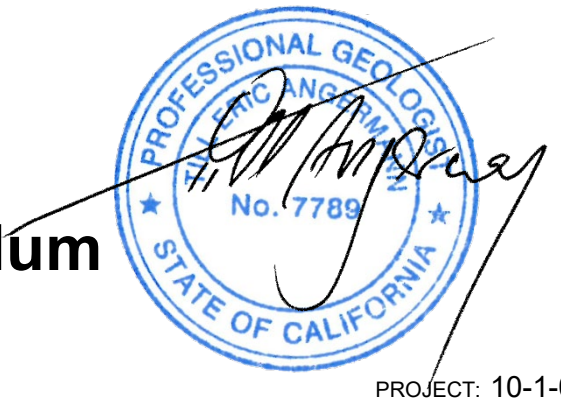
Appendix E

Luhdorff & Scalmanini
Consulting Engineers

electronic submittal



Technical Memorandum

DATE: April 2, 2021 PROJECT: 10-1-074

TO: Mr. Jason Smith, Teichert Aggregates (JSmith@teichert.com)

FROM: Till Angermann, PG, CHG, Principal Hydrogeologist
Mohamed Nasser, PhD, Senior Engineer

SUBJECT: MOBILIZATION PROCESSES OF NATURAL ARSENIC IN GROUNDWATER AND THEIR APPLICABILITY TO THE SHIFLER PROPERTY AT TEICHERT'S WOODLAND FACILITY, YOLO COUNTY

History of Comprehensive Data Collection and Evaluation

In the context of Teichert's off-channel mining activities at is Woodland facility there is a robust record of comprehensive data collection, evaluation, predictive groundwater modeling. Importantly, the cumulative data record documenting over 20 years of mining activities plus pre-mining conditions shows no evidence or indication that mining operations have caused changes in groundwater levels or quality to date. This is congruent with predictions that were made as early as 1995 (LSCE 1995) and thereafter as mining activities progressed across the site from one property to the next. Proposed mining activities at the Shifler property are no different from previous and ongoing mining activities.

Luhdorff & Scalmanini Consulting Engineers (LSCE) has been providing professional services regarding groundwater resources in the context of off-channel aggregate mining operations to the Teichert corporation and other aggregate mining operations along Cache Creek since the mid-1980s. The early work was instrumental in comprehensively characterizing pre-mining groundwater conditions and provided insight into potential impacts on groundwater resources with the development of a numerical groundwater flow model (MODFLOW platform, developed by the U.S. Geological Survey). These efforts also helped inform the development of Yolo County's off channel mining ordinance, which sets forth robust groundwater and mining pit monitoring requirements for the duration of all mining phases (i.e., pre-mining, active mining, active reclamation, and post-reclamation). This includes sampling for arsenic as part of a much broader effort of metals sampling (i.e., Title 22 inorganics).

Mining activities have been occurring continuously for well over 20 years including the Coors, Storz, Haller, Muller, and Schwarzgruber properties. Most recently, potential impacts to groundwater resources due to wetpit mining and reclamation activities at the Shifler property

were comprehensively evaluated including the use of a calibrated numerical flow model including particle tracking for the analysis of multiple different mining and reclamation scenarios (LSCE 2016, 2019, 2020a). These analyses concluded very minor and local water level impacts and no impacts to groundwater quality. Importantly, similar predictions have been made in the past for other mining properties at the Woodland plant, most recently for the Schwarzgruber property (LSCE 2011) and have been demonstrated to be realistic by the ongoing monitoring program.

Mobilization via Direct Mining Activities

Mining activities proposed for the Shifler Property, such as the extraction of earthen materials (e.g., soil, overburden, aggregate, and fines such as silt and clay) and the washing of the extracted aggregate cause a disturbance to the natural state of these materials including the uppermost portion of the shallow aquifer. The potential for this disturbance to mobilize naturally occurring metals, including arsenic, was recognized by Teichert, Yolo County staff, and various stakeholders long before the first wet pit was created at the Teichert Woodland site. As a result, comprehensive groundwater quality monitoring activities, including extensive metals analyses, were initiated in the 1990s, approximately 10 years before the first wet pit was created.[1] This data collection effort also includes active mining excavations and efforts continue for ten years after active reclamation concludes (i.e., one year after all heavy equipment work has been completed in the vicinity of a mining pit).

The ongoing monitoring program and the results of the program are described in annual reports submitted to County of Yolo on an annual basis. These reports present the cumulative data record. The most recent of these reports (LSCE 2020b) and previous reports have concluded that the cumulative data record shows no evidence or indication that mining operations have caused changes in groundwater levels or quality to date.

Mobilization via Compaction of Interbedded Clays

Groundwater pumping from unconsolidated aquifer-aquitard systems has caused land subsidence in many parts of the world including the San Joaquin Valley (SGMA Data Viewer online resource). The mechanism is described in standard groundwater textbooks such as Bouwer (1978) and Freeze and Cherry (1979). In brief, the extraction of groundwater reduces hydraulic pressure and, thus, increases intergranular pressure in aquifers and other underground materials. This can lead to the compaction of these materials. Clays (e.g., aquitard material) are typically 1 to 2 orders of magnitude more compressible than sand (e.g., aquifer material). Therefore, the majority of land subsidence caused by this process is attributed to the compaction of clay material that is interbedded with aquifer materials. During the compaction of these clays, water drains from them into the adjacent aquifer materials. If the chemical makeup of water that is drained from the aquitard is sufficiently different from the aquifer, and if drainage occurs in sufficient quantity, water quality changes may manifest in the water extracted from the aquifer. This process was, for example, examined in the Mekong Delta in Vietnam where extreme regional over-pumping of an aquifer-aquitard system is reported to

[1] Groundwater level monitoring activities were initiated earlier in the 1980s.

have caused rapid land subsidence and the associated arsenic contamination of groundwater (Erban et al. 2013).

The mechanism of mobilization via compaction of interbedded clays has been of no concern in the Project area. There is no indication or reports of any significant historical pumping-induced land subsidence in the Project area (see SGMA Data Viewer referenced above). This is particularly insightful in the context of the historical groundwater level data record, which dates back to the 1940s and documents a wide range of water level variability, including deeper levels than seen in recent years (LSCE 2020b). As stated above, Teichert's cumulative data record shows no evidence or indication that mining operations have caused changes in groundwater levels to date. This is not surprising, given that an estimated 90% of the groundwater that Teichert extracts is almost immediately returned to groundwater on-site. Groundwater and pit-water monitoring activities will continue in accordance with the Yolo County Surface Mining and Reclamation Ordinance.

In addition, the Sustainable Groundwater Management Act of 2014 (SGMA) provides a robust framework to avoid undesirable results in the future (SGMA specifically identifies "significant and unreasonable land subsidence" as an undesirable result).

References

Bouwer, H. 1978. Groundwater Hydrology. McGraw-Hill Series in Water Resources and Environmental Engineering. ISBN 0-07-006715-5

Erban, L. E., S. M. Gorelick, H. A. Zebker, and S. Fendorf. 2013. Release of arsenic to deep groundwater in the Mekong Delta, Vietnam, linked to pumping-induced land subsidence, Proc. Natl. Acad. Sci. U. S. A., 110(34), 13,751–13,756, doi:10.1073/pnas.1300503110

Freeze, R. Allan and John A. Cherry. 1979. Groundwater. Prentice Hall. ISBN 0-13-365312-9

Luhdorff and Scalmanini Consulting Engineers. 1995. Groundwater Conditions in the Vicinity of Planned Wet-Pit Mining Operations, Teichert Aggregates' Woodland Properties. Report. November 1995. LSCE file 95-1-119.

Luhdorff and Scalmanini Consulting Engineers. 2011. Groundwater Conditions in the Vicinity of Planned Wet-Pit Mining Operations, Schwarzgruber Property. Report. April 25, 2011. LSCE file 10-1-074.

Luhdorff and Scalmanini Consulting Engineers. 2016. Groundwater Conditions in the Vicinity of Planned Wetpit Mining Operations, Shifler Property. Report. February 8, 2016. LSCE file 10-1-074.

Luhdorff and Scalmanini Consulting Engineers. 2019. Groundwater Conditions in the Vicinity of Planned Wet Pit Mining Operations, Shifler Property, Woodland. Technical Memorandum. December 9, 2019. LSCE file 10-1-074.

Luhdorff and Scalmanini Consulting Engineers. 2020a. Supplemental Analysis of Groundwater Conditions, Planned Mining and Reclamation Activities, Shifler Property, Woodland, Yolo County. Technical Memorandum. February 5, 2020. LSCE file 10-1-074

Luhdorff and Scalmanini Consulting Engineers. 2020b. 2020 Annual Report, Groundwater Conditions in the Vicinity of the Woodland Plant Site. Teichert Aggregates, Yolo County, CA. October 30, 2020. LSCE file 07-1-004.

SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub

Attachments

Resumes: T. Angermann and M. Nassar

Luhdorff & Scalmanini
Consulting Engineers

Till E. Angermann, P.G., C.H.G.

Principal Hydrogeologist

EDUCATION

M.S. Hydrologic Sciences,
University of California, Davis, CA 2001

B.S. Geology,
Freie Universität, Berlin, Germany 1993

PROFESSIONAL REGISTRATIONS

CA Professional Geologist No. 7789
CA Certified Hydrogeologist No. 853

PROFESSIONAL EXPERIENCE

Luhdorff & Scalmanini,
Consulting Engineers,
Woodland, CA

Principal Hydrogeologist	2014 - present
Senior Hydrogeologist	2011 - 2014
Project Hydrogeologist	2005 - 2011
Staff Hydrogeologist	2000 - 2005

University of California, Davis, CA
Department of Land, Air & Water Resources
Graduate Research Assistant 1998 - 2000

PROFESSIONAL AFFILIATIONS

Groundwater Resources Association of California

SUPPLEMENTAL INFORMATION

Selected peer-reviewed journal articles

Angermann, T.E., Wallender, W.W., Wilson, B.W., et al. 2002. Runoff from orchard floors – micro-plot field experiments and modeling. Journal of Hydrology 265: 178-194.

Joyce, B.A., Wallender, W.W., **Angermann, T.E.,** et al. 2004. Using Infiltration Enhancement and Soil Water Management to Reduce Diazinon in Runoff. Journal of the American Water Resources Association 40(4): 1063-1070.

Former reviewer

American Geophysical Union's Water Resources Research and American Society of Civil Engineers' Journal of Hydrologic Engineering

Specialization

Mr. Angermann has more than 20 years of professional experience as a hydrogeologist. His expertise includes (a) research methodology and conceptualization of hydrogeologic systems, (b) groundwater hydraulic, hydrologic, hydrogeologic, hydrochemical, analysis and computations, (c) parametric and nonparametric statistical evaluation of environmental data, (d) assessment of surface water/groundwater interactions, watershed hydrogeology, infiltration and runoff processes, (e) data quality objectives, groundwater sampling and testing protocols, (f) monitoring well design and design of effective monitoring well networks and programs, (g) ambient water quality evaluation, (h) nitrogen cycling, irrigated agriculture, and subsurface loading, (i) management of multi-facetted and contentious projects, (j) regulatory compliance, and (k) effective communicator of complex technical material to both professional and lay audiences.

Representative Professional Assignments

Estimation of Well Extraction

Mendota Pool Group – Estimated monthly extraction volumes from over 80 agricultural supply wells in Madera County from power records and well efficiency data obtained from pumping tests. Estimates were made in the context of a highly contentious 10-year water exchange, including groundwater pumping of up to 25,000 acre-feet annually. The localized groundwater extraction caused temporary groundwater level declines beneath adjacent stakeholders' agricultural land, which resulted in increased pumping costs. The pumping estimates were critical in the reimbursement computations for impacted stakeholders. The accuracy of estimated extraction volumes was checked against several wells that were equipped with totalizing flow meters and compared favorably. Stakeholders included the U.S. Bureau of Reclamation, several water districts, and private land owners. The work was conducted within a complex regulatory framework including several Environmental Assessments and an Environmental Impact Statement.

Innovative Monitoring Well Network Design

Dairy Cares – Conceptualization of a pioneering, industry-wide Representative Monitoring Program (RMP) in response to the Regional Water Quality Control Board's 2007 Dairy General Order saved the dairy industry millions of Dollars. The Dairy General Order was the Regional Board's first effort to address agricultural non-point source contamination of groundwater and it required groundwater conditions assessment on all Central Valley dairies including the installation of several thousands of monitoring wells. The RMP proposed to take advantage of key similarities between dairies while fully accounting for substantive differences with a customized network of 443 monitoring wells on a subset of 42 dairies

Representative Professional Assignments (cont.)

between Redding and Bakersfield. After initial dismissal of the RMP approach, the Regional Board's eventual approval marked a regulatory paradigm shift that subsequently shaped the development of General Orders under the Irrigated Lands Regulatory Program.

Technical Program Management

Central Valley Dairy Representative Monitoring Program (CVDRMP) - Developed and implemented a comprehensive Central Valley-wide technical program complementing the newly approved RMP. The program explicitly recognized that groundwater monitoring alone is not a suitable tool to evaluate on-farm management practices and would not suffice to identify "solutions and upgrades" as required by the Dairy General Order. Therefore, other investigative techniques were included such as targeted soil coring, several geophysical methods, traditional agronomic field studies, seepage rate quantification from earthen-lined liquid manure storage basins, and mass balance models. This effort corrected fundamental misconceptions and misinformation regarding specific sources of contamination on dairies, identified critical weaknesses in the regulatory approach, and ultimately resulted in the development of robust diagnostics and other proposed improvements that are expected to be considered for incorporation in a revised future Dairy General Order.

This project included the coordination of two external technical advisory committees, and technical briefings at the Governor's office and briefings of top administrators at the California Department of Food and Agriculture, the California Environmental Protection Agency, presentations to the State Water Board, Regional Water Board, and various stakeholder groups.

Agricultural Panel of Experts

State Water Resources Control Board – Served among eight experts. This panel was convened in May 2014 by the State Board in the context of Chapter 1 of the Second Extraordinary Session of 2008 (SBX2 1, Perata) to assess existing agricultural nitrate control programs and develop recommendations, as needed, to ensure that ongoing efforts are protective of groundwater quality. The final report was presented in September 2014.

Wastewater Detention Basin Seepage

CVDRMP and Sacramento Regional County Sanitation District – Used a novel investigation approach to quantify seepage rates of working, earthen-lined liquid manure basins on over 20 dairies and the Sacramento Regional County Sanitation District Wastewater Treatment Plant's effluent basins. The methodology is capable of quantifying daily seepage rates in the sub-millimeter realm and an associated uncertainty with specified confidence. The seepage investigations were highly successful, and results supported momentous conclusions, which guided the development of efficient and effective mitigation efforts.

Surface Water Hydrology

Napa County – Conducted a review of existing data sources and measurement efforts by different entities, compiled and evaluated findings, identified data gaps and redundancies, and provided guidance on (i) the design of a county-wide network of precipitation and streamflow monitoring stations and (ii) near-stream groundwater level monitoring for assessing surface water/groundwater interactions. The objectives of this work effort were to (i) improve the County's understanding of the major watersheds' responses to precipitation and natural and/or anthropogenic changes, (ii) help attain goals outlined in the Napa River Sediment TMDL and Habitat Enhancement Plan that pertain to instream sediment occurrence and temperature, and (iii) delineate an adequate data collection effort to continue the ongoing calibration of the County's extensive water quantity and water quality modeling efforts.

Luhdorff & Scalmanini
Consulting Engineers

Mohamed K. Nassar, PhD

Senior Engineer

EDUCATION

PhD, Civil and Environmental Engineering,
University of California, Davis CA 2015

M.S., Groundwater Hydraulics,
Cairo University 2004

B.S., Civil Engineering,
Cairo University 1999

PROFESSIONAL EXPERIENCE

Luhdorff & Scalmanini
Consulting Engineers
Senior Engineer *2021 - Present*
Project Engineer 2015 - 2020

University of California-Davis
Post-Doctoral Fellow 2016 - 2017

Teaching:

University of California, Davlis, 2015 - 2016
ECI141 (Hydraulics Lab), HYD146 (Hydrogeology and Contaminant Transport), HYD144 (Hydrogeology), ECI144 (Groundwater Systems Design), ECI114 (Probabilistic Systems Analysis for Civil Engineers), ECI271 (Inverse Problem), ECI272A, B, C (Advanced Hydrogeology-Flow, Transport, Reactive Transport).

Theoretical:

Teaching different UC-Davis courses at Civil and Environmental Engineering (CEE) and Land, Air, Water Resources (LAWR) departments at with focus in analytical and numerical groundwater flow and transport modeling.

COMPUTER SKILLS

- Hydrogeology forward modeling (flow, transport, reactive transport): MODFLOW, MT3DMS, MT3D-USGS, SEAWAT, PHREEQC, PHT3D, SHEMAT and HYDRUS
- Inverse modeling: UCODE
- Programming: FORTRAN, MATLAB, MathCAD.
- Geostatistics: GS+, SURFER.

Specialization

Mohamed's areas of specialization include modeling of groundwater flow, saltwater intrusion, fate and transport of solute, groundwater age, and multicomponent reactive transport in natural media and parameter estimation of mathematical models given different kind of observation data (head, age, and solute concentration), groundwater sustainability through quantification and simulation of groundwater age at regional scales. Mohamed worked on the transport simulations for the AID MZ Model for the CV-SALTS SNMP Archetype Management Zone project. Also, he developed the regional scale solute transport model for Westland water district to quantify unreasonable water quality key related to SGMA. Mohamed devolved a mathematical modeling of the dynamics of bio-chemical reaction on porous media properties (porosity and intrinsic permeability) during microbially-induced biocementation. These efforts have involved intensive use of a wide range of computer modeling tools including MODPATH, MODFLOW, MT3DMS, MT3D-USGS, SEAWAT, PHT3D, PHREEQC and UCODE. Mohamed is also experienced in using geostatistical tools to estimate required variables at unsampled locations.

Representative Professional Assignments

- Surface water-Groundwater interaction study at Sunol Valley Groundwater Basin
- Modeling of transport at Westland Basin, CA, USA for SGMA
- Modeling of groundwater flow at Tulare Lake Groundwater Basin, CA, USA for SGMA
- Groundwater-Surface water interaction of Feather River and Groundwater Basin, CA, USA.
- Modeling of flow and transport of Alta Irrigation District (AID) as management zone archetype, CA, USA.
- Modeling of regional saltwater intrusion of the Gulf of Taranto, Italy.
- Modeling of multicomponent reactive transport and biogeochemical process in natural media, CA, USA.
- Modeling of groundwater flow and age in the northern part of San Joaquin Valley, CA, USA.
- Modeling of salinity mixing to control salinity the Mendota Wildlife Area (MWA), CA, USA.
- Modeling of ground water flow at Teichert Woodland (Shifler Parcel), CA, USA.

Referenced Publications

Nassar, M.K., Deviyani Gurung, Mehrdad Bastani, Timothy R. Ginn, Babak Shafei, Michael G. Gomez, Charles M. R. Graddy, Doug C. Nelson, Jason T. DeJong (2018), **Large-Scale Experiments in Microbially Induced Calcite Precipitation (MICP):** Reactive Transport Model Development and Prediction, Water Resources Research, DOI: 10.1002/2017wr021488

Ginn, T. R., L.G. Schreyer, X. Sanchez-Vila, M.K. Nassar, A.A. Ali, S. Kräutle (2017), **Revisiting the Analytical Solution Approach to Mixing-Limited Equilibrium Multicomponent Reactive Transport Using Mixing Ratios:** Identification of Basis, Fixing an Error, and Dealing with Multiple Minerals, Water Resources Research, DOI: 10.1002/2017wr020759

Kamai, T., M. K. Nassar, K. E. Nelson and T. R. Ginn (2015), **Colloid Filtration Prediction by Mapping the Correlation-Equation Parameters from Transport Experiments in Porous Media**, Water Resour. Res., doi: 10.1002/2015WR017403

Nassar, M. K. and T. R. Ginn (2014a), **Impact of numerical artifact of the forward model in the inverse solution of density-dependent flow problem**, Water Resour. Res.,50, doi: 10.1002/2013WR014672

Nassar, M. K., and T. R. Ginn (2014b), **Cauchy data requirement of the inverse problem of the mean age equation**, Water Resour. Res., 50, doi:10.1002/2013WR014674

Presentations/Workshops & Training Courses

Nassar, M.K., D. Gurung, M. Bastani, T.R. Ginn, M. Gomez, C. Graddy, D. Nelson, J. DeJong (2019), **"Modeling a large scale experiment in MICP using independently determined parameters"**, 11th International Conference on Porous Media & Annual Meeting (InterPore2019), May 6 - 10, 2019, Valencia, Spain.

Nassar, M. K., D. Gurung, M. Bastani, M. Gomez, C. Graddy, J. DeJong, D. Nelson, T.R. Ginn (2018), **"Large-Scale Experiments in Microbially-Induced Calcite Precipitation (MICP): Reactive Transport Model Development and Prediction",** ", EGU General Assembly, April 8-13, Vienna, Austria

Nassar, M. K., V. K. Grabert, Dalgish, B. J. Dickey, D. Moss, (2018) **"A Flow and Transport Model Developed as a Salt and Nitrate Management Analysis Tool for a Management Zone in California's Eastern Kings Subbasin",** 24th CWEMF ANNUAL MEETING "California Sustainability of Resources, the Environment & Lifestyle through Modeling" April 2-4 2018, Folsom-CA, USA.

Kamai, T., M. K. Nassar, K. E. Nelson, and T. R. Ginn (2017) **"Using data from colloid transport experiments to parameterize filtration model parameter",** EGU General Assembly 2017, April 23-28, Vienna, Austria.

August 08-09, 2016: Workshop in title of **"PHT3D Short Course –MICP Focused"** organized and presented by M. K. Nassar, D. Gurung, and T. R. Ginn, for participants in the NSF ERC Center for Biomediated and Bioinspired Geotechnics, Civil and Environmental Engineering Department, at UC Davis. This two-day workshop detailed the theory and mathematical modeling of the dynamics of bio-chemical reaction on porous media properties (porosity and intrinsic permeability) during microbially-induced biocementation. This process involves in-situ stimulation of native ureolytic bacteria which then serve as distributed catalyst for ureolysis of injected urea, leading to distributed calcite precipitation. We examined the mathematical modeling of experiments in the context of geotechnical manipulation of subsurface soil strength. The workshop involved description and teaching of the use of MODFLOW-PHT3D as well as presentation of the challenges of modeling the biotic phase. The workshop closed with focus on frontier engineering science questions involved in extending the model to application to real field problem.