

## **Section 7**

### **Consistency with Long-Term Protection of the State's Water, Agricultural, and Natural Resources**

The 2011 Plan is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources and is developed based on guidance principles outlined in the Texas Administrative Code Chapter 358- State Water Planning Guidelines. The 2011 Plan was produced with an understanding of the importance of orderly development, management, and conservation of water resources and is consistent with all laws applicable to water use for the state and regional water planning areas. Furthermore, the plan was developed according to principles governing surface water and groundwater rights. Availability of water for new surface water supplies considered environmental flow needs by adhering to pass-through requirements consistent with the Consensus Criteria for Environmental Flow Needs (Appendix H), and protection of existing water rights. For groundwater, the 2011 Plan recognizes principles for groundwater use in Texas, and estimates of groundwater availability take into consideration regional and local drawdown constraints (Appendix B).

The 2011 Plan identifies actions and policies necessary to meet the Brazos G Area's near and long-term water needs by developing and recommending water management strategies to meet needs with reasonable cost, good water quality, and sufficient protection of agricultural and natural resources of the state. The Brazos G RWPG has recommended water management strategies that consider the public interest of the state, wholesale water providers, protection of existing water rights, and opportunities that encourage voluntary transfers of water resources while balancing economic, social, and ecological viability. When needs could not be met economically with water management strategies, a socioeconomic impact analysis was performed to estimate the economic loss associated with not meeting these needs (Appendix I).

The 2011 Plan considers environmental information resulting from site-specific studies and ongoing water development projects when evaluating water management strategies. Cumulative effects of water management strategies on Brazos River instream flows and inflows to the Gulf of Mexico were considered, as documented in the various evaluations of water management strategies. A list of endangered and threatened species in the Brazos G Area for each county was obtained from the U.S. Fish and Wildlife Service and possible impacts to these habitats were considered for each water management strategy evaluated.

The 2011 Plan consists of initiatives to respond to continuing drought conditions in the western part of the region, and makes use of relatively low-impact strategies such as reuse of wastewater return flows and the Brazos River Authority's proposed System Operations Permit to increase supplies. As a further drought protection provision, the Brazos G RWPG adopted use of safe yield analyses for purposes of determining water supply for municipal supply reservoirs upstream of Possum Kingdom Reservoir. The use of safe yield analyses anticipates that a future drought may occur that is greater in severity than the worst drought of record and reserves a certain amount of water in storage (i.e., a 1- or 2-year supply) for such an event. Use of safe yield in the upper Brazos Basin is justified based on the severity of the recent and ongoing drought. Figure 7-1 shows how flows during the current drought are significantly less than those of the 14 years of the drought of record (1950's drought).

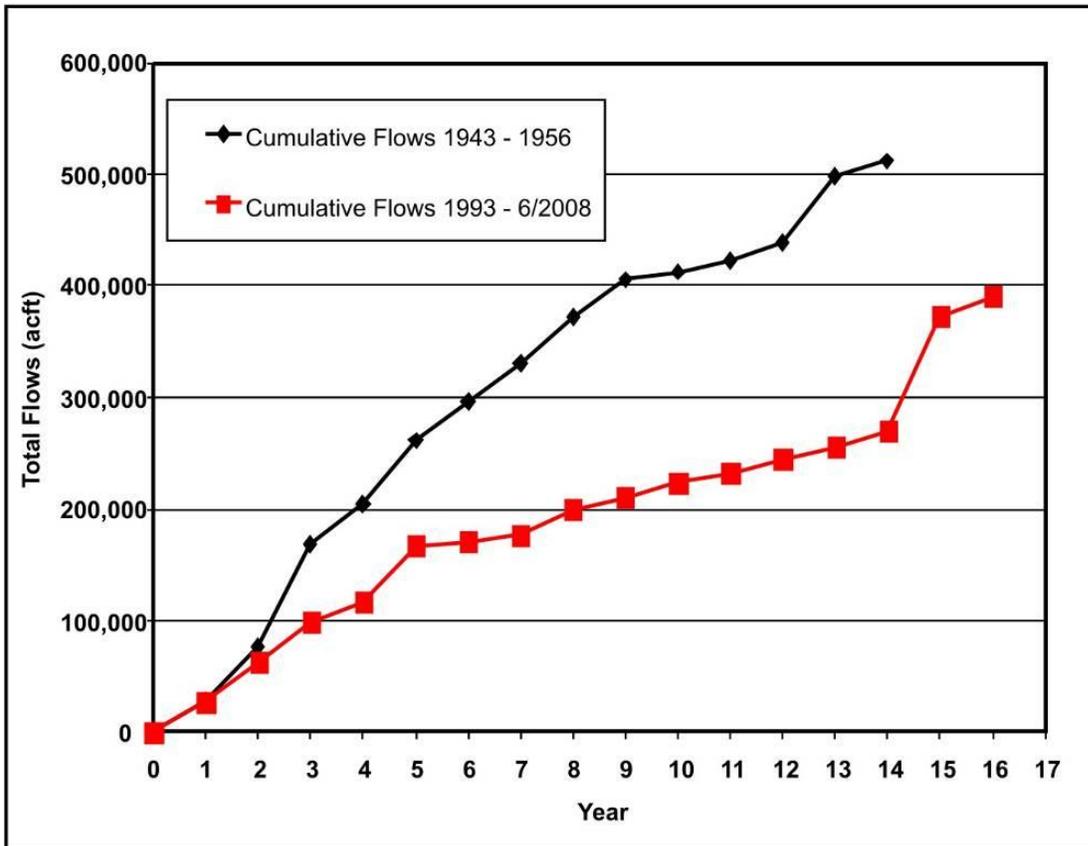


Figure 7-1. Cumulative Gaged Flows at Clear Fork of the Brazos near Nugent

The Brazos G RWPG conducted numerous meetings during the 2011 planning cycle, which were open to the public, and decisions were based on accurate, objective, and reliable information. The Brazos G RWPG coordinated water planning activities with local, regional and state agencies, and was committed to facilitating the initiatives and addressing the concerns of local and regional entities.

The Brazos G RWPG considered recommendations of stream segments with unique ecological value by Texas Parks and Wildlife and sites of unique value for reservoirs. At this time, the Brazos G RWPG recommends that no stream segments be designated as unique; however, there are recommendations to make certain reservoir sites unique (Section 8). The Brazos G RWPG developed policy recommendations regarding State water policy after extensive consideration and deliberation and these are presented in Section 8 of this report.

The following sections describe in more detail the hydrologic effects of the recommended water management strategies on surface water and groundwater resources.

## **7.1 Cumulative Hydrologic Effects of Regional Water Plan Implementation**

### **7.1.1 Surface Water**

Sophisticated hydrologic models have been employed to quantify the cumulative effects of implementation of the 2011 Plan through the year 2060. Surface water effects were quantified using the Brazos G WAM, which was the standard tool utilized to determine surface water supplies available in the region and also to evaluate potential water management strategies. The Brazos G WAM utilizes the Water Rights Analysis Package (WRAP) and a modified TCEQ WAM dataset that incorporates approved Brazos G planning assumptions concerning return flows, reservoir sedimentation and priority calls agreements, among others.

The cumulative effects of the plan can be quantified by comparing conditions prior to implementation of the plan (base condition) to conditions with the plan in place. At the direction of the Brazos G RWPG, the base condition against which to compare conditions with the plan in place was streamflow computed by the Brazos G WAM model used to determine availability of surface water supplies in the year 2060. In this scenario, all existing water rights are fully utilized, all major reservoir capacities are reduced to expected year 2060 sedimentation conditions, wastewater effluent discharges (return flows) are include with an aggressive level of reuse assumed, and all BRA contractual commitments are placed at their actual diversion locations.

The conditions with the plan in place include the base condition assumptions, with the addition of any recommended strategies that could measurably affect streamflows, i.e., those that result in development of additional water supply. The recommended water management strategies, listed in Table 7-1, were incorporated into the model. Specific strategies not included in the analysis are reuse projects, conservation, strategies transferring water from one entity to another through new or increased purchases, and development of additional groundwater. The base condition already assumes a level of reuse that is somewhat greater than in the plan; therefore, the reuse aspects of the plan will not cause any further reductions in streamflow below the base conditions. The base condition assumes full utilization of water rights, and conservation or transfers of water will not impact the assumption of full utilization of water rights. Surface water/groundwater interactions are difficult to quantify, but reductions in streamflow due to increased utilization of groundwater resources are expected to be low. For example, groundwater availability model (GAM) simulations of the Carrizo-Wilcox Aquifer with pumping at the full estimated groundwater availability resulted in only 22 cubic feet per second (cfs) reduction in base streamflow, summed for all streams crossing the Carrizo-Wilcox Aquifer.

The Brazos G RWPG selected the eight locations presented in Table 7-2 at which to evaluate the cumulative effects of the 2011 Plan on streamflow. Each selected location is located in the Brazos G portion of the Brazos River Basin, except the Brazos River at Richmond site. This location was included in the analysis to illustrate the impacts of not only Brazos G strategies on the lower part of the basin, but also to include the effects of the Region H strategies that were included in the analysis.

The strategies were operated with seniority to the proposed appropriation under the BRA System Operations Permit. It was assumed that some form of priority calls agreement would be reached between the BRA and the entity developing a new water supply project, and the new water supply would not be required to pass flows to the new BRA appropriation. In all cases, the priorities of BRA's existing rights were honored, as simulated under system operations.

**Table 7-1.  
Recommended Water Management Strategies Included in  
Cumulative Impacts Analysis**

<b>Recommended Water Management Strategy</b>	<b>WUG or WWP</b>	<b>Plan Section</b>
Millers Creek Reservoir Augmentation	North Central Texas Municipal Water District	4B.7
Cedar Ridge Reservoir	City of Abilene	4B.12.1
BRA System Operations	Bosque, Hill and Limestone County WUGs	4B.4
Turkey Peak Reservoir	Palo Pinto County MWD #1	4B.12.5
Federal Storage Reallocation – Aquila Reservoir	Brazos River Authority	4B.18.1
BRA System Operations – Lake Granger Augmentation	Williamson County WUGs	4B.5
Coryell County Reservoir	Brazos River Authority	4B.13.7
Groesbeck Off-Channel Reservoir	City of Groesbeck	4B.13.2
Millican Reservoir – Panther Creek Site	Brazos River Authority	4B.12.8
Raise Level of Gibbons Creek Reservoir	Grimes County Steam Electric	4C.12.5
Allens Creek Reservoir (Region H) <sup>1</sup>	Brazos River Authority	n/a
Brushy Creek Reservoir	City of Marlin	4B.12.10
<sup>1</sup> Allens Creek Reservoir is a recommended strategy in the Region H Plan. Allens Creek is neither recommended nor discouraged in the Brazos G Plan.		

**Table 7-2.  
Locations for Evaluating the Effects of  
Recommended Strategies on Streamflow**

<b>Location</b>	<b>WAM Control Point Identifier</b>
Brazos River at South Bend	BRSB23
Brazos River near Glen Rose	BRGR30
Brazos River near Aquilla	BRAQ33
Bosque River near Waco	BOWA40
Little River near Cameron	LRCA58
Brazos River near Bryan	BRBR59
Brazos River near Hempstead	BRHE68
Brazos River at Richmond	BRR170

The Region H portion of the supply made available under BRA System Operations was diverted at the Richmond control point (BRR170) in the model. The remaining Brazos G portion not assigned to specific WUG strategies (5,742 acft) was diverted in the model at the Brazos River near Hempstead location, the main stem location furthest downstream in the Brazos G Area. The existing priority calls agreements with the BRA and other water right holders were considered in this model run. The inclusion or exclusion of the subordination agreements does not affect the resulting streamflows at the selected locations in a substantive manner.

The cumulative effects of the recommended water management strategies on streamflow were evaluated by comparing descriptive streamflow statistics for the base condition with those from the plan condition at the selected evaluation locations. Figures 7-2 through 7-9 present these comparisons for regulated streamflow at each of the evaluation locations. Regulated flow is the total streamflow remaining in the stream after all existing water rights have been exercised and other water management activities have taken place. It represents the total flow passing a location (control point) after all water rights have appropriated the flows to which they are entitled.

One noticeable trend in the monthly median graphs for most locations is that monthly median streamflows are significantly greater January through June than July through December. In order to investigate this apparent trend, a comparison of naturalized flows with the regulated flows was completed to verify if this trend was a by-product of the modeling, or if it occurs naturally in the streamflow records. Figure 7-10 illustrates the median naturalized flows at the Brazos River at Richmond location compared to the regulated flows of both the base and the implemented plan scenarios. This graph demonstrates that the trend in flows follows the same pattern in the underlying natural flows upon which the simulations are based.

The results show that the streamflows generally tend to decrease between the base run and the implemented plan run for those locations downstream from where reservoirs have been recommended. However, some locations exhibit larger flows with implementation of the 2011 Plan than with the base condition. This is due primarily to the releases being made from upstream BRA reservoirs as part of the BRA System Operations to the diversions modeled at various locations along the main stem of the Brazos River.

The Brazos River near South Bend and the Brazos River near Glen Rose are the only two locations that show that there are more months where the median streamflow decreased between the base and the plan than where it stayed the same or increased. These reductions are the result

of the implementation of the Cedar Ridge Reservoir, Millers Creek Reservoir Augmentation, and the Turkey Peak Reservoir projects. The increases in median flow, especially at the Brazos River near Glen Rose, are the results of BRA System Operations releases from Possum Kingdom and Granbury. For the South Bend location the largest decrease occurs in March at 16%, and the largest increase occurs in July at 4%. For the Glen Rose location, the largest decrease occurs in July at 49%, and the largest increase occurs in May at 31%. Even with these modest differences in median streamflow, the frequency plots show that the overall change to the flow regime at these points is minor.

The Brazos River near Aquilla location shows increases in median streamflow for 9 of the 12 months. The range of differences at this location is a 19% decrease to a 65% increase. Again these differences are primarily attributed to the impacts of BRA System Operations and new upstream reservoirs. The Bosque River near Waco location controls a relatively small watershed compared to the other locations investigated in this analysis. Changes associated with this location are relatively negligible. The Run 8 flows are much greater than the base or plan flows, apparently from non-utilization of existing water rights. The Little River near Cameron location reflects changes from projects recommended for implementation in the Little River watershed, specifically the Lake Granger Augmentation. While monthly median flows exhibit mostly increases up to 42%, little difference is apparent in the overall frequency of flows.

The three most downstream locations, Brazos River near Bryan, Brazos River near Hempstead and the Brazos River at Richmond, are all located on the main stem of the Brazos and the changes in streamflow at these locations show similar trends. These locations are located downstream in the basin and downstream from the majority of the recommended water management strategies. These locations have the potential to be impacted by the implementation of any of the proposed strategies. New reservoir and diversion projects will tend to reduce streamflow at these locations, while the BRA System Operations tends to increase streamflows as releases from upstream reservoir pass these locations to satisfy demands at downstream locations. The impacts of the Millican – Panther Creek Reservoir are evidenced in the reduction in flow at Hempstead and Richmond that is not reflective of the Bryan location. This is because the confluence of the Navasota River with the Brazos River is located between Bryan and Richmond. The Bryan location shows increases in median streamflow for 10 of the 12 months by as much as 28%, with the largest reduction of 11%. Hempstead sees 6 months with increase in median streamflow and 6 months with a reduction ranging from a decrease of 13% to a 16%

increase. Similarly, at the Richmond location the months with increases and decreases area about even ranging from an 11% decrease to a 15% increase. Only the Hempstead and Richmond locations show a noticeable reduction on the frequency plots for larger flows that occur about 40% of the time.

Overall the cumulative effects of the implemented plan will have a slight to modest effect on streamflows in the Brazos Basin with both increases and decreases. Locations below new reservoirs or reservoirs with augmented supplies will generally experience reduced streamflows; although generally not to a significant level, and the detrimental effects of these reductions can be minimized with proper consideration of reservoir pass-through requirements to maintain flows necessary to meet the needs of the environment. Locations lower in the basin will often experience greater streamflows in the lower portion of the streamflow regime, as the BRA System Operations releases water during dry times to downstream diversion points. None of the locations will experience significantly different streamflows with implementation of the recommended water management strategies in the 2011 Plan.

Also included in Figures 7-2 through 7-10 are flows as obtained from the version of the Brazos WAM maintained by the TCEQ known as Run 8. Run 8 attempts to duplicate flows under "current" conditions of use for individual water rights, return flows, and year 2010 reservoir sedimentation conditions. Differences between Run 8 and the implementation flows are not due solely to the water management strategies recommended in the plan, but also due to full utilization of existing water rights, differences in assumed return flows, reservoir sedimentation conditions, and locations of BRA diversions. The Run 8 information is provided as a snapshot of the current utilization of supplies in the Brazos basin and allows for comparison with the base and plan scenarios.

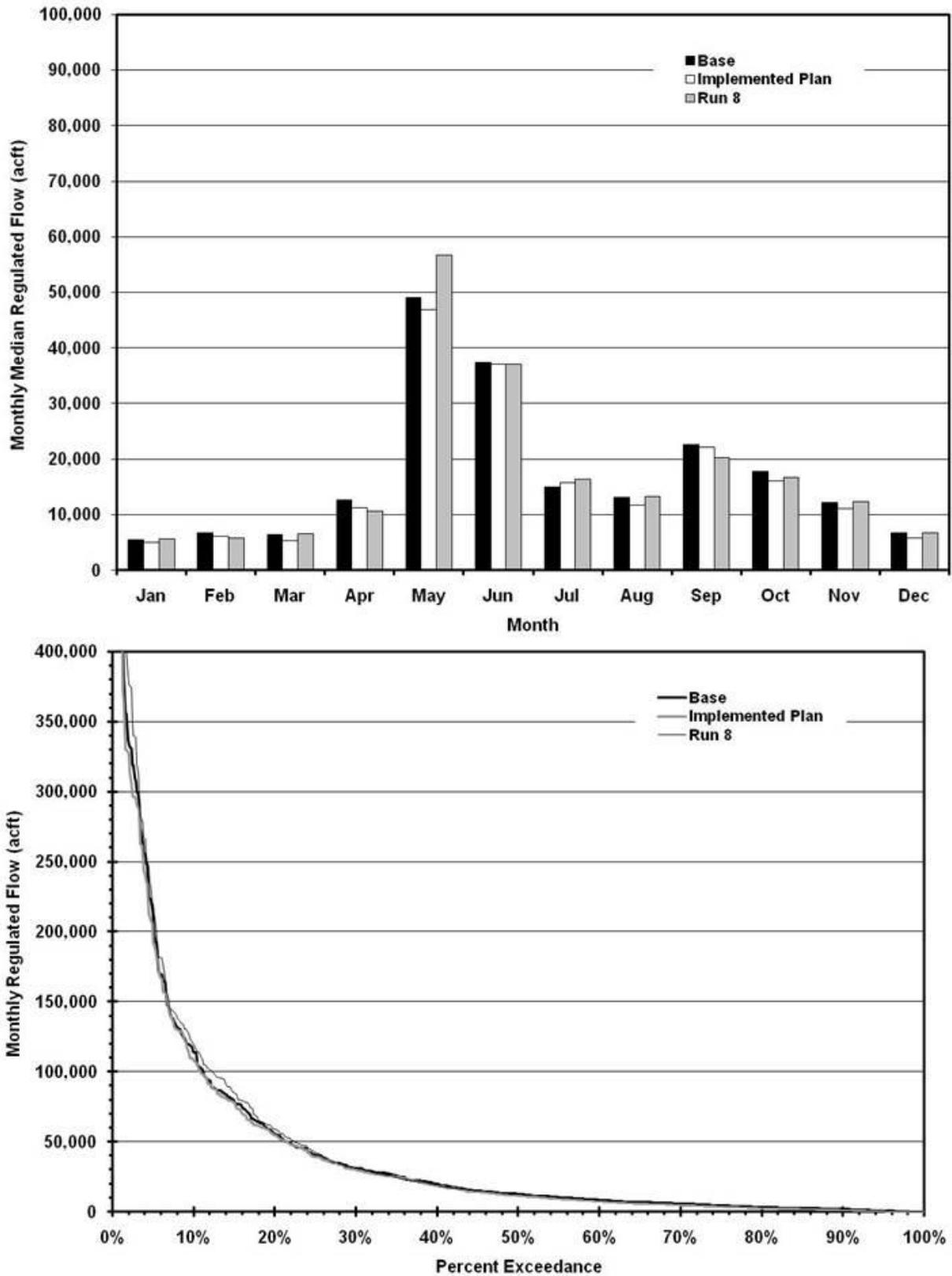


Figure 7-2. Brazos River at South Bend

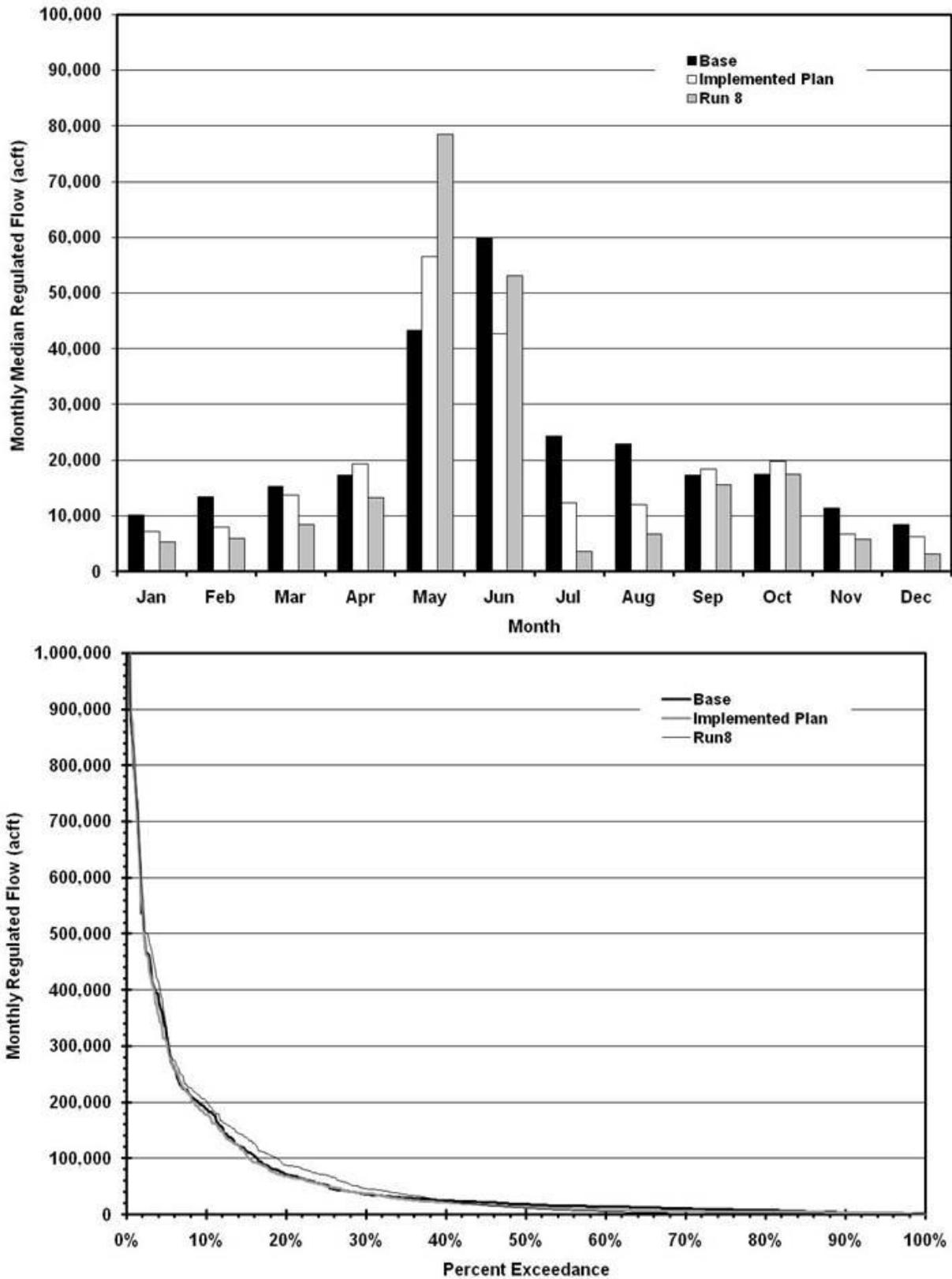


Figure 7-3. Brazos River near Glen Rose

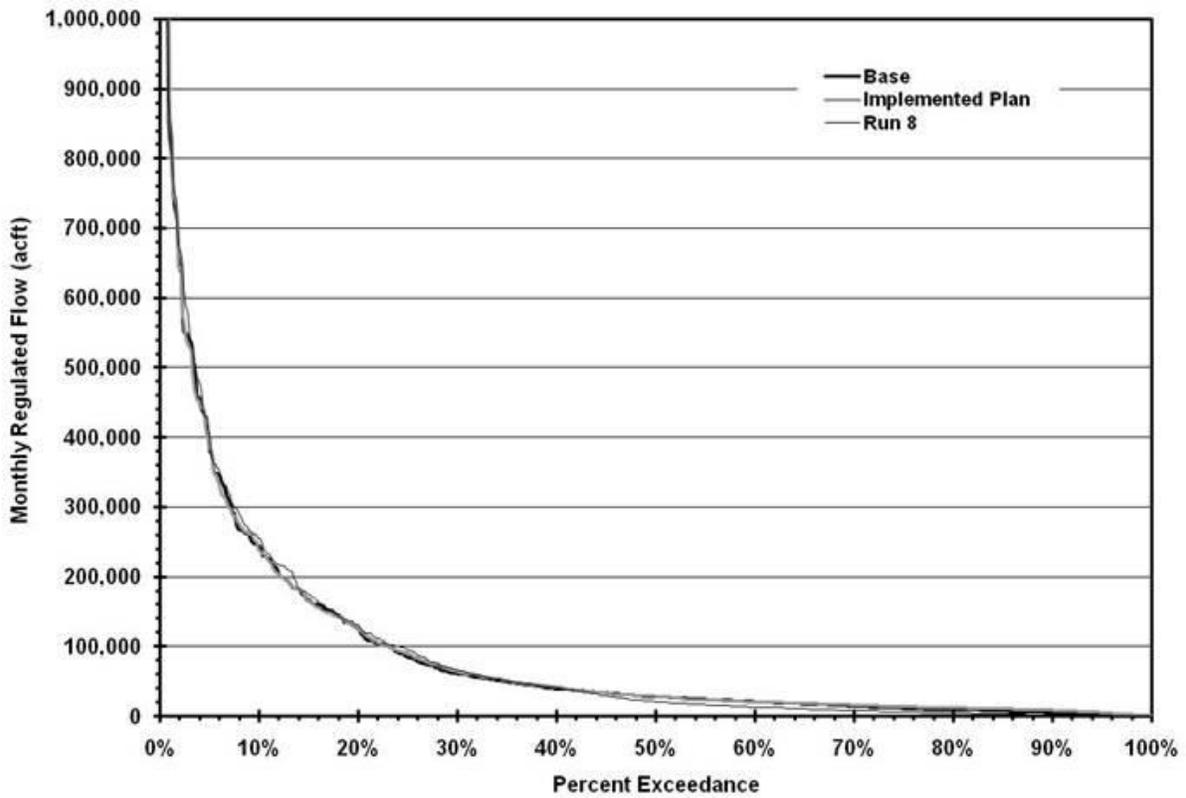
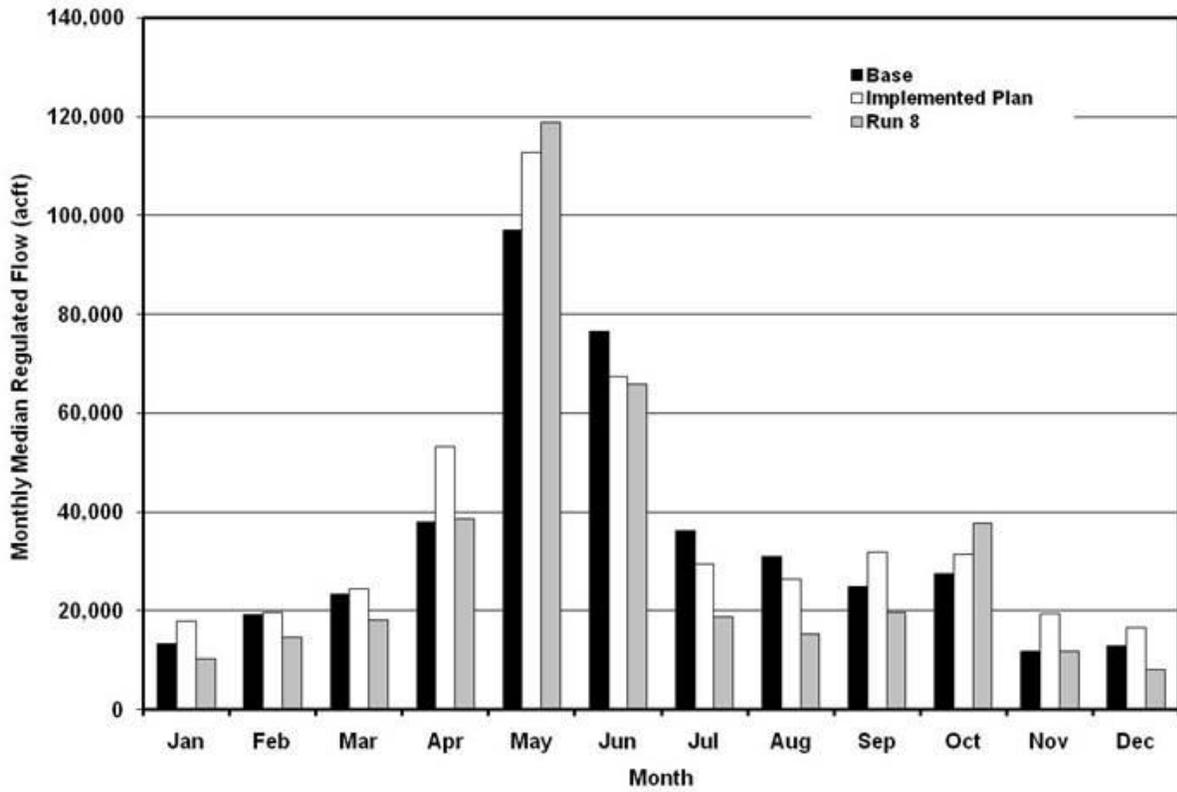


Figure 7-4. Brazos River near Aquilla

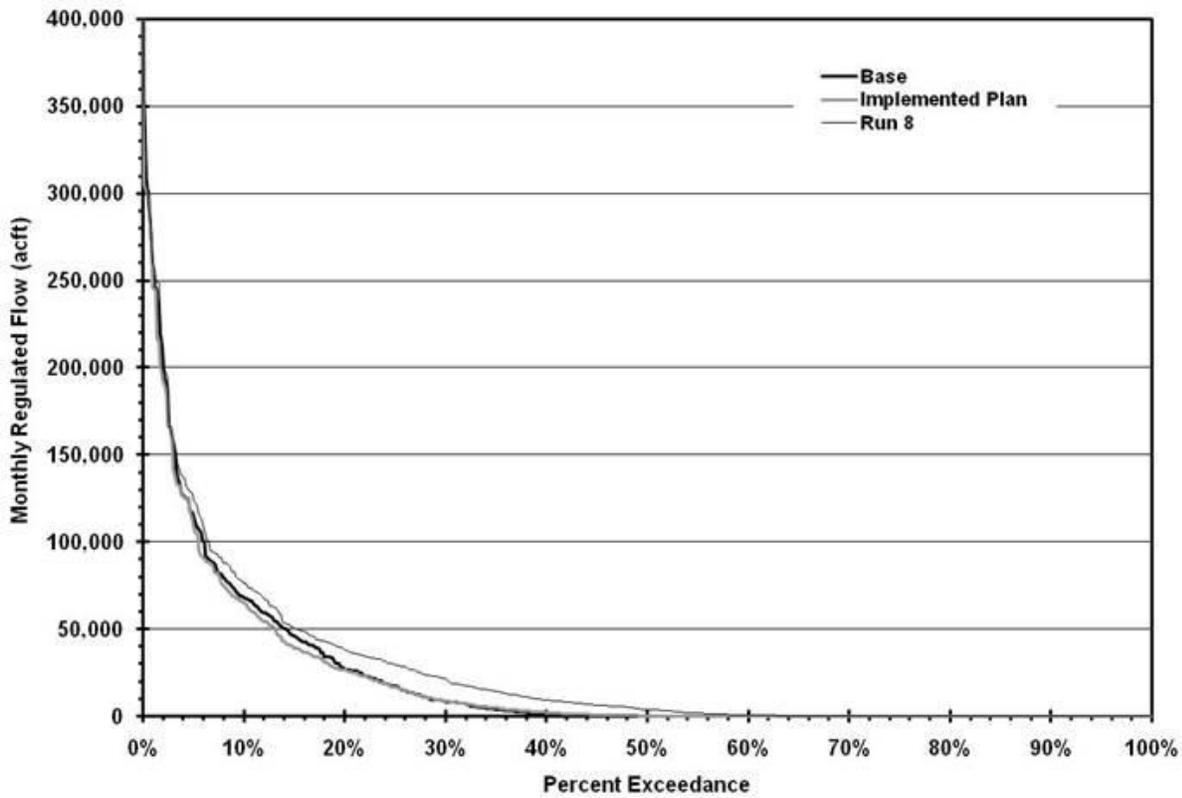
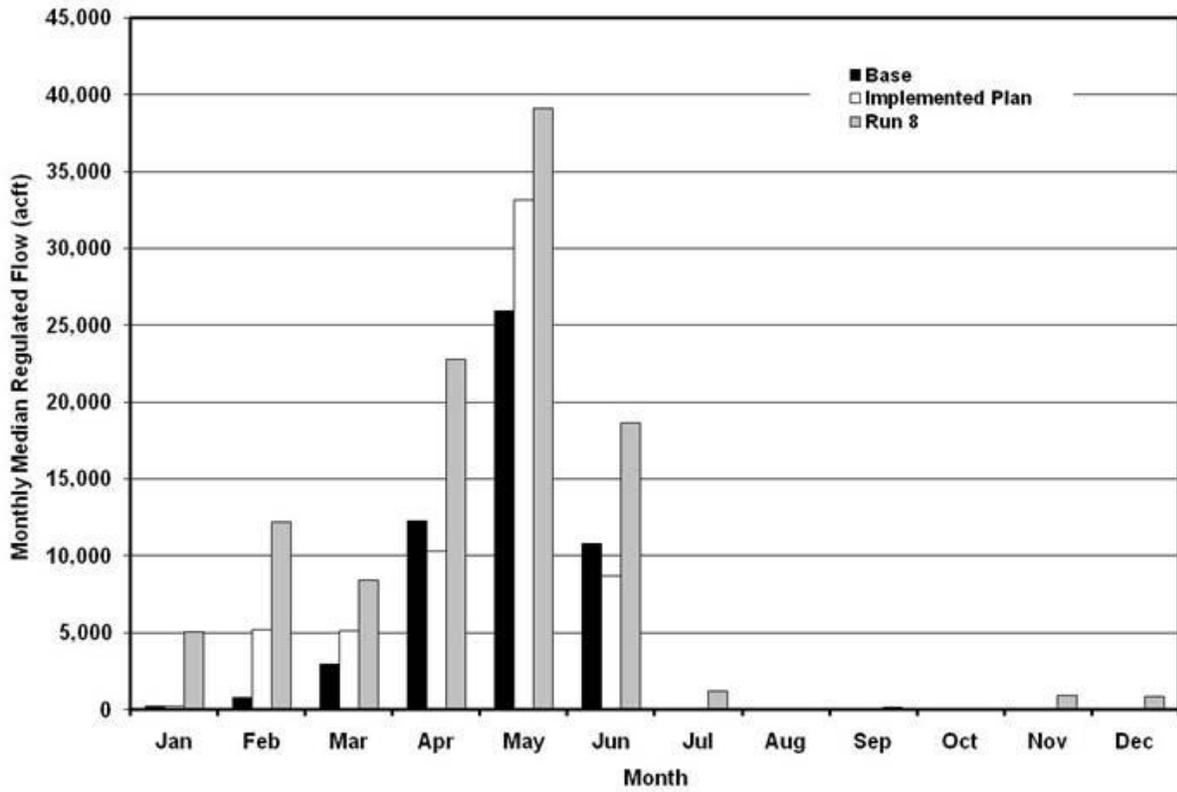


Figure 7-5. Bosque River near Waco

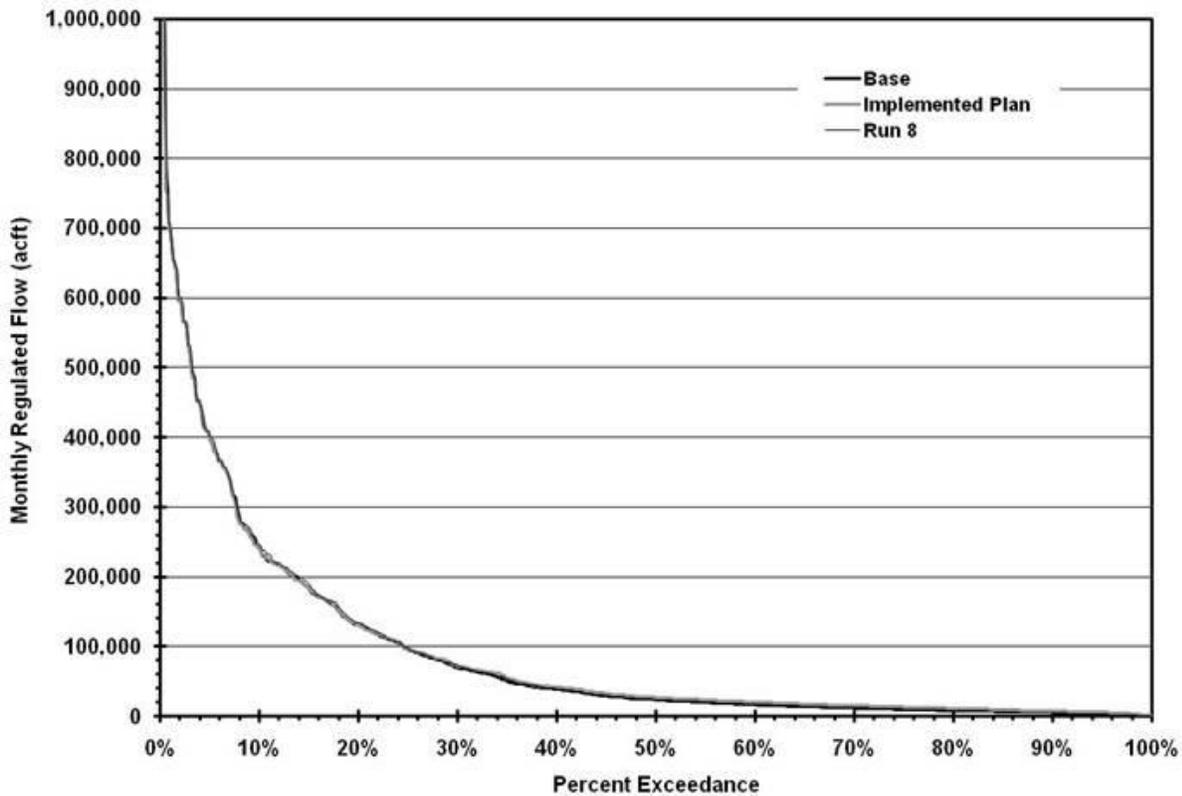
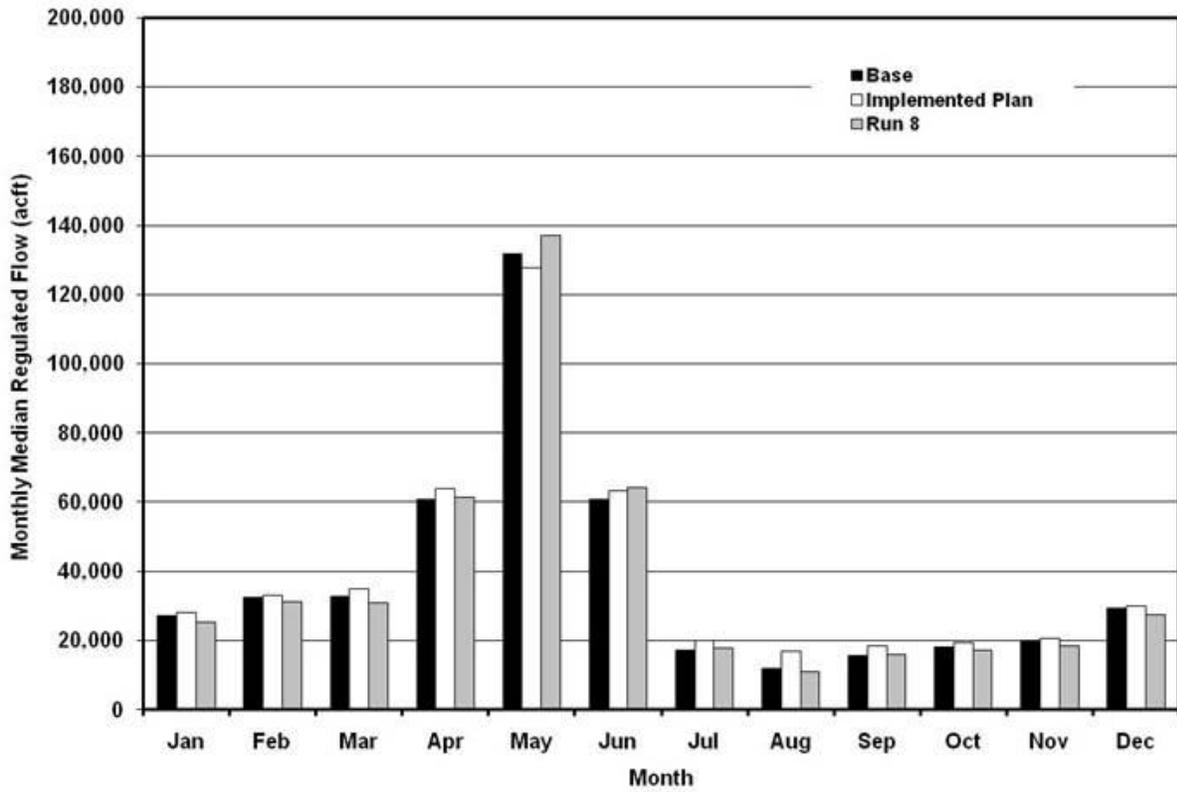


Figure 7-6. Little River near Cameron

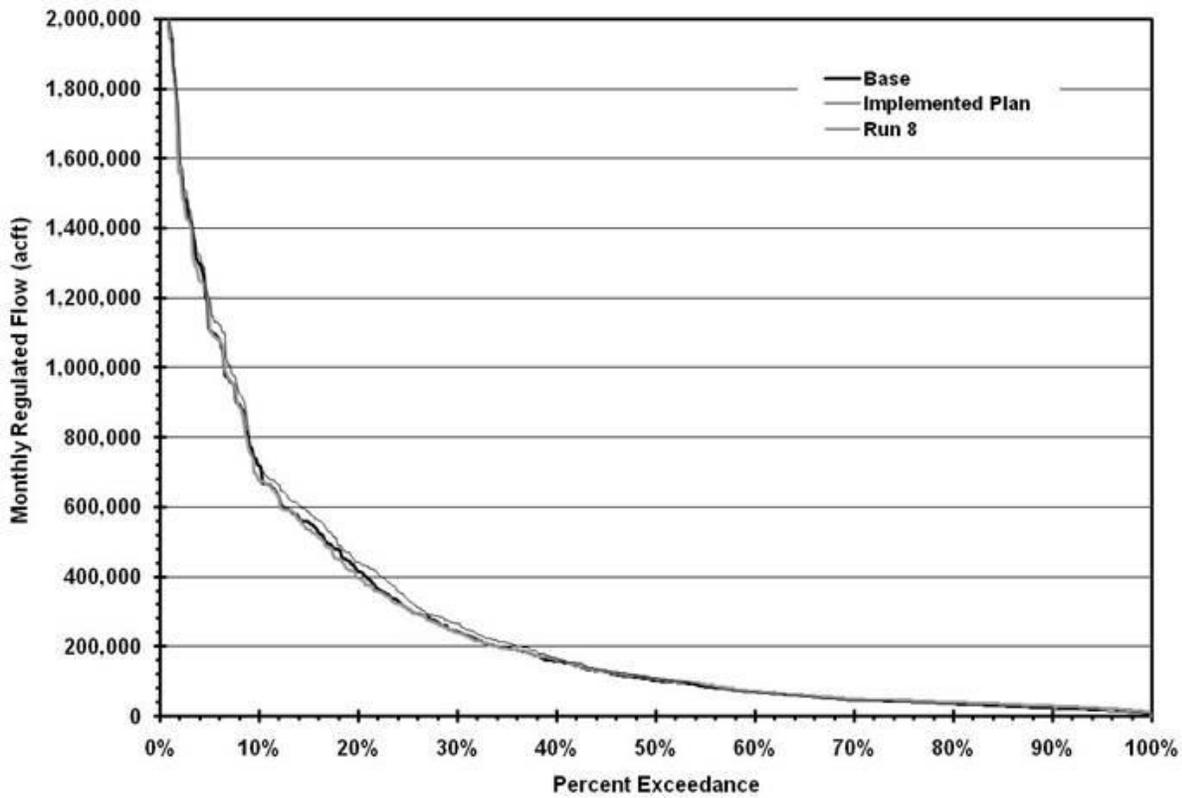
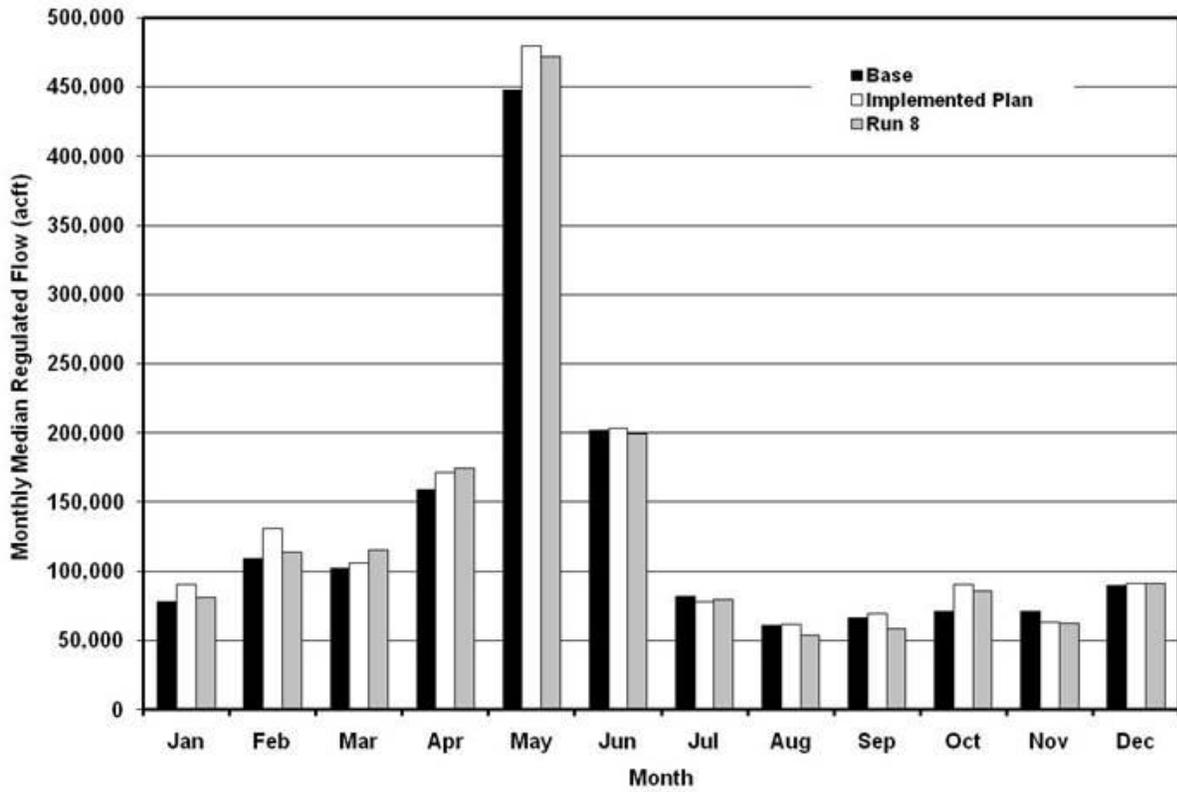


Figure 7-7. Brazos River near Bryan

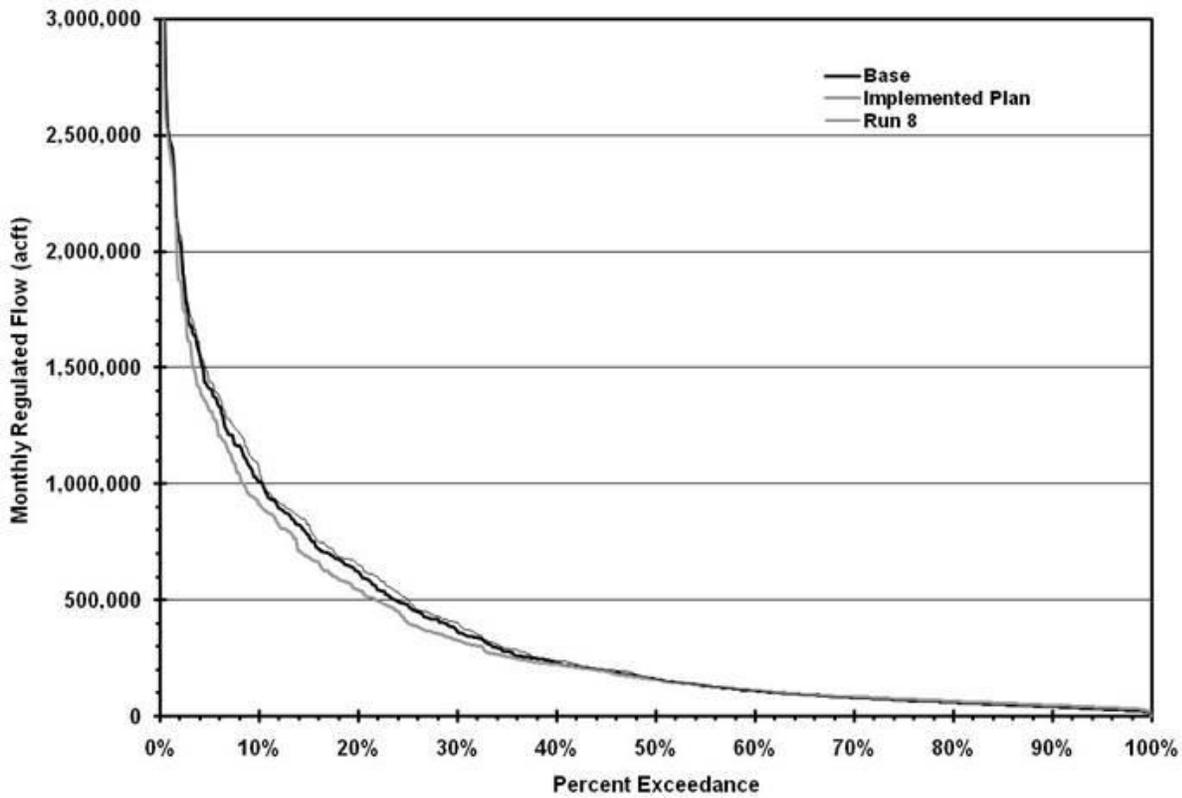
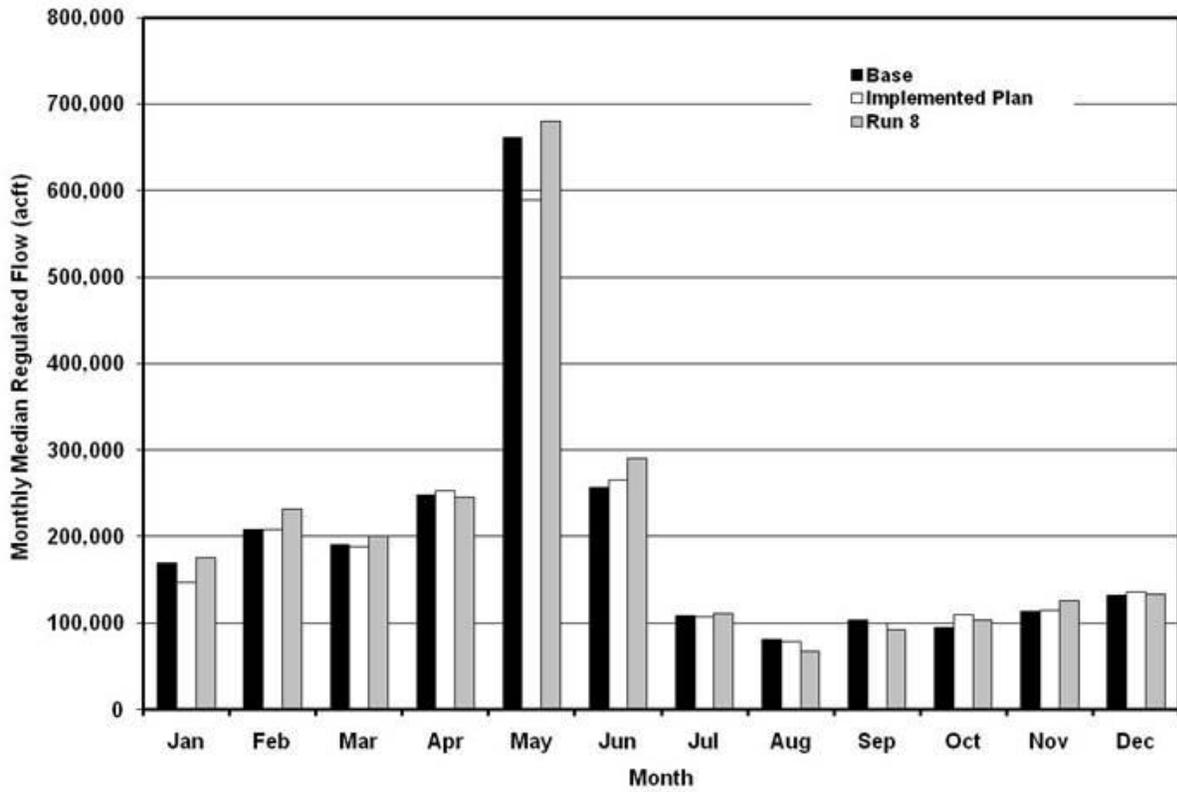


Figure 7-8. Brazos River near Hempstead

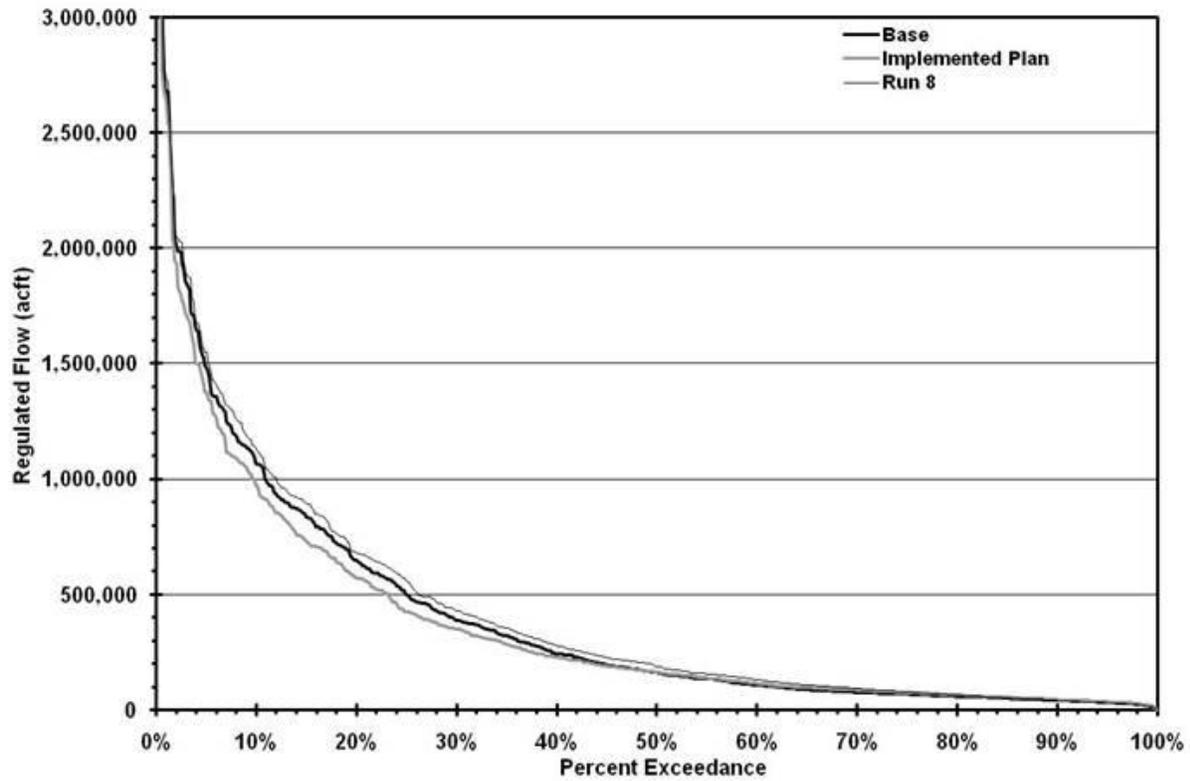
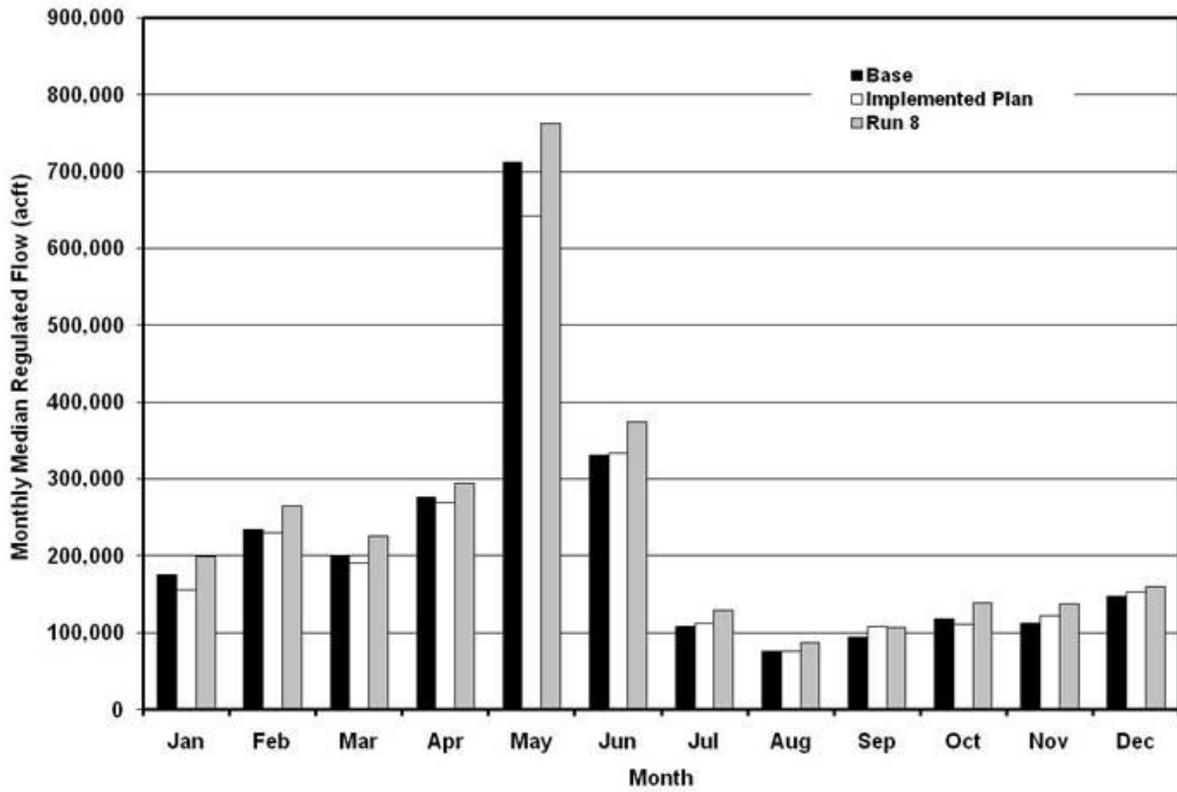
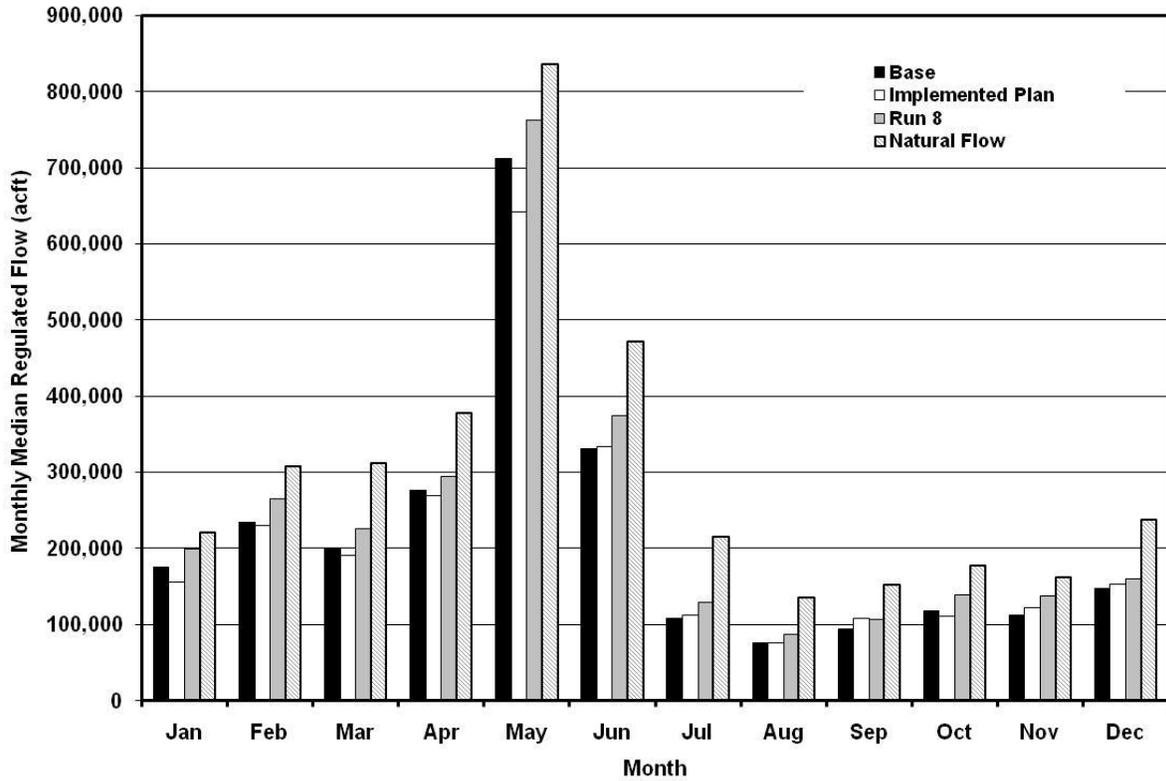


Figure 7-9. Brazos River at Richmond



**Figure 7-10. Brazos River at Richmond – Comparison of Regulated and Natural Flows**

**7.1.2 Groundwater**

The development of groundwater as a water management strategy has the total production increasing from slightly less than 20,000 acft/yr in 2010 to slightly less than 70,000 acft/yr in 2060. The greatest increase occurs in the Carrizo-Wilcox where groundwater pumpage would increase from about 9,000 acft/yr in 2010 to about 50,300 acft/yr in 2060. In the Trinity Aquifer, the increase ranges from about 9,400 acft/yr in 2010 to about 9,700 in 2060. Overall, the amount of groundwater identified for water management strategies is rather modest in comparison to the amount from all the other water management strategies. However, the development of groundwater is likely to be concentrated in a few areas, which could experience noticeable declines in groundwater levels. None of the strategies increase projected groundwater pumpage beyond the estimated groundwater availability from any single aquifer in any county; thus, projected groundwater level declines are expected to be within a range that the Brazos G RWPG considers manageable.

## **7.2 Summary of the Environmental Effects of the Plan**

Overall, the strategies recommended in the 2011 Plan will have limited negative effects on the environment. The largest localized impacts will be from new reservoirs. New reservoirs recommended as strategies in the 2011 Plan (Cedar Ridge Reservoir, Turkey Peak Reservoir, Millers Creek Diversion and new Dam, Coryell County Off-Channel Reservoir, City of Groesbeck Off-Channel, Millican Reservoir (Panther Creek Site), and Brushy Creek Reservoir) will inundate more than 84,000 acres (71,000 from the Millican Reservoir Panther Creek site project alone), reducing wildlife habitat, bottomland hardwood forestland and cultivated farmland as documented in the individual strategy evaluations (Volume II, Sections 4B.12 and 4B.13). However, permitting for these projects will require mitigation land of at least equal ecological value, reducing the negative environmental consequences of the projects. Streamflows immediately downstream from these projects will decrease, but permit requirements will also specify reservoir pass-through flows necessary to maintain ecological health in the downstream receiving stream.

Many elements of the 2011 Plan augment existing resources and delay or eliminate the need for new constructed projects. For example, the BRA's proposed System Operations will make better use of existing reservoir facilities and make available additional supply that previously would have only been made available through construction of a major water supply project. Utilization of water from the Colorado River Basin's Highland Lakes System in Williamson County eliminates the need for a new major water supply project to serve Williamson County needs. The utilization of reuse water by several WUGs and WWPs will extend supplies and could delay the need for new raw water projects. Municipal conservation targets in the plan could increase supplies by roughly 19,000 acft/yr, with conservation overall accounting almost 40,000 acft/yr of new supply. Augmentation of Lake Granger through conjunctive use of groundwater reduces sole dependence on either supply, and maximizes the use of the existing reservoir facility.

Overall the strategies recommended in the 2011 Plan maximize use of existing resources and reduce the need for several large, costly reservoir projects, minimizing impacts to the environment.