



GEOTECHNICAL INSTRUMENTATION & MONITORING



SUMMARY

Senior staff of KUE have nearly 50 years' combined experience with the planning, installation, implementation, interpretation and reporting on instrumentation and performance monitoring programs for underground projects. The firm is familiar with the installation of various types of instruments including observation wells, vibrating wire piezometers, inclinometers, extensometers, convergence, geophone vibration sensors and survey prisms measured by traditional surveying methods and/or with an automated mechanical total station (AMTS). KUE is capable of providing a turnkey service from design to implementation for geotechnical instrumentation programs.

KEY PROJECTS

CDOT | I-70 CENTRAL PROJECT | KIEWIT | DENVER, CO | JAN 2019 - ACTIVE



KUE has been retained by the Contractor to develop an Instrumentation Plan using an AMTS that shoots an array of 400 L-Bar prisms mounted onto a soldier pile structure and 3 sets of UPRR tracks running through the project site. An AMTS mounted to a steel pole records readings of each of the prisms every 4 hours to monitor potential settlement in the area of the soldier piles and the zone that trains pass through. The \$1.2B project will dramatically alter the landscape of the 10 mile stretch of the I-70 corridor from I-25 in Denver to Chambers Road in Aurora. Construction began in September 2018 and the project is expected to be completed sometime in 2022.

CITY OF AURORA | 56TH & PICADILLY | GARNEY CONSTRUCTION | AURORA, CO | FEB 2020 - ACTIVE



KUE has been retained by the contractor to develop an Instrumentation Plan to monitor ground behavior for a 48-inch diameter steel casing being installed 920 LF beneath the north and southbound lanes of E-470 at Picadilly Road. Pipe is being advanced via an MTBM and aside from actively monitoring the roadway, KUE has installed Deep Settlement Monitoring Points (DSMP) at both the launch and reception shaft as well as located and installed monitoring points on a water line, gas line, two fiber optic lines and multiple buried electric lines that all run through the path of the MTBM. Utilizing a Total Station, our team of survey technicians are on site during tunneling operations to monitor all Sub-Surface Points (SSP) as well as each Utility Monitoring Point (UMP) and provides the data to the contractor daily.

CDOT | US 82 TREE FARM HAMMER BORE | BTRENCHLESS | BASALT, CO | MAY 2020 - ACTIVE



KUE was retained by the Contractor to create and implement an Instrumentation & Monitoring plan to record surface elevations for the installation of a 36" OD steel case pipe housing a 12-inch waterline beneath Highway 82 in Basalt, CO. The installation is expected to be performed via Hammer Bore methodology in silty sand alluvium ground conditions. The project is part of a new 43-acre, \$250 million development project that will bring retail, dining, hotels & condos to the Roaring Fork Valley in Eagle County, Colorado.

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KEY PROJECTS (CONTINUED)

PARKER WATER & SANITATION DIST. | CHERRY CREEK INTERCEPTOR | BTRENCHLESS | PARKER, CO | MAY 2020 - ACTIVE



KUE has been retained by the Contractor to develop an Instrumentation Plan for the installation of a new wastewater pipeline in Parker, Colorado. The Parker Water and Sanitation District is installing the Cherry Creek Interceptor (CCI), a waste water gravity pipeline to convey wastewater flows from the existing South Water Reclamation Facility to the existing North Water Reclamation Facility. The CCI project includes approximately 2.5 miles of 21-inch, 36-inch, and 48-inch gravity interceptor pipelines with trenchless crossings planned for the 36-inch & 48-inch pipeline crossings.

CITY OF BROOMFIELD | NORTH AREA FORCE MAIN | T. LOWELL | BROOMFIELD, CO | MAR 2020 - ACTIVE



KUE was retained by the contractor to assist with the installation of a new waterline in Broomfield, Colorado. The City and County of Broomfield plans to develop a sanitary force main system by constructing a new waterline to convey wastewater from the North Area Lift Station to the nearby Broomfield Wastewater treatment plant. The trenchless portion of the project required two 345 LF drives of 30-inch bored steel casing housing 18-inch PVC carrier pipes under Northwest Parkway. Both tunnels were advanced utilizing an auger bore system. KUE was on-site daily during active tunneling to monitor the east and west-bound lanes of the Northwest Parkway along with UMP's installed on two edge drains and a buried communication line used for highway signal. The project is on schedule to be completed by early June 2020.

CITY OF BERTHOUD | TAFT AVE BORE | BTRENCHLESS | BERTHOUD, CO | MAR 2020 - ACTIVE



KUE has been retained by the Contractor to develop an Instrumentation Plan for the installation of a dual bore 42-inch stormwater pipe advanced 200 LF beneath Highway 287 in Berthoud, Colorado. Both drives were advanced via Guided Auger Bore methodology with one drive utilizing tri-lock steel casing and the other utilizing permalok pipe. Due to the heavy flow of traffic on Hwy 287, KUE was on-site twice per day to monitor all points during active tunneling. The project is on schedule to be completed by the end of May 2020.

CITY OF DENVER | 39TH AVE PARK HILL | SEMA CONSTRUCTION | DENVER, CO | NOV 2019 - APRIL 2020



Similar to the work performed on the Central 70 project, KUE was retained by the Contractor to develop and implement an Instrumentation Plan using an AMTS mounted onto a nearby building to monitor ground behavior throughout the installation of an 84-inch RCP storm sewer. Working within a sensitive area that contains two sets of RTD tracks and a public road, a TBM was elected as the best method of installation. Our survey crew has worked diligently in installing and maintaining surface array points in the roadway and prisms adhered to both sets of RTD tracks to ensure the contractor and owner that influences to the ground near the project site will be tracked in real-time and allow piece of mind to continue tunneling operations without fear of damage to the RTD tracks and other nearby structures.

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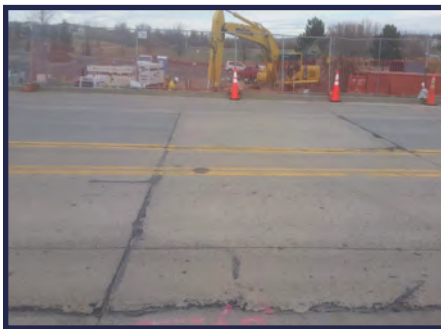
KEY PROJECTS (CONTINUED)

EVERGREEN METRO DISTRICT | HIDDEN VALLEY WATER CONNECTION | CGRS | EVERGREEN, CO | OCT 2019 - APRIL 2020



KUE was retained by the Contractor to create and manage an Instrumentation plan for monitoring a 6-inch pressurized water main installation utilizing a Horizontal Directional Drill. The project site was on a busy roadway and tunneling operations were to cross under Evergreen Parkway in Evergreen, CO. The waterline was encased in a 10-inch OD steel cased pipe, and HDD methodologies were elected to minimize traffic disruptions and third-party impacts. KUE is responsible for monitoring the Parkway and one existing waterline for settlement and/or heave caused by the HDD installation. The project is currently underway and estimated to be completed by May 2020.

CITY OF PARKER | STROH ROAD INTERCEPTOR | PEI | PARKER, CO | NOV 2019 - JAN 2020



KUE was retained by the Contractor to create and implement an Instrumentation & Monitoring plan to record surface elevations throughout the installation of a 42" OD sanitary sewer line beneath Stroh Road in Parker, CO. The sewer line measured 110 LF and was installed via auger bore methodology. It was determined that the best practice for measuring surface elevations was via sub-surface monitoring points (SSP) installed in an array on the shoulders of the road. The project was completed successfully in early January 2020.

CITY OF LYONS | APPLE VALLEY | BTRENCHLESS | LYONS, CO | AUG 2019 - OCT 2019



KUE was retained by the contractor to assist with a waterline relocation project just outside the town of Lyons, Colorado. Aside from performing engineering design on the project, KUE was hired to create an instrumentation plan and actively monitor a section of county roadway for an approximate 100 LF tunnel being advanced via pipe ramming methodologies. The steel casing pipe measured 36-inches in diameter and encased a 12-inch diameter pressurized waterline. Cover above the crown of the alignment ranged between 9 and 13 feet. KUE's daily monitoring ensured the contractor and the municipality that the project could be performed without the need to close off the road. The project was successfully completed by September of 2019.

CITY OF WESTMINSTER | LITTLE DRY CREEK | BRANNAN | WESTMINSTER, CO | NOV 2017 - ON HOLD



KUE has been retained by the Contractor to develop an Instrumentation Plan for the installation of six shafts, two HDD tunnels and one 48-inch diameter auger bored tunnel. The auger bored tunnel was beneath an existing roadway and crossed beneath BNSF and RTD tracks, while the HDD's ran beneath a roadway and drainage canal. Instrumentation to monitor tunnel subsidence included arrays of surface survey points (SSP's), utility monitoring points (UMP's) and vibration monitoring points. After collecting a frequency of readings and establishing a threshold with action limits, KUE collected data and provided up to the minute reporting to the contractor.

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KEY PROJECTS (CONTINUED)

DOMINION WATER | EASTERN PIPELINE | BTRENCHLESS | CASTLE ROCK, CO | MAR 2019 - DEC 2019



KUE was retained by the Contractor to develop an Instrumentation Plan using arrays of surface survey points (SSP's), utility monitoring points (UMP's) and rail prisms. The project involves a 42-inch diameter steel casing tunnel undercrossing multiple sets of active BNSF rail lines and crosses, Hwy 85 in Castle Rock and Manhart Ave in Sedalia. KUE recorded readings each day during tunneling activity and provided the client with daily readings reflecting ground settlement caused by tunneling operations.

CITY OF DENVER | 27TH STREET INTERCEPTOR | IRON WOMAN | DENVER, CO | SEPT 2018 - AUG 2019



KUE was retained by the Contractor to manage all project surveying, including perform a Pre-Construction Survey and develop an Instrumentation Plan for the active monitoring of streets, sidewalks, existing utilities and third party structures for the installation of twin 96-inch RCP tunnels running parallel up 27th Street in the RINO district of Denver. KUE recorded daily readings using surface survey points (SSP's) in the roadways and utility monitoring points (UMP'S) to measure settlement of all utilities crossing the path of the tunneling operations. KUE is also performing vibration monitoring to provide the client with up to the minute data reflecting ground behavior due to construction operations.

CITY OF LONGMONT | RESILIENT ST. VRAIN 2B WATERLINE | UIT | LONGMONT, CO | JAN - MAR 2019



KUE was retained by the Contractor to develop an Instrumentation Plan to monitor 2 tunnels being advanced utilizing an auger boring methodology. The first tunnel consisted of 220 linear feet of 30-inch diameter casing being advanced below the St. Vrain Creek. The second tunnel consisted of a 30-inch diameter steel casing extending 120 linear feet beneath BNSF railroad tracks. The instrumentation plan developed by KUE included the placement of several rail prism arrays adhered to BNSF tracks as well as an array of prisms mounted at the face of the launch shaft to monitor potential settlement during tunneling operations. After establishing a frequency of readings, thresholds and action limits, KUE collected data and provided daily reporting to the contractor.

EL PASO WATER | WTP CANAL TUNNEL | PSC | EL PASO, TX | MAY 2018 - JAN 2019

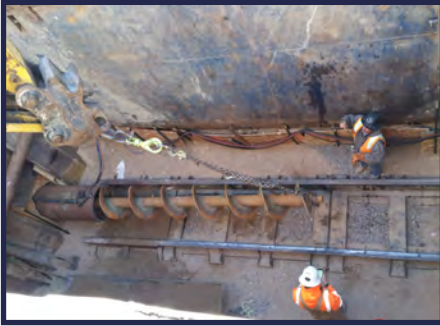


KUE was retained by the Contractor to provide a project Constructability Review, shaft excavation design, backfill/grout plan and develop an Instrumentation & Vibration Monitoring plan for the construction of a 48-inch transmission main tunnel installed via microtunnel that would run through an active BNSF railyard containing 17 sets of tracks. KUE setup prisms on each set of tracks and used a mounted AMTS to get hourly readings indicating potential settlement during tunneling operations. After collecting a frequency of readings and establishing a threshold with action limits, KUE collected data and provided up to the minute reporting to the contractor.

GEOTECHNICAL INSTRUMENTATION & MONITORING

KEY PROJECTS (CONTINUED)

DENVER WATER | 52ND & MILWAUKEE | UIT | DENVER, Co | OCT - DEC 2018



KUE was retained by the Contractor to develop an Instrumentation Plan to monitor 5 sets of UPRR tracks and 7 utilities for the installation of two shafts and a 12-inch diameter Main Extension Tunnel extending 240 linear feet with 24-inch steel casing installed via guided auger boring. Instrumentation included arrays of surface survey points (SSP's) and utility monitoring points (UMP's) spread throughout the UPRR corridor. After establishing a frequency of readings, threshold and action limits, KUE collected data and provided daily reporting to the contractor.

LOWRY TRUST | LOWRY LANDFILL POTW DISCHARGE LINE | BRANNAN | AURORA, Co | SEPT - NOV 2018



KUE was retained by the Contractor to develop an Instrumentation Plan to monitor the east and westbound lanes of E470 near Hampden Ave. The project involved the installation of two shafts and 3 tunnels, ranging in diameter from 12 to 20-inches. The tunnels were excavated utilizing jack and bore methodologies. Instrumentation to monitor tunnel subsidence included arrays of surface survey points (SSP's) on the E-470 roadways and utility monitoring points (UMP's) near the face of each shaft. After establishing a frequency of readings, thresholds and action limits, KUE collected data and provided daily reporting to the contractor.

RTD | GLOBEVILLE LANDING OUTFALL | KIEWIT | DENVER, Co | JAN 2018 - AUG 2018



KUE was retained by the Contractor to provide an Instrumentation Plan for the monitoring of an active UPRR rail yard containing 17 sets of tracks and an active RTD rail line. The project involved the installation of twin 105-inch tunnels, each extending about 550 linear feet with Hobas casing beneath the rail yard and RTD line. Since manned entry was not permitted for the RTD rail line, an AMTS was installed that actively monitored prisms that were installed on the rails within the influence zone. The tunnels were designed to route storm water and were excavated utilizing microtunneling methodologies. Instrumentation to monitor tunnel subsidence included arrays of surface survey points (SSP's), utility monitoring points (UMP's), extensometers (EXT's) and vibration monitoring points measured with seismographs.

CITY OF AURORA | LARGE VALVE REPLACEMENT | T. LOWELL | AURORA, Co | MAY - JULY 2018



KUE was retained by the Contractor and was responsible for managing an Instrumentation Plan for a project that involved the excavation, removal and replacement of two existing valves on a 36-inch diameter ductile iron pipe (DIP) at two separate excavations, each adjacent to the RTD commuter light rail tracks. KUE developed an Instrumentation Plan that involved potholing to monitor utilities, installing an array of surface survey points (SSP's) to monitor settlement around the area of excavation, and vibration monitoring to oversee ground behavior near the RTD commuter light rail tracks. After establishing a frequency of readings, thresholds and action limits for both vibration and settlement monitoring, KUE collected data and provided daily reporting to the contractor.

GEOTECHNICAL INSTRUMENTATION & MONITORING

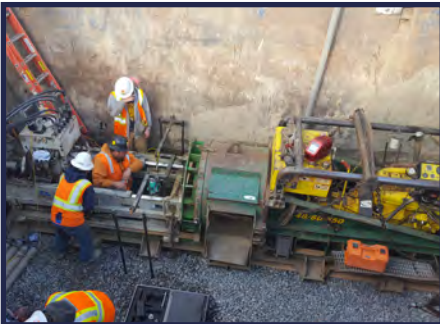
KEY PROJECTS (CONTINUED)

CITY OF LAFAYETTE | ORANGE ZONE PIPELINE | T. LOWELL & UIT | LAFAYETTE, Co | AUG - NOV 2017



KUE was retained by the Contractor, to perform a Pre-Construction Survey and develop an Instrumentation Plan to monitor streets, sidewalks, existing utilities and third party structures. The project involved the installation of four shafts and two tunnels, one 48-inches in diameter and the other 36-inches in diameter, with both extending about 150 linear feet with steel casing beneath existing roadways and railways. The tunnels were excavated utilizing guided auger boring methodologies. Additionally, the project had a 30-inch HDD that was approximately 800 linear feet in length. Instrumentation to monitor tunnel subsidence included arrays of surface survey points (SSP's), utility monitoring points (UMP's), and vibration monitoring points. KUE established the threshold and exceedance values for vibrations in peak particle velocities (PPV). After establishing a frequency of readings, threshold and action limits, KUE collected data and provided daily reporting for the project.

THE FOUNDRY | FOUNDRY UTILITY IMPROVEMENT | CONNELL | LOVELAND, Co | FEB - OCT 2017



KUE was retained by the Contractor to perform a Pre-Construction Survey and develop an Instrumentation Plan to monitor streets, sidewalks, existing utilities and third party structures for the installation of two shafts and twin 48-inch diameter tunnels extending 150 linear feet with steel casing installed via guided pipe ramming under an existing roadway. Instrumentation included arrays of surface survey points (SSP's), utility monitoring points (UMP's) and vibration monitoring points. After establishing a frequency of readings, threshold and action limits, KUE collected data and provided daily reporting for the project.

TOWN OF KIRYAS JOEL | CATSKILL AQUEDUCT | D'ANNUNZIO & SONS | HIGHLANDS, NY | SEPT 2015 - SEPT 2016



KUE was retained by the Contractor to develop Instrumentation Drawing Submittals for the installation of a 36-inch steel casing, about 100 linear feet in length via auger boring method with a rockhead Small Boring Unit (SBU). The plan included the placement of several surface survey point (SSP's) arrays, extensometers, utility monitoring points (UMP'[s) and crack gauges placed on an existing concrete box culvert bridge near the tunnel installation. KUE reviewed data obtained by the Contractors Surveyor and provided reporting to the Owner's Engineer, Hazen & Sawyer.

CDOT | TWIN TUNNELS WESTBOUND | HARRISON WESTERN | IDAHO SPRINGS, Co | MAR - NOV 2014



KUE performed a Preconstruction Survey and was responsible for managing the subcontractors who performed vibration monitoring, and measured air overpressure for the drill and blasting of 90,000 cubic yards of rock excavation at the approaches for the westbound twin tunnels expansion project. KUE's preconstruction survey consisted of photos, videos and documentation of third party structures, public roads, sidewalks and existing utilities, and was summarized in a report to the contractor.