

MEMORANDUM

TO: Chuck Williams, City Engineer, City of Moab, Utah

FROM: Kenneth Kolm, President, Hydrologic Systems Analysis, LLC
Paul van der Heijde, Hydrologic Consultant

SUBJECT: Response to Comments on Phase 3 and Phase 4 Reports to Date

DATE: October 13, 2020

The Phase 3 (2020) and Phase 4 (2020) reports completed for the City of Moab by Kolm and van der Heijde, along with the Phase 1 and Phase 2 reports, ultimately addressed the complexity of the Spanish Valley/La Sal Mtns hydrologic systems using the HESA Approach and Water Balance calculations. The explicit purpose of the HESA is to use a stepwise, multidisciplinary, iterative approach to integrate various natural and anthropogenic systems resulting in determining the hydrologic and environmental systems of the area of concern, in this case, to protect the City of Moab wells and springs. The area has a minimum of complete engineering data so therefore it was necessary to use the spatial and temporal distribution of natural systems data to determine the hydrologic framework and physical and chemical processes, with regards to atmospheric water, surface water, and groundwater. Specifically, the most reliable data over time includes the weir monitoring the flow of water from Mill Creek to the Colorado River, the groundwater output estimates from the entire system to the Colorado River provided by the USGS (2019), the weirs monitoring the Mill Creek surface water on either side of the Ken's lake diversion, the City of Moab data on Wells and springs over time, and the weather station data at Moab and La Sal for precipitation. Most of the rest of the data are limited to certain site-specific and time specific measurements for various studies, for example, the Blanchard (1990) groundwater study and the more recent USGS 2019 investigation. These measurements were valuable for understanding the systems hydraulics and uniqueness. The results of our investigations show that the Spanish Valley/La Sal Mtn systems are broken up into five subsystems (Phase 1) with various connectivity between these systems. Based upon Phase 1, Phase 2 focused on the GCMC system as this was the system to directly affect the City of Moab's Wells and Springs. Given the complexity of the GCMC system, a water balance approach was used to quantify, on a yearly basis, the distribution of water in the system. However, the Water rights question raised concern of the combined Pack Creek Mill Creek groundwater system (PCLA) and the GCMC system, so Phase 4 was completed. Phase 4 addressed the complexity of the PCLA system, so a water balance approach was used to quantify, on a yearly basis, the distribution of water in that system. Also in Phase 4, both the GCMC and PCLA system were combined for water rights purposes, and a water balance was completed to quantify the inputs and outputs. Phase 2 and Phase 4 also quantified the storage of groundwater based on the hydrogeology. This is not water that is developable per se, but attests to the sustainability of the system. Finally, the results were all analyzed through the EPA filter of drinking water protection zones, and a monitoring plan was developed to protect the City of Moab wells and springs, and the Spanish Valley wells and springs. These results and an

explanation of the various systems will be presented on October 29 to the City Council, and this is an ideal time to explain in detail these systems.

The first key point is that these systems are complex, interconnected, and have cascading effects. We were hired as experts to discern the complexities, not to over simplify or to perform a risk analysis (probability or stochastic analyses) of the individual variables or features. Given the broken up nature, we did not do a model this study. We do have a 1994 MODFLOW model of this area which is Basye, 1994, but we have since determined the study area is more complex than our understanding in 1994. Nor did we use empirical or stochastic methods to determine variables, but did deterministic evaluations. There can be discussion on estimates and numbers, but on the flow system hydraulics (physics and hydrogeology) we stand firm. This is a complex fracture and fault controlled set of hydrologic systems with thick alluvial deposits in some areas.

The Water Bucket Model presented by Duncan is an interesting concept for trying to illustrate the water balance concepts, but is too simplified to be useful. The concept of recharge is not just about stationary precipitation, which should be spatially distributed based on fractures and elevation and eolian cover, but about stream losses (and gains) to the aquifer, notably Mill Creek and the North Fork of Mill Creek in the GCMC system. Specifically, the recharge by precipitation doesn't address the high altitude water that is derived by the Mill Creek fracture zone and underlying groundwater derived from the La Sal Mtns, nor the high altitude Mill Creek surface water that enters the groundwater system via losing stream sections originally derived from the La Sal Mtns. The bucket full of alluvial sand doesn't address the bedrock complexities, both temporal and spatial, of both matrix and fractures for specific yield and hydraulic conductivity. Finally the outflow of springs and wells is only part of the story. The surface water outflow and phreatophytes are major features of the water balance that need to be addressed and are not addressed by the Water Bucket Model.

Our simplified Water Bucket Model is presented in Phase 2 Figure 11 for the GCMC system, and Figures 14a and 14b for the PCLA system. The water balances quantify these water bucket models. The importance of predevelopment and post development calculations is to evaluate changes in storage. But the safe yield, which we are currently evaluating now, is more of a change in hydraulics that affects Spring discharges, and stream flow at the top of the system. Deflected recharge in the GCMC groundwater system, via additional diversion to Ken's Lake from Mill Creek, will have more of an effect on the safe yield for City of Moab Springs and Wells than climate change in the short term, although in the long term, drought will show up (and already is showing up).

There have been three emails with comments including a Water Bucket Model that have been submitted for us to review. The following are some of the responses to these comments:

Chuck, Carly, Kara, Arne,

I have reviewed chapter 3, *Preliminary Water Budget of the Pack Creek Lower Alluvium (PCLA) Hydrologic Subsystem*, of Ken Kolm's Phase 4 report. I want to thank Ken for that report, which together with earlier phase 1, 2 and 3 reports is an enormous amount of work on a very difficult aquifer.

Response: Thank you Mike for reading and trying to absorb the information. This is quite a complex engineering report.

On the subject of safe yield, I agree with Ken's statement in section 3.3, page 23: *Although some wells in Spanish Valley show a decline in water levels, uncertainties in the PWB do not support including a continuing, multi-year release of water from subsurface storage at this time.* Having said that, I add that it's unfortunate that that is the case. Certainly I wish it were not so. I had hopes that this study would shed more light on the overriding question we all have: *How much water do we have to use?* Local governments have difficult decisions to make with consequences for decades to come. Note that the study does not say "*There is no continuing, multi-year release of water from subsurface storage at this time.*" It says not much more than *We're not sure.* This is a different conclusion than Kolm obtained for the GCMC aquifer in Phase 2 which did include such a term. From the city's point of view, since the city's culinary springs and wells are in the GCMC and outside the PCLA area, it is the Phase 2 report that matters the most.

Response: With regards to the City's wells and springs, Phase 2 with a modified budget presented in Phase 4 was critical for Phase 3.

There is no easy way to establish safe yield (for the Spanish Valley aquifer and its watershed, which includes Kolm's Phase 2 Glen Canyon Mill Creek aquifer and Phase 4's PCLA aquifer). I know of three other methodologies: 1) Estimate recharge over the entire watershed directly via precipitation and infiltration models; 2) Estimate total surface and ground discharge over the entire watershed, assume no change in storage, then use discharge as a surrogate for recharge; and 3) Observe water table levels over the entire watershed, in particular in places where springs and wells are located, and infer water table stability (or lack of it) at existing withdrawal rates.

Response: We are currently writing a report regarding safe yield and sustainable yield.

As in Phase 2, Kolm has elected still another method: to define a subset of the valley's watershed, in this case the valley floor, as the PCLA study area. It's chosen to include most features of interest while its perimeter is chosen to represent a "no (surface or ground) flow" boundary. The latter constraint greatly simplifies the calculations. But this method too has its weaknesses:

- The model essentially sums a group of inputs, each with differing associated uncertainty (aka error bound), then subtracts from that the sum of a group of outputs,

each again with differing associated uncertainties, to arrive a small difference, the change in storage. If all the errors are uncorrelated (i.e. statistically independent) the uncertainty (or noise/error) of that difference is the square root of the sum of the squares of all the component IN and OUT terms that went into the difference. If the errors are correlated, the total error will be even worse. This is why this model is of limited usefulness and why it's hard to say what it means.

Response: The water balance is not intended as a stochastic analysis with uncertainty. The data is not available or collected such for this type of analysis. But for management purposes, it is intended to enable managers to think through

- Unlike Phase 2's "no flow" perimeter which used low conductivity confining geologic layers to establish No Flow, it's not obvious (to me) what establishes No Flow along the PCLA perimeter. Ground water movements across the perimeter are assigned in very restricted widths at very restricted depths where they enclose surface stream flows. Alluvium layers Qal and Qaf are common along the No Flow perimeter yet said to be dominant paths for ground water flow.

Response: This is predominantly an alluvial aquifer with various depths and flow paths. The fracture zones on the periphery are an interesting set of bedrock aquifers with their story. The two dominant fault zones on the east side of the study area are the Mill Creek French Drain (in the GCMC system) serving as a conduit, and the main valley Kayenta fault and fracture zone which serves as a conduit for Skakel, but a block for the main valley flow producing the City springs. However, in the south area of the Spanish Valley, the Kayenta fault and fracture zone becomes a conduit from Ken's Lake to the Grand County wells. This is not a simple system.

Comments and questions on Ken Kolm's Phase III report, Chapters 1 through 3: Source Water Protection Zones.

Questions:

What is/are the regulatory question(s) about the delineations including the entire Mill Creek Watershed in the La Sal Mountains?

Response: The regulation is interpreted by EPA based on Travel times. The state has approved the concept of steady state capture area for water amounts that sustain the springs discharges.

Where is a figure that outlines the areas delineated in Appendix A.?

Response: The figures are in Phase 2 and Phase 4 reports.

General Comments: Ken has done a fine job delineating Source Water Protection zones according to standard practices of the industry. Adoption of these zones will satisfy the regulatory requirements of the Safe Drinking Water Act. In general it appears the zones he has delineated do cover the area "above" the high K zones where the water in the aquifer that supplies Moab City Springs and Wells, including Skakel travels. They also cover a large amount of area where the water in the aquifer is not traveling and the aquifer is not receiving recharge from. It should be noted that the zones he has

defined do not include the area where recharge is occurring to the aquifer that is supplying water to Moab City Springs and Wells, including Skakel. It should also be noted that the latter point is somewhat mute as the travel time for water in that aquifer is great enough to overcome most potential contamination.

Comments on Typographical errors in the report:

As noted in comments on earlier phases, Utah Division of Water Rights is abbreviated UDWRi.

Page 11 first sentence Utah State EPA?

Response: We will correct.

Comments and questions on Ken Kolm's Phase III report Chapter 4: Preliminary Monitoring Plan.

Questions:

I don't have any.

General Comments:

It would take me quite a bit of time to discuss the elements of this plan. Ken has taken some time to put forth a rather large scale monitoring plan. As stated in the report, several of his plan's components are already being performed by the City because they are required by regulation and a few of this plans components are already being actively performed by other entities (although not necessarily to the extent proposed in this plan). It is also eluded to in the report that several of the sites recommended are already being monitored by other entities not mentioned in this plan (again, although not necessarily to the extent proposed in this plan). I didn't see it mentioned in Ken's report but several of the sites that aren't currently being monitored and some of his recommended monitoring at those sites has also been recommended by other entities like the USGS and UDWRi. Most of those sites recently recommended by other entities are generally concerned with water quantity. Water quantity is probably the first priority for this watershed as without sufficient quantity, water quality issues are moot.

I would like to comment on the approach Ken has taken for surface water quality monitoring. It appears he has determined locations that would reflect any upstream issues with water quality. That is an approach taken by most studies or monitoring plans. I support that approach. For example if you sample the North Fork of Mill Creek above the confluence with the Main Fork of Mill Creek and you don't have any quality issues, you can reasonably assume that the water quality above that sample site in the North Fork doesn't have any water quality issues either. Several of the sites listed in this text are of that nature but several are upstream on tributaries that shouldn't need to be sampled if the water quality downstream doesn't have any issues. Furthermore, of the sites that are strategically located, several of them are already being collected on a six year rotating basis by the Division of Water Quality and don't have water quality issues. If there was a change in land use in these catchments, more frequent monitoring might be prudent. But without any major changes in land use, I wouldn't support increased monitoring of those surface sites.

Response: We have listed the monitoring sites as suggestions and prioritized them. This then is up to the City to decide what is important, and what is affordable. Much discussion here!

Several of the sites he has proposed water quality/quantity sampling are technically up gradient of the Moab City's springs and wells and it is inferred that the monitoring would help protect the quality of Moab's drinking water. My opinion is that surface water be monitored at its point of diversion and if problems are found, then move upstream to locate a source. However, groundwater is a different situation and monitoring should be done in recharge areas. Several of the sites he has suggested are not in the recharge area for the aquifer of concern.

I agree and it has been pointed out by several other entities that this hydrobasin could use more stations gauging precipitation and other climate metrics. Those are my general comments on this preliminary monitoring plan. It would take a brainstorming session with several entities and perhaps four hours to hash through this list and the sites others are recommending.

- Relatively little precipitation falls in the PCLA compared to the higher and wetter La Sal mountain watershed to its east. This makes surface and ground in-flow (and out-flow) observations and models critical. Yet no sanity check on watershed contributions was made. Any significant disagreement between modeled ground underflow and groundwater recharge higher in the mountains is not known.

Response: We contend that the "huge underground river" is not hydrogeologically feasible. However, we do have our major groundwater recharge source in the both systems is Mill Creek and Mill Creek groundwater in fracture (GCMC) and Bromley Creek (PCLA) and Pack Creek (PCLA) for those systems.

- Since precipitation in the PCLA area is at low elevations primarily as rain (rather than snow), and further that rain often falls as part of short, intense thunderstorms, it seems likely that a 16% recharge figure is too high and direct runoff to streams too low.

Response: We disagree. We see this in the Grandstaff system without La Sal Mtn support, and in the Kanab system in southern Utah with out high altitude support. The role of fracture zones for recharge and transmission is large (see the USGS wells in 2019 report), and the role of eolian and gravel cover is large.

- As in Phase 2, this PWB makes no attempt to use a recurring surface water balance as a sanity check on the total (surface + ground) water balance in the PCLA. If one separates IN and OUT terms into Surface and Ground categories (per Figs 14a and b), Table 1 (pre-development environment) shows that there is about 3000 ac-ft/yr more surface water going into the PCLA than comes out, and similarly 3000 ac-ft/yr less groundwater that comes in than goes out. It's possible that pulling Riparian Vegetation (aka Phreatophytes) consumptive losses in part from ground rather than surface water (as with crops) will mitigate this imbalance.

Response: The phreatophyte consumptive losses are calculated based on field research, and the surface water losses to groundwater are based on the losing ditches. Phreatophytes play a large role in groundwater losses, and tend to be overlooked by investigators. These are both calculated, so are not used to mitigate an imbalance.

- The pre-development model assumes no Consumptive Crop losses. However the Moab Irrigation Company, who holds more than 4000 ac-ft/yr of Mill Creek rights, supplied primarily agricultural users in the valley for decades before the start of the modeled 1971 pre-development period.

Response: But for true predevelopment model that the state should accept is pre crops by definition.

More from Arne

Here they are:

Comments and questions on Ken Kolm's phase IV report: Preliminary HESA-Based Preliminary Water Budget and Aquifer Storage Evaluation for the Pack Creek Lower Alluvium (PCLA) and Combined PCLA and GCMC Preliminary Water Budget.

General Comments: In the Executive Summary the report states on page vii and on page 29 that the Sheley diversion has resulted in a 31% reduction of springs and seeps discharge. I haven't found information in the document to support that conclusion, I don't think the cumulative body of science and data in the Spanish Valley hydrobasins supports that conclusion.

Response: We have used the cumulative body of science and data to support this analysis. Our primary database in predevelopment is the water rights database. One can argue that this may not be accurate, but this is what is available.

My last question below was one of many similar questions I could have asked about the "estimates" used in the preliminary water budget.

Questions:

Table 2 and 3 contain the pre and post preliminary water budgets, why is the post-water budget in Table 3 over 10% higher than the pre-water budget in Table 2?

Response: The increase budget number for post vs pre-development in the PCLA system is due to the Sheley diversion and the diversion by the City of water from springs and wells in the GCMC system towards the City in the PCLA system. The increase in the GCMC system

between pre- and post-development is due to the mining of groundwater (release from storage) as accounted for in the tables (i.e., water use is exceeding safe yield already....)

Page 23 first full paragraph, Sentence 3 What is meant by the sentence “Although some wells in Spanish Valley show a decline in water levels, uncertainties in the PWB do not support including a continuing, multi-year release of water from subsurface storage at this time.”

Response: We don't have evidence of a major decline in the PCLA system probably due to Ken's lake recharge to the system and changing land use from agricultural (higher ET) to urban.

Section 3.19 uses 1.15 % as a conversion factor for post water from current estimates. I thought using the data in Section 3.11 the factor would be 1.10? Where did the 1.15 come from?

Response: 1.15 comes from the average difference in pre/post Sheeley and pre/post Powerhouse delta. $(1.2 + 1.1)/2$.