Resolution Copper Project and Land Exchange
Environmental Impact Statement

USDA Forest Service
Tonto National Forest
Arizona

November 5, 2020

Process Memorandum to File

Proceedings of the Groundwater Modeling Workgroup and Water Resources Workgroup

This document is deliberative and is prepared by the third-party contractor in compliance with the National Environmental Policy Act and other laws, regulations, and policies to document ongoing process and analysis steps. This document does not take the place of any Line Officer's decision space related to this project.

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Revision History

Date	Personnel	Revisions Made
11/5/20	Chris Garrett	Process memorandum created
1/13/21	Chris Garrett	Final update prior to release of FEIS to incorporate recent submittals

Purpose of Process Memorandum

The purpose of this process memorandum is to provide details for the project record about the proceedings of a series of workgroups that were convened by the Tonto National Forest in order to help assess and analyze various water resource issues.

Note that it is not a purpose of this memo to provide any professional opinions resulting from these workgroups, but only an overview of the proceedings.

Overview of Water Resources Workgroup Process

In general, the various water resources workgroups fall into two categories: before release of the draft environmental impact statement in August 2019 (pre-DEIS), and after receipt of public comments (post-DEIS).

Pre-DEIS – Groundwater Modeling Workgroup

After scoping and during preparation of the DEIS, a groundwater modeling work group was created. The Tonto National Forest (TNF) determined that the most appropriate approach to review the mine site groundwater modeling work being conducted by Resolution Copper would be to collaboratively review the modeling approaches and results with stakeholders, including cooperating agencies.

Regular meetings of the groundwater modeling work group were held starting in September 2017. Regular attendees included Forest Service (TNF specialists, as well as enterprise specialists), third-party specialists contracted to prepare the NEPA documents (SWCA Environmental Consultants, HydroGeo Inc., BGC Engineering Inc., and other subcontractors), Resolution Copper and contractors (WSP, Montgomery & Associates, WestLand Resources), Arizona Department of Water Resources, Arizona Game and Fish Department, specialists on behalf of the San Carlos Apache Tribe, and U.S. Environmental Protection Agency. The complete list of attendees and qualifications is described elsewhere in this process memo.

Pre-DEIS – Geochemistry/Water Quality Workgroup

During preparation of the DEIS, a separate workgroup was formed to address geochemistry and water quality issues, including the effects of seepage from the tailings storage facility. Unlike the groundwater modeling workgroup, this workgroup did not involve outside stakeholders or

cooperating agencies, and was limited to the Forest Service, third-party NEPA team specialists, and Resolution Copper and their contractors.

Post-DEIS – Water Resources Workgroup

The DEIS was released in August 2019, with the analysis of groundwater impacts strongly informed by the proceedings of both the groundwater modeling workgroup and the geochemistry/water quality workgroup.

The public comment period on the DEIS closed in November 2019 (December 2019 for tribes). A substantial amount of the total comments received on the DEIS (roughly 10%) involve water resource issues.

The TNF reconvened the groundwater modeling workgroup in January 2020 in order to help assess these comments, but with an expanded scope of analysis to include not just the mine site groundwater model, but also the Desert Wellfield groundwater model, surface water analysis, and water quality issues. The need for the expanded scope of analysis was directly due to the types of comments received. The expanded workgroup has essentially the same participants as the groundwater modeling workgroup but incorporates members of the geochemistry/water quality workgroup as well.

The reference to "Water Resources Workgroup" in this process memo is meant to reflect the combined water resources workgroup (post-DEIS).

Workgroup Participants and Qualifications

The following is a consolidated list of participants for the workgroups. This list contains many of the regular participants for the workgroups since 2017 but should not be considered a full list of all participants.

Resumes and qualifications submitted by participants are included as Attachment 1 to this process memorandum.

<u>Third-Party NEPA Team</u>

Chris Garrett (SWCA). Role: Coordination and facilitation of working group; coordination of internal and external parties; strategic guidance.

Donna Morey (SWCA). Role: Administrative/logistical support from project management team.

Gabi Walser (BGC). Role: Technical modeling expertise; ensure modeling work is compatible with hydrologic interpretations.

Mark Williamson (Geochemical Solutions). Role: Geochemistry and water quality expertise.

Mike Henderson (BGC). Role: Strategic guidance and general technical expertise.

Nick Enos (BGC). Role: Strategic guidance and general technical expertise.

Derek Hrubes (BGC). Role: General technical expertise and management.

Hamish Weatherly (BGC). Role: Surface water and surface water modeling expertise.

Forest Service

Mary Rasmussen (Tonto National Forest). Role: Strategic guidance; ensuring work conforms with Forest Service overall approaches, decisions, and strategies.

Edward Gazzetti (Forest Service). Role: Water resources and modeling expertise.

Judd Sampson (Tonto National Forest). Role: Strategic guidance; minerals and geology expertise.

Lee Ann Atkinson (Tonto National Forest). Role: Strategic guidance; minerals and geology expertise.

Greg Olsen (Tonto National Forest). Role: Project hydrologist and water resources expertise.

Joe Gurrieri (Forest Service), Role: Water resources expertise.

Tim Stroope (Forest Service). Role: Water resources expertise.

Resolution Copper

Vicky Peacey (Resolution Copper). Role: Proponent representative and point of contact.

Cameo Flood (Tetra Tech). Role: Proponent technical and regulatory expertise.

Jim Butler (Parsons, Behle, and Latimer). Role: Proponent regulatory expertise.

Greg Ghidotti (Resolution Copper). Role: Proponent technical and water resources expertise.

Mark Logsdon (Resolution Copper). Role: Geochemical expertise.

Matt Wickham (Resolution Copper). Role: Geochemical and hydrology expertise.

Todd Keay (Montgomery & Associates). Role: Water resources expertise.

Tim Bayley (Montgomery & Associates). Role: Water resources and groundwater modeling expertise.

Gustavo Mesa-Cuadro (WSP). Role: Groundwater modeling expertise.

Doug Oliver (WSP). Role: Groundwater modeling expertise.

Ted Eary (Enchemica). Role: Geochemistry and water quality expertise.

Chris Pantano (WSP). Role: Groundwater modeling expertise.

Chris Gregory (Montgomery & Associates). Role: Water resources and groundwater modeling expertise.

Kate Patterson (Klohn Crippen Berger). Role: Facility design and site investigation.

Derek Groenendyk (Montgomery & Associates). Role: Water resources and groundwater modeling expertise.

Hale Barter (Montgomery & Associates). Role: Water resources and groundwater modeling expertise.

Other Agencies/Entities

USEPA (Hugo Hoffman; Pat Kelly; Hannah Dailey). Role: Water resources expertise; cooperating agency.

USACE (Mike Langley). Role: Project manager for Resolution Copper Clean Water Act 404 permit.

ADWR (Bret Esslin). Role: Water resources expertise; cooperating agency.

AGFD (Jim Ruff). Role: Water resources expertise; cooperating agency.

San Carlos Apache Tribe (Jim Wells). Role: Water resources expertise.

ADEQ (Wayne Harrison). Role: Water resources expertise; cooperating agency.

USGS. Role: while USGS specialists attended some early workgroup meetings, ultimately they declined involvement in the project.

Workgroup Charter/Sideboards

The expectations for the pre-DEIS Groundwater Modeling Workgroup and the post-DEIS Water Resources Workgroup were expressed to the participants at the respective kick-off meetings (September 2017 and January 2020).

Pre-DEIS Groundwater Modeling Workgroup

The following guidance was provided to the workgroup participants in September 2017:

> Overarching Modeling Philosophy:
>
> 1. The groundwater model is one tool that can be used to predict impacts, but not the only tool.
> 2. The groundwater model should represent the best available science.
> 3. The groundwater model should not be used to answer questions that are beyond its ability to answer.
> 4. The Forest Service is ultimately responsible for approving the groundwater model in all its aspects, but all voices at the table should be heard and considered.
> 5. Every effort will be made to make decisions on modeling approach before seeing the model output. It is not appropriate to rethink the model in order to arrive at a particular desired answer.

Post-DEIS Water Resources Workgroup

The following guidance was provided to the workgroup participants in January 2020:

> In August 2019 we published the Draft EIS, we have now received all public and agency comments on the analysis, and we are now on the road to the Final EIS.

NEPA regulations (40 CFR 1503.4) require that we assess and consider all comments received on the Draft EIS. *The purpose of reconvening and expanding the Water Resources workgroup is to assist the Forest Service and the NEPA team in determining the appropriate responses to water-related comments.*

We will respect every comment provided and will give it due consideration. For the purposes of the reconvened Water Resources workgroup there are several sideboards to keep in mind as we do this.

1. Some water-related comments may not be provided to the workgroup for evaluation, if they are more appropriately handled within the agency (i.e., decisions involving NEPA process or scope of analysis, legal interpretations) or by a different group or process (i.e., mitigation discussions).
2. The Forest Service has a valid rationale for the analyses that appeared in the Draft EIS, and we've documented that rationale in the project record. If this weren't the case, we would not have published a Draft EIS. Our default position is that the decisions made and rationale documented for the Draft EIS remain appropriate, unless reconsidered in response to a specific comment or new information. Put more simply, we are not reopening the analysis solely for the sake of reopening it.
3. As a general rule, the first step in responding to a comment will be to conduct a fact-check. We've noted that there are a substantial number of comments that at first blush appear to be based on demonstrably incorrect information, partial information (i.e., review of DEIS, but not background materials), or information clearly taken out of context.
4. A comment that simply disagrees with the approach used in the Draft EIS, but provides no actionable reason or critique, is likely not strong enough to warrant reopening the analysis. We need something concrete to which we can respond.
5. As with the previous workgroup efforts, the final decisions lie with the Forest Service. Consensus is desirable, but we aren't seeking it. Rather, our goal is to ensure that a wide variety of professional viewpoints are heard in order to inform the decisions made by the Forest Service.
6. We are currently planning on six months of monthly meetings. Each meeting will likely cover multiple topics. The order of these topics will be decided by the Forest Service, with an eye towards the most efficient use of time.

Process Steps, Data Requests, Data Submittals, and Project Record References

Logistically, the workgroup process involved:

- Circulation of pertinent materials to workgroup members;

- Open discussion of data, analysis, and issue during periodic workgroup meetings, typically monthly;
- During meetings, development of action items for workgroup members; often these action items were requests for additional data from Resolution Copper and their contractors; and
- Receipt and review of data submitted in response to action items.

The following three tables summarize the key process steps for the three workgroups described above. The following tables include dates of meetings, correspondence, and certain internal process steps; action items/data requests; responses to action items/data submittals; and where information can be located in the project record. Key aspects of the tables include:

- Note that many calls or meetings that were internal to the third-party NEPA team, with no Forest Service, Resolution Copper, or outside agency involvement, are not contained in the project record but still may be mentioned on this list.
- Internal drafts of EIS sections or similar work products generally are not captured in the project record, though some comments from workgroup members may be. Internal drafting of work products largely is not included in the tables. Where internal drafting steps are noted for completeness, the project record often is for the final document, not interim work products.
- The tables indicate the project record number for each document or work product. These lists are intended to be reasonably complete, but note that the project record remains the official repository of information and additional items may be in the project record that are not captured here.
- For completeness, these tables may include documents pertinent to water resource issues that were reviewed by the internal NEPA team, but not necessarily circulated to or discussed with the workgroup members.
- Where "action item" identifiers were used in the meetings, these are shown in the tables to help track data requests and data submittals in response to those requests. One purpose of including these identifiers is to demonstrate that all action items requested by the workgroup were resolved or cleared.
- Abbreviations used in the tables include the following:
    - FS – Forest Service. This could refer specifically to specialists or management staff at the Tonto National Forest, or more generically to Regional or enterprise Forest Service specialists.
    - SWCA – SWCA Environmental Consultants. SWCA is the third-party NEPA contractor working on behalf of the Forest Service.
    - BGC – BGC Engineering. BGC provided technical expertise on water issues to the Forest Service as part of the NEPA team.
    - RCM – Resolution Copper Mining. This could refer either to the company itself, or as a generic term including their contractors.
    - M&A – Montgomery & Associates. M&A worked on behalf of Resolution Copper, focused on water, water quality and modeling issues.

- WSP – WSP worked on behalf of Resolution Copper, primarily focused on groundwater modeling.
- KCB – Klohn Crippen Berger. KCB worked on behalf of Resolution Copper, focused on tailings design, engineering, and analysis.
- GDE – Groundwater-dependent ecosystem. This refers to springs, streams or other groundwater-supported water sources on the landscape.
- N/A – Indicates that no project record material exists for this process step.

Table 1. Pre-DEIS Groundwater Modeling Workgroup

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
10/18/16	Internal documentation	Process Memorandum to File - Summary of Hydrologic, Hydrochemical, and Geochemical Data Received to Date	0001189		
11/11/16	Internal documentation	Process Memorandum to File - Water Rights and Central Arizona Project Allocations	0001188		
3/30/17	Internal documentation	Process Memorandum to File - Summary of GIS Spring Coverage	0004475		
6/5/17	Internal documentation	Process Memorandum to File - Summary of Mine Water Balance and Sources	0001389		
8/16/17	Internal documentation	Process Memorandum to File - Addendum #1 to October 18, 2016 Process Memo "Summary of Hydrologic, Hydrochemical, and Geotechnical Data Received to Date"	0002105		
9/19/17	Meeting/call	Kickoff meeting for groundwater modeling workgroup. Major action items requested: • RCM: References from WSP report [GW-1] • RCM: Water balance information from WSP [GW-2] • SWCA: Circulate water balance memo and issues report [GW-3] • SWCA: Provide meeting notes [GW-4] • RCM: Submit groundwater model framework and calibration report [GW-5]	0002056	[GW-1] [GW-2] [GW-3] [GW-4] [GW-5]	
9/20/17	Correspondence	Water balance memo and draft final issues report distributed to workgroup [GW-3]	0001389; 0001533		[GW-3]
9/29/17	Correspondence	Meeting notes distributed to workgroup [GW-4]	0002056		[GW-4]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
10/2/17	Internal documentation	Process Memorandum to File - Addendum #2 to October 18, 2016 Process Memo "Summary of Hydrologic, Hydrochemical, and Geotechnical Data Received to Date"	0002106		
10/3/17	Data submittal	Seeps and springs catalog received	0002102		
10/18/17	Data submittal	WSP modeling report received [GW-5, and GW-44 is also addressed by Appendix A of report]	0002006		[GW-5] [GW-44]
10/20/17	Data submittal	Near West baseline hydrology report received	0002048		
11/7/17	Correspondence	Internal comments from G. Olsen with USGS modeling guidance received	0004880		
11/8/17	Correspondence	USGS guidance provided by G. Olsen circulated to workgroup	0004881		[GW-8]
11/8/17	Correspondence	Internal comments from J. Guerreri received	0002220		
11/13/17	Correspondence	Interim response from USGS on involvement in groundwater modeling workgroup received	0002101		
11/14/17	Data submittal	Oak Flat water feature monitoring report received	0002599		
11/14/17	Meeting/call	Full groundwater modeling workgroup meeting. Major action items requested: • RCM: Cross-sections [GW-6A] • RCM: Contours for calibration [GW-6B] • RCM: Flow direction [GW-6C] • RCM: Gaining/losing reaches [GW-6D] • RCM: Steady-state water balance [GW-6E] • RCM: Cross-sections w/ model grid and hydrologic units [GW-6F]	0002170	[GW-6A] [GW-6B] [GW-6C] [GW-6D] [GW-6E] [GW-6F] [GW-6G] [GW-6H] [GW-7] [GW-7A]	

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• RCM: Check that hydrologic units go back to a reference [GW-6G] • RCM: Boundary water balances [GW-6H] • ALL: Climate change information from other models [GW-7] • SWCA: Distribute climate change process memo [GW-7A] • SWCA: Circulate modeling guidance provided by G. Olsen [GW-8] • FS/SWCA: Internal discussion of Desert Wellfield modeling needs [GW-9]		[GW-8] [GW-9]	
11/28/17	Data submittal	Near West conceptual hydrology report received (revised 12/5/17)	0002124		
12/6/17	Correspondence	Internal comments from G. Olsen received	0004882		
12/11/17	Correspondence	Comments from EPA received	0004883		
12/12/17	Meeting/call	Full groundwater modeling workgroup meeting. Major action items requested: • ALL: Bring forward any GDE information for consideration [GW-12—ongoing process throughout workgroup] • RCM: Discuss reason GHBs were assigned to surface flows [GW-13] • RCM: Quantify surface drain cell flux and compare to recharge along same reach [GW-14] • RCM: Quantify flux between shallow and deep system, through Whitetail Conglomerate [GW-15] • RCM: Proceed with predictive runs [GW-16A]	0002209	[GW-12] [GW-13] [GW-14] [GW-15] [GW-16A] [GW-16B] [GW-16C] [GW-16D] [GW-17] [GW-27] [GW-31] [GW-32]	

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• RCM: Provide flux for drain cells in subsidence zone [GW-16B] • RCM: Provide drawdown hydrographs for GDE locations [GW-16C] • RCM: Provide drawdown spatial contours [GW-16D] • RCM: Need to understand GHB during baseline and predictive runs, demonstrate flux across boundaries [GW-17] • FS/SWCA: Complete global determination of how to handle baseline conditions [GW-31] • RCM: Calibration contours at end of calibration period [GW-27] • RCM: Provide steady-state water balance at beginning of historic model (pre-1910) [GW-32]			
12/14/17	Correspondence	Comments from J. Wells, re: caving zone received	0002649		
12/14/17	Correspondence	Internal comments from G. Olsen, re: stream package received	0004885		
12/14/17	Data request	Revised action item list sent to group, including additional action items for J. Wells and G. Olsen comments: • RCM: Explanation for why MODFLOW SFR package isn't appropriate [GW-54] • RCM: Explanation for changing properties in subsidence zone [GW-55]	0004884	[GW-54] [GW-55]	
12/15/17	Correspondence	Internal comments from G. Olsen received	0004886		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
12/18/17	Correspondence	Climate change information provided by J. Ruff	0004887		[GW-7]
12/19/17	Correspondence	Internal comments from G. Olsen received	0004888		
1/9/18	Data submittal	Response to 11/14/17 and 12/12/17 action items received: • Item #1. GHB boundary assessment [GW-6H, GW-13, GW-17] • Item #2. Comparison of DRN cell flux and recharge rates [GW-6D, GW-14] • Item #3. Downward flow through Whitetail [GW-15] • Item #4. Calibration contours [GW-6B, GW-6C, GW-27] • Item #5. Comparison of Devil's Canyon DRN cells to field flow measurements [GW-14] • Item #6. Steady-state water balance [GW-6E, [GW-32] • Item #7. Cross-section of geology model vs. model grid [GW-6A, GW-6F] • Item #8. Discussion of why SFR package was not used, why DRN cells were used [GW-54] • Item #9. Clarify handling of caving zones [GW-55; GW-43]	0002212		[GW-6H] [GW-6A] [GW-6F] [GW-6E] [GW-6D] [GW-6B] [GW-6C] [GW-13] [GW-14] [GW-15] [GW-17] [GW-27] [GW-32] [GW-43] [GW-54] [GW-55]
1/16/18	Meeting/call	Full groundwater modeling workgroup meeting • FS/SWCA: Determine policy on raw model files [GW-18] • FS/SWCA: Research use of Anderson, Woessner, Hunt reference [GW-19] • SWCA: Expand GDE document to incorporate more supporting data [GW-20]	0002192	[GW-18] [GW-19] [GW-20] [GW-21] [GW-22] [GW-23] [GW-24]	

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• RCM: Quantify drain and recharge cells to support graphical depictions [GW-21] • FS/SWCA: Look into pertinent hydro/geo information from Pinto Valley or Carlota [GW-22] • RCM: Clarify supporting documentation for interpretation of ALT/WTC hydraulic properties/anisotropy [GW-23] • RCM: Consider ways to allow a reality check on drain/recharge values [GW-24, GW-30] • RCM: Clarify time period depicted on graphs of flux/recharge [GW-25] • RCM: Provide time series of recharge and discharge, and discuss relative timing [GW-26] • RCM: Provide residual heatmap of calibration errors [GW-28] • RCM: Provide figure with gaining reaches based on DRN cells, compared to measured field flows [GW-29] • RCM: Clarify if drains in 1/9/18 #6 table are active during 2016 period [GW-33] • RCM: Clarify why drain flows in mine workings show a reduction [GW-34]		[GW-30] [GW-25] [GW-26] [GW-28] [GW-29] [GW-33] [GW-34]	
1/19/18	Correspondence	Series of clarification questions posed by EPA	0004889		
1/25/18	Data request	Clarification questions posed by EPA circulated to workgroup	0004890		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
2/7/18	Correspondence	C. Garrett contacted author of Anderson et. al. re: use of publication in project record; received no follow-up from attempt to contact publisher. Default to treat as normal reference.	0004891		[GW-19]
2/13/18	Meeting/call	Full groundwater modeling workgroup meeting • RCM: Expected report for recreation of aquifer tests with model [GW-35] • RCM: Expected report for M&A water balance [GW-36] • RCM: Expected report comparison USGS regression for surface water data set [GW-37; done as part of surface water modeling by BGC, PR #0110781] • RCM: Expected report for Wickham fault memo [GW-38] • RCM: Specific model hydrographs at GDE locations, or rationale for why not appropriate [GW-39] • RCM: Changes in flux in drain cells along Devil's Canyon, for LOM and post-closure models [GW-40] • RCM: Change in wetted length along Devil's Canyon [GW-41] • RCM: Drawdown in aquifer units extending into Superior basin [GW-42] • RCM: Clarification of fault pressure handling [GW-43] • RCM: Clarify selection of hydraulic conductivity [GW-44] • RCM: Clarify assignment of recharge [GW-45] • RCM: Sensitivity analyses [GW-46]	0002320	[GW-35] [GW-36] [GW-38] [GW-39] [GW-40] [GW-41] [GW-42] [GW-43] [GW-44] [GW-45] [GW-46] [GW-47] [GW-48] [GW-49] [GW-50] [GW-51] [GW-52] [GW-53]	[GW-16A] [GW-16D]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• EPA: Send examples of ecolological risk assessment pertinent to possible crater lake [GW-47] • FS/SWCA: Look at use of reduced flux values in Devil's Canyon effect on hydrograph [GW-48] • FS/SWCA: Look at application of drawdown to Devil's Canyon [GW-49] • FS/SWCA: Continue prep of GW Modeling Group Tech Memo, to circulate to group when ready [GW-50] • Decision to table discussion of model and water quality [GW-51--see geochem work group] • RCM: Reiteration of GW-17 needs [GW-52] • RCM: Need for sensitivity runs for recharge amounts [GW-53]			
2/13/18	Data submittal	Response to 1/25/18 questions from EPA received: • Item #2. Comparison of DRN cell flux and recharge rates [GW-21; GW-26; GW-25] • Item #4. Calibration contours [GW-28] • Item #5. Comparison of Devil's Canyon DRN cells to field flow measurements [GW-29] • Item #6. Steady-state water balance [GW-33; GW-34]	0002323		[GW-21] [GW-25] [GW-26] [GW-28] [GW-29] [GW-33] [GW-34]
2/23/18	Data submittal	Pit lake approach examples submitted by EPA [GW-47]	0004892		[GW-47]
2/23/18	Meeting/call	Internal Forest Service water status meeting	0004893		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
2/28/18	Correspondence	Internal request sent to Forest Service water specialists regarding pit lake analysis and background fluctuations	0004894		
3/1/18	Correspondence	Reply to 2/28/18 request by G. Olsen received	0004895		
3/1/18	Correspondence	Reply to 2/28/18 request by J. Sampson received	0004896		
3/6/18	Correspondence	Silver King APP received from FS	0004897		
3/13/18	Meeting/call	Full groundwater modeling workgroup meeting • FS/SWCA: Expand GDE list to incorporate G. Olsen comments [GW-56] • FS/SWCA: Obtain copies of Silver King APP background file docs from G. Olsen [GW-57] • RCM: Tech memo addressing available data for GDEs, to supplement SWCA memo [GW-58] • FS/SWCA: Circulate draft tech memo for internal comment [GW-59] • SWCA: Post WSP references to SharePoint [GW-60; ongoing process throughout workgroup] • SWCA: Distribute Climate Change process memo to group, consider for ramifications on recharge [GW-61] • SWCA: Research thresholds for groundwater drawdown from other EISs [GW-62] • RCM: Provide predicted drawdown in individual cells related to start of perennial reach, to evaluate as a trigger for loss of base flow [GW-63]	0003410	[GW-56] [GW-57] [GW-58] [GW-59] [GW-60] [GW-61] [GW-62] [GW-63]	[GW-40; GW-41; GW-48; GW-49 all tabled after discussion of using heads vs. flux for output]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
3/14/18	Correspondence	Draft groundwater tech memo circulated to FS specialists [GW-59]	0004898		[GW-59]
3/16/18	Correspondence	Climate change process memo circulated to workgroup [GW-7A, GW-61]	0002345		[GW-7A] [GW-61]
3/19/18	Correspondence	Full hardcopy of Silver King APP received from FS for review, not copied or entered into record in whole, but excerpts circulated 4/16/18 [GW-57]	N/A		[GW-57]
3/21/18	Meeting/call	Internal call with Forest Service water specialists to discuss GDE comments [GW-59]	0005000		[GW-59]
3/21/18	Correspondence	Historic topographic map link from G. Olsen received	0004899		
3/21/18	Correspondence	Comments on draft groundwater tech memo received from T. Stroope [GW-59]	0004900		[GW-59]
3/23/18	Meeting/call	Internal Forest Service water status meeting	0002442		
3/26/18	Data submittal	Missing 70-day aquifer test report submitted by RCM	0002365		
3/27/18	Correspondence	Discussion of drawdown thresholds received from EPA for discussion at next meeting [GW-62]	0002361		[GW-62]
3/27/18	Correspondence	Comments on draft groundwater tech memo received from M. Rasmussen, J. Guerrieri, G. Olsen	0005001-0005003		[GW-59]
3/29/18	Correspondence	Consolidated comments on tech memo sent back to G. Walser	0005004		
4/2/18	Correspondence	Clarification requested of WPS on software details	0005005		
4/3/18	Correspondence	Response from 4/2 request received from WPS	0005006		
4/3/18	Correspondence	Additional riparian response literature received from G. Olsen	0005006		
4/5/18	Correspondence	Additional riparian response literature received from J. Gurrieri	0005108		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
4/10/18	Correspondence	NEw copy of PR #0000044 PDF (Queen Creek Corridor report) requested from RCM	0005007		
4/11/18	Internal documentation	Process Memorandum to File - Selection of Appropriate Baseline Conditions for NEPA Analysis	0002841		[GW-31]
4/12/18	Correspondence	GDE impact framework; GDE portfolios; literature review circulated to workgroup for review	0005008		[GW-56]
4/16/18	Correspondence	Draft groundwater tech memo circulated to workgroup [GW-50]; Silver King APP information circulated to workgroup	0005009		[GW-50]
4/17/18	Meeting/call	Full groundwater modeling workgroup meeting • SWCA: Conduct independent review of evidence for water sources for GDEs [GW-64] • RCM: Desired output from model—site-specific hydrographs for each GDE on list; color flood map of drawdowns for entire model domain; [GW-65] • RCM: Prepare mixing cell model for block-cave zone [GW-66] • Further validate use of drain cells by: estimate near-surface groundwater from NDVI or veg surveys and compare geographically [GW-67A], compare drain flux to regional water balance [GW-67B]	0002720	[GW-64] [GW-65] [GW-66] [GW-67A] [GW-67B]	[GW-39; GW-63 both superceded by GW-65; GW-67A]
4/17/18	Correspondence	Requested data sets received from G. Olsen	0005010		
4/18/18	Correspondence	Summary of meeting circulated to workgroup	0005011		
4/18/18	Data submittal	• Requested references [GW-1] • HGU/geologic unit correlation table [GW-6G]	0000768 0002365		[GW-1] [GW-6G]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• GDE table • Seeps and springs report • Hydrologic info for Miami area [GW-22] • Report on aquifer test simulation with groundwater flow model [GW-24; GW-30; GW-35] • Suggested references for pumping tests to support ALT/WTC interpretations [GW-23] • Clarification of how recharge was assigned [GW-45] • Tech memo with supplemental GDE information [GW-58]	0002497 0002498 0002499 0002500 0002501 0002502 0002503 0002504 0002505 0002506 0002574		[GW-22] [GW-23] [GW-24] [GW-30] [GW-35] [GW-45] [GW-58]
4/18/18	Data submittal	Devil's Canyon flyover information from AGFD received	0002451		
4/19/18	Correspondence	Follow-up correspondence received from H. Gluski	0005012; 0005015		
4/19/18	Correspondence	Acoustic televiewer information received from G. Olsen	0005013		
4/19/18	Correspondence	Recharge information received from G. Olsen	0005014		
4/20/18	Correspondence	AGFD Devil's Canyon flyover information circulated to G. Olsen	0005016		
4/20/18	Meeting/call	Internal Forest Service water status meeting	0002466		
4/23/18	Correspondence	Devil's Canyon modeling questions received from G. Olsen	0005017		
4/29/18	Correspondence	Overall water quality plan to tackle remaining analyses for groundwater quality, surface water quality, and GDE water source assessment prepared and circulated to internal NEPA group.	0005018		
5/1/18	Correspondence	Follow-up sent to J. Ruff (AGFD) on GDE approaches	0005019		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
5/3/18; 5/4/18	Correspondence	Concerns from G. Olsen regarding model software received, for discussion on 5/15 and 5/18	0005020; 0005021		
5/4/18	Correspondence	Feedback received from J. Gurrieri on 4/29 submittal, with suggestions for possible approaches	0005023		
5/4/18	Data submittal	List of proposed sensitivity runs submitted by RCM; circulated to workgroup	0005022		[GW-53]
5/8/18	Correspondence	Feedback received from G. Walser	0005024		
5/13/18	Correspondence	Clarification on runs requested from WSP	0005203		
5/14/18	Correspondence	Clarification on runs provided by WSP in response to 5/13 request	0005027		
5/14/18	Correspondence	Responded to G. Olsen 5/3/ email re: modeling software, and notified H. Gluski about likely discussion of MODFLOW-SURFACT	0005025		
5/15/18	Meeting/call	Full groundwater modeling workgroup meeting • Received sensitivity results • RCM: Updated table for Appendix C and add figures to show zones [GW-68] • RCM: Compare fluxes across northern boundary during calibration and during predictive run [GW-69] • RCM: Water table maps for entire model area for 1910, and for end of calibration/beginning of predictive runs [GW-70] • RCM: Add specific yield in cave zone to sensitivity runs [GW-71]	0002755	[GW-68] [GW-69] [GW-70] [GW-71]	[GW-42; GW-46; GW-53; GW-65 all discussed during meeting] [GW-66 superceded by decisions on formation of crater lake]
5/15/18	Correspondence	Obtained NDEP report raised by G. Olsen, reviewed for pertinence	0005028		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
5/23/18	Analysis	Began GDE water source investigation; final results captured on GDE process memo	0110673		[GW-56] [GW-64]
5/30/18	Analysis	Internal GDE analysis completed, to be compiled into process memo	0110673		[GW-56] [GW-64]
6/7/18	Analysis	Prepared internal documentation to address adherence with ASTM and reference standards, provided to G. Walser to incorporate into overall workgroup memo	0005029		
6/13/18	Correspondence	Draft impact language circulated to workgroup	0005030		
6/13/18	Data submittal	• M&A report: System-wide Hydrologic Water Flow Budget [GW-2, GW-36] • Wickham report: Fault Core Review and Guidance for Groundwater Flow Modeling [GW-1; GW-38]	0002641 0002642		[GW-2] [GW-36] [GW-38]
6/18/18	Data submittal	• Water table map 2017 [GW-70] • Water table map 1910 [GW-70] • List of sensitivity runs and ranges [GW-71] • Maps and cross-sections, hydraulic conductivity zones • Excel table, hydraulic conductivity zones [GW-68]	0002741 0002742 0002743		[GW-68] [GW-70] [GW-71]
6/18/18	Correspondence	Received uncertainty language example from Montanore SEIS from J. Gurrieri	0005031		
6/19/18	Meeting/call	Full groundwater modeling workgroup meeting • Sensitivity results discussed • SWCA: Post alternative portfolios so SharePoint [GW-72]	0002667	[GW-72] [GW-73] [GW-74] [GW-75]	[GW-17; GW-46; GW-52, GW-53, GW-64, GW-69; GW-71

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
		• SWCA: Provide process memo to workgroup with alternative naming conventions [GW-73] • RCM: Clarifications of water balance from AZ Water Company component and ADOT water use [GW-74] • RCM: Resubmit 6/18/18 information with elevations and units added [GW-75] • RCM: Submit water level map with: difference between 1910 and 2017 maps; zoom into area near Magma Mine [GW-76] • RCM: Provide further detail for boundary fluxes for GHB vs. No-flow comparison, and compare flux change to model pumping stresses [GW-77] • SWCA: Revise GDE memo to reflect rationale discussed in meeting, and circulate [GW-78] • RCM: M&A to provide additional rationale for GDEs not connected to regional system [GW-79A], also submit Seeps and Springs Catalog 2.0 [GW-79B] • RCM: Provide explanation of how "impact" is calculated [GW-80] • RCM: Clarify use of DHRES-16 as analog for Superior [GW-81] • SWCA: Rewrite proposed impact language as per workgroup discussion and agreement on 6/19 and circulate to group [GW-82]		[GW-76] [GW-77] [GW-78] [GW-79A] [GW-79B] [GW-80] [GW-81] [GW-82]	all discussed during meeting]
6/20/18	Correspondence	Follow-up information on ADOT received from G. Olsen [GW-74]	0005032		[GW-74]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
6/21/18	Correspondence	Action items circulated to workgroup	0005033		
6/22/18	Data submittal	M&A springs catalog v.2 received [GW-79B]	0002677		[GW-79B]
6/22/18	Analysis	Developed detailed outline for Affected Environment and Environmental Consequences; internal only, not in record	N/A		
6/28/18	Correspondence	Data Analysis Requests #2 and #3 concerning proper archiving of model files submitted by FS to RCM	0002732		[GW-18]
6/28/18	Correspondence	Comments received on baseline conditions process memo	0005034		
7/5/18	Correspondence	Revised impact language/approach circulated to workgroup [GW-82]	0005035		[GW-82]
7/5/18	Correspondence	Comments received from G. Olsen	0005036		
7/6/18	Correspondence	Revised draft language in response to G. Olsen comments circulated to workgroup [GW-82]	0005037		[GW-82]
7/9/18	Correspondence	Comments received from M. Rasmussen and G. Walser	0005041		
7/9/18	Analysis	Revised GDE process memo to incorporate physical constraints [GW-78; GW-81—explained in analysis of DHRES-16]	0110763		[GW-78] [GW-81]
7/9/18	Correspondence	Posted alternative portfolios and naming memo to SharePoint for workgroup [GW-72, GW-73]	0005039		[GW-72] [GW-73]
7/12/18	Correspondence	Query on acoustic televiewer data received from G. Olsen	0005042		
7/13/18	Meeting/call	Internal water status meeting	0002753		
7/15/18	Analysis	GDE process memo revised [GW-78]	0110763		[GW-78]
7/16/18	Correspondence	M. Rasmussen responsed to G. Olsen 7/12 query	0005043		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
7/17/18	Meeting/call	Full groundwater modeling workgroup meeting	0002786		[GW-66 superceded by decisions on formation of crater lake]
7/20/18	Data submittal	Skunk Camp baseline hydrology site reconnaissance report received	0002781		
7/24/18	Correspondence	Comprehensive EIS outline for all three water sections circulated to hydrology/geolgoy team	0005044		
7/24/18	Correspondence	Climate change memo circulated o workgroup	0005045		
7/24/18	Meeting/call	In person technical meeting to review groundwater model between WSP and G. Walser; no meeting notes prepared	N/A		
7/25/18	Correspondence	Files requested from WSP by G. Walser	0005046		
7/25/18	Data submittal	Files requested by G. Walser from WSP received	0005047		
7/30/18	Correspondence	Comments received from J. Ruff (AGFD) on climate change memo	0005049		
7/30/18	Correspondence	Water balance question received from G. Walser; internal decision to postpone request until receipt of latest information	0005048		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
8/6/18	Data submittal	• Predictive modeling results [GW-81; GW-16A; GW-16C; GW-16D] • Revised material properties sheet [GW-75] • 1910-2017 water table difference map [GW-76] • GHB comparison [GW-77] • Discussion of impact calculation methodology [GW-80]	0110556 0002844		[GW-16A] [GW-16C] [GW-16D] [GW-75] [GW-76] [GW-77; which is similar to GW-17; GW-52; GW-69] [GW-80]
8/9/18	Correspondence	Request for mitigation workgroup received from G. Olsen; response provided by M. Rasmussen	0005050; 0005051		
8/14/18	Internal documentation	Process Memorandum to File - Surface Water Quality Standards	0110845		
8/15/18	Correspondence	Modeling result question received from J. Ruff; submitted to RCM/WSP	0002902		
8/20/18	Correspondence	Response received on 8/15 question from RCM/WSP	0002903		
8/21/18	Data submittal	M&A memo clarifying GDEs not connected to regional system received [GW-79B]	0002932		[GW-79A]
8/21/18	Data submittal	Wickham technical memo received, missing reference [GW-1]	0002900		
8/22/18	Correspondence	Clarification requested from RCM on [GW-79B]submittal	0005054		[GW-79B]
8/31/18	Data submittal	Groundwater modeling sensitivity results received [GW-46; GW-53; GW-71]	0002950		[GW-46] [GW-53] [GW-71]
9/4/18	Correspondence	Clarification received from M&A from 8/22 request	0110537		[GW-79B]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
9/6/18	Data submittal	Alternatives water balance memo received	0110517		
9/10/18	Analysis	Revised GDE process memo and impacts summary for discussion at groundwater workgroup meeting [GW-78]	0110763		[GW-78]
9/11/18	Correspondence	Obtained clarification from M&A on Bitter Spring modeling results	0005056		
9/12/18	Meeting/call	Full groundwater modeling workgroup meeting • RCM: Provide water balance components from GW model to compare to M&A water balance memo; provide mine dewatering drain cell water balance from GW model to compare to RCM estimates of pumping rates [GW-83] • RCM: WSP to re-issue October 2017 report [GW-84] • RCM: WSP to re-issue August 6 tech memo [GW-85] • SWCA: Circulate latest version of GDE process memo [GW-86] • SWCA: Circulate revisions to effects table based on input from 9/12 meeting [GW-87] • SWCA: Incorporate GDE classification table into Affected Environment [GW-88] • RCM: WSP to provide separate tech memo with all recharge zones +/- 50% to inform climate change discussion [GW-89] • RCM: WSP to provide Excel data fro hydrographs [GW-90] • SWCA: Circulate surface water tech memo from Hamish [GW-91 done as part of surface water modeling by BGC, PR #0110781]	0110613	[GW-83] [GW-84] [GW-85] [GW-86] [GW-87] [GW-88] [GW-89] [GW-90] [GW-91]	[GW-61; GW-80 both discussed at meeting] [GW-67B superceded by GW-83] [GW-78 superceded by GW-86]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
9/12/18	Analysis	Summarized GDE impacts for wildlife specialists	0005057		
9/12/18	Correspondence	Climate change data source received from J. Ruff (AGFD) for discussion	0005058		
9/13/18	Data submittal	Desert Wellfield modeling report received [GW-9]	0110568		[GW-9]
9/14/18	Correspondence	GDE memo and action items circulated to workgroup [GW-86]	0005059		[GW-86]
9/14/18	Correspondence	Clarification received from M&A on Harborlite well	0005060		
9/17/18	Correspondence	Revisions to 9/14 Attachment 7 received from M&A	0005061		
9/19/18	Correspondence	Clarification received from M&A on Harborlite dewatering	0005062		
9/21/18	Correspondence	Additional information received from J. Ruff and G. Olsen on Harborlite discharges	0005056 0005066		
9/27/18	Correspondence	Comments on GDEs and impact language received from P. Kelly (EPA), with concurrence from M. Rasmussen	0005067		
9/30/18	Data submittal	WSP dewatering flow data received [GW-83; GW-16B]	0110638		[GW-16B] [GW-83]
10/1/18	Correspondence	Additional clarifications requested by G. Walser	0005068		
10/9/18	Data submittal	Response to Analysis Data Request #2 received, assuring proper archiving of groundwater model documentation	0110662		[GW-18]
10/11/18	Data submittal	WSP watershed water balance received [GW-83], responsive to G. Walser 10/1 request	0110676		[GW-83]
10/11/18	Analysis	Process Memorandum to File - Summary and Analysis of Groundwater-Dependent Ecosystems, final version incorporating all comments received since 9/12	0110673		[GW-20] [GW-86]
10/22/18	Analysis	Draft groundwater technical memo received from G. Walser	0110913		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
10/24/18	Analysis	Prepared Attachment 1 for BGC to add to tech memo	0110913		
11/2/18	Analysis	Revised version of draft groundwater technical memo received from G. Walser	0110913		
11/6/18	Data submittal	• Receipt of revised modeling predictive analysis [GW-85] • Receipt of climate change sensitivity run [GW-89] • Receipt of NDVI comparison for model [GW-67A]	0003061 0003062 0003063		[GW-67A] [GW-85] [GW-89]
11/9/18	Meeting/call	Meeting with ADWR to discuss Desert Wellfield model and permitting process	0110916		
11/12/18	Data submittal	Hydrograph Excel files received from RCM	0005069		[GW-90]
11/12/18	Analysis	Draft of groundwater quantity section completed, renamed "Groundwater Quantity and Groundwater-Dependent Ecosystems"	0003304		
11/14/18	Data submittal	Revised modeling sensitivity analysis received	0005071		
11/14/18	Correspondence	Additional input on Harborlite mine from AGFD received	0005070		
11/15/18	Correspondence	Clarification requested on hydrograph Excel files	0005072		
11/15/18	Analysis	Supporting appendix for DEIS prepared with all hydrographs	0003304		
11/19/18	Correspondence	Comment from P. Kelly received on presentation of results	0005073		
11/20/18	Data submittal	Revised Excel files received in response to 11/15 request; revised sensitivity report received	0110774		[GW-90]

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
11/21/18	Correspondence	Suite of information forwarded to workgroup with request for 12/10 deadline for comments: - P. Kelly 11/19 comments - draft DEIS groundwater section [GW-87; GW-88] - Groundwater Process Memo - Draft Workgroup Tech Memo [GW-50]	0005075		[GW-50] [GW-87] [GW-88]
11/21/18	Correspondence	Comments received from N. Enos	0005076		
11/28/18	Meeting/call	Meeting held with ADWR AMA section to discuss regulatory framework for Desert Wellfield	0110942		
12/5/18	Correspondence	Comments received from B. Esslin	0005077		
12/10/18	Correspondence	Comments received from J. Ruff and E. Gazzetti	0005078 0005079		
12/11/18	Correspondence	Comments received from G. Olsen	0005080		
12/12/18	Correspondence	Comments received from RCM and P. Kelly	0005081 0005082		
12/17/18	Correspondence	Groundwater GIS coverages requested	0005083		
12/17/18	Data submittal	GIS coverages received from M&A	0005084		
12/18/18	Data submittal	GIS coverages received from M&A and WSP	0005085		
12/18/18	Correspondence	Information requested from M&A on historic pumping	0005086		
12/18/18	Data submittal	Information on historic pumping received from M&A	0005086		
12/18/18	Internal documentation	Process Memorandum to File - Summary of Alternative Water Balances	0110959		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
12/27/18	Analysis	All comments on circulated material disposed of; resulted in need to write a "dissenting opinion" section for the groundwater technical memo	0110913		
1/7/19	Analysis	Provided BGC with instructions for completing groundwater workgroup technical memo in response to comments	0005088		
1/18/19	Analysis	Receipt of revised groundwater workgroup technical memo	0110913		
1/18/19	Analysis	Circulated "dissenting opinions" section to BGC based on comments received in December.	0110913		
1/24/19	Correspondence	Last remaining action items sent to RCM (4 items) - ESRV modeling of additional subsdivision/AWS (M&A) - GW-84 – Reissue October 2017 report (WPS) - Replacement for Brown & Caldwell reference (for amount of pumping) - Need InSar data files (RCM)	0005089		
1/30/19	Analysis	"Dissenting opinions" section sent to FS for review after completion of government shutdown, request for comments by 2/22	0005090		
1/31/19	Correspondence	Comments received from D. Morey	0005091		
2/4/19	Analysis	M. Rasmussen approved "dissenting opinions", with instructions to proceed to make all changes necessary	0005092		
2/7/19	Analysis	Revised groundwater technical memo received from G. Walser	0110913		
2/12/19	Analysis	Administrative draft of DEIS rolled out to cooperating agencies for review	0003057		
2/15/19	Data submittal	Backup InSAR raw monitoring data for Oak Flat received from RCM	0005093		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
2/18/19	Data submittal	Revised WSP report received, with replacement of Brown and Caldwell reference [GW-84; GW-44—Addressed by Appendix A]]	0003010		[GW-44] [GW-84]
2/19/19	Correspondence	Circulated revised WSP report to workgroup	0005094		
2/20/19	Analysis	Circulated revised groundwater technical memo to workgroup, including dissenting opinions	0005095		
2/21/19	Correspondence	Forwarded revised WSP modeling report to H. Hoffman (EPA)	0005096		
2/21/19	Correspondence	Comments received from L. Atkinson	0005097		
2/22/19	Correspondence	Comments received from E. Gazetti	0005106		
2/27/19	Correspondence	Request received from J. Wells for additional documents	0005098		
2/28/19	Correspondence	Additional documents sent to J. Wells as requested	0005099		
3/21/19	Correspondence	Comments received from RCM and WSP on revised technical memo circulated 2/20/19	0005100		
3/22/19	Data submittal	Assured Water Supply list received from rCM for East Salt River Valley	0005101		
3/25/19	Data submittal	GIS for assured water supplies received from RCM	0005102		
3/31/19	Analysis	Worked on responding to comments on administrative draft of DEIS. Included decision to simplify approach to calculating “impact” different from workgroup discussions; addition of information on water rights	0003304		
4/8/19	Analysis	Information on surface water rights compiled	0003304		
4/9/19	Meeting/call	Meeting with ADWR to discuss modeling and permitting	0003321		
5/24/19	Analysis	DEIS section fully revised and response to water section comments prepared	0003304		

Date	Process Step	Description	Project Record #	Groundwater Modeling Workgroup Action Item # ASSIGNED	Groundwater Modeling Workgroup Action Item # COMPLETED
6/2/19	Analysis	Revised DEIS section sent to FS for review	0005103		
6/7/19	Analysis	Comments received from RCM on revised section	0005104		
6/27/19	Analysis	Final changes in response to comments incorporated into section	0003304		
7/30/19	Analysis	Determined changes necessary to make to update Groundwater Modeling Workgroup technical memo to match DEIS section; concurrence received from BGC with request for data compilation for G. Walser for further review; decision to maintain draft designation until after comments on DEIS	0005105		
8/1/19	Analysis	Groundwater Modeling Workgroup technical memo revised and posted with DEIS	0110913		
8/5/19	Analysis	Process Memorandum to File - Water Resource Analysis: Assumptions, Methodology Used, Relevant Regulations, Laws, and Guidance, and Key Documents; final version for DEIS, revised, formatted, 508ed and posted with DEIS	0110832		
8/9/19	Analysis	DEIS released to public	0003304		

Table 2. Pre-DEIS Geochemistry/Water Quality Workgroup

Date	Process Step	Description	Project Record #
11/17/16	Meeting/call	Full geochemistry workgroup meeting	0001200
3/3/17	Data request	Baseline Data Request #1 sent to RCM for water and geochemistry internal procedures	0001293
5/4/17	Data request	Electronic geochemistry database requested	0005109
5/12/17	Data submittal	Response to 5/4/17 data request submitted, with geochemistry data tables and lab reports	0002004
6/20/17	Data request	Linkup tables for geochemistry requested	0005110
7/11/17	Data submittal	Response to 6/20/17 data request submitted, with linkup tables	0002650
8/9/17	Data submittal	Response to 6/20/17 data request submitted with additional linkup tables	0001731
8/9/17	Internal documentation	Process Memorandum to File - Percentages of Rock Type Mined over Mine Life	0001731
8/29/17	Internal documentation	Process Memorandum to File - Block Caving Geochemistry Database	0001721
9/15/17	Data request	Rock tonnage data requested	0005111
10/2/17	Data submittal	Response to 9/15/17 data request received, with tonnage table	0002003
10/2/17	Internal documentation	Process Memorandum to File - Tonnage of Rock Type Mined and Tailings Produced over Mine Life	0002003
10/3/17	Meeting/call	Internal team call	N/A
10/4/17	Data request	Clarification on rock types requested	0005112
10/10/17	Data submittal	Response to 10/4/17 data request received	0002005
10/17/17	Internal documentation	Process Memorandum to File – Summary of geodatabase related to tailings	0002481
10/18/17	Data submittal	Near West baseline geochemistry report received	0002007

Date	Process Step	Description	Project Record #
11/28/17	Meeting/call	Internal team call	N/A
1/9/18	Meeting/call	Internal team call	0005113
3/8/18	Data Request	Analysis Data Request #1 – Tailings Seepage submitted	0002317
3/13/18	Meeting/call	Internal team call	N/A
3/20/18	Correspondence	Surface standard calculator received from G. Olsen	0005114
4/13/18	Correspondence	Internal geochemical statistical analysis received from M. Williams	0005115
4/20/18	Correspondence	Internal geochemical statistical analysis received from M. Williams	0005116
4/29/18	Correspondence	Overall water quality plan to tackle remaining analyses for groundwater quality, surface water quality, and GDE water source assessment, prepared and circulated to workgroup	0005018
5/24/18	Meeting/call	Internal team call	N/A
8/14/18	Internal documentation	Process Memo – Surface water quality standards	0110845
8/14/18	Meeting/call	Internal team call	N/A
9/11/18	Meeting/call	Internal team call	0005117
9/17/18	Data submittal	Mixing cell model results received	0110587 0110588 0110589 0110590
9/18/18	Meeting/call	Full geochemistry workgroup meeting	0110648
9/18/18	Correspondence	Water quality issues received from P. Werner	0005118
9/23/18	Data submittal	Geochemical references received from RCM	0110584 0005120
9/23/18	Data request	Information on Silver King closure cover requested	0005119
9/24/18	Data submittal	Information provided for 9/23/18 request	0005121

Date	Process Step	Description	Project Record #
10/8/18	Data submittal	TSF barrier permeability memorandum received	0110650
10/10/18	Data request	Analysis Data Request #4 submitted	0005122
10/9/18	Meeting/call	State permitting meeting	0110695
10/11/18	Data submittal	Fate of mill reagents memorandum received	0110675
10/16/18	Meeting/call	Full geochemistry workgroup meeting	0110718
10/26/18	Correspondence	Specific items to focus on at meeting requested	0005123
11/1/18	Data request	Analysis Data Request #4 – Geochemical Model Review submitted	0110737
11/5/18	Data submittal	Response to Data Request #4 received	0110755 0110756 0110757
11/6/18	Data submittal	Additional case studies received from RCM	0003032
11/6/18	Meeting/call	Internal team call	0110752
11/8/18	Meeting/call	Internal team call	N/A
11/13/18	Meeting/call	Full geochemistry workgroup meeting	0110767
11/16/18	Correspondence	Internal work on seepage rates submitted to RCM	0005124
12/11/18	Internal documentation	Process Memo - Screening of Geochemistry Predictions for Effects on Wildlife	0003102
12/11/18	Meeting/call	Internal team call	N/A
12/11/18	Meeting/call	Full geochemistry workgroup meeting	0005125
12/21/18	Internal documentation	Affected Environment surface water quality analysis received from M. Williamson	0003304

Date	Process Step	Description	Project Record #
12/21/18	Data submittal	Multiple geochemical responses received from RCM	0003064 0003065 0003066
1/9/19	Data submittal	Steady-state modeling report received	0003068
1/10/19	Meeting/call	Internal team call	N/A
1/15/19	Meeting/call	Full geochemistry workgroup meeting	0003071
1/24/19	Correspondence	Provided summary of outstanding items to RCM	0005126
1/30/19	Data submittal	Revised seepage items received from RCM	0003096 0003067 0003097 0003098
1/31/19	Data request	Additional output requested	0005127
2/4/19	Meeting/call	Full geochemistry workgroup meeting	0003070
2/4/19	Data submittal	Updated Near West steady-state model report received	0003113
2/6/19	Data submittal	Updated fate and transport models received from RCM, with spreadsheets	0003076
2/13/19	Data submittal	Additional case studies received from RCM	0003311
2/19/19	Internal documentation	Environmental Consequences section circulated to team internally	0003304
2/22/19	Data submittal	Aternatives seepage control level summary received from RCM	0003026 0003027
2/19/19	Meeting/call	Internal team call	0005128
2/26/19	Meeting/call	Internal team call	0005129
2/27/19	Correspondence	Additional questions on Goldsim results sent to M&A	0005130
2/27/19	Correspondence	M&A response to 2/27/19 question received	00005131

Date	Process Step	Description	Project Record #
2/27/19	Correspondence	Additional question on Alt 4 approach sent to M&A	0005130
2/27/19	Correspondence	Response to question from 2/27/19 from M&A (C. Gregory)	0005131
2/29/19	Internal documentation	Environmental Consequences section circulated to team internally	0003304
3/1/19	Correspondence	M&A response to question from 2/27/19 received (T. Bayley)	0005133
3/7/19	Meeting/call	Internal team call	N/A
3/7/19	Correspondence	Requested clarification from M&A on interpreting model components	0005134
3/8/19	Correspondence	Response received from M&A	0005135
3/8/19	Correspondence	Circulated EPA 1999 report during biweekly, requested that RCM identify pertinent info on TENORM	0005136
3/11/19	Correspondence	Clarification requested by G. Walser	0005137
3/11/19	Correspondence	Response received from M&A	0005138
3/14/19	Data request	“Predicted total” results requested from M&A	0005140
3/14/19	Correspondence	Figure requested from WPS by G. Walser	0005139
3/14/19	Correspondence	Response received from WPS	0005141
3/15/19	Data submittal	Results received from M&A	0003312
3/15/19	Internal documentation	Additional sections prepared on stormwater quality and seepage control	0003304
3/14/19	Meeting/call	Internal team call	N/A
3/15/19	Meeting/call	Internal team call	N/A
3/26/19	Meeting/call	Internal team call	N/A
3/29/19	Correspondence	Water quality briefing paper prepared for cooperating agency mitigation discussion	0005142
4/1/19	Correspondence	Water quality briefing paper circulated to cooperators by FS	0005143
4/2/19	Correspondence	Water quality questions received from EPA	0005144

Date	Process Step	Description	Project Record #
4/5/19	Meeting/call	Internal team call	N/A
4/10/19	Correspondence	EPA request received on water quality section	0005145
4/11/19	Correspondence	Response provided to M. Rasmussen for EPA	0005146
4/12/19	Internal documentation	Full section 3.7.2 circulated for internal review	0003304
4/23/19	Correspondence	Provided EPA roadmap on water quality references	0005147
4/24/19	Data request	Clarification on thin-lift water balance requested	0003224
4/26/19	Correspondence	Missing documents requested	0003329
4/27/19	Internal documentation	Process Memorandum to File - Receipt of Water Quality Modeling Results in Native Format	0003089
4/29/19	Internal documentation	Full section circulated to TNF for review	0003304
4/30/19	Correspondence	Documents received	0003329
5/16/19	Correspondence	Received water quality comments from EPA	0005149
5/22/19	Correspondence	Received water quality comments from aDEQ	0005152
5/17/19	Correspondence	Received water quality comments from E. Gazzetti	0005150
5/16/19	Correspondence	Received water quality comments from BLM	0005148
5/20/19	Meeting/call	Conference call with EPA to discuss comments	0005151
5/21/19	Data submittal	KCB report on TENORM received	0003228
5/22/19	Correspondence	Concurrence received from FS on plan to address EPA comments	0005153
5/22/19	Data request	Critical needs request sent to RCM	0003209
5/22/19	Data submittal	Response received to 5/22/19 request	0003209
5/22/19	Data request	Information on consolidation requested from RCM	0003204
5/23/19	Data submittal	Gila River water quality data received	0003203 (1-3)
5/23/19	Data submittal	Asbestos data received from RCM	0003212

Date	Process Step	Description	Project Record #
5/23/19	Data submittal	Response from KCB on consolidation received	0003208
5/23/19	Data submittal	Response from Golder on consolidation received	0003204
5/23/19	Data request	Additional model output requested	0005154
5/27/19	Internal documentation	Process Memorandum to File - Gila Conglomerate and Cover Material Summary	0003162
5/28/19	Correspondence	Clarification on water balance issue received from KCB [see 0003860 for final resolution of this issue]	0005157
5/28/19	Correspondence	Confirmation sent to RCM that consolidation info is sufficient	0005156
5/28/19	Correspondence	Confirmation sent to RCM that asbestos info is sufficient	0005155
5/30/19	Data submittal	Subsidence lake information received from WSP	0003210
6/3/19	Correspondence	Confirmation sent to RCM that Gila River info is sufficient	0005159
6/3/19	Correspondence	Comments received from ASLD	0005158
6/14/19	Internal documentation	Revised full EIS section sent to TNF for review	0003304
6/26/19	Correspndence	Final comments received from TNF	0005160
6/28/19	Internal documentation	Final changes made to section	0003304

Table 3. Post-DEIS Water Resources Workgroup

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
11/1/19	Data submittal	Skunk Camp site investigation report	0003561 (1-4)		
11/7/19	Data submittal	Aquifer Testing Results for Skunk Camp Hydrogeological Investiation, Pinal and Gila Counties, Arizona	0003724		
1/23/20	Meeting/call	Water Resources Workgroup Meeting #1 Action items (responsible party shown in parentheses): • WR-1 (ALL): Provide resumes for project record • WR-2 (SWCA): Produce "Proceedings" process memo to document all data requests, data submittals, and workgroup actions (pre-DEIS and post-DEIS) • WR-3 (SWCA): commit to sending the meeting notes prior to the next meeting • WR-4 (SWCA): notify the group of substantial updates to documents • WR-5 (SWCA): provide access to a SharePoint site • WR-6 (RCM): Updated water data around mine site • WR-7 (RCM): Water data for Skunk Camp & Gila River • WR-8 (RCM): Skunk Camp modeling presentation • WR-9 (RCM): Springs Inventory 3.0 (April) • WR-10 (RCM): Closure and reclamation information, cover design • WR-11 (RCM): ESRV cumulative effects modeling	0003998	[WR-1 – Attached to this process memo] [WR-2 – Refers to this process memo] [WR-3, WR-4, WR-5 are ongoing procedural steps, not tracked further] [WR-6] [WR-7] [WR-8] [WR-9] [WR-10] [WR-11] [WR-12] [WR-13]	

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
		• WR-12 (RCM): pull well records and other information for QV and consider ways to model the impacts • WR-13 (RCM): Written responses to Prucha comments/criticisms • WR-14 (SWCA/BGC): Screen thru Prucha report/comments		[WR-14]	
1/24/20	Data submittal	Desert Wellfield cumulative modeling report and presentation received	0005161		[WR-11]
1/27/20	Correspondence	[WR-11] and site investigation information circulated to workgroup	0005162		
2/20/20	Meeting/call	Water Resources Water Workgroup Meeting #2 Action items (responsible party shown in parentheses): • WR-15 (M&A): Investigate possible analytical tools or an approach to evaluate the local subsidence issue in or near the Desert Wellfield • WR-15A (BGC): Prepare memo to consolidate and review information on subsidence • WR–16 (RCM): Provide usage numbers for ESRV for comparison to RCM pumping • WR-17 (TNF): Follow up with ADWR on ESRV model update approval • WR-18 (BGC): Review SRV model and purpose, prepare memo on M&A extension and appropriateness of model • WR-19 (RCM): Resend September 2019 powerpoint	0004302	[WR-15] [WR-15A] [WR-16] [WR-17] [WR-18] [WR-19] [WR-20] [WR-21]	

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
		• WR-20 (RCM): Provide input on potential for stormwater release and estimate of quality. Focus on operations. • WR-21 (M&A): Estimate remaining water in aquifer at several snapshots in time.			
3/17/20	Data submittal	Powerpoint received from M&A	0005163		[WR-19]
3/23/20	Data submittal	Response to IHS/Prucha comments received from WSP	0003812		[WR-13]
3/25/20	Correspondence	[WR-13] circulated to workgroup	0005164		
3/26/20	Data submittal	Updated data set for mine site (hydrochemistry, water levels, surface monitoring) received from M&A	0004075		[WR-6]
3/26/20	Meeting/call	Water Resources Water Workgroup Meeting #3 Action items (responsible party shown in parentheses): • WR-22 (RCM): Information on modeled gradients near block cave over time; verify hydraulic containment will occur • WR-23 (RCM): KCB to send contingency information for Design of Facility able to handle varying percentage split between pyrite/scavenger tailings. • WR-25 (RCM): Provide previous water submittal that should provide examples of analog design features; possibly add additional water closure projects that could also be analogs in arid environments, if any; provide discussion on how tailings are managed/tested during operations based on Kennecott	0004733	[WR-22] [WR-23] [WR-25] [WR-25A] [WR-26]	

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
		• WR-25A (BGC): Compile data into comprehensive memo • WR-26 (M&A): provide GIS layer of springs and wells			
4/2/20	Correspondence	Request sent by FS to ADWR requesting confirmation of involvement in Desert Wellfield model inputs	0004063		[WR-17]
4/7/20	Data submittal	Part 1 submittal on [WR-25] received	0004064		[WR-25]
4/8/20	Correspondence	Response received from ADWR on 4/2/20 FS request	0005166		[WR-17]
4/9/20	Correspondence	[WR-6], [WR-25] response circulated to workgroup	0005167		
4/17/20	Data submittal	Additional Part 1 material on [WR-25] receoved	0005168		[WR-25]
4/20/20	Data submittal	Assessment of Queen Valley data and hydrologic connection received	0004201		[WR-12]
4/21/20	Data submittal	Springs and seeps inventory, Version 3.0, received	0003823		[WR-9]
4/21/20	Correspondence	[WR-13], [WR-25] circulated to workgroup	0005169		
4/22/20	Data submittal	WSP report on hydraulic containment, gradients at closure received	0004870		[WR-22]
4/24/20	Correspondence	[WR-9], [WR-12], [WR-22] responses circulated to workgroup	0005170		
4/23/20	Meeting/call	Water Resources Water Workgroup Meeting #4 Action items (responsible party shown in parentheses): • WR-27 (RCM): Document current conditions and expected conditions of discharge under AZPDES and exploration of discharges during transitional times of mine life. • WR-28 (M&A): Determine low flow from 7Q10 for low flow and how that would affect over median flows.	0003214	[WR-27] [WR-28] [WR-29]	[WR-15] [WR-16] [WR-21]

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
		Minimum for Alt 6, maybe for Alt 5 [Later rescinded—low flow analysis was conducted by NEPA team] • WR-29 (SWCA): Distribute BGC Prucha responses for consideration with WSP Prucha responses; categorize comments for future discussion Meeting included presentation of Desert Wellfield subsidence investigation [WR-15], presentation of pumping comparisons [WR-16], and presentation information on aquifer [WR-21]			
4/24/20	Data submittal	Data for Skunk Camp and Gila River received	0004442		[WR-7]
5/11/20	Data submittal	Response to IHS/Prucha comments received from BGC	0005171		[WR-14]
5/13/20	Data submittal	Receipt of water GIS data received	0005172		[WR-26]
5/18/20	Data submittal	Clarification submitted to USACE on Skunk Camp data	0004741		[WR-7]
5/19/20	Correspondence	[WR-7], [WR-26] response circulated to workgroup	0005173		
5/26/20	Data submittal	Response to Action Item WR-23: TSF Storage Contingency received	0003850		[WR-23]
5/26/20	Data submittal	Summary of Additional Desert Wellfield Pumping 100-Year Drawdown Analysis for ADWR Evaluation received	0004734 0004737		[WR-16] [WR-21]
5/28/20	Meeting/call	Water Resources Water Workgroup Meeting #5 Action items (responsible party shown in parentheses): • WR-30 (M&A): Submittal of Skunk Camp conceptual and predictive modeling reports Meeting included presentation of Skunk Camp modeling results [WR-8]	0003974	[WR-30]	[WR-8]

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
5/28/20	Data submittal	Information on tailings geochemical sampling and analysis program received	0004481		[WR-25]
6/2/20	Correspondence	[WR-16], [WR-21], [WR-23], [WR-25] circulated to workgroup	0005174		
6/4/20	Data submittal	Skunk Camp Closure Study, Site Investigation and Laboratory Testing Summary received	0004209		
6/8/20	Data request	Additional model output requested, action item [WR-18A]	0005175	[WR-18A]	
6/8/20	Data submittal	USGS Regression Equation Computation Updates for Skunk Camp (Alternative 6) Queen Creek, Devil's Canyon, & Dripping Springs Wash received	0004477		
6/11/20	Meeting/call	Water Resources Water Workgroup Meeting #6 – Cancelled	N/A		
6/11/20	Data submittal	Information on AZPDES discharges received	0004476 0004736		[WR-27]
6/12/20	Data submittal	TSF Reclamation Plan, including cover design received	0004206		[WR-10]
6/16/20	Correspondence	[WR-10], [WR-27] response circulated to workgroup	0005176		
6/19/20	Data submittal	Response to Dr. A. Maest Comments to DEIS received from M. Williamson	0004478		
6/21/20	Correspondence	Whitepaper incorporating [WR-14] [WR-29] circulated to workgroup	0005178		[WR-14] [WR-29]
6/21/20	Data submittal	Additional model output received [WR-18A]	0005177		[WR-18A]
6/22/20	Internal documentation	Process Memorandum to File – Clarification of Perceived Discrepancies in Water Balance Data	0003860		

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
6/25/20	Meeting/call	Water Resources Water Workgroup Meeting #6 – Rescheduled Action items (responsible party shown in parentheses): • WR-31 (WSP): Additional modeling output requested in whitepaper assessing Prucha comments • WR-32 (SWCA): Consider need for an additional memo on modeling of stormwater or water quality compared to the BGC memo on groundwater model [Rescinded after decision to handle within FEIS body] • WR-33 (RCM): Nitrate calculations and inputs with references	0003875	[WR-31] [WR-32] [WR-33]	
6/26/20	Data submittal	1D seepage modeling for Skunk Camp (KCB) received	0003886		[WR-30]
6/29/20	Correspondence	KCB report [WR-30] circulated to workgroup	0005179		
6/29/20	Data submittal	Conceptual model for Skunk Camp water quality model (M&A) received	0003884		[WR-30]
7/3/20	Data submittal	Summary of Results for 2020 Site Investigations at the Skunk Camp Storage Facility (M&A) received	0003885		[WR-30]
7/5/20	Data submittal	Analysis of potential stormwater release scenario received	0004479 0004735		[WR-20]
7/6/20	Correspondence	[WR-20], [WR-30] circulated to workgroup	0005204		
7/8/20	Data submittal	Nitrogen Chemical Loads and Concentrations in the Geochemical Models used for the Resolution Copper Project received	0004482		[WR-33]
7/9/20	Correspondence	[WR-33] circulated to workgroup	0005205		
7/14/20	Data submittal	Subaqueous Disposal of Pyrite Tailings (BGC) received	0004480		[WR-25A]

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
7/17/20	Data submittal	Numeric groundwater flow model for Skunk Camp (M&A) received	0003945		[WR-30]
7/17/20	Correspondence	[WR-30] circulated to workgroup	0005180		
7/17/20	Data submittal	Additional model output in response to [WR-31] (WSP) received	0003946		[WR-31]
7/21/20	Data submittal	Additional information on graben well elevations received	0005181		[WR-31]
7/22/20	Data submittal	Additional information on graben well elevations received	0005182		[WR-31]
7/30/20	Meeting/call	Water Resources Water Workgroup Meeting #7 – Final meeting, with due date of August 7 for submittal of final comments to incorporate into record	0004827		
8/3/20	Data submittal	Review of Desert Wellfield model (BGC) received	0004407		[WR-18]
8/7/20	Correspondence	Final comments from Dr. Wells received	0004463		
8/7/20	Correspondence	Final comments from EPA received	0005183		
8/27/20	Correspondence	[WR-15A] circulated to workgroup	0005184		
8/27/20	Data submittal	Analysis of Desert Wellfield subsidence approach (BGC) received	0004457		[WR-15A]
8/27/20	Data submittal	Review of reclamation plan submitted under [WR-10] (BGC) received	0004211		[WR-10]
8/28/20	Data submittal	Water quality monitoring plan for Skunk Camp area received	0004823		
9/1/20	Data submittal	Revised Mitigation and Monitoring plan for GDEs and wells received	0004824		
9/8/20	Internal documentation	Process Memorandum to File - Post-DEIS Review of Updated Hydrological Data (2016-2019)	0004876		[WR-6]

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
9/10/20	Internal documentation	Process Memorandum to File - Gila Conglomerate and Cover Material Summary for the Skunk Camp Tailings Storage Facility (review of information in [WR-10] and other pertinent data]	0004204		[WR-10]
9/12/20	Internal documentation	Process Memorandum to File - Review of Queen Valley Hydrologic Connection to Queen Creek	0004202		
9/15/20	Internal documentation	Process Memorandum to File - Additional Post-DEIS Review of Geomorphology Impacts	0004213		
9/18/20	Data submittal	Clarifications on EPA comments submitted by RCM	0004467		
9/22/20	Data submittal	Final Numerical Groundwater Flow Model for the Skunk Camp Tailings Storage Facility received	0004466		[WR-30]
9/23/20	Internal documentation	Process Memorandum to File - Resolution Copper Reclamation Plan Adequacy Review	0004877		
9/23/20	Internal documentation	Process Memorandum to File - Post-DEIS Assessment of Reclamation and Closure Plans	0004250		
10/6/20	Internal documentation	Process Memorandum to File - Evaluation and Response to Public Comments on Groundwater Modeling Analysis	0004464		
10/20/20	Internal documentation	Process Memorandum to File - Post-DEIS Assessment of Mitigation	0004833		
10/23/20	Internal documentation	Memo – Adherence to professional standards for groundwater modeling (attachment to final workgroup memo)	0004460		
10/23/20	Data submittal	Final modeling workgroup memorandum received from BGC	0004461		
10/26/20	Data submittal	Review of Skunk Camp model (BGC) received	0004825		

Date	Process Step	Description	Project Record #	Water Resources Workgroup Action Item # ASSIGNED	Water Resources Workgroup Action Item # COMPLETED
11/5/20	Internal documentation	Process Memorandum to File - Proceedings of the Groundwater Modeling Workgroup and Water Resources Workgroup [This document, first draft with continuing updates through publication of FEIS]	0004459		
11/13/20	Internal documentation	Process Memorandum to File - Assessment of Factual Basis for Comments on Dewatering Amounts, Water Usage, and Power Usage	0004861		
12/11/20	Correspondence	BGC review of Skunk Camp water quality model circulated to workgroup	0004826		
12/14/20	Correspondence	Mitigation and monitoring items circulated to workgroup	0005185		
12/22/20	Correspondence	Response received from San Carlos Apache Tribe and Dr. J. Wells with respect to BGC review of Skunk Camp water quality model and FS use of model	0005186		
12/31/20	Correspondence	Response received from M&A with respect to BGC review of Skunk Camp water quality model, with technical clarifications	0005187		
1/8/21	Correspondence	FS response submitted to San Carlos Apache Tribe 12/22/20 letter, re: water quality model	0005188		
1/12/21	Correspondence	San Carlos Apache Tribe response to FS 1/8/21 letter received, re: water quality model	0005189		

ATTACHMENT 1 – RESUMES FOR WORKGROUP MEMBERS

Organization	Participant	Title	Role	Resume Attached?
USFS	Lee Ann Atkinson	Forest Geologist	Agency Review	n/a - Agency staff - NEPA Reviewer
USFS	Edward Gazetti	Hydrogeologist	Agency Review	n/a - Agency staff - NEPA Reviewer
USFS	Mary Rasmussen	NEPA Project Lead/Agency Project Manager	Agency Review	n/a - Agency staff - NEPA Reviewer
USFS	Judd Sampson	Forest Geologist	Agency Review	n/a - Agency staff - NEPA Reviewer
SWCA	Chris Garrett	Professional Hydrologist/Project	3rd party review	yes
SWCA	Donna Morey	Planner/Assistant Project Manager	3rd party review	yes
SWCA Consultant	Nick Enos	Principal Geoscientist	3rd party review	yes
SWCA Consultant	Mike Henderson	Geotechnical Engineer	3rd party review	yes
SWCA Consultant	Derek Hrubes	Senior Civil Engineer	3rd party review	yes
SWCA Consultant	Gabi Walser	Water Resources Engineer	3rd party review	yes
SWCA Consultant	Hamish Weatherly	Principal Hydrologist	3rd party review	yes
SWCA Consultant	Mark Williamson	Geochemist	3rd party review	yes
ADEQ	Wayne Harrison	Hydrogeologist	Agency Review	n/a - Agency staff - NEPA Reviewer
ADWR	Bret Esslin	Engineer	Agency Review	n/a - Agency staff - NEPA Reviewer
AGFD	Jim Ruff	Land and Water Program Supervisor	Agency Review	n/a - Agency staff - NEPA Reviewer
SCAT Representative	Jim Wells	Environmental Geologist	Tribal Representaive	yes
US ACE	Mike Langley	Senior Regulatory Project Manager	Agency Review	n/a - Agency staff - NEPA Reviewer
US EPA	Hannah Dailey	Physical Scientist	Agency Review	n/a - Agency staff - NEPA Reviewer
US EPA	Hugo Hoffman	Environmental Protection Specialist	Agency Review	n/a - Agency staff - NEPA Reviewer
Resolution	Greg Ghidotti	Principal Hydrogeologist	Project Proponent	yes

Resolution	Vicky Peacey	Environmental Engineer and Permitting	Project Proponent	no - project proponent
Resolution Consultant	Hale Barter	Groundwater Hydrologist	Project Proponent	yes
Resolution Consultant	Tim Bayley	Principal Hydrogeologist	Project Proponent	yes
Resolution Consultant	Jim Butler	Legal Counsel	Project Proponent	no - project proponent's legal council
Resolution Consultant	Ted Eary	Geochemist	Project Proponent	yes
Resolution Consultant	Cameo Flood	Environmental Permitting	Project Proponent	no - project proponent advisor
Resolution Consultant	Chris Gregory	Hydrogeologist	Project Proponent	yes
Resolution Consultant	Mark Logsdon	Geochemist	Project Proponent	yes
Resolution Consultant	Todd Keay	Principal Hydrogeologist	Project Proponent	yes
Resolution Consultant	Gustavo Meza-Cuadra	Lead Hydrogeologist	Project Proponent	yes
Resolution Consultant	Doug Oliver	Hydrogeological Conceptual Modeling Lead	Project Proponent	yes
Resolution Consultant	Chris Pantano	Senior Hydrogeologist	Project Proponent	yes
Resolution Consultant	Matt Wickham	Hydrology and Geochemistry Principal	Project Proponent	yes

MONTGOMERY & ASSOCIATES

Hale Barter
President / Groundwater Hydrologist

OFFICE: Tucson

YEARS OF EXPERIENCE

Total: 31 | M&A: 25

EDUCATION

M.S., Hydrology, University of Arizona (1995)

B.S., Hydrology, University of Arizona (1988)

KEY AREAS OF EXPERTISE

Project management and technical oversight

Groundwater modeling for mining, municipal, and industrial clients

Technical investigations for mine EIS and APP permitting

Analysis of aquifer hydraulic and water quality data

Design and supervision of aquifer testing and monitoring programs

Hale Barter provides technical leadership for M&A's Hydrologic Modeling team. His specialty is developing conceptual and numerical models to support investigations of groundwater and surface water impacts from mining or industrial operations to achieve feasibility and permitting objectives. For more than 30 years Hale has developed and overseen modeling projects covering a comprehensive range of mining applications in the United States and South America. Work included substantial investigations for feasibility and regulatory support for the Rosemont and Mt. Hope EIS studies in Arizona and Nevada, and Resolution project in Arizona.

Representative Projects

Mine Dewatering Feasibility: Cove Project, Au-Reka Gold Corporation
Lander County, Nevada

Supervised preparation of a new groundwater model in support of dewatering estimates and permitting

Tailings Design and Seepage Analysis Modeling: Resolution Copper Mining
Resolution Mine, Pinal County, AZ

Senior technical advisor for modeling team developing groundwater and tailings flow and transport model analyzing tailings design, groundwater/tailings water interaction, engineering controls efficacy, and seepage fate

Pit-Dewatering Analysis for an EIS: General Moly
Mt. Hope Mine, Eureka County, NV

Planned and coordinated groundwater modeling using telescoping-mesh techniques to simulate pit dewatering and subsequent pit lake development in a fractured bedrock system; evaluated impacts to surface water and agricultural pumping; interfaced with regulatory staff

Pit-Dewatering Analysis for an EIS & APP: Rosemont Copper
Rosemont Mine, Pima County, AZ

Developed a conceptual model and designed and oversaw the development of a numerical groundwater flow model to evaluate pit dewatering, post-mining lake development, and associated drawdown and surface water impacts; interfaced with regulatory staff

Tailings Seepage Analysis: Minera Chinalco Perú
Toromocho Project, Junín, Perú

Led groundwater flow and contaminant transport modeling to evaluate seepage impacts from a proposed tailings facility to support an EIS

Mine Dewatering Feasibility Analysis: Hochschild Mining plc
Inmaculada Project, Southern Perú

Supervised groundwater flow modeling to evaluate underground mine dewatering and subsequent groundwater recovery in a fractured bedrock system at a proposed gold mine

Mine Expansion/Dewatering Analysis for an EIA: Tahoe Resources
La Arena Mine, Perú

Supervised groundwater flow modeling in a fractured bedrock system to evaluate planned pit dewatering, post-mining groundwater recovery, and environmental impacts on stream flows

Feasibility Analysis: Resolution Copper Mining
Resolution Mine, Pinal County, AZ

Led modeling and other analyses to evaluate potential surface water / groundwater interactions in a volcanic, fractured-rock system for a potential block-cave underground mine

Pumping Impacts Analysis: Compañía Minera Riochilex S.A.
Salar de Atacama, Chile

Modeled the potential impacts of pumping at environmentally sensitive, groundwater-fed salar lakes and evaluated options for sustaining lake volumes and salinity levels

Brine-Extraction Wellfield Analysis: Galaxy Resources
Salar del Hombre Muerto, Argentina

Supervised the development of conceptual model and a density-dependent groundwater flow and transport model (constructed using MODFLOW-SURFACT) to evaluate the feasibility of extracting lithium from a wellfield in a dense brine aquifer

Water Supply Investigations: Rosemont Copper
Rosemont Mine, Pima County, AZ

Designed and provided oversight for groundwater flow modeling to evaluate the feasibility of developing a wellfield to supply the mine and project drawdown impacts in a regional, basin-fill aquifer system

Wellfield Optimization & Impact Analyses: Various Clients
Salares de Coposa, Lagunillas, Huachunta, Huarintapana, & Chilota, Chile & Perú

Modeled alternative wellfield configurations to maximize production and minimize the impacts to environmentally sensitive lakes and springs to address regulatory compliance and operational needs

Compliance Investigations: Rio Algom Mining
Former Uranium Mine, San Juan County, UT

Provided technical oversight for conceptual and numerical model development to characterize the groundwater system and demonstrate the hydraulic control of tailings seepage in complex aquifer system

Seepage Analysis: Compañía Minera Doña Inés de Collahuasi SMC
Salar de Michincha, Chile

Modeled groundwater flow and contaminant transport to assess the impacts of seepage from a waste-rock dump near a proposed open-pit mine

APP Support: Freeport-McMoRan Corporation
Sierrita Mine, Pima County, AZ

Developed a groundwater flow and solute transport model to project the capture of tailings seepage by interceptor wells and the extent of sulfate in groundwater; designed monitoring wells, supervised well construction, ran aquifer tests, and analyzed hydraulic and water quality data

Pumping Impacts Analysis: Southern Perú Copper
Cuajone & Toquepala Mines, Perú

Evaluated sustainable water supplies using climate, streamflow, and lake level data in conjunction with historical pumpage and water level data

Transport Analysis• Santa Cruz In Situ Copper Mining Project: ASARCO
Modeled groundwater flow and contaminant transport for in situ mining operations in fractured, mineralized bedrock **[PINAL COUNTY, AZ]**

Timothy Bayley, Ph.D.
Principal Hydrogeologist

OFFICE: Tucson

YEARS OF EXPERIENCE

Total: 12 | M&A: 11

EDUCATION

Ph.D., Hydrology & Water Resources, University of Arizona (2016)

M.S., Watershed Hydrology & Management, University of Arizona (2009)

B.S., Geology, Wheaton College (2005)

KEY AREAS OF EXPERTISE

Conceptual model development

Probabilistic modeling and decision support

Applied statistics for decision support, system characterization, and regulatory compliance

Numerical modeling

Aquifer and infiltration test design and analysis

ADDITIONAL TRAINING

2016: Remote Sensing Applications for Mine Tailings & Waste Rock Water Balances

2013: PEST

2013: MODFLOW-USG

2012: Untangling Multivariate Relationships

Tim Bayley brings his expertise to mining, environmental, and water resources projects throughout the western United States. He has led large-scale site characterization, groundwater remediation, and modeling studies. Recently, Tim led characterization, conceptualization, and modeling studies for the Resolution Copper mine's proposed tailings facility and has represented the mine as a consulting hydrogeologist for its Environmental Impact Statement. Tim frequently presents the results of his work to large groups of technical experts and diverse groups of stakeholders. He is the leader of the M&A GoldSim modeling team and has expertise in uncertainty analysis, decision support, and optimization.

Representative Projects

Mine Feasibility and Permitting: Resolution Copper Mining
Resolution Mine, Pinal County, AZ

Led team to compile and analyze a complex hydrologic dataset ranging from surface water to deep (more than 7,000 feet) groundwater systems; developed conceptual models and numerical models to support evaluation of mine impacts, water supply impacts, and tailings impacts; studied and evaluated groundwater-surface water interaction; participated in USFS groundwater working group to support EIS permitting; presented findings from investigations to groups ranging from advisory panels to community working groups.

Co-led field investigation involving drilling, construction, development, and testing program for over 50 wells; conducted slug tests and multi-well pumping tests; developed and implemented groundwater and surface water sampling program; analyzed data; prepared reports documenting results.

Led development of sophisticated MODFLOW-USG tailings model simulating the dynamic build out and intricate engineering controls of a proposed tailings facility.

Numerical Modeling: Confidential Client
Confidential Project, Northern AZ

Developed a regional flow-and-transport model using MODFLOW-USG; calibrated the model using PEST; conducted a wellfield analysis and recommended pumping strategies to improve water quality and reduce total plant water demand; developed an ensemble of calibrated models to assess the risk of pumping impacting the surface water system.

Tailings Seepage Characterization and Remediation
Rio Algom Lisbon Mine, San Juan County, UT

Led field characterization involving drilling and testing over 20 wells; characterized water quality; and developed conceptual model. Developed numerical model and conducted uncertainty analysis. Presented results to regulators and prepared reports.

Data Management & Analysis: Rosemont Copper
Rosemont Mine, Pima County, AZ

Processed and analyzed long-term groundwater monitoring data, correcting it for barometric effects; analyzed pumping test data.

Numerical Modeling: Confidential Client
Confidential Project, Western AZ

Developed a numerical flow model and performed steady-state and transient calibrations using PEST; conducted multi-scenario predictive analyses of groundwater extraction.

Dewatering Model: Compañía Minera Doña Inés de Collahuasi SMC
Collahuasi Mine / Rosario Pit, Chile

Prepared a forward-solution analytical model to project the groundwater level response to pumping associated with pit dewatering.

Pore-Pressure Modeling Support: Compañía Minera Doña Inés de Collahuasi SMC
Collahuasi Mine, Chile

Prepared data and layers for a finite-element, numerical pore-pressure model for a large, open-pit mine.

Pit-Dewatering Analysis: General Moly
Mt. Hope Mine, Eureka County, NV

Managed data and prepared a GIS database to support the development of a local-scale model.

Dynamic Simulation Modeling: Freeport-McMoRan Copper and Gold
Bagdad Mine, Western AZ

Led the development of a GoldSim model for a wellfield in an alluvial aquifer to simulate well, pump, and aquifer interactions; used stochastic variables to simulate uncertain future recharge.

Dynamic Simulation Modeling: Freeport-McMoRan Corporation
Sierrita Mine, Pima County, AZ

Led the development of a GoldSim water-balance model to project outcomes under mining and non-mining conditions for a tailings pond and impoundment.

Dynamic Simulation Modeling: Freeport-McMoRan Corporation
Sierrita Mine, Pima County, AZ

Provided training and guidance to the client for the development of a hydromet facility water balance.

L. EDMOND (TED) EARY
GEOCHEMIST

Enchemica LLC
Loveland, Colorado

SUMMARY

Ted Eary is an applied geochemist with 40 years of professional experience. He started his career conducting experimental research on redox kinetics and solubility controls for dissolved metals. For the last 30 years, he has worked primarily on characterization of mining sites and development of simulation models for evaluation of water and chemical balance dynamics. He has also worked in various capacities on geochemical aspects of permit applications, reclamation, industrial site environmental assessments, and expert testimony. He is a certified trainer and solution provider for the GoldSim software and an experienced user of geochemistry modeling software.

EDUCATION

Ph.D. Geochemistry and Mineralogy, 1983, Pennsylvania State University
M.S. Geochemistry and Mineralogy, 1981, Pennsylvania State University
B.S. Geology, 1978, University of Michigan

EMPLOYMENT

- Current: Geochemist (owner), Enchemica, LLC
- 2015-2017: Senior Geochemist Consultant, Regional Director Water and Tailings, USA, Hatch
- 2010-2015: Principal Geochemist (owner), Interralogic, Inc.
- 2007-2010: Principal Geochemist, MWH
- 2004-2007: Senior Geochemist, MFG/Tetra Tech
- 2000-2004: Senior Backline Support Engineer, BEA Systems
- 1997-2000: Senior Geochemist, Shepherd-Miller, Inc.'
- 1984-1996: Senior Research Scientist, Pacific Northwest National Laboratory

SCIENTIFIC LITERATURE PUBLICATIONS

B.C. Johnson, P. Rohall, and T. Eary (2018) Coupling PHREEQC with GoldSim for a More Dynamic Water Modeling Experience. In: Wolkersdorfer, Ch.; Sartz, L.; Weber, A.; Burgess, J. & Tremblay, G.: Mine Water – Risk to Opportunity (Vol II). – p. 1081 – 1087; Pretoria, South Africa (Tshwane University of Technology).

L.E. Eary, H. Gluski, S., Mueller, K. Duke, M. Wickham, D. Castendyk, 2017. Sulfide oxidation kinetics in low-sulfide tailings. IMWA 2017 Proceedings (C. Wolkersdorfer, L. Sartz, M. Sillanpää, A. Häkkinen, Editors), Lapeenranta, Finland, pp. 737-744.

N. Eriksson, S. Mueller, A. Forsgren, Å. Sjöblom, A. Martin, M. O´Kane, L.E. Eary, A. Aronsson, 2017. Developing closure plans using performance-based closure objectives: Aitik Mine (Northern Sweden). Proceedings (C. Wolkersdorfer, L. Sartz, M. Sillanpää, A. Häkkinen, Editors), Lapeenranta, Finland,pp. 822-829.

Eary, L.E., 2015. Using oxygen consumption rates as a guide to scale up laboratory kinetic data to field conditions.10th ICARD Proceedings, Santiago, April 20-25, Gecamin.com.

D.N. Castendyk, L.E. Eary, L.S. Balistrieri, 2015. Modeling and management of pit lake water chemistry 1: Theory, Applied Geochemistry, 57, 267-288.

Eary, L. E. and D. Castendyk, 2013. Hardrock Metal Mining Pit Lakes: Occurrence and Geochemical Characteristics. In Acidic Pit Lakes (M. Schultz and W. Geller, Eds.), Springer, Berlin.

Eary, L.E., B. Johnson, J. Harrington, S. Davidson. 2012. Attenuation of Metals from the No Cash 500 Mine Adit Discharge in a Natural, Cold Climate, Peat Wetland Part 1 – Concentration Trends and Conceptual Model. ICARD 2012, Ottawa, Canada.

B. Johnson, L.E. Eary, B. Sherriff, J. Harrington, S. Davidson. 2012. Attenuation of Metals from the No Cash 500 Mine Adit Discharge in a Natural, Cold Climate, Peat Wetland Part 2 – Hydrological and Geochemical Mechanisms. ICARD 2012, Ottawa, Canada.

Eary, L. E., 2011. A review of closure strategies for pit lakes at hard rock metal mines in the United States. Mines and the Environment, Symposium 2011-Rouyn-Noranda.

Eary, L.E., 2010. Rates of greenhouse gas emissions at major gold mines. Soc. Min. Eng., Annual Transactions 2009, 326, 106-110.

Castendyk, D. and L. E. Eary, 2009. Principle Findings of the ADTI-MMS Pit Lake Workbook. Securing the Future and 8th ICARD Proceedings, June 23-26, 2009, Skellefteå, Sweden.

Bucknam, C. H., E. Perry, D. Turner, L. A. Figueroa, D. Castendyk, L. E. Eary, and J. J. Gusek, 2009. Update on the Acid Drainage Technology Initiative (ADTI), the INAP Global Alliance Member Representing the United States. Securing the Future and 8th ICARD Proceedings, June 23-26, 2009, Skellefteå, Sweden.

Castendyk, D. and L. E. Eary, 2009. The Nature and Global Distribution of Pit Lakes. In: Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability (D. Castendyk and L. E. Eary, Eds.), Chapter 1, Soc. Min. Eng., Littleton, Colorado, pp 1-12.

Eary, L. E. and W. M. Schafer, 2009. Approaches for Evaluating the Predictive Reliability of Pit Lake Geochemical Models. In: Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability (D. Castendyk and L. E. Eary, Eds.), Chapter 15, Soc. Min. Eng., Littleton, Colorado, pp 167-178.

Schafer, W. M. and L. E. Eary, 2009. Approaches for Developing Predictive Models of Pit Lake Geochemistry and Water Quality. In: Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability (D. Castendyk and L. E. Eary, Eds.), Chapter 10, Soc. Min. Eng., Littleton, Colorado, pp 115-126.

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Eary, L.E. and A. Watson, 2009. The Post-Mining Water Balance. Mining Conference Proceedings, Perth, Sept. 15-17, 2009, Australian Institute of Mining and Metallurgy, Carlton South, Victoria Australia.

Eary, T., J. Eshleman, R. Jakubowski, and A. Watson, 2008. Applying numerical hydrogeochemical models as decision support tools for mining closure planning. Tailings and Mine Waste '08, Proc. 12th Internat. Conf., Vail, Colorado, CRC Press/Balkema, pp. 221-232.

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Eary, L. E. and M. A. Williamson. 2006. Simulations of the neutralizing capacity of silicate rocks in acid mine drainage environments. 7th ICARD, March 26-30, 2006, St. Louis MO. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502, pp. 564-577.

Eary, L.E., D.D. Runnells, and K.J. Esposito. 2003. Geochemical controls on groundwater composition at the Cripple Creek Mining District, Cripple Creek, Colorado. Appl. Geochem. 18, 1-24.

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Eary, L.E., D. Rai, S.V. Mattigod, and C.C. Ainsworth. 1990. Geochemical factors controlling the mobilization of inorganic constituents from fossil fuel combustion residues. Part 2: Review of the minor elements. J. Environ. Qual. 19, 202-214.

Eary, L.E. and D. Rai. 1989. Kinetics of chromate reduction by ferrous ions derived from hematite and biotite at 25°C. Am. J. Sci. 289, 180-213.

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Eary, L.E., E.A. Jenne, L.W. Vail, and D.C. Girvin. 1988. Numerical models for predicting watershed acidification. Archives of Environmental Contamination and Toxicology 18, 29-53.

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Eary, L.E. and D. Rai. 1987. Kinetics of Cr(III) oxidation to Cr(VI) by reaction with manganese dioxide. Environ. Sci. Technol. 21, 1187-1193.

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Eary, L. E. 1985. Catalytic decomposition of hydrogen peroxide by ferric iron in dilute sulfuric acid solutions. Metallurgical Transactions 16B:181-186.

Eary, L. E. and L. M. Cathles. 1983. A kinetic model of UO_2 dissolution in acid, H_2O_2 solutions that includes uranium peroxide hydrate precipitation. Metallurgical Transactions 14B:325-334.

OPEN LITERATURE REPORTS

Norton, J., C. Petersen, L. E. Eary, J. Largey, S.K. Mills, N. Johnson, T. Berard, T.K. Parker, A. Duguid, A. Lamei, C. Roulet, G.Picard, and M. Couselan. 2009. Potential Goundwater Quality Impacts Resulting from Geologic Carbon Sequestration. Water Res. Foundation and American Water Works Association, 6666 West Quincy Ave., Denver, Colorado, 277 pp.

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Peterson, S.R., B.E. Opitz, M.J. Graham, and L.E. Eary. 1987. An Overview of the Geochemical Code MINTEQ: Applications to Performance Assessment for Low-Level Wastes. PNL-6112/UC-70, Pacific Northwest Laboratory, Richland, Washington.

Rai, D., C.C. Ainsworth, L.E. Eary, S.V. Mattigod, and D.R. Jackson. 1987. Inorganic and Organic Constituents in Fossil Fuel Combustion Residues, Vol. I: A Critical Review. EA-5176, Electric Power Research Institute, Palo Alto, California.

Rai, D., C.C. Ainsworth, L.E. Eary, S.V. Mattigod, and D.R. Jackson. 1987. Inorganic and Organic Constituents in Fossil Fuel Combustion Residues, Vol. II: An Annotated Bibliography. EA-5176, Electric Power Research Institute, Palo Alto, California.

Rai D., J.M. Zachara, C.C. Ainsworth, L.E. Eary, and B.M. Sass. 1986. Physiochemical Measurements of Soils at Solid Waste Disposal Sites. EA-4417, Electric Power Research Institute, Palo Alto, California.

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CURRICULUM VITAE

ROBERT (NICK) ENOS, M.Sc., CPG
Principal Geoscientist

Education

M.Sc., Geoscience/Geophysics, Oregon State University (1992)

B.Sc., Geology, California State University Chico (1988)

Experience

2017-Present Principal Geoscientist, BGC Engineering Inc.

2016-2017 Principal Environmental Subpractice Leader/Senior Environmental Project Manager, DOWL Engineering

2011-2016 Senior Permitting Manager, Barrick Gold Corp., Donlin Gold Project

2008-2011 Environmental Manager, Barrick Gold Corp., Donlin Gold Project

2005-2008 Environmental Coordinator, Barrick Gold Corp., Donlin Gold Project

2004-2005 Project Manager, Environmental Scientist, ASRC Energy Services

1997-2004 Exploration Geologist, Calista Corporation

1996-1997 Geologist, Kennecott Minerals, Kennecott Greens Creek Mine

1994-1996 Exploration Geologist, Kennecott Exploration (Rio Tinto)

1992-1993 Geologist, U.S. Bureau of Mines, Alaska Field Operations Center

Affiliations

American Exploration & Mining Association (AEMA)

Society for Mining, Metallurgy & Explorations (SME)

American Institute of Professional Geologists, Certified Professional Geologist

State of Alaska, Professional Geologist

Years of experience: 28

Robert (Nick) Enos is a senior geoscientist and environmental professional with over 28 years of experience in the mineral industry, primarily in environmental permitting, National Environmental Policy Act (NEPA) review, environmental management, reclamation & closure planning, and geo-environmental studies. Mr. Enos is skilled at managing complex multi-disciplinary projects, and has participated in several project feasibility studies, environmental impact statements (EIS), and third-party reviews. His experience includes over 10 years with Barrick Gold Corporation as the Environmental and Permitting Manager for the Donlin Gold Project in Alaska, where he contributed expertise in project permitting and regulatory approval planning. He has worked on a full spectrum of mineral resource projects, from exploration, to feasibility, stakeholder and community engagement, environmental review, project permitting, and mine closure planning.

Following is a summary of select projects in which Mr. Enos has been involved:

Teck American Anarraaq and Aktigiruq Exploration Project (Current since Jan 2018)
Mr. Enos is providing project permitting expertise to Teck American in advancing their Anarraaq and Aktigiruq Exploration Project, adjacent to the existing Red Dog Mine in Alaska. Mr. Enos is responsible for facilitating the Federal review of discharges under Section 404 of the Clean Water Act, and completion of an Environmental Assessment in compliance with the National Environmental Policy Act (NEPA).

Resolution Copper Environmental Impact Statement (EIS), Arizona. (Current since Jan 2017)
BGC is teamed with SWCA as the Third-Party Contractor to the USDA Forest Service for preparation of an Environmental Impact Statement (EIS) for approval of a plan of operations for the Resolution Copper Project in Arizona. Mr. Enos is providing mining project NEPA expertise to the EIS team, and serves as the BGC's Project Manager leading a team of experts in geosciences, geotechnical engineering, hydrogeology, hydrology, and tailings facility alternatives.

Nanushuk Project Environmental Impact Statement (Current since Jan 2016)
Mr. Enos serves as the Physical Science Team Lead and Senior Reviewer for Armstrong Energy's Nanushuk Project EIS, currently being completed by DOWL for the US Army Corps of Engineers. In this role, Mr. Enos leads a multidisciplinary team of subject matter experts in hydrology, geology, permafrost, mineral resources, air quality, and water quality. He authored various resource sections of the Draft and Final EIS, and led the completion of alternatives development for the EIS.

Barrick Gold Corporation, Donlin Gold Project, Alaska. (Aug 2005-Dec 2015)
Mr. Enos served as Environmental and Permitting Manager, leading the environmental, permitting, and regulatory programs for Barrick's Donlin Gold Project in Alaska. He had overall responsibility for a major permit application package in support of Federal and State regulatory review. He developed and managed a comprehensive baseline environmental studies program in support of project engineering and permitting. He developed and implemented a project Environmental Management System, and was responsible for reclamation planning and permit compliance. Mr. Enos represented the company in direct and constructive communications with stakeholders, including Native and community members, and State and Federal regulatory agencies.

ASRC Energy Services, Anchorage Alaska. (May 2004-Aug 2005)
As Project Manager, Mr. Enos was responsible for permitting, compliance and regulatory planning activities for oil and gas, and mining industry clients. He managed and prepared technical documents and permit applications in support of Alaska North Slope oil development projects, including Plans of Operations and Oil Discharge Prevention and Contingency Plans. He participated in pre-NEPA planning activities for several projects, including co-authoring Environmental Evaluation Document sections, critical issue identification, data research and

compilation, and coordination with regulatory agencies. Mr. Enos authored several client technical reports, including a seismic-risk analysis, an oil-spill contingency plan, and a land use study.

Calista Corporation, Anchorage, Alaska. (May 1997-May 2004)
Mr. Enos served as Exploration Geologist for Calista, responsible for mineral exploration and development, and the management of natural resources (minerals, natural gas, and construction materials) on Alaska Native lands. He conducted exploration field programs, including regional, local, and prospect scale geologic mapping, geochemical sampling, and economic evaluation. Mr. Enos assisted in the collection, processing, and interpretation of ground and airborne based geophysical data. He evaluated resource estimates and ore deposit models for advanced exploration projects, and provided technical support and review for project development issues.

Kennecott Greens Creek Mining Company, Juneau, Alaska. (May 1996-May 1997)
Mr. Enos served as Exploration Geologist, responsible for conducting surface and underground mineral exploration at the Greens Creek Ag-Au-An-Pb Mine on Admiralty Island, Alaska. He managed all exploration data, including integrated drill records, geology, geochemistry, geophysics, and land claim information in an exploration geodatabase. He conducted spatial analysis of geochemical and geological data to generate primary exploration targets, and completed underground and surface geologic mapping. Mr. Enos participated in the collection and interpretation of geophysical data, and the structural interpretation of airborne magnetic and electromagnetic data.

Publications

Enos, R. & Jeffress, B. (2018). Innovation in Mine Closure. Alaska Miners Association Short Course.

Enos, R. (2016). Permitting Mining Projects in Alaska – Current Perspectives, Challenges, and Strategies. Short Course at Alaska Miners Association Conference.

Enos, R. (2014). Donlin Gold Project. Presentation to the Alaska Miners Association Annual Conference, Anchorage, video and abstract available.

Enos, R. (2011). Designing an Environmental Baseline Program at Donlin Creek. Presentation to the Alaska Association of Environmental Professionals (AAEP).

Enos, R. (2008). Design for Closure. Short course presented at Modern Mine Closure, AMA, presentation and published abstract.

CHRIS GARRETT, B.S., P.HGW., PROJECT MANAGER

Mr. Garrett has spent much of the last decade as a third-party National Environmental Policy Act (NEPA) project manager on large mining Environmental Impact Statements (EISs) for the U.S. Forest Service (USFS). Initially working as the project hydrologist, Mr. Garrett stepped up as the third-party NEPA project manager of the Rosemont Copper Project in 2011, working with the Coronado National Forest. He successfully led the project through the Draft EIS, Final EIS/Draft ROD, objection process (in 2013, Rosemont was the first large EIS to undertake the new objection process), objection resolution, and the Final ROD. In 2015, the Tonto National Forest selected Mr. Garrett as the third-party NEPA project manager for the Resolution Copper Project. Mr. Garrett has driven the Resolution project, on schedule, through scoping, alternatives development, and the Draft EIS. In addition to his work on the Rosemont and Resolution EISs, he has been involved in more than 50 NEPA projects over his career (about half EISs, about half EAs) for multiple federal agencies, including the Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Federal Energy Regulatory Commission. Mr. Garrett is also a professional hydrologist with a specialization in groundwater, also recently serving as an expert witness on behalf of Freeport-McMoRan in a high-profile water rights case before the Superior Court in Arizona.

YEARS OF EXPERIENCE

26

EXPERTISE

Management and preparation of EIS documents for complex projects

NEPA compliance

Clean Water Act compliance

Expert witness

Water rights adjudications

Hydrology and water resource permitting; water supply analysis

Groundwater/surface water interaction studies

Toxic tort

EDUCATION

B.S., Hydrology; University of Arizona, Tucson; 1995

REGISTRATIONS / CERTIFICATIONS

Registered Professional Hydrologist, Arizona No. AZ, 04-H-1623; American Institute of Hydrology

TRAINING

Adjunct Faculty, Water Resources Technology Program, Gateway Community College; 2004–2008

SELECTED PROJECT EXPERIENCE

Resolution Copper Project and Land Exchange EIS; Pinal County, Arizona; U.S. Forest Service, Tonto National Forest. SWCA is the third-party contractor assisting in preparation of an EIS to document the impacts of the proposed Resolution Copper Project and land exchange. SWCA completed a robust public scoping process, with over 150,000 comments being processed on schedule. The project includes numerous technical and complex analyses such as potential deep groundwater impacts, air quality impacts, and the impacts from a large surface subsidence zone that is expected to develop due to the panel caving mining techniques. *Role: Project Manager.*

Rosemont Mine Environmental Impact Statement; Rosemont Copper Company; Tucson, Pima County, Arizona. As a third-party contractor, SWCA worked with the USFS and Coronado National Forest to determine and document potential environmental impacts of a proposed open-pit copper, molybdenum, and silver mine on more than 5,000 acres of private and National Forest lands in the Santa Rita Mountains in southeastern Tucson. *Role: Project Manager / Hydrologist. Since 2010, has served as lead hydrologist and Project Manager, responsible for oversight of expert peer review of groundwater modeling, geochemical modeling, and surface water modeling. Served a key role in designing mitigation and monitoring components for this project. Project required a sophisticated and robust approach to hydrologic and geochemical modeling, and assessment of impacts to riparian resources.*

Litigation Support – Rosemont Copper Project; USDA Forest Service; Pima County, Arizona. SWCA provided litigation support to the USFS, Coronado National Forest, in lawsuits regarding the Rosemont Copper Project. *Role: Project Manager.*

MEMBERSHIPS

Member, American Institute of Hydrology

Member, Arizona Hydrological Society

Ray Mine Supplemental Environmental Impact Statement; ASARCO LLC; Kearny, Multiple Counties, Arizona. SWCA is working to complete the Ray Land Exchange Supplemental EIS under the guidance of the Arizona State Office and Tucson Field Office of the BLM. The copper mining firm ASARCO LLC hopes to acquire up to 10,976 acres of BLM surface and mineral estate adjacent to its long-established Ray open-pit mine in east-central Arizona in exchange to BLM of approximately 7,304 acres of riparian and other sensitive native habitat, primarily in northwestern Arizona. *Role: Hydrologist.*

Kaibab National Forest Environmental Impact Statement; VANE Minerals, LLC; Coconino County, Arizona. As a third-party contractor, SWCA assisted the Kaibab National Forest in producing a NEPA-compliant EIS for proposed uranium exploratory wells and accompanying infrastructure. *Role: Hydrologist.*

Bagdad Mine Stockpile Extension NEPA Study; Freeport McMoRan Bagdad Incorporated; Bagdad, Yavapai County, Arizona. As a third-party consultant for the project, SWCA is assisting the BLM Kingman Field Office with analyzing proposed modifications to the current Bagdad Mine Plan of Operations. If approved through the current EA process, Freeport McMoRan's proposed mine plan modifications, which include extending the present stockpile and constructing access roads, monitoring wells, and other distributed facilities, could result in disturbance of as much as 600 acres of BLM-managed public lands. *Role: Hydrologist.*

Southline Transmission Environmental Impact Statement; Southline Transmission LLC; Las Cruces, New Mexico, to Wilcox, Arizona. SWCA served as the third-party NEPA consultant to the BLM and Western Area Power Administration in writing a NEPA-compliant EIS for 440-miles of new and rebuilt transmission line project crossing southern Arizona and southern New Mexico that includes both new conduction and segments upgrades. *Role: Provided senior oversight of hydrologic analyses and NEPA expertise.*

Northern Arizona Proposed Withdrawal Environmental Impact Statement; U.S. Bureau of Land Management; Coconino and Mohave Counties, Arizona. SWCA was the primary contractor to the BLM and four federal cooperating agencies to determine the potential impact of a 20-year withdrawal of approximately 1 million acres of federal lands from new mineral exploration and mining near Grand Canyon National Park. *Role: Environmental Specialist. Served as the lead author for the Reasonably Foreseeable Development scenario that formed the basis for analyzing the No Action Alternative. Provided review role on hydrologic analyses and developed tools to allow the efficient receipt and processing of the huge volume of public comments received (294,000).*

Prescott National Forest Boundary Fuels Management Project; URS Corporation; Yavapai County, Arizona. SWCA prepared an environmental assessment for proposed fuel management on portions of the Prescott National Forest. Work involved assessment of watershed response, in terms of water quality, water quantity, and soil losses, to the proposed activities, which included prescribed burns, brush crushing, and timber harvesting in ponderosa pine and chaparral. *Role: Soil and Watershed Specialist.*

Payson Little Diamond Rim Environmental Assessment; Town of Payson; Payson, Gila County, Arizona. SWCA assisted with environmental and hydrologic analysis under NEPA for a special use permit with the Tonto National Forest to allow the Town of Payson to drill wells on USFS land. The project included an extensive public outreach component and use of geophysical investigation to site wells. *Role: Environmental Specialist.*

Cragin Reservoir Pipeline and Water Treatment Plant Site Environmental Assessment; Town of Payson; Payson, Gila County, Arizona. SWCA completed an EA in accordance with Forest Service NEPA guidelines, including biological, cultural, and wetland resource studies. The project was granted a Decision Record and Finding of No Significant Impact. *Role: Environmental Specialist.*

Uintah Basin Natural Gas Development Environmental Impact Statement; Badlands Energy, Inc.; Uintah and Duchesne Counties, Utah. SWCA assisted the BLM in writing an EIS and record of decision (ROD) for the proposed drilling of approximately 1,500 deep natural gas wells. The project included wells, pipelines, roads, and associated ancillary

facilities and encompassed approximately 236,000 acres of BLM, state, and private land in eastern Utah. The Draft EIS was published in late 2010, followed by the Final EIS published in spring 2012 and by a ROD in June 2012. *Role: Hydrologist.*

U.S. Bureau of Land Management Resource Management Plan (RMP); U.S. Bureau of Land Management; Vernal, Multiple Counties, Utah. SWCA was selected by the BLM to revise the RMP for the Vernal field office. For the RMP, SWCA resource specialists assisted the BLM with all phases and tasks of the RMPs/EISs, including development of mineral potential and socioeconomic baseline reports, development of alternatives, preparation of the draft and final EISs, and comment response. *Role: Hydrologist.*

Moab and Monticello Resource Management Plans and EISs; U.S. Bureau of Land Management; Moab, Monticello, Grand, and San Juan Counties, Utah. SWCA was retained by the BLM offices in Moab and Monticello, Utah, to assist in the revision of their existing RMPs and associated EIS, which included both public lands and federal mineral estate lands. As part of the project, SWCA developed a public scoping strategy for which the BLM received the Public Affairs Golden Spike Award from the Public Relations Society. *Role: Environmental Specialist.*

Jonah Infill Drilling Project Environmental Impact Statement; EnCana Corporation; Pinedale, Sublette County, Wyoming. SWCA was selected by the BLM and EnCana Oil & Gas, USA, to finish a stalled, third-party-sponsored EIS for the development of 3,100 natural gas wells on a 30,500-acre Jonah Infill Drilling Project Area in west-central Wyoming. *Role: Environmental Specialist.*

Rio Grande Basin Water Quality Assessment; U.S. Bureau of Reclamation; Multiple Counties, Multiple States. SWCA assessed water quality conditions and developed water quality models for selected reaches of the Rio Grande from its headwaters in Colorado to Fort Quitman, Texas. Also included in this assessment was the analysis and modeling of water quality conditions in the Rio Chama and Rio Jemez in New Mexico. The models developed were used to evaluate the potential impacts of a variety of reservoir operations alternatives within the Rio Grande Basin. Results of the modeling efforts were compared with the water quality standards for the states of Colorado, New Mexico, and Texas and several Rio Grande Pueblos in New Mexico. Final work products were used to identify operational alternatives that either improve or minimally impact water quality conditions in the basin. Work included the development of a surface water quality model on the Rio Grande system, analysis of water quality on existing reservoirs on the Rio Grande, development of trends, and correlation analysis. Information was used to assess different river operation plan effects on future water quality. *Role: Environmental Specialist.*

Estancia Basin Watershed Monitoring; Claunch-Pinto Soil and Water Conservation District; Torrance County, New Mexico. For this 5-year contract, SWCA monitored forest and watershed health in relation to forest thinning on the eastern slopes of the Manzano Mountains to evaluate the effectiveness of thinning treatments. Work included the design, installation, and monitoring of hydrologic data collection network. *Role: Environmental Specialist.*

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GREGORY A. GHIDOTTI

EXPERIENCE

October 2018 – Current *Resolution Copper Mining Permitting & Approvals (Rio Tinto Copper and Diamonds)*
Principal Hydrogeologist

- Primary SME reviewer of hydrogeologic, geochemical and tailings seepage predictions for Resolution Copper EIS
- Delivery of hydrological field program for tailings site characterization and base line studies
- Preparation of water related permitting submittals to regulatory agencies
- Primary point of contact with regard to stakeholder engagement with local communities affected by the Resolution Project and associated field activities for tailings and infrastructure studies.

December 2016 – September 2018 *Rio Tinto Growth and Innovation / Rio Tinto Copper and Diamonds (split role)*
Principal Hydrogeologist

- Group wide verification of material water risks and evaluation of control framework
- Technical Evaluation Group reviewer in advance of capital funding RTKC, RC, RTA
- RT internal review of baseline monitoring and groundwater models for Resolution TSF and mine
- Delivered Tamarack conceptual study (approvals, hydrology, environment) and OM study plan
- Principal SME review of depressurization programs and models at multiple Rio Tinto sites
- Key member of RT government stakeholder group with regard to evolving environmental compliance criteria

June 2014 – Nov 2016 *Kennecott Utah Copper (Rio Tinto)*
Project Manager, Mine Dewatering

- Direct accountability for developing and implementing a comprehensive five year dewatering plan to include:
    - Performance of underground drainage galleries
    - In pit horizontal drain installation
    - Production wells targeted into abandoned mine workings
    - Surface water diversion and catchment impounds
    - All electrical and mechanical infrastructure
    - Integration with downstream process controls, water quality targets and state compliance requirements
    - Aligning stakeholders to quickly achieve tactical and strategic success
    - Project controls and financial oversight
    - $149M capital project budget

- Principal reviewer of all hydrological input to slope deformation models
- Built a high performing team via influence and collaboration throughout the value stream from product group executive to operators in the field.
- Rio Tinto expert review for RTKC PFS closure studies
- RTKC POC for Copper and Diamonds drilling protocol
- Conducted multiple internal technical and business reviews for water, environment and approvals in advance of Investment committee decisions

February 2009 – May 2014 *Resolution Copper Company (Rio Tinto)*
Manager, Hydrogeology & Baseline Studies

- Responsible for preparation of water management sections of PFS and Plan of Operations
- Successful in permitting multiple state of AZ plans of operation including section 7 consultation with USFW
- Key driver and owner's team manager for successful federal EA
- Principal reviewer of all hydrological modeling for Resolution including APP

- Direct supervision of a eight person technical staff and > eighty contractors
- Responsibility for $67 M project budget
- Recorded over 310,000 man hours no lost time
- Responsible for regional & mine site hydrological modeling and baseline studies
- Successfully installed 35 complex hydrological testing wells in adverse greenfield terrain
- Completed 25 kilometers of remote road construction
- Logistical oversight and permitting of complex drilling, grouting, pumping and discharge tasks

January 2007 – January 2009 *Rio Tinto Technology and Innovation*
Principal Advisor Geology

- Project Manager Kennecott mine to tails arsenic study
- Evaluation of mine scheduling alternatives Kennecott UT Copper (KUC)
- Implemented changes to KUC mine/mill reconciliation methods
- OM study of smelter stock pile options for concentrate blending at KUC
- FS of alternative KUC tails management and hydro-met plant processes
- OM study Green River uranium project WY USA.

August 2005 – December 2006 *Resolution Copper Company (Rio Tinto)*
Senior Exploration Geologist

- District synthesis of brownfield exploration targets
- USFS liaison for drill site environmental compliance
- Oversight of district geophysical studies (wire line, gravity, seismic)
- Direct supervision of core processing, logging and warehouse personnel
- Direct supervision of exploration drilling program

June 2000 – May 2004 *GLD Resources Owner & President*
Gold and Base Metals Exploration Geologist

- Land tenure research
- Permitting drill sites with BLM
- Drill program oversight for Canadian juniors
- Interpretation of regional geophysics
- Remote camp manager

August 1995 – May 2000 *University of Arizona and Homestake Mining Company*
Graduate Associate exploration drilling program

- District targeting brownfield oxide gold deposits
- Permitting of hydrology drilling and site compliance
- Supervision of FS infill deposit drilling at Homestake's Ruby Hill Mine
- Graduate studies in Mineral Economics, Applied Geochemistry and Geophysics

May 1985 – July 1993 *United States Army*
Battalion Nuclear Weapons Chief US Europe & Middle East

EDUCATION

November 2012 Economic Evaluation & Investment Decision Making
Colorado School of Mines Stermole and Stermole

August 2011 Embedding a Zero Harm Culture (*Rio Tinto)*
March 2008 Operational Leadership (*Rio Tinto*)
December 1992 – 2000 UNIVERSITY OF ARIZONA
B.S. Geosciences - M.S. Geochemistry of Ore Deposits

SKILLS

Building lean, high performing teams. Functional understanding of federal and state

permitting requirements, Securing funding in a capital restricted environment, Contract negotiation. Expert reviewer of hydrological models for UG, surface mines and tailings impoundments, Disseminating technical information to key stakeholders with non-technical backgrounds. Advanced drilling and monitoring techniques. Underground and Surface mine design requirements.

REFERENCES

Available upon request

MONTGOMERY & ASSOCIATES

Chris Gregory
Hydrogeologist

OFFICE: Tucson

YEARS OF EXPERIENCE

Total: 10 | M&A: 7

EDUCATION

M.S., Water Resources Engineering, Oregon State University (2009)

B.S., Geology, Wheaton College (2007)

KEY AREAS OF EXPERTISE

Technical oversight and coordination of field programs

Supervision of drilling, construction, development, and testing

Analysis and interpretation of aquifer tests

Geospatial data management with ArcGIS and AutoCAD

PROFESSIONAL AFFILIATIONS

International Association of Hydrogeologists

Chris Gregory specializes in providing technical oversight for field programs, analyzing data, and preparing reports. He has worked on projects in the United States, Latin America, and Southeast Asia. His field experience includes supervising drilling (reverse circulation, conventional, and diamond drill hole), well construction and development, and hydraulic testing for aquifer characterization. Prior to joining M&A's Tucson office, Chris lived in Peru for six years. He is fluent in Spanish.

Representative Projects

Field Characterization: Compañía Minera Antamina
Antamina Mine, Huaraz, Peru

Led and reported on field activities — specifically, the drilling, installation, and development of piezometers, wells, and horizontal drains — to support an active pit-dewatering program.

Prefeasibility Studies: Confidential Client
Land Subsidence Investigation, Harquahala Basin, AZ

Investigated the potential for land subsidence near client property within the Harquahala Basin; used historical data and expected future groundwater withdrawals to prepare maps, tables, and figures, and provided client with technical assessment and guidance.

Prefeasibility Studies: Resolution Copper
Resolution Mine, Superior, AZ

Coordinated aquifer testing field program for Skunk Camp proposed tailings storage facility site; supervised slug tests, constant-rate pumping tests, and constant-head injection tests at nine wells; analyzed test data and prepared final report.

Prefeasibility Studies: MMG Limited
Sepon Mine, Savannakhet, Laos

Supervised extensive packer testing of a geotechnical corehole in the Dao Luek area to characterize carboniferous shale, dolomite, ryhodacite porphyry, and local fault systems; prepared technical reports summarizing test results, which showed variable hydraulic conductivities; supervised ODEX drilling of test wells; performed solid slug tests on piezometers; observed pumping test activities.

Feasibility Studies: AUX Grupo EBX (formerly Ventana Gold)
El Gigante (La Bodega) Project, Santander, Colombia

Supervised the drilling and installation of piezometers and wells in variably altered, fractured gneiss; conducted packer, slug, and pumping tests in wells and boreholes.

Feasibility Studies: Tahoe Resources Inc. (formerly Rio Alto Mining)
Shahuindo Project, Cajabamba, Peru

Supervised the drilling, installation, and development of piezometers and test wells; conducted packer tests; prepared cross sections and supporting analyses for a hydrogeologic report.

Feasibility Studies & EIA: BHP Billiton
Cerro Matoso Mine, Montelíbano, Colombia

Supervised the drilling, construction, development, and testing of piezometers and wells to characterize groundwater flow near a proposed dynamic heap-leach facility for a lateritic nickel ore.

Prefeasibility Studies: Anglo American
Minas Río Project, Minas Gerias, Brazil

Defined spatial extents and calculated total areas for tailings storage facility options; developed ArcGIS figures of watersheds, drainage paths, and dwelling groups in the project area.

Scoping & Prefeasibility Studies: Stonegate Agricom Ltd. & Mantaro Perú
Mantaro Phosphate Project, Junin District, Perú

Conducted a "desktop" study of the geology, hydrology, and climate of the project area; co-authored scoping reports on potential groundwater and effluent water supplies; conducted a site visit and supervised water quality sampling from springs and rivers.

Mine Water Supply Investigation: Lumina Copper Corporation
Taca Taca Project, Salta, Argentina

Identified potential sites for water supply wells based on surface characteristics and structural geological controls; oversaw drilling operations for piezometers and an exploration well; conducted packer tests.

Mine Water Supply Investigation: Azure Minerals Ltd.
Mesa de Plata Project, Sonora, Mexico

Performed site reconnaissance, collected field data, and collaborated on a hydrogeological conceptual model to identify favorable locations for exploration wells; prepared maps, helped evaluate water supply options, and prepared drilling and well specifications to solicit bids from drilling companies.

Mine Water Supply Investigation: Tahoe Resources Inc. (formerly Rio Alto Mining)
Shahuindo Project, Cajabamba, Perú

Identified favorable locations for exploration wells, coordinated field operations, supervised well drilling and construction, and prepared technical reports on behalf of the client for submittal to the Peruvian National Water Authority for groundwater use permitting.

Water Supply Investigation: Los Portales
Las Dunas de La Florida, Ica, Perú

Provided technical oversight of field activities related to the drilling of a production well for a real estate development project; analyzed and described lithologic drill cuttings.

Water Supply Investigation: Edifica

Las Palmeras del Chipe, Piura, Perú
Coordinated field activities with client and staff and provided technical support to this real estate client regarding drilling methods and recommendations.

Community Water Supply Wells: Tahoe Resources Inc. (formerly Rio Alto Mining)
Liclipampa and Siguis, Cajabamba, Perú

Participated in site selection, drilling supervision, construction, and testing of two community water supply wells near the Shahuindo mine; prepared technical documents and hydrogeologic studies for Peru's national water authority to request water use licenses for the wells.

Groundwater Characterization: Resolution Copper
Resolution Mine, Superior, AZ

Provided technical oversight and field coordination of water quality monitoring program for the Near West study area. Monthly and quarterly water quality samples were collected from wells, surface waters and springs over a ten-month period using a combination of dedicated and portable pumps, bailers and Hydrasleeve™ samplers.

Model Simulation • Tailings Alternatives: Resolution Copper
Resolution Mine, Superior, AZ

Developed GoldSim contaminant transport models to simulate fate and transport of seepage from tailings alternatives to downstream groundwater and surface water monitoring locations; prepared technical memorandums detailing model results and participated in client discussions regarding strategic planning.

Mine Closure Planning: Freeport-McMoRan Corporation
Cerro Verde Mine, Arequipa, Perú

Prepared a hydrogeologic report to update a mine closure plan and support the expansion of mining operations in accordance with Peruvian regulatory requirements.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CURRICULUM VITAE

MICHAEL E HENDERSON, P.Eng., P.E.

Civil and Geotechnical Engineer

Education

Post-graduate studies, Geotechnical Engineering, University of Nevada and Colorado State Universities (1991)

M.Sc., Civil Engineering, University of Pittsburgh (1984)

B.Sc., Civil Engineering, Colorado State University (1979)

Experience

2016-Present Senior Civil and Geotechnical Engineer, BGC Engineering Inc.

Affiliations

Association of State Dam Safety Officials

International Committee on Large Dams

National Society of Professional Engineers

Society for Mining Metallurgy and Exploration

Mr. Henderson has an extensive experience providing civil and geotechnical engineering design services. He is responsible for senior review and leadership on a wide range of engineering projects, including tailings impoundments, water storage reservoirs, heap leach facilities, and mine planning. Mike's technical background relating to designing mining facilities includes design-engineering experience on a wide range of projects in the US and overseas, operations experience at several large mines, mine and energy research for the US Bureau of Mines and Department of Energy, and expert witness testimony related to mining issues.

Following is a summary of select projects in which Mr. Henderson has been involved:

Rosia Montana, Gabriel Mining Corporation
Chairman of the Tailings Review Board for Gabriel on this large gold mining project in Romania. The other TRB member is Dr. Norbert Morgenstern.

Cameco Resources, Key Lake Project
Member of the external geotechnical review board with Dr. Morgenstern and Dr. Hari Mittal for this project in Canada.

Cameco Resources, Kintyre Project
External geotechnical expert for 3rd party review of tailings impoundment design and pit stability for this project in Australia.

State of Alaska Large Mines and Dam Safety Program, Statewide, Alaska
Principal in Charge for a 2-year contract for the Alaska Department of Natural Resources (ADNR) Large Mines and Dam Safety program. The State requires assistance in reviewing applications for mining facilities under the responsibility of the Department. This can include review of reports, plans, specifications, and operation performance data, and site reconnaissance of existing tailings, mine waste, pit slopes, and water retention dams. The assistance is needed to supplement the existing capabilities either with special technical expertise or additional support personnel to meet schedules. Since the award of this latest term contract, Mike has overseen geotechnical studies for Red Dog Mine, Fort Knox Mine, and for the Healy Hydraulic Pit.

Donlin Mine Dams Final Review, Crooked Creek, Yukon
Donlin is a very large proposed gold mine complex located in Western Alaska, near Bethel. The project is currently at the feasibility-level design and permitting stage, and the owner has submitted initial design information to the State of Alaska Dam Safety office of the Alaska Department of Natural Resources (ADNR). ADNR utilizes external third-party consultants to review technical issues related to dam permitting and dam safety. Mike is the Principal external consultant to ADNR responsible for reviewing the design and geotechnical aspects of the proposed Donlin Gold tailings and jurisdictional water dams. He conducted a detailed site review and participated in an external review board. Mike also participated in meetings with agency personnel, mining company staff, and contractors.

Veladero, Barrick Gold Corporation
Review board Chairman, reporting directly to the Barrick board of directors, on a wide range of technical and operational issues at the Veladero Mine, in Argentina. Responsible to help set design standards, review corporate risk and exposure, and to assess management activities.

Tailings Disposal Facilty, Southern Peru Copper, Peru
Senior external reviewer, with Earle Kohln, on siting and design of tailings facilities and heap leach facilities at the Southern Peru Mining complex. Tailings facilities consisted of concrete-faced rockfill dams up to 300 meters in height, in a highly seismic region.

Susego Gold Project, Vale Mining
External geotechnical reviewer for this gold mining project located in the Amazon River basin in Brazil.

Years of experience: 41

Lagunas Norte Project, Barrick Gold Corp
Independent reviewer for geotechnical and civil design of a greenfield gold mining project in Northern Peru.

Goldstrike and Cortez Mines, Barrick Gold Corporation
Conducted Dam Safety Reviews for tailings dams at the Goldstrike and Cortez Mines in 2018.

Jabal Sayid Mine, Barrick Gold Corporation and Ma'aden Mining
Conducted a Dam Safety Review of the dry stack tailings facility at the Jabal Sayid Mine in Saudi Arabia.

Pierina Mine Design Services, Barrick, Peru. External
Project Reviewer for Barrick for design and construction of the physical plant facilities at the Pierina Project. Project Manager on design of an outfall pipeline to the Rio Santo. Reviewer on site hydrology, hydrogeology, and geotechnical issues.

Rainy River Mine, Newgold
Technical reviewer for design and operation of the tailings disposal facility at the Rainy River Mine in Ontario.

Red Chris, Imperial Metals
Technical reviewer for tailings dam design, construction and operation of a centerline copper tailings facility in northern British Columbia.

Rio Tinto Corporate
Principal-level review and audit of Rio Tinto's corporate standards related to conducting tailings dam breach modeling, evaluating populations at risk, and evaluating the corporate risk profile. Project also included developing a draft technical standard for conducting dam breach analysis at all of Rio's properties.

Mine for Leach (MFL) Morenci Mine, Phelps Dodge
Technical review of the pipe crushing evaluation, including an evaluation of the numerical modeling for the 1,000 foot high leach dump at the Morenci Mine.

Silver Bell Heap Leach Review, Marana, Arizona
Third party review of proposed design of the Mammoth Heap Leach pad at the Silver Bell Mine, located west of Marana, Arizona. Specific areas of concern were slope stability, ore degradation, liner adequacy, and pipe crushing under high loading conditions. Mike was the Principal reviewer for the technical aspects of the project. He met with the design engineer and owner to coordinate comments and to develop a corrective path forward.

Freeport McMoran, CERCLA 108(b) Response
Principal author under Freeport's corporate attorney, to develop a detailed response to proposed regulations governing mining and mine waste management under the USEPA CERCLA 108(b) regulatory authority. EPA ultimate sided with the industry in determining that a regulatory need had not been defined. The Freeport document was cited on several occasions as providing solid technical and regulatory arguments which were used by EPA in making their final decision.

Gold Reserve Mining Corporation vs the Government of Venezuela
Expert witness on issues related to surface water hydrology, hydrogeology, tailings and waste rock storage, mine permitting and environmental compliance, and construction. The Venezuelan Government nationalized a major copper/gold property in eastern Venezuela in the early 2000's, prompting the lawsuit in World Court under the provisions of an international trade treaty between the governments of Canada and Venezuela.

Groundwater Contamination Litigation, Helms Pit, Sparks, Nevada
Expert technical support to the State of Nevada on a Natural Resource Damage Assessment suit relating to groundwater contamination. Damage assessment included a cost analysis of restoration, and a technical review of the data acceptability, and the reliability of the proposed treatment alternatives.

Mining Operations Litigation, US National Oceanic and Atmospheric Administration, Idaho
Expert Witness to the federal government on a case being pursued under the Natural Resource Damage Assessment statutes. Involvement includes geotechnical and erosional stability of historic mining operations and workings, and their impact on downstream water users, water quality, and ultimately on the northwest salmon fisheries.

Quarry Stability and Safety Litigation, Hawaiian Cement, Maui, Hawaii
Expert Witness on a case involving stability and safety of an historic quarry. Involvement includes geotechnical engineering and regulatory interpretation.

Waste Containment Facility Deterioration Litigation, ARNCO, Los Angeles, California
Expert Witness on geotechnical and mining issues for a case involving premature chemical deterioration of a waste containment facility. Provided testimony on technical requirements of state environmental laws and regulations.

Underground Mining Operations Litigation, Marshall Earth Resources
Expert Witness on a case involving the potential for underground mining operations inducing subsidence in surface structures, including historic structures. Project involvement included geophysical blast monitoring, blast attenuation modeling, and permissible structural acceleration.

Sanitary Sewer Outfall Failure Litigation, International Technology, San Francisco, California
Expert Witness for geotechnical issues related to a lawsuit between International Technology and the Central Sanitation District (Bay area). The lawsuit involved liability associated with unexpected settlement and premature failure of a large diameter sanitary sewer outfall that discharged into San Francisco Bay.

Ortiz Mine Closure Litigation, Santa Fe, New Mexico
Expert Witness for mine closure lawsuit. Areas of testimony include acid mine drainage control technology, groundwater hydrology, surface water control structures, and environmental regulations relating to closure.

Hazardous Waste Facility Litigation, Baker Facility, Martinez, California
Expert Witness on geotechnical and hazardous waste issues relating to a lawsuit involving a California Class I hazardous waste facility, and assisted in preparing closure plans.

Pascua Project Tailings Dam Design, Argentina and Chile, Argentina
Project Manager for design of a 175-meter high tailings disposal facility and ancillary facilities in the high Andes. Developed a novel approach to tailings dam construction, based upon asphaltic core construction techniques developed in Norway.

Las Brisas Tailings Impoundment Design, Venezuela
Project Principal on a design of a tailings impoundment for a gold mine in Venezuela. Unique parameters or design concepts included high rainfall environment, lateritic soils, and the potential to utilize the Robinsky deposition method.

Coeur Rochester Mine Stability Assessment, Lovelock, Nevada
Project Manager on stability issues for the mine waste dumps at the Rochester Mine. Stability assessment included static, pseudo-static, and dynamic assessment, along with a drilling program to assess the actual rock strength.

Tintaya Tailings Impoundment Design, Peru
Senior Reviewer on the expansion of an existing facility and design of a new tailings impoundment at the Tintaya Copper Mine. Issues included liquefaction potential assessment of the current facility, methods to speed consolidation, and cyclone operation.

Goldstrike Mine Tailings Management Plan, Barrick Goldstrike Mines, Elko, Nevada
Project Manager responsible for performing tailings management studies aimed at improving the efficiency of the tailings facility, with an emphasis on sub-aerial deposition. The study included a probabilistic assessment of the long-term precipitation events in addition to normal and upset operating conditions and influences from the design storm.

Erdenet Mine Tailings Facility Stability Assessment, Mongolia
Project Manager and Principal on stability assessment of the existing tailings facility at the Erdenet Mine. Included assessment of static and dynamic stability, and installation of inclinometers and additional piezometers.

Sullivan Project Tailings Facility Design, Gabbs, Nevada
Senior Reviewer on the siting and design of a large tailings facility in central Nevada.

Robinson Tailings Dam Design, Ely, Nevada
Principal Engineer on the siting and design of a 300-million-ton copper tailings disposal facility in eastern Nevada. The project included seismic and geotechnical investigations of various sites, planning for construction of the centerline embankment, and static and dynamic evaluation of the proposed structures.

Deming Tailings Dam Design, Deming, New Mexico
Senior Reviewer on the siting, design, and permitting of a copper tailings dam in southern New Mexico.

Centralia Mine Tailings Impoundment Design, Washington
Senior Reviewer on this unique project which involves inducing liquefaction in a coal tailings impoundment followed by physical displacement to a final waste filtering/storage area. The project involved rheological testing of the tailings material, cone penetrometer testing of the relatively weak foundation material, and design of a passive filtering system.

Cyprus Tonopah Mine Tailings Impoundment Design, Tonopah, Nevada
Senior Reviewer on a significant upstream raise to this cyclone tailings impoundment. Addressed stability of the embankment under earthquake loading conditions and operational considerations associated with cyclone operations.

Silver Peak Tailings Dam Design, Tonopah, Nevada
Senior Reviewer on the siting, design, and permitting of a new tailings impoundment. Previous work at the site included the design of several raises to an upstream tailings dam.

Marigold Project Tailings Facility Design, Valmy, Nevada
Senior Reviewer responsible for siting studies and conceptual design of a tailings facility capable of storing 4 million tons of tailings.

Tonkin Springs Tailings Dam and Storage Reservoir Design, Eureka, Nevada
Project Manager responsible for geotechnical design of a 4-million-ton storage capacity earthen tailings dam and storage reservoir for a new gold mine. Design aspects included a geotechnical investigation, a hydrologic study, static and dynamic stability assessments, and a seismic evaluation.

Twin Creeks Pinion Tailings Impoundment, Winnemucca, Nevada
Senior Engineer on a program to evaluate the potential for speeding tailings consolidation using radial wick drainage. Project involved laboratory testing, numerical modeling, a pilot field demonstration project, and final design.

West Tailings Disposal Pipeline Redesign (Phase II), Climax, Colorado
Senior Engineer for redesign and construction of 6 miles of 24-inch slurry pipeline to partially replace the 42-inch system. The reduction in pipeline diameter was associated with a reduction in the mill production from Climax, to a daily rate of 18,000 tons per day.

Mineria Las Cuevas, San Lius Potosi, Mexico
Senior Engineer on field investigation and subsequent design of a large fluorspar tailings impoundment in central Mexico. Construction drawings and technical specifications were written in English and Spanish.

Kingston Project Engineering Services, Austin, Nevada
Project Manager responsible for geotechnical engineering and design services for retrofit of an existing tailings facility and for design of a new tailings structure.

Gold Bar Project Engineering Services, Eureka, Nevada
Project Manager responsible for geotechnical engineering, design, stability analyses, and hydrological investigation related to a tailings dam at this gold mine.

Goldstrike Project Engineering Services, Elko, Nevada
Project Manager responsible for geotechnical engineering and design of a 225-foot-high, 12-million-cubic-yard embankment for an earthen tailings dam. The design aspects included hydrologic studies, dynamic and static stability analyses, a seismic evaluation, and permitting assistance.

Mayflower, Tenmile, Robinson Tailings Dam Raise, Climax, Colorado
Project Manager responsible for performing embankment designs, slope stability analyses, and support facility redesigns necessary for annual upstream dam raises.

McLaughlin Project Engineering Services, Clearlake, California
Project Manager responsible for performing engineering relating to site selections and embankment design on tailings dams and waste rock disposal sites.

Tailings Dam # 4 Treatment Evaluation, Climax, Colorado
As Senior Engineer, evaluated physical and chemical treatment and stabilization alternatives for controlling excessive acid mine drainage from this sulfide mill tailings impoundment. Physical treatment alternatives included encapsulation, removal and landfill disposal and reprocessing. Chemical stabilization and treatment alternatives included cementation processes, precipitation, and buffering.

Kubaka Tailings Impoundment Project, Russia
Principal engineer for construction and operation of a tailings impoundment and milling facility on the Kamchatka Peninsula. Project located in the far north, in an area of continuous permafrost. Designed and oversaw installation of thermosiphons to reduce or eliminate thawing of permafrost below a rockfill embankment.

Stillwater Mine 5900 Portal Remediation, Nye, Montana
The Stillwater Mining Company's (SMC) 5900 Portal and surrounding colluvial slopes are experiencing a number of stability issues. DOWL is assisting in remediation of these stability issues. Mike was the senior geotechnical engineer responsible for direction and oversight of the portal redesign and upgrade.

Kensington Mine Waste Dump Design, Juneau, Alaska
Kensington is conducting conceptual design of a waste rock storage area called the Pit 4 dump. This waste rock storage area is intended to contain up to about 300,000 tons of non-reactive waste rock. The project includes design of storm water diversion and sediment control structures, physical design of the waste dump, volumetrics, and a slope stability assessment. Mike is the Project Manager and senior geotechnical engineer for conceptual design of the Pit 4 waste rock dump.

ASARCO's Mammoth Heap Leach Facility at Silver Bell Mine, Marana, Arizona
Mike was the Project Manager at ASARCO's Silver Bell Mine to complete the design and oversee the construction of their Mammoth Heap Leach Pad. The initial phase was final design and engineering of the new heap leach facility. The design elements including pond sizing, pad grading, and collection pipe sizing were revised based on detailed analysis . These changes to the design have ultimately saved the owner over $3M on the construction costs of the pad. Prepared the construction bid package for the approximately $70 million project, and has assisted them with procurement of the construction contractor and supplies

Robinson Mine Tailings Expansion Study, Ruth, Nevada. For this study,
This study identified nine separate tailings facility expansion alternatives in the first phase. In the second phase, the nine were narrowed down to three primary alternatives using a multiple accounts analysis (MAA) approach, and scoping-level design was provided for those three. After comparing the three primary alternatives thoroughly and objectively, including construction methods, further expansion opportunities, permitting assessments, capital and operating costs, and hazard/risk assessments, one optimal solution was identified for future expansion of their tailings disposal facilities. Mike lead the effort as the Project Manager for this study. His ability to transition effectively and timely when important variables changed throughout the project resulted in the ultimate success of the study and the satisfaction of the client.

Rock Creek Project, Nova Gold, Nome, Alaska
Principal engineer on design, construction, operation and closure of a large rockfill dam located near Nome, Alaska. Specific technical issues included evaluation of permafrost hydrogeology and geotechnical issues, settlement of frozen rockfill. Designed an embankment monitoring system including piezometers, thermistors, and inclinometers.

Goldstrike Mine Water Balance, Barrick Goldstrike Mines, Elko, Nevada
Senior Engineer on a facility-wide evaluation and prediction of the short- and long-term water balance at the Barrick Goldstrike Mine. The system approach included inflows from direct precipitation and runoff plus makeup water from the open pit

dewatering. The effect of the tailings impoundment, water storage reservoirs, and heap leach pads was included into an overall probabilistic computer model, which was used to optimize operations, avoid excess water balances in wet cycles, and to time construction requirements. As a novel approach, the large heap leach pads were used as medium- term reservoirs, wherein excess water volumes were temporarily stored as -inreservoir attenuation,-in thus allowing operators to deal with excess precipitation events without incurring additional capital expenditures.

Lone Tree Mine Sampling Program, Winnemucca, Nevada
Project Manager responsible for assisting with scoping a sampling program to adequately characterize various geologic units in a large open pit mine. Representative samples were identified via comparison with the Kriged mine model and were evaluated with static and kinetic geochemical tests to provide data for a geochemical model of the open pit.

Tailings Material Handling Study, Green River, Wyoming
This project is located at a chemical processing plant near Green River, Wyoming. It involved conceptual engineering and cost estimating, and was aimed at identifying material handling and disposal area expansion to extend the life of the current grit waste disposal area. Options evaluated included slurry transportation, conveyor transport, and trucks. Mike was the Project Manager and senior engineer, directing activities on the project.

Stabilization of the North Bank of the Niobrara River at Spencer Dam, Boyd County, Nebraska, Nebraska Public Power District, North Platte, Nebraska
Principal geotechnical engineer. The north bank of the Niobrara River downstream of the hydroelectric outlet has experience numerous failures since initial construction in the 1930's. Current stabilization project included remove of a portion of the existing sheet pile wall, placement of 22 ground anchors, installing grouted riprap, construction of new surface and subsurface drains, and temporary and permanent erosion control measures.

Sherman & Arcadia Diversion Dams Inspections, Central, Nebraska
Mike been the engineering consultant to the Sargent and Farwell Irrigation Districts in central Nebraska for nearly 15 years. As such, he is the Engineer of Record for the 65,000 acre foot Sherman Reservoir and the largest river diversion dam on the Loup River system, Arcadia. Mike performs annual inspections of the two dams for structural stability.

Dahla Dam, Afghanistan, US Corps of Engineers, Afghanistan
Principal geotechnical engineer for feasibility level analysis. Evaluated rehabilitation options for Dahla, or replacement with a new (Hasanzay) dam. Dahla is an earthen dam 55 meters high, with a grouted foundation. It supplies both hydropower to Afghanistan and irrigation water for downstream users. Initially constructed in 1952. Total power capacity is 22 MW.

Kensington Mine FMEA Workshop for Stage 3 Tailings Dam Raise, Juneau, Alaska
Conducted a Failure Modes and Effects Analysis (FMEA) workshop for Kensington Mine's Stage 3 proposed tailings dam raise. The 3-day workshop was attended by the owner, the design engineer, and representatives from the US Forest Service, The State of Alaska Department of Natural Resources, the State of Alaska Department of Environmental Conservation. Mr. Henderson was the workshop coordinator for the FMEA. His role was to help lead the discussions and facilitate agreement on appropriate failure modes, the likelihood of failure actually occurring, and the consequences should a failure occur. Mr. Henderson was the primary author on the final report summarizing the results of the FMEA workshop.

Resolution Copper Project EIS, Superior, Arizona
Resolution is the largest greenfield (undeveloped) underground copper mine in the world, and is being developed by a joint venture of Rio Tinto and BHP. The ore body is located approximately 5,000 feet below surface, near the town of Superior in Arizona. This project is to develop an Environmental Impact Statement (EIS) for the US Forest Service, under the National Environmental Policy Act (NEPA). Mike is technical lead for the EIS team, responsible for engineering, scientific review, and analysis. He is also the Principal reviewer and lead author for geotechnical, mining, and civil engineering.

Captain William Henry Moore Bridge Replacement, Skagway, Alaska
The State of Alaska Department of Transportation and Public Facilities (DOT&PF) is completing the design and environmental documentation phase to realign the Klondike Highway and construct a roller compacted concrete (RCC) structure to replace the existing Captain William Henry Moore (CWHM) Bridge. Mike was the senior geotechnical engineer for design of the RCC structureThis involves managing a design team to prepare the final configuration of the bridge structure, and oversees detailed finite element modeling of the structure. The FEM model was used to analyze stresses in the RCC structure that would result from gravity (static), earthquake and thermal loads.

Talapoosa Project PEA Support, Reno, Nevada
This project was a feasibility-level study of an open pit gold mine in western Nevada, near Carson City. Mike’s responsibilities included project infrastructure, design of the Merrill Crowe plant, design of a large heap leach pad, and project infrastructure. The project also included design of the water and power supply for the project. Mike was the Project Manager for aportion of the feasibility study. He also served as the principal author and Qualified Person for the 2015 NI 43-101 pre-feasibility study.

State of Alaska Dam Safety Program
External geotechnical expert for on-call support related to water storage, mine tailings, and hydroelectric projects in Alaska. Special areas of expertise include permafrost and seismic aspects.

Repairs to Lake Maloney Dam, Nebraska Public Power District, North Platte, Nebraska
Registered engineer supervising preparation of plans and specifications, and overseeing construction. Repairs to the Lake Maloney Dam included replacement of approximately 3,135 feet of sheet pile wall, investigation and replacement of a concrete

slope protection slab system, installation of soil nails, and void grouting. Project was permitted with the Federal Energy Regulation Commission since it is a hydropower water storage reservoir.

TS Ranch Reservoir Design, Elko, Nevada
Principal design engineer for design of a 24,000-acre foot water storage reservoir. The design was a new approach for the United States, consisting of a geomembrane core in place of a standard clay core, resulting in a multi-million dollar cost saving. The project also included both operating and emergency spillways, a 42-inch diameter outlet pipe, energy dissipation structures, and upstream and downstream canal design. The inlet canal was designed to reduce water temperatures from the initial inflow temperatures of 140-degrees F to less than 100-degrees F.

Santa Rosa Diversion Dam Design, Morenci, Arizona
Project Principal on a concrete dam designed to intercept and control copper-bearing solutions and storm flows. Design included a pressure grouted interception curtain and grouted rock bolts.

BHP Navaho Mine Seepage Interception Design, New Mexico
Principal Engineer for design of a seepage interception system for the Doby Pit power plant ash disposal project.

Camden Dam Design and Permitting, Tennessee
Project Manager and registered engineer for design and permitting of a clay-core water retention reservoir in central Tennessee. The reservoir was designed to contain surface runoff flows and provide water storage and containment of sediment and waste byproducts from titanium processing.

Willow Creek Reservoir Restoration, Winnemucca, Nevada
Project Manager on the restoration of a large water storage reservoir in north-central Nevada. The project involved structural rehabilitation of a concrete arch dam, foundation assessment and treatment, and expansion of the emergency spillway to pass the design storm.

Open Pit Runoff Central Reservoir Design, Climax, Colorado
Senior Engineer for design and construction of a soil-cement water retention and sediment control reservoir. Project included embankment design, construction specifications, and associated water diversion structures.

Fruitgrowers Reservoir, Grand Junction, Colorado
Engineer on retrofit of an existing water storage reservoir to meet increased spillway discharge requirements under the State of Colorado regulations.

Blanche Park Reservoir Rehabilitation, Grand Mesa, Colorado
This project involved the rehabilitation and enlargement of an existing breached dam. Increased reservoir storage capacity from 50 ac-ft to 125 ac-ft. by raising the dam embankment height by 8 feet and added new outlet works and spillway. Services include hydrology, dam design, State Dam Safety approval, and construction phase. Mike was the senior reviewer on design of the rehabilitation of the Blanche Park Reservoir. This review specifically addressed geotechnical design issues and constructability.

State of Alaska Division of Water Resources Project Review, Alaska
Principal review consultant to the State Engineer for new and existing jurisdictional dam permitting. Responsible for reviewing and providing input into arctic (permafrost) issues, geotechnical issues, geochemical issues, seismic (earthquake) engineering, and operation on water storage dams, hydroelectric facilities, flood control and tailings dams.

Tailings and Heap Leach Facilities Designs, Southern Peru Copper, Peru
Senior Reviewer on siting and design of tailings facilities and heap leach facilities. Tailings facilities consisted of concrete-faced rockfill dams up to 300 meters in height.

Thompson Creek Molybdenum Mine Plan of Operations Review, Challis, Idaho
Senior Technical Reviewer under contract to the USDA Forest Service, evaluating the applicant's submitted plan of operations. Areas of concern evaluated included ARD potential from the tailings impoundment, waste rock dumps, and the open pit, and geotechnical stability of the tailings impoundment.

Mining Application Technical Reviews, Nevada, California, Montana, and Idaho
As Technical Expert, performed technical review as to the suitability of various mining applications as related to environmental impacts. The technical reviews have primarily involved the adequacy of the proposed containment of mining wastes, acid mine drainage issues, and geotechnical considerations. Involved in Nevada and California in the development on State regulations dealing with the control of mining wastes.

Hayden Hill Tailings Dam Design, Susanville, California
Project Manager on the siting and design on a large tailings dam and heap leach facilities at this gold mine in northern California.

Office of Surface Mining Dam Safety Project, Pittsburgh, Pennsylvania
As Project Manager, Mr. Henderson supervised the design, testing, and analysis required to assess the stability and Office of Surface Mining regulations of large waste disposal embankments. This project included full-scale simulation of 500-foot embankments consisting of minus-24-inch material.

ADNR Mine Reclamation Guidelines, Statewide, Alaska
Project Manager on state guidelines related to sources of variability that drive the ranges of indirect costs observed with reclamation and closure (R&C) projects in and outside of Alaska, based on input from State and Federal agencies with

authority over reclamation and closure efforts. Local construction contractors were contacted for insight into their experiences with indirect costs. Reviewed the R&C cost estimation guidance, including documents from the United States Forest Service, Bureau of Land Management, State of Nevada, and State of Alaska. Provided suggestions and recommendations regarding what range of indirect cost variability will provide adequate assurance for R&C by further refining the indirect cost calculation process and enhancing the methodology descriptions. The Guidelines will be used in the development of formal agreements between mine operators and the Stat

Pascua Lama Tailings Impoundment Project, Chile and Argentina
Project manager for design of a major tailings impoundment, water storage reservoir, and tunnel in the high Andes. The project was located on the Chile/Argentina border, at an altitude ranging from 4,000 to 5,800 meters. Discontinuous permafrost and local glaciers found onsite.

Key Lake Uranium Mine Tailings Impoundment, Saskatoon, Canada
Senior geotechnical engineer on design and construction of a large uranium tailings impoundment in northern Saskatoon.

Sierra Lakes Environmental Impact Report (EIR), Marysville, California
Senior Author/ Reviewer on the surface and groundwater hydrology sections of an EIR prepared under the California Environmental Quality Act. The northern California project included development of a large open-pit copper mining operation, followed by residential development as part of the mitigation and reclamation activities.

Red Dog Project, US Environmental Protection Agency, Region 10, Alaska
Principal Geotechnical engineer on the 2010 Supplemental Environmental Impact Statement for the Aqqaluk deposit. Technical issues included assessing the thawing trend for the permafrost zone below the tailings dam and the impact on seepage and stability, evaluation of facility performance, conceptual design of a 50-mile long water outfall pipeline to the ocean, and closure planning. Mr. Henderson was the Project Manager on updating the 2009 closure plan for the overall facility. He was also the Principal Investigator on a 2000 evaluation of the waste rock geochemistry and stability at the site.

Pitch Uranium Mine, Colorado
Engineer of record on closure and reclamation of this large open pit uranium mine in western Colorado. Responsible for developing a detailed closure and reclamation plan, including a reclamation bond, and routine site monitoring. Developed and implemented plans to mitigate landslide movement, assess avalanche risk, re-establish surface water diversion structures, and decommission process facilities.

Greens Creek EIS, US Forest Service, Juneau, Alaska
Principal Geotechnical Engineer on the 2012 Environmental Impact Statement for the Greens Creek Mine Tailings Expansion for the Tongass National Forest. The Statement provided technical review of proposed actions relating to expanding the dry tailings disposal facility, waste rock disposal, and related facilities.

State of Colorado Division of Reclamation, Mining and Safety, Colorado
Principal engineer on issues related to mine closure, groundwater, and safety. Multi-year contract, with multiple sites to be mitigated under an abandoned mines program.

Independence Mine Environmental Impact Statement (EIS), Elko, Nevada
Senior Geotechnical Engineer for preparation of the groundwater hydrology, waste dump stability, and closure and reclamation portions of the Environmental Impact Statement.

Brookhaven National Laboratory Environmental Audit, Long Island, New York
As Project Manager, participated in a facility-wide environmental audit as part of a pre- tiger team inspection. Areas of responsibility included Resource Conservation and Recovery Act, Clean Water Act (National Pollution Discharge Elimination System), waste management practices, fuel storage, and mixed waste (i.e. radioactive) disposal.

Pittsburgh Research Center Regulatory Compliance, Pittsburgh, Pennsylvania
Project Manager responsible for modifying facility program to bring it into compliance with the State and Federal CERCLA - Community Right-to-Know and Materials Safety Data Sheets Program.

Questa Mine Slurry Pipeline, Taos New Mexico
Project manager for design of a high head, high density slurry pumping and pipeline system. The project included design of two high head positive displacement pumps capable of transporting 60 percent slurry to a final repository located approximately 1,500 feet above the mill Other components of the $300M project included design of a high density thickener, design of a new pump building, a tunnel, and a cross-country slurry pipeline.

Henderson Mine Pipeline System Design, Empire, Colorado
Project Principal on redesign of the existing decant pipeline system to meet updated design parameters.

Nogales International Wastewater Treatment Plant Admin/O&M building, New Mexico, US International Boundary and Water Commission, Nogales, New Mexico
Registered geotechnical engineer. Geotechnical investigation and recommendations for the Administration and O&M guilding in Rio Rico, Arizona. On-site drilling to investigate site, leading to recommendations on excavation and foundation design criteria.

Safford Project Design and Permitting Services, Safford, Arizona
Project Manager on design and permitting of the largest lined leach pad of its kind in North America. The initial leach pad was designed to leach up to nearly 1 billion tons of low-grade ore, to a maximum height of 600 feet. Technical challenges included

design of a geomembrane liner and solution collection piping system capable of withstanding static loads of 900 feet (1.5 x design).

Carlota Copper Project Design and Permitting Services, Miami, Arizona
Project Manager on design and permitting of a large valley-fill copper leach project. Significant aspects of the project included three permitted dams and two large probable maximum flood diversion canals.

Brewery Creek, Yukon Territory, Canada
Senior reviewer to Kloen Crippen for design of a cold regions heap leach project. Technical issues included location in a discontinuous permafrost region, cold region operations of a process plant, and closure considerations.

Victory Gold, Yukon Territory, Canada
Technical sponsor for final feasibility study of a gold heap leach facility in the Yukon.

Red Dog Mine Geologic Hazards, Alaska
Project Engineer on various projects designed to control acid rock drainage, mitigate impacts to the permafrost, and dust control.

Western Contra Costs Landfill, Richmond, California
As Senior Scientist, provided expert regulatory guidance to the prime consultant relative to hazardous waste remediation and closure. The specific regulatory guidance and assistance included compliance with Resource Conservation and Recovery Act under Federal jurisdiction, and Titles 22 and 23 under the State of California. The specific agencies involved included the US Environmental Protection Agency Region 9, California Water Quality Control Board, California Department of Health Services, and Bay Area Air Quality Management District.

Department of Energy, Hanford Facility Plutonium Waste Monitoring
Senior Scientist/ Project Manager on a program to evaluate the use of advanced geophysical systems to monitor the environmental performance of the single and double wall plutonium waste storage tanks at the Hanford Facility. The project consisted of design and field testing of a remote sensing system to monitor leakage from the plutonium waste storage tanks during a waste removal and transfer program.

Brookhaven National Laboratory Pre-tiger Team Audit
Project Manager/ Senior Environmental Engineer on a multi-disciplinary team tasked with providing a detailed review of environmental compliance issues at the Brookhaven National Laboratory. Specific technical areas of responsibility included nuclear waste interim storage and handling, mixed waste storage and handling and Resource Conservation and Recovery Act waste storage.

High-Level Waste Storage Facility Engineering Services, California
Project Manager/ Senior Geotechnical Engineer for a project involving a proposed high-level waste storage facility. Evaluated the geologic containment of the proposed facility, the extent and quality of the regional and local groundwater system, and the reliability of the proposed underground storage facility.

Tailings Closure Summarize Services, General Atomics Panna Maria Facility, Southern Texas
Project Manager/ Senior Geotechnical Engineer for a new nuclear waste by- products waste disposal facility.

Landfill Compliance, Planning, and Design Services, Packaging Company of California, Red Bluff, California
Senior Engineer on a wide range of compliance, planning, and design enhancements at this solid waste landfill in northern California. Project included stormwater diversion and handling structures, closure design, groundwater monitoring, a study evaluating alternative disposal and/or recycling options including cogeneration, land farming, incineration, and co-disposal.

Nye County Landfill Design Services, Nevada
Senior Reviewer on a project to provide solid waste management services to Nye County. The project included preparation of a detailed solid waste management plan, closure planning for 35 known regulated and non-regulated landfills, design of a new solid waste landfill, design of a sludge handling and disposal facility, and environmental assessment of the proposed facilities.

West Contra Costa Landfill, Richmond, California
As Engineering Expert, supported the prime consultant on waste solidification and stabilization and on State and Federal regulations at the Class I hazardous waste disposal site.

Benson Ridge Stabilization Project, Lake County, California
Project Manager responsible for evaluating various methods to stabilize acidic wastes from the Geysers area geothermal projects. Processes evaluated included cement, flyash, and lime stabilization, and mechanical mixing of uncontaminated material.

US Department of Defense Deep Basing Program
Senior Engineer on a feasibility-level design program for the MX missile deep basing program. Evaluated various tunneling technologies and associated costs for use in tunnel construction, and using slurry handling techniques for tunnel muck haulage.

US Air Force Deep Basing System
As Senior Engineer, prepared design and construction estimation related to utilizing hydraulic transportation to transport rubble from a tunnel boring machine to a surface waste disposal area.

Radioactive Material Inventory/Disposal for Nuclear Waste Disposal Program, Pittsburgh, Pennsylvania.
Program Manager responsible for inventorying and disposal of radioactive materials at the Pittsburgh Energy Technology Center Research Facility.

Bureau of Mines Analytical Laboratory Supervision, Pittsburgh, Pennsylvania
Project Manager responsible for supervising the US Bureau of Mines Analytical Laboratory, specifically including chemical analyses of acid rock drainage treatment options and biologic treatment columns.

Atlas Moab Uranium Closure Project, Moab, Utah
Project Manager on geotechnical, geochemical and hydrologic issues supporting closure and reclamation of a 10-million ton uranium mill tailings impoundment located adjacent to the Colorado River.

San Manual Mine Closure, Arizona
Senior Reviewer on closure planning for this large underground and open pit copper mining facility.

Walker Mine Tunnel Safety Inspections, Portola, California
Project Manager, providing annual safety inspections of an abandoned, underground mine tunnel. Design work included mapping and designing a passive underground roof control system, which can provide for long life, high reliability, and low maintenance. Although pressure-treated timber was ultimately selected, steel sets, steel arches, rock bolts, and slip lining were fully evaluated.

Mine Facility Closure, Darwin Project, Darwin, California
Technical Reviewer and Principal Engineer for closure of a large mining facility in southern California. Issues included geochemical stability and stabilization, surface and underground environmental audits, and regulatory requirements.

Walker Mine Closure, Portola, California
Project Manager on an abandoned copper mine closure and remediation project, under contract to the State of California. The project included three major aspects: (1) rehabilitation of an existing mine tunnel, (2) assessment and treatment of acid mine drainage, and (3) surface and groundwater assessment and control. The major portion of the project was the acid mine drainage issue, wherein the underground and surface mine zones were assessed for contributions to the overall problem, and remediation measures proposed. The specific remediation measures included chemical and biologic treatment of the mine discharge, waste disposal alternatives, and groundwater flow controls.

Climax Molybdenum Mine Tailings Management Plan, Climax, Colorado
Project Manager on an overall plan to provide interim closure and reclamation of portions of the overall tailings disposal facilities, to redesign the tailings management practices to optimize beach construction and minimize mill water return pumping cost. The project also included design of a haul road constructed on submerged tailings, redesign of a large mill water pumping station, and design of long-term diversion canals and spillways from the tailings impoundment surfaces.

Round Mountain Pit Water Quality Evaluation, Round Mountain, Nevada
Technical Reviewer for evaluation of long-term impacts to local groundwater system resulting from exposing sulfide materials during mining operations, and allowing a lake to form as part of reclamation.

Mine Reclamation Plan, Climax Molybdenum Co, Climax, Colorado
Responsible for updating the site reclamation plan, as administered by Colorado Mine Land Reclamation Board. Prepared and submitted notifications of disturbance for mining and construction activities to the US Army Corps of Engineers, under Section 404 of the Clean Water Act.

Pinos Altos Mine Drainage Evaluation and Treatment, Silver City, New Mexico
Senior Engineer for evaluation and chemical treatment of mine drainage from an underground copper mine. Treatment alternatives included flocculation and precipitation of heavy metals to meet mine discharge standards.

Ironbark Mine Feasibility Study, Greenland
Principal geotechnical engineer for a 2010 feasibility study of a Greenfield zinc mine on the northern coast of Greenland. Technical challenges include effect of the mine of the local permafrost zone, development of water supply reservoir, tailings impoundment, and underground mine, and development of a summer port facility.

Nickel Laterite Mine Development, Goro Nickel Project, New Caledonia
Principal Engineer/Project Manager on overall development of a +US$1B nickel laterite mine in the South Pacific. Areas of responsibility include resource evaluation, mine planning, equipment selection, materials handling, and design of tailings disposal facilities, water storage reservoirs, and waste disposal facilities.

Pascua/Lama Gold Feasibility and Final Feasibility Studies, Argentina and Chile
Principal engineer on infrastructure for the US$2B Pascua/Lama Gold Mine for Barrick. Facilities included in the infrastructure portion of the studies included an underground tunnel, water supply reservoir, tailings disposal facility, waste rock disposal facility, and related infrastructure.

Las Brisas, Venezuela
Project Manager for prefeasibility, feasibility and final feasibility studies on this large US$700M copper/gold mine located in eastern Venezuela. Areas of responsibility included pit dewatering, open pit stability, tailings disposal, waste rock disposal, water diversions, roads and pipeline infrastructure, mill and related building foundations, rock quarry, geochemistry, and water supply.

Yarnell Mine Feasibility Study, Wickenburg, Arizona
Senior Engineer on an economic feasibility study and pre-acquisition environmental compliance audit of a proposed open pit mine in central Arizona. The environmental compliance portion of the project included scoping of the permits necessary for

construction and operation, specifically NEPA and MSHA issues and timeframes and Arizona Department of Environmental Quality aquifer protection permits.

Cananea Mine Feasibility Study, Cananea, Mexico
Senior Member of Acquisition Feasibility Team responsible for environmental compliance, existing and potential environmental liabilities, and tailings management.

Printer Boy Mine Development Services, Leadville, Colorado
As Project Manager, developed plan of operations and state permit applications necessary for a gold mine development project.

Selwyn Project, Yukon Territory, Canada
Principal geotechnical engineer on foundation design of large mill and mine structures for a gold mine in the Yukon.

Applied R&D, Barrick Goldstrike Mines, Elko, Nevada
As Project Manager, evaluated the potential for utilizing fine-grained tailings material in the construction of secondary soil liners. Evaluation consisted of physical permeability tests and geochemical evaluation (Toxicity Characteristic Leaching Procedure, meteoric water mobility) to determine if leachate from the tailings would exceed water quality discharge requirements as established by the State. The project also evaluated the potential for metals complexation where discharge limits were exceeded for specific constituents.

Cyprus Mining Efficiency Research
Principal Scientist on an applied research and development project aimed at improving the efficiency of copper dump and heap leaching by electro-osmotic pressure. Project resulted in three patent applications.

Phelps Dodge Technical Center, Phelps Dodge Corporation, Arizona
Principal Scientist on an applied research and development project to evaluate variably saturated flow conditions within a dump leach facility. Project ultimately resulting in Phelps Dodge changing their methodology regarding operating dump leach facilities.

Phelps Dodge Morenci, Arizona
Designed and installed a geophysical system to monitor three-dimensional flow during leaching of a dump leach test fill at the Morenci Mine. Variables that were evaluated included the depth of ripping (up to 11 feet), and variable flow (surging) effectiveness.

Water-Jet Assisted Cutting Program, Pittsburgh, Pennsylvania
Senior Engineer on a research project to evaluate the economical and efficiency benefits of utilizing water- jet only and water-jet assisted rock excavation techniques. The research was conducted under contract to Department of Energy and US Department of Defense.

Jet Pump Performance Testing, Fort Collins, Colorado
Lead Research Engineer on a World Bank-funded project to evaluate performance of low-head, high-volume jet pumps in improving the ability of Pakistan to increase the efficiency of their agricultural programs.

Cutthroat Flume Test Program, Fort Collins, Colorado
Lead Research Engineer on evaluating the accuracy of utilizing cutthroat flumes at various levels of downstream submergence.

Mining Operation Risk Assessment
Project Manager on evaluation of physical risks and mitigation options for a major mining operation. Risks were primarily associated with potential failures of tailings, water storage, and waste rock facilities. Downstream receptors included several towns and individual residences, and a major river system.

Mining Properties Acquisition Environmental Audit, Colorado
Project Manager on a Securities and Exchange Commission audit related to a mining company acquisition. Assessed probable and potential environmental liabilities associated with the various mining properties.

Feasibility Study, Department of Defense Rapid Response Program
Project Manager on a feasibility-level evaluation of re-excavating collapsed tunnels.

Environmental Assessment, Webster Sand and Gravel, Leadville, Colorado
As Senior Scientist, wrote an environmental assessment under National Environmental Policy Act, obtained Mine Safety and Health Administration certification, and acquired State and local permits for mining and air quality discharge on a new sand and gravel quarry operation.

Mining Equipment Test Facility, Pittsburgh, Pennsylvania
As Project Manager, supervised acquisition of Mine Safety and Health Administration approval on underground mining equipment. Supervised MSHA and Occupational Safety and Health Administration training, instructors, and mining operations at two underground coal and non-coal mines. Instigated development of company plan to conform with State and Federal Right-To-Know legislation.

Lower Lake County Road Slope Stabilization, Lake County, California
Senior Engineer on a slope stabilization project, primarily involving groundwater modeling and horizontal well installation.

BLM- New Bridgeport Bridge, Dominguez Canyon, Colorado
Siting and geotechnical engineering for the Bridgeport Bridge over the Gunnison River. This bridge provides access to the

Dominguez Canyon Wilderness Study Area (WSA). The existing Bridge was closed to public access in 1986, after the sagging structure was determined unsafe.

Dixie Valley Mine Groundwater Removal, Fallon, Nevada
Senior Technical Reviewer on basin investigation, modeling, dewatering system design, and discharge systems for removal of groundwater near a proposed open pit mining operation.

Third Creek Stream Restoration Project, Lake Tahoe Basin
Responsible for evaluating and designing a mitigation system for a portion of the Third Creek Stream, which was undercutting a large slope and potentially impacting several structures.

Antelope Creek Crossing Design, Elko County, Nevada
Responsible for designing a major road crossing over a creek. Two 60-inch diameter corrugated metal culverts were used to divert a creek under approximately 175 feet of rock fill. The upstream reservoir pool was used to attenuate the peak design flows so that the twin culverts could transfer the flows before encroaching into the reservoir freeboard.

Tennessee Valley Erosion Control Project, Lake County, Colorado
Project Manager responsible for evaluating short- and long-term stream geomorphology and designing mitigation structures. The mitigation and control structures incorporated typical civilengineering applications like geosynthetics and gabions with -insoft-science-in approaches like root wads and selective rock placement to result in a stable stream environment.

Nevada Test Site Groundwater Monitoring, Nevada
Senior Scientist working with the Department of Energy to evaluate the effectiveness in using geophysical technology to provide real-time monitoring of the groundwater system at Yucca Mountain.

Boulder Valley Infiltration Project, Elko, Nevada
Senior Engineer on the design of a surface infiltration system capable of recharging up to 15,000 gallons per minute to the groundwater basin. Project involved groundwater monitoring and modeling, basin design, pipeline design, and automated control systems.

Hydraulic Transport Research Facility Data Analysis Report
Principal Author on a slurry modeling and analysis textbook for the US Bureau of Mines, published by National Technical Information Service.

Deming Mill Groundwater Assessment, Deming, New Mexico
Senior Engineer for groundwater assessment of an existing mine and an adjacent Superfund site. Geochemical testing and modeling included source and effects of elevated levels of nitrates and sulfates on the local groundwater system.

Barrick Goldstrike Mine Surface Water Diversion Structure Designs, Elko, Nevada
Senior Engineer on the design of most of the surface water diversion structures for this large open pit mine. Projects included several miles of large diversion canals, energy dissipation structures, road crossings, and erosion control devices.

Benson Ridge Facility Engineering and Hydrological Studies, Lake County, California
Performed detailed geotechnical engineering and surface and groundwater hydrological studies related to remediation of a California Class II hazardous waste facility. Developed permit applications, agency review reports, and acted as the overall construction manager. Responsible for preparation of a closure/ post-closure report to meet EPA and California regulatory requirements.

Kitsalt Slurry Pipeline Design, British Columbia, Canada
Senior Reviewer on the design and construction of an overland and submarine slurry disposal system for AMAX. Suggested operational methods to improve system performance.

Hydraulic Transport Research Facility, Pittsburgh, Pennsylvania
As Project Manager, supervised government research on water, coarse coal and rock hydraulic transport in 6-, 12-, and 18-inch pipelines at concentrations up to 60 percent by weight. Wrote numerous reports and papers related to hydraulic engineering.

Camp Reroute Pipeline Design, Climax, Colorado
Project Engineer on a new 42-inch slurry pipeline and rerouted an existing pipeline to tie into a proposed mill expansion project.

East Tailings Disposal Line Design, Climax, Colorado
Designed a reroute of a 48-inch concrete slurry pipeline to permit expansion of the waste disposal area.

West Tailings Disposal Pipeline Design, Climax, Colorado
Senior Engineer for design and construction of a $9 million slurry pipeline project in Colorado. The pipeline system was designed for an operating capacity of 60,000 tons per day. This included the design of roads, pipelines, cyclones, pipe trestles, a slurry distribution system, a pumping stations, and overall tailings management.

Milwaukee Sewage Tunnel Project Engineering Designs, Milwaukee, Wisconsin
Designed hydraulic and pneumatic material transport systems to move waste rock from a tunnel boring machine to a waste disposal area.

East Tenmile Creek Reroute Design, Summit County, Colorado
Designed a creek diversion system consisting of a major inlet system, a series of minor stream collectors, a 48-inch reinforced pipeline, and an energy dissipation/outlet structure.

Publications

Henderson, M. Electronic Leak Detection System. Heap Leach Newsletter.

Henderson, M. Hydraulic Transport Research Facility. Data Analysis Report. Textbook written for U.S. Bureau of Mines.

Henderson, M. Mine Waste Management. Chapter 8 Closure.

Henderson, M. Mining Environmental Handbook. Chapter entitled Heap Leach Design.

Henderson, M. Tailings Dam Design and Risk Analysis. International Committee on Large Dams.

Cook, D.I., Henderson, M., & Kiousis, P. (2016). Finite Element Modeling of Pipe Deflections Under Heavy Loading and Leaching Degradation at a Heap Leach Facility. Tailings and Mine Waste 16, Keystone, Colorado.

DONNA MOREY, B.S., ASSISTANT PROJECT MANAGER

Ms. Morey is a project manager and regional planner at SWCA's Phoenix office. She has spent the last decade as a third-party NEPA assistant project manager on large mining EISs and land exchanges for the Forest Service and Bureau of Land Management. She has proven expertise in project management, public involvement, alternatives development, and logistics. Keen attention to project controls keeps schedule and budget at the forefront of her management style. Expertise in communication and coordination results in seamless stakeholder involvement; meeting facilitation, including coordinating and hosting meetings, project site visits, and open houses; and effective project correspondence and team management. Ms. Morey also has experience in logistics and database management, including compiling and maintaining administrative records for EISs, EAs, and other projects; fieldwork planning with safety focus; client and customer relations; GIS coordination; editing, formatting, and production of technical documents and newsletters; and maintaining project schedules, mailing lists, contracts, and budget tracking systems to ensure the project stays on schedule and within budget.

YEARS OF EXPERIENCE

11

EXPERTISE

Project controls

NEPA process

Administrative support management

Managing project logistics

Budget tracking

Administrative record management

Data management

EDUCATION

B.S., Urban Planning; Arizona State University, Tempe, Arizona; 2017

Associates Transfer Degree; Rio Salado College; Phoenix, Arizona; 2015

TRAINING

MSHA Safety Training, Arizona State Mine Inspector; 2019

NEPA Streamlining - Matt Peterson, SWCA Environmental Consultants; 2018

Project Managers Bootcamp, PSMJ Resources, Inc.; 2009

MEMBERSHIPS

Society for Mining, Metallurgy & Exploration and Member.

National Association of Environmental Professionals

As a “hosted” worker for the BLM of behalf of SWCA, Ms. Morey works seamlessly with agency staff. In this position, she manages project deliverables, public presentations, and team coordination to help ensure various projects stay on schedule. Ms. Morey has provided assistance to both USFS and BLM archaeologists and tribal liaisons when documenting and coordinating extensive Section 106 consultation. Most of her EIS project experience has addressed NEPA, Endangered Species Act, Clean Water Act, realty actions, plan amendments, and/or state environmental regulations or growth and land management requirements.

SELECTED PROJECT EXPERIENCE

Resolution Copper Mine and Land Exchange NEPA Services; U.S. Forest Service; Tonto National Forest, Multiple Counties in Arizona. SWCA is serving as the third-party NEPA contractor assisting with the preparation of the EIS and associated documents for the Tonto National Forest. The project involves complex NEPA considerations with the land exchange, the plan of operations, concurrent revisions to the Forest Plan, and the establishment of the Apache Leap Special Management Area. *Role: Assistant Project Manager. Coordination between agency, client, cooperating agencies, the public, and 15 tribes. Assists with daily communication and project coordination. Also responsible for maintaining mailing list, project schedule, project invoicing, contracting and budget monitoring. Assists with Section 106 Tribal Consultation meetings and documentation.*

Ray Mine Supplemental EIS; Bureau of Land Management; Pinal, Gila, and Mohave Counties, Arizona. SWCA is working to complete the Ray Mine Land Exchange Supplemental EIS under the guidance of the Arizona State Office and Tucson Field Office of the BLM. The copper mining firm ASARCO LLC hopes to acquire up to 10,976 acres of BLM surface and mineral estate adjacent to its long-established Ray open-pit mine in east-central Arizona in exchange to BLM of approximately 7,304 acres of riparian and other sensitive native habitat, primarily in northwestern Arizona. *Role: Planning Specialist. Coordinates with agency, client, third-party contractor, the public, and tribes. Assists BLM and SWCA project managers with daily communication and project coordination. Also responsible for maintaining mailing list, project record,*

project schedule and meetings, project invoicing, contracting, and budget monitoring.

Bagdad Mine Stockpile Extension NEPA Study; Bureau of Land Managment; Bagdad, Yavapai County, Arizona. As a third-party consultant for the project, SWCA is assisting the BLM Kingman Field Office with analyzing proposed modifications to the current Bagdad Mine Plan of Operations. If approved through the current EA process, Freeport McMoRan's proposed mine plan modifications, which include extending the present stockpile and constructing access roads, monitoring wells, and other distributed facilities, could result in disturbance of as much as 600 acres of BLM-managed public lands. *Role: Administrative Support. Compiles and maintains administrative record, assists Project Manager Charles Coyle with project invoicing, and schedule and budget monitoring.*

Rosemont Copper Mine EIS; U.S. Forest Service; Coronado National Forest near Tucson, southeastern Pima County, Arizona. As a third-party contractor, SWCA worked with the USFS and Coronado National Forest to determine and disclose potential environmental impacts of a proposed open-pit copper, molybdenum, and silver mine on more than 5,000 acres of private and National Forest System lands in the Santa Rita Mountains in southeastern Tucson. *Role: Administrative Support. Project invoicing and schedule and budget monitoring.*

Northern Arizona Proposed Withdrawal EIS; Bureau of Land Managment; Coconino and Mohave Counties, Arizona. SWCA was the primary contractor to the BLM and four federal cooperating agencies to determine the potential impact of a 20-year withdrawal of approximately 1 million acres of federal lands from new mineral exploration and mining near Grand Canyon National Park. *Role: Project Administrator. Coordination among agency, client, cooperating agencies, the public, and tribes. Assisted BLM and SWCA project managers (Charles Coyle) with daily communication and project coordination. Maintained mailing list, project schedule, administrative record, project invoicing, contracting, and budget monitoring.*

Southline Transmission EIS; Bureau of Land Management; Las Cruces, New Mexico, to Wilcox, Arizona. SWCA served as the third-party NEPA consultant to the BLM and Western Area Power Administration for a 440-mile transmission line project crossing southern Arizona and southern New Mexico that includes both new conduction and segments upgrades. *Role: Administrative Support. Project invoicing and schedule and budget monitoring.*

Sonoran Solar Energy Project EIS; Bureau of Land Managment; Maricopa County, Arizona. SWCA assisted the BLM as the third-party contractor in completing an EIS and Record of Decision for a solar energy project proposed on public lands in southern Arizona. *Role: Project Administrator. Compiled and maintained administrative records, project invoicing, and schedule and budget monitoring.*

Sonoran Valley Parkway Environmental Impact Statement; Bureau of Land Management; Maricopa County, Arizona. Under the direction of the BLM Phoenix District Office, SWCA prepared an EIS as a third-party contractor for the City of Goodyear. The project included a proposed parkway stretching between Goodyear and Mobile, Arizona. SWCA was responsible for coordinating the NEPA process, developing alternatives, completing impacts analysis, and conducting field surveys for natural and cultural resources on a minimum of three alternatives, each measuring approximately 20 miles. *Role: Administrative Support. Compiled and maintained administrative record, project invoicing, and schedule and budget monitoring.*

Second Knoll Target Range EA and Special Use Permit Plans; Arizona Game and Fish Department; Navajo County, Arizona. SWCA was lead consultant for the NEPA compliance required for the Arizona Game and Fish Department's proposed Second Knoll Shooting Range Project on approximately 80 acres of the Apache-Sitgreaves National Forest. SWCA also performed Biological, Cultural, and Jurisdictional Delineation surveys and reports. *Role: Project Administrator. Assisted with the project record, public involvement, and project controls.*

Gila River Sand and Gravel Environmental Assessment; Gila River Sand & Gravel Corp.; Sacaton, Pinal County, Arizona. SWCA facilitated public scoping, preparation, and publication of an EA for a sand and gravel mine expansion on Gila River Indian Community land. *Role: Project Administrator. Assisted with project planning, and project controls.*

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CURRICULUM VITAE

DEREK HRUBES, B.Sc., P.Eng., P.E.

Senior Civil Engineer

Education

B.Sc., Civil Engineering, Gonzaga University

Experience

2017-Present Civil Engineer, BGC Engineering Inc.

2014-2017 Civil Engineer, DOWL Inc.

2010-2014 Civil Engineer, Tetra Tech Inc.

2007-2010 Civil Engineer, River City Consultants Inc.

2006-2007 Transportation Engineer, Washington State Department of Transportation

Affiliations

Association of Professional Engineers and Geoscientists of Saskatchewan (P.Eng.)

State of Texas (P.E.)

State of Colorado (P.E.)

State of Washington (P.E.)

Society for Mining, Metallurgy & Exploration

American Society of Civil Engineers

Years of experience: 14

Derek Hrubes, P.E. is a Project Manager and Engineer with extensive experience in engineering design, project management, construction management, resident field engineering support, geotechnical modeling, hydrology modeling, hydraulic modeling, land surveying, training, stability monitoring, and monitoring equipment installation for a wide variety of local, national, and international projects. His general fields of focus include civil, mining, hydrology, hydraulics, geotechnical, environmental and transportation.

Following is a summary of select projects in which Mr. Hrubes has been involved:

Equinox Gold Corp. - Heap Leach Pad 4 Design (Current since Jan 2019)
Design engineer responsible for reviewing the previous design information, as-built reporting, and supporting analyses associated with construction of previous phases; evaluating optimizations for the heap leach pad; facilitating additional site investigations and laboratory programs; evaluating and determining design criteria; and completion of any additional design and analyses necessary to support the optimizations. This includes all related calculations, determinations, specifications, drawings, capital cost estimate, and construction documents.

Homestake Mining Company, Pitch Reclamation Project, Colorado, USA (Current since Jan 2018)
Assistant Project Manager responsible for closure design efforts associated with the Pitch Mine Reclamation Project near Sargents, Colorado. Responsibilities include developing an updated Reclamation and Closure Plan, Exhibits, and Attachments; developing issue-for-construction (IFC) designs and drawings for remaining closure efforts; site geohazard mapping; instrumentation data collection and reporting; and development of Standardized Reclamation Cost Estimator (SRCE) models for regulatory bonding for closure costs.

New Gold, Rainy River Project, Ontario, Canada (Current since Jan 2018)
Project Engineer responsible for supporting the project review and detailed design for the Tailings Management Area (TMA), located at the Rainy River Mine in Ontario, Canada. Responsibilities for the TMA dams included coordinating the design effort; developing issue for construction (IFC) drawings, technical specifications, and material take offs (MTOs); reviewing and updating the Operations, Maintenance, and Surveillance (OMS) Manual; reviewing and updating the Emergency Preparedness and Response Plan (EPRP); and performing filter compatibility checks on the construction materials.

Goldcorp's Red Lake Gold Mine, SRCE Model Review and Recommendations, Ontario, Canada (Current since Apr 2019)
Project engineer responsible for a high-level SRCE model review for closure bonding associated with the Red Lake Gold Mine. The review included various assumptions made for model input variables, cost-data files, and the development of initial regional correction factors.

Lucara Botswana's Karowe Diamond Mine, Review of Monitoring Configurations, Botswana (Current since Dec 2018)
Provided third-party review of stability monitoring instrumentation, including slope monitoring radar. Responsibilities included a detailed review of the configuration and operation of all hardware and software components, providing general guidance on the establishment of movement limits and associated thresholds, and assisting in a thorough geological assessments of the slopes.

Constantine North Inc., Palmer Exploration Project Conceptual and Final Designs, Alaska, USA (Current since Jan 2018)
Project Engineer responsible for supporting the conceptual and final designs for the Palmer Exploration Project near Haines, Alaska. Responsibilities included hydraulic modeling; the design of sediment collection ponds, a temporary rock storage pad, a land-application-disposal (LAD) system, and a piping and valving network; the development of conceptual and final design reports and figures; and the development of issue-for-construction (IFC) drawings, technical specifications, and material-take-offs (MTOs).

MX Gold's Max Mine, OMS Manual Update, British Columbia, Canada (Current since 2017)
Responsible for updating the Operations, Maintenance, and Surveillance Manual for the Tailings Storage Facility at MX Gold's Max Mine. This included verification of regulatory compliance and providing recommendations for geotechnical and instrumentation enhancements. Also involved with the completion of Dam Safety Inspections and responsible for the development of corresponding reporting.

Cameco Corporation's Key Lake Operation, North Wall Slope Remediation, Saskatchewan, Canada (Current since 2017)
Project manager and engineer responsible for the development of slope remediation alternatives and completion of the ultimate detailed design. Included an alternatives analysis, geotechnical analyses, hydrology and hydraulic analyses, preliminary and final designs, wind/wave erosion analyses, and construction support.

Jabal Sayid Copper Mine, Tailings Storage Facility Design, Kingdom of Saudi Arabia (May 2018-Nov 2018)
Project Engineer responsible for supporting the pre-feasibility design and trade-off studies for a dry stack tailings storage facility (DSTSF), located in the Kingdom of Saudi Arabia. Responsibilities included reviewing existing grading plans and DSTSF designs; developing pre-feasibility designs for future phases; refining the DSTSF conceptual ultimate layout; performing design alternative trade-off studies, including stacking and phasing plans; and developing a conceptual closure plan for the ultimate DSTSF.

Suncor Energy Inc., Coke Landform Design Guide FMEA, Calgary, Alberta (Jan 2018-Jul 2018)
Project Engineer responsible for supporting the Failure Modes and Effects Analysis (FMEA) associated with Suncor's Coke landform Design Guide. Responsibilities included the analyses of generic landform designs relating to slope stability, hydrology, gully erosion, water table, leachate toxicity, constructability, and coke transport requirements.

Fairbanks Gold Mining Inc., Barnes Creek HLF Conceptual Design, Alaska, USA (Dec 2017-Feb 2018)
Project Engineer responsible for supporting the Conceptual Design of the Barnes Creek Heap Leach Facility at the Fort Knox Mine near Fairbanks, Alaska. Responsibilities included conceptual-level design of the heap leach pad, solution collection system, event pond, stormwater collection ponds, and conveyor corridor; analysis on GCL compatibility with process leach solution; slope stability analysis of the HLF; and material-take-offs (MTOs).

Large Open Pit (LOP) Group's Monitoring Guidelines (Current since 2017)
Supporting the development of the LOP's Monitoring Guidelines for global application to large open pits. Focus has included chapters relating to the training and certification of monitoring support personnel. This has included the creation of a monitoring skills matrix as a dynamic platform to assist in developing desired skills for site personnel, both directly or indirectly involved in onsite monitoring.

Resolution Copper Tailings Alternatives, Arizona, USA (Current since 2017)
Involved in the identification and development of potential tailings storage facility (TSF) alternatives, as part of the broader development of a reasonable range of TSF alternatives to be analyzed in the Resolution Copper Project Draft Environmental Impact Statement. This included the conceptual design and evaluation of preferred alternatives and their relative ranking based on qualitative and quantitative metrics.

Cameco Corporation's Key Lake Operation, Gaertner Pit Analysis, Saskatchewan, Canada (Current since 2017)
Project engineer responsible for a geotechnical stability analyses of pit walls to evaluate slope stability at various defined pond water levels. Includes establishment of safety setbacks for the pit and identification of potential impacts to existing and planned infrastructure near the pit. Protection and/or mitigation measures defined with guidance focused on worker safety and protection of critical operational infrastructure and environment.

JR Simplot's Smoky Canyon Mine Radar Training, Idaho, USA (2017)
Provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications.

KGHM's Robinson Mine Radar Training, Nevada, USA (2017)
Provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications.

Newmont's Twin Creeks Mine Radar Training, Nevada, USA (2017)
Provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications.

Kinross' Round Mountain Mine Radar Training, Nevada, USA (2017)
Provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications.

KGHM's Sierra Gorda TSF Design, Chile (2017)
Project Engineer responsible for the design and analysis of tailings storage facility raises at KGHM's Sierra Gorda facility. This included the development of design drawings and evaluation of instrumentation systems.

Barrick's Hemlo Mine Radar Training and Monitoring Support, Ontario, Canada (Current since 2016)
Provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications. Additional support being provided in the operation and integration of the stability monitoring radar. Responsibilities include assisting in the configuration and operation of all hardware and software

components, providing guidance on the establishment of movement limits and associated thresholds, and training geotechnical personnel. Additional responsibilities include thorough geological assessments of the slope and a failure analysis.

Mesa County Bosley Wash Detention Pond, Colorado, USA (2016)
Project manager responsible for final design and construction of a jurisdictional stormwater detention pond intended to provide 81 acre-feet of runoff storage. Included performing a detailed review of existing design information and implementing supplementary field investigations to further classify site conditions, including geophysical surveys, drilling, and laboratory testing. Responsibilities included performing hydrologic and hydraulic modeling, developing the detention pond and facility design, providing agency/utility/and public coordination, and developing and reviewing design drawings and reports.

UMTRA Superfund Site Geological Assessment, Slope Failure Analysis, and Radar Monitoring, Utah, USA (Current since 2015)
Project manager responsible for providing support in the operation of the movement and surveying radar equipment. Responsibilities include assisting in the configuration and operation of all hardware and software components, providing guidance on the establishment of movement limits and associated thresholds, and training geotechnical personnel. Additional responsibilities include the interpretation of movement data and alarm notifications generated by the equipment and performing a thorough geological assessment of the slope and a failure analysis. Mr. Hrubes also provided certified radar operator training for stability monitoring radar technology to site geotechnical and geological personnel, including training in theoretical and practical applications.

Kensington Mine Multiple Facilities Design, Alaska, USA (2015-2017)
Project manager responsible for the conceptual design and layouts of two waste rock dumps and one topsoil storage facility. Entailed the development of staged stacking plans and haul routes to optimize the placement efforts and storage capacity of the facility. Responsibilities also included the overall facility and stormwater infrastructure design, performing stability analyses on pre- and post-deposition conditions, and performing hydrology and hydraulics analyses of the facility. Additional responsibilities included the development of necessary design reports and the review of corresponding design drawings.

Mesa County 29 Rd Drainage Study and Design, Colorado, USA (2015-2016)
Project manager and client contact person responsible for all professional design services required for the 29 Road Drainage Study and Design Project, performed for Mesa County and located in Grand Junction, Colorado. Involved a master drainage study, which encompassed a major subdivision, and verification of existing storm drain infrastructure and their capacities. Responsibilities included the development of final design plans, construction specifications, and construction contract documents. This included facilitating all data collection and engineering design activities, as well as disseminating all necessary information and communications between project members. This also involved coordination and communication with property owners and utility providers impacted by the project.

Resource West Evaporation Tests, Colorado, USA (2015)
Project manager and client contact person responsible for the development of evaporation test procedures, testing oversight, and engineering verification of obtained results for high volume wastewater evaporator units. This also included the development of all technical documentation summarizing testing methods and results, as well as identifying correlations with nation- wide pan evaporation databases.

DMEA Substation Pads Evaluation, Colorado, USA (2015)
Project manager and client contact person responsible for an engineering evaluating of Delta-Montrose Electric Association's existing transformer pads . This served to facilitate pending transformer replacements and included recommendations on required modifications to the transformer pads, as well as the development of supporting design and specifications information. Additionally, this involved an evaluation of the existing Spill Prevention, Control, and Countermeasure (SPCC) Plans for these two locations to account for the replacement transformers and any necessary updates or modifications.

ASARCO's Mammoth Heap Leach Facility at Silver Bell Mine, Colorado, USA (2015)
Project engineer responsible for performing hydrology and hydraulics analyses on the proposed Mammoth heap leach facility. The initial phase included final design and engineering of the new heap leach facility and design elements including pond sizing, pad grading, and collection pipe sizing. Additional responsibilities included the review of applicable design reports and corresponding design drawings.

ADNR Mine Reclamation Guidelines, Alaska, USA (2014-2015)
Investigation of the sources of variability that drive the ranges of indirect costs observed with reclamation and closure (R&C) projects in and outside of Alaska, based on input from State and Federal agencies with authority over reclamation and closure efforts. Review of the R&C cost estimation guidance, including documents from the United States Forest Service, Bureau of Land Management, State of Nevada, and State of Alaska. Development of suggestions and recommendations regarding what range of indirect cost variability will provide adequate assurance for R&C by further refining the indirect cost calculation process and enhancing the methodology descriptions.

Boe Ranch Pipeline Engineering Review, Montana, USA (2014-2015)
Project manager responsible for all professional design services required for the engineering review and construction support of the Boe Ranch Pipeline. This entailed a thorough analysis and inspection of the existing pipeline construction and engineering completed to date, as well as identification of any current deficiencies and remaining activities required to put the pipeline into serviceable condition. Additional services included providing recommendations on qualified contractors and identifying and specifying the associated materials required to complete the pipeline work. Required the development of a corresponding technical memorandum summarizing all pertinent findings and providing recommendations.

DMEA North Entrance Evaluation, Colorado, USA (2014)
Project manager and client contact person responsible for the north entrance evaluation at Delta-Montrose Electric Association's north entrance, at their Montrose, CO Facility. This included evaluating ponding and ice accumulation issues occurring at this location and providing conceptual options for improving and/or mitigating the resulting adverse conditions. Responsibilities included a site visit and inspection, evaluation of site conditions, analysis of improvement options, and the development of a summary technical memorandum with applicable recommendations.

Robinson Mine Tailings Expansion Study, Nevada, USA (2014)
Project engineer responsible for assisting in the development and evaluation of numerous tailings storage facility expansion options and methods using a multiple accounts analysis (MAA) approach. This included overseeing the generation of feasibility-level drawings and a determination of corresponding quantities and costs associated with the various options. This also included the development of options analysis reports summarizing the finding and providing recommendations.

Eagle Gold Heap Leach Facility, Yukon Territory, Canada (Current since 2013)
Civil engineer responsible for assisting in the development of site and grading design options and quantities determinations for the heap leach facility. Responsibilities have included the design and analysis of corresponding liner and collection systems, riser pipe analysis, and geotechnical evaluations of native materials, including deep dynamic placer tailings compaction. Responsibilities have also included static and pseudo-static geotechnical modeling, liquefaction analysis, and sensitivity analyses of designs, development of design drawings, as well as all corresponding reporting needs.

Hecla's Lucky Friday Mine Tailings Engineering Services, Idaho, USA (Current since 2013)
Project manager and civil engineer responsible for the development of as-built reports and corresponding drawings, evaluating groundwater instrumentation data and trends, and analyzing correlations with allowable groundwater levels and providing subsequent recommendations. Involvement in the development of tailings impoundment expansion options and quantities determinations. Additional responsibilities have included hydrological and hydraulic analysis and design, groundwater instrumentation data analysis, and the development of abandonment plans and cost estimates.

Barrick's Goldstrike Mine, Heap Leach Facility Expansion, Nevada, USA (2013)
Project engineer responsible for assisting in the data consolidation, site layout, grading design, and stormwater modeling for a heap leach facility expansion at Barrick's Goldstrike Mine. Responsibilities also included geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, and potential liquefaction.

Cameco Corporation's Key Lake Operation, Resident Geotechnical Engineer, Saskatchewan, Canada (2012-2013)
Resident geotechnical engineer responsible for on-site engineering support during construction. Responsibilities included daily geotechnical and construction inspections, site coordination, daily instrumentation systems inspections, configuration/maintenance/diagnostics of real-time slope monitoring systems, developing visual and data correlations, developing safety and monitoring protocols and providing training for site personnel. Responsibilities also included status updates to clients and construction personnel regarding slope and instrumentation conditions, providing field QA/QC for construction, material testing and sampling, heading up geotechnical investigation programs, coordinating and implementing the installation of instrumentation, and performing geophone vibration testing.

Mohave Desert Mineral's Gold Road Project, Tailings Management Facility Design and CQA, Arizona, USA (2012-2013)
Project engineer responsible for assisting in the layout, grading design, report development, and stormwater modeling for a proposed tailings management facility expansion, including the development of tailings management facility expansion options and quantities determinations. Responsibilities also included geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, and potential liquefaction. This also included evaluating construction design revisions and permitting requirements, as well as developing corresponding as-built reports and drawings.

GCC Energy's National King Coal Mine, Drilling and Underground Seal Inspections, Colorado, USA (2011-2012)
Project engineer responsible for oversight of a geotechnical drilling program, as well as the design review and on-site inspection of underground mine seal forms in southern Colorado.

Fortesque Metals Group Ltd.'s Cloud Break Project, Tailings Management Facility, Western Australia (2011-2012)
Project engineer responsible for assisting in the layout, grading design, report development, and stormwater modeling for a proposed tailings management facility at Fortesque Metals Group Ltd.'s Cloud Break Project. His responsibilities also included geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, and potential liquefaction.

Cameco Corporation's Kintyre Project, Tailings Management Facility, Western Australia (2011-2012)
Project engineer responsible for assisting in the layout, grading design, report development, and stormwater modeling for a proposed tailings management facility at Cameco Corporation's Kintyre Project. Responsibilities also included geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, potential liquefaction, and construction bench ponding.

Cameco Corporation's Key Lake Operation, Instrumentation and Monitoring Support, Saskatchewan, Canada (Current since 2010)
Project engineer responsible for the development and implementation of a composite geotechnical instrumentation monitoring program for use prior to, during, and after slope remediation construction. Selected instrumentation included groundwater level sensors, vibrating wire piezometers, and two ground-based movement and survey radar units. The systems were configured to provide monitoring of groundwater levels behind the slope, pore water pressure within the slope, and physical slope

deformation, using near real-time monitoring methods. The system also incorporated automated early warning alarms at pre-determined thresholds. Continued monitoring support for the project during flood-back of the facility.

Cameco Corporation's Key Lake Operation, West Wall Stabilization Project, Saskatchewan, Canada (2010-2014)
Project manager, project engineer, and civil design lead involved with all design and construction aspects required for the completion of a multi-million-dollar slope remediation project at Cameco Corporation's Key Lake Operation in northern Saskatchewan. Responsibilities included layout, grading design, stormwater modeling, and constructability reviews. This involved the development of design reports, drawings, and specifications for the multiple stages of the project (feasibility, preliminary, final, and construction). Responsible for substantial geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, potential liquefaction, and construction bench ponding.

Arizona Natural Gas Storage, LLC, Brine Ponds, Arizona, USA (2010)
Project engineer responsible for facility layout and grading design, report development, development and review of conceptual drawings, and site stormwater modeling and design for multi-cell brine ponds in southern Arizona. Responsibilities also included liner system design, including leakage rate and wind uplift calculations, and geotechnical analyses and reporting for global and local stability, static and pseudo-static conditions, and potential liquefaction.

Grand Valley Transit, Transfer Station Analysis, Colorado, USA (2009)
Staff engineer responsible for the conceptual layout of a proposed Grand Valley Transit Transfer Station. Responsibilities included the analysis and design of conceptual stormwater best management practices.

CO State Highway 139 Access, Colorado, USA (2009)
Staff engineer responsible for the design and layout of multiple semi-truck and trailer access locations along Colorado State Highway 139 north of Loma. Required knowledge of Colorado Department of Transportation highway access and easement protocols, as well as his familiarity with all necessary manuals and design criteria (site-distance requirements, approach angles, etc.).

Washington State Department of Transportation (WSDOT), US 395 – North Spokane Corridor, Washington, USA (2006–2007)
Transportation engineer responsible for assisting in the production and review of all aspects of plan sets pertaining to the design and construction of the $2.2 billion dollar US 395 – North Spokane Corridor limited access highway. Involved collaboration with municipal and county engineers and coordination with WSDOT Real Estate Services for utility easement and franchise delineations. Mr. Hrubes applied his proficiencies in industry standard drafting and design programs, such as Microstation and InRoads. Additional responsibilities included performing land and construction surveys to support design and construction activities.

Presentations

GCLs in Heap Leach Pads: State of the Art and Practice, Geosynthetics Mining Solutions 2014 (Vancouver, BC)

Movement and Surveying Radar: Specialized Monitoring Projects, Slope Stability 2015 Workshop (Cape Town, South Africa)

Performing Geotechnical and Geological Assessments, Reutech User’s Group Conference (Lima, Peru)

Radar Data Interpretation and Alarm Thresholds, Reutech User’s Group Conference (Lima, Peru)

Reutech Operator’s Training, Ongoing (Various Client Locations)

Radar Optimization, Reutech User’s Group Conference (Seville, Spain)

Publications

Meyer, T., Hrubes, D., & Salewich, C. (2014). Geotechnical Instrumentation and Monitoring for Pit Slope Stabilization and Remediation.

MONTGOMERY & ASSOCIATES

Todd Keay, P.G.
Principal Hydrogeologist

OFFICE: Tucson

YEARS OF EXPERIENCE

Total: 34 | M&A: 34

EDUCATION

B.A., Geology, Temple University (1983)

KEY AREAS OF EXPERTISE

Groundwater resource development

Regional hydrogeologic characterization

Evaluation of mining impacts on groundwater and surface water systems

Interpretation of aquifer test data and hydrochemical data

Satellite image analysis

Evaluation of pumping-related impacts on aquifer systems

Analysis of borehole geophysical logs

PROFESSIONAL REGISTRATIONS

Registered Professional Geologist #25063, AZ

Registered Professional Geologist #5511, CA

Todd Keay brings his expertise to projects located throughout the United States and South America, where he has led large-scale exploration and water supply development programs in complex and varied hydrogeologic settings. He is skilled in all aspects of field operations, and he has extensive experience assessing the potential for and impacts of developing groundwater resources for drinking water and industrial supplies. Todd specializes in helping our mining and industrial clients meet their project's design, permitting, and compliance requirements, providing critical support during feasibility studies and environmental impact study (EIS) processes. Where appropriate, he recommends and oversees the use of geophysical tools and cutting-edge downhole aquifer characterization techniques in conjunction with traditional hydrogeologic approaches. His integrated approaches ensure that the necessary site-specific and regional data is available to decision makers.

Representative Projects

Hydrogeologic Characterization: Resolution Copper
Resolution Mine, Pinal County, AZ

Managed large-scale hydrogeologic investigations to assess the potential impacts of proposed mining operations on regional groundwater and surface water systems; led drilling and testing programs for multiple characterization wells (2,000–7,000 feet) to evaluate conditions within and adjacent to a deep ore zone; coordinated regional surface water and spring mapping surveys and delineation of Groundwater Dependent Ecosystems (GDEs).

Feasibility Investigations: Minera Chinalco Perú
Toromocho Project, Junín, Perú

Coordinated the characterization of baseline groundwater and surface water conditions for a proposed open-pit copper mine in the Andes Mountains; evaluated a range of water supply options; coordinated the development of a supplemental groundwater supply.

Wellfield Optimization: Freeport-McMoRan Corporation
Bagdad Mine, Mohave County, AZ

Led a multi-phase evaluation to optimize groundwater production from a 40-year-old wellfield; designed a well replacement / rehabilitation program; successfully developed a new, highly efficient wellfield.

Wellfield Optimization: ASARCO
Ray Mine/Hayden Operations, Gila County, AZ

Conducted an evaluation to optimize groundwater production from a 90-year-old wellfield; coordinated the design and installation of new, highly efficient production wells.

Groundwater Exploration: Compañía Contractual Minera Candelaria (Freeport-McMoRan Corporation
Candelaria Mine, Northern Chile

Designed and supervised the construction and testing of high-capacity production wells; coordinated regional groundwater exploration investigations in the Río Copiapó Valley and adjacent areas.

Groundwater Exploration: Sociedad Contractual Minera El Abra (Freeport-McMoRan Corporation)
El Abra Mine, Northern Chile

Designed and supervised the construction and testing of high-capacity production wells; evaluated sites in the Salar de Ascotán Basin for groundwater exploration; assessed the impacts of pumping on surface water resources

Technical Evaluation: Compañía Minera Antamina S.A.
Antamina Mine, Ancash, Perú

Conducted a third-party technical evaluation of hydrogeology and water quality studies for a slurry-water reuse system located near a concentrate off-loading facility.

Groundwater Exploration: Anglo American Quellaveco S.A.
Quellaveco Project, Moquegua, Perú

Led a groundwater exploration program that included geologic mapping, surface geophysical logging, drilling, testing, and modeling to develop a high-capacity production wellfield; coordinated hydrologic impact analyses for a feasibility study and an EIS.

Groundwater Exploration & Development: Compañía Minera Doña Inés de Collahuasi SMC
Collahuasi Mine / Salar de Coposa, Northern Chile

Designed and supervised the construction and testing of exploration wells and high-capacity production wells.

Technical Review: Resolution Copper
Resolution Mine, Pinal County, AZ

Provided technical guidance for dewatering of Shaft No.9 and historical mine workings and oversaw design and implementation of deep groundwater monitoring system to evaluate impacts from mine dewatering.

Technical Evaluation: Rio Tinto / Kennecott Utah Copper
Bingham Canyon Mine, Salt Lake County, UT

Conducted a third-party technical evaluation of hydrogeologic studies, geotechnical studies, and a dewatering program for active open-pit copper mine.

Technical Review: Rio Tinto / Kennecott Utah Copper
Bingham Canyon Mine, Salt Lake County, UT

Served as the hydrogeology subject matter expert on the Rio Tinto Technical Evaluation Group (TEG) for the review of proposed mine plans.

Hydraulic Continuity Analysis: BHP Billiton (formerly Magma Copper Company)
San Pedro River Valley, Pinal County, AZ

Coordinated field programs to investigate hydrogeologic conditions and evaluated the potential impacts of large-scale groundwater pumping on surface water flow.

Remedial Investigations: North American Philips Corporation
Various Electronics Manufacturing Facilities, NJ/TX

Assessed hydrogeologic and water quality conditions and led reclamation well construction and testing efforts for the remediation of groundwater contamination.

Field Oversight: Hassayampa Steering Committee
Hassayampa Landfill Superfund Site, Maricopa County, AZ

Supervised field operations for a remedial investigation of soil and groundwater contamination.

Contaminant Assessment: Rockwell International
Rocketdyne Division, Santa Suzanna & Canoga Park Facilities, Ventura & Los Angeles Counties, CA

Investigated hydrogeologic conditions and groundwater contamination by industrial solvents, fuels, and oils.

Groundwater Supply Evaluation: Town of Chloride
Sacramento & Detrital Valleys, Mohave County, AZ

Analyzed hydrologic data, mapped the local geology, assessed existing wells and water supply systems, and evaluated options for developing a new water supply for this rural community, resulting in the identification of long-term, secure water source.

Groundwater Supply Evaluation: Town of Ash Fork
Western Coconino Plateau, Yavapai & Coconino Counties, AZ

Tested an existing production well, analyzed hydrologic data, mapped the local geology, and identified new target areas for developing an additional water supply for this rural community, resulting in the successful development of a second production well.

Groundwater Supply Evaluation: Chemical Lime Company
Nelson Plant Site, Yavapai County, AZ

Developed and successfully implemented a regional exploration program to evaluate options for augmenting an existing water supply for industrial use, resulting in the successful development of new production wells.

Waterlogging Evaluation: ADWR
Phoenix AMA, Maricopa County, AZ

Evaluated waterlogging problems in the west Salt River and Hassayampa sub-basins of the Gila River.

Publications & Presentations

Using fully grouted nested piezometers for deep aquifer characterization
Weber, D.S., Hall, D.G., Keay, T.K., Thomasson, M.J., and Davis, L.A., 2009, NGWA Ground Water Summit, April 19–23, Tucson, AZ

Exploration and development of groundwater resources in arid and semi-arid regions, northern Chile and southern Perú
Rosko, M.J., and Keay, T., 2000, Fourth Geologic Conference, March 6–8, Hermosillo, Mexico

MARK J. LOGSDON

EXPERIENCE

40+ Years

EDUCATION

- M.S. Geology
- A.B. Honors, Geology

AFFILIATIONS

- American Association for Advancement of Science
- Geochemical Society
- Geological Society of America
- Mineralogical Society of America
- Society of Economic Geologists
- Society of Sigma Xi

SPECIALTIES

- Environmental Geochemistry in Mining
- Hydrogeochemistry and Hydrogeology

WORK EXPERIENCE

- President/Principal Geochemist, Geochimica, Inc.
- Sr. Hydrogeochemist/Vice President, Adrian Brown Consultants
- Project Manager / Hydrogeologist, Nuclear Regulatory Commission
- Economic Geologist, New Mexico Bureau of Mines and Mineral Resources
- Hydrogeologist, Lee Wilson and Associates
- Consultant in Exploration Geochemistry

Mark Logsdon is a geochemist with more than 40 years of experience in geology, hydrogeology, and environmental chemistry related to mining and mine-waste management. His work experience includes teaching, mining-exploration geochemistry, government service, research, and consulting. Since 1984, Mr. Logsdon has been in private consulting, focused on mining issues, particularly (a) seepage and drainage chemistry of mine wastes; (b) water-quality conditions in natural and mined ground, including surface and ground-waters; (c) planning for and executing mining exploration, development, operations, closures, and remediation / restoration. Such assessments typically involve not only geochemistry and flow, but also the underlying geology and mineralogy and the relationships of hydrogeology, mining and site-engineering practices and costs.

Mr. Logsdon has worked on more than 250 mining projects, mines across the U.S. and Canada, Mexico, Guatemala, Honduras, Argentina, Brazil, Chile, Columbia, Peru, Venezuela, Eire, France, Portugal, Russian, Spain, Guinea, Mozambique, South Africa, Tanzania, Australia, Laos, Mongolia, New Zealand, Indonesia, Papua New Guinea, and the Philippines.

Recent projects that use a risk-based evaluation process to guide the planning and execution of coordinated engineering, gas/liquid –transport, and geochemical evaluations include:

- Corporate Assurance Evaluations , Mined-Land Groundwater Chemistry. New Mexico
- Corporate Assurance, Waste Rock and Tailings Planning for Closure. Minnesota
- Development of a Reliability-Based Planning Process for Geochemistry. Arizona
- Application of FMEA to Planning for Management of Geochemically Active Waste Rock, Ontario, Canada
- Independent Peer Review Board – Abandoned Mine Closures (multiple). Canada
- Acid Mine Drainage Risk Review. Indonesia
- Mine Waste Management Review. Mozambique
- Mine Waste Management and Closure Review. Laos
- Acid Mine Drainage Reference Group – Feasibility Studies. Peru

GUSTAVO MEZA-CUADRA

Lead Hydrogeologist

Years with the firm

10

Years total

10

Professional qualifications

MSHA surface metal and non-metal, coal certification

Areas of practice

Mining Hydrogeology; Groundwater Modeling; Mine Dewatering & Slope Depressurization; Surface Hydrology; Mine Closure Studies; Water Quality; Environmental Permitting; Project Management; Business Development

Languages

English

Spanish

French

CAREER SUMMARY

Gustavo Meza-Cuadra is a hydrogeologist and Mine Water Team Leader for the water & environment group at WSP USA. He has ten years of experience focused on hydrogeology, water resources and environmental permitting for large international companies. The main portion of his experience is in mining, in both in North and South America (US, Canada, Mexico, Peru and Chile) where he has successfully executed projects for some of the largest open-pit and underground mines in the world. He has provided services in mine hydrogeology, mine dewatering and slope depressurization, closure studies and permitting. Outside of mining, Gustavo has contaminated site experience including phase 1 and 2 investigations.

His specialty is in constructing complex three-dimensional groundwater models for quantifying groundwater flow and transport. He has ample knowledge of the main regulatory approved numerical flow modeling codes (MODFLOW, FEFLOW, MT3D, MODPATH) and a strong background in inverse modeling using PEST. He is familiar with most pre- and post- processing software including Groundwater Vistas, Visual MODFLOW, ArcGIS, Python and LeapFrog. Additionally, he has field experience in piezometer installation, groundwater sampling and aquifer testing.

EDUCATION

M.Sc., Environmental Engineering (Water Resources), UNALM, Peru	2010
B.Sc., (Honors), Physics, Imperial College London, UK	2007

ADDITIONAL TRAINING

Mine Safety and Health Administration (MSHA): surface, coal, metal, and non-metal	2019

PROFESSIONAL MEMBERSHIPS

Society of Mining Engineers – Registered Member

National Groundwater Association

Colorado Groundwater Association

Royal College of Science, UK

PROFESSIONAL EXPERIENCE

Mining Hydrogeology

— Agnico Eagle Mexico, Pinos Altos, Chihuahua Mexico (2019): WSP was contracted to provide hydrogeological services to Agnico Eagle Mexico (AEM) at their Pinos Altos operations. As part of the Pinos Altos expansion projects, an exploration tunnel (Cubiro) was built beneath a river and potential flows into the tunnel were expected. A groundwater model was constructed and calibrated, which would be used to plan the dewatering of the underground mine. Personal Responsibilities included project management, lead technical support on model construction and review.

- Rio Tinto, Kennecott Copper, Slice 2 South Pushback Feasibility Study (FS) Groundwater Modeling, Salt Lake City, Utah (2018 – 2019): WSP was contracted to providing annual pore pressure predictions for use in assessment of geotechnical slope stability analyses. The project consisted of the model construction, calibration, and predictive simulations of seven 2D cross sectional FEFLOW models, as well as a 3D MODFLOW-SURFACT pit scale groundwater model. Main responsibilities included leading review efforts in modeling and data analysis, overseeing and mentoring junior modelers.
- Rio Tinto, Resolution Copper Mining, Superior, Arizona (2014 – 2019): WSP was contracted to provide hydrogeological services at the Arizona site for this multi-year project. The client required a regional groundwater model to analyze the potential impacts of developing a block cave mine deep underground. A large 3D model was constructed for the EIS process, calibrated and used for Life of Mine and closure simulations. The modeling included a PEST calibration and uncertainty analysis. The latter stages of the project included presentations to a multi-disciplinary committee, including various regulatory agencies (Forest Service, EPA and ADWR). Main responsibilities included serving as lead modeler and project manager, which required proposal writing, reporting and on-site presentations.
- ArcelorMittal, Mt. Wright, Quebec, Canada (2017-2018): The Mt. Wright mine, a large iron ore open pit deposit required a hydrogeological and geotechnical review of the wall stability at their Paul's peak pit. WSP was contracted to review the work by a separate consulting company, and improve the understanding of the rock mass within Paul's Peak. A groundwater flow model was constructed and calibrated using FEFLOW to provide pore pressure estimates within the geotechnical numerical model. Personal responsibilities included model review and report writing.
- Kinross, Fort Knox Mine, Alaska (2016 – 2017): The Fort Knox mine in Alaska requires continuous updates to its long-term water management strategy. WSP was tasked with updating the existing GoldSim water balance model with recent data and mine plans to inform its long-term water strategy. The model required input of multiple water sources into a chemical mixing model using PHREEQC. Personal responsibilities included analysis of chemical data and GoldSim model construction.
- Rio Tinto, Kennecott Copper, Utah (2014 – 2017): The Bingham Canyon Mine needed to re-evaluate their geotechnical mine plan post Manefay slide in 2014. WSP was contracted to provide modeling services, constructing seven pore pressure 2D sections based on defined geotechnical sections. The predictive scenarios included multiple dewatering and depressurization scenarios (i.e. dewatering wells, horizontal drains, drainage gallery, etc.). Main responsibilities included leading reviewing efforts in modeling and data analysis.
- Freeport-McMoRan, Climax Molybdenum, Colorado, (2014 – 2016): WSP was tasked to provide hydrogeological support for the open pit molybdenum mine. The project included the drilling of multiple horizontal drains and vertical pilot holes for depressurization and hydraulic testing. Field results were used to inform a 2D pore pressure groundwater model section built in support of a geotechnical study. Personal responsibilities include leading the hydrogeology/modeling and project management.
- Kinross, Fort Knox Mine, Alaska, (2016 – 2017): WSP provided hydrogeological support to estimate pore pressure profiles for geotechnical models to support the depressurization efforts. WSP constructed and calibrated multiple 2D cross section

slice models to current site conditions. Following calibration, various future predictive model scenarios were simulated to understand the required dewatering and depressurization measures to safely complete future mine plans. Personal responsibilities included groundwater modeling using FEFLOW.

— Freeport-McMoRan, Morenci, Arizona (2015): WSP supported FMI Morenci in the Western Copper dewatering study, providing groundwater flow modeling services. Three 2D pore pressure models were constructed to assess the viability of multiple dewatering scenarios including surface horizontal drains, underground tunnel and a directionally drilled well. Personal responsibilities included groundwater modeling using FEFLOW.

— Freeport-McMoRan, Morenci, Arizona (2015): WSP was contracted to apply new directionally drilling technology for dewatering in the Garfield pit. The project goals were to drill and complete pit dewatering wells that were penetrated beneath the planned mine pit shell and were collared outside of the active mining areas to maximize well run times for pit dewatering. Personal responsibilities in the project included supporting in the trajectory assessment based on rock properties (RQD, lithology) using geologic block model (Petrel).

— Freeport-McMoRan, Cerro Verde Mine, Arequipa, Peru (2011 – 2013): WSP was contracted to carry out a comprehensive pit dewatering analysis of the Cerro Verde and Santa Rosa expansion pits with life of mine until 2045. Five 2D pore pressure sections were constructed and calibrated using SEEP/W. Main responsibilities included leading groundwater modeling efforts to be used in geotechnical evaluations of slope stability.

— Rio Tinto, La Granja, Chiclayo, Peru (2012): WSP was contracted to provide hydrogeological services in a pit dewatering study for the large porphyry-skarn copper project in the north of Peru. Geological modeling efforts were carried out in Petrel and the 2D pore pressure modelling in SEEP/W. The results were used for the geotechnical stability analysis of the pit in the pre-feasibility evaluation of the project. Main responsibilities included leading groundwater modeling efforts.

— BHP, Xstrata, Antamina, Ancash, Peru (2013): WSP was contracted for hydrogeological services to evaluate the potential impacts from the construction of a waste rock facility in the Nequip catchment – a complicated fractured aquifer with karstic formations. Responsibilities included developing a 3D MODFLOW flow and transport model incorporating a stochastic numerical simulator (SKS) developed in conjunction with the University of Neuchatel (Switzerland).

— GoldFields, Cerro Corona, Cajamarca, Peru (2013): The Cerro Corona mine is a Gold and Copper mine operation in the north of Peru. WSP was tasked with constructing a 3D groundwater model of the pit and surrounding areas to estimate dewatering flow into the pit, and drawdown impact analysis downstream of the mine. Responsibilities included acting as lead modeler constructing a 3D FEFLOW flow model and report writing

— Newmont, Conga Project, Cajamarca, Peru (2012): WSP was contracted to provide hydrogeological services for the Conga project: a 5 billion USD mining project near Cajamarca, Peru. WSP was tasked with constructing a groundwater flow model that would evaluate potential environmental impacts of the project to the surface and groundwater. The model was audited and approved by an external international committee of reviewers. Responsibilities included acting as lead modeler constructing a 3D FEFLOW flow model and report writing.

— Freeport-McMoRan, Cerro Verde, Arequipa, Peru (2012): WSP was contracted to construct a regional flow and transport model (FEFLOW) for the Cerro Verde Mine, which included a total of 14 catchments, two tailings facilities, three heap leaches and four waste rock dumps. The model was a key part of the Cerro Verde Expansion EIS which increased mine production up to 1 billion pounds of copper in 2015. Responsibilities included acting as lead modeler constructing the transient groundwater flow model and report writing for the EIS document.

— GoldFields, Cerro Corona, Cajamarca, Peru (2012): The Cerro Corona mine required a tool to manage the water at their site. WSP constructed an integrated GoldSim water balance model for tailing facility and surface water management operations. The model assisted in decision making for potential expansions to the tailings facility and strategic water management decisions. Personal responsibilities included carrying out a precipitation study and calibrating the GoldSim model.

— BHP Billiton, Rio Tinto, Escondida, Antofagasta, Chile (2012): As part of a pit expansion, WSP provided 2D pore pressure modelling (SEEP/W) to be used in the geotechnical slope stability assessment. The modeling was carried out along four 2D sections providing hydrogeological support at the porphyry deposit considered the largest mine in the world. Personal responsibilities included constructing and calibrating SEEP/W models, and running predictive simulations.

— Newmont, Yanacocha, Cajamarca, Peru (2011): WSP constructed a 3D transient MODFLOW model used to estimate impacts for permitting documents. The Yanacocha mine required constant updates to the model, recalibrating to new data and running predictive simulations to estimate its dewatering requirements. WSP was tasked with annual updates to the model based on new hydrogeological and mine plan information. Personal responsibilities included processing data and updating the model calibration.

— BHP Billiton, Xstrata, Antamina, Ancash, Peru (2011). Antamina requested an integrated hydrogeologic study of the Tucush Basin where it was planning the construction of a new Waste Rock Facility. The multi-year project including drilling, aquifer testing, a tracer study and modelling to evaluate the potential impacts on the catchment karstic aquifer. Personal responsibilities included participating in tracer field program and groundwater modeling.

— Southern Copper Corporation, Tia Maria, Arequipa, Peru (2011): Southern Copper requested WSP provide environmental permitting for the greenfield copper mine in the south of Peru. Personal responsibilities included data analysis and report production.

Water Resources and Hydrogeological Studies

— Boulder Community Hospital, Colorado (2017): The client was expanding to their hospital complex and required a dewatering system for underground construction, without impacting groundwater levels within a wetland area nearby. A slurry wall was installed to prevent drawdown within the wetland and a monitoring network of piezometers was installed to observe water levels in the area. Personal responsibilities included participating in the groundwater monitoring and sampling program.

— Fosfatos del Pacífico, Piura, Peru (2013): The client contracted WSP to provide a conceptual evaluation of an alternative seawater intake to supply 1500 m3/hr to the phosphates mine in the north of Peru. An infiltration gallery was designed to be buried in the beach near the project, creating a natural intake for a

desalinization plant. Personal responsibilities included client management, contractors management and data analysis including a MODFLOW model.

Site Assessment and Remediation

— Manufacturer of Semiconductors and Passive Electronic Components, Hicksville, NY (2017): A 3D groundwater flow and transport model of contaminated site was reviewed and recommendations were made for improving it. Personal responsibilities included providing GIS analysis support for estimating recharge values for input into the model for the project site and surrounding area.

— PlusPetrol, Block 1AB & 8, Trompeteros, Peru (2013): WSP was contracted to provide hydrogeological services assessing the potential brine release from an oil well into a shallow aquifer. Multiple methods of sampling were used, including water quality, hydraulic testing and geophysical tomography. To simulate the discharge, a flow and transport FEFLOW model was constructed, and calibrated using density effects. Responsibilities included leading modeling efforts, client management and on-site presentations.

— BASF, Lima Chemical Plant, Lima, Peru (2010): The chemical company required a site investigation (phase 2) to assess potential sources of groundwater and soil contamination at the chemical plant in Lima. Responsibilities included soil and water quality sampling, coordinating lab testing and results interpretation.

— Repsol (Peru LNG), Melchorita Project, Lima, Peru (2010): The Liquid Natural Gas (LNG) pipeline requires a site investigation of the Topará Valley aquifer evaluating potential water quality impacts due to nearby quarry exploitation. Responsibilities included soil and water quality sampling, coordinating lab testing and results interpretation.

PUBLICATIONS AND PRESENTATIONS

Presentations

— Pantano C., Meza-Cuadra G. Edington D., Bridging the gap: Coupling of geotechnical and groundwater models in the mining industry, MODFLOW and More 2017, May 21-24, 2017.

DONNA MOREY, B.S., ASSISTANT PROJECT MANAGER

Ms. Morey is a project manager and regional planner at SWCA's Phoenix office. She has spent the last decade as a third-party NEPA assistant project manager on large mining EISs and land exchanges for the Forest Service and Bureau of Land Management. She has proven expertise in project management, public involvement, alternatives development, and logistics. Keen attention to project controls keeps schedule and budget at the forefront of her management style. Expertise in communication and coordination results in seamless stakeholder involvement; meeting facilitation, including coordinating and hosting meetings, project site visits, and open houses; and effective project correspondence and team management. Ms. Morey also has experience in logistics and database management, including compiling and maintaining administrative records for EISs, EAs, and other projects; fieldwork planning with safety focus; client and customer relations; GIS coordination; editing, formatting, and production of technical documents and newsletters; and maintaining project schedules, mailing lists, contracts, and budget tracking systems to ensure the project stays on schedule and within budget.

YEARS OF EXPERIENCE

11

EXPERTISE

Project controls

NEPA process

Administrative support management

Managing project logistics

Budget tracking

Administrative record management

Data management

EDUCATION

B.S., Urban Planning; Arizona State University, Tempe, Arizona; 2017

Associates Transfer Degree; Rio Salado College; Phoenix, Arizona; 2015

TRAINING

MSHA Safety Training, Arizona State Mine Inspector; 2019

NEPA Streamlining - Matt Peterson, SWCA Environmental Consultants; 2018

Project Managers Bootcamp, PSMJ Resources, Inc.; 2009

MEMBERSHIPS

Society for Mining, Metallurgy & Exploration and Member.

National Association of Environmental Professionals

As a “hosted” worker for the BLM of behalf of SWCA, Ms. Morey works seamlessly with agency staff. In this position, she manages project deliverables, public presentations, and team coordination to help ensure various projects stay on schedule. Ms. Morey has provided assistance to both USFS and BLM archaeologists and tribal liaisons when documenting and coordinating extensive Section 106 consultation. Most of her EIS project experience has addressed NEPA, Endangered Species Act, Clean Water Act, realty actions, plan amendments, and/or state environmental regulations or growth and land management requirements.

SELECTED PROJECT EXPERIENCE

Resolution Copper Mine and Land Exchange NEPA Services; U.S. Forest Service; Tonto National Forest, Multiple Counties in Arizona. SWCA is serving as the third-party NEPA contractor assisting with the preparation of the EIS and associated documents for the Tonto National Forest. The project involves complex NEPA considerations with the land exchange, the plan of operations, concurrent revisions to the Forest Plan, and the establishment of the Apache Leap Special Management Area. *Role: Assistant Project Manager. Coordination between agency, client, cooperating agencies, the public, and 15 tribes. Assists with daily communication and project coordination. Also responsible for maintaining mailing list, project schedule, project invoicing, contracting and budget monitoring. Assists with Section 106 Tribal Consultation meetings and documentation.*

Ray Mine Supplemental EIS; Bureau of Land Management; Pinal, Gila, and Mohave Counties, Arizona. SWCA is working to complete the Ray Mine Land Exchange Supplemental EIS under the guidance of the Arizona State Office and Tucson Field Office of the BLM. The copper mining firm ASARCO LLC hopes to acquire up to 10,976 acres of BLM surface and mineral estate adjacent to its long-established Ray open-pit mine in east-central Arizona in exchange to BLM of approximately 7,304 acres of riparian and other sensitive native habitat, primarily in northwestern Arizona. *Role: Planning Specialist. Coordinates with agency, client, third-party contractor, the public, and tribes. Assists BLM and SWCA project managers with daily communication and project coordination. Also responsible for maintaining mailing list, project record,*

project schedule and meetings, project invoicing, contracting, and budget monitoring.

Bagdad Mine Stockpile Extension NEPA Study; Bureau of Land Managment; Bagdad, Yavapai County, Arizona. As a third-party consultant for the project, SWCA is assisting the BLM Kingman Field Office with analyzing proposed modifications to the current Bagdad Mine Plan of Operations. If approved through the current EA process, Freeport McMoRan's proposed mine plan modifications, which include extending the present stockpile and constructing access roads, monitoring wells, and other distributed facilities, could result in disturbance of as much as 600 acres of BLM-managed public lands. *Role: Administrative Support. Compiles and maintains administrative record, assists Project Manager Charles Coyle with project invoicing, and schedule and budget monitoring.*

Rosemont Copper Mine EIS; U.S. Forest Service; Coronado National Forest near Tucson, southeastern Pima County, Arizona. As a third-party contractor, SWCA worked with the USFS and Coronado National Forest to determine and disclose potential environmental impacts of a proposed open-pit copper, molybdenum, and silver mine on more than 5,000 acres of private and National Forest System lands in the Santa Rita Mountains in southeastern Tucson. *Role: Administrative Support. Project invoicing and schedule and budget monitoring.*

Northern Arizona Proposed Withdrawal EIS; Bureau of Land Managment; Coconino and Mohave Counties, Arizona. SWCA was the primary contractor to the BLM and four federal cooperating agencies to determine the potential impact of a 20-year withdrawal of approximately 1 million acres of federal lands from new mineral exploration and mining near Grand Canyon National Park. *Role: Project Administrator. Coordination among agency, client, cooperating agencies, the public, and tribes. Assisted BLM and SWCA project managers (Charles Coyle) with daily communication and project coordination. Maintained mailing list, project schedule, administrative record, project invoicing, contracting, and budget monitoring.*

Southline Transmission EIS; Bureau of Land Management; Las Cruces, New Mexico, to Wilcox, Arizona. SWCA served as the third-party NEPA consultant to the BLM and Western Area Power Administration for a 440-mile transmission line project crossing southern Arizona and southern New Mexico that includes both new conduction and segments upgrades. *Role: Administrative Support. Project invoicing and schedule and budget monitoring.*

Sonoran Solar Energy Project EIS; Bureau of Land Managment; Maricopa County, Arizona. SWCA assisted the BLM as the third-party contractor in completing an EIS and Record of Decision for a solar energy project proposed on public lands in southern Arizona. *Role: Project Administrator. Compiled and maintained administrative records, project invoicing, and schedule and budget monitoring.*

Sonoran Valley Parkway Environmental Impact Statement; Bureau of Land Management; Maricopa County, Arizona. Under the direction of the BLM Phoenix District Office, SWCA prepared an EIS as a third-party contractor for the City of Goodyear. The project included a proposed parkway stretching between Goodyear and Mobile, Arizona. SWCA was responsible for coordinating the NEPA process, developing alternatives, completing impacts analysis, and conducting field surveys for natural and cultural resources on a minimum of three alternatives, each measuring approximately 20 miles. *Role: Administrative Support. Compiled and maintained administrative record, project invoicing, and schedule and budget monitoring.*

Second Knoll Target Range EA and Special Use Permit Plans; Arizona Game and Fish Department; Navajo County, Arizona. SWCA was lead consultant for the NEPA compliance required for the Arizona Game and Fish Department's proposed Second Knoll Shooting Range Project on approximately 80 acres of the Apache-Sitgreaves National Forest. SWCA also performed Biological, Cultural, and Jurisdictional Delineation surveys and reports. *Role: Project Administrator. Assisted with the project record, public involvement, and project controls.*

Gila River Sand and Gravel Environmental Assessment; Gila River Sand & Gravel Corp.; Sacaton, Pinal County, Arizona. SWCA facilitated public scoping, preparation, and publication of an EA for a sand and gravel mine expansion on Gila River Indian Community land. *Role: Project Administrator. Assisted with project planning, and project controls.*

DOUGLAS OLIVER, PG

Project Manager
Hydrogeological Conceptual Modeling Lead

Years with the firm

4

Years total

26

Professional qualifications

Professional Geologist, State of Utah, 2003 (5239246-2250)

Areas of practice

Hydrogeology; Groundwater Modeling; Mine Dewatering; Environmental (CERCLA RI/FS/PP/ROD/RD/RA); Contaminant Fate and Transport; Water Resources

Languages

English

CAREER SUMMARY

Doug Oliver is a principal hydrogeologist with over 25 years of experience, having been project manager, technical lead, and technical reviewer on a variety of projects for mining, industrial, federal, and municipal clients. He has worked on planned and active mines (both underground and open pit), as well as closed/legacy sites for several commodities including copper, iron ore, uranium, lithium and borates, in a variety of geographic settings/climates throughout the world ranging from extreme desert environments to the arctic. He has evaluated data and developed conceptual models of hydrogeologic systems and performed and overseen groundwater modeling studies to evaluate impacts from mine dewatering, tailings storage facility seepage, compare alternatives for remediation of contaminated sites, predict future impacts to water quality for planned mine facilities, and evaluated capture zones for extraction / dewatering wells. He is area manager for the WSP Mine Water Services Group.

Doug's strengths include:

- Hydrogeology: Field characterization program planning and oversight, monitoring network design and installation, hydrogeological data evaluation, aquifer testing and analysis, conceptual model development, numerical modeling oversight
- Environmental: Water quality evaluation, contaminant fate and transport modeling oversight, acid-rock drainage (ARD) evaluation, hydrogeochemical modeling oversight, CERCLA Remedial Investigations and Feasibility Studies, remediation system design and performance monitoring
- Technical Assurance: Value protection and risk evaluation for water, environment, and permitting-related issues
- Mine Project Life Cycle: Detailed understanding of project life cycle, study phases, requirements for mining industry

EDUCATION

MS, Hydrology, New Mexico Institute of Mining and Technology, Socorro, New Mexico	2001
MS, Civil and Environmental Engineering, Utah State University, Logan, Utah	1992
BA, Environmental Sciences (Geology) and Economics, University of Virginia, Charlottesville, Virginia	1988

ADDITIONAL TRAINING

Geological Field Methods, Yellowstone-Bighorn Research Association, Princeton University	1988
MSHA Experienced Surface Miner (annual refresher)	2019

PROFESSIONAL MEMBERSHIPS

Society for Mining, Metallurgy, and Exploration (SME)

National Ground Water Association (NGWA)

PROFESSIONAL EXPERIENCE

- Resolution Copper Environmental Impact Statement Regional Groundwater Model, Arizona, USA. project manager for groundwater modeling to predict impacts to groundwater flow and levels as a result of a proposed block-cave copper mine. Reviewed modeling work and reviewed draft report. Provided technical support to RCM for NEPA process. Met with U.S. Forest Service, the lead agency for the EIS and presented hydrogeology and groundwater model. Client: Rio Tinto.
- FMI Bagdad Operations Pit Dewatering Modeling, Arizona, USA. project manager for pit dewatering support for the Bagdad open pit copper mine. Work involved updating a 3D groundwater model of the pit and surrounding area and subsequent dewatering predictions for use in geotechnical slope stability modeling. Client: Freeport McMoRan, Inc.
- FMI Bagdad Operations Drilling Oversight, Hydraulic Testing and VWP Installation, Arizona, USA. project manager for drilling oversight, hydraulic testing and vibrating wire piezometer (VWP) installation in support of the pit dewatering program for the Bagdad open pit copper mine. Work involved overseeing drilling and hydraulic testing, and installation of vibrating wire piezometers. Client: Freeport McMoRan, Inc.
- Kennecott Copper Closure Pre-Feasibility Study, Utah, USA: project manager for hydrogeological aspects of the RTKC Closure Study. This involved numerical modeling of various wet and dry pit scenarios for closure of the mine, which is one of the largest open pit mines in the world. Groundwater modeling results were provided to the geotechnical team for slope stability analysis and geochemical team for water quality studies. Client: Rio Tinto.
- Jadar Lithium-Borate Project Pre-Feasibility Study, Serbia: project manager and technical lead for the hydrological and hydrogeological characterization program for Pre-Feasibility Study. Designed groundwater and surface water monitoring programs to meet Rio Tinto study standards for PFS and general industry standards. Worked closely with Rio Tinto staff and hydrogeologists from University of Belgrade and hydrologists from Institute Jaroslav Cerni. Oversaw consultant work and reviewed data and reports. Oversaw groundwater modelers from Institute Jaroslav Cerni for numerical groundwater modeling. Assisted with modeling of mine plan for development and life of mine. Reviewed plans for characterization of tailing storage facilities. Client: Rio Tinto.
- Rio Tinto Legacy Management Site Remediation Technical review, multiple sites: provide technical review for soil and groundwater remediation of legacy sites with trichloroethene (TCE) contamination for the Pechiney Vernon Site (California, USA) and Pechiney Plastics Pohatcong site (New Jersey, USA). Provided TEG review support.
- Kennecott Copper Drainage Gallery Ore Feasibility Study, Utah, USA: project manager for groundwater modeling conducted to predict dewatering requirements for the Drainage Gallery Ore Feasibility Study. This is an underground ore body beneath the Bingham pit. Client: Rio Tinto
- Recreational Land Use Mitigation and Communities Technical Support, Arizona, USA: technical support for recreational land use mitigation and community support related to outdoor recreational resources at the Resolution Copper site. Identified resources that may be impacted and alternatives for mitigation. Client: Rio Tinto.

Past Experience

Mining-Related Hydrogeology

— Rio Tinto Technical Assurance: participated in several technical reviews for the Technical Evaluation Group (TEG), which are independent reviews submitted to the Rio Tinto Investment Committee (IC) to identify technical issues and critical risks for large funding requests (> $100M). Assessed water-related issues (water resources and supply, hydrology, hydrogeology, water quality, pit/mine dewatering) as well as environmental and permitting issues, with some overlap in geotechnical issues and community's issues. Collaborated with multi-discipline technical specialists. Client: Rio Tinto.

  Participated in TEG reviews for Oyu Tolgoi Copper (Mongolia; 2), Resolution Copper (Arizona; 4), Kennecott Copper (Utah; 4), Escondida Copper (Chile), Holden Mine Site Remediation Project (Washington; 3), and Diavik Diamond Mine (NWT, Canada): participated in similar technical reviews (pre-TEG reviews, risk reviews, and gap analyses) for Amargosa Bauxite (Brazil), La Granja Copper (Peru), Roughrider Uranium (SK, Canada), Oxbow, Pocket, and Billiard South at Yandicoogina Iron Ore Mines (Australia), and Jadar Lithium-Borate (Serbia).

— Minera Escondida Water Supply Evaluation, Chile: provided technical guidance to Rio Tinto Copper Group regarding status of water resources and water strategy. Evaluated well-field performance and provided recommendations for improving yields. Provided hydrogeology technical support to the MEL hydrogeology team. Client: Rio Tinto

— Rio Tinto Mergers & Acquisitions Due Diligence Guidance: authored hydrology and hydrogeology sections of Rio Tinto's due diligence guidance document, which provides instruction for undertaking due diligence in relation to an asset and/or company for its acquisition or divestment. Client: Rio Tinto.

— Kennecott Copper North Zone Groundwater Remedial Investigation and Focused Feasibility Study, Utah, USA: project manager and technical lead for an updated remedial investigation (RI) and focused feasibility study (FFS) for the North Zone (smelter and refinery areas) where groundwater is contaminated with selenium and arsenic. Evaluated data, identified data gaps, and oversaw work to fill these data gaps. Revised the groundwater contaminant fate and transport conceptual model. Prepared RFP/SOW for FFS to identify remedial alternatives for groundwater cleanup, identified qualified consultants, reviewed bids, and advised in consultant selection, Oversaw consultants and reviewed work products. Client: Rio Tinto.

— Dry Fork Remedial Alternatives Evaluation, Utah, USA: project manager and technical lead for groundwater contamination evaluation for contamination from the Bingham Canyon waste rock dumps. Client: Rio Tinto.

— Resolution Copper Land Use Mitigation and Communities Technical Support, Arizona, USA: provided technical support to the environmental, permitting, and communities group for land use mitigation and community support related to outdoor recreational resources at the Resolution Copper site. Identified resources that may be impacted and alternatives for mitigation. Client: Rio Tinto.

— Cerro Verde Copper Mine, Hydrogeological Evaluation for Quebrada Enlozada Tailing Storage Facility, Arequipa, Peru: project manager and technical lead for an evaluation of the potential impacts of the Enlozada Tailing Storage Facility (TSF) on groundwater flow and quality. Oversaw drilling, logging, packer testing, and

installation of monitoring wells. Evaluated water levels and potentiometric surface response to filling of the TSF. Evaluated water quality data to determine baseline water quality and evaluate if groundwater was impacted by the TSF. Evaluated effectiveness of seepage collection system and hydraulic containment system below the TSF. Oversaw numerical modeling of fractured rock aquifer with the finite element model FEMWATER to assess potential future impacts of the TSF. Presented findings to the External Technical Review Board, a board made up of world-renowned experts in the fields of geotechnical engineering, dam safety, hydrogeology, and seismology. Client: Freeport McMoRan.

— Resolution Copper Groundwater Quality Evaluation and Geochemical Modeling for Pre-Feasibility Study, Arizona, USA: managed team of geochemists to perform groundwater quality evaluation and geochemical modeling to predict impacts to groundwater quality as a result of a proposed block-cave copper mine in southeastern Arizona. Client: Rio Tinto.

— Resolution Copper Geochemical Lab Testing Program for Pre-Feasibility Study, Arizona, USA: managed geochemical lab testing program which involved whole rock analysis and humidity cell (column leaching studies) testing. Testing was performed to provide data for geochemical modeling to evaluate ARD characteristics for water treatment, disposal, and mine closure. Client: Rio Tinto.

— Holden Mine Site Remedial Design, Washington, USA: oversaw numerical groundwater modeling of remedial alternatives for the Holden Mine Site. Modeling was performed to optimize the remedial design. Client: Rio Tinto.

— Hollister Gold Mine, Water Quality Assessment, Nevada, USA: managed groundwater and surface water quality assessment for a gold mine in central Nevada. Water quality concerns were pH, sulfate, and cyanide associated with a pit lake, overburden stockpiles, and cyanide heap leach pad. Evaluated groundwater analytical data to assess operation of bioreactors for in-situ groundwater treatment of effluent from the heap leach pad and waste rock piles. Client: Newmont Mining Corporation.

CERCLA Remedial Investigations and Feasibility Studies

— Hill Air Force Base Operable Units 5, 8, and 12, CERCLA Remedial Investigations and Feasibility Studies, Utah: performed remedial investigations and feasibility studies for Operable Units 5, 8, and 12 at Hill AFB. Hill AFB OU 8 comprises groundwater contamination, primarily trichloroethene (TCE) and 1, 2-dichloroethane (1, 2-DCA), beneath the industrial area of Hill AFB. TCE and 1, 2-DCA plumes extend two miles off base beneath residential areas. Hill AFB OU 5 consists of two groundwater contamination plumes, primarily TCE, that are each over one mile long. Hill AFB OU 12 consists of a TCE plume that is two miles long. As part of field investigations, drilled and installed numerous monitoring wells and performed numerous aquifer and slug tests, and analyzed these tests. Prepared RI reports characterizing the site hydrogeology, the nature and extent of groundwater contamination, and fate and transport of groundwater contamination. Prepared site conceptual model reports for contaminant fate and transport. Oversaw the groundwater flow and contaminant transport modeling (MODFLOW and MT3DMS) of the remedial alternatives for evaluation in the feasibility studies. Modeling was performed to assess the effectiveness of various remedial alternatives and estimate cleanup times. Primary author of the feasibility studies for OUs 5 and 12, which included developing remedial action objectives (RAOs), screening remedial technologies, and assembling alternatives for remediation of groundwater and soil. Obtained

regulator buy-in (EPA and Utah DEQ) and approval of modeling process. Client: U.S. Air Force.

— FMC Plant Site Operable Unit, Supplemental Feasibility Study for Groundwater, Idaho, USA: oversaw numerical groundwater flow and contaminant transport modeling (with MODFLOW and MT3DMS) of arsenic and orthophosphate for the FMC Plant Site. Modeling was performed to evaluate the effectiveness of various remedial alternatives and estimate cleanup times for the FMC Plant Site Supplemental Feasibility Study. Remedial alternatives evaluated included monitored natural attenuation, hydraulic containment, and pump and treat. Met with the EPA Region 10 team and their groundwater modeling experts to provide progress reports and obtain intermediate reviews at all major steps in the modeling process. Assisting with preparation of Supplemental Feasibility Study. Client: FMC.

— Wasatch Chemical Site Focused Feasibility Study for Groundwater, Utah, USA: technical lead on the Focused Feasibility Study that is being prepared to support a ROD amendment for a remedy change from pump and treat to monitored natural attenuation for the Wasatch Chemical Site. Oversaw numerical groundwater flow and contaminant transport modeling (with MODFLOW and RT3D) of PCE and TCE and their degradation products that was performed to evaluate remediation time frames in support of monitored natural attenuation. Client: Questar Gas.

— Camp Bullis Army Reserve, San Antonio, Texas - Site 8 Landfill Remedial Investigation: analyzed and interpreted groundwater data for the Site 8 landfill at Camp Bullis, Texas. Contaminants (primarily TCE and other chlorinated compounds) from the Site 8 landfill at Camp Bullis entered the Trinity Aquifer, a karst aquifer that recharges the Edwards Aquifer, a sole-source aquifer providing the water supply for the city San Antonio, a city of over one million people. Work included interpreting data from tracer tests and aquifer pumping tests performed to evaluate groundwater flowpaths at the site. Used the transport model CXTFIT to analyze tracer tests. Analyzed stage-based sampling data to correlate contaminant concentration data to water-level stage. Oversaw and analyzed aquifer testing to evaluate hydraulic properties and connections of the aquifer. Interpreted geophysical data from a variety of surface and borehole geophysical methods to better understand aquifer characteristics. Developed conceptual model for groundwater flow and contaminant fate and transport. Reviewed remedial action plan for the U.S. Army Corps of Engineers. Met with Texas Commission for Environmental Quality and U.S. EPA on a regular basis. Client: U.S. Army Corps of Engineers.

Groundwater Remediation System Design

— Emery Landfill, Groundwater Corrective Actions Study, Kansas, USA: developed conceptual model of hydrogeology and contaminant fate and transport for the Emery Landfill Corrective Actions Study. Oversaw numerical groundwater flow and contaminant transport modeling (with MODFLOW and MT3D) of TCE. Modeling was performed to evaluate the effectiveness of various hydraulic containment options (extraction wells, extraction trenches, cutoff walls). Client: Boeing Corporation.

— Hill AFB Operable Unit 12 Base Boundary Hydraulic Containment System, Utah, USA: performed predesign fieldwork for the OU 8 Base Boundary Hydraulic Containment System, which was installed as an Interim Remedial Action (IRA). Prepared a groundwater model for OU 8 and simulated groundwater flow and contaminant migration with MODFLOW and MODPATH to evaluate extraction well configurations for the design. Determined locations and depths of extraction wells

for the system. Field team leader for installation of extraction wells and monitoring wells for the Base Boundary Hydraulic Containment System. Client: U.S. Air Force.

— Hill AFB Operable Unit 8 Base Boundary Hydraulic Containment System, Utah, USA: performed predesign fieldwork for the OU 8 Base Boundary Hydraulic Containment System, which was installed as an Interim Remedial Action (IRA). Prepared a groundwater model for OU 8 and simulated groundwater flow and contaminant migration with MODFLOW and MODPATH to evaluate extraction well configurations for the design. Determined locations and depths of extraction wells for the system. Field team leader for installation of extraction wells and monitoring wells for the Base Boundary Hydraulic Containment System. Client: U.S. Air Force.

— Hill AFB Operable Unit 12 Permeable Reactive Barrier, Utah, USA: oversaw groundwater modeling for OU 12 and simulated groundwater flow and contaminant migration with MODFLOW and MT3DMS to evaluate permeable reactive barrier dimensions for the preliminary design of a zero-valent iron permeable reactive barrier. Client: U.S. Air Force.

SYSTEM PERFORMANCE MONITORING and REMEDIAL PROCESS OPTIMIZATION

— Hill Air Force Base Operable Units 3, 4, 5, 6, 7, 8, and 12 Performance Monitoring Plans and Performance Standard Verification Plan, Utah, USA: developed performance monitoring plans/performance standard verification plans for OUs 3, 4, 5, 6, 7, 8, and 12. Monitoring plans were developed for groundwater remediation systems that included hydraulic containment systems (extraction wells and an extraction trench with cutoff wall), a permeable reactive barrier wall with zero-valent iron, an air-sparging trench, and monitored natural attenuation. Monitoring plans were also developed to evaluate effectiveness of caps over source areas. These plans will be used to guide long-term monitoring of the sites which will ultimately lead to site closure. To prepare plans, past performance of systems was evaluated through a variety of methods including statistical analysis of data and modeling with CXTFIT, MODFLOW, MODPATH, and/or MT3DMS. Client: U.S. Air Force.

— Hill Air Force Base Operable Unit 5 Groundwater Extraction System Evaluation, Utah, USA: evaluated performance of the OU 5 Phase II Groundwater Extraction System (GES). The GES consisted of five extraction wells withdrawing a combined total of 1.2 gpm. Mass removal rates had declined exponentially since operation began. Cumulative mass removal data were fit with a logarithmic function which predicted that 30 to 40 years will be required to remove the same contaminant mass removed in the first three years of operation. Transport modeling with MT3DMS supported these findings. Based on this evaluation, it appeared that the GES had little overall effect on site restoration, so we recommended that operation of this system be discontinued. With the support of this evaluation, Hill AFB received approval from the Utah Department of Environmental Quality and the U.S. EPA to discontinue operation of the system, saving the Air Force approximately $1,000,000. Client: U.S. Air Force.

CHRISTOPHER PANTANO

Senior Hydrogeologist

Years with the firm

7

Years total

9

Areas of practice

3D Visualization; CAD Drafting; Dewatering, Depressurization; Drilling; Directional Drilling; Field Work; Geochemistry; Geographic Information Systems (GIS); Groundwater Modeling; Groundwater Monitoring; Hydrogeology; Hydrology; Isotope Geochemistry; Project Management; Water Quality

Languages

English

CAREER SUMMARY

Christopher Pantano has 9 years of industry experience with responsibilities that feature groundwater modeling, geochemical modeling, project management, field work, and data analysis. Christopher is proficient in a wide variety of software including ArcMap, AQTESOLV, AquaChem, AutoCAD, FEFLOW, Groundwater Vistas, Leapfrog, Petrel, and PhreeqC. Christopher has worked on multiple 2D and 3D groundwater modeling projects; most notably on a project requiring the integration of geotechnical model output into transient hydrogeologic properties. Extensive field work experience includes groundwater monitoring, aquifer testing, lithology logging, well site supervision, and borehole installations. He has been associated with several field projects, many of which, associated with drilling and completion activities for water wells and piezometers. Christopher has also been involved in numerous hydrogeologic characterization and dewatering reviews in which a large responsibility was data management and data analysis.

EDUCATION

M.S., Hydrology, University of Arizona, Tucson, Arizona	2012
B.S., Earth Science: Geohydrology, Montana State University, Bozeman, Montana	2010

ADDITIONAL TRAINING

Mine Safety and Health Administration (MSHA): surface, metal, and non-metal	2020
Hazardous Waste Operations and Emergency Response (HAZWOPER)	2020

PROFESSIONAL MEMBERSHIPS

Colorado Ground Water Association	2020
National Ground Water Association	2020
Geological Society of America	2020
Society for Mining, Metallurgy & Exploration	2020

PROFESSIONAL EXPERIENCE

Project Management

Nevada Gold Mines, Groundwater Modeling & Dewatering System Evaluation, Goldstrike, Nevada (2020 – Present): project and technical manager of modeling project evaluating various strategies for dewatering of an underground gold mine. Groundwater modeling was conducted for assessing the effectiveness of each dewatering strategy and providing pore pressure estimates for a geotechnical stability analysis. Dewatering strategies were also evaluated with respect to cost to determine the most cost-effective means for dewatering the future mine plan.

Rio Tinto Kennecott Copper, Slice 2 PFS & FS Modeling, Salt Lake City, Utah (2018 – 2019): project and technical manager of modeling project involving 2D and 3D groundwater modeling for pit slope pore pressure predictions. Worked in conjunction

with the client as part of a larger project study team requiring collaboration with geotechnical engineering and mine planning teams.

Resource Company, Greenland Ranch, Confidential Location, (2012 – present): project manager of a water supply project involving two groundwater production wells and two groundwater monitoring wells in two aquifers. The project goal is the development and distribution of the client's groundwater resource to a future party of interest. Our group has advised and executed the drilling, testing, completion, and eventual production of the groundwater on behalf of the client. Project management responsibilities include maintaining multiple permits related to future project construction, overseeing a continued groundwater monitoring program, and managing project assets.

Groundwater Modeling

Nevada Gold Mines, Groundwater Modeling & Dewatering System Evaluation, Goldstrike, Nevada (2020 – Present): lead modeler for modeling project evaluating various strategies for dewatering of an underground gold mine. Groundwater modeling was conducted for assessing the effectiveness of each dewatering strategy and providing pore pressure estimates for a geotechnical stability analysis. Dewatering strategies were also evaluated with respect to cost to determine the most cost-effective means for dewatering the future mine plan.

Rio Tinto Kennecott Copper, Slice 2 PFS & FS Modeling, Salt Lake City, Utah (2018 – 2019): lead modeler for groundwater modeling project providing annual pore pressure predictions for assessment of geotechnical slope stability. The project consisted of model construction, calibration, and predictive simulations of seven 2D cross-sectional FEFLOW models, as well as a 3D MODFLOW-SURFACT pit-scale groundwater model. In addition to modeling, a methodology was developed for modifying 2D and 3D model pore pressure results for the purpose of quantifying the sensitivity of geotechnical slope stability models to variance in pore pressure predictions. Project required extensive use of 3D geological modeling and visualization software for processing geologic block model and presentation of model results.

Resolution Copper Mining, LLC, 3D Regional Groundwater Model, Resolution Copper Mine, Superior, Arizona, (2014 – present): supporting modeler to a 3D regional groundwater modeling project for an Environmental Impact Study (EIS) for a proposed block cave mine. The client requires a regional groundwater model for analyzing the potential impacts of moving forward with a planned mine. Main efforts were focused on the integration of geotechnical modeling outputs for incorporation into the life of mine (LoM) predictive groundwater model. This integration required defining time-varying material properties (TMP) to model hydrogeologic property changes over time that represent progression of the proposed mine development and fracturing of rock induced by mining to determine regional impacts. Project required extensive use of 3D geological modeling and visualization software for processing geologic block model, integration of mining method, and presentation of model results.

Freeport-McMoRan, Climax Molybdenum West Wall 2D Pore Pressure Modeling, Leadville, Colorado (2015): main modeler utilizing pore pressure data collected on-site to simulate 2D cross sectional slice modeling to assess the effectiveness of installing drains into the pit slope for reducing pore pressures and improving slope stability. Modeling tasks involved construction of an updated 2D slice model mesh, re-calibration to updated datasets and incorporating transient boundary conditions. Future predictive modeling was than completed to understand the benefits of the drilling and installation of horizontal drains into the pit slope.

Freeport-McMoRan, Morenci Western Copper East Wall 2D Pore Pressure Modeling, Morenci, Arizona (2016): supporting modeler for calibration and predictive simulations of two 2D cross sectional pore pressure. Modeling was aimed at determining the current pore pressure profile for a geotechnical analysis of an exceptionally high pit slope wall. In addition, a specific geologic/hydrogeologic unit was of particular interest to the safety and stability of the pit slope highwall. Dewatering and depressurization scenarios were simulated to better understand essential infrastructure required for ensuring slope stability.

Rio Tinto Kennecott Copper, Bingham Canyon 2D Pore Pressure Modeling, Salt Lake City, Utah (2016): supporting modeler for repeated 2D pore pressure slice modeling of various pit slope cross sections. Our work on the project is a continuation of numerous 2D models developed to estimate pore pressure profiles for future mine plans and geotechnical stability. Tasks include model construction and implementation of various depressurization measures (i.e. dewatering wells, horizontal drains, drainage gallery, etc.) for predictive model simulations.

Fairbanks Gold Mining, Inc., Fort Knox East Wall and Yellow Pup Pit 2D Pore Pressure Modeling, Fairbanks, Alaska (2016-2017) supporting modeler for the construction, calibration, and predictive simulations of three site cross sections. Our role is to provide estimated pore pressure profiles for geotechnical analysis assuming multiple predictive scenarios which assess on-site implementation of dewatering a depressurization measures. Tasked with construction and calibration of 2D cross section slice models to current site conditions. Following calibration, various future predictive model scenarios were simulated to understand the necessary dewatering and depressurization measures required to safely complete future mine plans.

Manufacturer of Semiconductors and Passive Electronic Components, Hicksville, New York (2017): technical support for 3D groundwater model was reviewed and recommendations were made for improving the model for predictions of a contaminant plume from an industrial site. Provided supporting analysis for estimating recharge values for input into a 3D groundwater model for the project site and surrounding area. Analysis involved pairing rainfall runoff catchments with land use for providing empirical estimates of enhanced recharge to basins.

Dewatering Depressurization

Freeport-McMoRan, Chino Mine, Santa Rita, New Mexico (2016): data analyst for recommendations regarding completion of pilot hole locations into two pit dewatering wells. Reviewed and analyzed various data collected during drilling and hydraulic testing of six pilot boreholes around the perimeter of an open pit mine. Following analysis, recommendations were provided that identified boreholes which should be completed as pumping wells for intercepting groundwater inflows into the pit, as well as pit dewatering.

Freeport-McMoRan, Morenci Western Copper, Morenci, Arizona, (2014-2017): data analyst and field support for long term project focused on proactive measures for ensuring pit dewatering and highwall depressurization for successful implementation of the mine plan. Project activities have included the drilling of numerous pilot holes for hydraulic testing to determine ideal locations for pit dewatering wells. Remaining pilot holes were equipped with multi-level vibrating wire piezometers (VWP) for pore pressure monitoring. In addition to pilot holes, horizontal drains were planned and drilled into the east highwall to promote pit slope depressurization. Annual project updates have involved data review and dewatering summary reports for determining the progress of previous drilling programs.

Freeport-McMoRan, Morenci Garfield Pit, Morenci, Arizona (2012-2014): data analyst for annual dewatering reviews were performed to understand the previous year's dewatering progress and identify any shortcomings as it pertained to continued dewatering and achieving proposed mine plans. A large piezometer network and recorded data measurements were managed and analyzed against pumping records to define areas within the pit that responded to various pumping wells. Pit dewatering sectors were delineated and pumping well locations were recommended based on areas where piezometer drawdown was not observed.

Fairbanks Gold Mining, Inc., Fort Knox Annual Dewatering Plan, Fairbanks, Alaska, (2014 – 2016): data analyst and technical support involved in annual dewatering progress reports and development of yearly dewatering plan. Dewatering progress reports reviewed the previous year's dewatering plan against the executed plan to determine how effective dewatering measures implemented matched with yearly dewatering goals. Based on the results and future mine plans, the following years dewatering plan was developed. Tasks included pit sector pumping and hydrograph analyses. Performed quarterly updates of pumping and piezometer data and produce updated charts and maps displaying pit water levels and drawdown. Annual reviews were then utilized for developing the following year's pit dewatering plan.

Directional Drilling

Freeport-McMoRan, Morenci Directional Well Placement, Morenci, Arizona (2012-2015): technical planning, data analyst, and field support for completion of two directional dewatering well placement projects, one of which was the first ever completed at a mine. The project goals were met to drill and complete pit dewatering wells that were penetrated beneath the planned mine pit shell and were collared outside of the active mining areas to maximize well run times for pit dewatering. Tasks included feasibility level well placement analysis, project engineering, project planning, development and data collection for a hydrogeologic summary report during drilling. Planning involved assessment of various drilling trajectories with respect to hydrogeologic conditions as determined through analysis in 3D geologic modeling software. Hydrogeologic summary reports were developed in real-time onsite and comprised of lithology logging, groundwater yield estimation, drilling parameter measurements, and correlation between data. After completion, hydraulic step testing and long term pump testing data were summarized and analyzed. Following the completion of the wells, extensive dewatering reviews were performed to determine the effects of the directional well placement and to address dewatering issues in the future. Tasks included data analysis and summary of a pit wide network of piezometers and pumping wells, construction of maps, and estimation of requirements for the future.

Freeport-McMoRan, Morenci Northwest Extension Horizontal Directional Drain, Morenci, Arizona (2016 – 2017): technical and field support involved in a unique directional drilling project for the planning of a horizontal directional drain targeting an extremely large volume of pregnant leach solution (PLS) trapped within a long-term heap leach dump. The goal of the project was to access the unrecoverable PLS from a down-gradient location for a natural, gravity driven drain. Developed the planned trajectory for penetrating the heap leach dump while avoiding historic pits and fill material that could negatively impact drilling. Planning involved assessment of various drilling trajectories with respect to hydrogeologic conditions as determined through analysis in 3D geologic modeling software.

Groundwater Monitoring

Resource Company, Greenland Ranch, Confidential Location (2012 – present): data analyst of on-going monitoring of pre-development groundwater level monitoring for defining base line water levels and fluctuations within two aquifers underlying the project site. The monitoring is important to set a baseline for conditions prior to groundwater development from the project location. Annual summary reports record observations and discuss findings relating to the project.

Valley Water Management Co., Cymric, Maricopa, and Southeast Taft, Bakersfield, California (2014 – 2018): technical support for groundwater level and water quality monitoring at three sites where settling ponds are located and are required to be monitored by regulators. Quarterly and semi-annual reports are prepared summarizing onsite observations.

Rio Sava Exploration, Jadar, Belgrade, Serbia (2016): data analyst reviewing vibrating wire piezometer (VWP) measurements and associated data to determine if any notable errors were made during installations performed by a third party.

Hecla Mining Co., Bulldog Silver, Creede, Colorado (2012): field support for monitoring a network of piezometers used to define water levels in an underground mine. Oversaw the installation of groundwater monitoring equipment and pumping equipment.

Boulder Community Health, Boulder Hospital Wetlands, Boulder, Colorado (2012 – 2015): data analyst and field support of a dewatering system for construction of the expanding hospital complex, but was unable to impact groundwater levels within a wetland area nearby. A slurry wall was installed to prevent drawdown within the wetland and a monitoring network of piezometers were installed to observe water levels in the area. Water pumped from the construction site was routed into the wetlands during the summer and fall to help maintain wetland water levels. Quarterly site visits were made to download data obtained from the monitoring network and sample discharge to a nearby creek for water quality analysis.

Drilling Field Work

Freeport-McMoRan, Climax West Wall, Leadville, Colorado (2013 – 2014): field support participating in field work associated with pilot hole drilling programs for site characterization and depressurization plans. Hydrogeologic testing and installation of vibrating wire piezometers (VWP) were performed for boreholes drilled. Oversaw drilling boreholes of using casing advance and reverse circulation (RC). During drilling, lithology logging and hydrogeologic testing was performed including water chemistry data collection, groundwater yield testing, and injection testing. After drilling, VWP installations were completed via fiberglass rod (FGR) at multiple levels based on data obtained during drilling. VWP data now provide multi-depth data for monitoring pore pressures at multiple locations within the pit.

AngloGold Ashanti, Cripple Creek & Victor Gold Mine, Cripple Creek, Colorado (2015): field support which oversaw the drilling and installation of VWPs within deep core holes (>2000 ft). Hydraulic packer tests were also performed to estimate in-situ rock permeability. In addition, deep water samples were taken for defining groundwater chemistry at depth. Groundwater sampling required the use of a fluorescent tracer to distinguish water added during drilling from natural groundwater.

Freeport-McMoRan, Morenci Western Copper, Morenci, Arizona (2014 – 2017): field support which participated in numerous pilot hole drilling projects for Western Copper Pit characterization and dewatering. Projects involve well site supervision, hydrogeologic testing during drilling, and piezometer installation. Hydrogeologic

testing has included packer testing and injection testing to determine hydrogeologic properties of boreholes in which VWP installations were completed at multiple depths alongside geotechnical instruments.

Rio Tinto Kennecott Copper, Bingham Canyon Fortuna Parnell Drilling, Salt Lake City, Utah (2014): field support and data analyst for the large open pit copper mine. Extensive time spent on-site overseeing the drilling and installation of multi-level piezometers and dewatering wells in a critical area of interest and targeting specific formations. Geophysical logs were performed and analyzed to assist in identifying contacts and informing piezometer placement. Further data analysis and monitoring of this critical area was performed to characterize the pit slope using 2D and 3D visual representations.

Freeport-McMoRan, Safford, Safford, Arizona (2014): field support participating in pilot hole drilling for pit characterization and dewatering. Project involved well site supervision, hydrogeologic testing during drilling, and piezometer installation. Hydrogeologic testing airlift and injection testing to determine hydrogeologic properties of boreholes in which VWP installations were completed at multiple depths.

BP, Eagle Ford, Langtry, Texas (2013): field support participating in a multi-stage project for the collection of geologic data pertaining to an outcrop of interest and subsequent completion of a groundwater production well. Oversight was provided for the drilling of a core (HQ) borehole in which the core sampling was handled by a third party sub-contractor. Following coring, the hole was opened to a larger diameter for geophysical wireline logging to be performed. After logging, the borehole was completed to depth as a groundwater well in which lithology logging, well development, and well construction was provided. Throughout the project, in accordance with well site supervision, an HSE role was essential to ensure that the project was completed safely by all parties involved.

NV Energy, North Valmy Power Station, Valmy, Nevada (2013): field support participating in the oversight of drilling, construction, and aquifer testing of large diameter production wells. Replacement production wells were required to maintain water supply to the power generation plant on-site. Tasks included facilitating daily work permits, recording pertinent data to the drilling, well construction, and aquifer testing of multiple wells.

Resource Company, Greenland Ranch, Confidential Location (2012 – present): field support participating in field work associated with the drilling and testing of two groundwater production wells. Field work during drilling included the logging of lithology in efforts of defining production versus non-production zones. After drilling, wireline logs were run and analyzed to further identify aquifer contacts and define production zones. Step testing was performed to determine well efficiency and observe drawdown during pumping. Constant rate pump testing was also performed to determine drawdown over a longer period of time and to estimate groundwater levels for future operations.

AWARDS

Performed by Schlumberger Bronze Award for “Industry 1st Integrated Mine Dewatering Technology.”	2013
Performed by Schlumberger Bronze Award for “New Mine Dewatering Technology Workflow.”	2015

PUBLICATIONS AND PRESENTATIONS

Publications

- Pantano, Christopher P., “Hydrogeochemical Controls on Microbial Coalbed Methane Accumulation in the Williston Basin, North Dakota.” Master’s Thesis, University of Arizona, 2012.
- Pantano, Christopher P., “Improving Critical Groundwater Predictions for Block Cave Mining.” WSP Insights. WSP, 2019.

Presentations

- Pantano, Christopher. "Bridging the Gap: Coupling of Geotechnical and Groundwater Models in the Mining Industry.” MODFLOW & More, 2017.
- Pantano, Christopher. "Geotechnical and Groundwater Modeling: An Integrated Approach for Block Cave Mining.” Society for Mining, Metallurgy, & Exploration (SME), 2019.

BGC ENGINEERING INC.
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CURRICULUM VITAE

GABRIELE WALSER
Water Resources Engineer

Education

Ph.D., Civil Engineering, University of Colorado (1995)

M.Sc., Environmental Engineering, Montana State University (1990)

Dipl. Ing. (FH), Engineering Physics, University of Applied Sciences Munich, Germany (1988)

Experience

2018-Present Senior Water Resources Engineer, BGC Engineering Inc.

2002-2018 Senior Engineer/Hydrologist, HydroGeo, Inc

1997-2001 Intermediate Engineer/Hydrologist, TRC Hydro-Geo Consultants

1995-1997 Junior Engineer/Hydrologist, Baker Consultants

1988 Junior Environmental Engineer, State Government of Bavaria

Affiliations

American Geophysical Union

International Mine Water Association

American Society of Civil Engineers

State of Colorado (EIT)

Years of experience: 25

Ms. Walser holds a Ph.D. in Civil Engineering and a Masters in Environmental Engineering, with more than 20 years of consulting experience. She has worked for consulting companies and regulatory agencies on environmental and water resources related projects primarily in mining and petroleum permitting, in the United States and abroad.Ms. Walser has conducted hydrologic studies, including water balance and recharge evaluations, spring surveys, ground water evaluations, and contaminant transport studies.

Following is a summary of select projects in which Ms. Walser has been involved:

Asarco, Leadville, Colorado
Developed a FORTRAN program to model temporary water retention in old underground mining tunnels before piping to a water treatment plant in Leadville, Colorado.

Khurmulinskoye Coal Mine, Russia
Used an analytical mode to simulate the de-watering effects of pumping wells to de-water a coal seam in advance of mining.

Kinross Gold Kettle River Tailings Facility, Republic, Washington
Completed a calculation of potential seepage from tailings facility, based on an empirical formula.

Rochester Mine, Coeur Mining, Pershing County, Nevada
Leakage from tailings had contaminated groundwater. Simulated cyanide contamination and cleanup of a small, perched aquifer with a finite element ground water model and random walk solute transport model.

Battle Mountain Gold, Battle Mountain, Nevada
Participated in creating a ground water model using MODFLOW, which included formation of pit lakes.

Jonah Infill Project, Pinedale, Wyoming
Oil and gas development EIS. Completed a water depletion and hydrologic impact analysis using a numerical groundwater flow model (MODFLOW) to support the EIS. Later completed an erosion, sediment and salt loading surface water study using KINEROS2 and SWAT models.

Stone Energy, Dugout Creek Project, Carbon County, Utah
Coalbed methane EA. Modeled groundwater drawdown projections and completed ground water and geology sections for EA.

Rock Creek Mine, Nome, Alaska
Planned gold mine. Created a groundwater flow model with Modflow to perform a groundwater management study. The model domain covered areas of permafrost, and non-permafrost.

West Elk Mine, Gunnison County Colorado
Coal Mine. Collected hydrological and climate data. Created hydrologic monitoring program database for the project to maintain routine ground and surface water monitoring and water quality data. Compiled Annual Hydrologic Reports and Permit Revisions as part of the mine's permit requirements for the Colorado Division of Reclamation and Mine Safety.

Blackfoot Bridge Project, Caribou County, Idaho
EIS for a Phosphate Mine. Participated in surface water flow and quality data collection for phosphate mine EIS.

Bird Canyon Field Development Project, Rock Springs, Wyoming
EIS for an oil and gas development project. Performed flood frequency calculations using empirical regression equations, and runoff and erosion modeling using KINEROS with AGWA.

Midas Gold, Golden Meadows Project, Idaho
Proposed gold mine. Planned and executed spring survey.

Lander Peak Area Exploratory Proposal, Big Piney, Wyoming
Oil and gas exploration project. Analyzed potential impacts due to erosion and sediment transport using the Tahoe Basin Sediment Model of the Water Erosion Prediction Project model (TBSM/WEPP).

Poorman Magnetite Mine, Prince of Wales Island, Alaska
Performed storm water runoff calculations, using the NRCS TR-55 method.

Mt. Emmons, Crested Butte, Colorado
Planned molybdenum mine. Created a water plan and performed a spring survey.

Green River, Utah
Used HEC-RAS to estimate the flood plain of a portion of the Green River in Utah.

South Piney Natural Gas Development Project, and Pinedale Anticline Project Area EIS, Wyoming
Completed erosion, sediment and salt loading surface water studies using KINEROS2 and SWAT models with the AGWA modeling environment within Arc-View.

Seminoe Road Project, Wyoming
Created a reservoir mixing model for the Seminoe Reservoir, estimating mixing of project discharge water and discharge chemicals with reservoir water, before reservoir water is released into the 'Miracle Mile" of the North Platte. Performed hydrologic monitoring program for the project including baseline ground and surface water studies, NPDES monitoring, database management, and completion of NPDES Monitoring Reports for the Wyoming Department of Environmental Quality. Participated in limnologic study of Seminoe Reservoir using depth profiling and baseline water quality analyses periodically for over a year. Completed surface water sections of the Seminoe Road Gas Development Project EIS.

Transwestern Pipeline Company, Phoenix Expansion Project, Arizona
Prepared water use and quality report for pipeline project. Prepared ground water sections for EA.

Meeker Gas Plant Expansion Project, Meeker, Colorado
Prepared ground and surface water sections for EA.

Husky 1 North Dry Ridge Mine Project, Soda Springs, Idaho
Proposed phosphate Mine. Project management. Participated in setup of groundwater modeling study for phosphate mine EIS.

Cardinal Draw Coal Bed Methane Project, Carbon County, Utah
Created analytical pumping and injection model for use in EA. Analyzed potential impacts of dewatering on water rights. Prepared surface and ground water sections of EA.

Fram Oil and Gas Project EA, Mesa and Montrose Counties, Colorado
Preparation of the groundwater and surface water sections of the EA.

Greens Creek Mine Tailings Disposal Facility Expansion EIS, Lead/Zinc/Silver/Gold Mine, Juneau, Alaska
Prepared the groundwater section for the EIS

Red Dog Mine SEIS, Kotzebue, Lead/Zinc Open Pit Mine Expansion, Alaska
Prepared groundwater sections of a Supplemental EIS.

Montanore Mine EIS Peer Review, Libby Montana
Completed a peer review for the Forest Service of several ground water flow models used to analyze the potential hydrologic impacts from the proposed Montanore Gold Mining Project, located in the Cabinet Mountains Wilderness Area, Montana.

Minera Yanacocha, Open Pit Gold Mine, Peru
Prepared a hydrology study for a 50,000 ha mining district near Cajamarca, Peru. Developed a spreadsheet model to estimate water depletion, which incorporated numerous field parameters. Participated in the creation of maps, delineating the watershed boundaries and significant surface water features.

Newmont South Operations Area, Open Pit Gold Mine, Carlin Nevada
NEPA Studies: Reviewed modeling results from various consultants for the groundwater model and stream flow depletion. Reviewed modeling results for pit lake creation and pit lake chemistry. Wrote the water resources portion of the EIS.

Publications

Walser, G.S., Illangasekare, T.H., & Corey, A.T. (1999). Retention of Liquid Contaminants in Layered Soils. Journal of Contaminant Hydrology. (39)1-2 pp. 91-108.

Illangasekare T.H., Znidarcic, D., Walser, G.S., & Weaver, J.W. (1994). An Experimental Evaluation of Two Sharp Front Models for Vadose Zone Non-Aqueous Phase Liquid Transport. EPA Report, EPA/600/R-94/197

Walser, G.S. (1994). Experimental Study of Macro-Scale Entrapment in Layered Soil in the Vadose Zone. Paper presented at Hydrology Days, Fort Collins, Colorado

Walser, G.S., & Illangasekare, T.H. (1994). Entrapment of Non-Aqueous Phase Liquids in Layered Materials. Paper presented at Hazardous Waste Conference, Bozeman, Montana

Walser, G.S. (1993). A Modular Approach for Multiphase Contaminant Flow Modeling - Experimental Validation of Model Components. Paper presented at Conference on Hazardous Waste Research, Great Plains - Rocky Mountain Hazardous

Substance Research Center, Kansas State University, Manhattan, Kansas.

Walser, G.S. (1992). Experimental Evaluation of Simple Sharp Front Multiphase Flow Models. Paper presented at Hydrology Days, Fort Collins, Colorado.

Lewandowski, Z., Walser, G.S., & Characklis, W.G. (1991). Reaction Kinetics in Biofilms. Biotechnology and Bioengineering, Vol. 38, pp. 877-882.

Walser, G.S., Znidarcic, D., Illangasekare, T.H., & Weaver J.W. (1991). Development of Transient Saturation Data for Evaluation of Vadose Zone NAPL Models. Paper presented at AGU Fall Meeting, San Francisco, California.

Lewandowski, Z., Walser, G., Larsen, R.W., Peyton, B.M., & Characklis, W.G. (1990). Biofilm Surface Positioning. Environmental Engineering Proceedings 1990, EE Div/ASCE, Arlington, VA, July

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CURRICULUM VITAE

HAMISH WEATHERLY, M.Sc., P.Geo.

Principal Hydrologist

Education

M.Sc., Geological Sciences, University of British Columbia (1998)

B.Sc., Applied Earth Sciences, University of Waterloo (1996)

Experience

2005-Present Principal Hydrologist, BGC Engineering Inc.

2001-2005 Hydrologist and Fluvial Geomorphologist, KWL Associates Ltd.

1999-2001 Research Associate, University of British Columbia

1996-1998 Slope Stability Analyst, EBA Engineering

Affiliations

Association of Professional Engineers and Geoscientists of British Columbia (P.Geo.)

Association of Professional Engineers and Geoscientists of Alberta (P.Geo.)

American Institute of Professional Geologists (CPG)

State of Washington (LG)

Canadian Water Resources Association

Canadian Society for Hydrological Sciences

Years of experience: 24

Mr. Weatherly has experience in the areas of hydrology, fluvial geomorphology, and debris flow/debris flood modeling. In recent years, he has worked extensively on the development of water management plans for proposed, in-construction and existing mines, as well as closure activities. This work includes diverse climatic environments such as British Columbia, Alaska, Chile, Argentina, Russia, and the Dominican Republic. Hamish has been involved in all aspects of water management including the development of site water balance models, water management strategies (in wet, arid and northern environments), and the design of infrastructure such as pond volumes, pumping capacities, diversion channels and spillways.

Following is a summary of select projects in which Mr. Weatherly has been involved:

Pascua, Chile (Current since 2017)
Technical lead to develop a snowmelt and hydrological model for various locations in the Rio del Estrecho at the proposed Pascua mine site. An energy balance snowmelt module developed by BGC for use in GoldSim (HSPF-SNOW module) was used to simulate daily snowmelt and glacier melt volumes, while a modified version of the Australian Water Balance Model (AWBM) was used to route the melt volumes to the downstream river network. Model results were used for both a pre-feasibility study and an EIA.

Faro Mine Site, Yukon, Canada (Current since 2016)
The Faro Mine Site is an abandoned zinc mine located in northern Canada. The mine site is currently under care and maintenance, but an urgent project is currently being completed to improve water quality in the receiving environment. The objective of the North Fork of Rose Creek Realignment Project is to separate non-contact water from a 124 km2 watershed and contact water seeping from historic waste rock dumps. To support separation between the non-contact NFRC flows and impacted seepage water, a non-contact diversion channel is being designed to an IFC level. The diversion channel will be raised above the valley floor to provide vertical separation from the contact water. Hamish is the hydrotechnical lead for this project: design elements include an ice pilot channel, a steep step-pool section (5%) and fish habitat considerations.

Mitigation Design, North America (Current since 2011)
Hydrotechnical lead for mitigation design of numerous pipeline exposures in BC and Alberta rivers that are subject to scour and bank erosion.

Donlin Gold Mine, Alaska, USA (Current since 2007)
As hydrotechnical lead, Hamish has been involved with all hydrotechnical aspects of the Donlin Gold Project in Alaska, USA since 2007. This work has involved: development of a calibrated site-wide WBM development of water management strategies peak flow estimates detailed hydraulic design for surface water infrastructure dam breach analyses. Numerous iterations of the mine plan have been assessed at PFS, FS, and permitting levels. The proposed gold mine is currently in the midst of a formal state Environmental Impact Assessment (EIA), which is expected to be completed in 2016. Hamish has continued to provide support to Donlin Gold through this environmental review process, as numerous questions are brought forward by regulators on an ongoing basis.

Veladero Mine, Argentina (2016-2017)
Technical lead for the development of a snowmelt prediction model in support of operational aspects related to the water management of the Heap Leach Facility (HLF) at the Veladero mine site. The request followed well above average snowpacks developing in both 2015 and 2016. The snowmelt modelling exercise was approached using two different models: an energy-based model based on the SNOW module within the Hydrologic Simulation Program Fortran (HSPF) package and the temperature index GoldSim-SRM model. The energy balance model provided a superior fit to the observed snowpack evolution.

Various Creeks, District of North Vancouver, BC, Canada (2016)
The District of North Vancouver (DNV) retained BGC to complete quantitative flood, debris flood and debris flow risk assessment and conceptual risk reduction designs for 35 steep

creeks within the District of North Vancouver. The lower portion of these creeks flow through areas containing over 20,000 buildings and a network of roads, utilities, and stormwater management infrastructure. Technical lead for the flood and debris flood hazard assessment, which included estimates of the peak flow threshold for full mobilization of the channel substrate for debris-flood prone creeks.

Cougar Creek, AB, Canada (2016-2014)
Detailed forensic and hazard assessment of debris floods at Cougar Creek in Canmore, AB. A significant debris flood in June 2013 deposited 90,000 m3 on the fan and damaged a number of homes. Short-term mitigation was recommended, including a debris net at the fan apex, bank protection with cabled concrete mats and grade control structures. These works were constructed in 2014.

Pipeline and Cortez Hills Mines, Nevada, USA (2015)
Barrick operates the Pipeline and Cortez Hills mine complexes as part of the overall Cortez Operations in southern Crescent Valley, Nevada. The mineralized zones occur below the historical water table at both the Pipeline and Cortez Hills complexes, so dewatering is required in advance of mining. Hamish developed a water balance model to evaluate the potential impacts to a regional creek from the simulated groundwater discharge reduction

Line 9B Reversal, Ontario, Canada (2015)
Senior hydrotechnical review for over 300 river crossings along Line 9B, which is an existing 639 km long pipeline. This pipeline section runs from North Westover, Ontario to Montreal, Quebec, and Enbridge has applied to the National Energy Board (NEB) to reverse the flow of oil in the pipeline. As part of this application, hydrotechnical hazards have been assessed in detail at each watercourse rossing. This work has included floodplain delineation, peak flow estimates, scour assessments for the regulatory flood, and geomorphic characterization.

Brucejack Gold Mine Project, BC Canada (2014-2017)
Development of a water management plan and site-wide water balance model (WBM) for a proposed underground mine in northern BC. The work included feasibility-level assessments for Environmental Assessment (EA) and Mines Act (MA)-Environmental Management Act (EMA) permitting. Hydrologic and hydraulic design of a contact water pond and a low level weir at the lake outlet. The project recently received final provincial and federal permits, and is currently under construction.

Trans Mountain Expansion Pipeline (TMEP), BC, Canada (Current since 2014)
Senior hydrotechnical review for over 800 river crossings along the TMEP for Kinder Morgan. This pipeline would twin an existing pipeline, which runs from northwest Alberta to Vancouver, BC. Hazards assessed include scour, bank erosion, avulsion and channel degradation. The primary deliverable of this work is recommended burial depths and setback distances for sagbends. This work has included a quantitative risk assessment (QRA) of all geohazards, including hydrotechnical hazards.

Giscome Quarry, BC, Canada (Current since 2014)
Hydrotechnical lead for federal and provinical permitting of a limestone quarry located near Prince George, BC. The work has involved detailed design of four sedimentation ponds, including pipeline and pumping infrastructure, a site-wide WBM and a water management plan for all phases of the project – construction through post-closure.

Exshaw Creek, AB, Canada (2014-2015)
Project manager and main hydrotechnical lead for a hazard and risk assessment of debris floods at Exshaw Creek and Jura Creek in the town of Exshaw, AB. A significant debris flood in June 2013 deposited over 20,000 m3 on the fan and damaged a number of homes. Debris flood magnitude (peak flows and sediment volume) was defined for various return periods. A detailed risk assessment was also conducted based on hydraulic modelling, followed by conceptual design options to mitigate against future hydrogeomorphic events.

Bow River, Canmore, AB, Canada (2014)
Project manager and technical review for development of a HEC-RAS 1D hydraulic model to assess the existing hydraulic capacity of dykes located on a 10 km stretch of the Bow River. The model was developed for the Town of Canmore and used in emergency preparedness and response prior to the 2014 freshet.

Ajax Mine Project, BC, Canada (Current since 2013)
Technical lead for development of a site-wide WBM for a proposed copper mine outside of Kamloops, BC. The work included a detailed WBM and water management plan for provincial EA and MEMA permitting. This site is complicated in that much of the streamflow is generated at higher elevations, upgradient of the mine site, while local tributaries show no evidence of surficial runoff

Prince Rupert Gas Transmission Line (PRGT), BC, Canada (2013-2015)
BGC's technical lead for detailed hydrotechnical (scour, bank erosion, avulsion and channel degradation) assessments for the proposed PRGT. The approximately 900 km pipeline is expected to deliver natural gas from a point near the District of Hudson's Hope to the proposed Pacific NorthWest LNG facility within the District of Port Edward on Lelu Island. The primary deliverable of this work was recommended burial depths and setback distances for sagbends.

Flood and Geohazard Risk Review, Southwestern Alberta, Canada (2013-2015)
Flood and Geohazard Risk Review, Southwestern Alberta, Canada (2013 to 2015)

Hydrotechnical lead/review for a risk-based prioritization of steep creek fans, encroachment and flood hazards in a 70,000 km2 region of Southwestern Alberta. The assessment included the first complete inventory of over 700 fans intersecting major roads or development, and analysis of encroachment and flood inundation hazards affecting 3,400 linear km of highways.

Town of Canmore, Alberta, Canada (2013-2014)
Forensic analyses for 9 creeks within the Town of Canmore that were impacted by debris floods and debris flows in 2013.

Pacific Trails Pipeline (PTP), BC, Canada (2013)
Hydrotechnical lead for detailed river crossing assessments for the proposed gas pipeline in British Columbia, the PTP, including the evaluation of aerial crossings. The PTP is a proposed 480 km natural gas pipeline that will deliver gas from Summit Lake, B.C. to the Kitimat LNG facility site at Bish Cove on the northwest coast of British Columbia.

Gibraltar Mine, BC, Canada (2013)
Technical lead for detailed hydrotechnical design of a 6 km containment ditch at Gibraltar Mine in central British Columbia. The ditch is used to contain surface contact runoff from a waste rock dump. Erosion control included sediment ponds, riprap and turf-reinforced mats (TRMs).

Detour Lake Gold Mine, Ontario, Canada (Current since 2012)
Technical lead for development and ongoing calibration of a WBM for Detour Lake Mine in northern Ontario, which began production in January 2014. The model is being used to guide future development of the facility (a total of three tailings cell are currently proposed) and the potential need for water treatment.

Porcupine Gold Mine, Ontario, Canada (Current since 2012)
Technical lead for development and ongoing calibration of a WBM for Porcupine Gold Mine in northern Ontario. The probabilistic WBM is used by operations to determine the extent of water treatment of supernatant tailings pond water in late summer and fall. The guiding principle of water management is to prevent spills of tailings water to the environment.

New Afton Mine, BC, Canada (Current since 2012)
Technical lead for development and calibration of a WBM for the New Afton Mine in Kamloops, BC. This underground mine has subaerial tailings disposal and uses fresh water from the Thompson River, which is a sensitive resource.

Albion and Road Thirteen Dike, BC, Canada (2012-2013)
Project manager and hydrotechnical lead for a flood hazard and risk assessment of the Albion Dike. This dike protects a largely industrial area adjacent to the Fraser River in Maple Ridge, BC.

Donlin Gold Mine, Alaska, USA (2012)
Evaluation of potential scour depths for a proposed gas pipeline in Alaska, USA, which would deliver gas to the Donlin Gold Project.

Natalka Gold Project, Russia (2012)
Development of a feasibility-level WBM for the Natalka gold deposit in Russia, as technical lead. This work included teaching a 2-day course on WBMs and water management strategies to Polyus Gold employees in Moscow, Russia. Technical issues included constructing a 10 km long, low-gradient freshwater diversion channel through permafrost terrain.

Mitigation Design, North America (Current since 2011)
Hydrotechnical lead for mitigation design of numerous pipeline exposures in BC and Alberta rivers that are subject to scour and bank erosion.

River Crossings, North America (Current since 2011)
Hydrotechnical and geomorphic assessment of existing pipeline river crossings throughout western North America (British Columbia, Alberta, Montana, Wyoming, Missouri, Kansas) for numerous clients including Enbridge, Plains Midstream, Terasen Gas, Kinder Morgan, Pembina, Alliance, Specta Energy, and Suncor. Assessments include evaluation of potential scour depth for different return period floods and bank erosion rates that could expose or rupture pipelines. Bank erosion is assessed using historical air photographs and a bank erosion model developed internally by BGC. Hamish is BGC's main hydrotechnical lead and reviewer for a comprehensive program, which typically includes on the order of 100 detailed studies a year.

Cochenour Gold Mine, Ontario, Canada (2011-2013)
Development and calibration of a WBM for Cochenour Mine in northwestern Ontario. Also development of a tailings management plan, which involved hydrologic routing and hydraulic calculations for spillways.

Cheekye River, BC, Canada (2010-2011)
Debris flow modelling (FLO-2D) of Cheekye Fan, Brackendale for return periods of up to 1:10,000 years.

La Coipa Mine, Northern Chile (2010-2011)
This operating gold mine is located at the southern fringes of the Atacama Region of northern Chile, a very arid region with less than 100 mm of annual precipitation. A groundwater contamination plume, related to tailings disposal, currently extends downstream of the mine site in an alluvial aquifer. Recharge estimates were conducted for the site as part of an assessment of the groundwater contamination.

Wabush Mine, Labrador, Canada (2010-2011)
Project manager and hydrotechnical lead for detailed design and construction supervision of two settling basins at the Wabush iron ore mine in Labrador. The first phase of the project involved the evaluation of repeated TSS exceedances at the mine site and the identification of mitigation options. Settling ponds with flocculent dosing was identified as the only viable option to reduce TSS levels. Design and construction of these ponds was completed in late 2011.

Cerro Casale, Chile (2010)
Conducted a hydrotechnical assessment of river crossings and provided recommendations regarding burial depth and sagbend

locations for two mine-related pipelines (total length = 335 km) and a transmission line that cross high Andean terrain in northern Chile (Cerro Casale).

Donlin Gold Mine, Alaska, USA (2010)
Analysis of potential bank erosion due to waves generated from barges, Lower Kuskokwim River, Alaska.

Upper Clowhom River, BC, Canada (2010)
Geomorphic analysis of the impacts of a run-of-river project on sediment transport rates and channel morphology (Upper Clowhom River, BC).

Kootenay River, BC, Canada (2009-2012)
Project manager and hydrotechnical lead for a flood risk study completed for the Kootenay River south of Kootenay Lake (Creston Valley). This work was conducted for the Lower Kootenay Band and the end product was a floodplain management plan that balances flood risk management with consideration of economic, ecological, social, and cultural values. The key deliverable was a floodplain management plan (FMP) that could be realistically implemented by the local community. The work occurred over a four year period (2009 to 2012) and included: hydrologic analysis hydraulic modelling assessment of bank erosion, dike stability and evaluation of repair costs for almost 100 km of diking economic consequence assessment of valley-wide flooding due to a dike breach an environmental assessment and quantitative flood risk assessment (QFRA), including a cost-benefit analysis, to evaluate various strategies for flood management and mitigation.

Cerro Casale, Northern Chile (2009-2012)
This proposed gold mine is located in northern Chile in a region with low annual precipitation on the order of 80 to 150 mm. The work involved feasibility-level studies for the proposed mine including: development of a calibrated site-wide WBM, development of water management strategies, peak flow estimates, and hydraulic design for surface water infrastructure (freshwater diversion channels and contact water collection ditches).

Fedorovo Project, Northwest Russia (2009-2010)
This proposed gold mine is located in northwest Russia above the Arctic circle. The scope of work included: development of a calibrated site-wide WBM, development of water management strategies, peak flow estimates, and hydraulic design for surface water infrastructure (freshwater diversion channels and contact water collection ditches).

Wapisiw Lookout (Pond 1), Alberta, Canada (2009-2010)
Hydrologic modelling using HSPF was used to support the detailed closure design of Pond 1 in the Oil Sands Area of Fort McMurray. Wapisiw Lookout is the first oil sands tailings pond (220 ha) transformed to be actively revegetated and reclaimed. The first step in the reclamation was infilling the pond with 30 Mt of reclaimed tailings sand. Sand was also used to develop drainage systems and swales to manage runoff from the reclaimed landscape. Pond reclamation was complete by the end of 2010.

Suncor, Alberta, Canada (2009)
Hydrotechnical lead for development of a detailed closure drainage plan (CDP) for Suncors's West Side in the Oil Sand Area of Fort McMurray. A similar scope of work was conducted for Syncrude's Mildred Lake facility.

Mildred Lake, Alberta, Canada (2008-2014)
Hydrotechnical lead for development of a detailed closure drainage plan (CDP) for Syncrude's Mildred Lake Operations in the Oil Sand Area of Fort McMurray. The work estimating streamflows for a closure landscape using the hydrologic model – Hydrologic Simulation Program-Fortran (HSPF), which has been calibrated to site conditions. The synthetic streamflows were then used for detailed channel and end pit lake (EPL) design. As evaporation can exceed precipitation is many years, soil moisture storage is an important component of the hydrologic cycle. Several iterations of the CDP have been developed since 2008.

Pueblo Viejo Gold Mine, Dominican Republic (2008-2012)
Hydrotechnical lead for detailed hydrologic and hydraulic design (storage and pumping capacity, spillways) of cofferdams (2) and dams (3) for the Pueblo Viejo project in the Dominican Republic. BGC was the engineer of record for these structures, construction of which was completed in 2012. Annual rainfall in the area is around 2000 mm with the hydraulic design criteria governed by high intensity storms of short duration and Class IV hurricanes in the Caribbean. Additional work completed included: development of a calibrated site-wide WBM and development of water management strategies for operations (with a particular emphasis on extremely wet and dry periods). Production at this mine started in late 2012.

Donlin Gold Mine, Alaska, USA (Current since 2007)
As hydrotechnical lead, Hamish has been involved with all hydrotechnical aspects of the Donlin Gold Project in Alaska, USA since 2007. This work has involved: development of a calibrated site-wide WBM, development of water management strategies, peak flow estimates, detailed hydraulic design for surface water infrastructure, dam breach analyses. Numerous iterations of the mine plan have been assessed at PFS, FS, and permitting levels. The proposed gold mine is currently in the midst of a formal state Environmental Impact Assessment (EIA), which is expected to be completed in 2016. Hamish has continued to provide support to Donlin Gold through this environmental review process, as numerous questions are brought forward by regulators on an ongoing basis.

Fraser River, BC, Canada (2007-2008)
Pilot study for the City of Chilliwack where flood risk due to a dike breach along the Fraser River was evaluated. Various dike breach scenarios were modelled using MIKE FLOOD, and the resulting floodplain depths were used to estimate the direct and indirect costs of flooding. These results can then be applied to prioritize floodplain management planning.

Fitzsimmons Creek, BC, Canada (2007)
Debris flood modelling (using FLO-2D, a 2-D hydraulic model) of landslide dam outbreak floods at Fitzsimmons Creek, Whistler, BC.

Pascua Lama Project, Chile (2006-2007)
Investigation into cryosphere reserves (glaciers, permafrost and rock glaciers) at the proposed gold mine in the Argentine Andes. The work involved the identification of cryosphere reserves at this high altitude, arid site, followed by an assessment of the role of these reserves in contributing runoff to the downstream stream network.

Lower Nooksack River, Washington, USA (2006)
Sediment budget (bedload) for a 35 km reach of the Lower Nooksack River, Washington State.

Lower Nooksack River, Washington, USA (2005-2006)
Development of a Sediment Management Plan for Lower Nooksack River, Whatcom County, Washington State.

Lillooet River, BC, Canada (2004-2005)
Development of a Sediment Management Plan for Lillooet River within the town of Pemberton.

Swift Creek, Washington, USA (2004-2005)
Investigation of a large earthflow at Swift Creek in Whatcom County, Washington State and associated sedimentation and debris flow hazards.

Landslide Modelling, CIDA, Chile (2004)
Overview course on numerical landslide modelling in Santiago, Chile for a CIDA (Canadian International Development Agency) funded landslide project administered by the Geological Survey of Canada and involving all Andean countries and their respective geological surveys.

Gravel Removal Design, BC, Canada (2003-2004)
Design of gravel removal at Fitzsimmons Creek, Whistler and Lynn Creek, District of North Vancouver.

Jones Creek, Washington, USA (2003-2004)
Detailed debris flow investigation of Jones Creek, Whatcom County, Washington including radiocarbon dating of debris flow deposits on the fan.

Squamish River, BC, Canada (2003)
Erosion assessment of Squamish River for reaches downstream of BC Hydro's Cheakamus Generating Station.

Lower Fraser River, BC, Canada (2002-2006)
Design of gravel removals from various gravel bars on Lower Fraser River from 2002 to 2006. Excavations were designed to minimize adverse habitat and morphological impacts.

District of North Vancouver, BC, Canada (2002-2003)
Detailed debris flow and debris flood studies of ten creeks within the District of North Vancouver, BC. This work included debris flow modelling to delineate the fan hazards of Mackay Creek and Percy Creek in the District of North Vancouver, and Jones Creek in Whatcom County.

Canyon Creek, Washington, USA (2002-2003)
Debris flood study for Canyon Creek, Whatcom County, Washington including: 1-D modelling of landslide dam outbreak floods 2-D modelling on Canyon Creek fan for 1:500 year event determination of debris flood magnitude for various return periods and preparation of a debris flood hazard map.

Eagle River, BC, Canada (2002)
Geomorphic and hydraulic assessment of fish obstruction on Eagle River (CP Rail) due to channel straightening.

Lilloet River, BC, Canada (2001-2002)
Lower reaches of Lillooet River have been severely affected by engineering works over the past 60 years, including meander cutoffs, base lowering of Lillooet Lake, dyking and extensive bank protection. Historic changes in channel cross-section and planform (using orthorectified airphotos dating back to 1947) were analyzed to determine to determine sediment transport rates, and predict future trends in bank erosion and channel stability. This work was conducted for the Pemberton Valley Dyking District.

Vedder River, BC, Canada (2001)
Modelling of sediment (bedload) transport in Vedder River, a tributary of Fraser River

Lower Fraser River, BC, Canada (2000-2001)
Statistical analysis of suspended sediment data from Fraser River relating suspended sediment concentrations to discharge (contaminant transport).

Lower Fraser River, BC, Canada (2000)
Analysis of potential channel changes at a number of bank erosion sites on Lower Fraser River using channel mapping that extends back to 1913.

Lower Fraser River, BC, Canada (1999-2001)
Assisted in the development of a sediment budget for a 60 km reach of the Lower Fraser River using bathymetric surveys from 1952, 1984 and 1999.

Publications

Eaton, B.C., MacKenzie, L., Jakob, M., & Weatherly, H. (2017). Assessing erosion hazards due to floods on fans: physical modelling and application to engineering challenges. . Journal of Hydraulic Engineering 143(8).

Weatherly, H., & Jakob, M. (2014). Geomorphic response of Lillooet River British Columbia to meander cutoffs and base level lowering. Geomorphology 217 48-60

Jakob, M., Holm, K., Weatherly, H., Liu, S., & Ripley, N. (2012). Debris flood risk assessment for Mosquito Creek British Columbia Canada. Natural Hazards DOI 10.1007/s11069-012-0436-6

Jakob, M., McDougall, S., Weatherly, H., & Ripley, N. (2012). Debris-flow simulations on Cheekye River British Columbia. Landslides DOI 10.1007/s10346-012-0365-1

Jakob, M., Weatherly, H., & Ellis, E. (2010). Determining the design event at Fitzsimmons Creek. 63rd CWRA National Conference June 15-18 2010 Vancouver BC

Weatherly, H. (2010). The utility of monthly water balances. 63rd CWRA National Conference June 15-18 2010 Vancouver, BC

Jakob, M., & Weatherly, H. (2008). Integrating uncertainty Canyon Creek hyperconcentrated flows of November 1989 and 1990. Landslides 5 83-95

Jakob, M., & Weatherly, H. (2005). Debris flow hazard and risk assessment Jones Creek Washington. Landslide Risk Management Edited by Hungr Fell Couture

Jakob, M. & Weatherly, H. (2003). A hydroclimatic threshold for landslide initiation on the North Shore Mountains of Vancouver, British Columbia. Geomorphology 54: 137-156

Jakob, M., Weatherly, H., & Pittman, P. (2003). Jones Creek - 5000 years of debris flow history. Geological Society of America Annual Meeting and Exposition November 2-5 2003 – poster presentation Seattle Washington

Jakob, M., & Weatherly, H. (2003). A hydroclimatic threshold for landslide initiation on the North Shore Mountains of Vancouver British Columbia. Geomorphology 54 137-156

Weatherly, H. & Jakob, M. (2003). Lillooet River – geomorphic change and its impact on floodplain management. 56th CWRA National Conference – June 11-13, 2003. Vancouver, British Columbia.

Weatherly, H., Jakob, M., Cooper, P.J., & Currie, M.V. (2003). Outbreak floods at Canyon Creek – a hazard assessment. Geological Society of America Annual Meeting and Exposition – November 2-5 2003 Seattle Washington

Weatherly, H., & Jakob, M. (2003). Lillooet River – geomorphic change and its impact on floodplain management. 56th CWRA National Conference – June 11-13 2003 Vancouver British Columbia

Ferguson, R.I., Church, M., & Weatherly, H. (2001). Fluvial aggradation in the Vedder River British Columbia testing a one-dimensional sedimentation model. Water Resources Research 37(12) 3331-3347

L. EVERETT & ASSOCIATES
ENVIRONMENTAL CONSULTANTS

James T. Wells, PhD, PG

Environmental Geologist

L. Everett & Associates, LLC
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Santa Barbara, CA 93105
805-880-9302
jwells@everettassociates.net

Education

University of Washington, Ph.D., Geological Sciences, 1990

University of Washington, M.S., Geological Sciences, 1986

Dartmouth College, B.A., Earth Sciences, 1981

Professional Registration

2001/California: Professional Geologist (Reg. No. 7212)

Professional Societies

Geological Society of America

American Ground Water Association

American Chemical Society

International Society of Environmental Forensics

Dr. Wells is an environmental geologist with over 25 years of experience in hydrogeology and geochemistry and is a Professional Geologist, registered in California. His area of expertise includes groundwater hydrology, fate and transport of contamination in soil and groundwater, environmental forensics and the geochemistry of metals in the environment. He is a member of the Editorial Board of the journal, Environmental Forensics, a quarterly peer-reviewed scientific journal of national and international circulation. He is the author and coauthor of numerous scientific publications, including the recently published forensic review articles in Environmental Science & Technology (U.K. Edition) Special Issue dedicated to Environmental Forensics.

Dr. Wells has worked on over 100 sites around the country, each with unique issues related to soil or groundwater quality. He serves clients in the areas of site investigations, soil and groundwater remediation, risk-based studies of soil and groundwater contamination, and litigation support. Dr. Wells has managed complex environmental programs on behalf of large corporations. His environmental forensics practice focuses on using advanced analytical techniques to solve questions related to the origin, cause, timing and evolution of subsurface contamination. He has extensive experience in groundwater and vadose zone computer modeling, as well as in the statistical analysis of geological systems. L. Everett & Associates' billing rate for Dr. Wells is $275/hr. His hourly rate for deposition and trial testimony is $500/hr.

Employment History

L. Everett & Associates, LLC. 2010-present

Haley & Aldrich. 2006-2010

Shaw Environmental. 2005-2006

Haley & Aldrich. 2001-2005.

Ogden Environmental. 2000-2001

Metcalf & Eddy. 1991-2000

Representative Project Experience

SIMA Property Corporation – Chlorinated Solvent Site in California.
Conducted site characterization, remediation planning, regulatory negotiation for PCE in soil, soil vapor and groundwater at this dry cleaner site, with special emphasis on the potential for vapor intrusion into nearby commercial buildings.

Reedley Remediation Trust – Chlorinated Solvent Site in California.
Provided site characterization and remediation planning advice for this comingled

PCE groundwater plume. Also advised on the formation of a remediation trust to insure adequate resources for a long-term cleanup program.

Isola Law Group – Rialto-Colton Superfund Site. Provided litigation support in complex, multi-party lawsuit concerning cost allocation, contaminant fate and transport and remediation technologies for large (5-mile long) perchlorate and TCE groundwater plume.

San Carlos Apache Tribe – Technical Advice on Proposed Copper Mine. Advised the Tribe on environmental aspects of large proposed copper mine project which the Tribe opposed. This work involved meetings and negotiations with mining company and officials of the US Forest Service regarding intergovernmental consultations and the EIS process, expert testimony in an administrative hearing, presentations at Tribal Council meetings, meetings in Washington DC with Council on Environmental Quality, EPA, USDA and Congressional staff.

Applies expertise in geo-chemistry and hydrogeology to solve environmental problems

KB Gardena – Litigation Support & Subsurface Remediation. Provided attorneys with technical advice and assistance with cost allocation strategy for multi-million dollar case with multiple PRPs. Conducted site remediation for PCE, metals and other VOCs.

Pacific Gas & Electric Company – Forensic Geochemistry. Analyzed high-resolution petroleum hydrocarbon data, including PIANO analysis, relative solubility and hydrocarbon weathering assessments to evaluate the theory that contamination discovered on client's property originated from off-site sources and was not due to on-site releases. PIANO analysis is a forensic technique for complex hydrocarbon mixtures using gas chromatography to speciate individual hydrocarbon compounds and group the compounds into their molecular classifications: paraffins (P), isoparaffins (I), aromatics (A), naphthalenes (N) and olefins (O).

Rand Family Trust – Petroleum hydrocarbons in soil and groundwater. Conducted site characterization and site remediation for a commercial site in Santa Barbara, California. Achieved closure of this case from the local regulatory agency.

Pacific Gas & Electric Company – Litigation Support. Provided litigation support, including participation in mediation, for a case involving petroleum hydrocarbons in soil and groundwater.

USEPA – Del Amo and Montrose Superfund Sites. Analysis of potential exposure scenarios and efficacy of remediation plans from PCBs, metals and VOCs from Superfund sites in Los Angeles under EPA's TASC program (Technical Assistance Services for Communities).

Terracon, Inc. – Groundwater Modeling and Litigation Support. Complex construction defect case involving claims of $60 million in damage allegedly due to soil expansion caused by rising groundwater from irrigation of nearby golf

course and residential areas. Opposing experts spent two years and $2 million on groundwater modeling which was eventually excluded from trial after we demonstrated unreliability and lack of relevance to judge.

St. Joe, Missouri—Chromium in Tannery Waste. Provided litigation support for case in which tannery waste had been spread as soil amendment over approximately 56,000 acres of agricultural land. It had been known that the sludge contained elevated levels of metals, including chromium. It was apparently not known that some of the chromium was in the form of toxic Cr(VI) which posed a serious risk to human health and the environment.

His area of expertise includes environmental forensics and fate and transport of organic and inorganic contaminants in soil and groundwater

State of Idaho – Soil Remediation Pilot Study for Metal Stabilization on the Coeur d'Alene Mining District. Conducted field pilot study on metal stabilization along the Coeur d'Alene River. The river feeds Lake Coeur d'Alene which is highly-impacted by the cumulative effects of 100 years of mining in the watershed and is the primary source of drinking water for over 50,000 residents of northern Idaho. Work was sponsored by the U.S. Environmental Protection Agency (EPA) and State of Idaho in an effort to find a cost-effective means of addressing widespread soil contamination along a 30 mile stretch of the Coeur d'Alene River.

Confidential Client – Environmental Forensics for Metals. Conducted forensic analysis of groundwater contamination allegedly emanating from a mining operation. The project involved fate and transport evaluations, groundwater hydrogeology, and geochemistry.

Litigation Support – Metals Contamination
Provided litigation support in case involving alleged lead and arsenic soil contamination due to pesticides.

Koch Oil, Oklahoma – Forensic Geochemistry. Conducted forensic geochemical evaluation on naturally-occurring compounds in groundwater to assess whether historical groundwater concentration trends constituted natural background variability or potential releases from client's brine impoundments.

Tri-County Public Airport, Herington, Kansas – Forensic Geochemistry. Conducted oxygen, deuterium, chlorofluorocarbon (CFC), carbon isotope analysis of groundwater and chlorinated contaminants in order of evaluate contaminant fate and transport at a former military facility.

Gonzalez & Robinson – Groundwater Modeling. Used groundwater computer modeling to simulate groundwater flow in a residential region of Sonoma County, California.

Confidential Client – Environmental Forensics for Chlorinated Solvents. Conducted forensic analysis of chlorinated solvent contamination extending in groundwater over two miles under a community. The site involved multiple releases from multiple locations and complex hydrogeology and attenuation histories.

Kimberly-Clark, Ohio – Forensic Geochemistry. Conducted forensic geochemical analysis to demonstrate that significant component of groundwater contamination under client's site had migrated from an off-site source. Utilized compound-specific carbon isotope analysis of chlorinated compounds and daughter product abundance. This analysis was complicated by the fact that there were low levels of residual contamination from an old on-site release, which needed to be definitively differentiated from the larger off-site flux of contaminants.

Western States Petroleum Association – Risk-Based Clean-up Studies. Conducted a study to develop risk-based clean-up standards for crude-oil-impacted soils, including studies of the comparative environmental risks posed by crude oil, gasoline, and diesel oil in the subsurface. Applied leaking underground fuel tank evaluation methods to crude oil sites and developed cost-effective site assessment strategies.

Tesoro Petroleum Company – San Fernando Investigation and Remediation of MTBE Plume. Managed a project in Southern California to delineate and clean-up a large release of methyl tert-butyl ether (MTBE) to soil and groundwater. A particular challenge of this project was to account for the presence of multiple high-volume water supply wells near the project site, a situation involving extensive regulatory negotiation with California Regional Water Quality Control Board (RWQCB), California Department of Health Services and Upper Los Angeles River Area Watermaster.

Isola Bowers, LLP – Environmental Litigation Support. Served as expert witness in a case involving a large release of MTBE-bearing gasoline to groundwater. Estimated volume of release and reconstructed release and plume migration history.

Gallagher & Kennedy – Litigation Support. Provided litigation support for a lawsuit involving a 996-acre brownfield site. The site, used since the 1930s for munitions manufacturing and assembly, had soil and groundwater contamination from historic releases of perchlorate and chlorinated solvents. When the local municipality took 13 acres of the property by eminent domain to build a new regional highway, the property owner sued to recoup the cost of the land. The municipality estimated a cleanup cost of $220 million and, based on this, valued the land at only $142,000. With colleagues, developed a soil and groundwater remediation plan and cost estimate. Through extensive soil and groundwater data analysis and 3D modeling, demonstrated that while portions of the site were highly contaminated, much of the site was not contaminated and a lower cost remediation was feasible. Our remediation plan dovetailed remediation with pre-development activities and employed state-of-the-art remediation technologies for perchlorate at a cost $27 million. A jury accepted the accuracy of Haley & Aldrich's remediation estimate, and awarded the owner over $12 million for land value and severance damages.

ContiGroup Companies, Stockton, CA – Groundwater Remediation.

Completed comprehensive subsurface characterization study and designed a remediation strategy for this grain elevator site with carbon tetrachloride and other volatile organic compounds in groundwater. Due to the complex stratigraphy and heterogeneous distribution of contaminant throughout the aquifer, an in-situ chemical treatment strategy was designed for this site coupled with an initial, short-term phase of groundwater extraction to achieve containment of the contaminant plume.

Confidential Client - Aircraft Manufacturer – Service Delivery Leader. Served as Service Delivery Leader, responsible for coordinating quality and consistency for a team located in six offices and providing environmental services simultaneously on up to ten large projects. Also conducted vadose zone computer modeling to evaluate clean-up standards for soil that would be protective of future groundwater quality.

Northrop-Grumman Corporation—Remediation Planning. Provided analysis of environmental data and regulatory requirements for large site with multiple occurrences of contamination in soil and groundwater. Advised client on cost-effective strategies and technologies for resolving environmental impairment.

Archbald & Spray, LLP – Environmental Litigation Support. Served as expert witness on environmental issues for the case, Exxon v. Ebasco. In this case, environmental issues included storm water management, erosion control, hazardous waste handling, water quality and regulatory compliance during construction of a large petroleum processing facility in Santa Barbara County, California.

Price, Postel & Parma, LLP – Environmental Litigation Support. Provided environmental review and interpretation in support of legal cases. Served as expert witness on cases involving groundwater contamination and aquifer remediation.

Tesoro Petroleum Company – Feasibility Study for Remediation of Free Product. Conducted a feasibility study for containment and remediation of a large plume of free phase petroleum plume at a refinery in Kenai, Alaska. Migration of the light non-aqueous phase liquid was influenced by complex fluvio-glacial stratigraphy and by fluctuating groundwater levels.

Exxon Company, U.S.A. – Remediation Planning. Developed remediation and regulatory strategies for the closure of a large urban oil field in California, which consists of over 500 production sites over four square miles of residential and commercial districts. The proposed strategy was a risk-based approach addressing such factors as cost, schedule, future liability and land use.

Confidential Client - Aircraft Manufacturing Site Redevelopment Environmental Program. Team member for comprehensive subsurface investigation program for 343-acre former manufacturing facility. This complex project involved over 1500 soil borings, web-based data repository, risk-based formulation of clean-up standards, production of data reports specifically

designed for use by potential buyers and other stakeholders and close coordination with redevelopment staff.

Nestlé, U.S.A. –Aquifer Remediation. Working with Nestlé technical staff, developed a technical strategy and gained regulatory acceptance of a passive bioremediation approach at an underground storage tank (UST) site which contained hydrocarbon contamination in groundwater in a beneficial-use aquifer.

San Diego County Aquifer Storage and Recovery. Served as technical advisor on project evaluating the feasibility of aquifer storage and recovery operation in central San Diego County, California. Project involved extensive groundwater modeling, evaluation of climate variability and evaluations of geochemical compatibility of various potential sources of water with native groundwater and aquifer matrix.

County of San Luis Obispo Water Supply – Nitrate in Groundwater. Conducted a study of nitrate contamination in shallow groundwater at Los Osos, California, a community that relies solely on groundwater for its municipal water supply. The study incorporated site-specific data on the transport and transformation of nitrogen in the subsurface to develop a nitrogen mass balance for all significant nitrate sources. This work resulted in quantitative estimates of the contribution of septic system effluent to nitrate levels in groundwater.

U.S. Navy – Groundwater Investigations and Remediation Planning. Managed site investigations, feasibility studies and remediation planning at eight contaminated sites overlying (and in some cases, impacting) the sole-source aquifer at Camp Pendleton Marine Corps Base.

Santa Barbara Historical Society – Environmental Consulting. Provided environmental consulting services, advice, reviews of reports and data and participated in negotiations with Southern California Edison (the responsible party) on behalf a Santa Barbara nonprofit organization. This work focused on soil and groundwater investigations, remediation plans and associated risks related to soil and groundwater contamination at a former manufactured gas plant on the nonprofit's property.

Sequoia Voting Systems – Groundwater Investigations. Managed a project involving chlorinated compounds in groundwater in which I developed supporting data and argued for relief from active remediation on the grounds of the existence of natural contaminant of the chlorinated plume. Our approach was approved by the state.

Los Angeles Metropolitan Transportation Authority (LACMTA)– Comprehensive Environmental Services. Project manager for comprehensive hazardous waste assessment contract with the LACMTA. For this project, M&E provided environmental services in support of land acquisition and construction for a light-rail commuter line in the Los Angeles area.

Private Client – Vadose Zone Studies. Performed detailed vadose zone

investigations in support of landfill siting projects which involved geophysical surveys and soil testing to assess the nature and distribution of soil moisture and to assess the potential for contaminant migration in the vadose zone.

State of California – Soil and Groundwater Remediation. Implemented an air sparging/soil vapor extraction soil and groundwater remediation system at a UST site with extensive vadose zone and dissolved groundwater plumes.

U.S. Air Force – Risk-based Strategies for Soil. Utilized the California RWQCB Designated Level Methodology to establish clean-up levels for soil contaminated with petroleum hydrocarbons at Beale Air Force Base, California. This project involved vadose zone contaminant transport computer modeling to arrive at soil clean-up levels that would produce acceptable predicted impacts to underlying groundwater.

Various Clients – Geostatistical Programs. Developed programs for the statistical analysis of groundwater monitoring data for a mining facility, petroleum refinery, wastewater reclamation operation and a municipal waste landfill, all in Central California. Projects involved the implementation of EPA-approved statistical techniques to evaluate the differences between background and downgradient concentrations of groundwater contaminants.

Depositions and Trial Testimony

2020. Houlihan v. UTC, et al., Deposition Testimony.

2020, Acosta v. Shell Western E&P, et al., Trial Testimony.

2019, Strong v. Republic Services, et al., Deposition Testimony.

2019, McClurg, et al. v. Mallinckrodt, Inc., et al., Deposition Testimony.

2019. Brooks v. PB Products North America, et al., Deposition Testimony.

2018, Renzel v. Ventura, Deposition Testimony.

2018, Weiand Automotive Industries, Inc. et al., Deposition Testimony.

2017, Greenfield MHP Associates, L.P., et al.vs. Ametek, Deposition Testimony.

2017, Wyatt, et al., vs. ABB, Inc., Deposition Testimony.

2016, Kirk vs. Schaeffler, Deposition and Trial Testimony.

2016, Goldberg vs. Goss-Jewett, et al., Deposition Testimony.

2015, Hawkins, et al., vs. Vista Ridge Development Corp., et al., Deposition Testimony.

2013, Enns Pontiac, et al., vs. Flores, et al., Deposition Testimony.

2012, Steadfast, et al., vs. Terracon, et al., District Court of Jefferson County, Colorado, Deposition and pre-trial Hearing Testimony.

2012, Kartal vs. Chang, et al., Deposition Testimony.

2011, Johnson, et al., vs. Prime Tanning Corp., et al., Circuit Court of Buchanan County, Missouri, Deposition Testimony.

2010, United Alloys vs. Flask, United States District Court, Central District of California, Deposition and Trial Testimony.

2010, Acevedo, et al., vs. California Spray Chemical Company, et al., Superior Court of the State of California, County of Santa Cruz, Deposition .

2009, ITT vs. BorgWarner, et al., United States District Court for the Western District of Michigan, Deposition and Trial Testimony.

2009, DePascale. Et al., vs. Sylvania, United States District Court for the Eastern District of New York, Deposition and Trial Testimony.

2009, Clark, et al. vs. City of Santa Rosa, et al., Superior Court of the State of California, County of Sonoma, Deposition and Trial Testimony.

2008, Hinds Investments, L.P., et al. vs. United Fabricare Supply, Inc., et al., Deposition, Los Angeles, California, Deposition.

2008, Acevedo, et al., vs. California Spray Chemical Company, et al., Superior Court of the State of California, County of Santa Cruz, Deposition and Trial Testimony

2005, City of Santa Clarita vs. Santa Clarita, LLC, et al., Superior Court of the State of California, County of Los Angeles, Deposition.

2003, City of Morgan Hill, Santa Clara County, California, Deposition and Trial.

1999, Unocal vs. Terrible Herbst, Las Vegas, Nevada, Deposition and Trial Testimony.

1998, Exxon v. Ebasco, Santa Barbara County, California, Deposition.

Publications and Papers

Expert Witness Services for Environmental Scientists and Engineers: Professional Opportunities at The Intersection of Law and Science, in: *Applied Geology of California,* Anderson and Ferriz, eds., Chapter 29 (with Schaal, Matos and Everett).

“Emerging Trends in Environmental Forensics,” presentation and paper for

American Law Institute Conference on Environmental Litigation, Washington, DC, 2013.

"Tracking Chlorinated Solvents in Nature – Classic and Emerging Forensic Techniques", with I. G. Petrisor, in *Environmental Forensic*s, Volume 26 in the Issues in Environmental Science and Technology series, 2008.

"Perchlorate: Is Nature the Main Manufacturer?", with I. G. Petrisor, in *Environmental Forensics*, Volume 26 in the Issues in Environmental Science and Technology series, 2008.

"Environmental Forensics," presentation to the AIHA Joint Symposium, Long Beach, California, 2004.

"A Lattice Gas Model for Heterogeneous Chemical Reactions at Mineral Surfaces and in Pore Networks," with D.R. Janecky, and B. Travis, *Physica D, vol. 47, pp. 115-123,* 1991.

"Coupled Fluid Flow and Chemical Reactions in Mid-Ocean Ridge Hydrothermal Systems: The Behavior of Silica," with M.S. Ghiorso, *Geochimica et Cosmochimica Acta, vol. 55, pp. 2467-2482,* 1991.

"The Influence of Fluid Flow and Reaction Kinetics on Mass Transfer in Mid-Ocean Ridge Hydrothermal Systems." Dissertation, University of Washington, 1990.

"3-D Numerical Models for Examining Processes in Geothermal-Hydrochemical Systems," with D.R. Janecky, B.J. Travis, G. Zyvloski, N. Rosenberg. Chapman Conference on Crustal-Scale Fluid Transport, Snowbird, Utah, 1990.
"Cellular Automata Simulations of Mineral Surface Reactions," with D.R. Janecky, and B. Travis, Geological Society of America Annual Meeting, St. Louis, 1989.

"Determining Fluid Velocity of Black Smoker Jets from Digital Correlation of Video Images," with M.O. Smith, V.A. Atnipp, and R.E. McDuff, American Geophysical Union Fall Meeting, San Francisco, 1989.

Matthew P. Wickham

Over 35 years of international project experience in groundwater and vadose-zone hydrogeology and aqueous geochemistry primarily for the mining industry. Expertise includes:

- Quantitative hydrogeology
- Unsaturated flow characterization and prediction
- Geochemical characterization of mine wastes
- Water chemistry assessment and prediction
- Mine closure and reclamation

PROFESSIONAL EXPERIENCE

Principal Advisor, Geochemistry **2012-2015, 2017-Present**
Copper & Diamonds, Rio Tinto

Providing technical guidance, oversight, and assurance to product groups and their business units, project and study shaping, risk and opportunity assessment, and contractor management. Area Lead for Kennecott Utah Copper Closure (OoM and PFS) for tailings and waste rock reclamation and tailings hydrogeochemistry. Principal water quality modeler for tailings seepage, pit lake closure scenarios, and waste rock dump seepage. Supporting geochemist for Resolution Copper, including tailings seepage chemistry predictions for permitting. Authored RT sulfide oxidation and seepage prediction model SOX-MIM.

Principal, Hydrogeology & Geochemistry **2015-2017**
Wickham GeoGroup LLC, Colorado

Hydrogeologic and geochemical characterization, water management, permitting, remediation, and reclamation. Technical guidance, oversight, and assurance, project and study shaping, risk and opportunity assessment, and contractor management.

Principal and Practice Leader, Hydrogeology & Geochemistry **1996-2012**
Golder Associates Inc., Colorado

Conducted and managed large multidisciplinary projects involving hydrogeologic and geochemical characterization, water management, permitting, remediation, and reclamation. Managed a team of hydrogeologists, geochemists, and geologists as geoscience group lead.

Senior Hydrogeologist/Modeler **1989-1996**
Hydro Geo Chem, Inc., Arizona

Principal investigator and project manager for data collection, laboratory analysis, data analysis and interpretation, and regional modeling for use in hydrogeologic and geochemical characterization of water supplies.

Hydrologist/Modeler **1985-1988**
Arizona Department of Water Resources

Developed a comprehensive numerical groundwater flow model for the Pinal Active Management Area including the Eloy and Maricopa-Stanfield Sub-basins for groundwater management planning and decisions.

Hydrologist/Modeler **1984-1985**
U.S. Army Corp of Engineers - Waterways Experiment Station, Mississippi

Developed a tactical streamflow-forecasting computer model for floodplain analysis and flood forecasting. Streamflow forecasting instruction to Army Terrain Analysis Teams.

Hydrologic Technician **1983**
U.S. Army Corp of Engineers, Los Angeles District, California

Provided technical support to engineers and hydrologists for surface water, groundwater, meteorologic, and water quality studies.

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Matthew P. Wickham

EDUCATION

M.Sc., Hydrology (Hydrogeology/Geochemistry), Department of Hydrology and Water Resources, University of Arizona, 1992

B.Sc., Watershed Hydrology, Department of Renewable Natural Resources, University of Arizona, 1984

PROJECT EXPERIENCE - MINING

Minera Barrick Misquichilca S.A. (Barrick), Alto Chicama Mine **Peru**

Authored the closure plan prepared and submitted as a component of the EIA. Responsibilities included site-wide predictive water and chemical mass balance model, demonstration of compliance with water quality standards, and closure and post-closure cost estimates. Included predictions of heap leach draindown and cover infiltration modeling.

Compañía Minera El Indio (Barrick), El Indio Mine **Chile**

Characterized mine site hydrogeologic conditions for closure. Designed and oversaw hydraulic shut-in testing in the underground workings, interpreted test data to estimate formation properties and aquifer boundaries, and predicted mine inflows under drained and bulkhead options. The results of the study were used to construct a detailed flow and mass balance model of the workings and overall site.

Minera Barrick Misquichlca S.A. (Barrick), Pierina Mine **Peru**

Developed closure plans for the mine pit, waste rock and heap leach facilities, and other mine components. Responsibilities included cover design and performance assessment, heap draindown and waste rock uptake predictions, site-wide water balance modeling, hydrogeologic characterization and pit lake modeling, and geochemical modeling for ARD prediction. Developed closure and post-closure cost estimates.

Minera Argentina Gold S.A. (Barrick), Veladero Mine **Argentina**

Developed a detailed heap leach draindown model to support closure planning. The model included heap loading, leaching, and final rinsing plans, atmospheric inputs, coupled with a batch-processed HYDRUS model to predict drainage rates for operations through post closure.

Barrick, Bald Mountain Complex **Nevada, USA**

Assisted the mine with enhanced heap leach recovery using fluid injection. Included design and interpretation of injection tests, prediction of fluid movement, heap stability analysis, and approval of an engineering design change to NDEP.

Barrick, Federova Tundra Project **Kola Peninsula, Russia**

Predicted pit lake water chemistry based on 1) geoenvironmental models for the deposit type and 2) a simple water chemistry mixing model using water chemistry from the geoenvironmental model, and site specific water chemistry data.

Battle Mountain Gold, Kori Kollo Mine **Bolivia**

Investigated seepage fate at a tailings disposal facility. Developed a water balance with estimates of free water surface and near surface tailings evaporation and deep seepage of cyanide-containing tailings water to the underlying aquifer. The spreadsheet-based water balance model was prepared and calibrated to account for rainfall infiltration, tailings drainage, liner seepage, and evaporation from beaches and pond.

Battle Mountain Gold (Confidential location) **Nevada, USA**

Developed a tailings water budget for a bankable feasibility study for a proposed gold tailings facility. The study involved predicting net infiltration into a tailings facility to support additional stability modeling studies. Modeling involved coupled head, vapor, and moisture transport using SOILCOVER.

BHP, Pinto Valley Operation **Arizona, USA**

Directed geochemistry and cover performance programs for an extensive closure analysis of a large copper mine. The project involved waste rock dumps, leach dumps, tailings, process and storm ponds, processing facilities, and pit. Analyses included site characterization, ARD prediction from leach dumps, waste rock, and tailings impoundments, design and prediction of cover infiltration and performance, and evaluation of pit lake chemistry.

BHP, Pinto Valley Operation **Arizona, USA**

Performed a liner compatibility investigation of an existing clay-lined raffinate (barren leach solution) pond to determine what effect, if any, raffinate had or will have on the potential seepage rate from the acid pond. An extensive geochemical and hydraulic testing program was developed and conducted on the clay liner materials to document chemical, mineralogical, and geotechnical property changes during exposure to raffinate.

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Cerro Matoso S.A. (BHP) **Colombia**
Conducted slag characterization and waste rock dump engineering at the ferronickel mine. Responsibilities included geochemical characterization, development of a groundwater monitoring plan, well siting, laboratory testing, facility siting, and closure planning.

Chevron Mining Inc., Questa Mine **New Mexico, USA**
Conducted a variety of projects at the Questa Mine since 2001 including final cover evaluations at the Questa Tailings Facility, water balance evaluations, test plot design (barrel lysimeters and soil water sensors), geochemical characterization of potential cover borrow sources, climate and lysimeter data reduction and interpretation, detailed modeling studies, tailings geochemical characterization, and tailings water management evaluations. Provided technical and engineering support for an ongoing solar test facility constructed on the tailings. Support has included design and construction of 9 large instrumented basin lysimeters to measure the effect of solar panels on net infiltration through the proposed ET covers.

Cleveland Cliffs, Northshore Mine **Minnesota, USA**
Directed an impact analysis for a pit disposal plan for Type II Virginia Formation materials. Included the development of a detailed water and chemical mass balance model, with ARD predictions, to predict pit sump and pit lake chemistry during operation through post closure. Provided permitting support for the closure plans.

Companhia Vale do Rio Doce (CVRD), Carajas Mine **Brazil**
Conducted an evaluation of unsaturated hydraulic behavior of a prospective ore for heap leaching including laboratory testing, modeling of unsaturated flow dynamics under simulated heap leaching conditions, and prediction of expected behavior.

Empire Mine State Historical Park **California, USA**
Conducted a hydrologic evaluation of the Magenta Drain discharge rates to support evaluation and planning for the implementation of a treatment plant to treat the mining influenced water (MIW) discharging from the Magenta Drain.

Energy Fuels Inc., Piñon Ridge Project **Colorado, USA**
Conducted detailed peer review of the water supply evaluation for the mine. The review included detailed interpretation of existing site data and aquifer testing results, reformulation of the hydrogeologic conceptual model, refinement of predicted water supply potential, and final report preparation.

Eurogold Madencilik A.S., Ovacik Mine **Turkey**
Conducted fate and transport analysis for potential leakage of wastewater from the tailings facility. The constituents of concern included arsenic, antimony, and cyanide with water supply wells as potential receptors. The analysis considered mechanical dispersion, adsorption, and microbial decay and volatilization on CN fate.

Falkirk Mining Company, Falkirk Mine **North Dakota, USA**
Completed a hydrogeologic characterization at a large coal strip mine in North Dakota to support pit dewatering operations and municipal water supply protection. The project involves numerical modeling using FEFLOW to design long-term aquifer testing, predict pit inflows, and pit dewatering strategies. The model was also used to predict potential impacts to nearby municipal water supply operations and to develop strategies to protect the municipal supply.

FMC, FMC Trona Mine **Wyoming, USA**
Evaluated remedial alternatives for brine migration at this trona mine and processing facility. Responsibilities included design and interpretation of underdrain tests to assess hydraulic capture and development and application of a numerical groundwater flow model to evaluate and optimize effectiveness of remedial measures.

Freeport McMoRan Miami Inc., Miami Mine **Arizona, USA**
Provided various hydrogeology and geochemistry services at this site since 1989. Projects have included Aquifer Protection Permitting, RI/FS, groundwater monitoring, pit lake assessments, and investigations of heap leaching operations, process solution recovery and storage facilities, processing facilities, underground workings, and acid rock drainage potential for waste rock dumps. Mr. Wickham is the engineering project manager for an ongoing $100 M reclamation project.

Freeport McMoRan Inc. (Confidential site) **Arizona, USA**
Performed extensive investigations into various sources of mass loading of acidic leachate and other solutions from over 100 years of mining operations. The investigations, conducted in preparation for litigation, involved geochemical fingerprinting of various sources and water chemistries, reactive fate and transport analyses, column studies, assessment of existing operational or remedial controls or measures, and development of various source apportionment scenarios as a basis for cost allocation.

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Freeport McMoRan Safford, Inc., Safford Mine **Arizona, USA**
Performed a peer review of heap leaching hydraulics. The review included additional interpretation of existing ore properties, direction of laboratory testing at the PTC, and limited numerical modeling of draindown. As a separate project, conducted a detailed heap leach pad liner geochemical compatibility study between the clay secondary liner system and leach solutions.

Freeport McMoRan Sierrita, Inc., Sierrita Mine **Arizona, USA**
Performed a contaminant attenuation study for an Aquifer Protection Permit compliance item. Complied data for potential sources, groundwater, existing studies with attenuation test results (e.g. short term batch testing, column studies), and literature values for attenuation factors. Prepared calculations showing attenuation characteristics for formations along the transport pathways.

Freeport McMoRan Inc., Henderson Mine **Colorado, USA**
Directed work being conducted at the Henderson mill facility. The project includes hydrogeologic characterization near the existing tailings facilities and precautionary assessment of containment efficiency for downgradient controls.

Gold Fields Exploration Inc., Essakane Project **Burkina Faso**
Conducted geochemical characterization of tailings samples for ARD generation and metals leaching potential. The program included screening level tests through elemental and mineralogical testing and static ABA and NAG testing.

Homestake Mining Company, Calvada Mine **Nevada, USA**
Designed and implemented a subsurface Br tracer study conducted through a Biopass treatment cell for treating residual cyanide and trace metals in gold leach pad effluent. The tracer study was used to identify and quantify preferential flow in the cell. The test was designed and interpreted using a self-authored code for 1-dimensional dual-regime flow and advective dispersion.

Homestake Mining Company, Glister Mine **Nevada, USA**
Evaluated heap leach geochemistry for closure planning. Responsibilities included predicting anticipated geochemical behavior of the heap materials using existing data (effluent chemistry, static test results) during closure and post closure. The evaluation considered ARD potential, short and long-term leachability, trace metal geochemistry, and comparisons to applicable standards.

Homestake Mining Company, Santa Fe Mine **Nevada, USA**
Performed hydrogeologic and geochemical evaluations for closure alternatives analysis for three gold heaps. The study involved geochemical characterization of heap materials, performance assessment of existing heap covers, prediction of long-term effluent quality, hydrogeologic investigations for effluent disposal/leach field design, and fate and transport analysis of effluent.

Homestake Mining Company, Lead Mine **South Dakota, USA**
Directed the characterization of the Grizzly Gulch Tailings to support closure planning. The program included barge drilling, CPT, hydropunch sampling of tailing spore waters, pond chemistry profiling, and monitor well construction.

IMC Potash Carlsbad Inc., Carlsbad **New Mexico, USA**
Developed an analytical model to estimate potential salt loading to the Pecos River associated with a proposed increase in the salt solution elevation in the tailings pond in Laguna Grande de la Sal. The analysis was conducted in conjunction with isotope fingerprinting to identify natural and mining-related sources of salt loading to the river.

Kinross, DeLamar Mine **Idaho, USA**
Conducted a cover design and performance assessment for existing waste facilities. The assessment included borrow sampling, laboratory testing, and numerical cover modeling. Due to the cold climate, the cover modeling included coupled thermal and moisture modeling to predict net infiltration rates for various cover designs.

LAC Minerals, Richmond Hill Mine **South Dakota, USA**
Assessed performance of existing cover systems for heap leach facility and pit backfill. Included review and analysis of existing designs and interpretation of lysimeter outflow, soil moisture sensor data, and drain flows in response to climatic conditions.

Lignitos de Meirama, SA., Limeisa Mine **Spain**
Conducted a coal pit closure analysis for the purposes of developing a post-mining recreational lake. The project involved development of a stochastic pit water and chemical mass balance model for closure planning. The project involved site data collection, conceptual model development, and predictions of pit filling rates, final pit levels, and pit lake chemistry.

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Lydian International Ltd. **Armenia**
Developed a comprehensive geochemical characterization program for mine wastes for a new open pit gold mine to support mine planning and permitting.

Molycorp Inc., Mountain Pass Mine **California, USA**
Conducted tailings paste and tailings cover performance assessment at a lanthanide mine. The paste project evaluated the use of thickened tailings deposition. Detailed numerical modeling included a dynamic accretion model co-developed by Mr. Wickham and Dr. Gjerapic to evaluate seepage and evaporation during deposition and consolidation.

PT Newmont Nusa Tenggara (Newmont), Batu Hijau Mine **Indonesia**
Managed all hydrogeologic modeling to support the engineering and management designs of large waste rock dumps (2 Bt) at this copper/gold mine. Saturated and unsaturated modeling was performed to quantify regional groundwater flow, pit flows, impoundment seepage, infiltration to dumps under various conditions, and fate of the waste rock seepage.

Newmont Mining Corporation, Corporate ESR **Colorado, USA**
Completing ESR closure and reclamation reviews for Northumberland (NV), Midas (NV), Waihi (New Zealand), Jundee (Australia) and Yanacocha (Peru). Contributed to the internal Newmont Closure Transition Guidance document.

Newmont USA Limited, Long Canyon Mine **Nevada, USA**
Conducted a hydrogeologic characterization of the proposed mine site and region to support mine water supply development, various impact assessments on municipal water supplies and natural springs, and permitting.

Newmont USA Limited, Phoenix Mine **Nevada, USA**
Conducted a geochemical characterization of waste rock for the Greater Phoenix Project to support permitting.

Newmont USA Limited, Rain Mine **Nevada, USA**
Conducted a detailed cover assessment reclamation alternatives analysis for an existing reclaimed waste rock disposal facility. Final project effort included preparation of a Final Permanent Closure Plan for submittal to the regulators.

Newmont USA Limited, Twin Creeks Mine **Nevada, USA**
Assisted with preparing the technical basis for an EDC for the L-31 Osgood pad, specifically to evaluate potential effects of injection on slope stability. Interpreted 579 Hydro-Jex stimulation tests from Lone Tree MC West 1-4, North Area Leach 1-32 and 5B, Non Property H Lift 1-10 and 13-14, and Non Property J lift 26, 29, 38, and 40. Documented effect of hydraulic stimulation on ore permeability.

Newmont USA Limited, Twin Creeks Mine **Nevada, USA**
Conducted a cover performance assessment involving analyses of TDR data, field and laboratory testing, and numerical modeling for a constructed cover to support final reclamation planning and regulatory permitting.

Newmont USA Limited, Carlin Mine **Nevada, USA**
Conducted a detailed technical evaluation of groundwater nitrate issues below the 4-2 Tailings Storage Facility, predicted hydraulic performance of the final reclamation cover, and preparation of a Final Permanent Closure Plan for the tailings facility to support closure planning and permitting.

Confidential Client **Papua New Guinea, Indonesia**
Conducted extensive hydrogeologic and geochemical characterization and assessments for a tailings facility to support operations and closure planning, engineering designs, and permitting.

Rio Tinto Kennecott Copper, Bingham Canyon Mine **Utah, USA**
Supporting numerous projects, including RI/FS programs for the South End Zone A plume and North End Se/As, waste rock and tailings ARD characterization, mine and tailings water management, and mine wide closure planning.

Rio Tinto Resolution Copper Company, Resolution Mine **Arizona, USA**
Providing assistance with NEPA and APP permitting studies, technical oversight of all geochemistry programs, and closure and permitting, and board member for Hydrogeologic/Geochemical Technical Steering Committee.

Rio Tinto, Legacy Management Sites **Various**
Providing technical assistance with various closure projects at the Holden Mine (WA), Flambeau Mine (WI), Robinson Mine (NV), and Blackbird Mine (ID).

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Rio Tinto, Diavik Diamond Mining, Inc. **NWT, Canada**
Conducted a mineral waste review, closure review, NCRP reclamation / closure PFS technical review. Designated as Independent Advisory Board (geochemistry and hydrogeology) for Closure PFS.

Rio Tinto Coal Moçambique **Moçambique**
Completed a rapid assessment of seepage and potential groundwater impacts associated with a tailings impoundment at the Benga Mine, Tete Moçambique to improve proactive management of tailings seepage, facility operation, and facility closure.

Rio Paracatu Mineracão S.A., Morro do Ouro **Brazil**
Developed water balance models for evaluating infiltration rates for final cover systems for a waste rock facility. The balance was developed using UNSAT-H to simulate hydraulic processes and estimate fluxes for the individual water balance components.

Teck Cominco, Trail Smelter **British Columbia, Canada**
Evaluated the fate and transport of a large ammonia plume issuing from the smelter complex. The analysis included data compilation, comprehensive identification of all possible attenuation mechanisms for the various nitrogen species present, and interpretation of site conditions relative to the mechanisms.

Teck Coal Ltd., Fording River Operation **British Columbia, Canada**
Conducted a selenium fate and transport study of the South Tailings Pond (STP) and the settling ponds located below the STP along the Kilmarnock alluvium. The evaluation included a review of available data; observations about changes in chemistry between the South Tailings Pond, seeps, and groundwater wells; and observations between the Kilmarnock settling ponds and nearby groundwater.

Western Silver Corporation, Peñasquito Project **Mexico**
Conducted geochemical characterization of tailings samples for ARD generation and metals leaching potential and analysis of supernatant in support of environmental permitting and tailings storage facility designs. The program included screening level tests through elemental and mineralogical analysis, static ABA testing, and leach testing.

White River Mine **Utah, USA**
Performed a hydrogeologic and geochemical characterization of abandoned oil shale mine to determine effects of backfilling with mine wastes. The mine shaft intersected an aquifer. The investigations determined possible effects on aquifer water chemistry. Examined potential for fill leaching to impact aquifer chemistry.

PUBLICATIONS, PRESENTATIONS, AND LECTURES

Vinton, B., K. Payne, P. Brown, M. Logsdon, M. Wickham, J. Waples, I. Schofield 2011. Progress in remediating ARD-contaminated groundwater at Bingham Canyon Mine, Utah, USA. 18th Annual British Columbia-MEND ML/ARD Workshop, "Evolution of Mine Drainage Chemistry and Performance of Mitigation".

Creek, M., M. Wickham, and G. Gjerapic 2011. ET Cover Performance in a High Desert Environment, North Waste Rock Disposal Facility, Rain Mine, Carlin, Nevada, USA. Proceedings from the Sixth International Conference on Mine Closure. Australian Centre for Geomechanics and the University of Western Australia's Centre for Land Rehabilitation. Lake Louis, Alberta, Canada.

Waples, J.S., M.P. Wickham, J. Sanders, and J. Gear 2009. A Geochemical Testing Program for Reclamation Cover Materials, Including Different Kinetic Testing Methods. Proceedings from the 8th International Conference on Acid Rock Drainage. Skellefteå, Sweden June 22 - June 26, 2009.

Brown, P.L., M.P. Wickham, J.S. Waples, C.R. Stevens, K.L. Payne, B.G. Vinton, and M.J. Logsdon 2009. Estimation of Long-Term Lime Demand for Remediation of ARD-Contaminated Groundwater at the Bingham Canyon Mine, Utah, USA. Proceedings from the 8th International Conference on Acid Rock Drainage. Skellefteå, Sweden June 22 - June 26.

Wickham, M., K. Greaser, S. Doyle, G. Gjerapic, and J. Gear 2008. "Development of Predictive Soil-Atmosphere Models for Test Plots at the Questa Mine, New Mexico", Proceedings from GeoCongress 2008: The Challenge of Sustainability in the Geoenvironment, Annual Congress of the Geo-Institute of ASCE, March 2008.

Wickham, M. 2007. Daubert in Practice: Mock Hearing and Expert Witness Cross-Examination. Invited speaker at Environmental and Toxic Tort Litigation Course, New Orleans, March 2007.

Wickham, M. 2006. The Molycorp Questa Mine Site Test Plot Program, NM, USA, Developing a Basis for Predicting Hydraulic Performance of Forested Covers. Invited speaker at Alternative Covers for Landfills, Waste Repositories, and Mine

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Wastes: Design, Modeling, Construction, and Monitoring, Denver, Colorado. Hosted by Desert Research Institute, US EPA, and University of Wisconsin, November 2006.

Gjerapic, G. and M. Wickham 2006. "Parameter Estimation from Stepped-Irrigation Tests on Instrumented Lysimeter Test Plots", Proceedings from Fourth International Conference on Unsaturated Soils (ASCE), April 2006.

Pottorff, E., M. Wickham, J. Waples, E. Pottorff, and B. Bertram 2005. "Case Study of Selenium Mobilization from Mancos Shale; Relationship to Nitrate Contamination", Geological Society of America, Rocky Mountain Section Annual Meeting, May 2005.

Wickham, M., B. Johnson, and D. Johnson 2004. "Dynamic systems-modeling approach to evaluating hydrologic implications of backfill designs". Mining Engineering, Vol. 56, No. 1, January 2004.

McClain M., M. Wickham, C. Yu, L. Butler, and R. Forlina 2002. "A Comparative Modeling Approach for an Alternative Final Cover Demonstration, Denver Arapahoe Disposal Site, Arapahoe County, Colorado". 2002 SWANA Arid Landfill Symposium, Grand Junction, Colorado.

Wickham, M., B. Berg, and B. Johnson 2002. "LandSim2 – A Groundwater Risk Assessment Tool for Landfill Design and Performance Assessment". 2002 Solid Waste Association of North America Arid Landfill Symposium, Grand Junction, Colorado.

Wickham, M. and Logsdon, M. 2002. "An Alternative Approach to Estimating the Composition of Existing Waste Rock Facilities". Canadian Institute of Mining, Metallurgy, and Petroleum, Vancouver, B.C., 2002.

Verburg, R.B., Wickham, M.P. and Stockdill, D. 2001. Geochemical Characterization and Environmental Stability of Coal Creek Station Fly Ash Paste. Submitted to American Coal Ash Association, 14th International Symposium on Management and Use of Coal Combustion Products, San Antonio, January 22-26, 2001.

Wickham, M., B. Johnson, D. Johnson 2000. "A Dynamic Systems Modeling (DSM) Approach to Evaluating Backfill Designs in Open Pits". 2001 SME Annual Meeting and Exhibit, Denver.

Invited speaker and panelist on "State of Numerical Modeling for Cover Performance", Annual SWANA meeting, Copper Mountain Resort, Colorado, 2000.

Wickham, M. 1999. "Understanding Preferential Flow for Heap Leach Dynamics" Randol Gold and Silver Forum '99, Denver

Wickham, M., E. Swanson, M. Logsdon, and J. Clark 1999. "An Alternative Approach to Characterizing Existing Waste Rock Dumps." Tailings and Mine Waste '99, Proceedings of the Sixth International Conference on Tailings and Mine Waste '99.

Wickham, M., and B. Johnson 1998. "Impacts to Groundwater from Stored Acidity." Arizona Hydrological Society Abstracts - 1998 AHS Symposium.

Wickham, M., B. Johnson, and A. Wilkinson 1997. "Considerations for Characterizing Background Groundwater Chemistry with Acidic Impacts from Historical and Present-day Discharges." Geologic Society of America Abstracts with Programs - 1997 GSA Annual Meeting.

Wickham, M. 1992. "The Geochemistry of Surface Water and Groundwater Interactions for Selected Black Mesa Drainages, Little Colorado River Basin, Arizona." Master Thesis, University of Arizona.

Invited Speaker on "The Geochemistry of Stream/Aquifer Interactions." The Second Annual Hydrology Research Exposition, "El, Dia Del Agua", Department of Hydrology and Water Resources, University of Arizona, 1992.

Wickham, M.P. and E.F. Corkhill 1989. "Pinal AMA Regional Groundwater Flow Model - Hydrogeologic Framework, Water Budget and Phase I Recommendations." Phase I Report, Hydrology Division, ADWR.

Engdahl, T.L., M.R. Jourdan, and M.P. Wickham 1986. "Hydrologic Forecasting in the Tactical Environment." 1986 Army Science Conference Proceedings, West Point, New York.

Wickham, M.P. and M.R. Jourdan 1985. "Military Hydrology Program - Tactical Environmental Applications." The Military Engineer, Vol. 77, p. 501.

"Advanced Terrain Analysis Course: Streamflow Forecasting", 1985. Manual prepared in association with the Military Hydrology Team, Waterways Experiment Station, U.S. Army Corps of Engineers at Fort Belvoir, Virginia.

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MARK A. WILLIAMSON, PhD

PROFILE

Dr. Williamson is an environmental geochemist with over 30 years of experience in consulting, basic/applied research and educational settings. Mark has worked extensively in the mining industry and has been involved in geochemical studies and site evaluations across the United States as well the Philippines, Peru, Australia, Indonesia, Argentina, Canada and Mongolia. Dr. Williamson has extensive experience with acid rock drainage (ARD), which began in earnest with his PhD graduate studies with the kinetics of pyrite oxidation. His experience has expanded to include characterization of mine material for potential ARD formation using industry standard methods, prediction of water quality from mine facilities, support for engineered construction design of mine waste facilities, pit lake models, and water treatment design support. In addition to ARD, Mark has extensive experience with metals in aquatic and terrestrial environments, engineering geochemistry (including remedial actions), and the fate and transport of chemicals in the environment. Beyond technical project reports and memoranda, Mark has provided expert testimony regarding litigation matters and has testified before the US Congressional Committee for Science, Space and Technology.

EDUCATION

PhD, Geochemistry, Virginia Polytechnic Institute & State University (Virginia Tech), 1992
MS, Chemistry/Geochemistry, Northern Arizona University, 1990
BS, Chemistry, Old Dominion University, 1983

PROFESSIONAL AFFILIATIONS

Geochemical Society
International Association of Geochemistry and Cosmochemistry
International Mine Water Association
Mineralogical Society of America
Sigma Xi, The National Scientific Research Society

PRACTICE AREAS

Environmental Geochemistry
Environmental Forensics
Mining Environmental Geochemistry
Engineering Geochemistry

SELECT PROJECT EXPERIENCE

Mining Environmental Geochemistry and Acid Rock Drainage

- ***Mule Canyon Mine Pit Lake Closure, Nevada.*** Provided geochemical assessment of potential future evolution of water quality in a series of mine pit lakes and the extent to which the pit lakes may be linked to chemical composition changes in monitoring wells.

- ***Phoenix Mine Waste Rock Geochemical Evolution Monitoring, Nevada.*** Successfully negotiated modified monitoring plan with state and federal agencies to ensure protection of local water resources. senior geochemist for development and design of future monitoring of key parameters regulating geochemical evolution of waste rock, including oxygen, moisture and temperature profiles collected using instrumented borings. Currently assessing multi-year database of monitoring data.

- ***Copper Basin Mine Rock Geochemical Characterization, Nevada.*** Lead mine rock characterization of copper and gold project in initial stages of permitting. Estimates of future water quality through use of laboratory testing and mineralogical analysis.

- ***Emigrant Mine Leach Pad Draindown Geochemistry, Nevada.*** Geochemist evaluating chemical composition of tailings draindown for closure, as part of a larger closure evaluation team.

- ***Kennecott Utah Copper, Salt Lake City, Utah***. Conducted geochemical investigations into geochemistry of copper heap leach solutions related to plume migration in alluvial aquifer, potential engineered hardpan formation for closure, biological sulfate reduction for removal of metal values, formation of secondary mineral phases on mixing of heap leach solutions and unaffected groundwater.

- ***Newmarket Gold Cosmo/Howley Operations, Darwin Australia***. Performed geochemical characterization of site materials and contributed to development of conceptual site model to quantify and control discharge of TDS impacted mine water.

- ***Rosemont Copper Mine, Pit Lake Modeling and Waste Rock Impact Characterization, Arizona***. Provided lead and oversight of team investigation of geochemistry of waste rock and potential seepage from same to ground water as well as pit lake model of future water quality.

- ***Bird Mine, Pennsylvania.*** Provided expert review of mechanism and processes related to iron production and well scaling in extraction wells for water control in an abandoned coal mine.

- ***Caldwell Canyon Mine, Idaho.*** Provided senior critical review and communications assistance for mine characterization work related to selenium and other constituents in phosphate mining overburden.

- ***Tailings Geochemistry Investigation, Sulawesi, Indonesia***. As senior geochemist, investigated geochemistry of tailings in subaqueous environments related to potential contaminate release..

- ***Kingking Copper/Gold Mine, Philippines.*** Acted as geochemist responsible for leading characterization of potential ARD waste and construction rock as well as mill tailings. Design and schedule characterization program and work with site personnel to implement plan.

- ***Grassy Mountain Gold Mine, Oregon.*** Developed approaches to mine rock characterization of copper and gold project in initial stages of permitting, with a goal to estimate of future water quality through use of laboratory testing and mineralogical analysis.

- ***Mine Pit Lake Geochemical Modeling, Yanacocha, Peru***. Served as senior geochemist responsible for geochemical testing of acid rock drainage potential (ARD) of mine rock to develop source terms for pit lake geochemistry model and team coordination on development of numeric simulation of sequential refill of three pit lakes.

- ***Ortiz Mine, New Mexico***. Served as geochemist for team-developed coupled geochemical-hydrologic model for prediction of future water quality associated with potential closure alternatives for the Ortiz Mine pit lake. Results of modeling were used as part of negotiated response to citizen action concerning long-term conditions for site.

- ***Shootaring Uranium Mill, Utah***. Provided an analysis of background geochemical composition of ground water in support of development of long-term monitoring practices and procedures.

- ***Wharf Mine Waste Rock Characterization, Lead, South Dakota***. Contributed as senior geochemist responsible for oversight and interpretation of waste rock testing and characterization program in support of a mine expansion permit application. Contributed to waste rock disposal design for management of acid rock drainage (ARD). Provided expert testimony for county and state hearings on the first permit application in South Dakota to receive unanimous approval at city, county and state levels.

- ***Geochemistry of Selenium Release from Phosphate Mining Overburden, Idaho***. Conducted comprehensive investigation of techniques employed to characterize selenium release as it pertains to permit development and waste management. Designed and conducted field scale investigations to characterize geochemical conditions within overburden, coupled with column leaching to identify principal release mechanisms and magnitudes.

- ***Phosphate Mining District Geochemical Monitoring of Waste Rock Facilities, Idaho***. Served as senior geochemist responsible for design, installation and monitoring of instrumented boreholes to characterize internal geochemical weathering conditions of waste rock. Investigations included both end-dumped facilities and those constructed in lifts by plug-dumping.

- ***ARD material water balance, Mt Todd, Australia***. Led team evaluation of effects of ARD loading on mine site water balance associated with pit dewatering.

- ***Vale PRC, Mendoza, Argentina***. Evaluated geochemical effects on aquifer stability on injection of waste brine from mineral processing.

- ***State of Virginia Uranium Mining Regulation Development.*** Contributed as senior geochemist on team that prepared summary/guidance document to support establishing best practices mining regulatory guidelines for uranium and hardrock mining. Advised on appropriate techniques and their application to mine waste materials.

- ***Haraat Uranium Development, Mongolia***. Conducted studies associated with mineral processing and potential groundwater effects associated with proposed uranium development.

- ***Tanco Mine, Manitoba, Canada***. Developed mass-loading mixing cell model for potential chemical loading to tailings storage facility associated with deposition of additional tailings.

- ***Cripple Creek and Victor Mine Waste Rock Investigation, Colorado***. As Senior Geochemist, conducted acid rock drainage (ARD) laboratory testing and interpreted results for waste rock associated with a proposed mine expansion.

- ***Elkhorn Mining District, Montana, Mine Rock and Tailings Geochemistry***. As project geochemist, characterized mine rock and potential produced tailings for environmental concerns related to water quality due to acid rock drainage (ARD). Acid-base accounting, humidity cell testing and other leach laboratory test data developed and interpreted for respective role in potential water quality management decision-making.

- ***Belden Mine, Eagle County Colorado***. Evaluated potential seasonal loading of zinc and other metals from historic waste rock facilities to the Eagle River.

- ***Wharf Mine Spent Ore Disposal, Lead, South Dakota***. Assessed environmental impact of waste rock disposal due to arsenic release. Constructed numerical model to simulate rate of release as well as fate and transport of arsenic and nitrate. Performed laboratory testing of amendments for arsenic attenuation to achieve reduction of impacts.

- ***Lamefoot Mine Expansion Metal Attenuation Investigation, Echo Bay Minerals, Washington***. As Senior Geochemist, designed and conducted laboratory investigation of metal attenuation from ARD solutions via precipitation and neutralization in support of mine expansion permit. Used results to develop inputs to water quality fate and transport model.

- ***Crown Jewel Mine Water Quality Characterization and Modeling, Washington***. As Senior Geochemist, contributed to development of background water quality characterization and modeling.

NEPA (EIS and EA)

- ***Resolution Mine Environmental Impact Statement (EIS), Arizona***. Served as senior geochemist responsible for an EIS evaluation of data adequacy and water quality impacts associated with mine development, including tailings and underground workings.

- ***Pinto Valley Mine Environmental Impact Statement (EIS), Arizona.*** Responsible for EIS analysis related to copper mine expansion with project components included assessment of pit lake water quality modeling, waste rock and tailings discharge.

- ***Rochester Mine Environmental Assessment (EA), Nevada***. Conducted the geochemical component of an EA evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock dumps.

- ***Greens Creek Mine Environmental Impact Statement (EIS), Alaska***. Acted as senior geochemist responsible for an EIS evaluation of data adequacy and water quality impacts associated with acid rock drainage (ARD) produced by dry stack tailings.

- ***Red Dog Mine Supplemental Environmental Impact Statement (EIS), Alaska***. Contributed as senior geochemist responsible for an EIS evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock.

- ***Golden Sunlight Mine Environmental Impact Statement (EIS), Montana***. As project geochemist , was responsible for an EIS evaluation of data adequacy and groundwater quality impacts associated with acid rock drainage (ARD) produced by waste rock.

Forensic Geochemistry

- ***Expert witness/forensics Zinc Smelter Impacts, United States***. Worked with Washington DC based legal firm in support of assessment of lead (Pb) and other metal contamination at a confidential former smelting location. Employed use of several geochemical fingerprinting techniques to investigate source of metals (smelter vs. domestic) and pursue allocation of damage costs.

- ***Expert witness/forensic, Washington.*** Worked with Denver, CO based legal firm in support of insurance litigation for recovery of remediation costs associated with a former uranium mine.

- ***Technical expert metal source forensics and apportionment, United States.*** Work with forensic analysis of copper and other metals in aquatic sediments related to remedial action and source apportionment.

- ***Expert Analysis Selenium Geochemistry, Idaho***. Prepared expert opinion report regarding evaluation of environmental impact analysis of selenium release from phosphate mining overburden, focusing on assessment of total modeled chemical loading to receiving groundwater.

- ***Expert witness/forensic, New Jersey***. Worked with Newark, NJ based legal firm in support of matter related to alleged sulfide mineral contamination of sand from sand manufacture as related to subsequent alleged damage to production of decorative concrete block via pyrite oxidation/staining.

- ***Expert consultant, Canada***. Provided expert report to Washington DC based legal firm on technical history of acid mine drainage formation and management in support of insurance settlement proceeding.

- ***Senior Geochemist, Forensics***. Conducted analysis of lead impacts from industrial and domestic sources. Performed a forensic assessment of relative timing and extent of environmental impacts in support of cost allocation, insurance settlement and remedial action.

- ***Project Geochemist, California***. Evaluated chromium geochemistry in sediments and local groundwater, as derived from power generating facilities, to establish/dismiss potential pathways to contaminate groundwater.

- ***Senior Geochemist Forensics, Illinois***. Assessed zinc impacts from several industrial sources operating on the same plant site. Evaluated sulfur isotopic systematics to quantify relative impacts in support of remediation cost allocation and remedial action.

Environmental Geochemistry

- ***Chromium Sludge Pond Closure, North Carolina***. Senior scientist and project manager for project to develop closure plan of sludge pond containing water treatment residue from a chromium processing facility. Consideration of geochemical speciation of chromium (trivalent vs. hexavalent) key focus to maintain long-term chemical stability of sludge. Addressed related issue to potential hazardous waste classification of sludge based upon chromium speciation.

- ***Chromium Characterization in Soil and Ground Water, Kansas.*** Geochemical support for on-going site investigation of soil and ground water contamination by chromium as lead-in to eventual remediation. Principal focus on geochemical speciation of chromium (trivalent vs. hexavalent) to guide remediation targets and goals, establish extent of ground water contamination requiring remediation, and establish background conditions. Major thrust of activity involved development of materials to educate regulatory representatives and public regarding the influence of chromium speciation of toxicity, risk and clean up targets.

- ***Ferris-Haggerty Mine, Wyoming, Abandoned Mine Copper Release***. Geochemist for project aimed at understanding the mechanism of copper release from the abandoned mine (collapsed portal) and the the fate and transport of copper downstream from that location.

Engineering Geochemistry

- ***Aquifer Store and Release (ASR), Corpus Christi, Texas.*** Evaluated existing groundwater geochemical conditions and the potential change in chemical quality of waste water treatment plant waster injection as part of a larger water resource management evaluation.

- ***Engineering Geochemistry, Nevada, Injection Well Clogging***. Evaluated cause of injection well plugging. Determined geochemical mechanism responsible for scaling of well screens (with calcite, calcium carbonate) and produced initial engineering conceptual design to modify solution composition prior to injection to avoid future scaling.

- ***Engineering Geochemistry.*** Expert due diligence review of confidential in situ copper leach project, metallurgy and environmental geochemistry, related to potential investment.

- ***Engineering Geochemistry, Arizona, Dissolution of Chrysocolla***. Laboratory investigation to develop a kinetic rate law for the dissolution of chrysocolla (copper silicate) in acidic lixiviants for the in situ recovery of copper.

- ***Engineering Geochemistry, Pennsylvania, Acid Drainage from Road Cuts.*** Developed a mitigation program for the avoidance of formation of acid rock drainage from rock produced during road cut construction in pyritic sandstone. Provided characterization procedures, in-field testing, segregation, disposal and monitoring.

- ***Engineering Geochemistry, California, Evaporative Disposal***. Constructed dynamic systems model (water balance) for engineered evaporation ponds, linked in series, for purpose of disposal of mill process water. Model accounted for increase in salt (sodium chloride) concentrations, precipitation of salt from solution filling ponds and associated timing for dredging of ponds, and changes in evaporation as a function of increases in salinity.

- ***Engineering Geochemistry, California, Nevada, South Dakota, and Utah***. As Senior Geochemist, participated in various studies to determine parameters germane to engineering design, contaminant migration, waste management, solution mining, engineered wetland construction, and water treatment.

- ***Engineering Geochemistry, Utah***. Laboratory investigation of ARD treatment with mineral phosphates to produce chemical hardpans in mine waste rock as a closure opportunity.

- ***Engineering Geochemistry***. Investigated an engineered biogenic sulfide treatment system for large-scale treatment of ARD produced during heap leach operations at a copper mine and associated contaminated groundwater.

Oil and Gas

- ***Geochemistry of Natural Gas produced waters and environmental consequences.*** Expert consultant to natural gas producer on geochemistry related to produced waters and industrial materials as related to potential effects on water resources.

- ***Oil Shale Thermal Degradation Evaluation, Colorado***. As Senior Geochemist, performed a geochemical evaluation of oil shale thermal degradation for groundwater remediation. Analyzed organic compound generation and inorganics such as selenium, arsenic, boron and fluoride. Conducted laboratory investigation to characterize attenuation of chemicals of concern through adsorption processes.

- ***Engineering Geochemistry, Colorado, Oil Production Waste Injection***. Evaluated observed overpressuring of oil/gas production water injection wells to identify potential geochemical controls on plugging. Differentiated between near- and far-field mechanisms, characterized geochemical features injection waters to develop potential treatment alternatives to alleviate plugging that led to overpressuring.

Other Geochemical Projects

- ***Environmental Impacts of Hazardous Waste Disposal, Utah***. Senior Geochemist tasked with determining environmental impacts of hazardous waste disposal. Included numerical modeling, interpretation for regulatory agency personnel, and general permit support.

- ***Natural ARD Characterization, Colorado***. Field study of naturally occurring ARD in Colorado, including comparison and contrast with mining ARD in associated districts.

- ***Abandoned Mine Laboratory Investigation, California***. Senior Geochemist responsible for investigating the rate of sulfide generation in an engineered upflow wetland as a mechanism of metal removal from ARD at an abandoned mine.

- ***Applied Geochemical Research for Oil Exploration, Gulf of Mexico***. As Visiting Research Scientist, performed applied geochemical research on the geochemical systematics in surficial sediments of the Gulf of Mexico as an aid to exploration. Identified sulfur geochemical relationships that significantly increased the percentage of producing wells in an overall exploration program.

- ***Kinetics and Rate-Determining Step of Aqueous Pyrite Oxidation***. Basic laboratory research of a rate law describing pyrite kinetics for a wide range of solution compositions. Reconciled lab data from multiple researchers spanning decades of research. Identified electron transfer as the rate determining step of the process. Published findings in premier research journal, which is a top-cited publication in geosciences.

- ***Kinetics of the Decomposition of the Aqueous Ferric Iron-Thiosulfate Complex***. Basic laboratory research of a rate law describing the reaction between ferric iron and thiosulfate, postulated as a key intermediate step in the production of sulfate from pyrite during aqueous oxidation.

- ***Thermodynamic Modeling of Aqueous Sulfur***. Basic computation research correlating the thermodynamic properties of aqueous sulfur ions with their molecular structure.

- ***Diagenesis of Metals in Lake Sediments, Arizona***. Field and laboratory research into geochemical processes that result in metal accumulation and release from high elevation lake sediments.

PUBLICATIONS

Williamson, Mark A. (2015) Pyrite oxidation in well-constrained humidity cell tests. International Conference for Acid Rock Drainage; proceedings; Santiago, Chile.

Keller, J.M., Busker, L.T., Milczarek, M.A., Rice, R.C. and **Williamson, Mark A.** (2011) Monitoring the geochemical evolution of waste rock at Newmont's Phoenix Mine. Proceedings of the Mine Closure Conference, September 18-21, Lake Louise, Alberta, Canada.

Williamson, Mark A., Kirby CS, Rimstidt JD. (2006) Iron dynamics in acid mine drainage. International Conference for Acid Rock Drainage; proceedings; St. Louis, MO.

Eary TE, **Williamson Mark A.** (2006) Simulations of the neutralizing capacity of silicate rocks in acid mine drainage environments. International Conference for Acid Rock Drainage; proceedings; St. Louis, MO.

Williamson Mark A. (1999) The geochemistry of iron. In: Marshall C, Fairbridge R, editors. The Encyclopedia of Geochemistry. Kluwer Publishers. p 348-53.

Williamson Mark A. (1999) The geochemistry of copper. In: Marshall C, Fairbridge R, editors. The Encyclopedia of Geochemistry. Kluwer Publishers. p 101-02.

Williamson Mark A., Rimstidt JD. (1994) The kinetics and electrochemical rate determining step for aqueous pyrite oxidation. Geochim. Cosmochim. Acta 58: 5443-54.

Williamson Mark A., Parnell RA, Jr. (1994) Partitioning of copper and zinc in the sediments and porewaters of a high-elevation alkaline lake, east-central Arizona, U.S.A. Applied Geochemistry 9:597-608.

Williamson Mark A., Rimstidt JD. (1993) The rate of decomposition of the ferric thiosulfate complex in acidic solutions. Geochim. Cosmochim. Acta 57:3555-61.

Williamson Mark A., Rimstidt JD. (1992) Correlation between structure and thermodynamic properties of aqueous sulfur species. Geochim. Cosmochim Acta 56:3867-80.

Williamson Mark A., Knight CL. (1989) Characterization of authigenic zeolite phases in vapor dominated hydrothermal systems with micro-Raman spectroscopy. In: Russell, PE, editor. Microbeam Analysis. p 574.

Knight CL, **Williamson Mark A.**, Bodnar RJ. (1989) Raman spectroscopy of zeolites: Characterization of natural zeolites with the laser raman microprobe. In: Russell, PE, editor. Microbeam Analysis. p 571.

Williamson Mark A.. (1989) Determination of copper with graphite furnace atomic absorption spectrophotometry: A student exercise in instrumental methods of analysis. J. Chem. Ed. 66:261-63.

PRESENTATIONS

Williamson, Mark A. (2017) Pyrite oxidation in water-limited environments. Invited speaker at Annual meeting of the Nevada Mine Water Association Mine Water Symposium. Reno, NV.

Williamson, Mark A. (2015) Pyrite oxidation in well-constrained humidity cell tests. International Conference for Acid Rock Drainage; proceedings; Santiago, Chile.

Williamson, Mark A. (2015) Calibrating humidity cell tests. Society for Mining, Metallurgy and Exploration Annual conference. Denver, 2015.

Williamson, Mark A. (2014) Pyrite Oxidation in Well-Constrained Humidity Cells. Geological Society of America Program with Abstracts.

Williamson, Mark A. (2013) Pyrite Oxidation in Unsaturated Settings. Geological Society of America Program with Abstracts.

Williamson, Mark A. (2010) Integrating Field and Laboratory Data to Understand Selenium Geochemistry in the Idaho Phosphate Mining District. Geological Society of America Program with Abstracts.

Williamson, Mark A. and Rimelman, R (2010) Avoiding Water Quality Pitfalls In Mine Permitting. Northwest Mining Association Annual Meeting Short Course, December. Spokane, WA.

Williamson, Mark A. and Rimelman, R (2009) Avoiding Water Quality Pitfalls In Mine Permitting. Northwest Mining Association Annual Meeting Short Course, December. Reno, NV.

Williamson, Mark A. (2008) Model Complexity**:** How Much Is Enough? Northwest Mining Association Annual Meeting, December. Reno, NV.

Williamson Mark A., Langmuir D. and Montana, A. (2001) Manganese geochemistry of the Cunningham Hill Mile Pit Lake. In: V. M. Goldschmidt International Conference for Geochemistry Abstracts with Programs.

Meyer WA, **Williamson Mark A.** and Streufert RK. (1996) A comparison of natural acid rock drainage occurrences in Colorado. Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP); 1996 Apr 28 to May 1; Keystone, CO.

Meyer WA, **Williamson Mark A.** and Brown A. (1997) Suppression of sulfide mineral oxidation in mine pit walls. II. Geochemical Modeling Mine Tailings and Waste Conference; 1997 Jan; Ft. Collins, CO.

Warren GC, Brown A, Meyer WA and **Williamson Mark A.**. (1997) Suppression of sulfide mineral oxidation in mine pit walls. I. Hydrologic Modeling Mine Tailings and Waste Conference; 1997 Jan; Ft. Collins, CO.

Rimstidt JD and **Williamson Mark A.**. (1995) The kinetics of acid mine drainage. V.M. Goldschmidt International Conference for Geochemistry Abstracts with Programs.

Williamson Mark A.. (1994) Precipitation and solubility of chrysocolla in near-neutral pH mine drainage solutions, south-central Wyoming. Geological Society of America Annual Meeting Programs with Abstracts, v. 26.

Brown A, **Williamson Mark A.**. (1994) Alternatives for prevention and remediation of acid rock drainage. Eleventh High Altitude Revegetation Workshop; 1994 Mar 16-18; Fort Collins, CO.

Rimstidt JD, **Williamson Mark A.**, Newcomb WD. (1992) Element redistribution in the Yucca Mountain radioactive waste repository produced by evaporation and condensation of water in a thermal field. In: American Nuclear Society Bulletin, Proceedings of Focus '91: Conference on Nuclear Waste Packaging.

Williamson A, Rimstidt JD, Newcomb WD. (1992) A comprehensive empirical rate law for aqueous pyrite oxidation by ferric iron and dissolved oxygen. Geological Society of America Annual Meeting Programs with Abstracts. p A209.

Mavrogenes JA, **Williamson Mark A.**, Bodnar RJ. (1992) Cu, Fe and S concentrations in magmatic/ hydrothermal fluids: Evidence from natural and synthetic fluid inclusions. Geological Society of America Annual Meeting Program with Abstracts. p A144.

Williamson Mark A., Kirby CS, Rimstidt JD. (1992) Kinetics in acid mine drainage. V.M. Goldschmidt International Conference for Geochemistry Abstracts with Programs.

Williamson Mark A., Rimstidt JD. (1992) The kinetics of the decomposition of the ferric thiosulfate complex in acidic aqueous solutions. V.M. Goldschmidt International Conference for Geochemistry Abstracts with Programs.

Williamson Mark A., Rimstidt JD. (1992) Catalysts and inhibitors as chemical probes of the mechanism of aqueous pyrite oxidation. American Chemical Soc. Geochemistry Div. Symposium on the Environmental Geochemistry of Sulfide Oxidation, Program with Abstracts.

Williamson Mark A., Rimstidt JD. (1991) Correlation between structure and thermodynamic properties of aqueous sulfur ions. Geological Society of America annual meeting Program with Abstracts. p A212.

Williamson Mark A., Rimstidt JD. (1990) Thiosulfate in geochemical processes: reaction with ferric iron in acidic solutions. Geological Society of America Annual Meeting Program with Abstracts. p A60.

Williamson Mark A., Rimstidt JD. (1990) Thermodynamic and kinetic constraints on the aqueous oxidation of sulfide minerals. V.M. Goldschmidt International Conference for Geochemistry Program with Abstracts. p 91.

Williamson Mark A., Rimstidt JD. (1989) Hydrothermal transport in Yucca Mountain tuffs. Geological Society of America Annual Meeting Program with Abstracts. p A103.

Williamson Mark A., Parnell RA, Jr. (1987) Trace metal accumulation and diagenesis in volcanic lake sediments of a near-neutral pH: Porewater chemistry. Arizona-Nevada Academy of Science 31st Annual Meeting Program with Abstracts.

EXPERIENCE

Principal Geochemist, Geochemical Solutions, LLC, 2010 - present
Senior Geochemist, Tetra Tech, 2003 to 2010
Principal Geochemist, Geochemical Solutions, LLC, 2001 to 2003
Principal Geochemist, Adrian Brown Consultants, Inc., 1997 to 2001
Senior Geochemist, Adrian Brown Consultants, Inc., 1992 to 1997
Pre-Doctoral Fellow/PhD Research, Department of Geological Sciences, Virginia Tech, 1988 to 1992
Research Geochemist, ARCO Oil and Gas Company, Geochemical Exploration Group, 1990
Teaching Assistant, Virginia Polytechnic Institute and State University, 1988 to 1992
Chemical Instrumentation Laboratory Supervisor, Northern Arizona University, 1984 to 1988
Chemistry Instructor, Department of Chemistry, Tidewater Community College, 1983 to 1984

AWARDS

Co-author of funded National Science Foundation proposal: The Mechanism of Sulfide Mineral Oxidation
Distinguished Scholar Award, The Microbeam Analysis Society
Research Grant-in-Aid Recipient:
Sigma Xi, the National Scientific Research Society
The Arizona-Nevada Academy of Science