Parker Water and Sanitation District
19801 EAST MAINSTREET PARKER, COLORADO 80138

July 13, 2010

Mr. Ray Alvarado
Water Information Section Chief
Colorado Water Conservation Board
1580 Logan St., Ste 200
Denver, CO 80203

RE: Comments on the Draft Phase I Colorado River Water Availability Study Report

Dear Mr. Alvarado,

Enclosed is a report authorized by Parker Water and Sanitation District (PWSD) regarding the draft Phase I Colorado River Water Availability Study (Study). The report constitutes formal comments to the Study and was prepared by Bruce Lytle of Lytle Water Solutions, LLC (LWS).

As you will note upon reviewing the comments, we believe the methodology of the Study is so flawed that the Study should remain in draft form until such time as an independent peer review panel of qualified professionals addresses the flawed data and methodology. Unfortunately, in addition to the Study's flawed methodology, the conclusions and implications of the Study are detrimental to Colorado's position within the Colorado River Compact and among the Upper Basin states, as well as between the Upper Basin states and the Lower Basin.

The residents served by PWSD have a significant stake in the outcome of any study that will influence policies related to the availability and distribution of the state's water. Although PWSD has taken vigorous action to conserve and reuse water, and has invested more than $100 million in Rueter-Hess Reservoir to extend the life of the aquifer, we remain short of water. That shortage is a product of the region's growth and dependence on non-renewable groundwater. And, we are not alone. According to studies by the Colorado Water Conservation Board, even if all of the projects currently being contemplated are built (which includes projects that will derive water from the Colorado River Basin), the area will still need 90,000 acre-feet of additional water by 2040. That is a key reason PWSD has joined with public water providers from Wyoming and the Colorado Front Range to study the feasibility of transferring available water from Flaming Gorge Reservoir to municipalities and public water providers in Wyoming and Colorado.

PWSD's most serious concern with the Study is not that the data is used beyond its level of reliability and the climate models are subject to substantial error, or even that its conclusions have negative implications for the state's residents' water supply, and hence, their quality of life and the economy. Our most serious concern is the lack of leadership in the State of Colorado to defend the state's rightful full compact entitlement.

That, of course, can not be remedied by a study. It will require a significant change in the State of Colorado's approach towards its responsibility of protecting and securing Colorado water.

Sincerely,

Frank Jaeger
District Manager
Parker Water and Sanitation District

Cc: Colorado Water Conservation Board
Colorado Water Congress
Front Range Water Coalition
Flaming Gorge Water Coalition

LYTLE WATER SOLUTIONS, LLC

July 15, 2010

Colorado Water Conservation Board
1580 Logan Street, Suite 200
Denver, CO 80203

Attn: Mr. Ray Alvarado
Water Information Section Chief

Subject: Comments on the Draft Phase I Colorado River Water Availability Study Report.

Project No. 1203-10

Dear Ray,

Lytle Water Solutions, LLC (LWS) represents the Parker Water and Sanitation District (PWSD) and is presenting these comments to the draft Phase I Colorado River Water Availability Study (Study) report on PWSD's behalf. PWSD is a quasi-municipal water supplier for a growing community along the Front Range in Colorado and is responsible for providing adequate water supplies for its current and future residents. As such, PWSD is concerned that the maximum beneficial use of Colorado's allocation under the Colorado River Compact (Compact) is achieved, since the purpose of Colorado's allocation is to serve all of the people of Colorado. Representatives for PWSD have reviewed this draft Study report, and we are concerned because this draft report does not achieve the objective of protecting and preserving Colorado's rightful water supply for future use because available data are not being fairly and accurately evaluated in a scientifically-defensible manner.

The conclusion of the Study that, on the low end, there is zero water availability for current uses, much less future uses, is bad public policy, since it is conceding Colorado's rights based on unrealistic assumptions regarding future use of water and scientifically-unfounded manipulations of available hydrologic and climatic data. A study that produces a margin of error of 1,000,000 acre-feet per year (ac-ft/yr) should be re-evaluated as to whether it has the necessary scientific validity.

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While it is purported that the Study results will provide important information to Colorado water users with respect to future availability, the fact that there is such a large range of water availability and no recommendations regarding water management options leaves water users, water managers, and policy makers to ponder the usefulness of the Study and what guidance it provides. At the same time, the Study results set a dangerous precedent by concluding that there may be no additional water available for development in Colorado from Colorado River resources.

The following sections describe LWS' issues related to the methodologies used to assess future water supply availability based on current uses and the assumptions used to define future demands based on current uses.

HYDROLOGIC ANALYSIS METHODS

The draft Study report identifies the following three means of evaluating water availability that were used in the Study:

- Historic hydrologic records analyses
- Paleohydrologic analyses
- Climate-adjusted analyses

According to the draft Study report, there are historic hydrologic records dating back to 1909 (although they are incomplete) and a more complete 56-year study period, which was used to represent historical hydrology (1950—2005). In addition to these historic gaged hydrologic data, the draft Study report also used paleohydrology analyses from more than 1,200 years of published tree-ring records. The third hydrologic analysis used in the draft Study report is to assess the magnitude of future water supply availability based on potential effects of climate change. A number of different global climate models were used in the Study to complete these analyses.

The evaluation and comparison of these alternative hydrologic analysis methods appears to be prudent at face value, only if one assumes that each analysis has received equal scientific rigor in the evaluations. The statement is made in the draft Study report's Executive Summary that "[w]hile the projections of future climate represented by the GCMs [General Circulation Models] are possible representations of future conditions, the Study provides other hydrologic scenarios to allow water managers, policy makers, and stakeholders to base their decisions and actions on a broad range of future possibilities." This would indicate that all of the hydrologic analyses would, and should, be given equal weight by the Study report. However, the historic hydrologic records analyses and paleohydrologic analyses seem only to serve a minor purpose in the Study, with the analyses (and in particular the results) being dominated by climate-adjusted water availability estimates.

Historic Hydrologic Records Analyses

Using historic hydrologic records has typically been the accepted means for projecting future water supply availability when coupled with a representative set of water demands. While this analysis was completed as part of the Study and the results indicate that between 430,000 and 790,000 ac-ft/yr of water is available for future consumptive use by Colorado (Figure 3-37 of the draft Study report), the analysis is given relatively short shrift in the report and is primarily used as a basis for comparison to the climate-adjusted analyses. Rather than drawing conclusions from the generally-accepted methodology for predicting future water availability, the *Conclusions and Recommendations* section of the draft Study report only describes the results of the climate-adjusted analyses (Page 4-1 of the draft Study report). While the results from the hydrologic records analysis is an equally-likely outcome for future water availability as climate-adjusted values, the range of water availability derived from the historic hydrologic record analyses is not reported in the *Conclusions and Recommendations* section of the report. In fact, this analysis, as well as the paleohydrologic analyses and some of the climate-adjusted analyses, provide a consistent estimate of water availability in the 450,000 to 900,000 ac-ft/yr range, yet this is not discussed as a conclusion of the study.

Paleohydrologic Analyses

Paleohydrologic analyses necessarily have to provide a link between climate and hydrology, and there are many factors related to climate that cannot be used to draw parallel conclusions to hydrologic conditions. For example, it is well known that two years can have the same climatic conditions related to precipitation, but because the precipitation patterns vary, runoff, and soil infiltration and percolation, can be distinctly different in the two years. For this, and other factors that are not well understood, while paleohydrologic reconstructions can be developed, care needs to be taken before incorporating these analyses into future predictive analyses.

Regardless of the constraints related to paleohydrologic analyses, and even though the draft Study report opines that there are more extended droughts and wet periods from the reconstruction of flow records using paleohydrology, the records for a period of over 500 years (Figure 2-4 of the draft Study report) indicate similar flow conditions to the observed period of record. In fact, in several of the reconstructions, the precipitation patterns are wetter than in the historic recorded period of record. This is also reflected in the estimate of water available for future consumptive use through the extended historical hydrology period, which indicates water availability in the range of 480,000 to 890,000 ac-ft/yr (Figure 3-37 of the draft Study report). Again, even with this extended period of record and similar results to the historic hydrologic record analyses, neither result is reported in the *Conclusions and Recommendations* section of the draft Study report.

Climate-Adjusted Analyses

LWS has numerous issues with the analyses conducted in the Study related to climate change, starting with the use of global circulation models (GCMs) with an extremely large grid discretization to questionable methodologies of taking limited data from these GCMs and making very site-specific conclusions from theses analyses. In fact, the Study team seems to acknowledge these shortcomings, as it was stated in the *Conclusions and Recommendations* section of the draft Study report (Page 4-1) that

> "[t]he primary underlying drivers for the broad range of Phase I results are 1) the inherent uncertainties in the available global climate models in projecting the magnitude and nature of future of greenhouse gas emissions; 2) the complexity of modeling atmospheric circulation; and 3) down-scaling the resulting effects of changed temperature and precipitation on natural flows in an area the size of the Colorado River Basin."

Regardless of this conclusion and the statement in the draft Study report text on climate change hydrology that states "[t]he problems with this coarse resolution [of the GCMs] are that it does not represent very well the mountainous terrain in Colorado, and the scale of the grid cells is very large compared to the watersheds that supply water within Colorado" (Page 2-19), the draft Study report conclusions still represent that the results from the climate-adjusted analyses are scientifically valid. No justification is provided, which is warranted, particularly in light of the seeming acknowledgment that there are several shortcomings in the methodologies.

Initially, we have serious concerns with the scientific validity of GCMs in general. One issue that is not discussed in the draft Study report is whether these GCMs have been calibrated to existing conditions. Typically, future predictive models are calibrated based on historical data to see if the models can replicate the historical data. Without such calibration, these models cannot initially be used as any reliable predictor of future conditions. Beyond such calibration, with the grid discretization of these GCMs, only one temperature and precipitation value can be obtained for each time step in the model per cell. Therefore, the values obtained from any GCM is averaged over the grid size. As acknowledged in the draft Study report, this coarse resolution means that temperature and precipitation data may be averaged over an area extending from the Continental Divide to Cortez, or from the Continental Divide to the Dinosaur National Monument, both very different climatic regions which would be averaged in one cell of the GCMs.

Beyond this averaging effect, based on the grid size of the GCMs, Figure 2-9 in the draft Study report shows how varied the results from the GCMs can be. With GCM data so scattered, how can the Study team have confidence that any prediction is accurate? Obviously, with such scattered results, the accuracy of (a) the input data, (b) the assumptions of the model, and/or (c) the algorithms used to depict air circulation patterns is put into question . Therefore, the use of GCMs as the starting point for the Study related to climate change effects raises serious concerns.

In addition to the accuracy of the GCMs to predict the future climatological conditions, our concern with this study is also directly related to the scientifically-unjustified manipulation of the GCM model data. The Executive Summary of the draft Study report states that "[t]his Study is likely the most rigorous and detailed study performed to date that utilizes GCM output and extends the analysis of potential effects to potential impacts of all the water uses (consumptive and non-consumptive) in an entire river basin" (emphasis added). While the Study team recognizes the inadequacy of GCMs to evaluate site-specific flow patterns in the Colorado River Basin by stating in the draft Study report that they can "not represent very well the mountainous terrain in Colorado," the Study team proceeds anyway, using very large extrapolative methods to achieve an end by "extending the analysis." That is, estimating future flow conditions in small sub-basins based on single temperature and precipitation values from the GCMs that cover many multiples of the sub-basin areas. The procedure described in the draft Study report is a consecutive, step-wise process of taking imprecise data from one step to the next, thereby compounding the errors in the analysis as the process continues.

According to the draft Study report on page 2-19, this step-wise procedure to "extend the analysis" was a "downscaling" to "translate the outputs from GCMs to a scale that is useful for hydrologic modeling in Colorado." What this means is that single outputs from the GCM over a large area were then modified to be more "representative" of individual sub-basins. However, there is no scientific justification that this manipulation from a large scale to a small scale is representative.

Regardless of the resolution of the GCMs, the draft Study report presents estimated flows at gages in drainage basins considerably smaller than 40,000 square miles, as shown in Table 1. The largest drainage area where flows were simulated is 8,050 square miles (Colorado River near Cameo), which requires the GCM results to be extrapolated and adjusted approximately 5 times from the model resolution, while the smallest drainage area hydrograph is 102 square miles (Colorado River near Grand Lake), which would require an extrapolation in resolution of 392 times from the GCM results. Since the GCM model results cannot provide this resolution, estimates of flow made by the Study team are not based on, nor can be justified by, use of the GCMs. To illustrate, Figure 1 shows the size of the CGM grid and some of the drainage areas where future flow characteristics are estimated in the study report (Table 1). These estimates cannot be made from the GCMs.

No explanation, or justification, is provided in the draft Study report as to how this large extrapolation in resolution was based (given that there are no future data projections at this resolution available), or what was the scientific basis for this type of analysis. In addition, there is no mention as to whether this methodology will produce, if applied to historic weather predictions, repeatable results to actual historic flow data. Independent peer review of the validity of this approach is necessary, particularly given the wide range of results that are projected (e.g., see Figure 2-9).

Regardless, these down-scaled data were then input to a hydrologic model (a variable infiltration capacity model) to derive flows in sub-basins using extrapolated and interpreted data as input to the model. As previously described, this maneuver only increases the probability of compounding the error in the analysis.

For example, a variable infiltration capacity model such as the one used for the Study has to simulate soil types, percolation/infiltration capacities, changes in soil moisture, evapotranspiration, and snow versus rainfall dynamics. However, as a precursor to any infiltration model, there also has to be accurate representation of the precipitation falling within the basin drainage area. The draft Study report indicates that localized thunderstorm activity and monsoon-type precipitation patterns were difficult to account for in the climate models (Page 3-11). However, there are several portions of the Colorado River Basin in Colorado where these types of precipitation events dominate the summertime precipitation volumes. Therefore, not only is there difficulty in accurately establishing all of the parameters which relate to either runoff or soil infiltration, but there is also difficulty in providing representative precipitation data, which can greatly affect the resultant stream flow estimates. Because of the importance of this step in estimating future water supply availability, LWS would also recommend that an independent peer review of the validity of this approach be conducted.

In conclusion, the climate-adjusted analyses in the draft Study report (1) take GCM output from the 40,000 square-mile grid, which admittedly is a problem in Colorado due to the mountainous terrain and the coarse resolution of the model, (2) then take these average precipitation and temperature data to "downscale" output from the GCMs using large extrapolation techniques, (3) then derive site-specific hydrologic factors for individual sub-basins, (4) then run a hydrologic model to estimate runoff under climate-change conditions using factors not found in the GCMs, and (5) use the results as evidence of the future water availability in the Colorado River for Colorado's Compact allocation. This is an unacceptable scientific procedure and, in our opinion, represents bad public policy relative to maximizing beneficial use of the waters of Colorado. Given the questionable techniques that were used in each step of this process renders the final product related to water supply availability highly suspect, as the errors in each step are compounded in reaching the final conclusion on water availability. Furthermore, these steps have ultimately resulted in the sole conclusion that, on the low end, there could be zero water available for Colorado's remaining Compact entitlement (even under current uses), even though the majority of the analyses in the Study reach significantly different conclusions. This means that available data have not been fairly and accurately evaluated in a scientifically-defensible manner and, as a result, puts Colorado's actual remaining Compact entitlement at risk.

This draft study report should not be allowed to be finalized until methodologies used to derive future stream flow estimates are fully vetted for their scientific accuracy, defensibility, and applicability to this study. Independent peer review by qualified professionals is required for this process, in addition to the public being allowed to evaluate and comment on these methodologies. Only analyses that can be fully defended on the scientific bases described above should be included in the Study report.

STUDY ASSUMPTIONS

While LWS has serious concerns related to the water supply estimates presented in the draft Study report, the assumptions used in this Study also exacerbate the estimates of depleted water supply availability. The assumption in the Study that all current operating and management practices are unchanged, even though the Study projects water supply availability and demands to the year 2070, is unrealistic, particularly for the alternative where temperatures are increasing and overall water supply availability is decreasing. For example, the draft Study report assumes no change in irrigation efficiency for the next 60 years, even stating that diversion efficiencies can be as low as 30 percent (Page 2-38). In addition, currently-irrigated acreage and crop types are also carried forward for 60 years, which results in the potential for an increase of approximately 350,000 to 500,000 ac-ft/yr of water for crop irrigation requirements (Table 3-5 of the draft Study report). With continuing growth in Colorado and limited available water supplies (with or without climate change), to produce a report which assumes that irrigated agriculture could increase by 20 percent in the future and that no further water management efficiencies will be implemented in the next 60 years is irresponsible.

In fact, one aspect where this Study report would be of benefit would be a discussion of the potential water management options so that maximum beneficial use can be achieved from the limited water supplies which are available. For example, the results of the Study indicate that more surface water storage is required, better efficiencies in irrigation practices are needed, and water banking concepts should be explored and developed to protect against water supply shortfalls in dry years.

COLORADO RIVER COMPACT

In assessing water availability to Colorado under the 1922 Colorado River Compact (1922 Compact) and the 1948 Upper Colorado River Compact (1948 Compact), future water availability estimates in the draft Study report which impose climate change appear to be based on the equal apportionment of 7,500,000 ac-ft/yr of water for the Upper Basin states and the Lower Basin states, with the allocation of 51.75 percent of this water to Colorado under the Upper Colorado River Compact. However, the draft Study report also says that the modeling in the Study adopts the 2007 United States Bureau of Reclamation Hydrologic Determination (Hydrologic Determination), which found that approximately 6,000,000 ac-ft/yr of water per year is available for the Upper Basin states. It is unclear in the draft Study report whether the Study is basing future water availability on equal

apportionment or the reduced volume used in the Hydrologic Determination. If the Hydrologic Determination values are the basis for future water supply availability in the draft Study report, LWS questions why Colorado would be willing (a) to accept anything less than an equal water allocation between the Upper Basin states and the Lower Basin states and (b) to further accept the sole burden of potential reductions in flow due to global climate change as part of Colorado's Compact entitlement, rather than work to protect its rightful Compact entitlement?

SUMMARY

This draft report should not be finalized until all of the methods used have been fully vetted for their scientific accuracy, defensibility, and applicability, and until the draft Study report has been fully and independently peer-reviewed by qualified professionals. The following issues need to be resolved:

(1) GCMs have to be fully calibrated to historic conditions before being used for future predictions.

(2) How can any analysis be accurately based on GCMs that have such variable results?

(3) How can GCM output data that produces one value for each time step over a 40,000 square-mile area (cell size) be used to predict flows in basins as small as 102 square miles?

(4) How can the accuracy of down-scaling be justified when there are no data to support such site-specific extrapolations?

(5) When most of the likely outcomes from the various hydrologic analyses are in a common range (approximately 450,000 to 900,000 ac-ft/yr (Figure 3-37)), why is one result (0 to 1,000,000 ac-ft/yr from the climate-adjusted analyses, which appears to be an outlier) emphasized in the *Conclusions and Recommendations* section, to the exclusion of the more common outcome?

(6) Why would the Study assume no changes in water management in the future, even though significant changes in water supply are predicted?

(7) Why would Colorado adopt a policy that is anything less than an equal apportionment of Colorado River water between the Upper Basin states and the Lower Basin states?

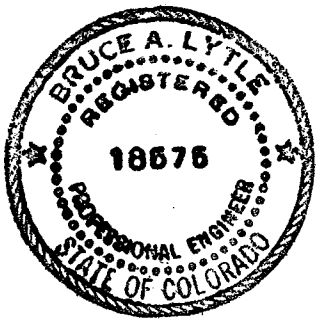
Colorado needs to be diligent in developing its rightful entitlement to Compact water for Colorado. The Colorado River is an important resource for future Colorado water needs and the maximum beneficial utilization of this resource would minimize impacts to agriculture and Colorado's rural

communities. Basing study results on questionable science is bad public policy, particularly when it can result in conceding Colorado's rightful entitlement. Because Colorado's entitlement needs to be fully protected, the draft Study report should not be finalized until all of these issues are fully vetted and only scientifically-justifiable results are presented. Steps should also be proposed in the Study report to secure Colorado's full Compact entitlement.

If you have any questions regarding our comments on the draft Study report, please feel free to give us a call.

Yours truly,

Bruce A. Lytle, P.E.
President



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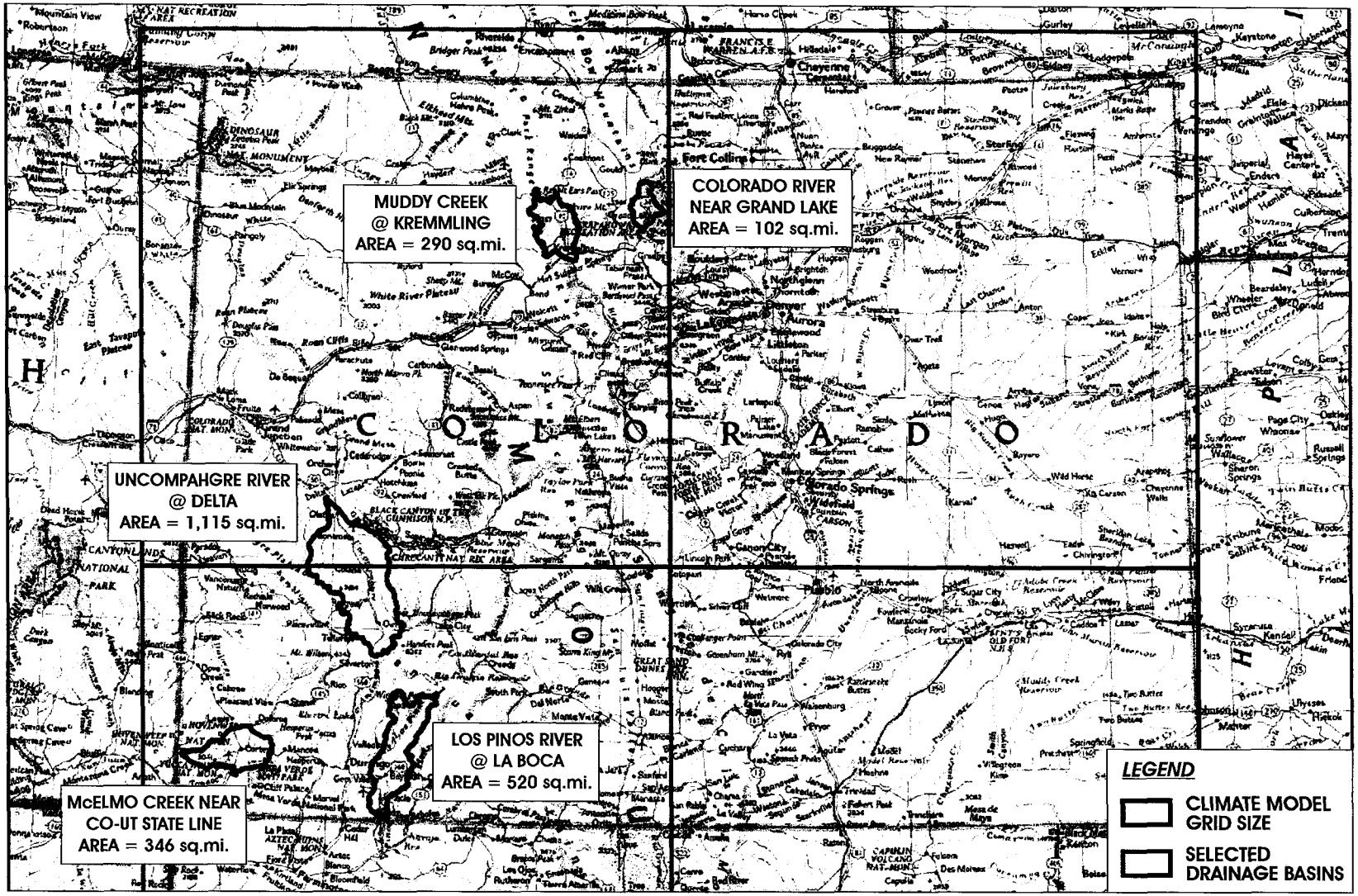

N

0 60 miles

Note:
Grid size is based on description of climate models from Colorado River Water Availability Study, March 22, 2010. Each grid cell is 200 miles x 200 miles (40,000 sq.mi.). Grid origin is unknown and the placement shown is for illustrative purposes only.

PARKER WATER AND SANITATION DISTRICT

CLIMATE MODEL GRID AND DRAINAGE BASIN COMPARISON

File Name: ClimateModelGrid.cdr		Date: 05/10/2010
Project No.: 1203-10	Drawn By: VAL	Fig. No.: 1

TABLE 1
DRAINAGE AREAS OF FLOW GAGES REFERENCED IN COLORADO RIVER WATER AVAILABILITY STUDY

Gage	Drainage Area (mi^2) [1)2]
Uncompahgre River at Delta	1,115
Colorado River near Grand Lake	102
Colorado River at Dotsero	4,394
Colorado River near Cameo	8,050
McElmo Creek near CO/UT State Line	346
Muddy Creek at Kremmling	290
Los Pinos River at La Boca	520
Gunnison River near Gunnison	1,012
Gunnison River near Lazear	5,241

1) The grid size of the climate models is 40,000 square miles.
2) From USGS gaging station data.