associated earth sciences incorporated

Memorandum

Date:	June 19, 2017	Project Manager:	Charles Lindsay
To:	Whatcom County Planning	Principal in Charge:	Charles Lindsay
Attn:	Gary Stoyka	Project Name:	Groundwater Model
Address:	322 North Commercial, Suite 110 Bellingham, WA 98225	Project No:	170054H001
Subject:	Response to comments/questions regarding groundwater model capabilities		

Gary,

Below are responses to the comments/questions you conveyed to me via email on May 26, 2017. It is my understanding that these comments/questions are from the Whatcom Water Supply Group. The following responses have been prepared in consultation with the project's groundwater modeling specialists, S.S. Papadopulos & Associates, Inc (SSPA). Please understand that many of these comments/questions cannot be adequately addressed until the numerical groundwater model is completed.

1. Model provides increased understanding of the relationship between surface water, groundwater, recharge, discharge, etc., which will lead to better policies (refer to 2013 Ecology letter to the Bertrand WID).

   - *Yes, the model will provide an increased understanding of the relationship between surface water, groundwater, recharge, discharge and other related hydrogeologic processes. The groundwater model will be developed with the overarching objective of supporting physically-based water resources management. The consulting team cannot predict how agencies will use this information to develop policies.*

2. Provides enough data for Ecology to act on water right applications, and provides a range of anticipated impacts that could be mitigated (can be used as a tool to develop appropriate mitigation).

   - *It is important to note that models do not provide data. Rather, models synthesize available data into a framework that captures the essential elements of a complex natural system. The model is being developed with the intent of being able to provide Ecology with information necessary for the evaluation of water right applications and to provide estimates of impacts that could be used to develop mitigation plans. The overall reliability of the model to predict potential impacts associated with a proposed water right appropriation will vary throughout the model domain, depending on the amount and quality of the available model input/calibration data and the specific characteristics of the water right application.*

Groundwater models like the one being developed have been used as tools to make water resource and water rights decisions in many places throughout the U.S. and other countries. The consulting team anticipates that the model being developed will provide sufficient information that can aid an agency in making water management decisions; however, the determination of the sufficiency of information for making water rights decisions shouldl be made by the agency on a case-by-case basis within the applicable legal framework once a potential application is made.

"Mitigation", as per the Foster Decision, will likely be required to <u>be in kind, in time, and in place.</u> Complying with these restrictions will likely require developing/acquiring a local source(s) of mitigation water. This may be difficult to accomplish because large portions of the model domain are closed year around to further appropriations of surface water and groundwater.

3. Provide impact for a given point of withdrawal for groundwater and associated range of accuracy, i.e., 30-60% accurate based on data available say in Ten mile vs. say 20-30% variable in Kamm vs. say 10-15% in Bertrand.

   - *It is not possible, and ethically questionable, to provide assurances of model reliability in advance of developing and calibrating any groundwater model. The model will be consistent with the available data. Predictions made with the model will be more certain in areas where the structure of the subsurface is well defined and there are abundant high quality data. In areas where the hydrostratigraphy is complex and high quality data are sparse, predictions made with the model will be less certain. It is also important to note that in areas that have not been stressed significantly, predictions of the potential effects of future large-scale stresses will be highly uncertain.*

4. In an area with enough data, hope that the level of confidence can be as high as 80% or more and therefore, if the model indicated 20% impact then the mitigation would be 20% + 4% (i.e., 20% of 20% mitigation) indicating 24% mitigation would meet the calculated and the margin of error to be conservative.

   - *These numbers are too precise. It should always be borne in mind that a groundwater model is a deliberate simplification of a complex natural system. The predictions of a groundwater model must always be regarded as a working hypothesis of how the system will respond to stress, that is, a best guess of how the system will respond. If "enough data" is interpreted as "abundant high quality data that characterize the groundwater system under stressed conditions" then there can be some assurance that model predictions will be reliable. It will only be possible to assess "how reliable" after the model has been calibrated and tested. The most important application of a model is not for predictions per se, but to guide the design of a monitoring program that is implemented ahead of a major groundwater taking and to guide the interpretation of the data that are collected.*

5. Provides enough information to assist Ecology and Counties in determining the effect of cumulative basin impacts of 5000 gal exempt uses.

    - *We are aware that Ecology and others have used numerical groundwater models to assist in developing conclusions regarding potential impacts to surface water bodies from the use of permit-exempt wells. However, it is our opinion that it would be difficult to defend the results of such numerical modeling analyses due to the very minor amount of consumptive water use associated with permit-exempt wells and the unavoidable variability/errors associated with the input and calibration data for the numerical model.*
    - *These limitations, associated with any model applied to predict the cumulative impact of multiple wells pumping at relatively low rates, are illustrated by the following simple analyses of a scenario that involves modeling of one square mile of the Bertrand Creek drainage that is assumed be developed to a high density with single-family permit-exempt wells.*

Example: Water Budget Resolution Within Bertrand Creek Drainage

Development and Water Use Assumptions

- A minimum residential lot size of 5-acres is assumed for this example analysis. There could be potentially 128 5-acre lots, each with a permit-exempt well, in one square mile (640 acres). However, due to roads, etc. it's more reasonable to assume that the maximum number of 5-acre parcels would be around 80% of 128 or approximately 100 wells per square mile.
- The assumed 100 single-family permit-exempt wells would result in a maximum of 500,000 gallons per day (gpd) of groundwater use (5,000 gpd per well). However, only approximately 25% of the groundwater use would be consumptive (assuming the use of on-site septic). Therefore, the consumptive impact over one square mile from 100 wells would be roughly 0.38 acre-feet per day (afd) or approximately 140 acre-feet per year (afy).
- It should be noted that the Whatcom County Coordinated Water System Plan (WCCWSP) indicates that typical permit-exempt use is approximately 350 gpd. A total consumptive impact of 0.027 afd or roughly 9.8 afy would be expected from a use of 350 gpd from 100 permit-exempt wells.

Groundwater Recharge

- USGS methodologies have been used to estimate that approximately two feet of groundwater recharge per year occurs in the Bertrand drainage.
- Two feet of recharge over one square mile is equal to 1,280 afy of groundwater recharge.

Groundwater Throughflow

- Groundwater throughflow is the amount of groundwater that flows into and out of an area and can be estimate using Q = KiA where:

  Q = Groundwater throughflow
  K = Aquifer hydraulic conductivity
  A = Aquifer cross section area
  i = Aquifer hydraulic gradient

- It is assumed that the hydraulic conductivity is 150 feet per day (ft/d), which is significantly less than the average K value of roughly 600 ft/d for the Sumas Aquifer estimated by the USGS (Cox & Kahle, 1999). It should be noted that assuming a higher K value would result in a greater volume of groundwater throughflow.
- The aquifer hydraulic gradient is assumed to be similar to the general slope of the ground surface in the upper portion of the Bertrand basin, which is about 0.003 or roughly 16 feet per mile.
- The aquifer thickness in the Bertrand drainage is reported by the USGS to range between 40 and 80 feet. An average thickness of 60 feet is assumed for this example.
- Based on these assumptions the groundwater throughflow beneath one square mile of the Bertrand drainage would be about 3.27 afd or roughly 1,195 afy.

Streamflow Measurement Accuracy

- Bertrand Creek typically has low flows of around 5 CFS (2,245 gpm or 9.9 afd) during the late summer and early fall as measured at the Rathbone Road gage.
- The best possible accuracy of the Rathbone Road gage streamflow measurements is roughly +/- 5% which means that any daily measured flow of 5 CFS at the Rathbone Road gage could have a potential error of 0.25 cfs, or about 0.5 afd.

Implications of the Example Analysis

- The estimated input to the groundwater system in a one square mile area is approximately 2,475 afy of groundwater recharge and throughflow. Based on an exaggerated maximum use of 5,000 gpd for each of the 100 wells, the maximum potential consumptive impact to the groundwater system is roughly 140 afy (0.38 afd) or about 5.6% on the inputs. Therefore, the maximum cumulative impact to groundwater system would be a little less than 6% of a conservative estimate of inputs to the aquifer.
- Based on a more realistic (WCCWSP) use of 350 gpd, the consumptive impact to the groundwater system from the use of the 100 wells would 0.027 afd (9.8 afy) which is less than 0.3% of the total system inputs.
- It is important to understand that impact to flow within a specific reach of a stream would be significantly less than the predicted impact to the groundwater system for this example, primarily due to aquifer/surface-water connectivity, variations in groundwater flow direction and the widely spaced nature of wells. An extremely conservative estimate assumes 100% of the estimated impact to the groundwater system is passed on to surface water within a

specific reach, such as the stream reach that is represented by the Rathbone Road gage.

- Part of the calibration of the numerical model will be based on measured stream flow at gages like the Rathbone gage. As discussed previously, streamflow measured at the Rathbone gage would likely have an error of no less than 0.5 afd (<u>5%</u>) of the typical late summer flow (9.9 afd). The exaggerated maximum worst-case potential impact to flow in Bertrand Creek from the 100 wells would be around 0.38 afd (<u>3.8% of late summer flow</u>) and the more realistic impact estimate, based on 350 gpd of use, is around 0.027 afd, or only <u>0.3% of late summer flow</u>.
- <u>Even in areas of the proposed numerical model with high data density, and good calibration data (Bertrand Creek drainage), the extremely conservative estimate of maximum potential impact to surface water from the use of 100 permit-exempt wells will be significantly less than the lowest possible streamflow measurement error that will be used to calibrate the model. The more realistic potential impact of 0.027 afd is less than 6% of the potential error associated with the streamflow measurement data. Therefore, any simulated predicted impact to the stream based on this scenario would be statistically insignificant and not defensible.</u>

6. Sufficient accuracy and sensitivity to quantify measurable impacts to surface water flow from groundwater withdrawals.

   - *The overall reliability and sensitivity of the model to predict potential impacts to surface water flow will vary throughout the model domain due to the variability of the amount and quality of the available model input/calibration data, and the specific characteristics of the proposed groundwater withdrawal. As illustrated in the previous example regarding the potential impact of permit-exempt water use on stream flow, to be "measurable" the predicted potential impact to surface water resources must be significantly greater than the +/-5% minimum error associated with measuring surface water flow.*

7. Model accurately represents the groundwater system appropriate to the scale.

   - *The numerical model will represent the groundwater system to the accuracy that is possible based on the available quantity and quality of the data.*

8. Expandable to other portions of the county as data becomes available; accuracy of the model improves with additional data for sub-basins and further improved with site specific data.

   - *Yes, additional data can be incorporated into the numerical model in the future as more high-quality data become available. We conceive of the groundwater model as a "living" conception of the groundwater system. As indicated previously, the greatest value of the model will lie in its application to guide the design of monitoring programs and support for the interpretation of new data. These applications are consistent with the concept of adaptive management of water resources. Expansion of the system beyond the model extents as delineated in the current scope of work will require considerably more effort than incorporating updated/refined data within currently specified model domain.*

9. Able to assess climate change impacts.

   - *Using the model to assess climate change is not in the negotiated scope of work for this project. However, the examination of "what if" scenarios is an appropriate application of the calibrated model. It is possible that the model could be used to develop some conclusions regarding the potential impacts of climate change on groundwater recharge and groundwater discharge to streams. The model will be well suited to provide insight regarding the impacts of future changes at the resolution of the information available to construct and constrain the model parameterization.*

10. Are the recommendations from the Lower Nooksack Water Budget Overview (Section 5.4., Recommendations, page 28) being incorporated in the groundwater model development? Specifically:

    a. The upcoming coordinated water system plan will determine more accurate information on the public water system and these data can be incorporated into the model during the next update. - *is this being coordinated with the ground water model development?*

    - *Incorporating the new "more accurate" public water system data into the model is not in the negotiated scope of work for this project and would require re-running the surface water model to develop revised groundwater recharge input parameter to the numerical model.*

    b. Water rights records gave a reference for determining the ratio of surface and groundwater use on a drainage average, but further information would be useful for better calibration, as the surface-groundwater source ratio is very sensitive to fitting the model to low flows. - *is this being coordinated with the ground water model development?*

    - *The ratio of surface and groundwater use described in the previously completed Lower Nooksack Water Budget was refined for the entire surface water model domain in Phase 3 of this project. It was refined to an even greater degree in the Bertrand Creek basin as part of the Phase 3 portion of this project.*

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