APPENDIX 10

MRGCD ALTERNATIVE HYDROLOGY ANALYSIS

Comparison of No Action (Baseline) Water Management Conditions in the Middle Rio Grande with the Proposed Action Condition Using ET Toolbox as Inputs for MRG Consumptive Uses.

1.0 Introduction:

The URGWOM model does a remarkably good job of simulating realistic water management scenarios through the Rio Grande/Rio Chama system to Cochiti Reservoir based on past gauge data, expected runoff volumes, and reservoir operating rules. However, the outputs from the URGWOM model become appreciably less certain once water passes below Cochiti Dam. This is due to a highly complex interaction of consumptive uses and groundwater exchange into and out of the river. In recent years, significant effort has gone into calibrating the URGWOM model to better reflect MRG conditions, and it is improved. Still, calibration has only been possible against observed conditions, and considerable unknowns remain. The model has been adjusted in the MRG to produce outputs that mesh with observed conditions, but some of the underlying mechanisms that produce those conditions are not understood well enough to actually be modeled. The use of URGWOM to model MRG flows entering the MRG is appropriate, but URGWOM inadequate when estimating the effects of those flows at points of interest within the MRG for Reclamation's BA.

Language in the ESA and BA guidance documents requires the analysis of the effects of a proposed action, compared to the baseline condition, which indicate conditions without the proposed action. The authors of this language must have logically assumed any proposed action would be a new occurrence, changing conditions from what they had previously been. In this case, the No-Action condition would likely be obvious, and the more difficult part of the equation would be what effects the Proposed Action might have. However, in the case of the RGSM and the MRG the Proposed Action is to continue current actions, and the unknown quantity is the No-Action condition. This seeming contradiction is becoming more common as the use of the ESA expands over the years. This BA is particularly unusual in that the "proposed action" is the continuance of activities that have been occurring to varying degrees for centuries. Thus, there is no way to calibrate the URGWOM model for the No-Action condition, since it has never been observed in historic times. A different approach is called for.

The No-action scenario to be modeled must be capable of showing the effects of the operation of existing reservoirs, and any actions that are not part of the Proposed Action condition. The No-Action condition must also demonstrate the range of flows expected through the MRG in the absence of the proposed actions, which below Cochiti reservoir is primarily the operation of MRGCD diversions for water delivery to agricultural consumers. Initial attempts using the URGWOM model were made by removing the MRGCD Demand or MRGCD Diversion from the consumptive use below Cochiti. However, these factors include consumptive uses which would continue under the No-Action scenario. The "MRGCD Demand" includes riparian consumptive use, evaporation from the river itself, and seepage to aquifer recharge, all of which would logically be expected to continue in the absence of irrigation water diversion. Similarly, "MRGCD Diversion includes a component that is not consumptively used by agriculture, but instead returns to the river or drain system, where it may be consumptively used by riparian vegetation, evaporate, become groundwater recharge, or appear again as surface flow in the RG.

A refinement to the modeled scenarios can be derived utilizing the ET Toolbox model (ETT). The ETT produces daily consumptive use values for agricultural, riparian, and open water consumptive use based on weather conditions and acreage extents. This allows for the effects of agricultural consumptive use related to the operation of MRGCD diversion dams to be removed for the No Action condition, and restored for the Proposed Action condition. Or, perhaps stated properly, the use of ETT allows the effects of open-water evaporation and riparian consumption to remain as consumptive demands upon the river under all conditions. As with any model, there are limitations to ET Toolbox. ETT does not contain a component for groundwater recharge, and this must be compensated for in another way. Prior to 2011, ET Toolbox riparian and agricultural values were based on a version of the Penman-Montieth equation (PM) that had been modified by agricultural researchers at New Mexico State University (NMSU). The NMSU PM method tended to overestimate MRG ET by about 30% ("Comparisons of ET Toolbox Reference ET with Other Methods Using Weather Data for the Period January 1 through December 30, 20110, BOR, Al Brower letter of March 20, 2012). For 2011, ETT adopted the more conservative FAO-56 PM method (Crop Evapotranspiration –Guidelines for Computing Crop Water Requirements, United Nations Food and Agriculture Organization, FAO-Irrigation and Drainage Paper 56, Richard Allen, 1998).

2.0 The Flow Model

To simulate MRG flows, a spreadsheet model was constructed (using MS EXCEL). The construction of this Flow Model (FM) is possible due to the geographic and hydrologic characteristics of the MRG. It has been said that the MRG is where the Rio Grande spreads itself out to dry. Most flow inputs to the Rio Grande occur upstream of the MRG. Most flow in the RG originates from winter snows, resulting in a pronounced and often dramatic increase in flow during the spring runoff period, and much lower flow the remainder of the year as baseflow from groundwater (also snow origin) drains from the high mountains. Within the MRG, hydrology is heavily dominated by depletion. As the RG enters the MRG area, its valley widens and its slope lessens. Tributary contributions within the MRG are limited to the Rio Jemez, and a number of arroyos that normally flow only during and immediately after precipitation events. Climatic conditions become more harsh and open-water evaporation increases. The broad valley supports an extensive riparian forest, which consumes a sizable percentage of the total flow. Riverside drains collect water from the river and from surrounding agricultural lands, and that water is either returned to the river at drain outfalls or used for agricultural irrigation. Groundwater pumping causes de-watering of both shallow and deep aquifers, which in turn draws additional water from the river corridor. And of course water is diverted from the RG, and delivered onto agricultural lands where it is consumed by agricultural use.

Within the MRG, the river system is neatly oriented north-south. It can be broken into "reaches" by creating east-west boundary lines. For URGWOM and ETT purposes, the MRG is separated into 8 distinct reaches. Not coincidentally, these reaches correspond with points of interest for water managers and for describing flow characteristics for the BA. Reaches are related to these flow points of interest as:

Reach 1-3: Cochiti reservoir outflow to Central Avenue gauge (Albuquerque)

Reach 4: Central Avenue Gauge to Isleta Diversion dam

Reach 5-6: Isleta Diversion dam to San Acacia Diversion dam

Reach 7: San Acacia Diversion dam to San Marcial Gauge

Reach 8: San Marcial Gauge to Elephant Butte Reservoir

All of these reaches experience consumptive use of water for agricultural and riparian evapotranspiration and open water evaporation, with the exception of reach 8. Reach 8 includes effectively no agricultural use, but does have extensive riparian consumption. Reach 8 also includes a large amount of open water evaporation, highly variable due to the changing pool elevation of EB reservoir. For these reasons, and since the downstream end of Reach 8 is not a flow point of interest for this BA, the FM does not include reach 8.

The underlying and simple premise of the FM is that a certain flow enters each reach, and the amount leaving that reach is determined by subtracting the known depletions in that reach from the inflow. The outflow from that reach then becomes the inflow for the next reach. There are complicating factors, primarily the interaction of water into and out of the drainage system. As noted above, some reaches are aggregated for consideration, which eases the difficulty in accounting for these complicating factors.

2.1 Model Inputs

The FM depends on an input of the flow expected to enter the MRG from the outlet works of Cochiti reservoir. This input value is derived from the previous URGWOM modeling for various conditions. The FM then uses ETT-derived depletion estimates for agricultural, riparian, and open water depletions; and an estimation of the impact of municipal groundwater pumping in the Albuquerque area (reaches 3 and 4) to estimate flows arriving at four key points in the MRG; Central Avenue gauge in Albuquerque, below Isleta Dam, San Acacia Gauge, and San Marcial Gauge. The FM is prepared to accept 10-year sequences of flows (runs). Flows at these points are evaluated in terms of number of years of successful spawn/recruitment condition during each run (Central Avenue only), days of major drying over the course of the run, days of intermittency over the course of the run, number of years during the run in which major drying occurs, and number of years during the run in which some intermittency occurs.

The FM is constructed so that the user can readily specify (or modify) values to test for spawn/recruitment conditions, major drying, or intermittency. For the runs described by this document, the following conditions were specified:

	Spawn Flow/Duration	Major Drying	Intermittency
Central Avenue	3000 cfs/7 days	10 cfs	100 cfs
Below Isleta Dam		30 cfs	100 cfs
San Acacia Gauge		10 cfs	200 cfs
San Marcial Gauge		10 cfs	50 cfs

The FM also includes a user-adjustable factor that allows the extent of agricultural consumption to be specified. This allows for full agricultural consumptive use to occur in the FM under the Proposed Action, where it should be set to 1. However, for No-Action runs, agricultural consumption may still occur in some areas even when no diversion for that purpose is occurring, due to groundwater accretion in MRGCD drains. Reaches 1-3 contain no lands which can practically be served from these drains. A considerable portion of agricultural lands in Reach 4 can be served from drains. While a lesser percentage can be served in Reach 5-6, the very large agricultural acreage in Reach 5-6 makes this an important component. In Reach 7, about a third of agricultural lands are expected to be served from drains, primarily MRGCD lands south of Socorro and on the BDA National Wildlife Refuge. The following factors are used for the No-Action conditions described here.

Reach 1-3: 0

Reach 4: 0.5

Reach 5-6: 0.25

Reach 7: 0.33

Should one wish to evaluate conditions if no agricultural consumption were to occur, and groundwater accretion to drains were routed back to the RG, these values should all be set to zero.

2.1.1. ET DATA for Depletion Input

Ag/Riparian Evapotranspiration and Open Water Evaporation should be reasonably constant year to year, though will vary substantially over the course of a year. It is practical and reasonable to establish evapotranspiration/open-water consumption curves (for our purposes, a series of steps, roughly describing a curve); similar to what was previously used in the URGWOM model for MRGCD Demand and MRGCD Diversion. This is considerably less subjective than previous efforts, since reliable estimations of evapotranspiration and open-water evaporation may be produced from mathematical evaluation of known plant/water functional relationships with climate.

ETT values used as inputs in the FM are determined through a separate set of spreadsheets:

AG_ET_Corrected_2Week.xls

RIP_ET_Corrected_2Week.xls

OW_EVAP_Corrected_2Week.xls

Each of these worksheets contains 5 years (2007-2011) of daily values from ETT. An Average value for each day is produced from the five years. Then, the average values are used to determine the average for every 2-week period beginning Jan 1. Two small exceptions occur; the last period of the year includes 15 days, and where leap years occurs (2012, 2016) Feb 29 is given the same value as Feb 28. The use of the 2-week average was found to be necessary to produce a logical and evenly distributed "curve" for ET throughout the year, damping out the effects of daily weather disturbances from

seasonal climate. The five years chosen represent a fairly limited sample, and a longer record would clearly be desirable. However, ETT underwent significant changes from its inception in 2000 through 2005, and 2006 was an exceptional year due to record rains in the critical July-September period. For these reasons only the last 5 full years of ETT data were used to construct the agricultural, riparian, and open water consumptive use inputs. ETT daily values for years 2007-2010 are multiplied by 0.70 in the worksheet to adjust them to the FAO-56 method used in 2011.

Along similar lines, MRGCD diversions were also processed through an excel spreadsheet:

2.1.2. Diversions_Corrected.xls

In this worksheet, daily recorded values for the past 4 or 5 full years were culled from MRGCD records. For Isleta Diversion, years 2007-2010 were used. Similar logic was applied as with ETT data, with 2002 and earlier data representing a different MRGCD operational policy, 2003 and 2004 being years of short supply, and 2006 being the exceptional year of high rainfall. 2011 data is not yet reviewed and available, so only the four years of 2007-2010 were used to get an average value for diversion at Isleta Dam on any day. For San Acacia diversion, 2011 data are available, so a full five-year set, 2007-2011, was used for this diversion point. At present, diversions for Cochiti and Angostura are not being considered in the FM, so data from these diversions are not yet included in the spreadsheet.

2.1.3. Leakage to Groundwater

A value for seepage to groundwater use is also necessary, particularly for estimating flows through the Albuquerque reach of the river. While there are lesser groundwater withdrawals throughout the MRG, an initial estimate of this is done only for the ABCWUA withdrawal/return. Evaluation by NMISC of the present rate of loss from the river to ABCWUA groundwater recharge is approximately 60,000 AF/year. While the rate will vary slightly throughout the year, this averages out to a steady loss from the river of about 80 cfs. This loss is spread throughout the Albuquerque area, and is complicated by the fact that ABCWUA makes a substantial contribution to river flow through its surface water treatment plant. At present, this rate of return is averages about 70 cfs (NMISC). For modeling purposes, ABCWUA replaces nearly as much water as leaks from the river due to groundwater pumping. However, the return occurs midway through reach 4, while loss happens throughout reaches 3 and 4. Flow at the lower end of Reach 3 is of concern for the BA, so this must be appropriately accounted for. Accordingly, a seepage loss of 40 cfs each is assigned to Reaches 3 and 4, with and an inflow of 70 cfs to Reach 4, in an effort to accurately reflect flow at the end of each reach.

Other groundwater consumptive use is occurring in the MRG. Most notable would be Rio Rancho/Bernalillo area, the Albuquerque South valley area with its myriad of private domestic wells, and the Los Ulnas/Belen area. These consumptive uses are clearly substantial, but are impossible to incorporate into the FM at this time. In the past, these consumptive uses have tended to be masked by agricultural operations, as agricultural deliveries supply a considerable portion of the recharge to offset consumption. More precise regulation and monitoring of agricultural supply in the future will probably lead to quantification of this water use, and eventually of its incorporation into models of this type. At present however, it should be noted by the users of the FM, that the model may tend to overestimate

flow at critical measuring points due to this shortcoming. As with a number of other factors which cannot be fully defined in the FM, the overestimation should be consistent across all conditions, so values between conditions should remain comparable.

2.1.4. FM Relationships

As previously mentioned, the FM begins with an input value representing flow entering the MRG. This is supplied by the user from URGWOM model outputs for a particular condition to be modeled. The FM then depletes this flow by the aggregated depletions occurring in Reaches 1-3 for Riparian evapotranspiration (column C), open–water evaporation (column D), Agricultural consumption (column E) and ABCWUA groundwater pumping (column F). These inputs are derived from the INPUT sheet in the workbook. Ag depletion is subject to the user-entered depletion factor in column AA on the INPUT sheet, allowing agricultural depletions to be switched on/off, or adjusted for partial service from drain accretions. The end result is a rate of flow arriving at the outflow from reach 3, equivalent to the Central Avenue gauge. It is important to note that outflow from Reach 3 is not (in this version) partitioned between floodway and drain, and that particularly at lower flows, an appreciable percentage of total flow may be in the drain, rather than the floodway, with the model thus tending to underestimate river drying at Central avenue.

In Reach 4, the flow at Central Avenue is depleted by Riparian evapotranspiration (column H), open–water evaporation (column I), Agricultural consumption (column J) and ABCWUA groundwater pumping (column K). Then the MRG's largest tributary, the ABCWUA return flow, is added as an input to Reach 4 in column. L. This produces the flow arriving at Isleta dam (column M). Drain flow at this point is not substantial, as most drain flow is returned just above the dam, and only minor flows bypass the structure on the west side of the Rio Grande. To arrive at the flow in the Rio Grande just below Isleta dam, The MRGCD diversion at Isleta Dam (column. N) Is subtracted from available flow (column. M). A logical test is applied in column O, preventing diversion from exceeding available supply, and the resulting flow past Isleta dam is then displayed in Col. O.

Moving downstream, aggregated depletions in Reaches 5 and 6 are deducted from the available water at Isleta Dam (Col M) for Riparian (col P), Open water (col Q), Agricultural (Col R), to produce the total available water arriving at San Acacia Dam (col S). Note that the depletions are applied to total available flow at Isleta, and not the flow in the floodway below Isleta Dam. At San Acacia Dam, the split of the flow arriving via the Unit 7 is determined through logic in column. T, and then the flow below San Acacia Dam is determined by subtracting both the MRGCD diversion at San Acacia (column U) and the flow in the Unit 7 Drain. This has the practical effect of drawing the dividing line between Reach 6 and 7 just upstream of San Acacia Dam, but downstream of the point where Unit 7 drain can re-enter the floodway. The logic in column V results in the contents of the Unit 7 drain returning to the floodway if MRGCD diversions are zero, or remaining out of the floodway and in the drain if MRGCD is diverting. Accretion to Unit 7 Drain in reaches 5/6 is based on a percentage (7%) of flow in the floodway below Isleta dam, and 50% of the MRGCD Isleta diversion less agricultural depletions. The end result is realistic values for flows below San Acacia Dam (column V).

Reach 7 calculations in the FM involve subtracting depletions for Riparian evapotranspiration (column W), open–water evaporation (column X), and agricultural consumption (column Y) from the total available water at San Acacia (column S) to produce the total available water arriving at San Marcial (column AA). As at San Acacia, the flow at San Marcial is then partitioned into the component in the LFCC (column AB) by assuming 30% of flow at San Acacia (column S) winds up as groundwater accretion to the LFCC, or MRGCD return flow. The flow in the floodway at the San Marcial Gauge (column AC) is then determined by subtracting the component of flow in the LFCC (column AB) from the total arriving at San Marcial (column AA).

2.1.5. Output Analysis

The FM spreadsheet includes a sheet titled ANALYSIS. In this sheet, the values from the FLOW MODEL sheet are compared to user test conditions. The user adjustable conditions are set in the boxes across the top of the sheet, and this then produces number of days or years that particular condition is met in the model. For Central Avenue, user-adjustable test conditions are in column C, For Isleta, they are in column K, for San Acacia, they are in column S, and for San Marcial, they are in column AA. With a little consideration, the purpose and use of these test conditions should be readily apparent to the user.

2.1.6. Using the Flow Model

Any particular set of flow conditions should begin by opening the Flow_Model_10Year_Template file. This should then immediately be saved as a new file name identifying the flow scenario to be entered, preserving the unaltered template. The newly created file should then receive appropriate inputs. All inputs should be made in the INPUTS sheet. The primary input will be column B, into which the flow entering the MRG below Cochiti Dam should be cut/pasted from URGWOM output. Columns in the INPUT sheet for depletions (columns C through S) can be changed if necessary, but presumably will remain the same for the present. For Flow scenarios where MRGCD diversions are expected to operate, no additional changes are necessary. However, columns T through U contain average MRGCD diversions at the Isleta and San Acacia diversions, so if a flow scenario includes no diversion for MRGCD, the values in these two columns should be replaced with 0's (check carefully, as the top of the columns always show zeros anyway). Finally, there are four values at the top of the sheet in column D that represent the percent of agricultural depletions that are to be met. The template contains values believed appropriate for the No-Action (MRGCD not diverting) scenario. These are user adjustable, and for scenarios where MRGCD is expected to be in normal operation, these for values should all be set to "1" (100% ag depletions met).

Column Z in the INPUT sheet was included to simulate the effects of an additional water source in Reach 7. This was specifically included so that the effects of supplemental pumping could be considered. In the absence of pumping by Reclamation from the LFCC, this column should include all zeros, or appropriate values if pumping is to be included. At present, it is simply added to the available flow arriving at San Marcial. No provisions for additional sources of water are included in the FM, though this could readily be done in the future if desired.

After providing the correct Input values, the user should switch to the ANALYSIS sheet. There, one can view the number of days, and the number of years in which the defined conditions are met. The conditions can be changed if desired. In the template, values of 10 cfs are used as condition 1 to represent major or complete drying. Since, for a variety of reasons, the FM still probably overestimates flow, 10 cfs was selected as the "dry" threshold value, though a larger number may well be appropriate. Condition 2 is used to represent some drying, or scattered intermittency, and is considerably more subjective that Condition. 1. Probably every user will have some slightly different idea of what this number should be. The template contains the values above which this author believed continuous flow was likely.

To evaluate the presence or absence of conditions believed likely to produce successful spawning, a logical test is provided for flow and duration between April 15 and June 15 of each year. The values used can be set in the same box as the flow conditions for Central Avenue. Initial values used were 3000 cfs, for a minimum of 7 days, based on conversations with Gary Dean at BOR and Mickey Porter at the Corps. However the user is free to substitute any conditions he deems appropriate for a successful spawn. The logic in column N starts a counter whenever the minimum flow is reached, which continues to increment every day the flow occurs. It resets to zero if the flow is not reached on a day, and a fresh count starts. Logic in column O evaluates whether the count has reached the value specified for minimum duration, and if so writes a "1". Logic in column P tests to see if the value in column O is greater than zero in any year, indicating that successful spawn conditions were met that year.

2.1.6 Considerations to be aware of

At present, flow at Central Avenue is not being partitioned between drain flow and floodway. This may be producing less than the actual number of days/years drying at this point, particularly in the No-Action condition where all drain accretion would likely be routed to supply agricultural need in the South Valley area, rather than being returned to the floodway. A future iteration of the FM will attempt to correct this.

Until Cochiti and Angostura Diversions are incorporated in the model, the FM will tend to overestimate drying, since it is subtracting the full agricultural depletion for each reach, even though the diversion may not be present to meet that supply. This is apparent in the proposed action runs in some years in which the MRGCD has no supplemental storage. If URGWOM can supply information on whether MRGCD is fully supplied or not, some logic can likely be placed in the FM to proportion agricultural depletion to available supply.

The FM is does not incorporate potential rainfall inputs in the MRG. Theses tend to be unpredictable, and no reasonable methodology appeared to allow their inclusion. However, MRG rainfall inputs generally occur in the form of thunderstorms in the July-August period. These flows can and do contribute appreciable volume of water to the river system, however the duration is usually very brief. So while rainfall events might tend to reduce the number of drying days in a given year, it would probably not be a large impact. Also, while the number of days might be reduced, the drying condition

for a year likely would not change. In other words in a particular year, the drying might change from 100 days to 90 days, or 40 days to 30 days, but the drying condition would still have been met in the year.

The influence of summer precipitation events is not completely absent from the FM. The URGWOM model incorporates summer precipitation inputs. As a result the flow entering the MRG used as the primary input for the FM reflects precipitation events upstream of Cochiti Reservoir. Also, precipitation events within the MRG and incorporated in the URGWOM model help to determine NM compact deliveries, and by extension storage of water in and release of water from upstream reservoirs.

Along the same lines as the earlier mentioned unquantifiable groundwater depletions, rainfall events should affect all No Action and Proposed Actions the same way, so the relative difference between conditions should be comparable.

The FM does not account for time-lag between physical points. A flow at Cochiti translates instantly into a flow at San Marcial. Of course this is not reality, but for the purposes of the FM, and especially since other factors (agricultural consumption, riparian evapotranspiration, open-water evaporation, and MRGCD diversions) are entered into the model as averages over time, this is expected to give reasonable results. The FM could be easily time-lagged if desired, but it would introduce another layer of complexity to the spreadsheets, trying to keep up with which rows corresponded, and probably would not produce significantly better results.

Numbers in the model have not been rounded. Although the formatting is set to display only integer values, most numbers are floating point with many digits to the right of the decimal.

3.0 Outputs from Flow Condition Runs.

3.1 No-Action Condition

Several different conditions have been evaluated using the FM. The first, the No-Action (or "baseline") condition consists of 5 runs (separate spreadsheets) , representing 10-year URGWOM flow sequences selected to reflect a 10%, 30%, 50%, 70%, and 90% probability of exceedance. For the No-Action condition, reservoirs are operated under existing rules for flood operations and compliance with the Rio Grande Compact, but do not store or release water for agricultural use by the MRGCD. The ABCWUA and Buckman Direct Diversion continue to divert surface water for municipal use, and release from storage. Consumptive uses upstream of the MRG and not included in this BA, including diversions in Colorado, at Velarde, PVID, on the Rio Chama, and by innumerable small Acequia systems in Rio Grande tributaries will continue. MRGCD diversion from the Rio Grande at the diversion dams does not occur. BOR would not operate reservoirs or the SJC project to supply water to agricultural users in the MRG. Some agricultural use in the MRG will continue through uncontrolled accretions to drains, and subsequent delivery through irrigation canals. Leakage to aquifer recharge, replacing decades of past pumping, as well as ongoing modern depletions will continue. Riparian consumptive use and open-water evaporation will continue. Processing the appropriate URGWOM outputs through the FM results in in the following No-Action (or "baseline) conditions:

Central Ave.	Less than 100 cfs	Less than 100 cfs	Spawn (years out of the 10-year sequence)
	Days	Years	3000cfs/7dys
90%	47	3	3
70%	34	4	6
50%	16	3	6
30%	23	4	6
10%	31	4	8
All (50 yrs)	151	18	27

Below Isleta Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	64	3	261	8
70%	40	4	141	4
50%	16	3	71	3
30%	25	4	68	4
10%	39	5	127	6
All (50 yrs)	184	19	668	25

Below San Acacia Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	447	6	831	10
70%	277	4	640	10
50%	186	5	597	9
30%	175	6	460	8
10%	276	7	668	9
All (50 yrs)	1361	28	3096	46

Below San Marcial	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	824	10	900	10
70%	723	10	787	10
50%	670	10	730	10
30%	547	8	618	9
10%	683	10	765	10
All (50 yrs)	3447	48	3800	49

From the above table, it is apparent that flows less than 100cfs, indicative of possible intermittency downstream from that point, occasionally occur in the No-Action condition. While this represents a relatively small number of total days, it occurs in all 5 flow sequences, and in a little more than a third of all possible years (18 out of 50). Of particular interest is that conditions thought to represent successful

spawning conditions occur just over half the time, 27 out of a possible 50 years in the No Action condition.

Below Isleta Dam there are 19 years in which significant to complete drying could be expected. In half the total years, at least some degree of intermittency between Isleta and San Acacia dams would occur. In the other 25 years, there would presumably be enough flow entering the MRG to prevent drying in the Isleta Reach. Both drying and Intermittency occur in all of the 10 year sequences.

Below San Acacia dam complete or nearly complete drying occurs in over half of all years; and in about half the years in each 10-year sequence. Intermittency is even more dramatic, occurring in 46 out of 50 total years. Intermittency occurs an average of 62 days per year in the San Acacia reach over the 50-year time span. The two driest sequences have drying in all 10 years.

Below the San Marcial gauge, some amount of drying would be expected in virtually every year. In only one or two years in the 2nd wettest 10 year sequence is there enough water arriving at San Marcial to make it likely that the RG would stay connected all the way through to Elephant Butte reservoir.

3.2 Proposed Action Conditions

Under the proposed action, MRGCD diversions of water would occur as normal to meet agricultural demand. Reservoirs would be operated to store water during the spring runoff, for release later in the season to meet that agricultural demand. Other operations and consumptive uses would occur upstream of the MRG as described in the No-Action condition. BOR would operate reservoirs and the SJC Project to supply water for agricultural users in the MRG. No specific conservation measures, such as Supplemental Water, are included in this condition. Processing the appropriate URGWOM outputs through the FM results in in the following Proposed Action conditions:

Central Ave.	Less than 100 cfs	Less than 100 cfs	Spawn (YRS)
	Days	Years	3000cfs/7dys
90%	411	5	3
70%	258	4	6
50%	139	3	5
30%	95	3	6
10%	122	2	8
All (50 yrs)	1025	17	27

Below Isleta Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1187	10	1373	10

70%	1008	10	1208	10
50%	907	10	1127	10
30%	673	9	880	10
10%	779	9	985	9
All (50 yrs)	4554	49	5573	49

Blw San Acacia Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1097	10	1486	10
70%	944	10	1391	10
50%	818	10	1266	10
30%	656	9	1046	10
10%	705	9	1092	10
All (50 yrs)	4220	48	6281	50

Blw San Marcial	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1224	10	1296	10
70%	1155	10	1228	10
50%	1030	10	1122	10
30%	853	10	914	9
10%	907	10	980	10
All (50 yrs)	5169	50	5540	49

Comparing the above tables, with those for the No-Action condition provides an indication of the effects of the proposed action. The Proposed-Action appears to have very little influence on number of years where successful spawning conditions are met. In both cases, the threshold condition (3000 cfs, 7 days) occurs in 27 of the total 50 years. The distribution changes slightly when considering the 10 year sequences separately, with some sequences gaining a year, and others losing a year. The effect on flows is significant, but slightly contradictory. The total number of days of potential intermittency (less than 100 cfs) increases under the proposed action, but at the same time the total number of years in which intermittency can occur decreases (17).

There is a dramatic increase in drying and intermittency at the Below Isleta Dam location. Since MRGCD diverts the largest portion of irrigation water at Isleta Dam, and a primary difference between the two conditions is the absence/presence of diversion dam operation, this is an expected result. Total number of days in which drying occurs (less than 30 cfs) rises from 178 days to 4554. Dividing the number of days by the number of years produces a value of 8days/year for the No-Action condition, compared with 93 days/year for the Proposed Action condition. However it may prove to be more critical to know the

number of years in which drying can be expected, rather than the length of the drying events. The number of years drying could be expected increases in the Proposed Action condition from 21 years to 48 years out of 50. Again, this is an expected result, and consistent with past experience below Isleta dam, where drying has historically occurred virtually every year.

Similarly, there are increases in both number of days and years in which drying occurs at the at the San Acacia Gauge location. Since San Acacia would be expected to experience a much greater incidence of drying under the No-Action condition, the effect of the Proposed Action is not as dramatic as at Isleta. Total number of days increases to 4220, over 48 years. This resolves to 93 days/year, compared to 48 days/year under the No-Action condition. The number of years in which drying occurs increases to 48 under the Proposed Action, compared with 28 years under the No-Action condition.

The difference is even less noticeable at San Marcial Gauge. San Marcial gauge could be expected to experience drying in 48 years under the No-Action condition, increasing slightly to 50 years for the proposed Action. Total drying days increases to 5169, compared to 3447. On a number of days per year basis, this results in a change from 71 days/year to 103 days/year.