MULTIPLE HDD APPLICATIONS FOR PORTLAND AIRPORT DEICING ENHANCEMENT PROJECT

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ABSTRACT

Horizontal directional drilling (HDD) was used to complete two very difficult portions of pipeline construction and installation for the Port of Portland (Port) Portland International Airport (PDX) Deicing Collection and Treatment System Enhancement Project in Portland, Oregon. The PDX Deicing Project added surface runoff treatment to the existing deicing system at the Portland Airport. The project consisted of more than 8 miles of piping on Port-governed property. HDD was selected for two of the most difficult areas of pipeline construction which included a new outfall into the Columbia River and a significant active airfield crossing.

The Columbia River outfall HDD installation presented several unique challenges. The installation included 1,100 feet of 30 inch polyethylene pipe. The HDD rig and boring operation was land-based while the pipe was installed using water-based flotation and insertion. Other challenges included tight in-water environmental constraints on construction techniques, activity on protected water with endangered species, crossing of an Army Corps of Engineers levee, and the need for underwater construction.

The active airfield HDD installation crossed active runways, taxiways, and ramp areas, and presented several unique challenges. The installation included a 24 inch and 6 inch fusible polyvinylchloride pipe dual insertion, installed in a single 3,800 foot bore. This installation also had tight environmental challenges regarding fusion and layout areas, a significant depth of bore required under working runway and taxiway crossings, and consideration of Transportation Security Administration airfield security requirements.

This paper will detail the design and construction efforts associated with both of these HDD installations and the lessons learned from both of these very challenging yet different uses of HDD methodology.

INTRODUCTION AND PROJECT BACKGROUND

PDX encompasses over 2,600 acres, serving over 15 million travelers annually to domestic and international destinations. It is also home to the 142nd Fighter Wing of the Oregon Air National Guard. A vital element to providing safe aviation service at PDX is the deicing and anti-icing of planes and pavement during periods when air temperatures are below 40 degrees Fahrenheit.
The Port of Portland (Port) is tasked with capturing and managing fugitive aircraft and pavement deicing and anti-icing chemicals, as well as collecting and treating large volumes of deicing chemical impacted stormwater on-site. The deicing and anti-icing fluids are collected and managed through the existing stormwater management system. The concern with excessive non-toxic deicing fluids in the stormwater is its high biological oxygen demand (BOD). To maintain stormwater discharge compliance with State and Federal regulations, the Port needed to make significant investments in the existing infrastructure to enhance the deicing collection and control system at PDX.

Under the terms of a Mutual Agreement and Order with the Oregon Department of Environmental Quality (ODEQ), the Port is required to comply with mandated milestones, including installation and operation of the enhanced deicing system, by April, 2012. Under an expedited schedule, the Port and CDM Smith designed and constructed additional collection, storage and treatment systems in order to maintain compliance with the ODEQ Order. Part of this system included a new outfall to the Columbia River to manage the treated discharges, balancing system requirements with protection of endangered species and other environmental. As shown in Figure 1 (see gallery in appendix), due to the significant restrictions placed upon construction activities at an airport, the enhanced system was located on the western edge of the airport property. However, the existing collection and management system is located in the central and eastern portions of the airport, representing significant design and construction obstacles in order to connect the two systems together.

**DESIGN AND CONSTRUCTION OF THE OUTFALL**

The installation of a new outfall into the Columbia River was key to the success of the Enhanced Deicing System. During the winter, coinciding with the required deicing season, the Columbia has an average flow rate well in excess of 150,000 cubic feet of water per second. This rate of flow allows for the effective dissipation of the high BOD fluids associated with the deicing system operation without adverse effects on the endangered species in the heavily regulated river. The permitting process for the impacted stormwater into the river required extensive flow and dissipation modeling, comprehensive endangered species investigation and studies, and lengthy reviews and evaluations by local, state and federal regulators.

In parallel with the environmental permitting process, the investigation, evaluation and design of the mechanical requirements to convey deicing fluids from the airfield into the river began in November 2008. Between the airfield and the river is a United States Army Corps of Engineers (Corps) flood control levee system managed by the Multnomah County Drainage District (MCDD). Open excavation of the levee was not practical for a multitude of reasons, including crossing the heavily traveled Marine Drive roadway which aligns with the crown atop the levee. Soil borings were drilled adjacent to the proposed outfall routing (Figure 2) to fully evaluate the potential crossing options. By reviewing the data from these borings and information from the Corps and MCDD on the construction of the levee (Figure 3), screening level options for the crossing were evaluated.

Many potential crossing options were eliminated from further consideration due to the fine grained dredge sands that make up and underlie the levee. The two options that advanced to further evaluation were the open cut or direct pipe bury, and HDD options. The additional investigation determined that HDD would be the least costly and presented the least potential short and long term impacts to the levee system.

After an extensive review process by both the Corps and MCDD, the Port was granted a permit to construct an outfall utilizing HDD installation methodology below the federal levee, and the Oregon Department of State Lands granted the permit for the diffuser on the bottom of the Columbia River (Figure 4). The parabolic shape of the boring was to remain well below the zone of influence of the levee, with the insertion being as close to the levee as permitted. Total length of the bore was anticipated to be 1,000 feet, with a 30 foot diffuser extending into the river.

High Density Polyethylene (HDPE) pipe and fusible polyvinylchloride pipe (FPVCP) were considered for this outfall. Bore depth and installation length dictated minimum wall thickness pull strength design requirements for both materials. Maintaining equal inner diameters and required flow areas for both materials meant that a 30” DR9 iron pipe size (IPS) HDPE pipe and 24” DR21 ductile iron pipe size (DIPS) FPVCP cross-section were evaluated as equals. FPVCP was recommended for land based insertion due to the reduced flexibility of the material compared to HDPE pipe. Based on environmental concerns, permitting requirements and significant additional driller costs to
operate and drill from the river to the land, it was determined that a land based drill with pipe insertion from the water side was the best solution. Therefore, HDPE was selected as the only suitable material for this installation.

A pre-qualification and competitive bidding process performed by JE Dunn (project Construction Manager/General Contractor) selected a joint venture of Northwest Underwater Constructors (NUC) and Kinnan Engineering (Kinnan) to perform the HDD installation. Construction activities began in December 2009, the month which is the beginning of the allowable, permitted “in-water” work window for the Columbia River. The work window has been established by the regulatory agencies in order to protect the endangered species that use the Columbia for migration. All construction activities had to cease by February, 2010, and if not completed by then had to begin and end in December, 2010, as a new regulated species would be added to the work window requirements.

To begin the HDD installation, 60 feet of 48 inch stand steel pipe was driven into the airfield side bore pit, and subsequent drilling of the 6 inch pilot hole completed within ten calendar days using an American Augers DD 210 Directional Drill rig (see Figure 11). The pilot hole emerged from the bottom of the Columbia within 1 foot of the target location. Divers then connected a receiving pipe to the drill, which was then extended to a work barge in the Columbia. Great care was taken to minimize any potential discharge, as regulators were concerned about the possibility of elevated levels of suspended solids from the drilling operation entering the Columbia and adversely impacting endangered species.

Successive reaming passes enlarged the borehole, with the final pass being with a 42 inch reamer. This hole size was required in order to accommodate the 30 inch DR9 HDPE pipe that was required for this outfall. The HDPE pipe was fused and pressure tested in NUC’s yard across the river in Vancouver, Washington, towed upriver, then pulled from the river back to the airfield side of the levee, further reducing the opportunity for drilling fluids to be discharged into the river. The total installation was completed in 80 calendar days include mobilization and demobilization.

**DESIGN AND CONSTRUCTION OF THE AIRFIELD CROSSING**

As previously noted, the new portions of the deicing enhancement system were designed on the far west side of the airfield, and the existing system was on the eastern and central areas. These two areas are roughly two miles apart, and the route between them passes through an active runway/taxiway system. Open cut or direct bury methodology around the runway was quickly eliminated as an option due to the distance and quantity of utility piping that would have to be managed. This option would also add significant cost to the project.

The option of using trenchless technology under the runway/taxiways would eliminate an additional piping cost, however the costs for removing and replacing aircraft-rated pavement greatly outweighed any potential cost savings on pipe. Additionally, the logistics of working on or temporarily closing a runway/taxiway made this option unfeasible.

Another option was a combination of open cutting and “jack and bore” installation methodology under the critical runway and taxiway facilities in the near surface soils, which could be done while the runway/taxiways were operational. Unfortunately, these near surface soils proved to be predominantly loose and unconsolidated, precluding the use of “jack and bore” technology.

After further and exhaustive review of potential options, evaluating potential risks and costs, HDD was advanced as the most cost efficient, viable option. Using historical geotechnical information (Figure 5) a proposed HDD boring plan was developed going under the cargo air operations and just south of the active runway (Figure 6). Due to the poor soils prevalent across the site, the proposed bore trajectory was taken to a depth of at least 75 feet, where competent soils were expected. The Port was very wary of HDD installation methodology within the airfield, due to contractor miscalculations on a previous project that resulted in the emergence of a sinkhole adjacent to PDX’s south runway. To mitigate this potential risk, this crossing’s bore path alignment was carefully selected to provide numerous viable “work arounds” if there were a similar issue that occurred under the cargo area or the very southern end of the active runway.

Further complicating this installation was the fact that two separate pipe sections were required for the crossing. One large primary conveyance, which was for storm water from the airfield collection areas, would require the same
24” FPVCP or 30” HDPE pipe similar to the outfall installation. The second conveyance, however, was much smaller and required for a concentrate stream pump back to the airfield side. Both 30” HDPE and 24” FPVCP were considered for this crossing, in the same manner that they were considered for the outfall installation. Bore depth again dictated minimum critical buckling design requirements, but the extreme length (3,800’) and bundled pull also required maximizing tensile strength to weight ratio. 24” DR18 DIPS FPVCP was chosen specifically due to its strength-to-weight ratio, allowing risk minimization on the bore by giving the driller the highest safe pull force to weight possible to meet any actual required pull force during pullback. The smaller line was also FPVCP, a 6” DR14 DIPS cross-section.

The same joint venture of NUC and Kinnan was selected to perform the HDD for the airfield crossing using the same American Augers DD 210 Directional Drill rig (Figure 11). Underground Solutions, Inc. (UGSI) provided the FPVCP pipe and fusion services for this crossing. During drilling, Kinnan encountered difficult and complicated drilling conditions. The same poor soils that precluded “jack and bore” methodology also had to be considered in the initial approach of the drill shot. Kinnan used a steel casing for the first ~120 feet of the installation to stabilize the bore, while at the exit end sink holes appeared following reaming within the security zone of the airport (Figure 10).

Due to airport security and access concerns, the perimeter road and surrounding fence needed to remain intact. While this was not an issue on the drilling side of the installation completing the pilot hole in 20 calendar days, on the pipe insertion side this presented a unique challenge since the pipe was staged outside of the airport property but would need to cross into the active airfield prior to being inserted into the bore alignment. To solve this issue, Kinnan installed a temporary corrugated plastic culvert under the fence and perimeter roadway which met both security and continuous access needs for PDX.

The required length of the bore, 3,800 LF, was a significant length of pipe to fuse and stage – not only to string out in one length, but to make sure that it lined up with the crossing alignment. The fusion and lay-down area for the fused pipe (Figure 7) presented a major challenge because wetlands and environmentally sensitive areas that could not be disturbed existed in the work area that had to be used. JE Dunn, CDM Smith, The Port of Portland, Kinnan, and UGSI ultimately identified an alternate alignment that did not disturb the wetlands, yet allowed for the full lengths for both 24” and 6” sections to be laid out.

Kinnan custom-fabricated a manifold-style pullhead to separately link the 6 inch and 24 inch pipes and their individual pullheads simultaneously (see Figures 8 and 9). Pullback commenced on July 27, 2010, with water ballast in the 24 inch pipe to reduce frictional force in the bore. The pull was completed in 13 hours, exerting a maximum pull force of 117,000 pounds. A successful pressure test was completed several weeks later. The total installation was completed in 140 calendar days include mobilization and demobilization.

CONCLUSIONS

Horizontal directional drilling played a major role in allowing construction of a surface runoff treatment to the existing deicing system at PDX. The project consisted of more than 8 miles of piping on Port governed property, but arguably the trenchless portions were by far the most challenging. HDD was selected for two of the most difficult areas of pipeline construction, which included a new outfall into the Columbia River and a significant active airfield crossing.

Both HDDs were demanding for a multitude of reasons, including environmental constraints, geotechnical constraints, water entry, layout concerns, and length and depth of each crossing. Although both were part of the same system, the specific requirements of each HDD necessitated a selection of two very different thermoplastic materials: HDPE for its flexibility for a water entry, and Fusible PVC due to its high tensile strength to weight ratio for an extremely long, bundled pull under an operating airfield.

By exhaustive study of alternate options, collection and review of both existing and additionally required geotechnical data, proper selection of materials and prequalification of acceptable drillers, and careful planning and coordination, these two very different and challenging HDDs were completed on schedule and budget as part of the same project.
REFERENCES


Fox, William (Cosmopolitan Engineering Group, 2009). Columbia River Discharge Schematic Design,


Figure 1. Final site plan showing new treatment and conveyance facilities on the western side of the PDX property and the existing facilities in the central and eastern portion of the PDX property.
Figure 2. Boring locations completed for Columbia River Outfall geotechnical survey (CDM Smith Geotechnical Data Report, June 2009).
Figure 3. Cross-section of subsurface soils for Columbia River Outfall (CDM Smith, Geotechnical Data Report, June 2009).
Figure 4. Design plan and profile for Columbia River Outfall, including diffuser location (CDM Smith, Geotechnical Data Report, June 2009).
Figure 5. Proposed Boring Plan for the active airfield crossing (CDM Smith, Geotechnical Data Report, June 2009).
Figure 6. Results of the Boring Plan along the chosen HDD alignment (Geotechnical Data Report, June 2009).
Figure 7. Lay-down area for the fused FPVCP sections.

Figure 8. Start of Pull into the insertion pit.

Figure 9. Pipe Bundle at Borehole Exit and casing.
Figure 10. Sink hole a receiving end of airfield crossing.

Figure 11. HDD drilling rig used for both segments.