TETRA TECH

MEMO

Report for 401(a)(2) Public Hearing

To:	U.S. Army Corps of Engineers, St. Paul District File No. MVP-1999-05528-TJH
From:	Greg Council and Scott Simpson, Tetra Tech (resumes provided in Attachment 1)
Date:	May 2, 2022
Subject:	401(a)(2) Public Hearing on PolyMet's NorthMet Project Section 404 Permit Response to Fond du Lac Band's Concern Regarding Mine-Induced Drawdown Affecting Downstream Water Quality

1.0 SUMMARY

In this report, we document our review of claims by the Fond du Lac Band of Lake Superior Chippewa (Band) that the NorthMet Project (Project) by Poly Met Mining, Inc. (PolyMet) will affect the Band's water quality on its Reservation located 116 miles downstream from the Project. Specifically, the Band was notified by the U.S. Environmental Protection Agency (USEPA) that discharges from the Project may affect water quality along the Band's reservation (**Figure 1**). The Band responded to this notification with what it describes as a "Will Affect" Analysis ("Analysis") dated August 3, 2021. The Analysis contains numerous critiques of the Project and argues that the Project will (with certainty) adversely impact the water resources upon which the Band depends.

This memo focuses on one of the Band's concerns related to groundwater drawdown impacts on water quality. The Analysis, at Section III.C., asserts that "Project De-Watering Operations Will Cause Changes in Regional Hydrology and the Release of Sulfate, Inorganic Mercury and Methylmercury from Impacted Wetlands." Notably, the Band's Analysis does not attempt to quantify the amount of additional sulfate, mercury (Hg), or methylmercury (MeHg) that would be generated or that would migrate to the Band's waters more than 110 miles downriver.

Our review of the Band's drawdown-related assertions (including the opinions of the Band's consultants provided in attachments) indicates that the Band has neglected key information related to wetland impacts and built a complicated conceptual model for sulfate and mercury release and transport based on speculative assumptions.

This memorandum offers a rebuttal to the Band's Analysis from both hydrologic and hydro-biogeochemical perspectives. In summary, the contention in the Band's Analysis that Project-related drawdown will lead to water-quality impacts on the section of St. Louis River in the Band's jurisdiction is incorrect because:

- The Band's Analysis fails to account for the removal of wetlands which will reduce generation of sulfate, Hg, and MeHg.
- The Band's Analysis overstates the aerial extent of drawdown and incorrectly asserts (without supporting calculations) that the generation of sulfate, Hg, and MeHg in allegedly affected wetlands will lead to net increases in transport to downstream waters.
- The Band's Analysis implies that MODFLOW groundwater modeling should have been used to directly calculate the extent of wetland desaturation, ignoring the limitations of groundwater modeling software for this purpose.
- The Band's Analysis does not address hydrogeologic and geochemical factors that will mitigate loading of sulfate, Hg, and MeHg to streams if and where drawdown-related impacts occur.

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2.0 PRIOR WETLAND DRAWDOWN ANALYSIS

The Final Environmental Impact Statement ("FEIS") used an "analog method" developed by the co-lead agencies to estimate the effects of the Project's mine pits on groundwater drawdown. The analog method relied upon historical groundwater measurements from 16 groundwater wells near the Canisteo Pit[1]. A numerical groundwater flow model (e.g. MODFLOW) was deemed to be an impractical tool for estimating drawdown in wetlands due to:

1. The degree and spatial scale of hydrogeologic heterogeneity at the Project's mine site, particularly in surficial deposits (glacial tills and peat) which exhibit ranges in hydraulic conductivity of more than five orders of magnitude (i.e., 0.00026 to 31 feet/day).
2. The demonstrated inability of a numerical flow model of the Canisteo Pit (Jones, 2002) to predict groundwater heads with sufficient accuracy to be a useful tool in assessing water level drawdown within a few feet or less, which is (at minimum) what would be needed to assess wetland impacts.

Analog method drawdown estimates based on the Canisteo Pit well data were considered conservative estimates by the co-lead agencies because bedrock hydraulic conductivities at the Canisteo site are higher than at the NorthMet site.

Predicted drawdown results from the analog method were used along with wetland information (e.g. wetland type and sensitivity to drawdown) to assess the likelihood of drawdown-induced indirect impacts on wetlands. The resulting "indirect" impacts considered likely (i.e. high and moderately likely) are shown in **Figure 2**, as are the wetlands that will be directly impacted by the NorthMet Project. The total wetland area of the four wetland types shown in **Figure 2** are summarized in **Table 1**.

3.0 RESPONSE TO "WILL AFFECT" ANALYSIS

The following sections provide some details of our review of the Band's assertions related to the alleged water-quality effects of mine-induced drawdown.

3.1 REMOVAL OF WETLANDS THAT CURRENTLY GENERATE SULFATE, MERCURY, AND METHYLMERCURY

As a starting point, it should be recognized that the Project will directly impact 749.5 acres of wetlands at the mine site (**Figure 2**). These wetlands will either be excavated or filled and will be within the near-mine development where surface water and groundwater is captured, sent to the Plant Site (during operations), and eventually treated prior to discharge. (The Project will mitigate the loss of wetland habitat.)

As the Band's Analysis notes, wetlands in this region generate dissolved sulfate and mercury which is transported via groundwater and surface-water flows. This happens currently, even without the Project. The direct removal of wetlands (e.g., filling of wetlands) will lead to decreased generation and migration of these constituents from the development area of the mine site. This is one reason why PolyMet's analyses, and those documented in the FEIS, indicate that the Project will result in a *decrease* in loading of sulfate, mercury, and methylmercury to the Partridge River and to the St. Louis River. This predicted baseline decrease in loading is ignored in the Band's Analysis.

[1] The Canisteo Pit is an existing mine pit in the Mesabi Range approximately 65 miles from the NorthMet Mine Site.

The total wetland area that is likely to be impacted by drawdown based on the FEIS analog method is 161.4 acres (sum of "High Likelihood" and "Moderate Likelihood" of being potentially impacted; **Table 1**). Assuming the drawdown-impacted and directly impacted wetlands currently produce similar amounts of dissolved constituents on a per-acre basis, the relative increase in loading from the 161.4 acres of wetlands likely to be impacted by drawdown would need to increase 460% for the total loading from drawdown-impacted wetlands to offset the loading reduction from wetlands excavated or filled during Project construction (749.5 acres)[2]. Such an extreme increase in per-acre loading to surface water is not suggested by the Band's Analysis or the scientific literature.

3.2 USE OF MODFLOW TO PREDICT WETLAND IMPACTS

In the Analysis, the Band notes its disapproval with the use of the "analog method" for setting distance ranges that are used to categorize the likelihood of indirect wetland impacts from drawdown and to identify wetlands for hydrologic monitoring. The Analysis suggests that the MODFLOW model used to predict groundwater inflow to the mine should have been used also to quantify wetland impacts. This is not a new concern and was specifically addressed by the cooperating agencies when the FEIS was issued.

The nature of MODFLOW—a modeling tool developed for, and best suited for, simulating groundwater flow (including flow to groundwater sinks such as mines)—makes it ill-suited to accurately quantify the predicted degree of desaturation of wetland sediments. The details of groundwater-surface-water interaction in wetlands are complex and vary on a finer spatial scale than can be practically used for MODFLOW model grids. Additionally, wetland saturation typically has greater temporal variation than groundwater levels, making accurate simulation more difficult. The changing nature of wetlands – including sediment deposition, erosion, and temporal damming of water – adds additional challenges for simulation, especially with groundwater modeling software.

Indeed, there is no numerical hydrological model widely accepted for predicting the degree of wetland-sediment depressurization or desaturation that will result from groundwater sinks such as mines. Considering this fact, it is sensible to (1) apply an alternative method that identifies the wetlands most likely to be adversely impacted, and (2) to design a monitoring strategy that allows for adaptive management of wetland impacts. The regulatory agencies directed the Project to do both, which are now required by the Section 401 water quality certification, 404 wetland permit, and Wetland Conservation Act decision.

3.3 AREA OF WETLAND IMPACTS AND AVERAGE IMPACTS IMPLIED

The Band asserts that over 6,000 acres of wetlands will be impacted by drawdown, contradicting the analysis of the FEIS that the co-lead agencies supported. In fact, the use of the analog method to assess indirect impacts from mine dewatering was one of the major differences of opinion between the FEIS co-lead agencies and the Bands, as listed in FEIS Section 8.3. Regardless, it should be noted that if drawdown impacts were as spatially extensive as the Band asserts, the amount of the impacts would be small on average.

The MODFLOW model predicts groundwater inflows to the mine pits that average approximately 500 gpm (1.1 cfs) over the planned operations period.[3] Much of this inflow comes from decreased groundwater storage, with the rest coming from: decreased flows to surface waters (including wetlands), increased flows from water bodies (including

[2] That is, the relative increase in loading from the impacted wetlands (161.4 acres) would need to equal the current total loading from the impacted wetlands plus wetlands to be excavated/filled (i.e. 161.4 acres + 749.5 acres = 910.9 acres). This total area is approximately 560% of the 161.4 acre impacted area, or 460% more than the existing area.

[3] For perspective, the average flow in the Partridge River at SW-006 is 87 cfs.

wetlands), and decreased evapotranspiration. If 500 gpm is spread out over 6,000 acres of wetlands, the average impact is 0.083 gpm/acre or 1.6 in/yr. This is approximately 5.4% of average direct precipitation, the primary inflow to many wetlands. Even taking it one step further, suppose that this water-budget impact of 5.4% (on average) resulted in a 5.4% increase in dissolved constituent generation: this would be like adding the equivalent of 330 additional acres of wetlands from the standpoint of water quality impacts, and this amount of constituent generation is still less than half of the constituent generation reduced through direct removal of 749.5 acres of wetlands.

3.4 POTENTIAL WATER QUALITY IMPACTS OF AQUIFER DRAWDOWN

A major concern raised by the Band relates to water table drawdown in wetland sediments near the NorthMet pits. The Analysis contends that:

> "*Prolonged (i.e., greater than approximately 30 to 45 consecutive days) drawdown of greater than approximately 10-12 inches, especially in organic soils, will cause organic matter to begin oxidizing. … Coleman-Wasik et al. (2015) found that prolonged deep drought resulted in substantial increases in pore water sulfate, total mercury and methylmercury concentrations upon re-wetting during wet periods in the fall and/or spring snow melt.*"

3.4.1 Necessary Hydrogeochemical Conditions

For aquifer drawdown to mobilize mercury and increase methylation of the mercury already present in wetland sediments, the following sequence of hydrologic processes and geochemical conditions is necessary:

1. A prolonged water table decline that introduces oxygen to previously saturated, anoxic, and sulfide-bearing sediments.
2. Oxidation of sulfide to sulfate.
3. Rising water table to re-saturate the sediments bearing the newly oxidized sulfate (or transport of the newly oxidized sulfate to a reducing environment).
4. Sufficient microbial activity to consume all electron acceptors that are more thermodynamically favorable than sulfate (i.e., dissolved oxygen, nitrate, manganese, and iron).
5. Sulfate reduction and Hg methylation by sulfate-reducing bacteria.

3.4.2 Loading to Surface Water from Wetlands

The Band's Analysis assumes that the hydrogeochemical conditions outlined in Section 3.4.1 will be met and will be exacerbated by Project-related drawdown. Sections 3.1 and 3.3 of this memo explain why sulfate, Hg and MeHg generation will not increase as a result of Project-related drawdown. But even if generation of these constituents were to increase, the following reasons support why the Band will not be adversely impacted by the Project:

1. **Potential impacts of drawdown on hydraulic gradients to surface water**. A hydraulic gradient is needed for sulfate, Hg and MeHg in wetland sediments to reach local streams via groundwater flow. Lower groundwater levels due to potential drawdown would also reduce the likelihood that soil water and groundwater in drawdown-impacted areas would flow to surface waterbodies. The magnitude of the groundwater flow inducing hydraulic gradients in these areas would necessarily be lower (on average) and therefore result in less discharge to surface waterbodies than under current average conditions. The area most impacted by any potential drawdown (e.g. near mine pits) will become a hydrologic sink (rather than a source), and sulfate/Hg/MeHg mass export will be reduced relative to current conditions. The areas

nearest the mine pits where drawdown is likely to be greatest—and where the probability of Project-induced sediment oxidation and mercury release/methylation is highest—are also the least likely to contribute soil water and groundwater to surface water; much of this groundwater would flow to the mine pits and be transferred to the Plant Site where it would eventually be treated. Conversely, the areas farthest from the mine pits are least likely to be impacted by potential drawdown and mine-related oxidation of wetland sediments is likely to be minimal.

2. **Potential impacts of drawdown on rainfall-runoff response**. High MeHg concentrations—in excess of the 1.3 ng/L total Hg standard—have been observed in Minnesota rivers during summer in response to wet hydrologic conditions (Balogh et al., 2006). The high MeHg concentrations during high discharge periods highlight the importance of high-flow events (i.e. spring snowmelt and summer rainfall events) on total MeHg mass loading to streams. Any potential water table drawdown near the mine pits would likely reduce the areal extent of wetland soils where the water table is at or above land surface. This reduction in saturated area would lead to greater infiltration of snowmelt and summer rainfall (due to desaturation of surface soils and increased infiltration capacity) and, therefore, less runoff and MeHg loading to streams.

3. **Vertical redistribution of Hg and MeHg**. Experimental results indicate that lowering the water table in wetland sediments leads to the redistribution of Hg and MeHg from near-surface sediments to deeper sediments (Haynes et al., 2019). The drawdown-induced migration of dissolved MeHg to deeper depths could lead to less mobilization of Hg and MeHg during the rainfall-runoff events when MeHg export to streams is highest (Balogh et al., 2006). Elevated MeHg concentrations in streamflow during high flow events are likely due to the rapid mobilization of MeHg stored in shallow sediments that are "flushed' during storm events. The two most plausible physical processes for this "flush" are:

    a. A rising water table that transports the MeHg in shallow, oxidized soil water upward, out of the soil and eventually to streams, and
    b. Runoff flowing over and/or through near-surface wetland sediments that incorporates MeHg in soil water and transports it to streams.

    If either of these mechanisms contribute to the MeHg flush previously observed during high flow events, then the downward migration of Hg and MeHg due to a generally lower water table would likely reduce Hg and MeHg mass loading via exfiltration to land surface (i.e. mechanism "a", above) or via runoff (i.e. mechanism "b" above).

4. **Role of demethylation as a competing process with microbially-mediated Hg methylation**. Whereas mercury methylation is a microbially-mediated process that occurs exclusively in anoxic environments, demethylation of MeHg is an important competing process that can occur in both oxic and anoxic sediments. Coleman Wasik et al. (2012)—a study conducted in sulfate-limited wetlands at Marcell Experimental Forest (central Minnesota) and cited numerous times in the Band's "Will Affect" Analysis—states that:

    "*Demethylation was a more important MeHg loss process than desorption coupled with advective transport out of the system*."

    and

    "*The finding that most of the MeHg lost … was likely due to in situ demethylation rather than export from the system implies that the majority of the MeHg produced in response to elevated sulfate deposition may not be transported to downstream aquatic systems*."

These two statements clearly indicate that Hg methylation is reversible, and that the demethylation process is an important factor to consider when assessing Hg dynamics in wetland environments. Furthermore, they also suggest that the methylation of Hg does not necessarily mean the MeHg produced will lead to increased MeHg loading downstream. The same bacteria that methylate Hg can also demethylate MeHg (Lu et al., 2016), and research in two northern Wisconsin wetlands (Creswell et al., 2017) found that "*demethylation rates [also] appear to regulate net methylmercury production*," among other factors. The importance of demethylation also indicates that net Hg methylation[4] in wetlands is the important factor to consider when assessing potential Hg loading from wetlands to streams. Furthermore, the assessment of Paranjape and Hall (2017), which states that "*short-term measurements of potential rates of methylation and demethylation have been found to be unrelated to gross measures of long-term MeHg accumulation,*" also highlights two important ideas:

- The balance between methylation and demethylation processes needs to be considered when considering mercury loading, and
- Short-term experiments (e.g. laboratory studies and potential methylation estimates based on short-duration field observations) are not necessarily good indicators of long-term behavior (e.g. annual MeHg loading to streams).

4.0 CONCLUSION

The Band's "Will Affect" Analysis describes the adverse impacts which they conclude—with certainty—will result from the NorthMet Project. Their predictions are speculative, and their absolute certainty of these negative impacts occurring is not supported by the cited documents and evidence. Most notably absent from the Analysis is a single example of drawdown inducing elevated Hg/MeHg loading to surface water despite there being numerous similar pits at other mines in the region. Despite the lack of any analogous examples to support their claims, the Band's Analysis overstates the Project effects, as follows:

1. **Project-induced water table drawdown will be limited in extent**. The Band's Analysis expands the extent of drawdown impacts beyond what is supported by the data used in the FEIS co-lead agencies' analog drawdown method. The Band's Analysis also fails to acknowledge the conservativeness of the analog method given the lower hydraulic conductivities at the NorthMet site relative to the analog (i.e. Canisteo Pit) site.

2. **Project-induced Hg and MeHg mass loading to the Partridge River due to drawdown will be minimal**. The Band's "Will Affect" Analysis assumes that increased dissolution of Hg and MeHg due to wetland soil oxidation will lead to increased Hg and MeHg mass loading to the Partridge River. This assumption neglects the effects that drawdown significant enough to oxidize sediments would also have on wetland hydrologic processes, namely the reduced potential for (1) groundwater discharge of wetland porewater to streams, and (2) runoff to streams during snowmelt and summer rainfall events when natural MeHg loading is highest.

3. **The Project will decrease Hg and significantly decrease sulfate to the St. Louis River**. The Band's Analysis assumes that increased loading to the Partridge River from impacted wetlands near the NorthMet mine would impact water quality in the St. Louis River more than 110 river miles downstream. This conclusion is speculative and not supported by the scientific evaluations in the FEIS, the Minnesota

[4] Net methylation is the difference between methylation and demethylation.

Pollution Control Agency's National Pollutant Discharge Elimination System (NPDES) permitting, or the 401 water quality certification processes. These evaluations account for the facts that (1) sulfate, Hg and MeHg are reactive species with complex cycling and transformation reactions, and (2) conservatively account for their fate and transport downstream of the Project in the St. Louis River to a location south of the Band's Reservation.

5.0 REFERENCES

Balogh, S.J., Swain, E.B., Nollet, Y.H., 2006. Elevated methylmercury concentrations and loadings during flooding in Minnesota rivers. Science of The Total Environment, 368, pp. 138-148.

Coleman Wasik, J.K., Mitchell, C.P.J., Engstrom, D.R., Swain, E.B., Monson, B. A., Balogh, S.J., Jeremiason, J.D., Branfireun, B.A., Eggert, S.L., Kolka, R.K., and Almendinger, J.E. , 2012 Methylmercury Declines in a Boreal Peatland When Experimental Sulfate Deposition Decreases, Environ. Sci. Technol. 46, 6663-6671.

Creswell, J.E., Shafer, M.M., Babiarz, C.L., Tan, S.Z., Musinsky, A.L., Schott, T.H., Roden, E.E. and Armstrong, D.E., 2017. Biogeochemical controls on mercury methylation in the Allequash Creek wetland. *Environmental Science and Pollution Research*, *24*(18), pp.15325-15339.

Haynes, K.M., Kane, E.S., Potvin, L., Lilleskov, E.A., Kolka, R.K. and Mitchell, C.P., 2019. *Impacts of experimental alteration of water table regime and vascular plant community composition on peat mercury profiles and methylmercury production*. Science of the Total Environment, 682, pp. 611-622.

Jones, P.M., 2002. *Characterization of Ground-Water Flow Between the Canisteo Mine Pit and Surrounding Aquifers, Mesabi Iron Range, Minnesota*. Water-Resources Investigations Report 02-4198. Mound View, MN: U.S. Geological Survey.

Lu, X., Liu, Y., Johs, A., Zhao, L., Wang, T., Yang, Z., Lin, H., Elias, D.A., Pierce, E.M., Liang, L. and Barkay, T., 2016. *Anaerobic mercury methylation and demethylation by Geobacter bemidjiensis Bem*. Environmental Science & Technology, 50(8), pp. 4366-4373.

Paranjape, A.R. and Hall, B.D., 2017. *Recent advances in the study of mercury methylation in aquatic systems*. Facets, 2(1), pp. 85-119.

Table 1. Wetland areas likely to be impacted at the NorthMet Mine Site.

Type of Impact	Area (acres)
Direct	749.5
Fragmentation	26.5
Potentially Impacted (High Likelihood) by Drawdown	42.5
Potentially Impacted (Moderate Likelihood) by Drawdown	118.9

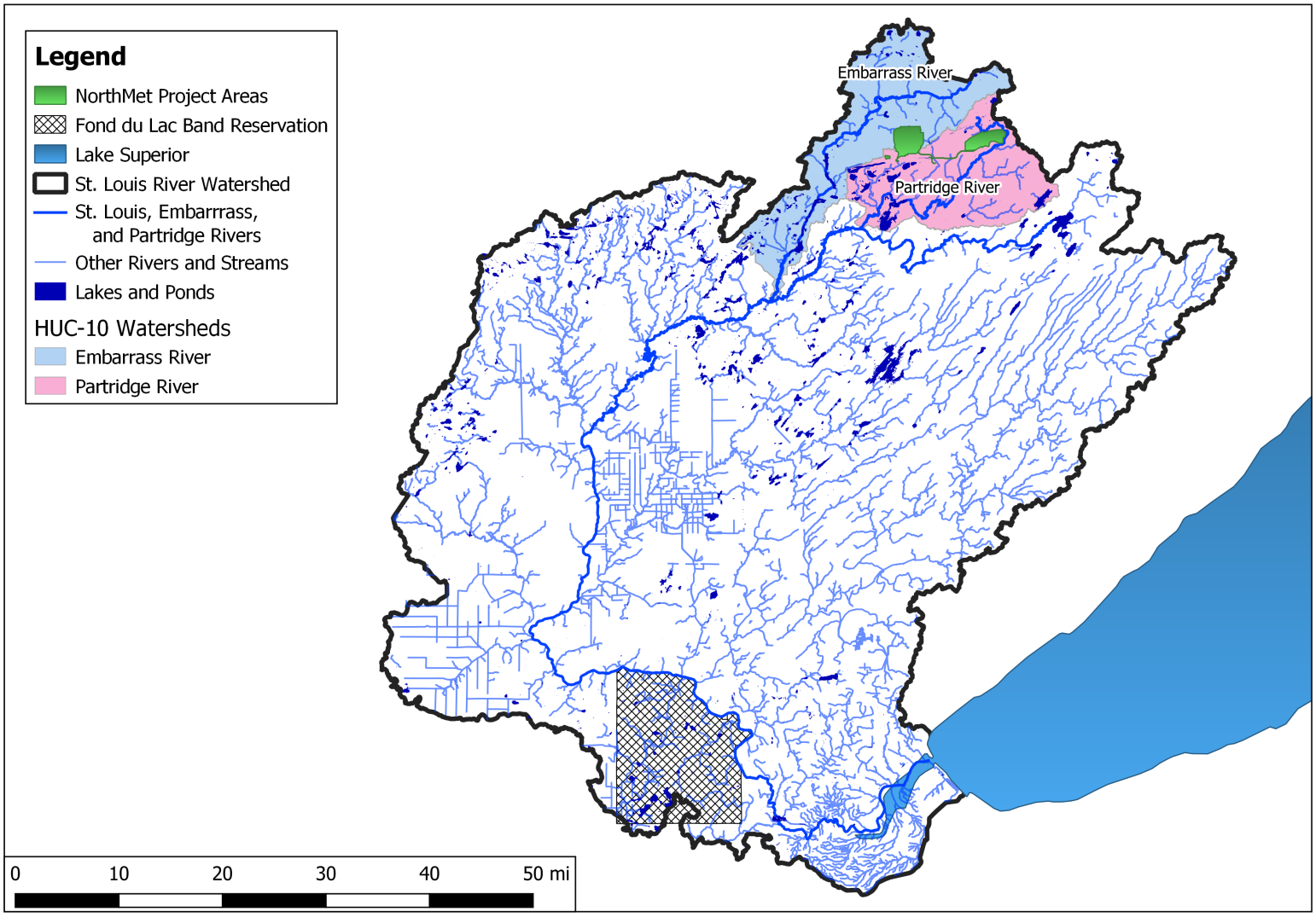

Figure 1. Location of the NorthMet Project and Project watersheds in the St. Louis River watershed.

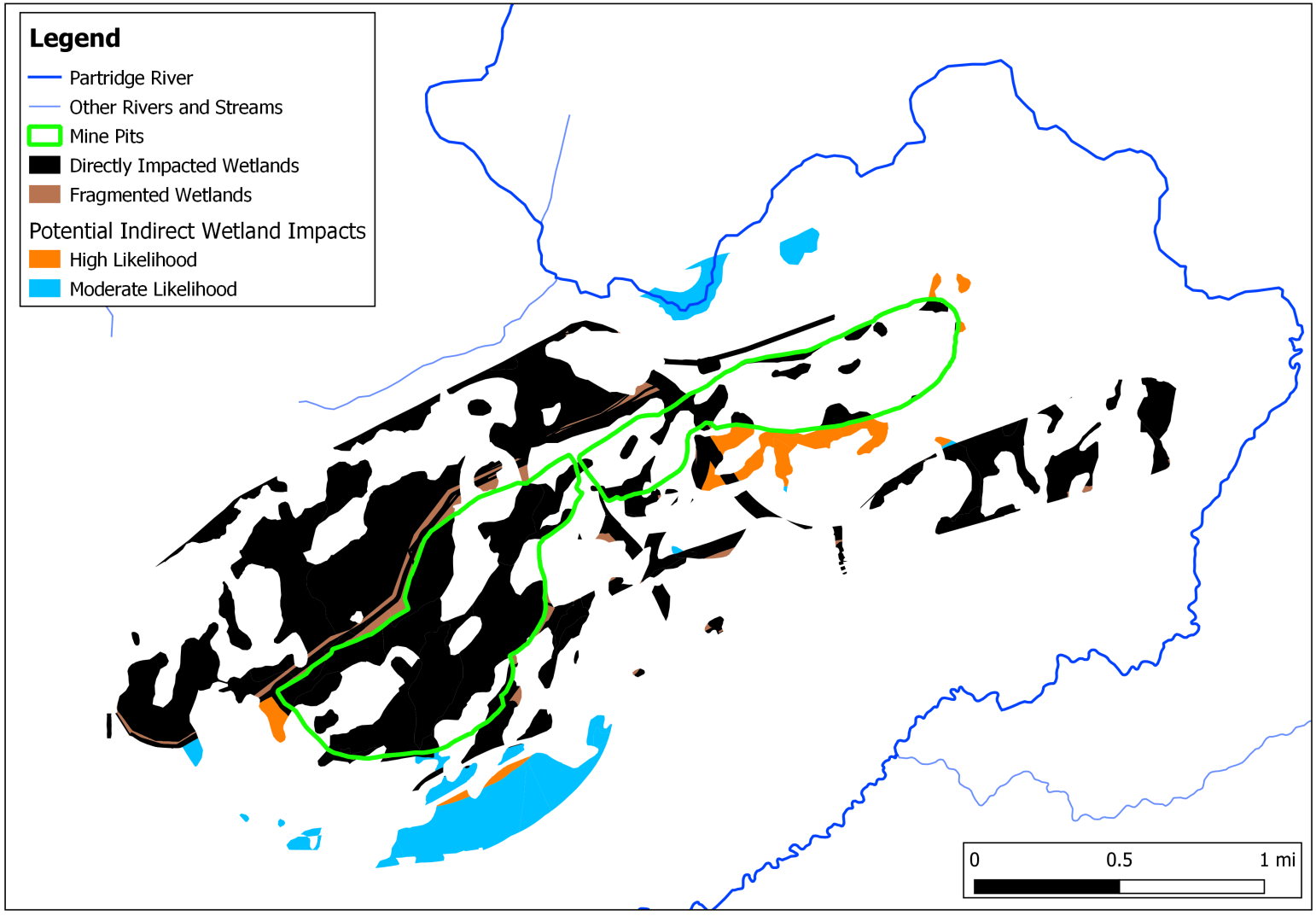

Figure 2. Directly impacted wetlands and wetlands likely to be impacted indirectly at the NorthMet Mine Site.

ATTACHMENT 1 AUTHOR RESUMES

TETRA TECH

Gregory W. Council, P.E.
Principal Engineer

EXPERIENCE SUMMARY

Mr. Council has 28 years of experience in environmental engineering, consulting, and groundwater analyses. He is a project manager and technical expert for diverse environmental projects including groundwater modeling, remediation, and investigation.

EXPERIENCE

PolyMet Mining Corporation, Hoyt Lakes, Minnesota (through Foth Infrastructure and Environment). Model peer review. Provided review of GoldSim water management models and groundwater flow models for a proposed open-pit mine site and a proposed ore processing plant/tailings facility for the NorthMet project. Provided comments on project documents. Led discussions on model Quality Assurance with USEPA Region 5.

Kennecott Eagle Minerals Company, Marquette, Michigan (through Warner Norcross & Judd). Groundwater modeling expert for litigation. Provided peer review of groundwater models of mine inflow and water-resource impacts. Constructed and calibrated a new groundwater flow model and used the model to assess potential impacts of mining on groundwater levels and surface-water flows. Used FEFLOW and MODFLOW for modeling analyses. Reviewed and critiqued modeling analyses submitted by others. Testified at the mine permit contested case hearing.

Confidential Mining Client. Developed & updated sophisticated hydrogeologic flow and transport models (GSFLOW, MODFLOW, and MT3D) of a proposed mine and tailings storage facility to estimate environmental impacts. Reviewed GoldSim water balance models.

Nicolet Minerals Company, Crandon, Wisconsin (through Foth and Van Dyke). Estimated the environmental effects of a proposed underground mine and a mine-tailings repository using 3-D numerical groundwater models and analytical techniques.

Mosaic Company, Ft. Meade, Florida (through Holland and Knight). Consulting expert for groundwater/surface-water modeling. Reviewed wetland hydroperiod modeling for a proposed phosphate mine expansion. Provided recommendations for strengthening the technical case at the permit hearing.

US Department of Energy, Savannah River, Aiken, South Carolina (through Savannah River Nuclear Solutions and Savannah River Remediation). Conducted groundwater flow and transport analyses of environmental impacts and remediation effectiveness at the Savannah River Site. Quality Assurance Manager, Task Manager, and/or technical lead for over 20 projects. Used a variety of tools and methods including GMS, MODFLOW, MT3D, GoldSim, probabilistic uncertainty analysis, multi-phase flow and transport simulation, and custom-designed analytical and discretized models.

US Department of Energy, Office of Civilian Radioactive Waste Management (through Bechtel/SAIC, Inc.). Reviewed and constructed models of radionuclide transport for the Yucca Mountain Project Total System Performance Assessment. Used the GoldSim probabilistic simulator and component models to evaluate the performance of the engineered barrier system at the proposed repository and to model flow and transport through the saturated and unsaturated zones.

EDUCATION

M.S., Civil and Environmental Engineering, Massachusetts Institute of Technology, 1994

B.S.E., Civil and Environmental Engineering, Duke University, Durham, North Carolina, 1992

REGISTRATIONS/ AFFILIATIONS

Professional Engineer, Georgia (25048)

American Geophysical Union Member

TRAINING/CERTIFICATIONS

Ralph M. Parsons Fellowship Grant, Division of Water Resources and Environmental Engineering, Massachusetts Institute of Technology, 1992-1993

Aubrey Palmer Award for Academic Achievement in Civil and Environmental Engineering, Duke University, 1992

Outstanding Senior Award, American Society of Civil Engineering (North Carolina), Duke University, 1992

Graduated Summa Cum Laude and Phi Beta Kappa, Duke University, 1992

OFFICE

Atlanta, Georgia

YEARS OF EXPERIENCE

28

YEARS WITHIN TETRA TECH

28

Reviewed the simulation of source release from waste packages and the simulation of colloid-facilitated transport. Developed alternative conceptual models and programmed them with GoldSim.

Tooele Army Depot, Tooele, Utah (US Army Corps of Engineers, Sacramento District). Developed a numerical model of TCE transport at the Tooele Army Depot along with the U.S. Army Hydrologic Environmental Center. Used the model to identify the important source areas, suggest improvements to remedial system operation, and identify important uncertainties. Presented model results at meetings with the lead UDEQ regulator. Performed automated calibration analyses. Addressed model uncertainty using Monte Carlo simulation with GoldSim and PEST. Assisted with definition and evaluation of alternatives in the Corrective Measures Study (CMS).

Nuclear Power Plant, Florida (Confidential Energy Client). Evaluated saltwater intrusion issues and the feasibility of potential engineered solutions. Conducted numerical modeling of saltwater intrusion using SEAWAT. Developed a salt/water balance model in Excel and in GoldSim.

St. Johns River Water Management District, Florida. Modeled groundwater/surface-water interaction in northwest Seminole County and northwest Volusia County using MODFLOW with the Surface/Vadose (SV) Package and Lake Package (project manager and code developer). Assessed the effectiveness of alternative water policies in the regions. Reviewed District water budget models for lakes. Trained the District staff on the use of the models.

Northwest Florida Water Management District, Florida. Used MODFLOW and SEAWAT models to assess the feasibility of an inland groundwater supply wellfield in Franklin County. Assessed potential aquifer drawdown, wetland impacts, and saltwater upconing due to the proposed wellfield. Converted a DSTRAM model to SEAWAT.

Hillsborough County, Florida (through Holland and Knight). Reviewed a numerical modeling analysis on seepage from a proposed reservoir. Used simple models and analytical calculations to demonstrate that the reservoir model underestimated groundwater seepage and potential land flooding. Reviewed integrated groundwater/surface-water modeling and uncertainty analyses.

Milan Army Ammunition Plant, Tennessee (for US Army Corps of Engineers, Mobile District). Developed a cost-effective approach for prioritizing contamination sites. Developed a plant-wide numerical model of groundwater flow and several simple analytical transport models. Simulated plume movement and remedial well capture zones.

Confidential Mining Client, Arizona. Peer review for modeling and analyses used to develop and analyze closure alternatives for a tailings facility and a mine site.

Roane Alloys State Superfund Site, Rockwood, Tennessee (for BHP Billiton through Bryan Cave). Project manager for site investigation and remediation of a former alloys smelter. Led a team of Tetra Tech and subcontractor personnel to collect data, improve the understanding of potential environmental impacts, and develop a site closure and restoration plan. Planned and conducted site investigation, human-health and ecological risk assessments, feasibility study, and remedial design. Designed a site remedy including source capping and stream re-routing. Prepared a probabilistic future-cost financial model and an assessment of health, safety, environmental, legal, and public-relations risks at the site. Identified and evaluated liability transfer and environmental insurance options. Met with the regulatory agency to present site data and discuss the course forward. The constituents of concern are hexavalent chromium, lead, arsenic, barium, and manganese. The pH of a creek running through the site was also outside the acceptable range.

Chem-Nuclear Solutions, Barnwell, South Carolina. Constructed and calibrated a groundwater flow and tritium-migration model for the Barnwell Low-Level Radioactive Waste Facility.

Peace River Manasota Regional Water Supply Authority, Florida (through Carey, Whittaker, O'Malley, and Manson, P.A.). Designed a reservoir storage and release model to predict the effectiveness of a proposed reservoir in southwest Florida for meeting environmental goals (minimum stream flows) and water-supply demand.

US Department of Energy, Nevada (through Shaw Environmental). Evaluated radionuclide transport pathways from underground test sites at the Nevada Test Site (Frenchman Flat Corrective Action Unit). Used the GoldSim program and Monte Carlo simulation to analyze the effects of different conceptual models (transport pathways) and understand transport uncertainty.

Shell Oil Company, Chevron, ExxonMobil, and the City of Santa Monica, California. Used sophisticated modeling to assist with the design of a treatment plant that would allow a municipal wellfield to return to operation.

Activities included three-dimensional MTBE plume visualization, model calibration, and transport model predictions. Made multiple technical presentations to the public/private client consortium.

PRP Groups, North Carolina and Michigan (through NewFields, Inc.). Evaluated proposed remedial alternatives for the Aberdeen Pesticides Dumps Superfund Site and the Bofors-Nobel Superfund Site with numerical modeling.

Hydrite Chemical Company, Cottage Grove, Wisconsin. Reviewed a FEFLOW groundwater modeling analysis. Made recommendations to streamline and improve the ongoing analysis.

Georgia Department of Natural Resources. Conducted probabilistic uncertainty analyses for models of lake water quality, watershed hydrology, and stream water quality in support of the Georgia Water Plan.

Georgia Department of Natural Resources. Developed numerical and semi-analytical models for BTEX transport in groundwater at several UST sites.

City of Kalamazoo, Michigan. Used modeling analysis to develop a construction dewatering plan.

Remedial Systems Evaluations of Superfund Sites (for USEPA Headquarters). Served as lead engineer on remedial optimization studies to identify opportunities to reduce costs and improve effectiveness of site characterization, design, and remedial actions at six government-financed Superfund sites across the country.

Woolfolk Chemical Works Superfund Site, Fort Valley, Georgia (for USEPA Region 4). Planned and executed remedial design optimization studies at the Woolfolk Chemicals Superfund site. Prior investigations at the site did not adequately delineate the groundwater plume, and the pump and treat design did not fully address the plume. Optimization strategies developed included dividing the remedy into two separate treatment trains to reduce operation and maintenance costs; revising groundwater monitoring locations to distinguish between the plume core and flank areas; and incorporating design changes for a streamlined pump and treat system.

Tutu Wellfield Site in the U.S. Virgin Islands. Performed capture zone analyses and recommended improvements to the pump-and-treat systems.

Benfield Industries Site in North Carolina. Recommended shutting down the existing groundwater extraction system and implementing monitored natural attenuation for cost savings.

Velsicol Chemical Site in Tennessee. Determined that the source area is continuing to act as a long-term source of groundwater contamination and recommended that EPA implement an SVE system that could be turned off when the rate of mass removal is no longer significant.

Palmero Wellfield Site in Washington. Reviewed capture zone information, treatment methods, and potential methods to mitigate vapor intrusion.

Cabot/Koppers Superfund Site, Gainesville, Florida (for Beazer East, Inc.). Conducted remedial actions while serving as Supervising Contractor for Remedial Design and Remedial Action under the Site Consent Decree. Facilitated a consensus-building process with the USEPA to select a comprehensive site remedy. The constituents of concern include PAHs, arsenic, and dioxin. Coordinated site investigation, interim action, and final remedy selection. Successfully negotiated changing the source-area remedy from in-situ solidification using deep soil mixing to in-situ geochemical stabilization (ISGS) saving the client approximately $20M. Discussed the major issues at the site and helped reach resolution and approval of client plans. Designed and oversaw construction of interim remedial measures and pilot tests. Coordinated off-site soil replacement at 100 parcels in a residential neighborhood impacted by dioxin. Designed a soil-bentonite cut-off wall.

Global Remediation and Environmental Services, Atlanta, Georgia. Client liaison for various investigation, remediation, and post-closure care projects throughout North America for Georgia-Pacific and affiliated companies. Identified staffing for projects, developed work plans, reviewed reports, and ensured client satisfaction. Providing advice and knowledge sharing on PFAS fate and transport, risk assessment, and remediation. Work has included environmental site assessments, soil/groundwater investigation, human-health risk assessment, remedial alternatives analysis, soil remediation, third-party peer review, and groundwater modeling. Conducting operation, maintenance, and monitoring at over 50 closed facilities with ongoing environmental liabilities.

Southern Wood Piedmont Sites: Macon, Georgia and Baldwin, Florida (for Rayonier Advanced Materials). Consultant and strategic advisor for two former wood-treatment sites. Prepared work plans, conducted field

investigations, assessed human/ecological risk, and communicated frequently with state regulators. The primary constituents are dioxins, PAHs, and arsenic. Conducted a ditch soil removal project in a residential neighborhood adjoining one Site. Used probabilistic risk assessment to develop an alternative soil cleanup target level for dioxin in soil that was approved by the Florida Department of Environmental Protection. Designed and implemented a soil-consolidation remedy.

Rayonier Cattle Dipping Vat Site, Waycross, Georgia (for Rayonier, Inc.). Calculated site-specific risk-reduction standards for arsenic and prepared a final HSRA Compliance Status Report that was accepted by the Georgia Environmental Protection Division. The site was then removed from the Georgia Hazardous Site Index.

Sixty-Minute Cleaners Site, Atlanta, Georgia (for Nationwide Insurance through Thompson Hine). Litigation expert for remediation design and cost estimation. Also performed subsurface investigation. Prepared two expert reports and was deposed.

Stine Lumber, Lake Charles, Louisiana (through Taylor Porter and Zurich). Groundwater contamination expert for litigation. Reviewed site documents and conducted site investigations. Prepared an expert report regarding contamination sources, migration pathways, and costs of remediation. Constituents include chlorinated solvents and petroleum hydrocarbons. Prepared for trial.

Koppers Tie Plant Facility, Grenada, Mississippi (for Beazer East, Inc. and Koppers Inc.). Designed and conducted two remediation projects involving removal of dioxin-impacted soil in a residential neighborhood and removal of impacted sediment in off-Site drainage ways. Also designed and implemented a plan to remove a former cooling pond from the site.

Former Crown Vantage Paper Mill, Parchment, Michigan (for Georgia-Pacific). Planned and executed an investigation of perfluoroalkyl substances (PFAS) in groundwater. PFAS impacts led to the shutdown of a municipal water-supply wellfield. Worked with the Michigan Department of Environment, Great Lakes & Energy to identify monitoring well locations and obtain access. Developed potential remediation strategies and cost estimates for the paper mill site and the adjacent paper-waste landfill areas. Conducted groundwater flow and transport modeling to show PFAS migration potential.

Former Paper-Residuals Landfills, Wisconsin (for Georgia-Pacific). Provided advice strategies to reduce long-term costs of leachate management at two closed paper-residuals landfills. Evaluated various on-site treatment and off-site disposal alternatives and developed closure cost estimates. Evaluating pre-treatment options due to PFAS levels in leachate.

Dantzler Wood Preserving Sites, Florida (for Beazer East, Inc.). Developed site remediation and closure strategies for an existing wood-treatment site in Jacksonville, Florida and a former wood-treatment site in Pompano Beach, Florida. Developed and compared potential remediation strategies and technologies. Designed and installed a permeable reactive barrier for an arsenic plume.

Rayonier Mill Site, Port Angeles, Washington (for Rayonier Advanced Materials). Prepared a feasibility study for addressing contamination in soil, groundwater, and sediment at a former paper mill.

Georgia-Pacific Gypsum Mill/Manufacturing Facility, Sigurd, Utah. Managed subsurface investigation of a hydraulic oil release and other petroleum releases. Developed a closure strategy for the site. Conducted analytical modeling and risk assessment to support monitored natural attenuation.

Manufacturing Facility, Ellisville, Mississippi (Confidential Client). Conducted pre-development investigation and provided analysis to show that measured arsenic concentrations exceeding state screening levels were not elevated relative to background.

Nevada Environmental Response Trust Site, Henderson, Nevada (for Nevada Environmental Response Trust). Preparing feasibility studies for remedial measures to address perchlorate, chromium, VOCs, and other contaminants at a former chemical manufacturing facility.

Superfund Site, North Carolina (for Confidential Client). Conducted soil sampling, soil-gas sampling and surface geophysical surveys at a site with chlorinated-solvent and PCB impacts. Conducted and reviewed analyses of impacts.

Kokomo Superfund Site, Indiana (for PPG). Evaluated likely sources of groundwater contamination and participated in meetings with USEPA Region 5 and PRP counsel to discuss regulatory and technical paths forward.

Southern Wood Piedmont Sites: Chattanooga, Tennessee and Waverly, Ohio (for Rayonier Advanced Materials). Managed post-remediation operation and maintenance activities at two former wood-treatment sites.

Various locations and clients. Conducted and managed Environmental Site Assessments.

PUBLICATIONS

1. Erickson, J., C. Gutmann, L.A. Doner, J. Toth, M. Isaacson, **G. Council**, M. Brourman, M. Slenska, M. Scalzi, and J. Mueller, 2016. In-Situ Geochemical Stabilization (ISGS) of Creosote DNAPL at a 3.5-Acre Process Area at a Former Wood-Treating Site. Battelle Conference – Remediation of Chlorinated and Recalcitrant Compounds. May.
2. Simpson, S.C., **G.W. Council**, T. Ijaz, D.J. Covert, & C.M. Teaf, 2016. Soil Cleanup Goal for Dioxin using Probabilistic Risk Assessment Techniques, *Soil and Sediment Contamination: An International Journal*, DOI:10.1080/15320383.2016.1205549.
3. **Council, G.W.** and M.C. Kavanaugh, 2011. Groundwater Modeling for the Santa Monica Water Project: Charnock Well Field Restoration, Santa Monica, California. Water Quality Technology Conference & Exposition.
4. Mueller, J., J. Moreno, J. Valkenburg, **G. Council**, J. Erickson, T. Al, D. Loomer, M. Slenska, and M. Brourman, 2010. In Situ Geochemical Stabilization (ISGS) for NAPL Management. Batelle's Seventh International Conference – Remediation of Chlorinated and Recalcitrant Compounds. May. Monterey, CA.
5. **Council, G.W**. and J.L. Ross, 2010. Predictions of TCE Plume Expansion Using Calibration-Constrained Monte Carlo Analysis. Ground Water Summit and Ground Water Protection Council Spring Meeting, Proceedings. April. Denver, CO.
6. **Council, G.W.** and Richards, C.J., 2008. A Saltwater Upconing Model to Evaluate Wellfield Feasibility. SWIM: 20th Salt Water Intrusion Meeting, Program and Proceedings. June 23-27. Naples, Florida.
7. Andersen, P.F. and **G.W. Council**, 2008. Making Calibration Targets Consistent with Expectations for Predictions. Proceedings of the MODFLOW and More 2008 Conference. May, 2008.
8. Andersen, P.F. and **G.W. Council**, 2008. Practical Tools for Calibration of Transient Groundwater Flow Models. Calibration and Reliability in Groundwater Modeling: Credibility of Modeling (Proceedings of ModelCARE 2007 Conference, held in Denmark, September 2007). Edited by J.C. Refsgaard, K. Kovar, E. Haarder, and E. Nygaard. IAHS Publ. 320.
9. Gee, J.R. and **G.W. Council**, 2007. In Situ Treatment of Dissolved-Phase Chlorinated Solvents. Paper H-50, in: A.R. Gavaskar and C.F. Silver (Symposium Chairs), In Situ and On-Site Bioremediation—2007. Proceedings of the Ninth International In Situ and On-Site Bioremediation Symposium (Baltimore, Maryland; May 7–10, 2007). ISBN 978-1-57477-161-9, published by Battelle Press, Columbus, OH.
10. **Council, G.W.**, 2005. The Surface/Vadose Package for Computing Runoff, Evapotranspiration, and Net Recharge in MODFLOW. Proceedings of the 2005 Georgia Water Resources Conference, April 27. The University of Georgia. Edited by Kathryn J. Hatcher.
11. **Council, G.W.**, P.F. Andersen, and A.L. Stieve, 2003. Groundwater Modeling to Evaluate Remediation Alternatives at the Savannah River Site, proceedings of the 2003 National Ground Water Association Mid-South Focus Conference: Environmental Monitoring & Modeling Issues: Hydrogeologic Model Calibration, Uncertainty and Confirmation, September 18-19. Nashville, Tennessee.
12. **Council, G.W.** 1999. A Lake Package for MODFLOW (LAK2): Documentation and User's Guide.
13. **Council, G.W.**, 1998. A Lake Package for MODFLOW, proceedings of the MODFLOW '98 conference, October 4-8. Colorado School of Mines. Edited by Eileen Poeter, Chunmiao Zheng, and Mary Hill.
14. **Council, G.W.**, 1998. Numerical Simulation of Lake-Groundwater Interaction: Method and Application at a Proposed Mine Site in Crandon, Wisconsin. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
15. Andersen, P.F. and **G.W. Council**, 1998. Design of a Solute Transport Model for the Tailings Management Area, Crandon Project. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.

16. Andersen, P.F., **G.W. Council**, R.T. Hagemeyer, and S.V. Donohue 1998. Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Crandon Mine. Presented at the AWRA Water Resources Management Conference, March 5 & 6. Green Lake, Wisconsin.
17. **Council, G.W.**, 1997. Simulating Lake-Groundwater Interaction with MODFLOW, proceedings of the 1997 Georgia Water Resources Conference, March 20-22. The University of Georgia. Edited by Kathryn J. Hatcher.
18. **Council, G.W.**, 1994. Solute Dispersion in Groundwater: The Synergistic Effect of Heterogeneity and Hydraulic Gradient Variability. Master's Thesis, Massachusetts Institute of Technology.

TETRA TECH

Scott C. Simpson, Ph.D
Senior Hydrologist

EXPERIENCE SUMMARY

Applied experience and academic training in:

- surface and subsurface hydrology;
- modeling groundwater-surface water interactions;
- model optimization using gradient (PEST/PEST++) and global search/ensemble evolution methods (CMA-ES, PESTPP-IES);
- flow and solute transport in variably-saturated media;
- use of geochemical tracers (including stable and radiogenic isotopes) to identify water sources, flowpaths, and residence times; geochemical modeling;
- uncertainty analysis; and
- sediment transport modeling.

FLOW & TRANSPORT MODELING EXPERIENCE

Sunshine Silver Mining & Refining, Los Gatos, Chihuahua, Mexico – Received sequence of steady-state and transient models from another modeling group. In a short time period, calibrated the models and produced predictive simulation results. Converted the models from MODFLOW-SURFACT to MODFLOW-NWT, created all the files necessary to execute an automated (PEST) calibration, and satisfactorily calibrated the flow models.

Northwest Florida Water Management District, Region II Groundwater Models, Havana, FL – Updated Region II MODFLOW ("R2MF") model and recalibrated using CMA-ES global search/ensemble evolution algorithm. Devised and implemented automated framework to execute R2MF model, extract R2MF results using FloPy to define transient boundary conditions for variably-density Coastal Region II SEAWAT ("CR2SWT") model. Calibrated CR2SWT model using PEST_HP to match observed heads, groundwater salinities, and spatiotemporal differences in heads and salinities. Applied R2MF-FloPy-SEAWAT model framework to perform predictive simulations used in determining the need for Minimum Flows and Levels (MFL) development.

Confidential Client – Developed integrated surface water-groundwater flow (GSFLOW) model that utilized the Streamflow Routing (SFR) and Unsaturated Zone Flow (UZF) Packages. Model datasets related to land surface-atmosphere interactions and surface water were generated using GSFLOW-ArcPy pre-processing utilities. Three-dimensional (3D) kriging was used and hydraulic conductivity (*K*) pilot points were calibrated to match field *K* estimates. Calibration to match *K* estimates, groundwater heads, and streamflows was performed using an automated ensemble evolution algorithm (PESTPP-IES) to facilitate predictive uncertainty analysis. MODPATH was used to predict post-closure groundwater flowpaths and travel times to surface water. Model refinement and recalibration is ongoing.

EDUCATION

Ph.D., Hydrology – Department of Hydrology and Water Resources (Minor in Geosciences), University of Arizona, 2011

M.S., Hydrology – Department of Hydrology and Water Resources, University of Arizona, 2007

B.A., Environmental Sciences – Department of Environmental Sciences, University of Virginia, 2004

REGISTRATIONS/ AFFILIATIONS

Member, American Geophysical Union, Hydrology Section

Member, National Ground Water Association

AWARDS

EPA Science to Achieve Results ("STAR") Doctoral Fellow

OFFICE

Atlanta, GA

YEARS OF EXPERIENCE

17

YEARS WITH COMPANY

11

Savannah River Nuclear Solutions, Southern Sector Flow and Transport Modeling, Aiken, SC – Task manager and senior scientist overseeing updates to numerical flow and transport model used in predicting trichloroethylene (TCE) plume movement in the Southern Sector of the Savannah River Site's (SRS) Administrative/Metallurgical ("A/M") Area. Project is ongoing.

Confidential Client – Created & updated a groundwater flow and transport model of a tailings storage facility to estimate potential mass loading of tailings seepage to a nearby river. Calibrated the MODFLOW-NWT model using an automated ensemble evolution algorithm (SCE-UA). Flow simulations used the Streamflow Routing (SFR) and Unsaturated Zone Flow (UZF) Packages, and MT3D-USGS transport simulations incorporated Surface Flow Transport (SFT) and Unsaturated Zone Transport (UZT) Packages.

Northwest Florida Water Management District, Eastern District Model, Havana, FL – Refined, calibrated, and applied a suite of MODFLOW-NWT groundwater-surface water flow models for use in developing Minimum Flows and Levels (MFLs) for springs and rivers. Devised and applied a novel calibration approach employing both the CMA-ES algorithm and the more widely-used PEST algorithm. Performed sensitivity and Monte Carlo uncertainty analyses using PESTPP suite. Also developed an automated ArcGIS preprocessor to produce MODFLOW packages from National Hydrography Dataset (NHD) geodatabases.

Florida Power and Light, Homestead, FL – Developed & updated a transient variable-density (SEAWAT) groundwater flow and transport model for estimating hypersaline groundwater extent and movement. Effects of salinity and temperature on density were both incorporated. Performed model calibration using automated parameter estimation (CMA-ES, PEST).

U.S. Army Corps of Engineers, Former Nebraska Ordinance Plant, Mead, NE – Developed a transient groundwater flow and transport model (MODFLOW + MT3DMS) for two contaminants (TCE, RDX), including estimating numerous contaminant mass source terms to simulate current plume conditions. Developed defensible range of continued source loading estimates and ran predictive simulations to determine when groundwater concentration objectives are likely to be achieved. Also performed extensive model sensitivity analyses.

St. John's River Water Management District, Minimum Flows and Levels (MFL) Projects, Palatka, FL – Developed, calibrated, updated, and applied a transient groundwater-surface water flow (MODFLOW-NWT) model for MFL development at a series of connected karst lakes. Surface water features were represented using the Lake (LAK3) and Streamflow Routing (SFR) Packages.

Irvine Ranch Water District, Irvine, CA – Applied a regulator-approved, Department of Navy-funded groundwater flow and transport model of Former Marine Corps Air Station El Toro on behalf of IRWD. Performed external model review and identified major conceptual errors in calibration and predictive models. Review and oversight of model corrections being performed by another firm is ongoing.

U.S. Army Corps of Engineers, Tooele Army Depot, Tooele, UT – Performed a predictive uncertainty analysis of a U.S. Army Corp of Engineers groundwater flow and transport model (MODFLOW + MT3D) using PEST.

U.S. Army Corps of Engineers, Iowa Army Ammunition Plant, Burlington, IA – Overhauled existing groundwater flow and transport model (MODFLOW + MT3D) in a closely-linked groundwater-surface water system. Calibrated flow and reactive transport parameters, including time-varying mass degradation rates. Performed predictive simulations to determine persistence of groundwater contaminants.

Confidential Client, Redlands, CA – Improved stream-aquifer interaction component of groundwater models by developing a specialized method for accurate representation of the timing and magnitude of flood-derived recharge. Also calibrated timing and spatial distribution of historic contaminant mass source term, and implemented loading in transport (MT3DMS) model.

WATER BALANCE & GEOCHEMICAL MODELING EXPERIENCE

BHP Billiton, Miami, AZ – Third-party reviewer of models at multiple mine sites. Converted multiple models from MODFLOW-SURFACT to MODFLOW-NWT to facilitate use of automated parameter estimation methods (CMA-ES, SCE-UA) to identify alternate parameter sets that achieved better calibration than original model. Assessed uncertainties in prior model's predictions using an alternative/multi-model approach. Reviewed and applied GoldSim water balance models to identify key uncertainties in site operations and additional monitoring and data collection needs.

Silver Bear Resources, Mangazeisky Silver Project, Toronto, ON, Canada – Developed an original GoldSim water balance model to estimate the total water demands of a proposed mine in Siberia (Yakutia, Russia).

Savannah River Remediation, Aiken, SC – Created an MS Access, ODBC-compliant model parameter database from an existing GoldSim mass balance model of the Department of Energy's Savannah River Site. Updated model to link model with the database directly, thereby allowing users to more easily revise parameters and track revisions.

OTHER PROJECT EXPERIENCE

Southern Wood Piedmont, Baldwin, FL – Devised, developed, and applied methodology for performing a Probabilistic Risk Assessment (PRA) for determining an alternative residential Soil Cleanup Target Level (SCTL) for dioxin near a form wood-treating site. The PRA was performed in GoldSim and used a Monte Carlo simulation approach to estimate exposure-related risk to human health. State regulators accepted the first-of-its-kind alternative dioxin SCTL determined by the PRA.

Mississippi Department of Environmental Quality, Model Review and Data Analysis, Jackson, MS – Performed nonparametric statistical analyses (Mann-Kendall trend test; Thiel-Sen estimator) on water level time-series using R to determine the existence, direction and significance of historic water level trends.

RESEARCH EXPERIENCE

Focused study of the impacts of spatially- and temporally-varying surface water conditions on groundwater recharge and solute transport, including the combined usage of physical measurements, isotopic and geochemical tracers, and numerical models. Developed application- and site-specific numerical models to (1) quantify recharge from surface water over a range of time-scales, and (2) determine the long-term impacts of surface water-groundwater interactions on solute transport, fate, and overall water quality.

PUBLICATIONS

PEER-REVIEWED JOURNALS

Simpson, S.C., G.W. Council, T. Ijaz, D.J. Covert, C.M. Teaf (2016). *Soil Cleanup Goal for Dioxin Using Probabilistic Risk Assessment Techniques*, Soil and Sediment Contam.: An International Journal, 10.1080/15320383.2016.1205549.

Simpson, S.C., T. Meixner and J. Hogan (2013). *The Role of Flood Size and Duration on Streamflow and Riparian Groundwater Composition in a Semi-Arid Basin*. J. Hydrol., 488: 126-135, 10.1016/j.jhydrol.2013.02.049.

Simpson, S.C. and T. Meixner (2012). *Modeling Effects of Floods on Streambed Hydraulic Conductivity and Groundwater-Surface Water Interactions*. Water Resour. Res., 48, W02515, doi:10.1029/2011WR011022.

Meixner, T., P. Brooks, J. Hogan, C. Soto, **S. Simpson** (2012). *Carbon and Nitrogen Export from Semiarid Uplands to Perennial Rivers: Connections and Missing Links, San Pedro River, Arizona, USA*. Geography Compass 6/9: 546-559, 10.1111/j.1749-8198.2012.00510.x.

Simpson, S.C. and T. Meixner (2011). *The Influence of Local Hydrogeologic Forcings on Event Water Recharge and Retention, (Upper San Pedro River, Arizona)*. Hydrological Processes, doi: 10.1002/hyp.8411.

OTHER

Simpson, S.C. (2011). *Impacts of Floods on Riparian Groundwater and Post-Event Streamflow Across Spatial and Temporal Scales,* Ph.D. Dissertation, Dept. of Hydrology and Water Resources, University of Arizona.

Simpson, S.C. (2007). *Modeling Stream-Aquifer Interactions During Floods and Baseflow: Upper San Pedro River, Arizona,* M.S. Thesis, Dept. of Hydrology and Water Resources, University of Arizona.