
Appendix H

Socorro-Sierra Planning Region Supporting Documents

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Socorro-Sierra Planning Region
Supporting Documents

Document 1: Technical Memorandum, Proposed Planning Alternatives – Preliminary Analysis of Hydrologic Impacts, 9/23/2002

Document 2: Technical Memorandum, Selected Planning Alternatives – Analysis of Hydrologic Impacts, 3/7/2003



Memorandum

Date: September 23, 2002
From: Karen Lewis, Debbie Hathaway
To: Socorro-Sierra Regional Water Planning Group
Subject: **Proposed Planning Alternatives – Preliminary Analysis of Hydrologic Impacts**

Background

The Socorro-Sierra Regional Water Planning group has developed an initial list of water planning alternatives (“long list”). By letter of June 8, 2002, the Socorro Soil & Water Conservation District requested that the ISC authorize SSP&A to provide preliminary review comments regarding many of the alternatives on this “long list”. By letter of July 8, 2002, the ISC authorized SSP&A to provide a general review and discussion of the noted alternatives (as part of work for the Middle Rio Grande Water Supply Study, Phase 3). Following subsequent screening of the alternatives by the Socorro-Sierra Planning Region, SSP&A will provide more detailed and specific analyses of alternatives on a “short list”. SSP&A has been requested to focus general comments at this stage of evaluation on the amount of water that can be gained or saved, and the overall hydrologic impacts of the “long-list” alternatives. The comments provided herein are provided at a reconnaissance level, and are not intended to be exhaustive or quantitative.

The list of alternatives submitted to SSP&A for preliminary hydrologic evaluation is provided below. Following the list is a discussion of the likely hydrologic impacts of each item on the list. Finally, the Socorro-Sierra Planning Region has asked for a qualitative ranking of water gained or demand reduced for consideration in development of a scoring matrix. This ranking, based on reconnaissance-level review, also is provided in this memo.

Socorro-Sierra Long-List Alternatives Identified for SSP&A Preliminary Review

1. Increase or preserve water supply
 - a. Reclamation, treatment, and use of saline water.
 - b. Wastewater treatment and reuse
 - c. Commercial and residential on-site water recycling
 - d. Storage of reservoir water at higher altitudes/latitudes
 - e. Evaporation control through reduced water surface areas in engineered and natural areas
 - f. Aquifer storage and recovery
 - h. Restriction of groundwater supply wells in sensitive areas

3. Reduce urban and agricultural water demand
 - e. Improve efficiency of surface water conveyance systems to agricultural land
 - Implement conveyance alternatives (e.g. concrete-lined ditches, pipelines)
 - Improve irrigation scheduling



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- Meter and manage surface water diversions and returns
 - f. Develop and implement alternative irrigation methods on croplands (e.g. drip)
 - g. Use precision agriculture techniques such as soil moisture monitoring and weather forecasting
 - h. Reduce agricultural consumptive use; test, develop and promote use of low (or lower) water use crops, implement protective agriculture where practicable
 - i. Improve on-farm irrigation efficiency
4. Improve water-use efficiency and management
- b. Control brush and weeds along water distribution system and drains
 - d. Remove exotic vegetation on a wide-scale
 - e. Restore bosque habitat and manage vegetation to reduce evapotranspiration
 - g. Delay start-up of irrigation system
 - h. Control competitive brush species
7. Implement legal, institutional, and economic improvements to water use and management
- a. Develop local markets for higher value, low-water use alternative crops (3h)
 - b. Assess the hydrologic reality of water transfers, both within and outside of the region
 - c. Develop a viable water banking system to facilitate transfer of water within the planning region
 - i. Preserve, but continue to draw, deep well water for drinking purposes only
 - j. Restrict domestic well use

Discussion of Hydrologic Impacts

The hydrologic impacts of these proposed alternatives are reviewed at a reconnaissance level. The goal of this review is to briefly describe each alternative in terms of its impact on the amount of water needed at the diversion point and on the amount of water consumed. Table 3 provides a score for each alternative, focusing on the opportunity to save (or gain) water both from a diversion and a consumptive perspective. While changes in diversions without commensurate consumptive changes typically don't impact the basin supply (or ability to meet Compact obligations), there may be benefits to modifying diversions at a regional or local level, particularly when considering cost and environmental issues. Where possible, comments are also offered on technical, economic and political feasibility.

This memo is intended to provide regional planners with a view of the relative hydrologic costs and benefits of each alternative, and to aid planners in further refining their chosen alternatives to maximize the efficiency and success of the water planning process in the region.

1 a) Reclamation, treatment, and use of saline water

Desalination is a fairly new technology, with only a few plants on-line, but is rapidly growing. Prices at desalination plants around the world currently range from \$1,220 to \$2,900 per acre-foot per year (\$3.75 to \$9.00 per 1,000 gallons). However, new plants proposed for Tampa Bay, FL (http://www.tampabaywater.org/MWP/MWP_Projects/Desal/Desal.htm) and



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Los Angeles, CA anticipate pricing on the order of \$760 per acre-foot per year (\$2.08 per 1,000 gallons).

In the Rio Grande region, Sandia National Laboratory and the US Bureau of Reclamation are working toward a research desalination plant in the Tularosa Basin (<http://wrri.nmsu.edu/tbndrc/tbndrc.html>). They are currently preparing a feasibility study and forecast having a plant initially on line in 2004 and at full operation in 2005. There is also proposal in progress for a private desalination plant using water from the Estancia Basin. Following the progress and results of these projects will allow Socorro-Sierra to assess the viability of desalination in their region.

New Mexico has large reserves of brackish water and is therefore a likely candidate for desalination should it become economically competitive and be ecologically sound. The potential for application of desalination technology within the Socorro-Sierra region is significant – there are large saline groundwater reservoirs that could be tapped. Saline groundwater basins that are not connected to the Rio Grande could be pumped with no hydrologic impact on the Rio Grande Compact deliveries. However, an assessment of local effects would still be required, including impacts on any adjacent freshwater aquifers and the potential for ground subsidence. Ecological and financial concerns will include options for disposal of the high concentration brine by-product.

If brackish water from non-tributary basins could be developed, these supplies would augment the supply available for both diversion and for consumptive use. Significant flexibility in controlling the timing of augmented supplies would also be advantageous. From a physical perspective, this option has high potential for improving the water supply to the region. However, the favorable qualitative scores reflected on Table 3 will be tempered by less advantageous cost and feasibility scores.

1 b) Wastewater treatment and reuse

Wastewater reuse will not change consumptive use; it will only change water use efficiency. Wastewater treatment and reuse is primarily of value to communities that are limited in the ability or capacity to divert water for treatment. (e.g. limited groundwater sources, or for downstream users where there is no surface-water flow-through).

Wastewater reuse will reduce return flow. In cases where municipal diversions are from groundwater, and returns accrue to surface water (i.e., City of Socorro), wastewater reuse will reduce river returns and may have a negative impact over the short-term on supply in the river (Compact deliveries). Over the long term, this negative impact would be offset by reduced river depletion, assuming that pumping rates were reduced due to the demand met by reuse. However, if the reused water were used to satisfy new consumptive uses and pumping rates were not reduced, the negative impact on the river would continue.

In the case of groundwater sources, reuse of wastewater will reduce the demands on the aquifer and will result in a savings in pumping. This may be of value if conserving groundwater resources is desired. However, if the aquifer is directly connected to the river and recharges quickly, it may not be worth the cost to treat and reuse wastewater since the linked surface/groundwater system is currently performing a similar role.



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The concept of wastewater reuse (without treatment) is fundamental to the design and present operation of the agricultural conveyance system. Agricultural return flow (both surface and subsurface) is routed to or intercepted by drains that provide part of the supply for downstream diversions. The magnitude of reuse could be increased through engineered modifications to the conveyance and drainage system. Such changes would not reduce net consumptive use but would reduce the diversion demand.

Wastewater treatment and reuse will be of value primarily for specific cases such as areas currently mining groundwater where a reduction in mining is desired, or for areas that need to reduce diversions from the river (for example, for habitat needs or to minimize seasonal shortages).

1 c) Commercial and residential on-site water recycling

See 1b) – water recycling will not reduce consumptive use and will not, therefore, result in water “savings” for the region. However, on-site reuse of gray-water will reduce the volume of wastewater requiring treatment and could result in a cost-savings for local municipalities. It will also allow for reduced river diversions and/or reduced municipal groundwater pumping, similar to option 1b, but will result in reduced wastewater returns to the river. A reduction in diversion via groundwater pumping with a concurrent reduction in wastewater returns to the river would result in a timing discrepancy; over an initial period of time the river would experience a greater impact from reduced wastewater returns than would be offset by reduced groundwater diversions, due to the distance of the wells from the river.

1 d) Storage of reservoir water at higher altitudes/latitudes

Potential savings in consumptive use would occur to the extent that evaporative losses were reduced by the alternate storage location. Presumably, this option is considering the large evaporative losses occurring from the Elephant Butte and Caballo Reservoirs. However, a complex suite of Congressional authorizations, and the Rio Grande Compact, control storage, releases and deliveries associated with these and other reservoirs. These institutional controls are substantial; alteration of these institutional controls is likely beyond the scope of the regional planning process.

1 e) Evaporation control through reduced water surface areas in engineered and natural areas

Reduction of water surface areas, such as a reduction in the wetted area of the Elephant Butte delta and reduction of ponded areas between San Marcial and the reservoir, is important for efficient delivery of water to Elephant Butte Reservoir for meeting obligations under the Rio Grande Compact. Under current conditions, the open water and swamp portions in the delta are significant and result in high evaporative losses.

The open-water area in the Elephant Butte delta is a function of reservoir level and groundwater elevation. The LFCC provides drainage in the region from San Acacia to the delta, and was designed to improve the delivery of diverted river water and intercepted drainage water to the reservoir. The lower part of the LFCC through the delta area is currently not functioning due to siltation and channel breaches; if the LFCC becomes functional again in this area, some reduction in evaporation from marshy areas will occur. However, it is not clear when the



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channel might be rebuilt. Once rebuilt, these changes are best viewed as a return to “status quo” operations established prior to the high water and breached conditions of the 1980s and 1990s, rather than a source of “new” water. Regardless, these maintenance activities are of prime importance in avoiding reduction of the water supply available to the entire Middle Rio Grande. It should be recognized that reduction of open water areas may not achieve the water savings anticipated, if the reclaimed area is colonized by riparian vegetation tapping shallow groundwater. Finally, maintenance of drainage conditions (and reduction of marshy areas) may be considered problematic for Southwest Willow Flycatcher habitat in some areas.

1 f) Aquifer storage and recovery

Aquifer storage and recovery can be a useful water banking approach if there is “extra” water available at predictable times. For the Middle Rio Grande region, the only years in which there is “extra” water is during spill years, which have occurred 5 times since the Rio Grande Compact was signed. It is unclear if aquifer storage is financially viable given this type of return period for flows.

Analysis of the projected cost of an aquifer storage project vs. the probable water available for storage and predicted value of that water is required to assess the economic viability of this option. The total volume of water spilled since 1982 is approximately 1.4 million acre feet, an annual average value of 70,000 acre feet. However, the 1982-2001 period has been particularly wet, having experienced 4 of 6 historic spills, and is therefore biased toward overestimating available water. Based on this very wet 20-year period, the benefit to the entire Middle Rio Grande region (Cochiti to Elephant Butte) is about 70,000 acre-feet per year, assuming all of the spill water could be captured. Given the low frequency and high volume of occurrence, successful capture of the spill water for aquifer storage would be difficult.

1 h) Restriction of groundwater supply wells in sensitive areas (shallow alluvial aquifers)

Restricted pumping from shallow alluvial aquifers will minimize near-term reductions in the surface water supply. If, as a consequence, water were drawn directly from the river, no change to the overall water supply and little change in the timing of river impacts would occur. Alternatively, if water were drawn from more distant wells, the negative impacts of pumping on the river would be shifted into the future. The impact of the restriction depends on how it is paired with compensating actions. One potential compensating action, moving pumping to more distant locations, is discussed below.

Restricting groundwater pumping from shallow alluvial aquifers may be paired with shifting pumping to deeper or more distant aquifer locations, thus delaying impacts to the river (unless wells are restricted from any area hydraulically connected to the river). Implementation of this alternative may result in a short-term increase in supply for diversion, through utilization of groundwater in storage. As the impacts translate to the river (as steady-state conditions are approached) this increase in supply will diminish, as the portion of supply met by river depletion increases. Furthermore, the amount of groundwater depleted from storage will be carried forward as a “debt” to the aquifer – when and if pumping ceases, the depleted storage will slowly be replaced (the debt will be physically repaid) by the river.



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This alternative could help with water supply management by flexibly timing groundwater extraction to optimize the regional supply through climatic cycles. In some periods (i.e., when river/reservoir conditions are abundant) it might be advantageous to tap the shallow alluvial aquifers and incur an immediate effect on the river. When river and reservoir supplies are low, the delay of impacts through use of more distant well fields might be desirable. However, attempts at managing and favorably timing well impacts could be undermined by an unexpectedly long period of drought.

3 e) Improve efficiency of surface water conveyance systems to agricultural land by implementing conveyance alternatives (e.g. concrete-lined ditches, pipelines), improving irrigation scheduling, and metering and managing surface water diversions and returns

Potentially large reductions to the agricultural diversion demand are possible through improvements in irrigation efficiency, though irrigation-related consumptive use reductions will be minimal (only ensuing from reductions in incidental depletions associated with efficiency improvements). In particular, selective lining of canals and rotational delivery operations show promise for achieving efficiency improvement. With significant reductions in diversion demand, water could be retained in upstream storage reservoirs longer and provide timing advantages for irrigation (or ancillary needs/benefits).

3 f) Develop and implement alternative irrigation methods on croplands (e.g. drip)

A well-designed drip irrigation system or subsurface drip irrigation system will lose practically no water to runoff or deep percolation and very little to evaporation. (There will be some evaporative losses, but they should be small. Water delivered by the drip emitters and not used by the crops will move upward due to the lower matrix potential of the drier surface soils and eventually evaporate.) Under this alternative, the consumptive demand would be reduced in an amount nearly equal to the elimination of evaporation from the flooded fields. The diversion demand would be reduced by the total of the reduction in consumptive demand and the reduction in return flow from excess applied water.

If we assume that evaporation from a flood irrigated field is equal to open water evaporation for one day for each flooding event, and evaporation per event is roughly 0.38 inches per day (average daily March 1-Oct 30 open water evaporation for Elephant Butte Reservoir), we can calculate water saved by multiplying by the number of irrigation events in a season (March 1-Oct 30). If we assume irrigation every other week, we have a savings of 0.032 acre-feet per acre for each of 16 events, or 0.51 acre-feet per acre. If this amount were salvaged over 12,000 acres (the approximate reported irrigated acres, not including fallow and idle lands, in 1997-1998 in the Socorro division of the MRGCD -- MRGCD Crop Census Reports, 1997, 1998) the consumptive demand would be decreased by 6,120 acre-feet.

The reduction in diversion demand would equal the reduction in consumptive demand plus conveyance losses plus excess applied water that otherwise would become return flow. If one acre-foot per acre of the farm delivery is assumed to become return flow, a significant portion of this might be eliminated with drip irrigation. However, some water may be needed for soil flushing and this full amount would not likely be available for salvage.



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3 g) Use precision agriculture techniques (soil moisture monitoring and weather forecasting)

Soil moisture monitoring and weather forecasting are already being conducted at a preliminary level throughout the MRGCD through the use of district climate stations and rain gages. If more accurate assessments and forecasts were available, it is possible that a few irrigation events could be eliminated each summer. Elimination of an irrigation event would result in a water savings of roughly 0.032 acre-feet per acre (see 3f). It is unlikely that more than 3 irrigation events could be eliminated in any given summer, for a maximum potential consumptive demand reduction of 1,150 acre-feet. This reduction in consumptive demand would be associated with a reduction in diversion demand of this amount, plus the conveyance losses and return flow associated with the eliminated irrigation events.

3 h) Reduce agricultural consumptive use; test, develop and promote use of low (or lower) water use crops, implement protective agriculture where practicable.

The crop breakdown for the Socorro Division of the MRGCD for 1997 and 1998 is shown in Table 1. The consumptive use of several crops grown in various regions of New Mexico is shown in Table 2. As can be seen in Table 1, the dominant crop in the Socorro division is alfalfa. From Table 2 it can be seen that alfalfa is the highest water user of the listed crop. Consequently, any shift toward low water use alfalfa or toward almost any alternative crop will result in an immediate water savings for the region.

Table 1: MRGCD Socorro Division Irrigated Crop Census, 1997 and 1998

| | 1997 Irr. Acres | 1998 Irr. Acres |
|-------------------|-----------------|-----------------|
| Alfalfa | 7173 | 7544 |
| Chili Peppers | 387 | 377 |
| Corn | 407 | 532 |
| Fallow | 0 | 0 |
| Family Garden | 28 | 12 |
| Fruit Trees | 1 | 1 |
| Grapes | 8 | |
| Grass | 0 | 1 |
| Grass Hay | 0 | 43 |
| Irrigated Pasture | 3010 | 2820 |
| Oats | 454 | 365 |
| Onions | 91 | 35 |
| Pond | 0 | 0 |
| Sudan | 100 | 20 |
| Trees | 0 | 1 |
| Vegetables | 0 | 9 |
| Wheat | 81 | 125 |
| Yard/Lawns | 0 | 1 |
| Total | 11740 | 11886 |



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Specific plans regarding crop conversion and/or low water use crops should be assessed to provide accurate quantitative numbers for potential water savings. Converting from alfalfa to grass hay would save about 0.42 acre-feet per acre of water; converting from alfalfa to corn, sorghum or cotton would save about 0.84 to 1 acre-foot per acre of water. Consequently, conversion of the 7,000 acres of alfalfa current grown in the Socorro division of the MRGCD to alternate crops could save (reduce consumptive demand) on the order of 3,000 to 7,000 acre-feet of water per year. This reduction would translate similarly to a reduction in diversion demand.

Table 2: Computed normal consumptive use of water in inches for selected crops and various irrigated areas in New Mexico. (From Technical Report 32 New Mexico State Engineer Santa Fe, NM. *Consumptive use and water requirements in New Mexico*, Blaney and Hanson, 1965.)

| Crop | Albuquerque | Belen | Bernalillo | Socorro | T or C |
|--------------------|-------------|-------|------------|---------|--------|
| Alfalfa | 29 | 32 | 29 | 35 | 39 |
| Grass Hay | | | | | 34 |
| Deciduous orchards | 22 | 25 | | | |
| Spring small grain | 16 | 16 | 15 | 15 | |
| Sorghum | 22 | 22 | 21 | 23 | 23 |
| Corn | 21 | 21 | 21 | 23 | 23 |
| Cotton | | 22 | | 25 | 27 |
| Beans | | | 13 | | |

3 i) Improve on-farm irrigation efficiency

Improvements in on-farm efficiency reduce diversion through the farm turnout primarily by reducing runoff and percolation to the aquifer. Smaller reductions are also effected through reducing ponding and, if sub-surface drip irrigation is used, by reducing evaporation out of the surface soil layer. Of these, only the smaller reductions (by reducing ponding and evaporation from soils) represent changes in consumptive use and have potential to reduce consumptive demand.

Other improvements to on-farm efficiency will reduce diversion demand through reducing return flow. If on-farm efficiency were improved from 50% to 75%, the farm delivery demand would decrease by one third, which would exceed one acre-foot per acre. The diversion demand would decrease also by a similar amount, plus conveyance losses.

With the exception of laser leveling fields, any improvements to on-farm efficiency would likely be costly in relation to their potential to reduce diversions, and very costly in relation to their potential to reduce consumptive use.

4 b) Control brush and weeds along water distribution system and drains

The Socorro Division of the MRGCD is estimated to have 200 miles of canals (134 measured miles, times 1.5 to account for smaller, unmeasured ditches and laterals). If we assume an average canal and associated riparian corridor width of 30 feet and an average open water/riparian ET for that width of 4 feet per year, canal evapotranspiration for the division is about 3,000 acre-feet per year (about 15 acre-feet per canal mile). Regular mowing of canal



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vegetation might reduce riparian ET by an estimated 50%. If we assume that half of the 30-foot width is open water and the other half riparian vegetation, the overall savings resulting from mowing is at most 25%, depending on the existing vegetation and the frequency of mowing. Piping would reduce losses for the stretch to zero.

Evapotranspiration from brush along drains, if we assume the same values, is 865 acre-feet/year (estimated 58 miles of drains). This alternative offers a potential reduction in consumptive use of perhaps a thousand acre-feet per year. While not a large sum, this alternative would be relatively simple to implement and would seem to be worth further investigation as part of an overall regional conservation program. As described above, this reduction in consumptive demand would be associated with a reduction in diversion demand of this amount, plus the conveyance losses to seepage.

4 d) Remove exotic vegetation on a wide-scale

Using data compiled in the Middle Rio Grande Water Supply Study (SSP&A, 2000) from the ET Toolbox and other USBR information sources, riparian acreage between San Acacia and San Marcial is estimated at 13,000 acres; between San Marcial and Elephant Butte at 11,300 acres; average consumptive use from 1985 to 1998 was estimated at 3.71 acre-feet per acre for San Acacia to San Marcia, resulting in a riparian usage of 49,452 acre-feet per year. At the same rate of consumption, consumptive use from San Marcial to Elephant Butte was estimated at 41,971 acre-feet per year.

Studies of riparian evapotranspiration currently suggest that salt cedar consumptively uses about 4 acre-feet per acre per year of water, while an established bosque uses about 3 acre-feet per acre per year of water (King and Bawazir, *Riparian Evapotranspiration Studies of the Middle Rio Grande*, 2000). Based on these values, if salt cedar were removed and replaced with native bosque, the potential water savings is 1 acre-foot per acre. Since most of the riparian acreage below San Acacia is dominated by salt cedar, the water savings can be applied to the total riparian acreage, resulting in a potential savings of 24,300 acre-feet per year. Removing exotic species and leaving the land bare, if this were possible, would result in a savings of 4 acre-feet per acre.

There are several potential complications under this alternative. First, the removal of exotic vegetation may potentially conflict with Endangered Species Act over southwest willow-flycatcher habitat. Second, once non-native vegetation is removed, it will need to be maintained on a regular basis. Cost of on-going maintenance should be figured into the planning. Third, because non-native riparian vegetation, such as salt cedar, consume large quantities of shallow groundwater, to some extent they control shallow groundwater levels. Reconstruction and maintenance of the LFCC to ensure adequate drainage will be important to ensure that water-logging and evaporative losses are not exacerbated upon removal of salt cedar. Water table response and alternatives for water table elevation management should be built in to any vegetation removal plan.



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4 e) Restore bosque habitat and manage vegetation to reduce evapotranspiration

See 4d. Additionally, it should be recognized that restoration of bosque habitat in areas where the river has been channelized or where development has encroached on the river may increase the consumption of water through the reach.

4 g) Delay start-up of irrigation system

A delay in start-up of the irrigation system would shorten the growing and irrigation season. The reduction in consumptive demand would probably be less than commensurate with the pro-rated period of time during which irrigation is not occurring, since lower temperatures and shorter daylight hours result in reduced water needs during the early season. Regardless, there would be some savings in both consumptive and diversion demand, and possibly some timing benefits later in the season.

4 h) Control competitive brush species

See 4d and 4e.

7 a) Develop local markets for higher value, low-water use alternative crops

See 3h for an assessment of the hydrologic impact of altering the crop mix. The development of local markets for low water use alternative crops has no direct bearing on potential water savings. (From a hydrologic perspective, if low water use crops are grown, it doesn't matter if they are marketed locally, regionally or nationally.)

7 b) Restrict transfer of water out of the planning region

Transfers, within or beyond the planning region, must recognize hydrologic reality if the river is not to suffer detrimental impacts. Assessment of hydrologic reality includes quantification and comparison of incidental conveyance losses and return flows at both the "move-from" and the "move-to" locations. These assessments can be technically complex, and require evaluation of local hydrologic conditions throughout the impacted areas and river reaches. In many cases, a reduction in the diversion or consumptive use will be required to preserve the "status quo" water balance after the transfer occurs, to compensate for increased losses to the new point of use.

Transfers over large distances are particularly difficult to implement without risk to the existing hydrologic balance. First, certainty in evaluating comparative conveyance losses and return flows becomes more difficult to achieve when transfers occur across large distances, for example, as would occur with water transferred outside of the planning region. Second, some elements of the existing infrastructure are sensitive to the magnitude of use; for example, some canals require a given head or volume of water for efficient delivery. Substantial transfers out of one area may jeopardize the efficient continuation of present uses within the move-from area.

We are not aware of a mechanism for restricting water transfer out of the planning region, but would encourage the planning region to critically review any such proposals or transfer applications.



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7 c) Develop a water banking system to facilitate transfer of water within the planning region

The advantage of a water banking system is increased flexibility to shift uses from one sector to another, to meet changes in demand in a timely fashion. The development of such a system would not be simple. Transfers, within any administrative system, must recognize hydrologic reality if the river is not to suffer detrimental impacts. Assessment of hydrologic reality includes quantification and comparison of incidental conveyance losses and return flows at both the “move-from” and the “move-to” locations. These assessments can be technically complex, and require evaluation of local hydrologic conditions throughout the impacted areas and river reaches. In many cases, a reduction in the diversion or consumptive use will be required to preserve the “status quo” water balance after the transfer occurs, to compensate for increased losses to the new point of use. The development of “rules” for transfer within and across hydrologic sub-zones may serve to provide sufficient flexibility for transfers, while maintaining the water balance. The Office of the State Engineer and the Interstate Stream Commission would need to ensure that any such banking systems did not result in actions contrary to state law, interstate compact, or other imperatives under their jurisdiction.

7 i) Preserve, but continue to draw, deep well water for drinking purposes only.

Assuming that this alternative is proposing to limit existing groundwater withdrawals from deep wells to drinking water only, the impact on the aquifer would be reduced from present levels. Impacts of pumping on the river would be delayed to some extent, providing flexibility in timing. Depletion of aquifer storage would not likely be a problem (depending on where wells were located) for many, many years, at such a limited rate of use.

Groundwater modeling can be used to provide a better understanding of the groundwater supply and impacts of various groundwater use scenarios. Such a study should quantify current usage, the rate at which water is currently being drawn down, and the rate of draw down that the region considers acceptable.

7 j) Restrict domestic well use

See 7i.

The State Engineer’s office restricts irrigation from a domestic well to one acre or less. If a large number of domestic wells are currently used for irrigation purposes, clearly some savings would result from restrictions. The Socorro-Sierra region should assess the magnitude of irrigation from domestic wells to quantify the benefit of this option.



Table 3: Qualitative Ranking of Hydrologic Impacts

A qualitative hydrologic impact score is assigned relative to three criteria: reduction in water diversions, reduction in consumptive use and increased flexibility in the timing of water availability. The scores, as follows, do not reflect consideration of cost, feasibility, or other non-hydrologic constraints:

- 1 = no impact likely or not applicable
- 2 = modest improvements possible
- 3 = potentially helpful improvements
- 4 = potentially significant improvements
- 5 = potentially large improvements

| Alt # | Alternative description | Score-Diversion | Score-Consumption | Score-Timing |
|-------|---|-----------------|-------------------|--------------|
| 1a | Reclamation, treatment and use of saline water | 4 | 4 | 4 |
| 1b | Wastewater treatment and reuse | 2 | 1 | 1 |
| 1c | Comm. / residential on-site water recycling | 2 | 1 | 1 |
| 1d | Storage of reservoir water at higher alt./lat. | 1 | 3 | 1 |
| 1e | Evaporation control -reduced water surface areas | 3 | 3 | 2 |
| 1f | Aquifer storage and recovery | 1 | 2 | 5 |
| 1h | Restriction of gw supply wells in sensitive areas | 1 | 1 | 3 |
| 3e | Improve efficiency of sw conveyance to ag | 5 | 2 | 3 |
| 3f | Alternative irrigation methods on croplands | 3 | 2 | 1 |
| 3g | Use precision agriculture techniques | 2 | 2 | 1 |
| 3h | Reduce agricultural CU (low water crops) | 4 | 4 | 2 |
| 3i | Improve on-farm irrigation efficiency | 3 | 2 | 1 |
| 4b | Control brush and weeds along water distribution system and drains | 2 | 3 | 1 |
| 4d | Remove exotic vegetation on a wide-scale | 3 | 5 | 2 |
| 4e | Restore bosque habitat and manage to reduce ET | 1 | 2 | 1 |
| 4g | Delay start-up of irrigation system | 3 | 3 | 1 |
| 4h | Control competitive brush species ¹ | NS | NS | NS |
| 7a | Develop local market for low-water crops (3h) | 1 | 1 | 1 |
| 7b | Restrict transfer out of the planning region | 3 | 1 | 1 |
| 7c | Develop a viable water banking system | 1 | 1 | 4 |
| 7i | Preserve, but continue to draw, deep well water for drinking purposes | 2 | 2 | 3 |
| 7j | Restrict domestic well use | 2 | 2 | 1 |

¹ We have not provided a ranking of alternative 4h. We are not entirely clear on what the planning group intends with this option. It appears 4h is a combination of options 4d and 4e. Rankings for 4d and 4e can be used to estimate a ranking for 4h.

Memorandum

Date: March 7, 2003
From: Karen Lewis, Debbie Hathaway
To: Socorro-Sierra Regional Water Planning Group
Subject: **Selected Planning Alternatives –Analysis of Hydrologic Impacts**

Background

The Socorro-Sierra Regional Water Planning group has developed a short-list of water planning alternatives. By letter of January 24, 2003, the Socorro Soil & Water Conservation District requested that the ISC authorize SSP&A to provide a hydrologic analysis of these chosen alternatives. By letter of January 30, 2003, the ISC authorized SSP&A to analyze the noted alternatives (as part of work for the Middle Rio Grande Water Supply Study, Phase 3). This analysis includes:

- Quantitative estimates of changes in water consumption and qualitative estimates of changes in diversions resulting from implementation of the proposed alternatives
- An evaluation of sensitivities and relationships between alternatives and between alternatives and other model parameters, with attention paid to how these sensitivities and relationships will impact water consumption, availability, and, to limited extent, to timing of deliveries and diversions. Required modifications to the MRG WSS models resulting from these sensitivities and relationships will be outlined.
- Modification of the MRG WSS Phase 2 models to reflect the proposed alternatives and their sensitivities and relationships. Results will be provided in the context of regional water supply and impact on Compact obligations.
- A quantitative evaluation of surface water flow into the Socorro-Sierra region north of Elephant Butte Dam. This quantification will be based on the MRG WSS Phase 2 model, modified to provide a regional break at the county line such that all flows at and below that point can be evaluated. The evaluation will be presented in a probabilistic format.
- Riparian and agricultural consumptive use and open water evaporation for the Socorro-Sierra region north of Elephant Butte Dam, including evaporation for Elephant Butte reservoir, based on the information and data currently contained in the MRG WSS Phase 2 model.

This memorandum addresses the first bullet above, or, Task 1 described in the letter of January 30. The list of alternatives submitted to SSP&A for evaluation is provided below. Following the list is a quantitative evaluation of the hydrologic impacts of each item on the list, as well as a qualitative estimate of the changes in diversions that would result from implementation of each proposed alternative.

Socorro-Sierra Short-List Alternatives Identified for SSP&A Review

Socorro/Sierra has chosen 16 alternatives that they are pursuing in greater detail. Of these, six alternatives have been identified for hydrologic analysis by SSPA (1e, 3e, 3i, 4b, 4d, and 7b) and one was identified for comment (1d). The seven alternatives are:

1. 1e - Evaporation control through reduced water surface areas in engineered and natural areas
2. 3e - Improve efficiency of surface water conveyance systems to agricultural land, including irrigation scheduling, metering, and ditch lining or piping.
3. 3i - Improve on-farm efficiency
4. 4b - Control brush and weeds along water distribution systems and drains
5. 4d - Remove exotic vegetation (i.e. Salt cedar, Russian olive) on wide scale
6. 7b - Encourage retention of water within the planning region
7. 1d - Move water to higher elevation

Discussion of Hydrologic Impacts

The hydrologic impacts of these alternatives are reviewed at a detailed level. The goal of this review is to quantify changes to water consumption resulting from implementation of the alternative. Table 1 provides a quantitative water savings for each alternative, focusing on the opportunity to save (or gain) water from a consumptive perspective, and a qualitative assessment of changes in diversions; while changes in diversions without commensurate consumptive changes typically don't impact the basin supply (or ability to meet Compact obligations), there may be benefits to modifying diversions at a regional or local level, particularly when considering cost and environmental issues. Where possible, comments are offered in the text on technical, economic and political feasibility.

This memo is intended to provide regional planners with an assessment of hydrologic costs and benefits of each of the chosen alternative to the best of our current knowledge, and to aid planners in further refining their chosen alternatives to maximize the efficiency and success of the water planning process in the region.

For purposes of this analysis, we have used agricultural data for the Socorro Division of the MRGCD and riparian data from ET Toolbox reaches 5, 6 and 7. The Socorro-Sierra region, however, extends further north than either of these boundaries. Consequently, agricultural estimates are low; roughly 20% of the Belen division is contained within Socorro County, i.e. approximately 6,400 additional irrigated acres and 64 miles of canals. The crop acreage within the Socorro-Sierra County planning region, outside of the Socorro Division, will be estimated from GIS coverages as part of Task 3. Riparian values used in the calculations will be similarly adjusted in Task 3. However, the adjustment will not be as significant as that for crop acreage, because the bulk of the Middle Rio Grande mono-typical salt-cedar stands lie below Bernardo.

1 Evaporation control through reduced water surface areas in engineered and natural areas

Reduction of water surface areas, such as a reduction in the wetted area of the Elephant Butte delta and reduction of ponded areas between San Marcial and the reservoir, is important for efficient delivery of water to Elephant Butte Reservoir for meeting obligations under the Rio Grande Compact. Under current conditions, the open water and swamp portions in the delta are significant and result in high evaporative losses. There are also many open water areas in state and federal wildlife and game refuges within the Socorro-Sierra region. Reduction in these open water areas could also reduce water lost to evaporation. An analysis of the reduction in water depletion through evaporation available through implementation of this alternative is presented for two conditions:

- A. Reducing evapotranspiration and evaporation from the Elephant Butte delta through channel construction and maintenance
- B. Reducing open water areas within the counties' wildlife and game refuges

Reducing evapotranspiration and evaporation from the Elephant Butte delta

The LFCC provides drainage in the region from San Acacia to the delta, and was designed to improve the delivery of diverted river water and intercepted drainage water to the reservoir. Currently, the lower part of the LFCC through the delta area is not functioning as designed due to siltation and channel breaches. As a result, the water carried in the LFCC is deposited in marshy areas in the delta. Additionally, water in the river channel, whose bed elevation has significantly aggraded over past decades, spreads into the delta area, with much of it contributing to ponded or marshy areas. Field studies to support the characterization of the water budget in the delta area have not been conducted, but the following general statements can be made:

- Water from the LFCC and the river spread across the delta area. The disposition of these waters includes: seepage into the subsurface, open water evaporation, evapotranspiration by riparian vegetation, and surface flow to the reservoir through a network of smaller channels;
- Water in the shallow subsurface of the delta area has the following disposition, with relative quantities unknown: evaporation from wetted soils, riparian evapotranspiration, subsurface flow to the reservoir, interception by portions of the LFCC in places where the LFCC water surface lies below the shallow groundwater elevation.

A pilot channel is currently under construction to reconnect the river to the reservoir. This channel also intercepts a main area of spreading LFCC drainage in its planned downstream reach. The lower portion of the channel is on schedule for completion at the end of April 2003. The upper portion of the channel is partially complete, but the schedule for full completion is unclear. The intent of these channel maintenance activities is to provide a channel that can effectively carry spring run-off to the reservoir, thus, avoiding the spreading of floodwaters into the delta area. If these activities are successful, the delivery of water will return to what might be considered a "baseline condition", akin to what existed prior to the flooding and high waters that occurred in the 1980's. At present, the depth of the channel has not been designed to drain subsurface water to an elevation beyond the reach of riparian vegetation.

In evaluating this alternative, three scenarios are defined:

- 1) Failed or no maintenance: Conditions as in the past decade. Water from the LFCC and the river spread across the delta and extensive ponding occurs.
- 2) Successful pilot channel, effective maintenance of channel: Conditions returned to those as occurred prior to channel siltation in the 1980s; however, potential exists for significant riparian re-colonization during pool recession.
- 3) Deepening of the channel to increase drainage of saturated sediments in the delta and upper reservoir area. Consequent reduction in potential for riparian re-colonization.

For each scenario, it is assumed that the reservoir level is below the Narrows. The potential for reduction in water depletion under each scenario is discussed below and is roughly quantified. Table 1 summarizes the estimated reduction in depletion.

- 1) *Failed or no maintenance.* Under this scenario, open water evaporation occurs at essentially the same rate as would occur with a full reservoir throughout the delta area and the (drained) upper reservoir area. No savings occur. Water depletion under a less-than-full reservoir will exceed that which occurred prior to the 1980s.
- 2) *Successful pilot channel, effective maintenance of channel.* Under this scenario, water depletions return to what some would term a “baseline condition” of normal operation. Water savings occur in two ways. First, spring run-off is routed quickly to the reservoir, rather than being held up through ponding, following a tortuous path through marshy areas and generally being subject to greater evaporation losses. Secondly, many ponded or marshy areas will dry, reducing open water evaporation. However, under this scenario, the groundwater elevation will likely still be within the reach of riparian vegetation. If colonization has been allowed to occur during recession, then evapotranspiration over a large area, potentially as large as the area previously covered by marshy conditions, may occur. The estimated (minimum) difference in water depletion between this scenario and scenario #1 is equal to the difference between open water evaporation and riparian evapotranspiration rates. Estimating annual average open water evaporation at 7 acre-feet per acre, and riparian evapotranspiration at 4 acre-feet per acre, this difference amounts to approximately 3 acre-feet per acre over the affected area. We don't have available data on the relative amounts of open water versus riparian vegetation in this area at present; nor do we have projections on how this will change upon completion of the pilot channel. The assumptions below should be refined if this analysis is critical in the decision making process. If we assume that presently, one half of the approximately 14,700 acres of the northern basin of Elephant Butte Reservoir, is characterized as marshy or ponded, and the other half consists of riparian area (50% marsh, 50% riparian as in scenario 1); and if the completion of the channel results in conversion of 75% of the open water area to riparian (scenario 2a, 12.5% marsh, 87.5% riparian), then, water depletion under this scenario is reduced by difference would amount to approximately 16,500 acre-feet per year. *It should be understood that this reduction in depletion from today's condition does not*

represent salvage or new water. In reality, this effort reduces excessive depletion that occurred due to the lack of effective channel maintenance over the past 18 years.

- 3) *Deepening of the channel to increase drainage of saturated sediments in the delta and upper reservoir area:* If the channel is deepened to drain surrounding delta and upper pool areas to the extent that it becomes difficult for riparian vegetation to colonize in areas exposed by reservoir recession, reduction in water depletion beyond the “baseline” level would result. The reduction would be equal to the difference between riparian evapotranspiration and bare ground evaporation (estimated at 1 acre-foot per acre for this calculation) in areas where depth to shallow ground water was adequately increased. Without field study of this area, it is not possible to know how deep channel excavation would need to be to accomplish adequate water table lowering nor is it possible to assess the feasibility. However, to enable discussion, we provide an estimate of hypothetical depletion reduction by assuming that riparian evapotranspiration would be limited to 50% of the exposed area, and drained ground will constitute the remaining 50% of the exposed area under the lowered water table scenario. Under these assumptions (scenario 3a), the change in water depletion, as compared to scenario 2a (87.5% riparian, 12.5% marsh), would be 22,050 acre-feet per year; or, as compared to scenario 1 (assumed present condition) would be 38,5990 acre-feet per year. This scenario, involving maintenance of drainage conditions (and reduction of marshy areas), may be problematic if Southwest Willow Flycatcher habitat develops in areas of the receding reservoir.

Table 1: Hypothetical evapotranspirative water use in the Elephant Butte northern basin under various scenarios.

| Elephant Butte northern basin hypothetical evaporation/evapotranspiration (total area assumed is 14,700 acre-feet) | | | | |
|--|----------------------------|-------------------------------|-----------------------------|-------------------------|
| | Marsh area (7 ac-ft/ac) | Riparian area (4 ac-ft/ac) | Barren area (1 ac-ft/ac) | Total ET (acre-feet) |
| Scenario 1 | 50% | 50% | | 80,850 |
| Scenario 2a | 12.5% | 87.5% | | 64,310 |
| Scenario 2b | | 100% | | 58,800 |
| Scenario 3a | | 50% | 50% | 42,260 |
| Scenario 3b | | 20% | 80% | 23,520 |

Reducing open water areas within the counties’ wildlife and game refuges

Open water evaporation from exposed open water bodies generally exceeds riparian evapotranspiration. Evaporation for small ponds shaded by trees and other growth, such as backwaters being constructed along the river for Silvery Minnow habitat, may have evaporation rates equal to or smaller than that of riparian vegetation.

Reduction in surface areas of these larger ponds could, therefore, result in reduced depletion for the region. Open water evaporation from Elephant Butte Reservoir is 7 feet per

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year; average open water evaporation for the San Acacia to San Marcial reach, as modeled in the ET Toolbox, is about 5.6 feet per year. Compared to evaporation rates of 4 feet per year for salt cedar and 3 feet per year for cottonwood, anywhere from 1.6 to 4 acre-feet of water per acre per year could potentially be saved by converting larger ponds to bosque.

A current number for acres of ponded areas between San Acacia and the Elephant Butte delta is unavailable. The ET Toolbox acreage for open water between Bernardo and the Elephant Butte Delta is 5,490 acres, this includes ponds, canals, drains, and river channel areas. For discussion purposes only, a rough estimate of hypothetical reduction in depletion follows. Further work is required to realistically assess these reductions via implementation of this option:

- Assume 30% of the open water acreage is stand-alone ponds (1,650 acres)
- Assume 20% of these could be replaced with native bosque (330 acres)
- The reduction in depletion would therefore range from 525 to 1,320 acre-feet per year.

The value of these areas to habitat and the ecosystem would need to be considered carefully if this option is pursued. This evaluation has not assessed the habitat value, but understands that many in this region favor the benefits provided by these open water areas. Furthermore, many, perhaps most, of these stand-alone ponds lie within state and federal wildlife and game refuges, and this issue is beyond the region's direct control.

2 Improve efficiency of surface water conveyance systems to agricultural land by implementing conveyance alternatives (e.g. concrete-lined ditches, pipelines), improving irrigation scheduling, and metering and managing surface water diversions and returns

Potentially large reductions in agricultural diversion demand are possible through improvements in irrigation efficiency. Irrigation-related consumptive use reductions will be minimal (only ensuing from reductions in incidental depletions associated with efficiency improvements). Reductions in diversion demand resulting from these changes would allow water to be retained in upstream storage reservoirs longer and provide timing advantages for irrigation (or ancillary needs/benefits). Reductions in consumptive use will both reduce the diversion demand and “save” water.

“Saved” water will not likely be directly available to the planning region; however, improvements to MRGCD efficiency will improve the ability of the MRGCD to provide a full supply to all irrigators, including those in this region. Because the basis of the MRGCD’s permitted water right is irrigated agriculture, any water not needed for this purpose due to conservation efforts is assumed to belong “to the public and is subject to appropriation for beneficial use” (New Mexico statutes, 1978, 72-1-1). In the Rio Grande Basin, which is considered by the State Engineer to be fully appropriated, these waters would satisfy other established water rights (which may be subject to shortage), subject to the constraints of the Rio Grande Compact. In other words, these savings, while not likely available for transfer to a specific use within the region, avoid what could be construed as waste, and would benefit the entire region by more efficiently using the available water supply.

Canal Lining/Piping

Canal lining will result in a reduction in seepage losses from the canals, thereby requiring smaller diversions to convey water to farms than under present conditions. Canal lining will also result in a reduction in riparian growth along the canals, and a commensurate reduction in evapotranspirative consumptive use.

Lining all of the canals in the region would be expensive, and probably unnecessary; it is likely that the majority of canal seepage comes from a minority of the canals. For this analysis, we have chosen to look at lining 20% of the canals. This is a placeholder value. Results can be scaled for other percentages.

The reduction in canal seepage is:

- 133.9 miles of canals in the Socorro divisions (obtained from project GIS coverages and reported in the MRGCD Efficiency Study, Table I-1), multiplied by 1.5 to take into account small canals and laterals not counted in the original survey
- 2001 division supply of 138,713 acre-feet of water
- canal seepage of 20 percent of canal flow (USBR Estimate) equals 27,743 acre-feet of water
- assume lining canals reduces seepage by 80%
- resulting reduction in the diversion requirement is 4,440 acre-feet/year. If the leakiest canals were located and lined, this value might be increased.

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We note that this reduction in seepage might result in effectively “new” water if the seepage is currently returning to the LFCC and is subsequently lost to evaporation in the delta – see item 1, Evaporation control.

The decrease in riparian consumption, based on the same lining of 20% of the canals, is:

- 133.9 miles of canals in the Socorro divisions (MRGCD Efficiency Study, Table I-1), multiplied by 1.5 to take into account small canals and laterals not counted in the original mileage survey
- Assume 20’ riparian corridor (10’ on either side of the canals)
- Assume 2’ annual ET from existing riparian growth (based on the average annual ET of salt grass – USBR report, Determination of Soil Conservation Service Modified Blaney-Criddle Crop Coefficients in New Mexico, 1997), and an eradication of that corridor by lining the canal.
- Water savings will be approximately 195 acre-feet per year from reduced riparian usage.

Additionally, there may be canals/laterals or sections of canals/laterals in the division that could be abandoned. Abandoning canals will reduce seepage and ET losses to near 0 for that stretch.

Irrigation scheduling/metering and managing deliveries and river diversions and returns

All of these options have the potential to significantly reduce required irrigation diversions. These options may result in reductions in consumptive use, but consumptive use changes are primarily incidental.

River diversions and returns are now metered in the Socorro Division of the MRGCD with the exception of the LFCC and the river as they exit the division. Much of this metering is relatively new, and over the next few years will allow the region to better understand irrigational water diversions and consumptions, which in turn will aid in planning and provide insight into potential areas where water can be saved or conserved. Estimates of both potential changes in consumptive use and reduced diversion demands as a result of this metering are unavailable at this time. Gaging the LFCC would further improve knowledge of regional water allocation. Currently, the LFCC is only gaged at San Marcial.

Rotational water delivery would reduce required diversions by reducing the amount of time canals must be run full. However, no data is currently available to quantify the improvement in off-farm efficiency resulting from rotational delivery. We note that rotational delivery is already practiced in some areas in the Socorro Division at some times.

Metering farm deliveries would reduce on-farm demand, and therefore reduce diversion requirements. Metering has been found to increase farmer’s efficiency with water by 10 to 20% in other irrigation districts (Fipps, *Potential Water Savings in Irrigated Agriculture for the Rio Grande Planning Region, Final Report*, Texas A&M University System, 2000). If the water required at the farm turnouts is reduced by 10 to 20%, required diversions are reduced by a minimum of 10 to 20% (for 2001, this would have meant a potential reduction in division diversions of 13,870 to 27,740 acre-feet). Depending on how the conveyance system is run in response to reduced on-farm demand, conveyance losses could also be reduced, further reducing diversion requirements.

3 Improve on-farm irrigation efficiency

Improvements in on-farm efficiency reduce diversion through the farm turnout primarily by reducing runoff and percolation to the aquifer. Smaller reductions are also effected through reducing ponding. Of these, only the smaller reductions (by reducing ponding) represent changes in consumptive use. Any other changes will impact required diversions only. As for prior alternatives, improvements to irrigation efficiency will improve MRGCD supply, and potentially increase water available for use in the Middle Valley at large, but may not make new water available for the region.

Most of the Socorro Division of the MRGCD is devoted to production farms, where laser-leveling and concrete lining of the on-farm ditches has already been done. Anecdotal evidence suggests that these improvements can reduce on-farm efficiency by 30%, and reduce turnout time to 25% of that previously required to irrigate the same acreage. This, in turn, reduces required diversions, makes rotational delivery far more efficient, and allows for increased off-farm efficiency.

Though many of the big production farms in the Socorro Division have already made efficiency improvements, some percentage of the district's irrigated lands remain unimproved. Focusing on improving these lands will boost district on-farm efficiency and allow for effective rotational delivery to these lands, further improving off-farm efficiency.

Laser-leveling can increase on-farm efficiency by about 30% (Darryl Reasnor, NRCS, personal communication). If we assume 30% of the Socorro Division is currently unimproved, we could then improve efficiency by 30% on 30% of the lands, or improve district on-farm efficiency by 9%. This, in turn, will allow for a minimum of a 9% reduction in required diversions. For 2001, this would have allowed for a reduction in diversions of about 12,500 acre-feet of water.

With the exception of laser leveling fields and improving on-farm ditches, any improvements to on-farm efficiency would likely be costly in relation to their potential to reduce diversions, and very costly in relation to their potential to reduce consumptive use.

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4 Control brush and weeds along water distribution system and drains

Currently, the MRGCD is mowing 100% of the canals and drains in the Socorro Division. Canals are mowed at least 2 to 3 times per year, and drains at least once per year. Complete eradication of vegetation along the canals and ditches would result in bank destabilization – plant roots currently provide bank support. Consequently, a balance needs to be maintained between controlling growth via mowing and maintaining adequate root mass to stabilize the canal and ditch banks. The primary vegetation along the canals and drains is weeds and grasses (johnny grass, kosha weed, mustard weed, some noxious weeds) with the occasional patch of willow. (This information was obtained from Johnny Mounyo in the Socorro Division MRGCD office.)

Water usage by weeds and grasses is likely 2 feet per year or less (salt grass uses about 2 feet per year). Some water savings might be achieved by increasing the number of mowings, but it is likely to be small. Currently, the data doesn't exist that would allow us to quantify the potential savings from increased mowing frequency.

5 Remove exotic vegetation on a wide-scale

The ET Toolbox, version of January 2003, reports riparian acreage between Bernardo and San Acacia as 6,600 acres, between San Acacia and San Marcial as 16,200 acres, and between San Marcial and Elephant Butte as 7,600 acres (30,400 acres total). (Note: This version updates the ET Toolbox acreage reported in the August 2000 MRGWSS study of 31,934 acres).

Average consumptive use from 1985 to 1998 was estimated at 3.71 acre-feet per acre for San Acacia to San Marcia (ET Toolbox value). Applying this to the entire stretch from Bernardo to Elephant Butte, the resulting riparian usage is 112,784 acre-feet per year. Studies of riparian evapotranspiration currently suggest that an established bosque uses about 3 acre-feet per acre per year of water (King and Bawazir, *Riparian Evapotranspiration Studies of the Middle Rio Grande*, 2000). Based on these values, if salt cedar were removed and replaced with native bosque, the potential reduced depletion is 0.71 acre-feet per acre. Since most of the riparian acreage between San Acacia and the Elephant Butte delta is dominated by salt cedar, this potential reduced depletion can conceivably be applied to the total riparian acreage, resulting in a total reduced depletion of 21,584 acre-feet per year. If we consider controlling salt-cedar on only a portion of these lands, which might be more realistic, re-establishing native bosque on 10% of the lands (3,000 acres) would result in a reduced depletion of about 2,200 acre-feet of water per year.

Alternately, the region could focus on areas where salt cedar habitat can be eliminated. The benefit of eliminating habitat is that salt-cedar is replaced by scrub, rather than bosque, further reduces depletions. A potential area where this might work is on the east side of the Rio Grande below San Acacia. This area is a roughly 4 mile wide stretch of land that was once used for agriculture. This area was abandoned by the MRGCD when it became too waterlogged to plant. This area is cut off from the Rio Grande by a continuous levee, and is also the outlet for multiple arroyos, which, because of the levee, no longer connect to the river. The result is that significant amounts of water are released into this former farmland on a regular basis, maintaining a high water table and providing excellent conditions for salt cedar growth. It is likely that if the arroyos in this area were reconnected to the river, salt cedar habitat would be reduced. Work to reconnect the major arroyos to the river appears to have been recently started. If this land were drained such that some portion of it became inhospitable to riparian growth, the resulting water usage on the drained land would drop to roughly the effective precipitation, reducing depletions by roughly 3 to 3.5 acre-feet of water per acre annually. Maintenance of the drainage system would be required to prevent salt-cedar from re-vegetating the area. However, this maintenance is likely smaller than that required to keep salt-cedar from re-vegetating areas that support active riparian communities.

A developing area of riparian vegetation is in the now-exposed Elephant Butte northern basin. As mentioned in the first alternative, successful completion of the pilot channel is a critical step; however, additional drainage and maintenance would probably be required to substantially reduce the potential for riparian re-colonization.

There are several potential complications to controlling non-native vegetation. First, the removal of exotic vegetation may potentially conflict with Endangered Species Act over southwest willow-flycatcher habitat. Second, once non-native vegetation is removed, it will need to be maintained on a regular basis, or the area will need to be returned to more "natural" conditions such that non-natives have less advantage over native vegetation. Cost of on-going

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maintenance, in the former scenario, or the potential for increased water use resulting from re-engineering the area to recreate “natural” conditions, should be figured into the planning. Third, because non-native riparian vegetation, such as salt cedar, consume large quantities of shallow groundwater, to some extent they control shallow groundwater levels. Reconstruction and maintenance of the LFCC to ensure adequate drainage will be important to ensure that water-logging and evaporative losses are not exacerbated upon removal of salt cedar. Water table response and alternatives for water table elevation management should be built in to any vegetation removal plan.

6 Restrict transfer of water out of the planning region

Implementation of this option will allow the region to maintain its current water supply. We are not aware of a mechanism for restricting water transfer out of the planning region, but would encourage the planning region to critically review any such proposals or transfer applications.

Transfers, within or beyond the planning region, must recognize hydrologic reality if the river is not to suffer detrimental impacts. Assessment of hydrologic reality includes quantification and comparison of incidental conveyance losses and return flows at both the “move-from” and the “move-to” locations. These assessments can be technically complex, and require evaluation of local hydrologic conditions throughout the impacted areas and river reaches. In many cases, a reduction in the diversion or consumptive use will be required to preserve the “status quo” water balance after the transfer occurs, to compensate for increased losses to the new point of use.

Transfers over large distances are particularly difficult to implement without risk to the existing hydrologic balance. First, certainty in evaluating comparative conveyance losses and return flows becomes more difficult to achieve when transfers occur across large distances, for example, as would occur with water transferred outside of the planning region. Second, some elements of the existing infrastructure are sensitive to the magnitude of use; for example, some canals require a given head or volume of water for efficient delivery. Substantial transfers out of one area may jeopardize the efficient continuation of present uses within the move-from area.

7 Storage of reservoir water at higher altitudes/latitudes

Moving storage of Elephant Butte Reservoir water to northern reservoirs has the potential to reduce total reservoir evaporation. Table 2, below, illustrates the potential reduction in evaporative loss for various reservoir storage scenarios. Reduction in evaporation in these scenarios, which are based on moving 100,000 acre-feet of storage from Elephant Butte to Abiquiu or Cochiti Reservoirs, which have lower evaporation rates than Elephant Butte as a result primarily of climate, range from 2,070 to 4,960 acre-feet. These calculations are based on current area-capacity tables for the specified reservoirs, and on measured annual pan evaporation rates, adjusted by a factor of 0.7 as is customary applied by the USBR and the ACOE in New Mexico. (These values are different from those in the DBS&A analysis presented to the Water Assembly, February 2003.)

Table 2: Reduction in evaporative loss resulting from moving water storage from Elephant Butte to Northern Reservoirs.

| Elephant Butte Reservoir | | Destination Reservoir | | Evaporative loss reduction (acre-feet) |
|----------------------------|-------------------------|-----------------------|--------------------------------|--|
| Storage Volume (acre-feet) | Water Moved (acre-feet) | Name | Volume Before Move (acre-feet) | |
| 1,000,000 | 100,000 | Cochiti | 50,000 | 2,070 |
| 1,000,000 | 100,000 | Abiquiu | 50,000 | 4,420 |
| 2,000,000 | 100,000 | Cochiti | 50,000 | 2,610 |
| 2,000,000 | 100,000 | Abiquiu | 50,000 | 4,960 |

The values in Table 2 are based on differences in evaporation between Elephant Butte and the destination reservoir, at the specified reservoir levels. These values do not take into account potential changes in conveyance loss resulting from moving water to Elephant Butte on a different schedule than that now applied. Increases in conveyance loss, if water were released slowly during the summer rather than routed to Elephant Butte during the spring flood wave, could potentially exceed the water savings for all options shown above, resulting in a net water consumption rather than a water savings, and negatively impacting New Mexico's ability to meet Compact delivery requirements. Data is presently unavailable to precisely quantify the increase in conveyance losses during the summer, but may be available in the near future (ISC staff, personal communication).

The Table 2 water savings values also do not account for riparian colonization of, and subsequent evapotranspiration losses from, the newly exposed sediments in the Elephant Butte delta area resulting from shifting water upstream. Rough quantification of these losses is presented below:

- For a change in storage of 100,000 acre-feet, starting from a base storage of 1,000,000 acre-feet, reservoir surface area changes from 20,860 to 19,320 acres.
 - If we assume 40% of this is in the northern delta, this is 640 acres.
 - If this area were populated by riparian growth with an evapotranspiration rate of 4 acre-feet/acre, resulting losses would be 2,560 acre-feet.

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- For a change in storage of 100,000 acre-feet, starting from a base storage of 2,000,000 acre-feet, reservoir surface area changes from 35,600 to 34,000 acres.
 - Using the above assumptions, resulting losses would be 2,464 acre-feet.

Table 2 water savings values should therefore be reduced by approximately 2,500 acre-feet (for the movement of 100,000 acre-feet of water) to account for delta evapotranspiration.

Additionally, there are many legal issues involved in implementing changes in reservoir storage. A complex suite of Congressional authorizations, and the Rio Grande Compact, control storage, releases and deliveries associated with both Elephant Butte and other reservoirs. These institutional controls are substantial; alteration of these institutional controls would be very time consuming and is beyond the scope of the regional planning process, though the region could lobby for changes.

Any reduction in evaporative depletions from changes to reservoir storage, assuming transit losses are not subsequently increased, effectively increase the amount of water available for other uses in the Middle Rio Grande (Cochiti to Elephant Butte) region. Under New Mexico water law, this water belongs “to the public and is subject to appropriation for beneficial use” (New Mexico statutes, 1978, 72-1-1). In the Rio Grande Basin, which is considered by the State Engineer to be fully appropriated, these waters would satisfy other established water rights (which may be subject to shortage), subject to the constraints of the Rio Grande Compact.

Table 2: Ranking of Hydrologic Impacts

A rough quantification of potential water savings resulting from each alternative, based on the assumptions outlined in the above text, is given below. Additionally, a qualitative hydrologic impact score is assigned for reduction in water diversions. The approximate water savings and diversion reduction scores do not reflect consideration of cost, feasibility, or other non-hydrologic constraints:

- 1 = no impact likely or not applicable
- 2 = modest improvements possible
- 3 = potentially helpful improvements
- 4 = potentially significant improvements
- 5 = potentially large improvements

| Alt # | Alternative description | Approximate Reduction in Depletion (acre-feet/year) | Score-Diversion |
|--------------|--|--|------------------------|
| 1e | Evaporation control -reduced water surface areas | 0 to 40,000 | 1 |
| 3e | Improve off-farm irrigation efficiency | 200, not including seepage to LFCC | 5 |
| 3i | Improve on-farm irrigation efficiency | Not quantifiable | 3 |
| 4b | Control brush and weeds along water distribution system and drains | 0 | 1 |
| 4d | Remove exotic vegetation on a wide-scale | 2,200 (for 10% of lands) | 2 |
| 7b | Restrict transfer out of the planning region | Not quantifiable | 3 |
| 1d | Storage of reservoir water at higher alt./lat. | 0 to 2,500, not including conveyance losses | 1 |