

**Minutes of the
Groundwater Modeling Technical Advisory Group
Metropolitan Council – M94 Office Park
October 11, 2007
10:00 AM – 12:00 PM**

Chris Elvrum, Metropolitan Council, moderated the meeting. Introductions were made; an attendance list is attached.

Synoptic Groundwater Level Measurement – Sue Langer, Chris Sanocki, & Tim Cowdery, USGS

Sue Langer discussed plans to conduct a regional synoptic water level measurement in March and August of 2008. One of the primary objectives of this project is to serve as a database framework. The plan is to measure the Prairie du Chien-Jordan (PDC-J) aquifer, the Franconia-Ironton-Galesville (FIG) aquifer, and the Mt. Simon aquifer. Water levels will be documented and compared to previous data. Approximately 230 wells were measured in the 1989 USGS measurement; these wells will be re-measured (if they still exist). Sue asked the group for information about additional observation wells to include.

Ray Wuolo asked if the MPCA had data from a synoptic water level measurement done in the 1990s. Andrew Streitz affirmed; he noted that the data was passed to the Metropolitan Council. Chris Elvrum noted that Gail Haugland from the MDH gave him a reference for this database of public supply wells. Steve Robertson also noted that he has this data.

Bill Olsen wanted to verify that the USGS was planning to address the PDC-J as a single aquifer and that measurements from the Prairie du Chien, Jordan, and multi-aquifer wells would be lumped together. He asked if the USGS was looking for new wells screened in only one aquifer or wells that were screened through both the Prairie du Chien and Jordan. Tim Cowdery clarified that the PDC-J would be addressed as a single aquifer in this project, but that it would be possible for others to break apart the aquifers in later analyses. Tim would prefer new wells to be screened in only a single aquifer, but that he will take data from any well he can get.

Bill Olsen commented that the synoptic data would be more meaningful if they were overlaid on continuous measurements at many wells. Dakota County owns 6-10 probes, and other organizations have them as well. Bill suggested getting probes installed across the metro area during the synoptic measurements. Randal Barnes concurred and added that the northern part of the Prairie du Chien is daylighting. He asked if surface water measurements would be made at the same time as the groundwater measurements to address the connection between the two systems. Ray Wuolo suggested that the DNR volunteer network might have useful data. Tim Cowdery noted that SCADA data is also available.

Amal Djerreri asked how the synoptic water level data would be incorporated into the groundwater flow model. Ray Wuolo noted that the data would be collected too late for inclusion in the initial model, but that this data could be used for later calibration.

Sherri Kroening wanted to know if the product will be a map of potentiometric surfaces, and if this work will be done on an ongoing basis like they do in other states. Tim Cowdery responded that the USGS is working to provide a database that would make future measurements less costly. ???

Ray Wuolo asked if the historic data set is available now. Tim Cowdery said yes, but it is still incomplete. The goal is to finish adding and verifying data from Hennepin County next week.

Sherri Kroening asked if water usage would be included in the analysis. Sue Langer said that pumping would be considered in this work, but that pumping data would not be included in the data analysis or in the final report.

Chris Elvrum reminded people to contact the USGS or Metropolitan Council if they were interested in participating.

Bill Olson suggested that the Metropolitan Council should make it a point to get surface water monitoring & management organizations (like Steve Kloiber and Karen Jensen at Met Council) to get out and measure during the synoptic. Lake elevation, stream stage, and flow data would be useful. Amal Djerrari pointed out that the quaternary aquifers would not be monitored. However, a synoptic measurement is expensive and lake levels are cheap. It seems logical to compare them.

Bill Olson noted that Dakota County would want the St. Peter and bedrock valley sediments monitored. He asked if Sue Langer would manage data for those wells, too. Tim Cowdery said that the USGS would incorporate that data. He clarified that budget restrictions on the project mean that the USGS can't make additional water level measurements and add new wells, but they will incorporate any data that others are able to collect. A good well log would need to accompany any data to be included in the synoptic database. Sue clarified that the database will be a product of this project, so any additional data added to the database will add value to the project.

Evan Drivas asked if the database will be compatible with the DNR observation well database. Sue Langer responded that Minnesota Unique Well numbers have been assigned to all wells in the database, which has been a huge effort.

Randal Barnes asked if the project will include any wells in Wisconsin. Tim Cowdery responded that no Wisconsin data would be included.

As the discussion ended, Sue Langer noted that she would be using the attendance list to contact the group about volunteering in the project.

Presentation: Soil-Water Balance Model – Tim Brown, Barr Engineering Co.

Ray Wuolo introduced Tim Brown, and noted an editorial in the September/October 2007 issue of the journal Ground Water ("It is the Discharge" by John by Bredehoeft) pointing out the effort being focused on recharge research and concluding that discharge is a real challenge to be addressed, too.

Tim Brown presented information about the SWB model that will be used to estimate recharge (water that moves past the root zone) for the groundwater flow model. The presentation is attached. An informal discussion took place during and following the presentation and is summarized below. Tim referred to the paper:

Dripps, W. R. and K. R. Bradbury. "A simple daily soil-water balance model for estimating the spatial and temporal distribution of groundwater recharge in temperate humid areas." Hydrogeology Journal Vol. 15 (2007): 433-444.

A pilot project was undertaken to test the SWB model for the Twin Cities metro area. The results from this test appear to be reasonable when compared to the recharge estimates made by the USGS. Some trouble-shooting of code and input files still needs to be done. Then, the final SWB model will be constructed and run for the entire metro area. Grid cells will be 30 m², which will generate approximately 20 million cells across the metro area.

Tim Cowdery asked why the SWB model was estimating recharge at the 30 m² scale. Is this at the flow model grid scale? Ray Wuolo responded by clarifying that the regional model would have larger cells, although the subregional models may be smaller than 30 m². The SWB uses 30 m² grid cells to make it more compatible with the regional DEM.

Randal Barnes asked what the free parameters are in the SWB model; obviously there are lumped parameters. Tim Brown explained that there are 4 input decks that go into the SWB model: land use (USGS data was used to identify ~13 land use classes keyed to a table of root zone, infiltration data), soil water capacity, infiltration capacity, and the DEM. The soil data came from the NRCS. Gaps in NRCS data were filled in with county data. If soil data was reported as a range, Tim split the difference and used that value for the model.

Amal Djerrari asked how the SWB model addressed rivers. Tim Brown explained that rivers will funnel water out of the model. For example, a lake is an open water land cover class that rejects water. Amal asked how the model addresses water in a closed basin. Tim responded that water will infiltrate in a closed basin cell until that cell can't hold any more, then it will run off. If, at the end of the day, there is excess water in a cell, it is removed from the SWB model.

Amal Djerrari asked about our confidence in the model output – how is the model calibrated? Tim Brown and Ray Wuolo pointed out that this model is not calibrated at all, because there is nothing to calibrate to. Instead, truthing and comparisons to other estimates will be used to verify the results.

Tim Cowdery clarified that the SWB model is primarily giving us an estimate of the distribution of recharge across the metro area. Tim Brown and Ray Wuolo concurred, noting that this model will give us a regional sense of recharge variability.

Ray Wuolo went on to discuss the obvious non-uniqueness of the solution and our need to try and constrain some of the groundwater flow model inputs. The SWB model was chosen to be a tool for the Metropolitan Council to address changes in land use.

John Freitag asked if the SWB model could use data from the Minnesota Land Cover Classification System (MLCCS). Tim Brown responded that this is possible, as long as a look-up table is created to translate from the MLCCS to the SWB input-file format.

SOMEONE asked if land use could be a temporally variable input into the SWM model. Tim Brown responded that the impact of land use change on recharge would have to be addressed by running multiple models with different land use inputs and then comparing them.

Randal Barnes expressed concern about using a 30 m² DEM with regionally uniform meteorological data. This is unrealistic, and the results of the model may be misunderstood by non-scientific people. Randal was also concerned about estimating recharge daily. Tim Brown replied that use of daily recharge estimates is inappropriate. The model uses daily data as an input file, but reasonable model results are monthly or annual. Randal suggested involving meteorological groups for better model input data. Ray Wuolo mentioned that the model is capable of incorporating daily mapping of precipitation.

Randal Barnes suggested a method of mechanistic validation to replace model calibration. Fictitious meteorological data could be input at different scales to test model sensitivity.

Amal Djerrari asked why the SWB method was being used instead of the recently published USGS method. Tim Cowdery responded that the SWB method considers coarseness of the soil, which the USGS method did not do. Tim also felt that the SWB method provides for a better distribution of recharge over the model domain.

Amal Djerrari expressed concern that the SWB method does not consider intra flow, flow beneath the vadose zone. Ray Wuolo countered that we do not have a better tool ready for use.

Randal Barnes questioned the appropriateness of using the SWB model, which is static. Steve Robertson clarified that the SWB model feeds the groundwater flow model; is the final purpose of the flow model transient or steady state?

Chris Elvrum reminded the group that Met Council...

Ray Wuolo commented that, if history tells us anything, this method (SWB) will be obsolete in a few years. Randal Barnes countered that, if the physics are good, the method is good. Changes in code won't change the results.

Randal Barnes addressed the SWB climatological inputs. He noted that the Minneapolis airport data is anomalous and suggested the model rely on St. Paul airport data.

Tim Cowdery pointed out that we are passionate and worried about the SWB recharge estimates because, as Ray pointed out earlier, we don't have good discharge numbers with which to check our recharge estimates.

Presentation: Flow model boundaries and layer geometry – Ray Wuolo, Barr Engineering Co.

Evan Christianson and Ray Wuolo presented a progress report on the groundwater flow model. Metropolitan Council-defined needs were presented, and the goal of making input files as grid and code independent as possible was stressed. The presentation is attached.

Randall Barnes wanted clarification that, given the stated purposes, we are fundamentally looking at static conditions. Ray Wuolo responded that the model will be used to address steady state questions, but that it would be calibrated to transient conditions. No ephemeral streams will be included in the model. Perennial stream elevations were determined based on established gage elevations or on DEM data. Lakes that are smaller than the size of a grid cell are not included in the model.

Amal Djerrari asked what the source of lake data was. Ray Wuolo responded that this data was collected from the MN DNR. Maximum lake depth was subtracted from water level elevation to determine lake bottom elevation.

Tim Cowdery asked if model layer surface elevations were interpolated manually. Randal Barnes asked if the model assumes all layers are present across the entire metro area. Evan Christianson responded that model layers are continuous across the model, but portions of each layer may be set inactive.

Tim Cowdery asked why the model extends into Wisconsin. Ray Wuolo responded that this was done to address groundwater flow into the St. Croix River from the east.

Evan Christianson spent some time discussing the two different ways that faults were addressed in the model. Faults in Carver County were tricky; a faulted block is represented entirely by zones in model layer 6. Evan pointed out that there is enough movement across the Carver County faults to fully offset units.

Tim Cowdery asked if the southern boundary of the model is a no-flow boundary. Randal Barnes expressed concern that the aquifers extend further north and south than the current model grid. Ray Wuolo and Evan Christianson responded that specified flux boundaries were assigned to the edges of the model to account for flow into the model from the north and south. Randal Barnes noted that an assessment of long-term stresses on the system may be impacted by those specified flux boundaries on the edge of the model.

Tim Cowdery asked how inaccuracy in land surface elevations was addressed when calculating water levels using CWI data. He noted that this messes up calibration targets. Ray Wuolo responded that the PCA's Metro Model calibration data, which has the best accuracy, will be used for calibration targets.

Steve Robertson asked how leakage between layers will be handled; this is a strong character of our aquifers and should be addressed.

Amal Djerrari asked about the rationale for adding layers 8 and 9. These two layers could be a separate model, which may be more appropriate. Ray Wuolo responded that, in some areas, there is a connection between the Mt. Simon and shallower units. Also,

adding layers 8 and 9 to the model is not computationally expensive, so he decided to create a single model.

The conversation turned to the subject of calibration, and Tim Cowdery asked for a definition of cross-validation. Evan Christianson explained that this is an automated way of removing outliers. This method was based on what was done for the PCA's Metro Model.

Randal Barnes noted ___ integrate fluxes ___ to determine a gross estimate of recharge which could then be compared to the recharge estimate by the SWB model. I DIDN'T TAKE NOTES HERE, AS I WAS TOO INTERESTED IN IT.

Amal Djerarri asked why recharge is defined as a given in this model. Recharge is very dependent on leakage. Ray Wuolo responded that the SWB output will set the spatial recharge distribution, but that the magnitude of recharge may be adjusted somewhat during model calibration.

Evan Christianson pointed out that the regional model would have a uniform grid spacing, but the three subregional models will have a non-uniform grid. The three subregional models will overlap one another along the major river corridors.

Tim Cowdery asked how valuable is using flux data along the rivers.

A discussion ensued about the calibration process. Someone asked what is gained by running a steady-state and transient calibration simultaneously. Why should a steady-state calibration be done at all? Ray responded that this would improve the model response to stresses. Ray noted that he also wants to avoid over-fitting the model, so pilot points will not be used for calibration. It was suggested that Ray and Evan "PESTIFY" to the steady state calibration targets, then run the model and compare to transient targets. Everything should not be wrapped up in PEST – solving/optimizing should not happen all at once. It was reiterated that it might be best to calibrate to steady state first, then to transient.

Randal Barnes asked how the model would calculate leakance. Ray Wuolo responded that vertical hydraulic conductivity is a parameter used to calculate leakance. A secondary estimate of leakance could be determined by applying prior knowledge of hydraulic conductivity and storativity (???) to aquifer test data.

What else can we do with this model? Tim Cowdery suggested that it could serve as the foundation for solute transport. Ray Wuolo responded that he felt very uncomfortable with that. Tim clarified that the model would provide an internally consistent data set to use as a starting point for additional modeling.

Randal Barnes commented that storativity values from this model will be crap. This is a very heterogeneous parameter that... The boundary approach is reasonable, beautifully explicit but not... Randal is uncomfortable with how the rivers are addressed by this model, particularly related to continuity of units.

Ray Wuolo noted that he is working with Jim Rumbaugh (creator of Groundwater Vistas) to dynamically link subregional models to the regional model; so as boundary conditions change in the subregional models, they will also change in the regional model.

Randal Barnes asked how we plan to represent uncertainty in the model results. This is critical for decision makers. Ray responded that predictive analysis can be used on a decision by decision basis.

Chris Elvrum pointed out that the Metropolitan Council will stress the coarseness of the model results and will provide information about how to apply the model to local problems.

Randal Barnes commented that the model report should describe how to do predictive analysis so there is no loss of expertise after the project ends.

What's in a name?

The group was asked to suggest a name for this modeling effort. Mindy Erickson proposed "MCWASP" and "MCMetro". "Metro21" was also suggested. A few people suggested sticking with "Metro Model", or even "Metro Model 2.0 - 'The saga continues...'".

Andrew Streitz was asked, as a representative of the original "Metro Model", what he felt would be an appropriate name. He gave his blessing for the use of "Metro Model" for this Met Council model update.

Conclusion

The next meeting is scheduled for mid to late December. Possible topics include a discussion of model results and how the model should/will be applied.

Randal Barnes asked to see the results of vertical flux, to look at surface water characteristics and how they move down through the layers.

John Freitag suggested that future meetings could address topics brought up by the Metro Area Water Supply Advisory Committee, so that this group could provide them with technical feedback.

Attendees
Groundwater Modeling Technical Advisory Group
Metropolitan Council – M94 Office Park
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