10 Applications of the COHYST 2010 Models

Prior sections of this documentation report have described the COHYST 2010 model as it now exists. This final section of the report discusses how the model can be applied and identifies some improvements that may be considered going forward.

10.1 Functionality

The COHYST 2010 model as it now exists consists of functional component models which reliably produce stable results when properly run individually and as an Integrated Model. The modeling team has identified the following factors that represent limitations on model functionality for those outside the initial modeling team.

- To run the surface water model, a user must acquire a licensed copy of the STELLA platform. Currently, there are no other requirements to acquire proprietary software to operate the COHYST 2010 model package.
- Model operation likely requires an experienced user base on the complexity of the models and their inputs. User's guides have been written for the Watershed model, and a graphical user interface has been developed for the Integrated Model.

10.2 Suitable Applications of the COHYST 2010 Model

The primary intended application of the model is to help evaluate possible water management strategies through simulation of "what if" future conditions. The models will quantify the relative changes in hydrology from such future conditions, compared to a future in which management is not changed. The COHYST 2010 Integrated Models have been used by varies Sponsors for evaluation of Water Management alternatives. These evaluations have tested the individual and integrated models. The 3 project evaluation efforts included the Conjunctive Water Management group, the Platte Basin Over-Appropriated Area Committee, and the Platte River Recovery Implementation Program.

10.2.1 Conjunctive Water Management Evaluations

The Conjunctive Water Management project evaluations are for the Surface Water Irrigation District canals in Dawson County, NE. The project sponsors include NDNR, NPPD, and CPNRD. Eight project evaluations have been completed for the Dawson County canals. The scenario's descriptions are;

1A No Surface Water Delivery and Groundwater Pumping

2 Isolate CNPPID system impacts

3A Main Canal Recharge – Leave CU in River – Non CU demand would be diverted

4A Expanded Surface Water delivery in Canal area

5A Excess Flow Diversion for canal recharge outside irrigation season

6A NPPD canals use Surface deliveries and CPNRD canals use Groundwater deliveries

7 Drought analysis using 2002 thru 2005 period repeated 21 times for 84 years

8 NPPD canals use Surface water deliveries from Natural Flow and Storage and CPNRD canals use Surface water deliveries from Natural Flow only. CPNRD canal storage water is diverted in fall for GW recharge.

Note for each scenario run with an A there was a B run which made the Lake McConaughy releases the same as the Baseline releases. This was done to help understand scenario results that were from changes in canal operations and not from Lake McConaughy release rules. The Integrated Models used for these project evaluations was COHYST 2010 Run 26b_13_25. If further evaluations are done Integrated Models Run28b_14_28 will be used. The results from the 8 scenarios provided realistic conjunctive water management comparisons and provide positive testing of the COHYST 2010 models.

10.2.2 Platte Basin Over-Appropriated Area Evaluations

The Platte Basin Over-Appropriated Area project evaluations include one, a Study of Conservation Practice effects on Stream flow and Groundwater Recharge and two, a Robust Review Study that evaluates land and water management changes made between 1997 and

2013. Both of these project evaluations are being done by the Platte Basin Coalition which includes representatives from 5 Platte River NRD's and NDNR. The Conservation Practice Study is using the COHYST 2010 Run 28b_14_28 Integrated Models to evaluate no-till farming practices and irrigation efficiency changes that have occurred during the 1950 thru 2010 period. The Robust Review study is using the COHYST 2010 Run 28b_14_28 Watershed and Groundwater Models to evaluate future effects of change sense 1997 in irrigated acres, in M&I pumping, plus in Excess Flow diversion to Surface Canals in 2011, and 2013 for groundwater recharge and baseflow return to the Platte River. These evaluations are underway and the baseline runs have been made and the changes runs are in development. The Platte Basin Coalition members are looking forward to using the results from these analysis in the Basin wide planning effort.

10.2.3 Platte River Recovery Implementation Program Evaluations

The Platte River Program project evaluations are being conducted using the COHYST 2010 Integrated Models which were extended back in time to 1947. The extended baseline was developed for the Integrated Models to allow future water supply management scenario's to be developed and compared with existing 1947 thru 1994 water supply analysis previously develop with a monthly Water Operation Program (OPSTUDY). The Program has 3 baseline water supply management projects that were implemented after 2007. They include an 100,000 AF Environmental Account in Lake McConaughy, additional storage added to Pathfinder Reservoir in Wyoming, and the 10,000 AF water supply retiming Tamarack Project along the South Platte River in CO. These water supply management projects may be studied by the Program using the COHYST 2010 Models. The Program along with other new water supply management projects are being studied by Program staff using the COHYST 2010 Models. The results should lead to recommendation on additional water supply management project for development by the Program.

10.2.4 – Testing scenarios

During development of the model, technical committee members were asked to identify scenarios of possible interest for testing the model. Examples of such scenarios are listed below, and some or all could be tested. Note these are not intended as real scenarios, but as tests to confirm the model meets Sponsor expectations with respect to model capabilities.

1. Convert some or all irrigated lands to dryland.
2. As above and eliminate reservoirs (pre-development condition).
3. Convert some or all dryland acres to well irrigation.
4. Convert some or all crops to corn.
5. Assume various limits on the amount of groundwater pumped per acre.
6. Convert all surface water use to groundwater; or do so for a given District.
7. Eliminate all power demands from reservoir rules.
8. Only release natural flows from Lake McConaughy.
9. Simulate lining of one or more canals.
10. Simulate using canals for recharge in winter.
11. Pump a single hypothetical well for 40 years at different distances from river.

The results to date indicate the model is capable of being applied to a variety of management evaluations. Typically, a reference case simulation will be run – this may reflect a repeat of historic conditions or some other baseline scenario simulating the future with no change in water supply, use or management. Then, if model inputs are adjusted to reflect an assumed change in climate, land use, reservoir operations or other condition, the model results are expected to reliably measure the types and magnitudes of most changes in the water budget that will occur when extended time periods and regional areas are considered (e.g. multi-years; counties).

Examples of appropriate model applications include answering the following.

- If rates of groundwater pumping change, what is the relative effect on streamflow resulting from changes in baseflow?
- If surface water is run through unlined canals outside the irrigation season, how will the aquifer respond to the extra recharge from seepage?

- If an entire irrigation district is retired, and the use of the water is not reassigned, what effects can be expected in upstream reservoirs where additional water for storage may now occur?

Many other examples could be given, but all fit the same pattern: if inputs reflect a change in water supply or use (whether from nature or management), the model will simulate how the surface water and groundwater systems respond in comparison to a future without the change, with results expected to be reasonably[1] accurate as to the location of the changes, the direction of the changes, and the approximate magnitude of the changes.

With proper care, the model also can be used for various administrative purposes. For example, changes in streamflow (timing, location, quantity) that result from new uses since 1997 can be approximated by running the model with and without those uses. Another potential application is to calculate the amount of pumping that would be in balance with long-term average recharge, so long as it is recognized that the result is highly dependent on what assumptions are made about climate, land use and other factors that impact such recharge.

When application of the integrated model is being considered, the modeling team considers the results will track trends in the water budget through wet and dry cycles, and in particular the effects of “what if” scenarios on reservoir operations and on aquifer water levels.

There are known limitations in the model, as illustrated by the following examples.

1. The model does not capture flood runoff events or times of significant loss of surface water to the aquifer. Such events can be important to actual water supply conditions but cannot be predicted or adequately modeled.
2. Under recent climatic conditions, the Platte River is observed to be a losing stream over substantial lengths and times. The current Integrated model has been calibrated to such dry conditions, and as a result the model under estimates river flows during wet years.

[1] The assessment of model results as “reasonable” is a professional judgment, the validity of which can be evaluated by others through review of the results presented in this report.

3. The most suitable time scale for the model is years or decades, not individual seasons, months, or days and thus it should not be used for surface water rights administration on a real time basis.

These issues do not prevent use of the model for evaluation of management scenarios, but they do indicate a need for caution in interpretation of model results that may be impacted by a listed deficiency. See also issues identified in Section 9.

10.3 Examples of Some Unsuitable Model Applications

The model as now constructed is to be used for change analyses, and not for prediction of a specific real-world quantitative result, such as the actual amount of seepage loss to be expected from an environmental account release, or the amount of drawdown resulting from approval of a particular new well. However, for both these examples, the model does provide a platform which can be improved upon and made useful to answer the desired question. Likewise, the model is not now designed to determine if a region in the basin is fully-appropriated or over-appropriated, but it can be adapted for that purpose.

More generally, the main constraints on using the model can be thought of as issues of scale. Use of the model to identify regional scale or long-term changes is generally appropriate; use of it to address local or short-term effects must be done with caution. An example is the effect on the Tri-County Canal groundwater mound if farmers convert from use of surface water to groundwater. If this question is posed at a county scale and for effects over many years, the model will give useful results. If the question were asked about a single user of surface water and effects in a particular year, the model results at best would be suggestive of what may happen.

10.4 Priorities for Model Modifications and Improvements

It has always been intended that Phase II of COHYST 2010 will be followed by a Phase III during which additional model updates will occur. The primary model upgrade that is deferred to Phase III is to update the modeling time period thru 2015 or 2016.

Other model improvements have occurred outside of COHYST 2010. For example, DNR, HDR, and Flatwater have extended the model timeframe back to 1950, an action originally identified as a Phase III activity. Details of this work are found in the Platte Basin Planning effort and the Platte River Program water supply studies, but without any recalibration.

Now that the COHYST 2010 models are completed, it is expected that localized refinements will be accomplished by water regulators or suppliers. As one example, if an NRD needs to assess the impacts of a new well field on other wells or evaluate groundwater recharge basins it could use the existing groundwater model as a framework. A likely approach would be to telescope in a sub-model with a finer-scaled grid (and even add a second layer) in the area of the proposed well field or recharge basin. Location-specific hydrogeologic data would be used to improve characterization of the aquifer in the area of interest, and actual historic pumping data would substitute for the generalized inputs from the watershed model. The telescoped portion of the model would then be recalibrated using local hydrographs, with the COHYST 2010 model serving to define boundary conditions at the margin of the telescoped component. With all this work accomplished, the resulting model would be the best tool available to assess the impacts of a new well field or new groundwater recharge basins.

10.5 Conclusion

The technical team recognizes that the model package is a simplified representation of reality. Nonetheless the team has confidence that the models will produce useful results. The root of this confidence lies in the fact that the model package represents a complete water budget (with some comparatively minor exceptions such as vadose zone storage) and, further, the links in the modeled budget have generally been verified as accurate against past data (again there are some limits, such as the inability to capture flood events). Model errors have been identified and corrected through model the development, calibration, and verification process.

Because the model captures a complete water balance with reasonable fidelity to historic observations, any change in model inputs will of necessity be fully balanced by changes in other parts of the budget, with responses that are consistent with historic relationships. A what-if scenario that adds to the water supply will result in more water in streams or in the aquifer in locations and amounts proportional to what has been observed in the past. A scenario with increased water use will predict changes in depletions within streams or groundwater, again using relationships that were verified through comparisons to past conditions.

For the system as a whole, while the exact numeric results from scenario runs will be approximate, no water will be lost or gained in the process and, as best we know, no water will be routed inappropriately. Therefore, evaluations of changes in hydrology that reflect changes in model input assumptions should be sufficiently accurate to be useful in decision-making.

The test and proof of model usefulness will occur from the practical applications of the model tools in the future.