

# Technical Justification for Phase 1 Monitoring Wells

## Former Galena Forward Operating Location, Alaska

### AFCEE Contract FA8903-08-D-8769, Task Order 0294

PREPARED FOR: AL Weilbacher/AFCEE  
Fred Vreeman/ADEC

PREPARED BY: CH2M HILL

DATE: July 15, 2011

The purpose of this memorandum is to provide additional technical justification for the proposed Phase 1 groundwater monitoring wells at the Former Galena FOL for installation in June and July 2011. Information presented includes the range of historic groundwater level fluctuations, subsurface lithology, historic groundwater contaminant concentrations from monitoring wells and groundwater grab sampling, and the rationale for the screen intervals proposed for each monitoring well. This information was used collectively to select the proposed Phase 1 well locations and well construction details presented herein. Table 1 provides a summary of well locations, construction details, and a brief statement of rationale for each of the 31 proposed Phase 1 monitoring wells. Figure 1 provides a map view of the locations, and Figures 2 through 5 provide cross-sectional views. The cross-sections incorporate most of the proposed monitoring well screened intervals along with available lithologic data, groundwater elevations, and dissolved benzene concentrations from wells and grab samples in the vicinity of each proposed well.

## Proposed Well Locations and Well Construction

### Well Cluster CG001-MW002 and MW003

Well Cluster CG001-MW002 and MW003 is shown on Figure 1 along cross section A-A' (Figure 2). This well cluster is being proposed for two primary reasons: 1) to replace Well 09-MW-05 that has undergone frost jacking in excess of four feet, and 2) to expand the monitoring network to include a deeper monitoring point at this location. The extent of frost jacking that well 09-MW-05 has undergone could potentially compromise the well construction (integrity of the grout seal and filter pack), and introduces uncertainty regarding the quality of any future groundwater quality and groundwater level data collected from this well. The reported screened interval of 09-MW-05 is 4.6 to 44.5 feet below ground surface (ft bgs) (134.1 to 94.2 ft Mean Sea Level (MSL)). A new well at this location will provide high quality data and remove questions regarding future data validity. A second deeper completion is also proposed at this location as no previous sampling data exists below the typical water table well construction of wells in this area (10 to 40 ft bgs). This additional completion will provide information regarding groundwater quality at greater depths than 09-MW-05, and will detect potential deeper contamination moving offsite to the west.

The boring log for Well 09-MW-05 suggests that the lithology at this location consists of silty sand and sandy silt in the upper 15 ft of the profile, transitioning to gravelly sand to a depth of 50 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 12 to 26 ft below ground surface (bgs), and will likely reside at approximately 15 ft bgs at the time of well installation. The most recent sampling data available from 09-MW-05 (09/17/2010) indicates a DRO concentration of 330 micrograms per liter (ug/L), a benzene concentration of 230 ug/L, and no detection of TCE above the detection limit.

The proposed well construction for the shallow completion at this location (CG001-MW002) is to install 30 feet of screen extending from 10 to 40 feet below ground surface (130 to 100 ft MSL). This unusually long screen interval is specified for two reasons: 1) to provide for saturated conditions and the ability to sample the well during the entire seasonal fluctuation in groundwater levels in this area (12 to 26 ft bgs), and 2) to provide a screened interval that is similar to the well construction of the existing well at the site which has a total depth of 45 feet. The proposed construction for the deeper well at this location (CG001-MW003) is to install a screened interval from 50 to 60 feet bgs (90 to 80 ft MSL). A well of this design will allow monitoring of groundwater quality at the depth interval of the aquifer just below that of CG001-MW002. No water quality data currently exist to evaluate the groundwater quality at this depth in the aquifer system.

## Well CG001-MW006

Well CG001-MW006 is shown on Figure 1 along cross section A-A' (Figure 2). The location for this monitoring well was selected to provide for collection of additional groundwater quality data along the western boundary of the Million Gallon Hill dissolved contaminant plume. There are currently no monitoring wells in the area and no grab groundwater samples have been collected in the vicinity to evaluate groundwater quality.

The nearest existing monitoring well is 09-MW-03 located approximately 330 feet to the east of the proposed location for CG001-MW006. The boring log for Well 09-MW-03 suggests that the lithology at this location consists of silty sand in the upper 10 ft of the profile, transitioning to sand from 10 to 15 ft bgs. Below 15 ft, the boring log indicates extensive gravelly sand to a depth of 50 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 14 to 25 ft below ground surface (bgs), and will likely reside at approximately 16 ft bgs at the time of well installation. The most recent sampling data available from 09-MW-03 (09/15/2010) indicates a DRO concentration of 24 ug/L, and no detections of benzene or TCE above the detection limits.

The proposed well construction for Well CG001-MW006 is to install a screened interval that extends from 15 to 35 feet below ground surface (127 to 107 ft MSL). This screened interval will provide for saturated conditions in the well throughout the year and will provide effective monitoring of shallow groundwater quality on the western boundary of Million Gallon Hill plume. Given that the probable release mechanism at this site is near surface hydrocarbon releases from surface spills or relatively shallow pipelines, the distribution of contamination would be expected to follow a pattern of highest groundwater concentrations at shallow depths and decreasing with greater depth. Therefore the initial well construction selected for this location was to construct a well that is screened near the water table. If

groundwater sampling of this well detects significant levels of contamination at this depth, additional wells screened at greater depths will be considered.

## Well Cluster CG001-MW007 and MW008

Well Cluster CG001-MW007 and MW008 is shown on Figure 1 along cross section A-A' (Figure 2). The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data along the western boundary of the Million Gallon Hill dissolved contaminant plume. This location was selected to augment the current monitoring provided by Well 09-MW-16. Well 09-MW-16 is screened from 33 to 43 feet below ground surface. The proposed well cluster will provide additional monitoring at greater depths within the aquifer system.

The nearest existing monitoring well, Well 09-MW-16, is located at the same location as the proposed CG001-MW007/8 well cluster. The boring log for Well 09-MW-16 is not available; however, the boring log for Well 09-MW-04 (located approximately 250 feet northeast of this location) suggests that the lithology in this area consists of sandy gravel in the upper 2 feet followed by silty sand to a depth of 12 ft, transitioning to sand from 12 to 15 ft bgs. Below 15 ft, the boring log indicates extensive gravelly sand and sandy gravel to a depth of 56 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 14 to 27 ft below ground surface (bgs), and will likely reside at approximately 16 ft bgs at the time of well installation.

The most recent sampling data available from 09-MW-16 (09/14/2010) indicates a TCE concentration of 1 ug/L, and no detections of benzene or DRO. A groundwater grab sample was also collected at this location (CG001-GW455). Samples at this location were collected at four depths: 32, 40, 52, and 64 ft bgs. These depths correspond to elevations of 108, 100, 88 and 76 ft MSL. Analytical results were non-detect for TCE at all depths. Benzene was detected at low levels (less than 5 ug/L) in the deepest two completions.

The proposed well construction for the two additional wells to be installed at this location consists of a mid-depth well (CG001-MW007) that is screened from 61 to 71 feet below ground surface (82 to 72 ft MSL) and a deep well (CG001-MW008) that is screened from 89 to 99 feet bgs (55 to 45 ft MSL). The screen interval for the mid-depth well (CG001-MW007) was selected to target the depth interval where the 78 ft MSL grab sample containing 3.7 ug/L benzene was collected. The screened interval for the deeper well at this location (CG001-MW008) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

## Well Cluster CG001-MW015, -MW016 and -MW017

Well Cluster CG001-MW015, -MW016 and -MW017 is shown on Figure 1 along cross section D-D' (Figure 5). The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data on the southwestern boundary of the Million Gallon Hill dissolved contaminant plume. There are currently no monitoring wells in the area and no grab groundwater samples have been collected in the vicinity to evaluate groundwater quality.

The nearest existing monitoring well, Well 09-MW-23, is located approximately 350 feet from the proposed CG001-MW015/16/17 well cluster. The boring log for Well 09-MW-23 suggests that the lithology in this area consists of silty sand in the upper 25 feet transitioning to sand and gravelly sand below this. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 15 to 24 ft below ground surface (bgs), and will likely reside at approximately 17 ft bgs at the time of well installation. The most recent sampling data available from 09-MW-23 (09/20/2010), screened from 5 to 35 ft bgs, indicates a DRO concentration of 260 ug/L, a benzene concentration of 1.3 ug/L, and no detection of TCE.

The proposed well construction for the three wells to be installed at this location consists of a shallow well (CG001-MW015) screened from 16 to 36 feet bgs (128 to 108 ft MSL), a mid-depth well (CG001-MW016) that is screened from 59 to 69 feet bgs (85 to 75 ft MSL) and a deep well (CG001-MW017) that is screened from 88 to 98 feet bgs (56 to 46 ft MSL). The screen interval for the mid-depth well (CG001-MW016) was selected to target the screened interval of nearby well 09-MW-30. Well 09-MW-30 is located approximately 350 ft southeast of the proposed location for this well cluster, is screened from 67 to 72 ft bgs (84.5 to 79.5 ft MSL), and samples collected from this well on 9/20/2010 contained benzene at 91 ug/L and DRO at 1600 ug/L. The screened interval for the deeper well at this location (CG001-MW017) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

## Well Cluster CG001-MW018, -MW019, -MW020 and -MW021

Well Cluster CG001-MW018, -MW019, -MW020 and -MW021 is shown on Figure 1 along cross section B-B' (Figure 3). The location for this monitoring well cluster was selected to provide for collection of groundwater quality data at the extreme downgradient (southern) extent of the Million Gallon Hill dissolved contaminant plume, adjacent to the Yukon River. There are currently no monitoring wells in this area; however, several grab groundwater samples have been collected in the vicinity and these will be discussed below.

The nearest existing monitoring well, Well 09-MW-30, is located approximately 350 feet north of the proposed CG001-MW018/19/20/21 well cluster. The boring log for Well 09-MW-30 is not available; however, the boring log for Well 09-MW-15 (located another 200 feet further north of the proposed well cluster location) suggests that the lithology in this area consists of sandy silt to silty sand in the upper 7 feet transitioning to sand and gravelly sand to a depth of 40 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 22 to 31 ft below ground surface (bgs), and will likely reside at approximately 24 ft bgs at the time of well installation.

The most recent sampling data available from 09-MW-30 (09/20/2010), screened from 67 to 72 ft bgs, indicates benzene was detected at 91 ug/L, DRO was detected at 1600 ug/L, and TCE was not detected. Groundwater grab samples were also collected at two locations along the banks of the Yukon River on 7/26/2008. These two sampling locations, referred to as Yukon-GW231 and Yukon-GW232, are located approximately 250 feet south of the location proposed for this well cluster. Groundwater grab samples were collected from Yukon-GW231 at depths of 10, 22, 34, 46, 58, and 70 feet bgs. Samples were non-detect for benzene at all depths except for a detection of 15.3 ug/L at 58 ft bgs and 10.4 ug/L at 70 ft bgs. All samples were non-detect for TCE. Groundwater grab samples were collected from Yukon-GW232 at depths of 27, 39, 51, 63, and 75 feet bgs. Samples were non-detect for benzene at all depths except for a detection of 4.6 ug/L at 63 ft bgs and 7.7 ug/L at 75 ft bgs. All samples were non-detect for TCE.

The proposed well construction for the four wells to be installed at this location consists of a shallow well (CG001-MW018) screened from 20 to 40 feet bgs (122 to 102 ft MSL), an upper mid-depth well (CG001-MW019) that is screened from 60 to 70 feet bgs (82 to 72 ft MSL), a deeper mid-depth well (CG001-MW020) that is screened from 82 to 92 feet bgs (60 to 50 ft MSL) and a deep well (CG001-MW021) that is screened from 112 to 122 feet bgs (30 to 20 ft MSL). The screen interval for the upper mid-depth well (CG001-MW019) was selected to target the depth interval of grab samples collected at 58 and 70 ft bgs in Yukon-MW231 and at 63 feet in Yukon-MW232. These samples all contained benzene at concentrations ranging from 4.6 to 15.3 ug/L. This screen interval is also slightly deeper than the screened interval of Well 09-MW-30 which is located approximately 500 ft upgradient (northeast) of the proposed location for this well cluster. Well 09-MW-30 is screened from 67 to 72 ft bgs (84.5 to 79.5 ft MSL), and benzene was detected at 91 ug/L, and DRO was detected at 1600 ug/L in this well when it was sampled on 9/20/2010. Based on the observed contaminant trends of benzene detection occurring deeper with distance traveled from the source areas, we would expect contamination to migrate slightly deeper as it travels 500 ft from the location of 09-MW-30 to the location of the proposed well cluster. The screened interval for the deeper mid-depth well (CG001-MW020) was selected to target the depth interval of the grab sample collected at a depth of 75 feet in Yukon-MW232. The screened interval for the deepest well at this location (CG001-MW022) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

## Well Cluster CG001-MW011 and MW012

Well Cluster CG001-MW011 and MW012 is shown on Figure 1 along cross sections B-B' and D-D' (Figures 3 and 5). The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data along the centerline of the Million Gallon Hill dissolved contaminant plume. This location was selected to augment the current monitoring provided by Wells 09-MW-15 and 09-MW-24. Well 09-MW-15 is screened from 5.5 to 34.5 feet bgs (135.3 to 106.3 ft MSL), while Well 09-MW-24 is screened from 44.91 to 54.91 feet bgs (95.89 to 85.89 ft MSL). The proposed well cluster will provide additional monitoring at greater depths within the aquifer system.

The boring logs for Wells 09-MW-15 and 09-MW-24 suggest that the lithology in this area consists of sandy silt and silty sand to a depth of 7 ft, transitioning to sand from 7 to 10 ft

bgs. Below 10 ft, the boring logs indicate extensive gravelly sand and sandy gravel to a depth of 60 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 11 to 20 ft below ground surface (bgs), and will likely reside at approximately 13 ft bgs at the time of well installation.

The most recent sampling data available from 09-MW-15 (09/12/2010) indicates a DRO concentration of 46 ug/L, and no detections of benzene or TCE. The most recent sampling data available from 09-MW-24 (09/21/2010) indicates a DRO concentration of 560 ug/L, a benzene concentration of 28 ug/L, and no detections of TCE. A groundwater grab sample was also collected at this location (MGH-GW196). Samples at this location were collected at four depths: 35, 47, 59, and 71 ft bgs. These depths correspond to elevations of 106, 94, 82 and 70 ft MSL. Benzene was detected at 11 ug/L at 35 feet, 69.4 ug/L at 47 feet, 57.4 ug/L at 59 feet, and 66.2 ug/L at 71 feet. All samples were non-detect for TCE.

The proposed well construction for the two additional wells to be installed at this location consists of a lower mid-depth well (CG001-MW011) that is screened from 66 to 76 feet below ground surface (75 to 65 ft MSL) and a deep well (CG001-MW012) that is screened from 85 to 95 feet bgs (56 to 46 ft MSL). The screen intervals for the additional wells were selected to complement the shallower screened intervals of the two existing wells at the site. The screened interval of CG001-MW011 also coincides with the deeper benzene detections in the grab samples collected at MGH-GW196. The groundwater contaminant concentrations observed in wells 09-MW-15 and 09-MW-24 suggest increasing contaminant concentrations with depth, and these two additional proposed wells will provide additional monitoring at greater depths within the aquifer system at this location, and potentially complete vertical characterization of the nature and extent of contamination at this location.

## Well Cluster CG001-MW009 and MW010

Well Cluster CG001-MW009 and MW010 is shown on Figure 1 along cross section B-B' (Figure 3). The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data along the centerline of the Million Gallon Hill dissolved contaminant plume in the extreme southern portion of the triangle area. This location was selected to augment the current monitoring provided by Well 09-MW-01. Well 09-MW-01 is screened from 5.1 to 44.8 feet bgs (135.1 to 95.4 ft MSL). The proposed well cluster will provide additional monitoring at greater depths within the aquifer system.

The boring log for Well 09-MW-01 suggests that the lithology in this area consists of sandy gravel and gravelly sand down to a depth of 4 feet, followed by a short interval of sandy silt from 4 to 5.5 feet, and returning to gravelly sand to a depth of 10 ft bgs. Below 10 ft, the boring logs indicate alternating intervals of sand and gravelly sand to a depth of 60 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 12 to 24 ft below ground surface (bgs), and will likely reside at approximately 14 ft bgs at the time of well installation. The most recent sampling data available from 09-MW-15 (09/21/2010) indicates a DRO concentration of 2300 ug/L, a benzene concentration of 60 ug/L, and no detections of TCE above the detection limit

The proposed well construction for the two additional wells to be installed at this location consists of a mid-depth well (CG001-MW009) that is screened from 55 to 65 feet below ground surface (85 to 75 ft MSL) and a deep well (CG001-MW010) that is screened from 84

to 94 feet bgs (56 to 46 ft MSL). The screen intervals for the additional wells were selected to complement the shallower screened interval of the existing monitoring well at the site. The two additional proposed wells will provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

### **Well Cluster CG001-MW013 and MW014**

Well Cluster CG001-MW013 and MW014 is shown on Figure 1 along cross section D-D' (Figure 5) The location for this monitoring well cluster was selected to provide for the collection of additional groundwater quality data to better characterize the eastern edge of the Million Gallon Hill dissolved contaminant plume. This location was selected to augment the current monitoring provided by Well 09-MW-20. Well 09-MW-20 is screened from 5.0 to 39.8 feet bgs (139.4 to 104.6 ft MSL). The proposed well cluster will provide additional monitoring at greater depths within the aquifer system in an area where higher concentrations are typically found deeper in the aquifer.

The boring log for Well 09-MW-20 is not available; however, the log for nearby existing monitoring wells 09-MW-26 and CG001-MW001, located approximately 250 feet to the southwest of the proposed location, suggests that the lithology in this area consists of silty sand down to a depth of 18 feet, followed by sand with gravel to a depth of 45 ft bgs. Below 45 ft, the boring logs indicate sand and gravelly sand to a depth of 75 feet, followed by silty gravel to 90 ft depth. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 15 to 24 ft below ground surface (bgs), and will likely reside at approximately 17 ft bgs at the time of well installation. The most recent sampling data available from 09-MW-20 (09/12/2010) indicates no detections of benzene, DRO or TCE.

The proposed well construction for the two additional wells to be installed at this location consists of a mid-depth well (CG001-MW013) that is screened from 69 to 79 feet below ground surface (75 to 65 ft MSL) and a deep well (CG001-MW014) that is screened from 88 to 98 feet bgs (56 to 46 ft MSL). The screen intervals for the additional wells were selected to complement the shallower screened interval of the existing monitoring well at the site, as well as provide monitoring data from the same approximate elevations as the two cross-plume clusters proposed further to the west (CG001-MW16/17 and CG001-MW-11/12). The two additional proposed wells will also provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

### **Well Cluster ST005-MW071 and ST005-MW072**

Well Cluster ST005-MW071 and ST005-MW072 is shown on Figure 1 along cross sections C-C' and D-D' (Figures 4 and 5) The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data along the western margin of the downgradient portion of the dissolved contaminant plume emanating from the POL Tank Farm. There are currently no monitoring wells in the area although several grab groundwater samples have been collected in the vicinity to evaluate groundwater quality.

The nearest existing monitoring wells, recently installed well cluster ST005-MW057/MW058/MW059, is located approximately 450 feet west of the proposed location. The boring logs for this well cluster suggest that the lithology in this area consists of sandy silt to silty sand in the upper 11.5 feet transitioning to well graded sand with gravel to a depth of 45 feet. Below 45 feet the log indicated a change to poorly sorted sand with gravel to a total depth of 88 ft bgs. Groundwater level data available from this well cluster are only available for the October 2010 and May 2011 water level surveys because the wells were installed in September 2010. Therefore, no data exist reflecting the most shallow groundwater conditions that occur in late spring/early summer. Available data at this cluster suggests a depth to water of about 22 ft bgs in October 2010 and May 2011 (prior to Yukon River breakup). Based on data from other sites, depth to groundwater at the time of well installation will likely range from 10 to 15 ft bgs. The only groundwater quality data available in this area are from groundwater grab samples POL-GW405, POL-GW406 and POL-GW367 collected on 10/2/2008. Samples at these locations were collected at multiple depths as shown on Figures 4 and 5. Sampling results from POL-GW405 indicate benzene concentrations of 2.96, 69.6, and ND at depths of 44, 64 and 84 feet respectively. Sampling results from POL-GW406 indicate benzene concentrations of ND, 4.29, and ND at depths of 44, 64 and 84 feet respectively. Sampling results from POL-GW367 indicate benzene concentrations of 1.82, 2.44, 141, 37.9 (38.3 duplicate) and 2.49 at depths of 24, 39, 64, 84 and 104 feet respectively. TCE was non-detect at all depths sampled in both borings.

The proposed well construction for the two wells to be installed at this location consists of a shallow well (ST005-MW071) screened from 57 to 67 feet bgs (85 to 75 ft MSL), and a deep well (ST005-MW072) that is screened from 82 to 92 feet bgs (60 to 50 ft MSL). The screen interval for the shallower well (ST005-MW071) was selected to target the depth interval of the highest concentration grab sampled in the nearby soil borings. The screened interval for the deeper well at this location (ST005-MW072) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

### **Well Cluster ST005-MW073 and ST005-MW074**

Well Cluster ST005-MW073 and ST005-MW074 is shown on Figure 1 along cross sections C-C' (Figure 4). The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data along the eastern margin of the downgradient portion of the dissolved contaminant plume emanating from the POL Tank Farm. There are currently no monitoring wells in the area although several grab groundwater samples have been collected in the vicinity to evaluate groundwater quality.

The nearest existing monitoring wells, recently installed well cluster ST005-MW057/MW058/MW059, are located approximately 700 feet west of the proposed location. The boring logs for this well cluster suggest that the lithology in this area consists of sandy silt to silty sand in the upper 11.5 feet transitioning to well graded sand with gravel sand to a depth of 45 feet. Below 45 feet the log indicated a change to poorly sorted sand with gravel to a total depth of 88 ft bgs. Groundwater level data available from this well cluster are only available for the October 2010 and May 2011 water level surveys because the wells were installed in September 2010. Therefore no data exist reflecting the most shallow groundwater conditions that occur in late spring/early summer. Available data at this

cluster suggests a depth to water of about 22 ft bgs in October 2010 and May 2011 (prior to Yukon River breakup). Based on data from other sites, depth to groundwater at the time of well installation will likely range from 10 to 15 ft bgs. The only groundwater quality data available in this area is from groundwater grab samples POL-GW405 and POL-GW406 collected on 10/2/2008. Samples at these locations were collected at depths of 44, 64 and 84 ft bgs (99.7, 79.7 and 77.7 ft MSL). Sampling results from POL-GW405 indicate benzene concentrations of 2.96, 69.6, and ND at depths of 44, 64 and 84 feet respectively. Sampling results from POL-GW406 indicate benzene concentrations of ND, 4.29, and ND at depths of 44, 64 and 84 feet respectively. TCE was non-detect at all depths sampled in both borings.

The proposed well construction for the two wells to be installed at this location consists of a shallow well (ST005-MW073) screened from 56 to 66 feet bgs (85 to 75 ft MSL), and a deep well (ST005-MW074) that is screened from 81 to 91 feet bgs (60 to 50 ft MSL). The screen interval for the shallower well (ST005-MW073) was selected to target the depth interval of the highest concentration grab sampled in the nearby soil borings. The screened interval for the deeper well at this location (ST005-MW074) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location. These elevations of the proposed well screens are also consistent with those proposed for the ST005-MW071 and -MW072 well cluster located cross-plume approximately 340 feet to the west.

### **Well Cluster ST005-MW075, -MW076, -MW077, and -MW078**

Well Cluster ST005-MW075, ST005-MW076, ST005-MW077, and ST005-MW078 is shown on Figure 1 along cross sections C-C' (Figure 4). The location for this monitoring well cluster was selected to provide for collection of groundwater quality data at the extreme downgradient (southern) extent of the POL Tank Farm dissolved contaminant plume, just north of the Yukon River. There are currently no monitoring wells in this area; however, several grab groundwater samples have been collected in the vicinity and these are discussed below.

The nearest existing monitoring wells, recently installed well cluster ST005-MW057/MW058/MW059, is located approximately 700 feet west of the proposed location. The boring logs for this well cluster suggest that the lithology in this area consists of sandy silt to silty sand in the upper 11.5 feet transitioning to well-graded sand with gravel and sand to a depth of 45 feet, with poorly sorted sand with gravel from 45 feet to a total depth of 88 ft bgs. Groundwater level data from this well cluster are only available for the October 2010 and May 2011 water level surveys because the wells were installed in September 2010. Therefore no data exist reflecting the most shallow groundwater conditions that occur in late spring/early summer. Available data at this cluster suggests a depth to water of about 22 ft bgs in October 2010 and May 2011 (prior to Yukon River breakup). Based on data from other sites, depth to groundwater at the time of well installation will likely range from 10 to 15 ft bgs. The only groundwater quality data available in this area is from groundwater grab samples Yukon-GW330 and Yukon-GW408 located on the banks of the Yukon River. These samples were collected in September and October 2008. Samples at Yukon-GW330 were collected at depths of 22, 32, 52, 72, 92 and 112 ft bgs (123, 113, 93, 73, 53 and 33 ft MSL). Samples at Yukon-GW408 were collected at depths of 29, 49, 69, and 89 ft bgs (116, 96, 76

and 56 ft MSL). Sampling results from both borings at all depths were non-detect for benzene and TCE.

The proposed well construction for the four wells to be installed at this location consists of a shallow well (ST005-MW075) screened from 23 to 43 feet bgs (122 to 102 ft MSL), an upper mid-depth well (ST005-MW076) that is screened from 60 to 70 feet bgs (85 to 75 ft MSL), a deeper mid-depth well (ST005-MW077) that is screened from 85 to 95 feet bgs (60 to 50 ft MSL) and a deep well (ST005-MW078) that is screened from 115 to 125 feet bgs (30 to 20 ft MSL). The screen interval for the upper mid-depth well (ST005-MW076) was selected to target the depth interval of grab samples collected at POL-GW405 and POL-GW406, located 400 feet upgradient, which contained the highest benzene concentrations. The screened intervals for both the upper-mid and deeper mid-depth wells (ST005-MW076 and ST005-MW077) were also selected to be consistent with the elevation of the screened intervals of both of the two-well clusters to be installed several hundred feet to the northwest and northeast. The screened interval for the deepest well at this location (ST005-MW078) was selected to provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

### **Well Cluster ST005-MW065 and ST005-MW066**

Well Cluster ST005-MW065, ST005-MW066 is shown on Figure 1 in between the north ends of cross sections B-B' and C-C'. The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data in the vicinity of a DRO hot spot identified during soil sampling during the 2010 field season near Wilderness Hall. The nearest existing monitoring well is 1837-MW-01. The screened interval for this well is 20 to 35 ft bgs (130 to 115 ft MSL).

The boring log for the nearby Geoprobe boring SS005-GP012 suggests that the lithology in the area consists of sandy gravel down to a depth of 12 feet, followed by a 6 foot thick layer of silt from 12 to 18 ft bgs. Below 18 feet, the lithology consists primarily of sand, with intermittent thin layers of gravely sand down to a depth of 42 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 20 to 29 ft below ground surface (bgs), and will likely reside at approximately 22 ft bgs at the time of well installation.

The most recent groundwater quality data available in this area is from groundwater grab samples collected in July and August 2010. The highest DRO concentrations observed were 2500 ug/L in SS005-GP002 at 21 to 25 ft bgs (129 to 125 ft MSL), 590 ug/L in SS005-GP0013 at 14 to 19 ft bgs (136 to 131 ft MSL) and 780 ug/L in SS005-GP009 at 21 to 25 ft bgs (129 to 125 ft MSL). Sampling results from all borings and depths were below 10 ug/L for benzene and non-detect for TCE.

The proposed well construction for the two wells to be installed at this location consists of a shallow well (ST005-MW065) screened from 15 to 35 feet bgs (135 to 115 ft MSL), and a deeper well (ST005-MW066) that is screened from 50 to 60 feet bgs (100 to 90 ft MSL). The screen interval for the shallower well (ST005-MW065) was selected to target the depth interval of the highest concentration grab samples in the nearby soil borings. The screened interval for the deeper well at this location (ST005-MW066) was selected to provide

additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

### **Well Cluster ST010-MW010, -MW011, and -MW012**

Well Cluster ST010-MW010, ST010-MW011 and ST010-MW012 is shown on Figure 1. The location for this monitoring well cluster was selected to provide for collection of additional groundwater quality data in the downgradient (southern) portion of site ST010. The nearest existing monitoring well is SE-MW05. The screened interval for this well is 20 to 35 ft bgs (130 to 115 ft MSL).

The boring logs for the nearby Geoprobe borings and well SE-MW08 suggest that the lithology in the area consists of silt to a depth of 10 feet, followed by silty sand to 15 feet, and sand down to 20 feet. Below 20 feet the logs suggest gravely sand down to a total depth of 35 feet. Groundwater levels measured at the site in 2010 and 2011 indicate that groundwater levels vary seasonally from approximately 15 to 25 ft bgs, and will likely reside at approximately 17 ft bgs at the time of well installation.

The most recent groundwater quality data available in this area are from groundwater grab samples collected in July and August 2010 and Well ST010-MW009. The highest DRO concentrations were observed in grab samples collected at ST010-HP002. DRO concentrations were 370 ug/L at 35 to 39 ft bgs (108 to 104 ft MSL), 320 ug/L at 50 to 54 ft bgs (93 to 89 ft MSL) and 62 ug/L at 65 to 69 ft bgs (78 to 74 ft MSL). Results from all samples at this location were non-detect for benzene and TCE. The other data available in this area are samples collected from well ST010-MW009. This well is screened from 50 to 60 ft bgs (93 to 83 ft MSL). DRO concentrations measured on 10/14/2010 were 330 ug/L, and non-detect for benzene and TCE.

The proposed well construction for the three wells to be installed at this location consists of a shallow well (ST010-MW010) screened from 18 to 38 feet bgs (125 to 105 ft MSL), a mid-depth well (ST010-MW011) screened from 50 to 60 ft bgs (93 to 83 ft MSL), and a deeper well (ST010-MW012) that is screened from 73 to 83 feet bgs (70 to 60 ft MSL). The screen interval for the shallowest well (ST010-MW010) was selected to target the depth interval of the highest concentration grab samples in the nearby soil borings. The screened interval for the mid-depth well at this location (ST010-MW011) was selected to coincide with the screened interval of nearby well ST010-MW009. The screened interval of the deepest well (ST010-MW012) will provide additional monitoring at greater depths within the aquifer system at this location and potentially complete vertical characterization of the nature and extent of contamination at this location.

**Table 1**

2011 Proposed Well Details

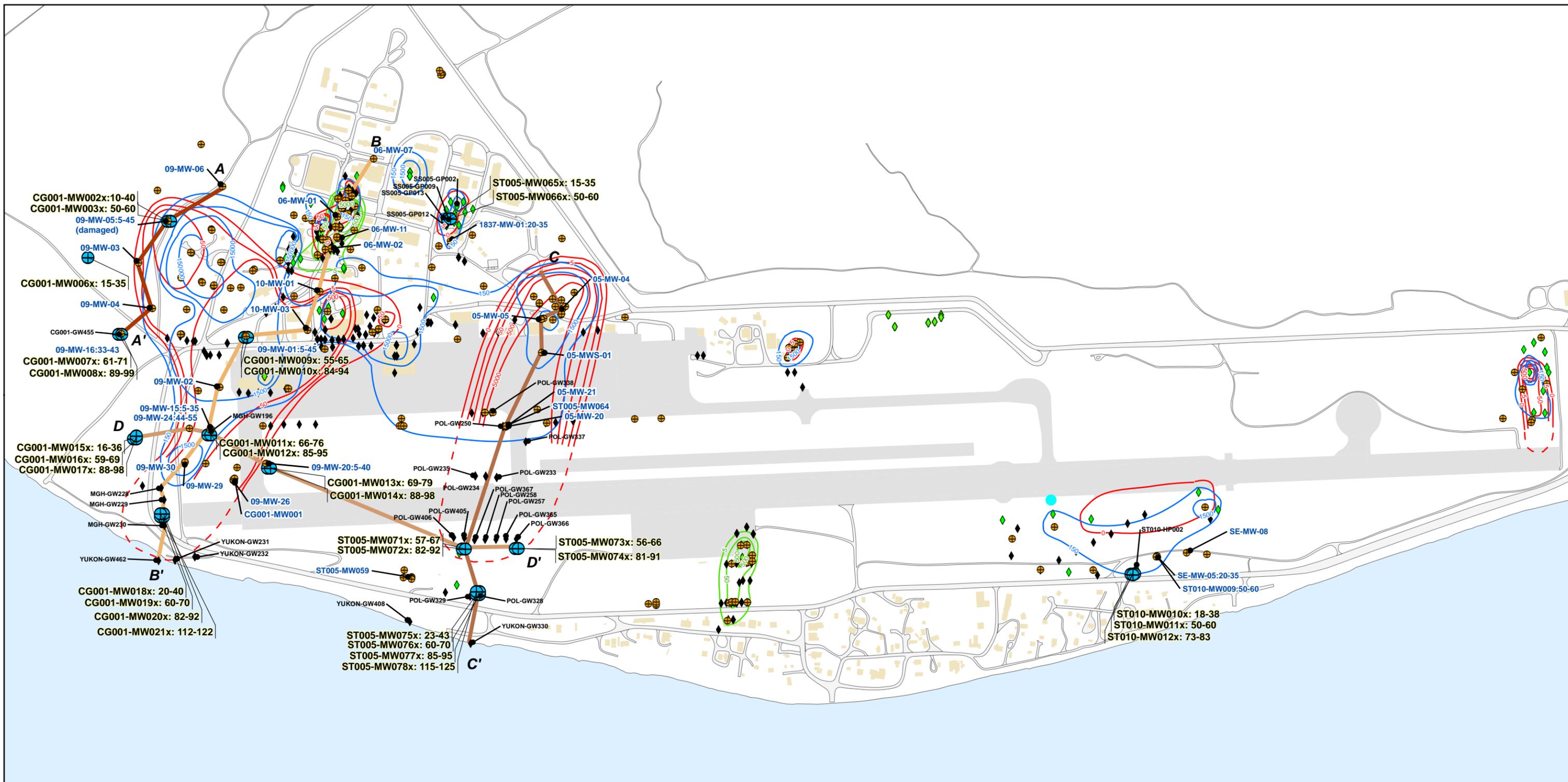
Temporary ID for Proposed Well	Easting	Northing	Approximate Ground Surface Elevation (ft MSL)	Elevation of Top of Screened Interval (ft MSL)	Elevation of Bottom of Screened Interval (ft MSL)	Top of Screened Interval (ft bgs)	Bottom of Screened Interval (ft bgs)	Screen Length (ft)	Rationale	Continuous Water Level Monitoring
CG001-MW002x	596988	7181157	140	130	100	10	40	30	09-MW-05 needs to be abandoned, replace with two-well nest	Yes
CG001-MW003x	596994	7181157	140	90	80	50	60	10	09-MW-05 needs to be abandoned, replace with two-well nest	Yes
CG001-MW006x	596832	7181086	142	127	107	15	35	20	Monitor conditions to the west, presumably beyond the extent of contamination	Yes
CG001-MW007x	596892	7180936	143	82	72	61	71	10	Monitor conditions at depth near plume boundary	Yes
CG001-MW008x	596898	7180936	144	55	45	89	99	10	Monitor conditions at depth near plume boundary	Yes
CG001-MW009x	597139	7180930	140	85	75	55	65	10	Monitor conditions at depth near center of multiple plumes	
CG001-MW010x	597145	7180930	140	56	46	84	94	10	Monitor conditions at depth near center of multiple plumes	
CG001-MW011x	597067	7180740	141	75	65	66	76	10	Monitor conditions at depth near center of multiple plumes	
CG001-MW012x	597073	7180740	141	56	46	85	95	10	Monitor conditions at depth near center of multiple plumes	
CG001-MW013x	597184	7180675	144	75	65	69	79	10	Determine and monitor extent of groundwater contamination; lateral extent of benzene plume poorly defined	
CG001-MW014x	597190	7180675	144	56	46	88	98	10	Determine and monitor extent of groundwater contamination; lateral extent of benzene plume poorly defined	
CG001-MW015x	596921	7180732	144	128	108	16	36	20	Determine and monitor extent of groundwater contamination; lateral extent of benzene plume poorly defined	Yes
CG001-MW016x	596927	7180732	144	85	75	59	69	10	Determine and monitor extent of groundwater contamination; lateral extent of benzene plume poorly defined	Yes
CG001-MW017x	596927	7180738	144	56	46	88	98	10	Determine and monitor extent of groundwater contamination; lateral extent of benzene plume poorly defined	Yes
CG001-MW018x	596974	7180580	142	122	102	20	40	20	Determine and monitor extent of groundwater contamination; distal end of benzene and DRO plumes poorly defined	Yes
CG001-MW019x	596980	7180580	142	82	72	60	70	10	Determine and monitor extent of groundwater contamination; distal end of benzene and DRO plumes poorly defined	Yes
CG001-MW020x	596980	7180586	142	60	50	82	92	10	Determine and monitor extent of groundwater contamination; distal end of benzene and DRO plumes poorly defined	Yes
CG001-MW021x	596974	7180586	142	30	20	112	122	10	Determine and monitor extent of groundwater contamination; distal end of benzene and DRO plumes poorly defined	Yes
ST005-MW065x	597537	7181162	150	135	115	15	35	20	Monitor conditions in area shown to have groundwater contamination but with no wells	
ST005-MW066x	597543	7181162	150	100	90	50	60	10	Monitor conditions in area shown to have groundwater contamination but with no wells	
ST005-MW071x	597566	7180517	142	85	75	57	67	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	
ST005-MW072x	597572	7180517	142	60	50	82	92	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	
ST005-MW073x	597670	7180518	141	85	75	56	66	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	
ST005-MW074x	597676	7180518	141	60	50	81	91	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	
ST005-MW075x	597594	7180428	145	122	102	23	43	20	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	Yes
ST005-MW076x	597600	7180428	145	85	75	60	70	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	Yes
ST005-MW077x	597600	7180434	145	60	50	85	95	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	Yes
ST005-MW078x	597594	7180434	145	30	20	115	125	10	Determine and monitor extent of groundwater contamination; distal end of benzene plume poorly defined	Yes
ST010-MW010x	598872	7180443	143	125	105	18	38	20	Determine and monitor extent of groundwater contamination; distal end of DRO plume poorly defined	Yes
ST010-MW011x	598878	7180443	143	93	83	50	60	10	Determine and monitor extent of groundwater contamination; distal end of DRO plume poorly defined	Yes
ST010-MW012x	598878	7180449	143	70	60	73	83	10	Determine and monitor extent of groundwater contamination; distal end of DRO plume poorly defined	Yes

Notes:

Proposed wells have postscript "x" that will be removed upon installation.

ft bgs = feet below ground surface

All 2011 wells will be 2" diameter



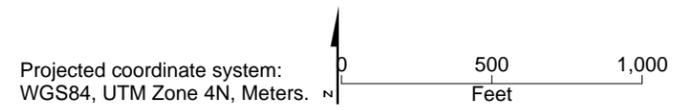
**LEGEND**

- ⊕ Phase 1 Proposed 2011 Monitoring Wells, with depth (ft) to screen
- ⊕ Current Monitoring Wells (depth [ft] to screen noted where relevant)
- DRO Contours
- Benzene Contours
- TCE Contours
- ◆ Pre-2010 Groundwater Grab
- ◆ 2010 Groundwater Grab

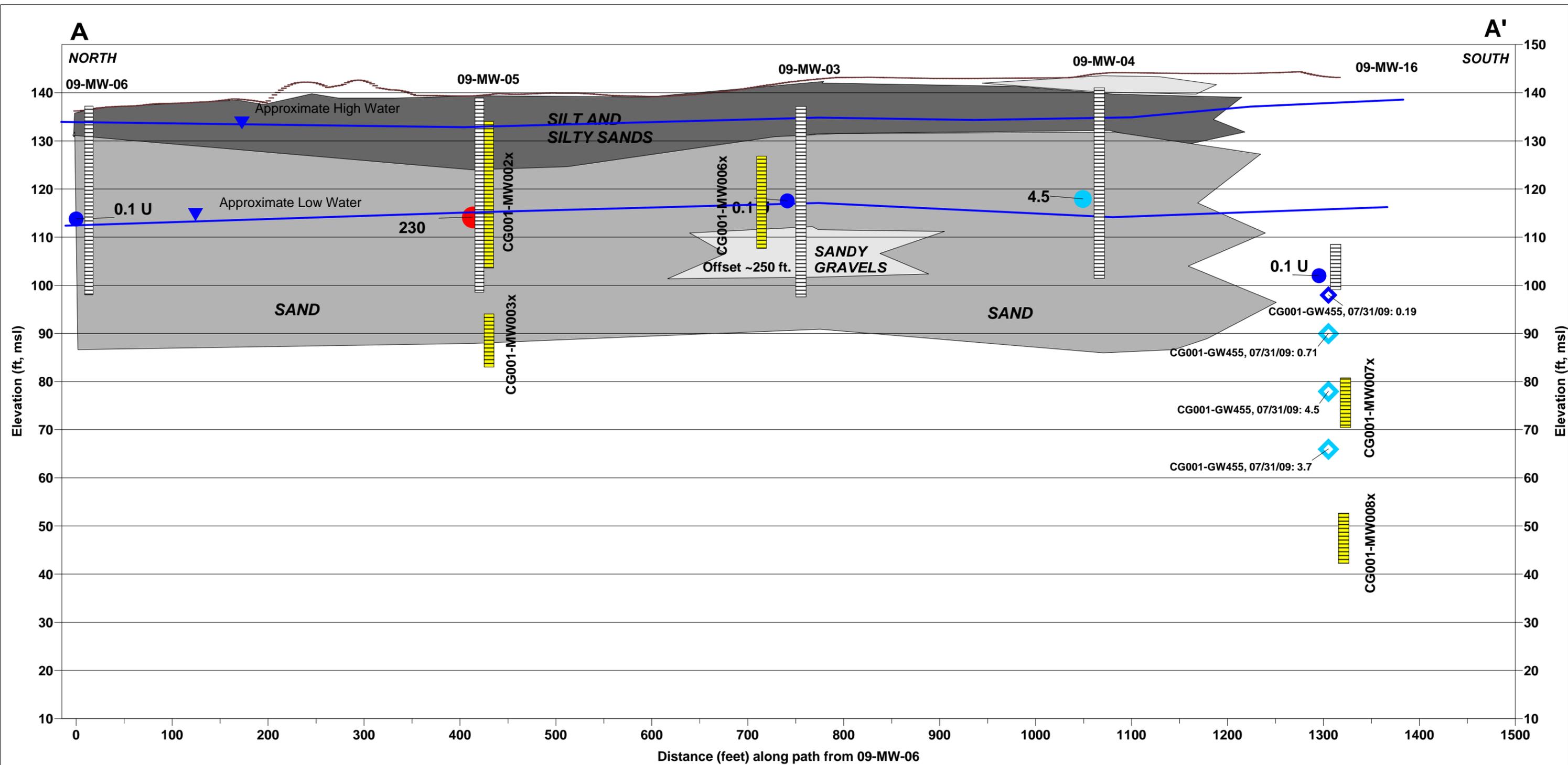
**Cross Section Locations**

- A - A'
- B - B'
- C - C'
- D - D'

Note:  
 1. Proposed well names have a subscript "x" that will be removed upon installation of the well.  
 2. Only current wells and borings discussed in the text or shown in other figures are labeled.



**FIGURE 1**  
**Proposed Monitoring Well Locations for 2011 Installation and Cross Section Locations**  
 Technical Justification for Phase 1 Wells - Former Galena FOL  
 Former Galena Forward Operating Location, Alaska



**LEGEND**

**LITHOLOGY**

- Silt and Silty Sands
- Sand and Gravelly Sand
- Sandy Gravel
- Approximate Min. and Max. Water Level

Well Screen

Proposed Well

**Benzene Concentrations (µg/L) in Groundwater**

Historical Boring Data  
2004-2009

- ◆ 0 to < 0.5
- ◆ 0.5 to < 5
- ◆ 5 to < 50
- ◆ 50 to < 500

October 2010  
Well Data

- 0 to < 0.5
- 0.5 to < 5
- 5 to < 50
- 50 to < 500

**Notes:**

1. Distances represent actual distances between wells.
2. 09-MW-05 is severely frostjacked and scheduled for abandonment.
3. Concentration values are appended with laboratory flags where needed.

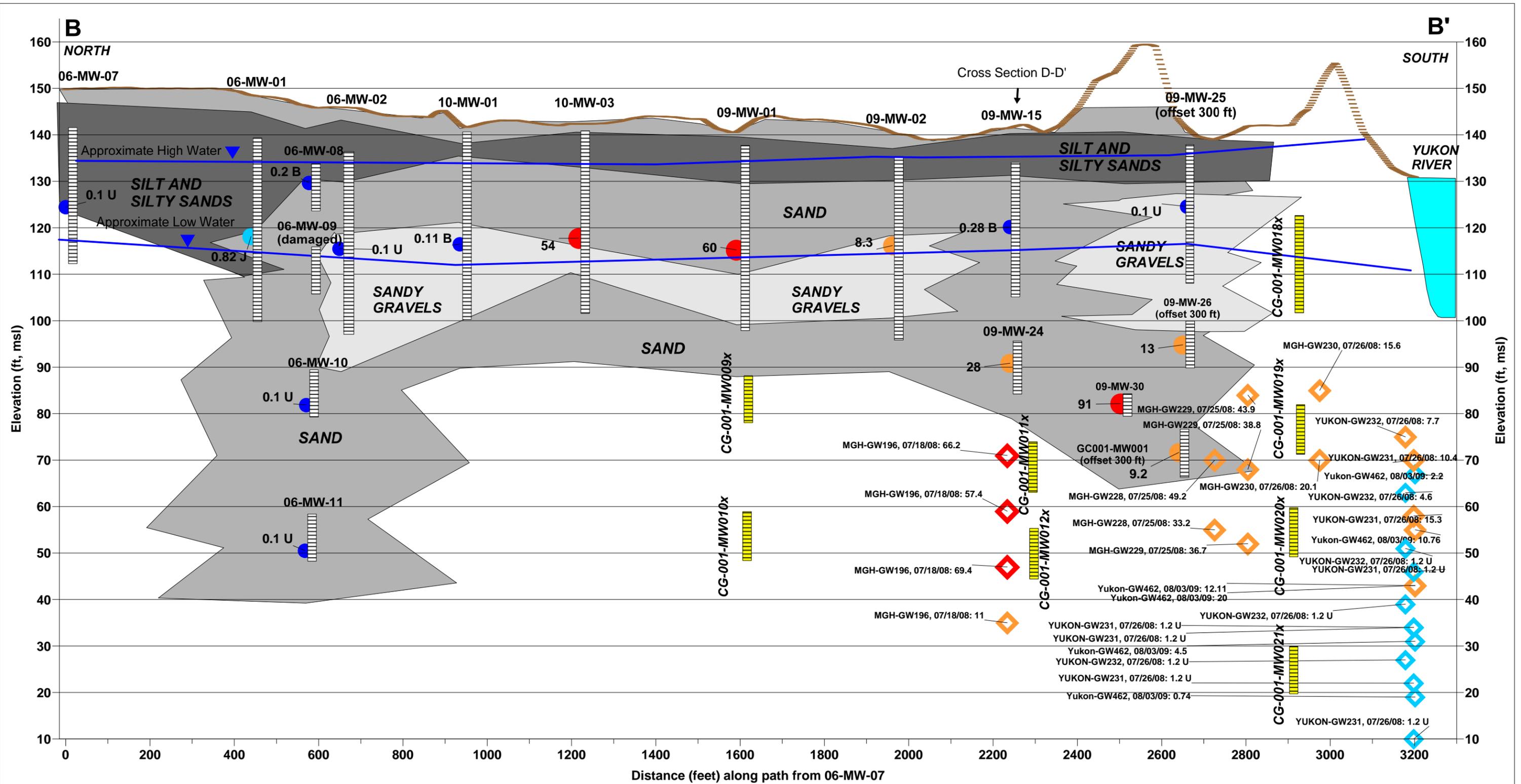
B: the analyte was detected in the associated method and / or calibration blank.

U and ND: the analyte was analysed for, but was not detected above the reported sample quantification limit.

Scale: Vertical = 20:1, Horizontal = 100:1

**FIGURE 2**  
**Cross Section A-A'**

Technical Justification for Phase 1 Wells  
Former Galena FOL  
Former Galena Forward Operating Location, Alaska



**LEGEND**

**LITHOLOGY**

- Silt and Silty Sands
- Sand and Gravelly Sand
- Sandy Gravel

Approximate Min. and Max. Water Level

Well Screen

Proposed Well

**Benzene Concentrations (µg/L) in Groundwater**

Historical Boring Data 2004-2009

- 0 to < 0.5
- 0.5 to < 5
- 5 to < 50
- 50 to < 500

October 2010 Well Data

- 0 to < 0.5
- 0.5 to < 5
- 5 to < 50
- 50 to < 500

**Note:**

1. Distances represent actual distances between wells, except 09-MW-25, 09-MW-26 and CG001-MW001 are offset to the east by 100 feet.
2. Concentration values are appended with laboratory flags where needed.

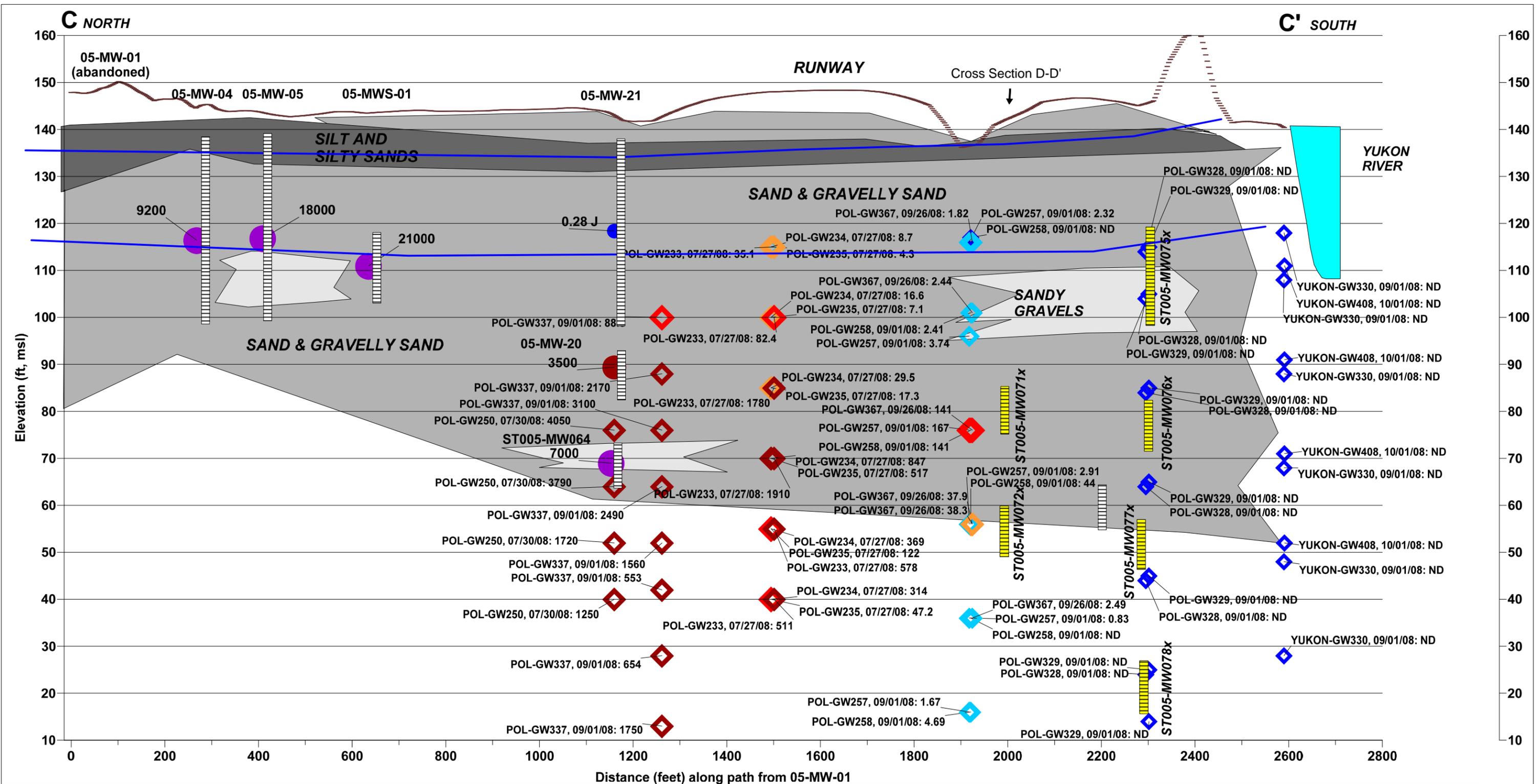
B: the analyte was detected in the associated method and / or calibration blank.

U and ND: the analyte was analysed for, but was not detected above the reported sample quantification limit.

Scale: Vertical = 20:1, Horizontal Scale = 220:1

**FIGURE 3**  
**Cross Section B-B'**

Technical Justification for Phase 1 Wells  
Former Galena FOL  
Former Galena Forward Operating Location, Alaska  
**CH2MHILL**



**LEGEND**

**LITHOLOGY**

- Silt and Silty Sands
- Sand and Gravelly Sand
- Sandy Gravel

Well Screen

Proposed Well

Approximate Min. and Max. Water Level

**Benzene Concentrations (µg/L) in Groundwater**

Historical Boring Data 2004-2009	October 2010 Well Data
0 to < 0.5	0 to < 0.5
0.5 to < 5	0.5 to < 5
5 to < 50	5 to < 50
50 to < 500	50 to < 500
500 to < 5000	500 to < 5000
5000 to < 50000	5000 to < 50000

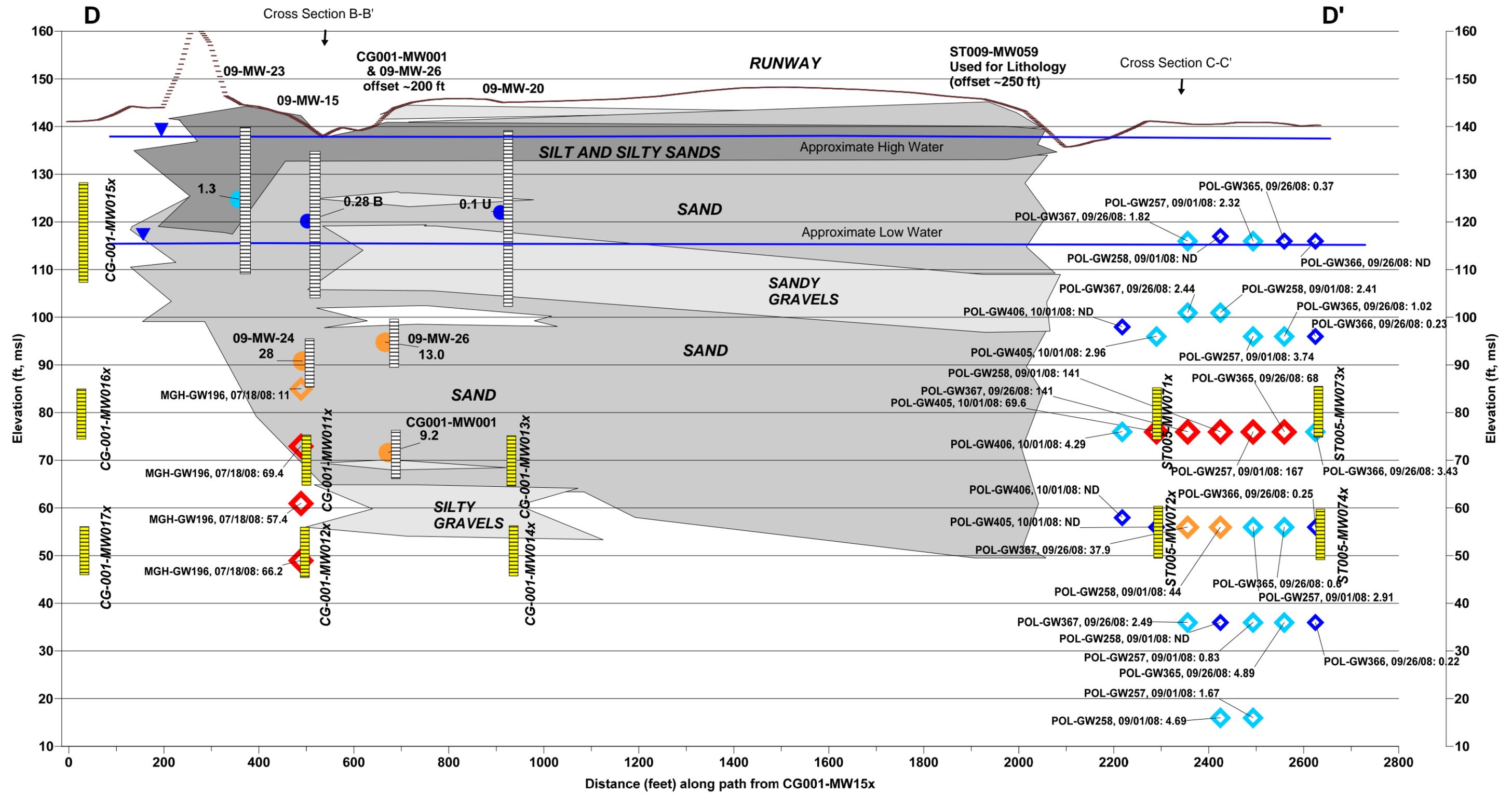
**Notes:**

- Distances represent actual distances between wells.
- Lithology at 2,200 ft is from ST005-MW059, ~250 ft west of the proposed 4-well cluster.
- Several borings are oriented east-west, and appear clustered here.
- 05-MW-01 was included for lithology only.

2. Concentration values are appended with laboratory flags where needed.  
 B: the analyte was detected in the associated method and / or calibration blank.  
 U and ND: the analyte was analysed for, but was not detected above the reported sample quantification limit.

Scale: Vertical = 20:1, Horizontal Scale = 200:1

**FIGURE 4**  
**Cross Section C-C'**  
 Technical Justification for Phase 1 Wells  
 Former Galena FOL  
 Former Galena Forward Operating Location, Alaska  
**CH2MHILL**



**LEGEND**

**LITHOLOGY**

- Silt and Silty Sands
- Sand and Gravelly Sand
- Sandy Gravel
- Approximate Min. and Max. Water Level

**Well Screen**

- Well Screen
- Proposed Well

**Benzene Concentrations (µg/L) in Groundwater**

Historical Boring Data 2004-2009		October 2010 Well Data	
<span style="color: blue;">◆</span>	0 to < 0.5	<span style="color: blue;">●</span>	0 to < 0.5
<span style="color: cyan;">◆</span>	0.5 to < 5	<span style="color: cyan;">●</span>	0.5 to < 5
<span style="color: orange;">◆</span>	5 to < 50	<span style="color: orange;">●</span>	5 to < 50
<span style="color: red;">◆</span>	50 to < 500	<span style="color: red;">●</span>	50 to < 500

**Note:**

- Distances represent actual distances between wells.
- Concentration values are appended with laboratory flags where needed.

B: the analyte was detected in the associated method and / or calibration blank.  
 U and ND: the analyte was analysed for, but was not detected above the reported sample quantification limit.

Scale: Vertical = 20:1, Horizontal Scale = 200:1

**FIGURE 5**  
**Cross Section D-D'**  
 Technical Justification for Phase 1 Wells  
 Former Galena FOL  
 Former Galena Forward Operating Location, Alaska  
**CH2MHILL**