Probabilistic Water Budget for the Middle Rio Grande

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A water budget is similar in concept to a financial budget: water inflow (supply) equates with income; water use (demand) equates with expenditures; and water stored equates with savings. The *Middle Rio Grande Water Supply Study* (MRGWSS) (S.S. Papadopulos & Associates, August 2000) developed a quantitative and probabilistic description of the water budget for the Middle Rio Grande region. From this evaluation, and using the financial analogy, a profile of the Middle Rio Grande water budget emerges:

"Financial" Profile of Mr. And Mrs. MRG Basin

Occupation:	Day Traders
Income:	Substantial, but highly variable
Savings:	A modest amount
Other income:	Small annuity (gift from uncle)
Available credit:	Excellent – 100 year loan, escalating payments
Spending Habits:	Growing
Debt:	Growing
Recommendations:	*See a counselor!*

Favorable conditions throughout much of the 1990s allowed *Mr. and Mrs. MRG Basin* to live reasonably well. A strong market (above-average water supply), annuity proceeds (San Juan-Chama water), and delayed impacts of borrowed resources (groundwater) supported their spending habits (expanding M&I use, agricultural and riparian uses); while, obligations (the Rio Grande Compact) were met. One year, 1996, brought less favorable conditions, with dry reaches occurring in the Rio Grande – a reminder that wet periods don't persist. More recently, in 2000, Mr. and Mrs. MRG Basin tapped savings in upstream reservoirs to supply water for the silvery minnow. Ultimately, water management is a budgeting question – in leaner times, hard choices will be required.

The water supply of the Middle Rio Grande is characterized by **variability** and **limitation**. **Variability** is exhibited in the historic record of inflow, including the Rio Grande mainstem inflow at the Otowi gage and tributary inflows below Otowi. The mean inflow at the Otowi gage in the past 50 years is on the order of 1.0 million acre-feet per year; but values throughout the range of 0.5 to 1.5 million acre-feet per year are not uncommon. **Limitation** on the water supply is a function of physical and legal constrains. Physically, inflow is limited by climatic conditions. Legal limitations include the Rio Grande Compact obligation to deliver a portion of inflow to users below Elephant Butte and New Mexico statutes governing water rights.

The Middle Rio Grande region's share of the water inflow at the Otowi gage is illustrated on Figure 1. This quantity, shown for the time period 1950-1998, is derived by subtracting the Rio Grande Compact obligation from the total gage inflow for each year. The portion of this net inflow comprised of San Juan-Chama Project water is also shown. This figure depicts the variability in the Middle Rio Grande region's share of inflow, with annual values typically ranging between about 200,000 and 500,000 acre- feet per year.

The supply of surface water available to the Middle Rio Grande region includes the portion of Otowi inflow shown on Figure 1 *and* tributary inflow from the Santa Fe River, Galisteo Creek, the Jemez River, the Rio Puerco, the Rio Salado, numerous ungaged tributaries and urban stormwater run-off. These tributary inflows are estimated to average about 130,000 acre-feet per year. However, tributary inflow exhibits a high degree of variability, as is illustrated on Figure 2 for one of the tributaries, the Rio Puerco.

As part of the MRGWSS, a probabilistic analysis of the Middle Rio Grande water supply was performed. This analysis provided a means of describing the combined variability of multiple inflow sources to the water supply. Figure 3 illustrates the probability distribution for the Middle Rio Grande region's share of the surface water supply. This figure shows the probability, or chance, that the surface water supply will fall into a particular range in any given year. (Inflows from or outflows to groundwater are not reflected in this illustration.)

Figure 4 provides a pie chart indicating the relative magnitude of various water use categories in the Middle Rio Grande region drawing from surface or groundwater. The values shown here represent mean, or average, values. Variability occurs in the water use terms, particularly in the value for reservoir evaporation. As shown, crop and riparian evapotranspiration are each of similar magnitude; together, they represent approximately two thirds of the water use in the basin. Reservoir evaporation (primarily, from Elephant Butte Reservoir) represents another significant component of the water budget for the Middle Rio Grande region. This evaporation is considered part of the water budget for the Middle Rio Grande because it is consumed geographically upstream from the delivery point under the Rio Grande Compact. The percentage shown for urban use includes groundwater – the impact of this use on surface water flow is delayed due to the distance of wells from the river. Ultimately, the effect of pumping groundwater is diminished flow at the river.

The mean annual water budget of the Middle Rio Grande region is depicted on Figure 5. This figure shows the mean available water supply at various points along the river system, after subtracting the Compact obligation and the depletions resulting from water use. This budget is based on the probabilistic analysis conducted for the MRGWSS and includes groundwater exchanges. A risk analysis model was used to incorporate the variation in flow and identified dependency relationships among inflow or depletion terms. Given present uses, the available supply, including trans-mountain diversions and wastewater return flow, on average, is virtually consumed within the Middle Rio Grande region.

The variability in the water budget is reflected in Figure 6. This figure illustrates the probability that the credit/debit under the Rio Grande Compact will fall within various ranges. Given the present water use conditions and the climatic variability represented in the past 50 year period, debits are expected to occur nearly as often as credits. A projection of present water use conditions into the future, when impacts of existing groundwater pumping are increasingly felt on the river, results in a shift of this balance towards greater likelihood of debit conditions.

In summary, the water budget indicates that the water supply is barely adequate to meet present demands in the Middle Rio Grande region. Under conditions of increased water use in any sector, a reduction of water use from other sectors will be required to maintain balance in the water budget. Planners are challenged to address increasing water demands with a highly variable and limited supply.

References

S.S. Papadopulos & Associates, Inc., 2000. Middle Rio Grande Water Supply. Prepared for the U.S. Army Corps of Engineers and New Mexico Interstate Stream Commission.

Figures

Figure 1. New Mexico's Share of Water Supply at Otowi Gage, 1950-1998

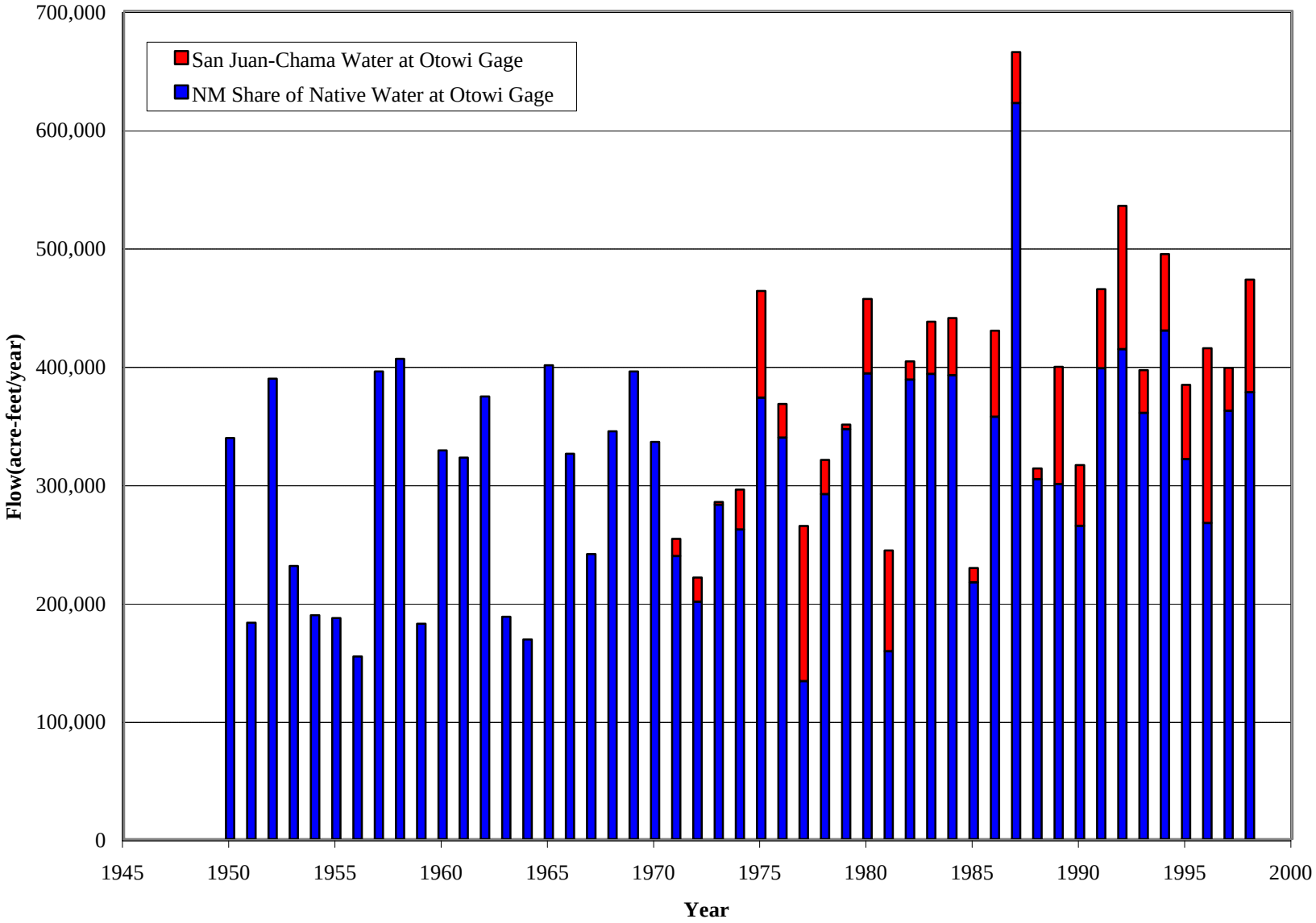
Figure 2. Rio Puerco Tributary Inflow, 1950-1998

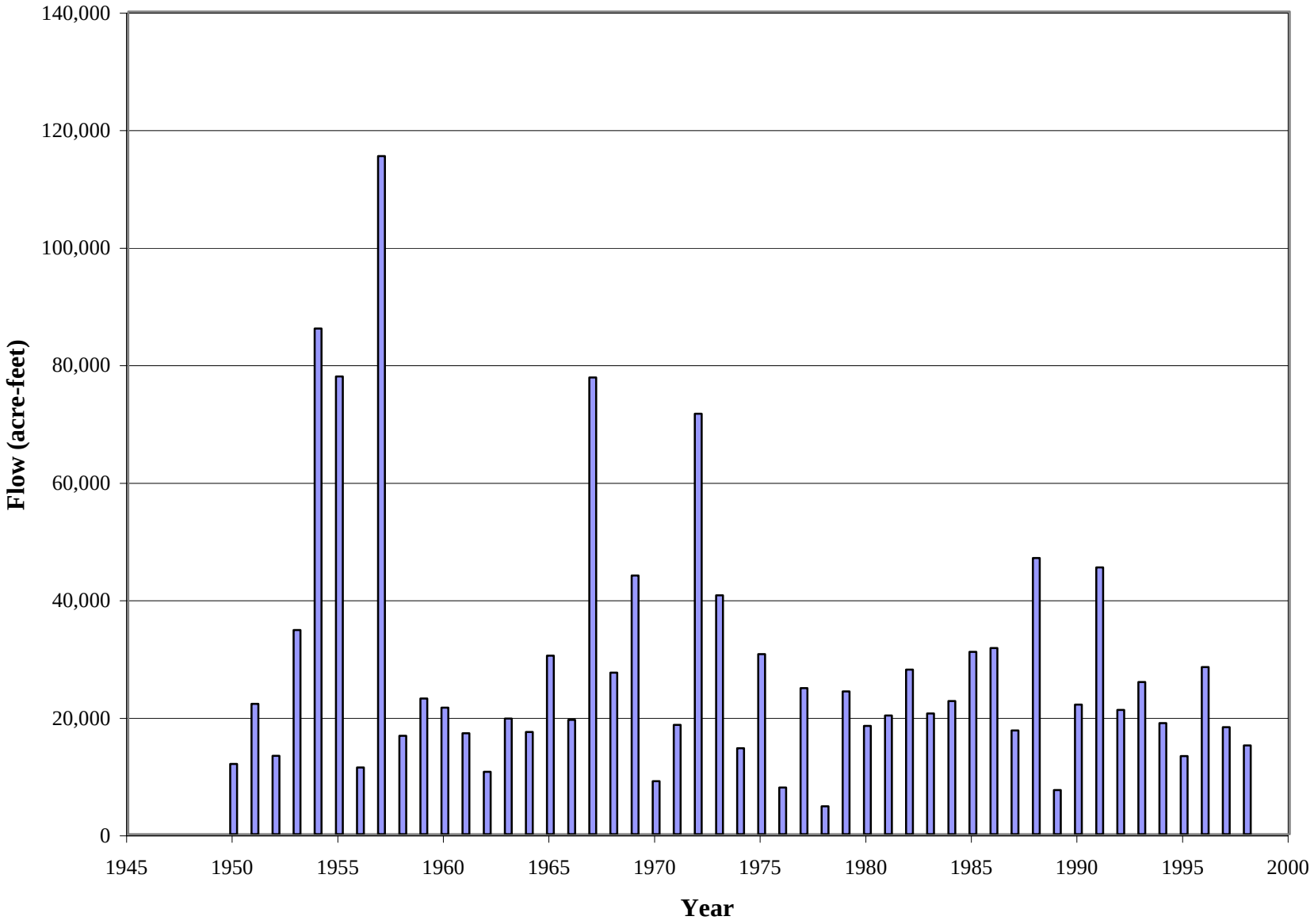
Figure 3. The Middle Rio Grande Share of Surface Water Supply: Probability Distribution

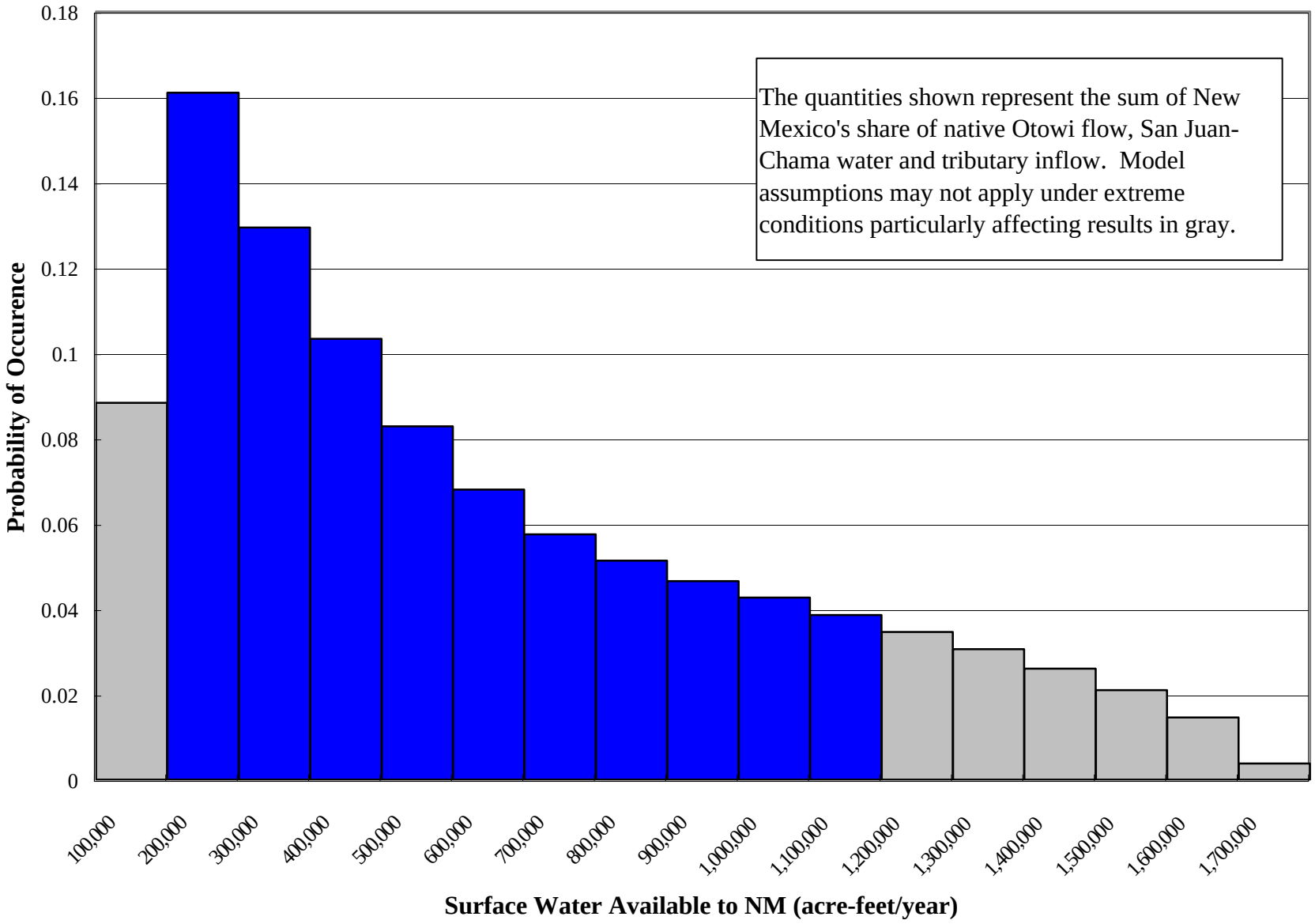
Figure 4. Summary of Mean Depletions

Figure 5. Mean Annual Middle Rio Grande Water Supply Under Present Conditions, Excluding Elephant Butte Scheduled Delivery (in thousands of acre–feet)

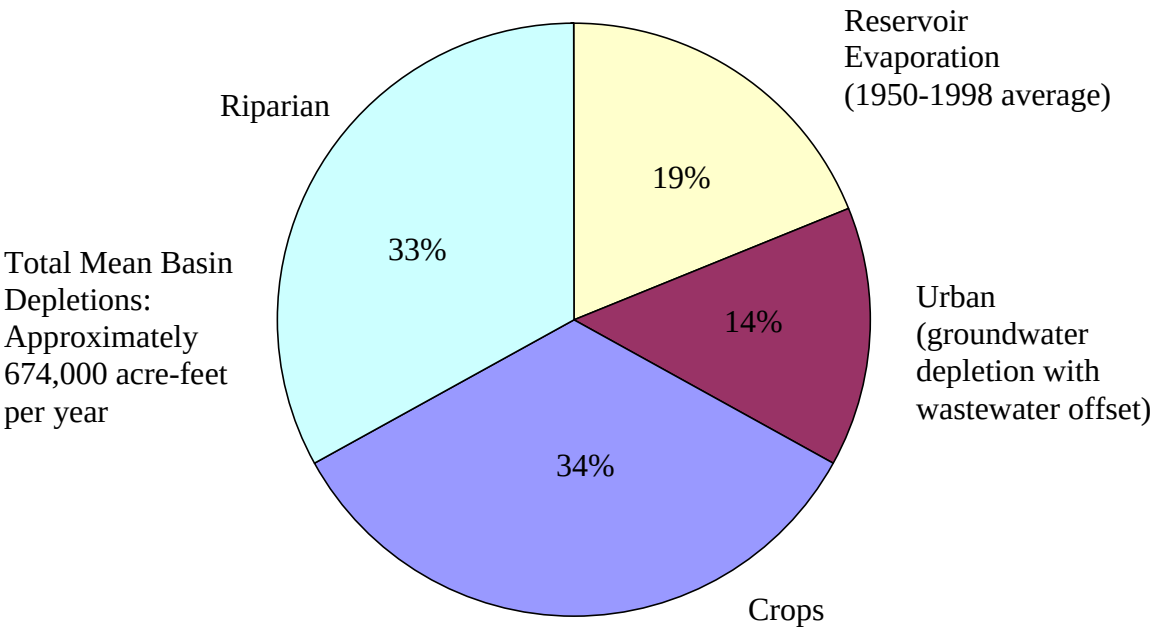
Figure 6. Rio Grande Compact Credit-Debit Probability Distribution, Present Development Condition, Year 2000

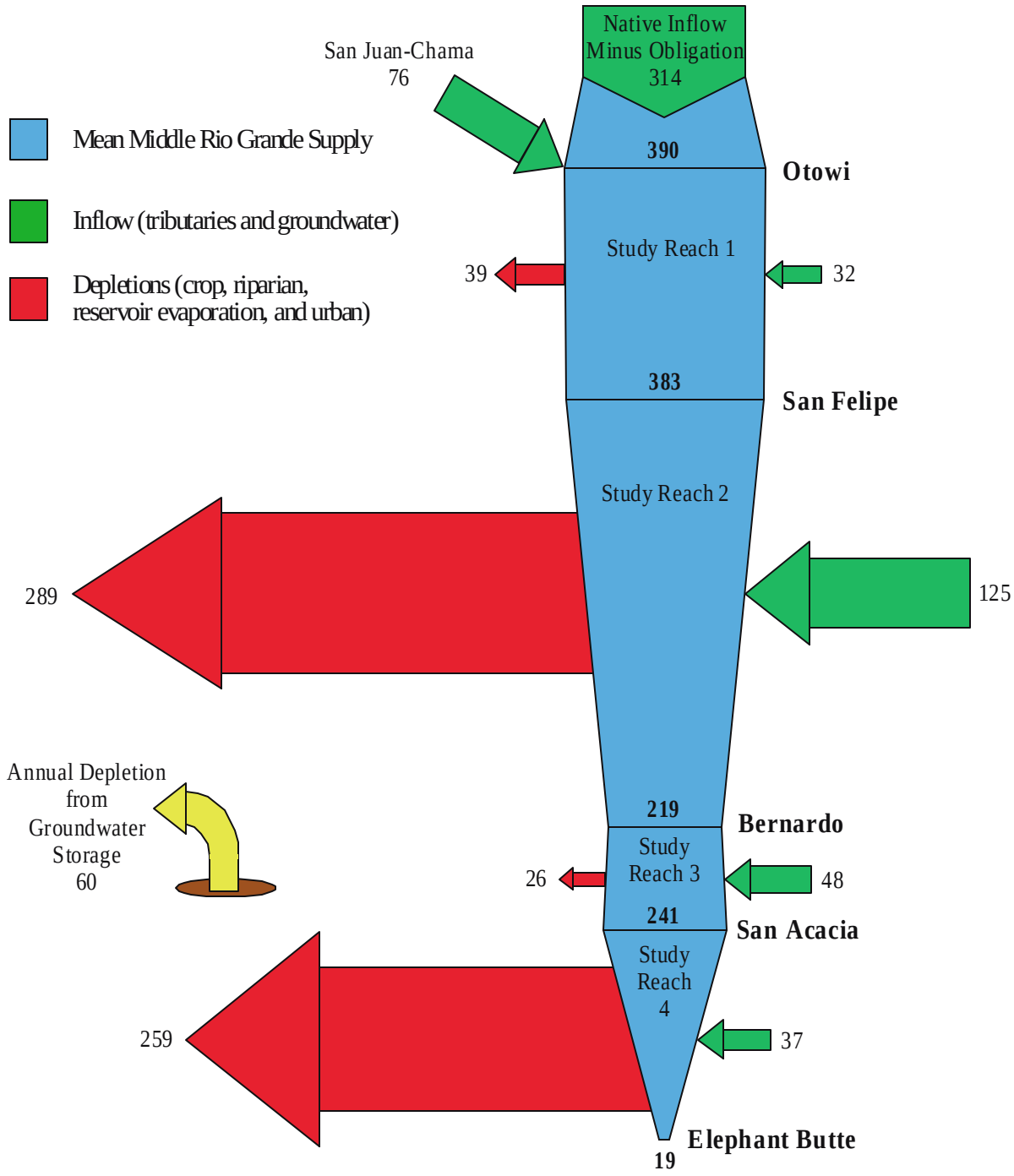

San Juan-Chama Water at Otowi Gage
NM Share of Native Water at Otowi Gage
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Flow(acre-feet/year)
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year


140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Flow (acre-feet)
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year


0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Probability of Occurence
The quantities shown represent the sum of New Mexico's share of native Otowi flow, San Juan-Chama water and tributary inflow. Model assumptions may not apply under extreme conditions particularly affecting results in gray.
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
900,000
1,000,000
1,100,000
1,200,000
1,300,000
1,400,000
1,500,000
1,600,000
1,700,000
Surface Water Available to NM (acre-feet/year)

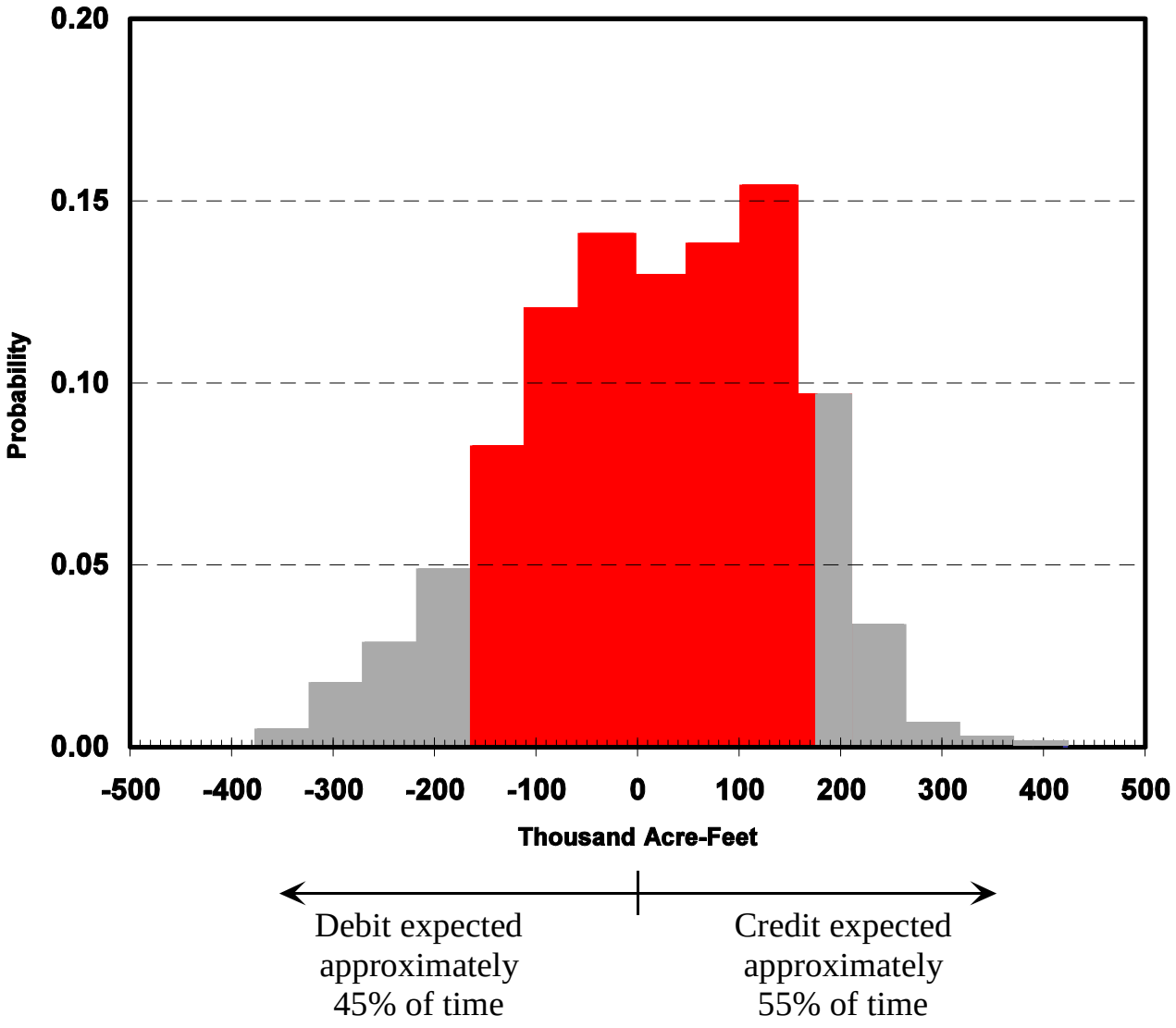
Mean total Middle Rio Grande depletions (including depletion from groundwater storage), under present land use and groundwater development conditions





Assumptions:

- Present development conditions for groundwater pumping, irrigation, and riparian uses
- Inflows based on mean value of risk model output, sampling from probability functions incorporating climatic variability, 1950-1998
- Rio Grande native inflow and reach flows represent simulated flows minus mean Compact obligation derived from risk model output



Some model assumptions may not apply under extreme conditions, particularly affecting results in gray area