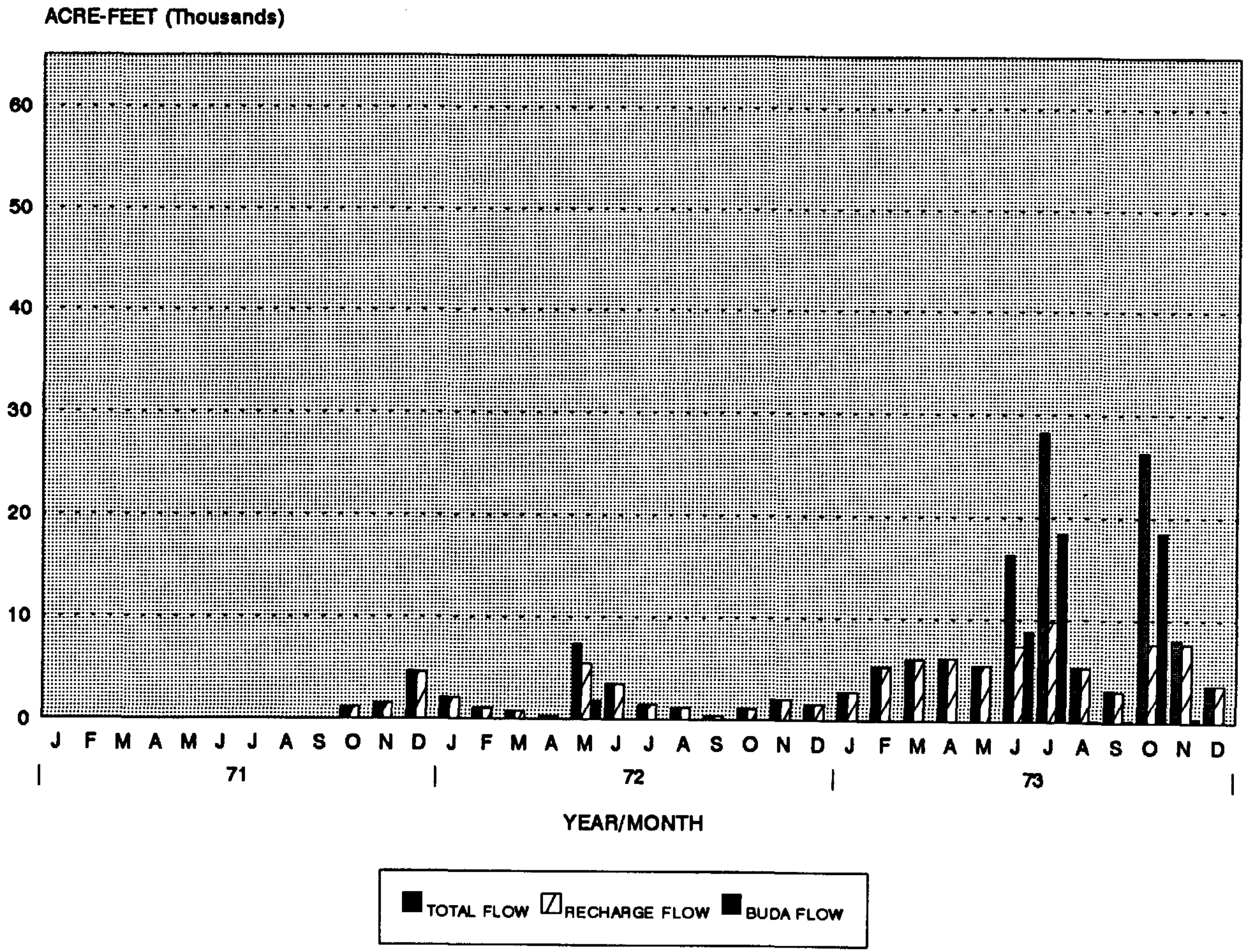
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



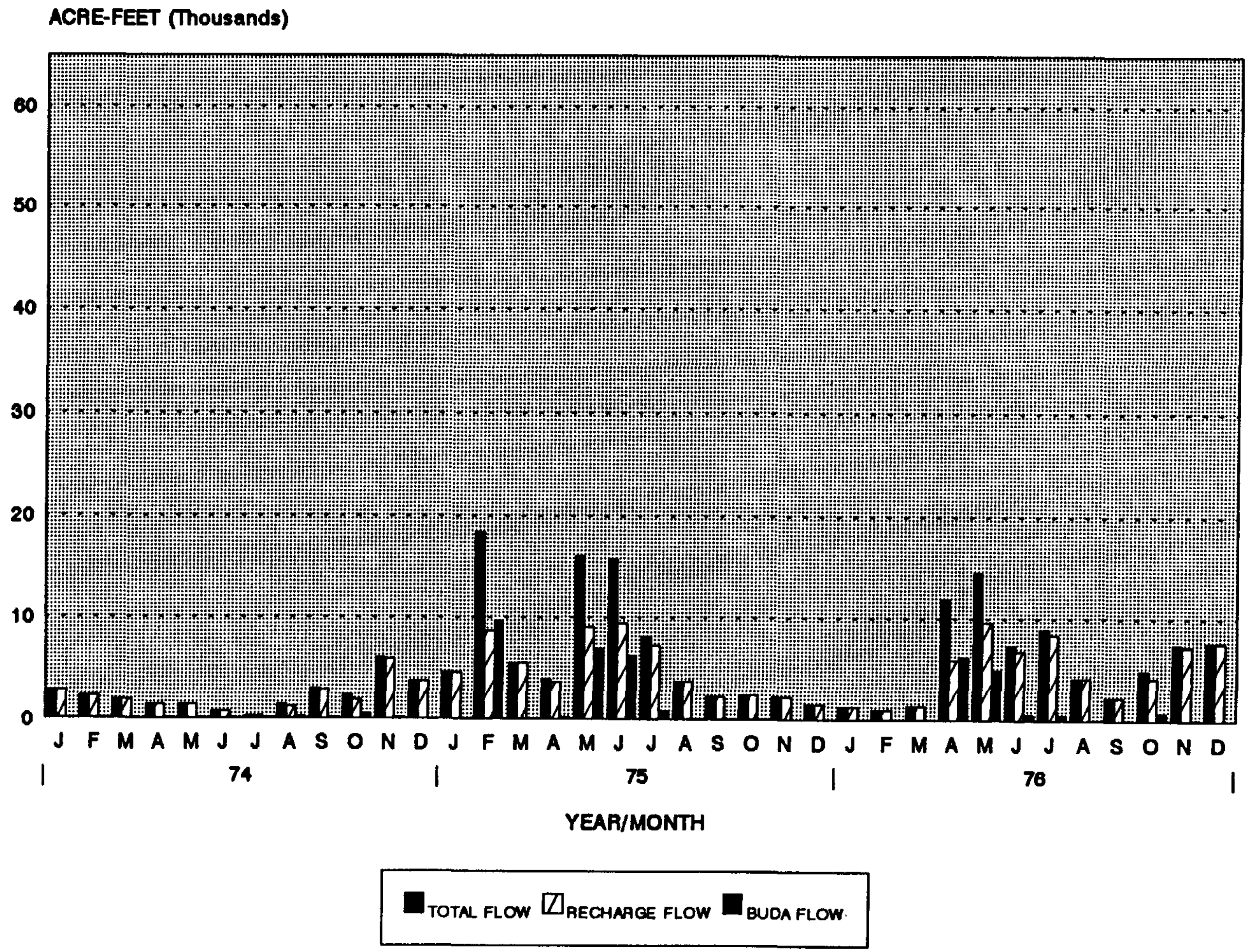
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



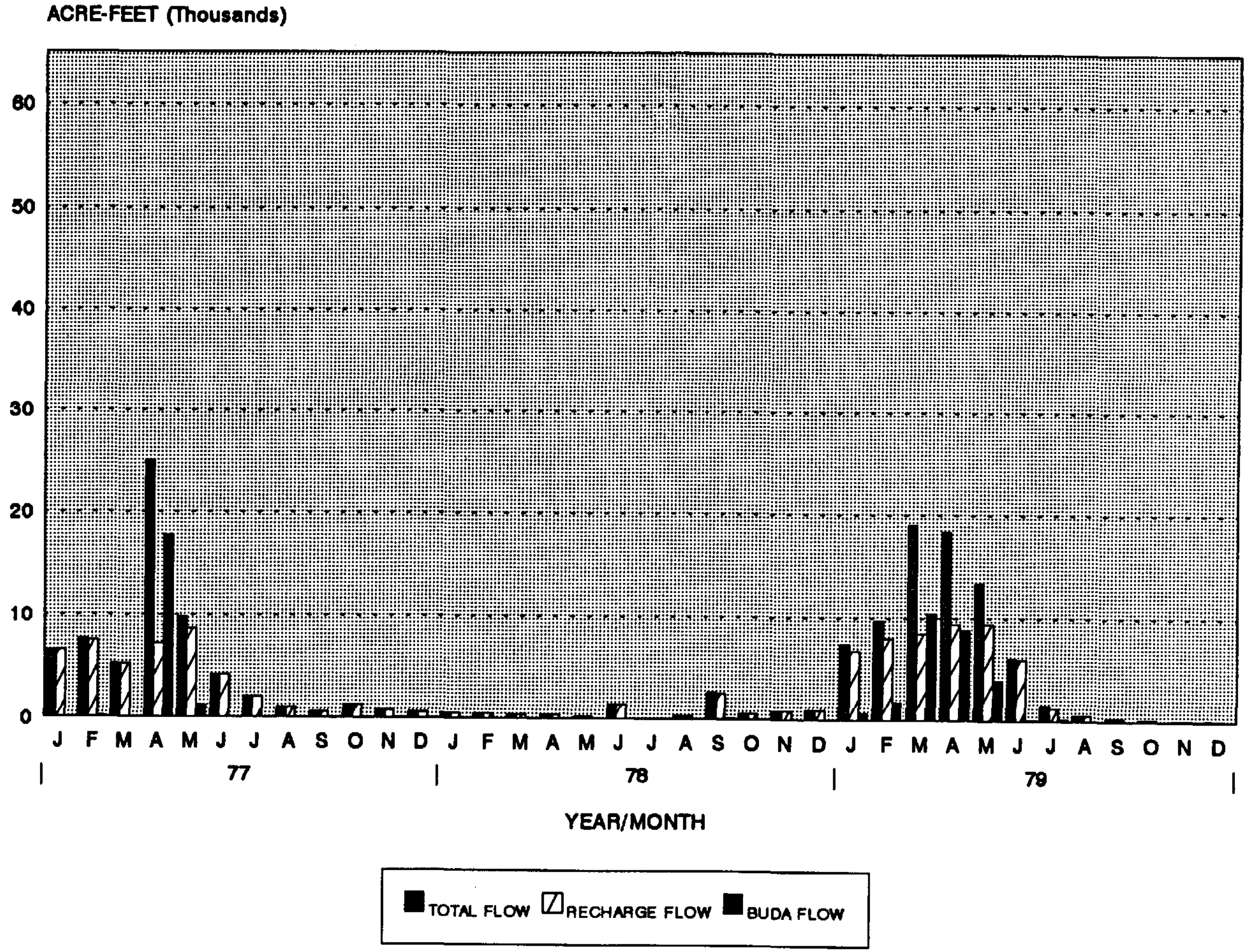
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



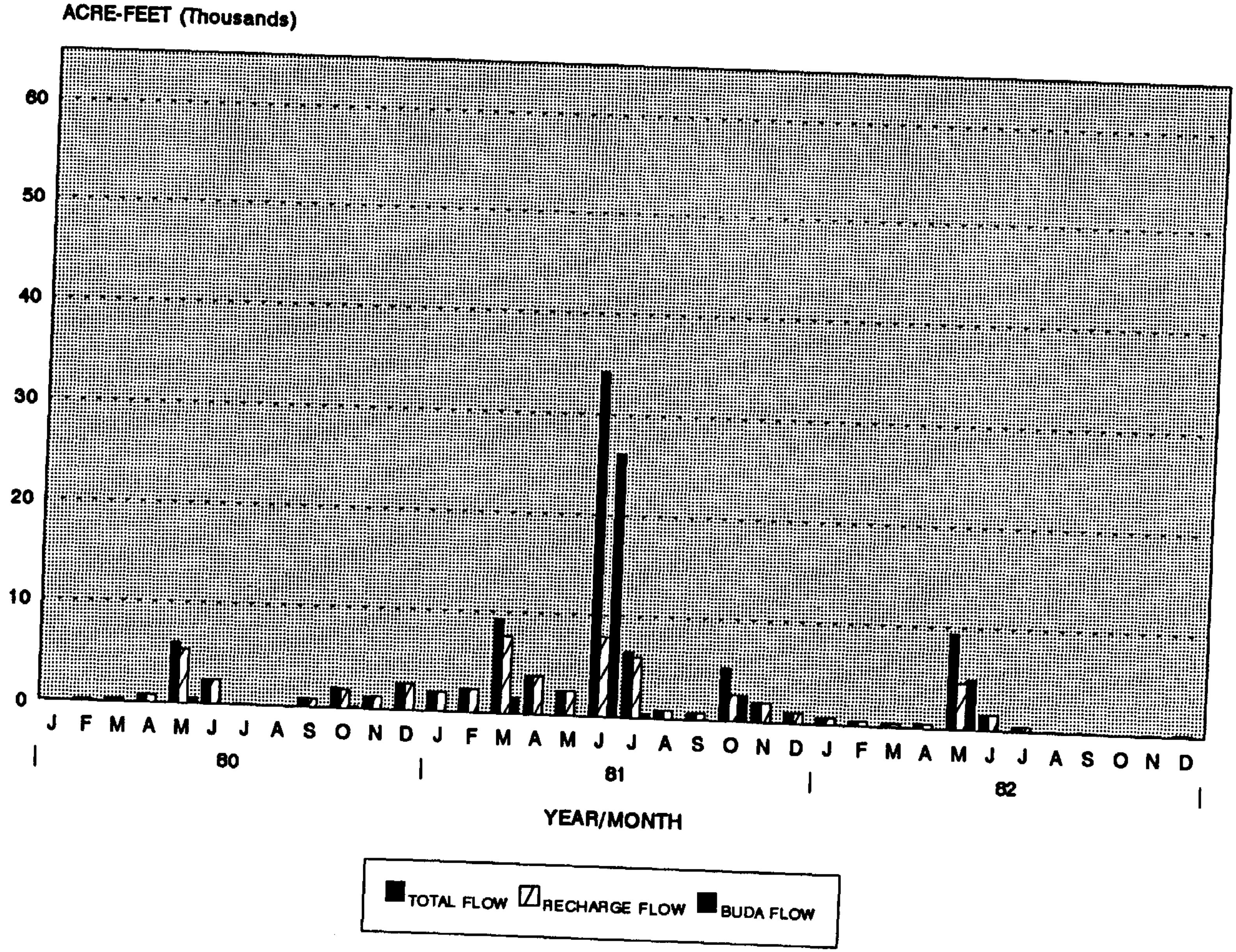
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



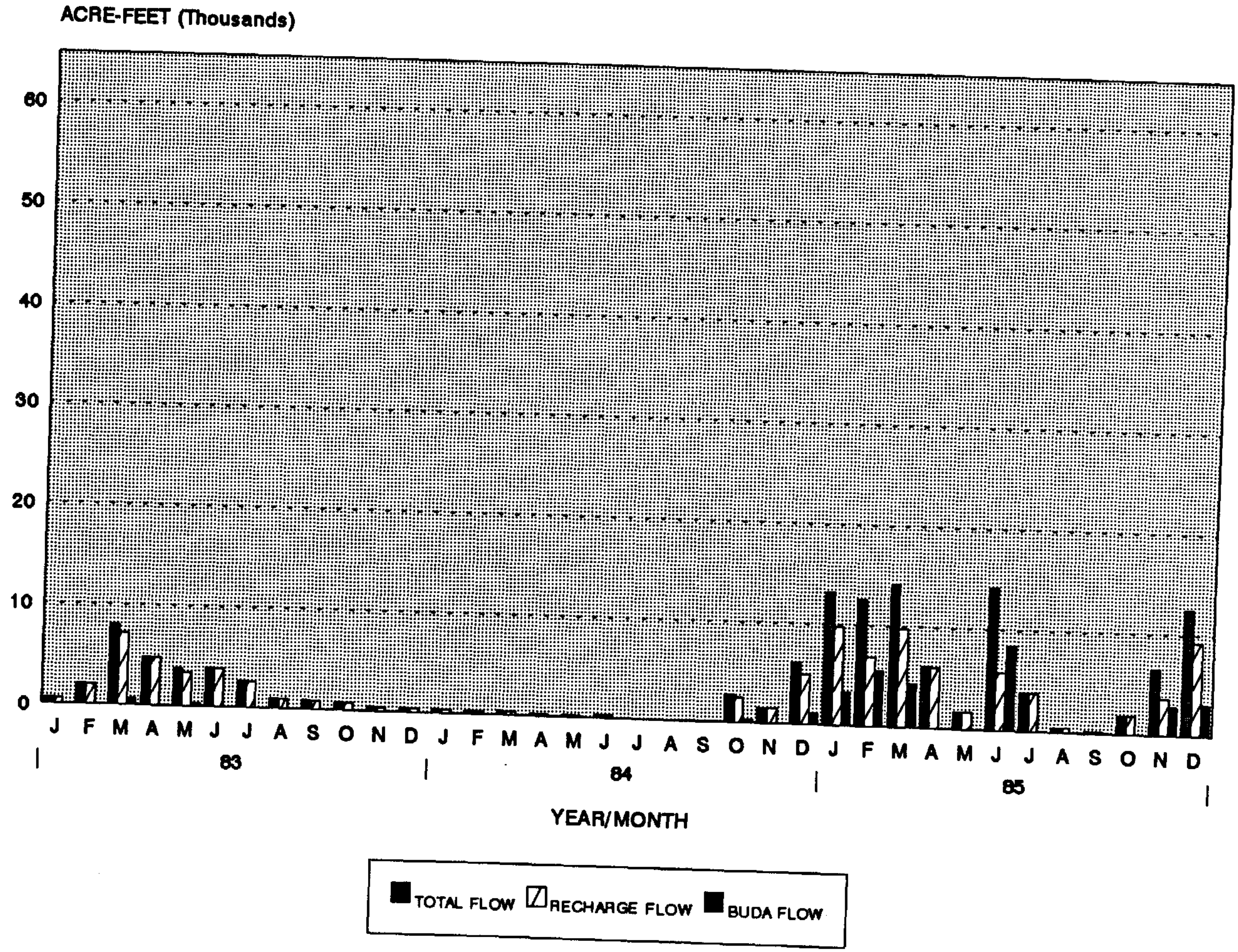
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



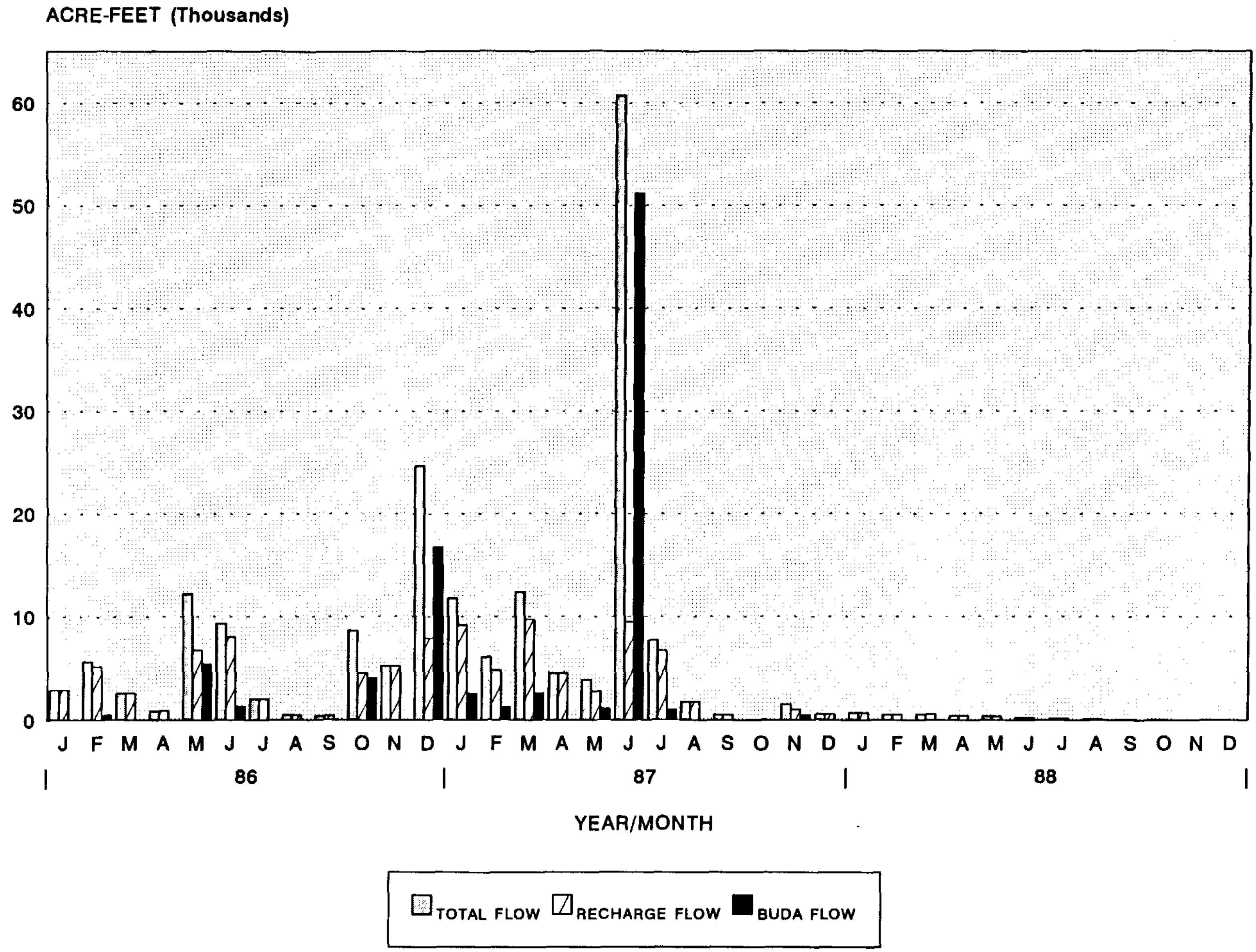
PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



PLOT OF MONTHLY FLOW AVAILABLE FOR RECHARGE
ESTIMATED VOLUME AND FLOW AT BUDA, TEXAS
ONION CREEK WATERSHED



APPENDIX F:

SPECIES OF POTENTIAL OCCURRENCE (BY HABITAT TYPE)
IN THE ONION CREEK WATERSHED

Mammal Species of Potential Occurrence (by Habitat Type) in the Onion Creek Watershed Project Area. Nomenclature according to Jones et al., 1982[1].

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Order Marsupialia							
Family Didelphidae							
Common Opossum *Didelphis virginiana*	X	X	X				
Order Insectivora							
Family Soricidae							
Least Shrew *Cryptotis parva*				X	X		
Family Talpidae							
Eastern Mole *Scalopus aquaticus*				X	X	X	
Order Chiroptera							
Family Vespertilionidae							
Red Bat *Lasiurus borealis*	X	X	X				X
Hoary Bat *Lasiurus cinereus*	X	X	X				X
Northern Yellow Bat *Lasiurus intermedius*	X	X	X				X
Mexican Brown Bat *Myotis velifer*	X	X					X
Evening Bat *Nycticeius humeralis*	X	X					X
Eastern Pipistrelle *Pipistrellus subflavus*	X	X					X
Brazilian Freetail Bat *Tadarida brasiliensis*	X	X	X				X
Order Edentata							
Family Dasypodidae							
Nine-banded Armadillo *Dasypus novemcinctus*	X	X	X	X	X		X
Order Lagomorpha							
Family Leporidae							
Black-tailed Jackrabbit *Lepus californicus*				X	X	X	
Swamp Rabbit *Sylvilagus aquaticus*	X	X	X				
Eastern Cottontail *Sylvilagus floridanus*		X	X	X	X	X	X

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Order Rodentia							
Family Sciuridae							
Mexican Ground Squirrel			X	X			
Spermophilus mexicanus							
13-lined Ground Squirrel				X			
Spermophilus tridecemlineatus					X		
Rock Squirrel							
Spermophilus variegatus							
Eastern Fox Squirrel		X					X
Sciurus niger							
Family Geomyidae							
Prairie Pocket Gopher				X	X	X	
Geomys bursarius							
Family Heteromyidae							
Plains Pocket Mouse			X	X	X	X	
Perognathus flavescens							
Merriam Pocket Mouse			X	X	X		
Perognathus merriami							
Family Castoridae							
Beaver		X	X				
Castor canadensis							
Family Cricetidae							
Pygmy Mouse			X	X	X		
Baiomys taylori							
Florida Packrat	X	X	X				X
Neotoma floridana							
Brush Mouse		X	X				X
Peromyscus boylii							
White-footed Mouse		X	X				
Peromyscus leucopus							
Deer Mouse	X		X	X	X		X
Peromyscus maniculatus							
Encinal Mouse	X	X	X				X
Peromyscus pectoralis							
Fulvous Harvest Mouse			X	X	X		
Reithrodontomys fulvescens							
Plains Harvest Mouse				X	X	X	
Reithrodontomys montanus							
Hispid Cotton Rat	X		X	X			
Sigmodon hispidus							
Family Muridae							
House Mouse		X		X	X	X	
Mus musculus							
Norway Rat		X		X	X	X	
Rattus norvegicus							
Black Rat						X	
Rattus rattus							
Family Capromyidae							
Nutria		X					
Myocaster coypus							

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Order Carnivora							
Family Canidae							
Coyote *Canis latrans*	X	X	X	X	X	X	X
Gray Fox *Urocyon cinereoargenteus*		X	X				
Family Procyonidae							
Ringtail *Bassariscus astutus*		X	X				X
Raccoon *Procyon lotor*	X	X	X			X	X
Family Mustelidae							
Hog-nose Skunk *Conepatus mesolucus*		X	X				X
Long-tailed Weasel *Mustela frenata*	X	X	X	X	X	X	X
Mink *Mustela vison*	X	X				X	X
Common Striped Skunk *Mephitis mephitis*		X	X				X
Eastern Spotted Skunk *Spilogate putorius*		X	X	X	X	X	X
Family Felidae							
Mountain Lion *Felis concolor*		X	X				
Bobcat *Felis rufus*		X	X				
Order Artiodactyla							
Family Cervidae							
White-tailed Deer *Odocoileus virginianus*	X	X	X	X	X	X	X
Axis Deer *Axis axis*		X	X	X			
Blackbuck Antelope *Antilope cervicapra*			X	X			

[1] Jones et al. 1982

[2] RW - Riparian Wetland
CW - Creek Woodland
UBS - Upland Brush and Savannah
RPO - Relictual Prairie/Old Field
TP - Tame Pasture
AF - Agricultural Fields
SC - Steep Canyons

Amphibians and Reptiles of Potential Occurrence (by Habitat Type) in the Onion Creek Watershed Project Area. Names are to Collins et al., 1982[1].

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Class Amphibia							
Order Caudata							
Family Ambystomatidae							
Small-mouthed Salamander *Ambystoma texanum*	X	X					
Eastern Tiger Salamander *Ambystoma tigrinum*	X	X					
Barred Tiger Salamander *Ambystoma figrinuna mavontium*	X	X					
Family Plethodontidae							
Texas Salamander *Eurycea neotenes*	X	X					
San Marcos Salamander *Eurycea nana*	X	X					
Barton Springs Salamander *Eurycea sp.*	X	X					
Cascade Caverns Salamander *Eurycea latitans*	X	X					
Comal Blind Salamander *Eurycea tridentifera*	X	X					
Valdina Farms Salamander *Eurycea troglodytes*	X	X					
Texas Blind Salamander *Typhlomolge buni*	X	X					
Blanco Blind Salamander *Typhlomogle robusta*	X	X					
White Throat Slimy Salamander *Plethodon glutinosus albagula*	X	X					
Order Anura							
Family Pelobatidae							
Couch's Spadefoot *Scaphiopus couchii*		X	X				
Family Leptodactylidae							
Barking Frog *Hylactophryne augusti*							X
Texas Cliff Frog *Syrrhophus marnocki*							X

(continued).

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Family Hylidae							
Blanchard's Cricket Frog *Acris crepitans blanchardi*	X	X					
Green Treefrog *Hyla cinerea*	X	X			X		
Southern Gray Treefrog *Hyla chrysoscelis*		X	X				
Northern Gray Treefrog *Hyla versicolor*		X	X				
Spotted Chorus Frog *Pseudacris clarki*			X	X			
Strecker's Chorus Frog *Pseudacris streckeri*	X	X	X	X	X	X	X
Family Bufonidae							
Gulf Coast Toad *Bufo valliceps*	X	X	X	X			
Green Toad *Bufo debilis*			X				
Texas Toad *Bufo speciosus*			X	X		X	X
Red-spotted Toad *Bufo punctatus*		X	X	X			X
Woodhouse's Toad *Bufo woodhousei*	X	X	X	X			X
Family Ranidae							
Bullfrog *Rana catesbeiana*	X						
Northern Leopard Frog *Rana pipiens*	X	X	X				
Family Microhylidae							
Great Plains Narrow-Mouthed Toad *Gastrophryne olivaceae*	X	X	X	X			
Class Reptilia							
Order Testudines							
Family chelydridae							
Common Snapping Turtle *Chelydra serpentina*	X						
Family Kinosternidae							
Yellow Mud Trutle *Kinosternon flavescense*	X						
Eastern Mud Turtle *Kinosternon subrubrum*	X						
Stinkpot *Sternotherus odoratus*	X						

(continued).

Taxonomy and Common Name	Suitable Habitat Types[2] RW	CW	UBS	RPO	TP	AF	SC
Family Emydidae							
River Cooter	X						
Pseudemys concinna							
Pond Slider	X						
Pseudemys scripta							
Texas Map Turtle	X						
Graptemys versa		X	X				
Three-toed Box Turtle							
Terrapene carolina				X	X		
Ornate Box Turtle							
Terrapene ornata							
Family Trionychidae							
Spiny Softshell	X						
Trionyx spiniferus							
Order Crocodilia	X						
Family Crocodilidae							
Alligator							
Alligator mississippiensis							
Class Squamata							
Order Lacertilia							
Family Gekkonidae							
Mediterranean Gecko	X	X	X				X
Hemidactylus turcicus							
Family Iguanidae							
Green Anole		X	X				X
Anolis carolinensis							
Collared Lizard			X				
Crotaphytus collaris							
Greater Earless Lizard			X				

(continued).

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Holbrookia texana							
Spot-tailed Earless Lizard			X				
Holbrookia lacerata							
Texas Horned Lizard			X	X			
Phrynosoma cornutum							
Eastern Fence Lizard		X	X				
Sceloporus undulatus							
Texas Spiny Lizard		X	X				
Sceloporus olivaceus							
Rose-bellied Lizard			X				
Sceloporus variabilis							
Tree Lizard		X	X				
Urosaurus ornatus							
Family Scincidae							
Short-lined Skink		X	X	X			
Eumeces brevilineatus							
Ground Skink	X		X				
Scincella lateralis							
Family Teiidae							
Texas Spotted Whiptail	X	X	X	X			
Cnemidophorus gularis							
Six-lined Racer		X	X	X			
Cnemidophorus sexlineatus							
Family Anguidae							
Texas Alligator Lizard		X	X	X			
Flathead Snake							
Tantilla gracilis							
Plains Blackheaded Snake					X		
Tantilla nigriceps							
Checkered Garter Snake							
Thamnophis marcianus							
Black-necked Garter Snake							
Thamnophis cyrtopsis							
Western Ribbon Snake							
Thamnophis proximus							
Lined Snake							
Tropidoclonion lineatum							
Rough Earth Snake							
Virginia striatula							

(continued).

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Order Serpentes							
Family Leptotyphlopidae							
Texas Blind Snake *Leptotyphlops dulcis*		X	X	X			
Family Colubridae							
Racer *Coluber constrictor*		X	X	X	X	X	
Texas Rat Snake *Elaphe ohsoleta lindheimeri*		X	X	X	X	X	X
Corn Snake *Elaphe guttata*		X	X	X	X		
Eastern Hognose Snake *Heterodon platyrhinos*			X	X			
Prairie Kingsnake *Lampropeltis calligaster*			X	X			
Speckled Kingsnake *Lampropeltis getulus holbrooki*	X	X	X				
Striped Whipsnake *Masticophis taeniatus girardi*		X	X				
Western Coachwhip *Masticophis flagellum testaceus*			X	X	X		
Blotched Water Snake *Nerodia erythrogaster tranverse*	X						
Diamond-backed Water Snake *Nerodia rhombifera*	X						
Rough Green Snake *Opheodrys aestivus*		X					
Bullsnake *Pituophis melanoleucus sayi*	X	X	X	X	X	X	X
Long-nose Snake *Rhinocheilus lecontei*	X	X					X
Texas Patch-nosed Snake *Salvadora grahamiae lineata*		X	X	X	X	X	X
Great Plains Ground Snake *Sonora semiannnulata*		X	X	X	X	X	
Texas Brown Snake *Storeria dekayi texana*	X	X				X	
Flathead Snake *Tantilla gracilis*		X	X				
Plains Blackheaded Snake *Tantilla nigriceps*			X	X	X	X	
Checkered Garter Snake *Thamnophis marcianus*	X	X					
Black-necked Garter Snake *Thamnophis cyrtopsis*	X	X					
Western Ribbon Snake *Thamnophis proximus*	X						
Lined Snake *Tropidoclonion lineatum*		X		X			
Rough Earth Snake *Virginia striatula*		X		X	X	X	X

(continued).

Taxonomy and Common Name	Suitable Habitat Types[2]						
	RW	CW	UBS	RPO	TP	AF	SC
Family Elapidae							
Coral Snake		X	X				
Micrurus fulvius							
Family Viperidae							
Copperhead		X	X				
Agkistrodon contortrix							
Western Cottonmouth	X	X					
Agkistrodon piscivorus							
Western Diamondback Rattler		X	X	X	X	X	X
Crotalus atrox							
Black-tailed Rattlesnake	X	X	X				X
Crotalus molossus molossus							

Source: Adapted from Longley, 1975.

1 Collins et al. 1982

2 RW - Riparian Wetland
CW - Creek Woodland
UBS - Upland Brush and Savannah
RPO - Relictual Prairie/Old Field
TP - Tame Pasture
AF - Agricultural Fields
SC - Steep Canyons

Birds of Potential Occurrence in the Onion Creek Watershed Project Area. Names are according to Bryan et al., 1989[1].

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Order Gauiiformes								
Family Gauiidae								
Common Loon	X							
Gavia immer								
Order Podicipediformes								
Family Podicipedidae								
Eared Grebe	X							
Podiceps nigricollis								
Least Grebe	X	X						
Tachybaptus dominicus								
Pied-billed Grebe	X							
Podilymbus podiceps								
Order Pelecaniformes								
Family Pelecanidae								
White Pelican	X							
Pelecanus erythrorhynchos								
Family Phalacrocoracidae								
Double-crested Cormorant	X							
Phalacrocorax auritus								
Olivaceous Cormorant	X							
Phalacrocorax olivaceus								
Family Anhingidae								
Anhinga	X							
Anhinga anhinga								
Order Ciconiiformes								
Family Ardeidae								
Great Blue Heron	X							X
Ardea herodias								
Green-backed Heron	X	X						
Butorides striatus								
Little Blue Heron	X							
Egretta caerulea								
Cattle Egret				X	X	X		X
Bubulcus ibis								
Great Egret	X							
Casmerodius albus								
Snowy Egret	X					X		
Egretta thula								
Tricolored Heron	X							
Egretta tricolor								
Black-crowned Night-heron	X							
Nyticorax nycticorax								
American Bittern	X							
Botaurus lentiginosus								
Family Threskiornthidae								
White-faced Ibis	X							
Plegadis chihi								
Roseate Spoonbill	X							
Ajaia ajaja								

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Order Anseriforme								
Family Anatidae								
Canada Goose *Branta canadensis*	X			X	X	X		
Greater White-fronted Goose *Anser albifrons*	X			X	X	X		
Snow Goose *Chen caerulescens*	X			X	X	X		
Rossi Goose *Chen rossii*	X			X	X	X		
Mallard *Anas platyrhynchos*	X							
Gadwall *Anas strepera*	X							
Northern Pintail *Anas acuta*	X					X		
Green-winged Teal *Anas creeca*	X							
Blue-winged Teal *Anas discors*	X							
American Widgeon *Anas americana*	X							
Shoveler *Anas clypeata*	X							
Wood Duck *Aix sponsa*	X	X						X
Redhead *Aythya americana*	X							
Ring-necked Duck *Aytha collaris*	X							
Canvasback *Aytha valisineria*	X							
Lesser Scamp *Aythya valisineria*	X							
Common Goldeneye *Bucephala clangula*	X							
Bufflehead *Bucephala albeola*	X	X						
Ruddy Duck *Oxyura jamaicensis*	X							
Hooded Merganser *Lophodytes cucullatus*	X							
Red-breasted Merganser *Mergus serrator*	X							
Order Falconiformes								
Family Cathartidae								
Turkey Vulture *Cathartes aura*		X	X	X	X	X		X
Black Vulture *Coragyps atratus*			X	X	X	X		X

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Family Accipitriae								
Osprey *Pandion haliaetus*	X							
Red-tailed Hawk *Buteo jamaicensis*			X	X	X	X		X
Mississippi Kite *Ictinia mississippiensis*	X	X	X					
Sharp-shinned Hawk *Accipiter striatus*		X	X					
Cooper's Hawk *Accipiter cooperii*		X	X					
Red-shouldered Hawk *Buteo lineatus*	X	X						
Broad-winged Hawk *Buteo platypterus*		X						
Swainson's Hawk *Buteo swansoni*			X	X	X			
Harris' Hawk *Parabuteo unicinctus*			X					
Golden Eagle *Aquilla chrysaetos*				X	X		X	
Bald Eagle *Haliaeetus leucocephalus*	X	X						
Northern Harrier *Circus cyaneus*	X			X	X	X		
Family Falconidae								
Crested Caracara *Polyborus plancus*			X					X
American Kestrel *Falco sparverius*				X	X	X		X
Merlin *Falco columbarius*			X	X				
Peregrine Falcon *Falco peregrinus*				X	X		X	
Prairie Falcon *Falco mexicanus*			X	X	X			
Order Galliformes								
Family Phasianidae								
Wild Turkey . *Meleagris gallopavo*		X	X					
Northern Bobwhite *Colinus virginianus*			X	X	X	X		
Order Gruiformes								
Family Gruidae								
Sandhill Crane *Grus canadensis*	X			X		X		
Whooping Crane *Grus americana*	X							
Family Rallidae								
Sora *Porzana carolina*	X					X		
Common Moorhen *Gallinula chloropus*	X							
American Coot *Fulica americana*	X							

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Order Charadriiformes								
Family Charadriiformes								
Killdeer				X	X	X	X	
Charadrius vociferus								
Semipalmated Plover	X							
Charadrius semipalmatus								
Snowy Plover	X							
Charadrius alexandrinus								
Lesser Golden Plover	X					X		
Pluvialis dominica								
Black-bellied Plover	X							
Pluvialis squatarola								
Family Scolopacidae								
Ruddy Turnstone	X							
Arenaria interpres								
American Woodcock		X						
Scolopax minor								
Common Snipe	X							
Gallinago gallinago								
Long-billed Curlew	X							
Numenius americanus								
Upland Sandpiper			X	X	X			
Bartramia longicauda								
Spotted Sandpiper	X							
Tringa solitaria								
Solitary Sandpiper	X							
Tringa solitaria								
Willet	X							
Catotrophorus semipalmatus								
Greater Yellowlegs	X							
Tringa melanoeuca								
Lesser Yellowlegs	X	X						
Tringa flavipes								
Pectoral Sandpiper	X							
Calidris melanotos								
White-rumped Sandpiper	X							
Calidris fuscicollis								
Baird's Sandpiper	X							
Calidris bairdii								
Least Sandpiper	X							
Calidris alpina								
Dunlin	X							
Calidris minutilla								
Short-billed Dowitcher	X							
Limnodromus griseus								
Long-billed Dowitcher	X							
Limnodromus scolopaceus								
Stilt Sandpiper	X							
Calidris himantopus								
Semi-palmated Sandpiper	X							
Calidris pusilla								
Western Sandpiper	X							
Calidris mauri								
Buff-breasted Sandpiper				X	X	X		
Tryngites subruficollis								
Sanderling	X							
Calidris alba								

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW[1]	UBS	RPO	TP	AF	SC	
Family Recurvirostridae								
Black-necked Stilt *Himantopus mexicanus*	X							
American Avocet *Recurvirostra americana*	X							
Wilson's Phalarope *Phalaropus tricolor*	X							
Red-necked Phalarope *Phalaropus lobatus*	X							
Family Laridae								
Herring Gull *Larus argentatus*	X							
Ring-billed Gull *Larus delawarensis*	X							
Laughing Gull *Larus atricilla*	X							
Franklin's Gull *Larus pipixcan*	X							
Bonaparte's Tern *Larus philadelphia*	X							
Forster's Tern *Sterna forsteri*	X							
Common Tern *Sterna hirundo*	X							
Least Tern *Sterna antillarum*	X							
Black Tern *Chlidonias niger*	X							
Black Skimmer *Rynchops niger*	X							
Order Columbiformes								
Family Columbidae								
Rock Dove *Columba livia*					X	X		
Mourning Dove *Zenaida macroura*			X	X	X	X		X
Inca Dove *Columbina inca*			X					
Common Ground-dove *Columbina passerina*			X	X				
Order Cuculiformes								
Family Cuculidae								
Black-billed Cuckoo *Coccyzus erythropthalmus*		X						
Yellow-billed Cuckoo *Coccyzus americanus*		X	X					X
Greater Roadrunner *Geococcyx californianus*			X					
Order Strigiformes								
Family Tytonidae								
Barn Owl *Tyto alba*		X						
Family Strigiformes								
Eastern Screech-owl *Otus asio*		X						
Great Horned Owl *Bubo virginianus*		X	X			X		
Burrowing Owl *Athene cunicularia*				X	X		X	
Barred Owl *Strix varia*		X						

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Order Camprimulgiforme								
Family Caprimulgidae								
Lesser Nighhawk			X	X				
Chordeiles acutipennis								
Common Nighthawk			X	X	X			
Chordeiles minor								
Common Poorwill			X					
Phalaenoptiles nuttallii								
Chuck's-will's-widow		X						
Caprimulgus carolinensis								
Whip-poor-will		X	X					
Caprimulgus vociferus								
Order Apodiformes								
Family Apodidae								
Chimney Swift							X	
Chaetura pelagica								
Family Trochilidae								
Rufous-tailed Hummingbird		X	X					
Amazilia tzacatl								
Black-chinned Hummingbird	X	X						
Archilochus alexandri								
Order Coraciiformes								
Family Alcedindae								
Belted Kingfisher	X							X
Ceryle alcyon								
Green Kingfisher	X							
Chloroceryle americana								
Order Piciformes								
Family Picidae								
Golden-fronted Woodpecker		X	X					
Melanerpes aurifrons								
Ladder-backed Woodpecker			X					
Picoides scalaris								
Northern Flicker		X	X					
Colaptes auratus								
Pileated Woodpecker		X						
Dryocopus pileatus								
Red-bellied Woodpecker		X	X					
Melanerpes carolinus								
Red-headed Woodpecker		X	X			X		
Melanerpes erythrocephalus								
Yellow-bellied Sapsucker		X						
Sphyrapicus varius								
Hairy Woodpecker		X						
Picoides villosus								
Downy Woodpecker		X	X					
Picoides pubescens								

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Order Passeriformes								
Family Tyrannidae								
Western Kingbird			X	X				
Tyrannus verticalis								
Eastern Kingbird		X	X			X		
Tyrannus tyrannus								
Ash-throated Flycatcher		X	X	X	X			X
Myiarchus tuberculifer								
Scissor-tailed Flycatcher			X	X	X			
Tyrannus forficatus								
Great Crested Flycatcher		X						
Myiarchus crinitus								
Eastern Phoebe		X	X	X	X	X		X
Sayornis phoebe								
Say's Phoebe			X				X	
Sayornis saya								
Yellow-bellied Flycatcher	X							
Empidonax flaviventris								
Acadian Flycatcher		X						
Empidonax virescens								
Willow Flycatcher		X	X					
Empidonax truillii								
Least Flycatcher		X	X					
Empidonax minimus								
Eastern Wood-pewee		X	X					
Contopus virens								
Olive Sided Flycatcher	X	X						
Contopus borealis								
Vermilion Flycatcher	X	X						
Pyrocephlus rubinus								
Family Aluadidae								
Horned Lark			X		X	X	X	
Eremophila alpestris								
Family Hirundinidae								
Purple Martin		X	X				X	
Progne subis								
Tree Swallow		X						
Tachycineta bicolor								
Bank Swallow		X				X	X	
Riparia riparia								
Northern Rough-winged Swallow							X	
Stelgidopteryx serripennis								
Barn Swallow						X	X	
Hirundo rustica								
Cliff Swallow						X	X	
Hirundo pyrrhonota								
Family Corvidae								
Blue Jay		X	X			X		
Cyanocitta cristata								
Scrub Jay			X					X
Aphelocoma coerulescences								
American Crow		X	X	X	X	X		
Corvus brachyrhynchos								
Family Paridae								
Carolina Chickadee		X						X
Parus carolinensis								
Tufted Titmouse		X	X	X				X
Parus bicolor								
Family Remizidae								
Verdin			X					
Auriparus flaviceps								

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Family Aegithalidae								
Bushtit *Psaltriparus minimus*			X					
Family Sittidae								
Red-breasted Nuthatch *Sitta canadensis*		X						
Family Certhiidae								
Brown Creeper *Certhia americana*		X						
Family Troglodytidae								
Cactus Wren *Campylorhynchus brunneicapillus*			X					
Rock Wren *Salpinctes obsoletus*			X				X	
Canyon Wren *Catherpes mexicanus*							X	X
Carolina Wren *Thryothorus ludovicianus*	X	X						X
Bewick's Wren *Thryomanes bewickii*		X	X					X
House Wren *Troglodytes aedon*			X	X		X		
Winter Wren *Troglodytes traglodytes*		X						
Marsh Wren *Cistothorus palustris*	X							
Family Mimidae								
Brown Thrasher *Toxostoma rufum*		X	X					
Curve Billed Thrasher *Toxostoma longirostre*		X	X				X	
Sage Thrasher *Oresoptes montanus*			X					
Gray Catbird *Dumetella carolinensis*		X						
Northern Mockingbird *Mimus polyglottos*		X	X					
Family Bombycillidae								
Cedar Waxwing *Bombycilla cedrorum*		X	X					

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Family Muscicapidae								
Blue-gray Gnatcatcher *Polioptila caerulea*		X	X					
Golden-crowned Kinglet *Regulus satrapa*		X						
Ruby-crowned Kinglet *Regulus calendula*		X	X					
Eastern Bluebird *Sialia sialis*		X	X			X		X
Mountain Bluebird *Sialia currucoides*			X	X				
Townsend's Solitaire *Myadestes townsendi*			X				X	
Veery *Catharus fuscescens*		X						
American Robin *Turdus migratorius*	X	X	X	X	X	X		
Wood Thrush *Hylocichla mustelina*	X	X						
Hermit Thrush *Catharus guttatus*		X						
Swainson's Thrush *Catharus ustulatus*	X	X						
Gray-cheeked Thrush *Catharus minimus*		X						
Family Motacillidae								
American Pipit *Anthus rubescens*				X	X			
Sprague's Pipit *Anthus spragueii*				X	X			
Family Laniidae								
Loggerhead Shrike *Lanius ludovicianus*			X	X				X
Family Sturnidae								
European Starling *Sturnus vulgaris*		X	X	X	X	X		X
Family Vireonidae								
White-eyed Vireo *Vireo griseus*		X						X
Bell's Vireo *Vireo bellii*		X	X					
Black-capped Vireo *Vireo atricapillus*		X	X					
Yellow-throated Vireo *Vireo flavifrons*		X						
Solitary Vireo *Vireo solitarius*		X						
Warbling Vireo *Vireo gilvus*		X	X					
Philadelphia vireo *Vireo philadelphicus*		X						
Red-eyed Vireo *Vireo olivaceus*		X						

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Family Emberizidae								
Blue-winged Warbler *Vermivora pinus*		X	X					
Golden-winged Warbler *Vermivora chrysoptera*			X	X				
Tennessee Warbler *Vermivora peregrina*		X	X					
Orange-crowned Warbler *Vermivora celata*		X	X					
Nashville Warbler *Vermivora ruficapilla*		X						
Northern Parula *Parula americana*		X						
Yellow Warbler *Dendroica petechia*	X	X						
Chestnut-sided Warbler *Dendroica pennsylvanica*		X						
Magnolia Warbler *Dendroica magnolia*		X						
Yellow-rumped Warbler *Dendroica coronata*		X						
Black-throated Gray Warbler *Dendroica nigrescens*			X					
Black-throated Green Warbler *Dendroica virens*		X						
Golden-cheeked Warbler *Dendroica chrysoparia*			X					
Blackburnian Warbler *Dendroica fusca*		X						
Yellow-throated Warbler *Dendroica dominica*		X						
Pine Warbler *Dendroica pinus*		X	X					
Bay-breasted Warbler *Dendroica castanea*		X	X					
Cerulean Warbler *Dendroica cerulea*	X	X						
Black-and-white Warbler *Mniotilta varia*		X						
Prothonotary Warbler *Protonotaria citrea*		X						
Ovenbird *Seiurus aurocapillus*		X						
Northern Waterthrush *Seiurus noveboracensis*	X	X						
Louisiana Waterthrush *Seiurus motacilla*	X	X						
Kentucky Warbler *Oporornis formosus*		X						
Mourning Warbler *Oporornis philadelphia*		X						
Common Yellowthroat *Geothlypis trichas*	X	X	X	X				
Hooded Warbler *Wilsonia citrina*	X	X						
Wilson's Warbler *Wilsonia pusilla*	X	X						
Canada Warbler *Wilsonia canadensis*		X	X					
Yellow-breasted Chat *Icteria vireus*		X	X					
Summer Tanager *Piranga rubra*		X						X
Scarlet Tanager *Piranga olivacea*		X						
Northern Cardinal *Cardinalis cardinalis*	X	X						X

Taxonomy and Common Name	Suitable Habitat Types[2]							Observed in Project Area
	RW	CW	UBS	RPO	TP	AF	SC	
Rose-breasted Grosbeak *Pheucticus ludovicianus*		X						
Black-headed Grosbeak *Pheucticus melanocephalus*		X						
Blue Grosbeak *Guiraca caerulea*		X	X	X				
Lazuli Bunting *Passerina amoena*		X	X					
Indigo Bunting *Passerina cyanea*		X	X					
Painted Bunting *Passerina ciris*		X	X					X
Dickcissel *Spiza americana*				X	X	X		
Green-tailed Towhee *Pipilo chlorurus*			X					
Rufous-sided Towhee *Pipilo erythrophthalmus*		X	X					
Canyon Towhee *Pipilo fuscus*			X				X	
Cassin's Sparrow *Aimophila cassinii*			X	X				
Rufous-crowned Sparrow *Aimophila ruficeps*			X				X	X
Chipping Sparrow *Spizella passerina*			X	X	X			
Clay-colored Sparrow *Spizella pallida*		X	X	X	X			
Field Sparrow *Spizella pusilla*			X	X				
Vesper Sparrow *Pooecetes gromineus*			X	X	X	X		
Lark Sparrow *Chondestes grammacus*			X	X	X	X		
Black-throated Sparrow *Amphispiza bilineata*			X				X	
Lark Bunting *Calamospiza melanocorys*			X	X				
Savannah Sparrow *Passerculus sandwichensis*			X	X	X			
Grasshopper Sparrow *Ammodramus savannarum*			X	X	X			
Fox Sparrow *Passerella iliaca*		X	X					
Song Sparrow *Melospiza melodia*		X	X					
Lincoln's Sparrow *Melospiza lincolnii*		X	X					
Swamp Sparrow *Melospiza georgiana*	X							
White-throated Sparrow *Zonotrichia albicollis*		X	X					
White-crowned Sparrow *Zonotrichia leucophrys*			X	X	X			
Harris' Sparrow *Zonotrichia querula*		X	X					
Dark-eyed Junco *Junco hyemalis*		X	X					X
McCown's Larkspur *Calcarius mccownii*				X	X	X		
Chestnut-collared Longspur *Calcarius ornatus*				X	X			
Red-winged Blackbird *Agelaius phoeniceus*	X	X				X		
Eastern Meadowlark *Sturnella magna*				X	X	X		
Western Meadowlark *Sturnella neglecta*			X	X	X	X		

Taxonomy and Common Name	Suitable Habitat Types[2] RW	CW	UBS	RPO	TP	AF	SC	Observed in Project Area
Common Grackle *Quiscalus quiscula*	X			X	X	X		X
Bronzed Cowbird *Moluthrus aeneus*			X	X	X	X		
Brown-headed Cowbird *Molothrus ater*		X	X			X		X
Orchard Oriole *Icterus spurius*		X						
Northern Oriole *Icterus galbula*		X						
Family Fringillidae								
Purple Finch *Carpodacus purpureus*		X	X					
House Finch *Carpodacus mexicanus*			X				X	
Pine Siskin *Carduelis pinus*		X	X	X		X		
Lesser Goldfinch *Carduelis psaltria*			X	X	X	X		X
American Goldfinch *Carduelis tristis*			X	X	X	X		
Family Passeridae								
House Sparrow *Passer domesticus*	X	X	X	X	X	X	X	X

[1] Bryan et al. 1989.

[2] RW - Riparian Wetland
CW - Creek Woodland
UBS - Upland Brush and Savannah
RPO - Relictual Prairie/Old Field
TP - Tame Pasture
AF - Agricultural Fields
SC - Steep Canyons

ENGINEERING ASSESSMENT AND ENVIRONMENTAL INVENTORY AND ISSUES REPORT ARTIFICIAL RECHARGE ENHANCEMENT , ONION CREEK, HAYS COUNTY , TEXAS

The following maps are not attached to this report. Due to their size, they could not be copied. They are located in the official file and may be copied upon request.

Plate 1 (Sheet 1 Of 2) Centerline Profile Onion Creek With Geologic Features

Plate 2 (Sheet 1 Of 2) Recharge Potential Map With Centex And Yo Reservoirs

Plate 3 Legend , High Recharge Potential, Moderate Recharge Potential

Plate 4 Sensitive environmental Features In The Vicinity Of The Proposed Project Alternatives

Plate 5 Land Use/Land Cover Map

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