RGDSS Memorandum
Final

To: Mike Sullivan, P.E. Colorado Division of Water Resources
James Heath, P.E. Colorado Division of Water Resources

From: Eric J. Harmon, P.E. HRS Water Consultants, Inc.

Subject: Review of RGDSS model grid documentation

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Introduction

HRS Water Consultants, Inc., was requested by the State to provide concise documentation on internal RGDSS documentation of the extent of the RGDSS model grid. We have prepared this memorandum in response to the State's request. HRS has worked on the ground water component of the RGDSS on a continuous basis since its inception in 1999, and also worked with the State on the RGDSS feasibility study (with State contractor RTI and subcontractor Boyle) in 1998. Not every discussion item between the State and its RGDSS contractors, including HRS, was captured in a task report. I have clear recollections of discussions with the RGDSS team in the early RGDSS phases as to the extent of the model grid and how to treat stream inflows at the Rio Grande and at the smaller "rim inflow" streams that enter the SLV at various points. This memorandum provides documentation of the RGDSS model grid extent.

Approach

1. Rio Grande Valley

Following is a brief recap of the reasoning for the extent of the RGDSS model grid, with emphasis on the upper Rio Grande valley (i.e. Rio Grande valley above Del Norte).

- The San Luis Valley, as a physiographic feature, most often is not considered to extend west of the water gap formed by the volcanic rock promontories that form the north and south boundaries of the Rio Grande valley at Del Norte ("Del Norte water gap").
- The geologic horizons that make up the unconfined aquifer and important geologic strata of the confining units and the confined aquifer of the San Luis Valley, including the sediments of the Rio Grande alluvial fan, the Alamosa Formation confining clays and alluvial fan deposits, and Santa Fe Formation sediments that comprise much of the confined aquifer, do not exist as subsurface aquifer or aquitard layers in the upper Rio Grande valley upstream of the Del Norte water gap.
- In addition, during Phase 1 of the RGDSS, in the 1999 – 2000 time period, it was decided by the RGDSS development team (State, HRS, Hydrosphere [now AMEC] and others) to terminate the model grid at the narrow Rio Grande valley water gap at Del Norte for the following reasons.
    - The Del Norte gauge and the measured canal diversions are well located to allow quantification of surface water inflows and thus provide a long history of records of surface inflow to the San Luis Valley at that location.
    - The volcanic extrusive rocks that form the narrow water gap are immediately beneath the Rio Grande stream alluvium in the subsurface, and are of relatively low hydraulic conductivity as compared to the stream alluvium.
    - Alluvial ground water underflow entering the San Luis Valley at the Del Norte water gap can be estimated readily on the basis of Darcy's Law inputs, including cross-sectional area, hydraulic conductivity, and water table gradient.
    - The alluvial ground water underflow at the Del Norte water gap is a very small fraction of the surface water base flow plus canal diversions in the Rio Grande at (or near) the Del Norte gauge, and thus the effect of any uncertainty in the ground water inflow component from the upper Rio Grande valley to the San Luis Valley at that location is minimal.
    - Due to the constriction in the upper Rio Grande valley at the Del Norte water gap, most ground water that exists as underflow above that point discharges as surface water and is captured in the Del Norte gauge and the canal gauges. Thus it was

felt by the RGDSS team that there would be minimal probability of any depletive impacts from ground water pumping in the San Luis Valley reaching upgradient to any points above the Del Norte gauge / water gap area.

- The primary water-producing stratigraphy in the San Luis Valley, i.e. the Layer 1 unconfined gravels, the Layer 2 confining series, and the Layer 3 Santa Fe Formation sediments, do not exist west of the Del Norte water gap. The relatively low-permeability Conejos Formation volcanic and volcaniclastic rocks exist beneath the Rio Grande alluvium in the Rio Grande valley upgradient of Del Norte, but due to their relatively low hydraulic conductivity, it was felt that ground water underflow from this source in the Rio Grande valley area to the San Luis Valley is minimal.

2. Other Model Grid Boundary Areas

It was decided by the RGDSS development team in the 1999 – 2000 time period to terminate the model grid at the geologic contact between the alluvial fan sediments at the outer edges of the San Luis Valley and the bedrock formations that exist outside of the San Luis Valley proper, for the following reasons.

- In the alluvial fans just downgradient of the bedrock / fan contact, the majority of the small streams that enter the San Luis Valley from the San Juan Mountains and the Sangre de Cristo Mountains are perched above the regional water table. Thus any depletive impacts due to ground water diversions in the San Luis Valley are isolated by the intervening unsaturated zone, and therefore would not propagate upgradient above the geologic contact.
- Ground water underflow in the bedrock formations immediately below the rim-inflow streams is minimal due to generally lower permeability in the bedrock formations as compared to the overlying unconsolidated formations.
- The majority of the geologic contacts between the bedrock formations outside the San Luis Valley, and the layers inside the San Luis Valley (i.e. the Alamosa Formation confining clay series and the Santa Fe Formation sediments) are faulted contacts, and

from empirical evidence and field observations, most of these fault contacts are of relatively low hydraulic conductivity. Thus it is very unlikely that any depletive effects from within the San Luis Valley would be transmitted up into the mountain fronts through the deeper formations.

- The model grid used in RGDSS initial development was closely coincident with the State's model grid developed in the late 1980's – early 1990's, and thus allowed initial estimation of inflow and outflow at comparable locations.

3. Model boundary mentions in RGDSS task memoranda

RGDSS feasibility study RTI, Boyle, HRS July, 1998

Most of the ground water model discussion has to do with data needs, improved resolution, adding streams within the model area, and basing drain flows on measurements, not on estimates and calibration. There is no mention of discussion of the model grid extent, or of including streams or the Rio G upgradient.

RGDSS Phase 1 Documentation

Task 2: Documentation of the SLV GW model (State's model) HRS 7/1999

HRS was tasked by the State with documenting Mr. Dewayne Schroeder's (State's) model, as no documentation accompanied his modeling in the late 1980's – early1990's, culminating in his testimony at the 1992 AWDI trial.

p. 14 of 124: "The areal extent of model layers is defined by the geologic boundaries imposed by the San Juan Mountains to the west and north of the SLV, the Sangre de Cristo mountains NE of the Valley, and the state boundary between CO and NM to the south."

p. 37 of 124: "General head boundaries used to simulate ground water inflow entering the San Luis Valley as underflow from the San Juan Mountains are located along the western boundary of the model (Figure 36).

p. 38 of 124: "General head boundaries were used to simulate underflow in the alluvium in the area where the Rio Grande enters the model area at Del Norte."

Task 4: Ground Water Budget Data HRS (10/2000, revised 1/2002, re-revised 6/2004)

p. 5 of 33: "In the State's model in the AWDI trial (Schroeder, 1991) Layer 1 (unconfined aquifer) ground water inflow to the valley is represented as a general head boundary to simulate flow through the Rio Grande River alluvium in the water gap at Del Norte. Inflow through the alluvium at that point averaged 5714 ac-ft/yr, (approximately 8 cfs). Hydraulic conductivity for the Rio Grande alluvium at Del Norte was estimated to be 75.7 ft/day[1]. There were no other ground water inflows to Layer 1 from outside the model boundary."

Conclusions

HRS concludes, based on physiographic, geologic, and hydrologic factors as discussed herein, that the extent of the RGDSS model grid as originally developed, and as refined from time to time throughout the course of RGDSS development and peer review, has been appropriate and reflects the best technical information available.

Comments and Concerns

None.

[1] RGDSS Ground Water Component Task 2 Memorandum, 1999, p. 92, figure 39.