Justin W. Knudsen, P.E.

Senior Civil/Geotechnical Engineer/Project Manager

Education

MS, Geotechnical Engineering, University of Colorado, 2002

BS, Civil Engineering, University of Colorado, 2000

Registrations/Certifications

Professional Engineer: Nevada (#019172, 2008); Missouri (#2014032638, 2014); Minnesota (56157); Colorado (54591); Idaho (18054)

Experience Summary

Mr. Knudsen is a Professional Engineer (Geotechnical BS and MS) and Project Manager with more than 15 years of experience in the mining industry applying his geotechnical expertise designing tailings dams, heap leach pads (HLP), waste rock dumps, and other earthen structures. Justin's field experience includes designing and executing geotechnical investigation plans using multiple drilling methods including hollow stem auger, diamond core, sonic, and cone penetration testing (CPT) equipment. Justin applied these field fundamentals to hone his analytical and modeling skills, which include geo-mechanical soil and rock testing, geosynthetic materials testing, slope stability, seepage, consolidation and settlement analyses.

With a fundamental foundation in field and analytical geo-techniques combined with sound mentoring and a team-player personality Justin advanced to a Lead Geotechnical Design Engineer and Project Manager leading projects from feasibility through final engineering and "for construction" designs. Many of Justin's designs have been built requiring him to serve as Resident Engineer and Deputy Engineer of Record (EoR) for operating tailings dam(s) throughout the Western United States, México, and Perú.

Project Experience

Mine Tailings / Waste Facilities

ENGINEER OF RECORD, JURISDICTIONAL DAMS, BARRICK GOLDSTRIKE MINE | ELKO, NEVADA

Deputy Dam Engineer for seven dams located at the mine requiring annual inspections and other EoR duties. Ongoing engineering support includes civil/geotechnical design of raises to existing tailings dams and design of new tailings dam. Recent experience includes a sonic drilling investigation, instrumentation installation, and advanced geotechnical analyses including 3-dimensional slope stability analyses evaluating dam raise design in a challenging geotechnical environment. Served as resident engineer during raise of a 500+ acre tailings dam. Prepared technical specifications, construction quality assurance manual, and As-Built Report, construction, and as-built drawings. Project Engineer during field investigations and analyses to maximize storage capacity in a tailings impoundment. Field investigation included CPT and soil and water sampling. Analysis included the use of FSConsol software. Supervised construction of two water diversion channels totaling approximately 5 miles in length. Completed the design of a seepage transfer pipeline to convey collected seepage in a double-contained pipeline over a distance of approximately 2,100 feet. Prepared construction drawings, technical specifications, and construction quality assurance manual. Directed multiple field investigations for design of future tailings impoundments. Completed designs of raises to existing tailings storage facility (TSF) and design of new facility. Designs include geotechnical modeling, civil design, hydrology, and geosynthetic liner design. (Tetra Tech 2004 to 2011; Tierra Group, 2012 to Present)

WILLOW CREEK DAM REHABILITATION | ELKO COUNTY, NEVADA

Project Manager responsible for concrete dam rehabilitation for a ±100-year old concrete water supply dam. Performed research and options study investigating methods and materials to rehabilitate the dam and outlet works. Rehabilitation plans were completed to repair damaged outlet valves, spalling concrete, and

general weathering. Completed rehabilitation plans and specifications. Provided resident engineering support during construction. (Tierra Group, 2017 to Present)

STIBNITE GOLD PROJECT TSF AND STORMWATER CONTROLS | STIBNITE, IDAHO

As Project Manager and Lead Geotechnical Engineer, led a team of engineers performing geotechnical investigations for the TSF, development rock storage facilities (DRSFs), mill, camp, and other infrastructures. Planned and directed sonic, cone penetration testing, geophysics, and hollow stem auger drilling campaigns. Trained client geologists to log and sample soil. Completed geotechnical characterization and design work based on findings to support feasibility study. Led an engineering team to develop diversion options to reroute creek flow around the TSF and DRSFs. A SWOT analysis and cost estimates performed providing an effective tool for mine planning. (Tierra Group, 2017 to 2018)

LAS BRISAS PEA | VENEZUELA

Project Manager responsible for 2.1-billion-tonne TSF design supporting a Preliminary Economic Assessment (PEA). Completed conceptual water management plan laying the groundwork for future engineering and studies. Worked with the external multi-disciplinary team to complete the PEA. (Tierra Group, 2017)

SWEETWATER TSF RAISE DESIGN | VIBURNUM, MISSOURI

Project Manager responsible for two raise designs for a 40+ year old TSF at Doe Run's Sweetwater Mine. Unique design challenges were overcome with a comprehensive field investigation including CPT and hollow stem auger drilling. Liquefaction analyses were performed and incorporated into the upstream raise design. A challenging hydrology model was completed and a raise to the existing spillway was designed. One raise design was approved by Missouri Department of Natural Resources (MDNR) Dam and Reservoir Safety Council in March 2016. Construction was completed in early 2017, support provided with Tierra Group overseeing construction activities and evaluating proposed design changes. An As-Built Report was completed in April 2017 conforming to MDNR requirements. A second raise (23 feet tall) included a rockfill buttress, saddle dam, and a new spillway which is currently being reviewed by MDNR Dam Safety. (Tierra Group, 2015 to Present)

BRUSHY CREEK TSF RAISE DESIGN | VIBURNUM, MISSOURI

Project Manager responsible for a 17-foot dam raise design for an existing TSF at Doe Run's Brushy Creek Mine. The dam was built in stages starting in 1973 using tailings cyclone underflow (coarse tailings) and the upstream construction method. The raise design required CPT, a liquefaction triggering analysis, seepage modeling, and slope stability modeling. In addition to the dam raise, a spillway raise was designed requiring hydrology and hydraulic modeling and riprap design. The design was approved by MDNR Dam and Reservoir Safety Council in February 2015. Provided EoR duties as the dam raise was constructed and completed an As-Built Report upon completion. (Tierra Group, 2014 to 2017)

BRUSHY CREEK 2 TSF | VIBURNUM, MISSOURI

Project Manager and Lead Engineer responsible for a new TSF design at Doe Run's Brushy Creek Mine capable of storing 36 million tons (Mt) of tailings solids. The new TSF requires a 185-foot tall dam planned for construction in four stages including a clay starter dam and three raises using tailings cyclone underflow. Hydrology and Hydraulic modeling was performed to design four spillways and a water balance was completed providing a planning tool for use throughout facility life. A geotechnical investigation was carried out which utilized both hollow stem auger and diamond coring techniques. The design was approved by MDNR Dam and Reservoir Safety Council in October 2015. (Tierra Group, 2014 to Present)

BRUSHY CREEK 3 TSF | VIBURNUM, MISSOURI

Project Manager and Lead Engineer responsible for designing an alternative iteration to the Brushy Creek 2 TSF designed to accommodate state requirements for land use. The TSF dam is 141 feet tall and capable of storing 16 Mt of tailings solids. Three stages are planned, including a clay starter dam and two downstream raises. A geotechnical investigation was performed using hollow stem auger and diamond core drilling. Challenging foundation conditions required a large key trench and integrated drainage system. Spillways were designed for each stage. The design was approved by MDNR Dam and Reservoir Safety Council in August 2017. (Tierra Group, 2016 to 2017)

DESMINIC TSF COVER OPTIMIZATION | LA LIBERTAD, NICARAGUA

Project Manager responsible for tailings consolidation modeling and deposition planning providing operators with a plan to deposit tailings late in the TSF life. Executing the end-of-life deposition plan will save significant closure costs because less fill will be required to cove r the facility. Work included evaluating closure cover options providing B2Gold with a planning tool for strategic closure of the site. (Tierra Group, 2017 to Present)

CAETÉ AND TURMALINA MINING COMPLEXES | BRAZIL

Lead Geotechnical Engineer responsible for the geotechnical investigation including CPT, hollow stem auger drilling, and in-situ sampling of dry stack and slurry TSFs. Liquefaction potential was evaluated using CPT and SPT data. Laboratory testing was important in correlating and extrapolating field data to similar facilities at each mine. Recommendations were made regarding tailings excavation and stacking procedures. Tierra Group's work was necessary to continue tailings storage operations in a challenging regulatory environment. (Tierra Group, 2016)

EL AGUILA CONCEPTUAL TAILINGS STUDY | OAXACA, MÉXICO

Project Manager leading a multi-disciplinary team to complete a conceptual evaluation to determine economic feasibility to add a filter plant, paste plant, and dry stack TSF contributing to mine life extension. Cemented paste backfill was needed to expand the underground mine. The team evaluated filter and paste plant design calculating CAPEX and OPEX costs needed for overall mine planning. Multiple dry stack facility layouts of various sizes were designed and compared using a comparative matrix evaluating qualitative and quantitative criteria. (Tierra Group, 2017)

PITARRILLA PROJECT FEASIBILITY STUDY | DURANGO, MÉXICO

Project Manager responsible for feasibility level design of a 112-Mt TSF for a world-class silver deposit. Successfully led a multi-disciplined project team completing the civil layout, staging optimization, water balance optimization, geotechnical investigations, geologic hazard mapping, seepage and slope stability modeling, and surface water diversion design. The design team also completed a site-wide water management plan for the project allowing advanced water supply planning. Led project team to complete engineering reports and capital cost estimates included in an NI 43-101 compliant feasibility study for the Pitarrilla Project. (Tierra Group, 2012)

CHINCHÁN SOUTH DRY STACK TSF | SAN MATEO, PERÚ

Project Manager responsible for design of dry stack TSF and ongoing construction support during construction of the facility as well as during facility operations. Completed reports and other submittals to local regulatory agencies (OSINERGMIN and MEM). Special considerations include steep topography, construction during inclement weather, and multiple successful peer reviews. (Tetra Tech, 2008 to 2011; Tierra Group, 2012)

TUCUSH TSF | HUARI ANCASH, PERÚ

Project Manager responsible for design of raises for the TSF as well as As-Built Reports to comply with regulatory requirements. This dam is built using cyclone underflow for the main embankment along with a waste rock shell for added stability. Limited available footprint area created design challenges that were overcome with unique engineering solutions. (Tetra Tech, 2008 to 2011; Tierra Group, 2012)

BOVILL KAOLIN PROJECT | LATAH COUNTY, IDAHO

Project Manager responsible for NI 43-101 compliant Preliminary Economic Assessment for a 1.5-Mt TSF. Multiple trade-off studies were completed to optimize the facility design while minimizing project costs. (Tetra Tech, 2011)

MT. TODD TSF | NORTHERN TERRITORY, AUSTRALIA

Responsible for civil and geotechnical design of multiple large TSFs for pre-feasibility and definitive feasibility studies. Project included stability assessment of current TSF for possible expansion and design of new facility. Innovative liner design was needed to maintain containment of tailings while allowing cost effective construction techniques. Multiple site visits were made over the years to oversee two field investigation campaigns and gather site specific data. (Tetra Tech, 2008 to 2011)

COZAMIN MINE TSF | ZACATECAS, MÉXICO

Project Manager responsible for design of centerline raises for the TSF as well as As-Built Reports to comply with requirements set for by the local environmental regulatory agency (SEMARNAT). Submittals included design and as-built drawings, construction specifications, and various reports. Special considerations included water management concerns, geotechnical design, and operation of the facility to maximize water recovery for process plant use. (Tetra Tech 2008 to 2010)

SOLEDAD TAILINGS EMBANKMENT SEEPAGE ANALYSIS | EL MOCHITO MINE, HONDURAS

As Geotechnical Engineer, performed finite element seepage analysis for new embankment design. Responsible for stability modeling and cross-section design for new tailings embankment. (Vector Colorado, 2005)

PASCUA LAMA PROJECT STABILITY ANALYSES | WESTERN ARGENTINA

As Geotechnical Engineer, responsible for stability analysis for a 102-meter (m) high earthfill tailings dam and a 30-m high earthfill and rockfill water storage dam located in the high Andes near the Chile-Argentina border. (Vector Colorado, 2005)

OLD VIBURNUM EARTHFILL BUTTRESS DESIGN | FLETCHER, BRUSHY CREEK, NEW LEAD BELT, MISSOURI

As Geotechnical Engineer, designed earthfill buttress for dynamic stability of existing tailings storage embankment. Design utilized on-site materials to minimize construction costs. (Vector Colorado, 2004)

MARLIN PROJECT DYNAMIC ANALYSES | MARLIN MINE, GUATEMALA

As Geotechnical Engineer, performed dynamic deformation and stability evaluations for an 85-m rockfill tailings embankment. Performed dynamic analyses for multiple earthquakes (predicting deformation for multiple slopes on the embankment) and a seepage study for the clay core of the embankment. (Vector Colorado, 2004)

MINA EL DORADO PREFEASIBILITY STUDY | SENSUNTEPEQUE, EL SALVADOR

As Geotechnical Engineer, performed slope stability modeling for siting and designed a tailings embankment and impoundment. Performed detailed design of embankment cross-section. (Vector Colorado, 2004)

Heap Leach Pads

LA TRINIDAD | SINALOA, MEXICO

Project Manager leading an experienced team providing HLP construction recommendations and a water balance. Work continued with a HLP expansion design, slope stability analyses, hydrologic analyses, diversion design, liner design, and leach solution collection piping design. Slope stability analysis interpretation and results provided Oro Gold with a safe stacking plan to maximize ore storage capacity. Water balance analyses and “outside the box” ideas made it possible to forego a stormwater pond expansion saving significant HLP expansion construction costs. (Tierra Group, 2017)

STERLING MINE HLP EXPANSION AND NEW PAD DESIGN | BEATTY, NEVADA

As Project Manager and Lead Geotechnical Engineer, responsible for design of an in-fill leach pad expansion and design of a new 20-acre HLP. The projects included civil layout, hydrology, hydraulic design, ore capacity optimization, liner design, solution recovery system design, slope stability modeling, and completion of a stacking plan. Challenges included adapting new designs to existing infrastructure including solution collection piping, ponds, and stormwater controls. Design packages were submitted to the State of Nevada for the heap leach slot in-fill project, a process plant pond and pipeline reconfiguration, and the new leach pad. (Tierra Group, 2013 to 2015)

EL GALLO HLP EXPANSION | SINALOA, MÉXICO

Project Manager and Lead Engineer responsible for design and construction oversight for a 65,000-m^2 expansion of an existing HLP. The HLP expansion design included slope stability modeling, civil layout, ore capacity optimization, liner design, solution recovery system design, and completion of a stacking plan to guide ore placement during operations. Project challenges included incorporating existing infrastructure into the expansion design and choosing construction materials and methods that would allow rapid construction of a safe, environmentally sound facility. Provided construction oversight through multiple site visits working with local engineers to ensure the facility was built according to design. (Tierra Group, 2012)

ZONIA MINE HLP DESIGN | YAVAPAI COUNTY, ARIZONA

Completed a site investigation, stability analyses, and directed civil design of a HLP in mountainous terrain. The Zonia Project is a brownfields project so the site investigation focused on the existing HLP and surrounding area investigating potential expansion of the existing pad. Civil and geotechnical design was completed to pre-feasibility level resulting in engineering reports, drawings, and cost estimates included in an NI 43-101 compliant pre-feasibility report. (Tetra Tech, 2009)

Mine Operations

AMERICAN GYPSUM HAUL ROAD SAFETY IMPROVEMENT EVALUATION | GYPSUM, COLORADO

As Project Manager, conducted an alternatives analysis to determine the most appropriate measures to improve safety on a steep haul road section. The analysis included basic engineering of runaway truck ramps, a mechanical vehicle arresting system, haul road realignment, and center berm arrestors. Alternatives were evaluated on effectiveness, construction requirements, maintenance needs, operational impacts, and environmental impacts. The alternatives analysis provided American Gypsum a tool to determine the most effective way to improve haul road safety. (Tierra Group, 2014)

FLORIDA CANYON ROCK SLOPE STABILITY EVALUATION | WINNEMUCCA, NEVADA

As Geotechnical Engineer, conducted an evaluation of rock slope stability at this large operating open pit gold mine to determine safe slope angles for continued pit expansion. Analyses included assessment of weak, shattered rock masses. (Vector Colorado, 2004)

Water Resources

MASBATE WATER TREATMENT PLANT DESIGN AND CONSTRUCTION | MASBATE, PHILIPPINES

As Project Manager, oversaw design and provided construction and commissioning support to a 15,000 m^3 per day water treatment plant (WTP) and over 7 km of pipelines. The WTP incorporates INCO and microfiltration processes to treat TSF supernatant water to Philippine discharge standards. The design team completed a geotechnical investigation and foundation design, pipeline design, and full WTP design including structural, chemical, and process engineering. Additional work included modifications to the WTP flowsheet due to changes in discharge standards. (Tierra Group, 2013 to Present)

SHERMAN DAM EVALUATION | LOUP CITY, NEBRASKA

As Geotechnical Engineer, performed evaluation of existing toe-drain and blanket drain. Investigation included trench excavation and geotechnical borings. (Vector Colorado, 2004)

MIDWAY PROJECT RAPID INFILTRATION BASIN DESIGN | TONOPAH, NEVADA

As Project Engineer, designed a rapid infiltration basin for the disposal of de-watering water produced during mining operations. Conducted field investigation including auger drilling and percolation tests and designed the basin to accommodate flows up to 2,000 gallons per minute (gpm). Prepared drawings, calculations and a final report in support of permitting efforts. (Tetra Tech, 2008)

RAILROAD VALLEY RAPID INFILTRATION BASIN DESIGN | ELY, NEVADA

As Project Engineer, designed a rapid infiltration basin for the disposal of water recovered during oil production. Conducted field investigation including test pits and percolation tests and designed the basin to accommodate flows up to 50 gpm. Prepared drawings and submittals in support of permitting efforts. (Tetra Tech, 2008)

Professional Affiliations

American Society of Civil Engineers; Member (2008 to 2011)

Society for Mining, Metallurgy, & Exploration (2011 to Present)

Colorado Mining Association; Member (2015)

Employment History

CURRENT EMPLOYER	**TIERRA GROUP INTERNATIONAL, LTD.**
POSITION	Senior Engineer
YEARS	2012 to Present
EMPLOYER	**TETRA TECH, INC.**
POSITION	Project Engineer
YEARS	2007 to 2011
EMPLOYER	**VECTOR COLORADO, LLC**
POSITION	Staff Civil Engineer
YEARS	2003 to 2007
EMPLOYER	**KRAZAN & ASSOCIATES**
POSITION	Staff Engineer
YEARS	2002 to 2003
EMPLOYER	**GOLDER ASSOCIATES INC.**
POSITION	Field Technician
YEARS	2000
EMPLOYER	**ADVANCED TERRA TESTING**
POSITION	Soil Technician
YEARS	1998 to 2000