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ANOTHER SUCCESS FOR THE CITY OF PORTLAND USING ALTERNATIVE CONTRACTING METHODS TO DELIVER THE BALCH CONSOLIDATION CONDUIT

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ABSTRACT: The City of Portland Bureau of Environmental Services has completed the design of the final segment of their West Side Combined Sewer Overflow (CSO) system, part of the City's overall CSO program. This project includes 6,900 feet of 84-inch microtunneling in five drives and 950 feet of 54-inch microtunneling in a single drive. The City chose to use an alternative contracting mechanism for project delivery that included choosing a contractor, based on qualifications, at the 60% design level. From the 60% to 100% design completion level, the contractor participated in final design decisions, made suggestions for modifications to existing design features and provided input to refine cost parameters. This mechanism was previously coined "The Portland Method" on the West and East Side CSO projects.

There were several challenging aspects to the project that included widely varied soils; from extremely soft silts that would not provide adequate bearing capacity of the microtunneling machine without ground improvement to extremely abrasive open-graded gravels. An extensive multiple-phase geotechnical investigation was conducted to carefully evaluate the soil conditions along the alignment. The Design Team worked together to analyze the soils, and from this information the City worked with the Contractor to procure a new microtunneling machine for the project.

Shaft depths ranged from 35 to 75 feet deep in soil zones with high groundwater where dewatering had to be minimized to prevent the movement of contamination plumes. All microtunnel drives were a minimum of 1,100 feet, with the longest drive on the project of 1,690 feet traversing beneath heavily traveled U. S. Highway 30.

1. INTRODUCTION

The Bureau of Environmental Services (BES) serves the Portland community by protecting public health, water quality and the environment. BES provides sewage and stormwater collection and treatment services to accommodate Portland’s current and future needs. The Balch Consolidation Conduit is a key component to the City’s Combined Sewer Overflow (CSO) Management Program.

The Project is needed to comply with the mandated Amended Stipulated and Final Order (ASFO) administered by the Oregon Department of Environmental Quality. The ASFO requires that the City construct facilities to control CSOs to the Willamette River to a level commensurate with four winter overflows annually and one summer overflow every three years. Control of 16 outfalls along the west side of the Willamette River must be completed by December 2006, and full control to the stipulated level, by December 1, 2011. The Balch Consolidation Conduit must be in place and operational by the December 1, 2011 deadline to meet requirements of ASFO.

The Balch Consolidation Conduit (BCC) Project will convey combined sewer overflows from the Balch Drainage Basin in Northwest Portland. The area is bounded by the Willamette River to the north and the Tualatin Mountains to the south. The Project will include approximately 6,900 feet of 84-inch-diameter sewer main, which will convey up to 390 cubic feet per second (cfs) of combined sewage from the Balch Basin to the existing Nicolai drop shaft on the Westside Combined Sewage Overflow tunnel.

The BCC Project was originally under the Westside Combined Sewer Overflow (WSCSO) design responsibility and was partially designed with a 54-inch pipe to intercept flows near Outfall 17. The Northwest Neighborhoods (NWN) predesign project then discovered additional flows in the Balch basin that required further study. The BCC project was shelved until the NWN predesign project could accurately model the basin. During this process it was discovered that the CSO pipe to Outfall 17 had deteriorated beyond repair. BES decided that the BCC project's original scope would be modified to intercept flows at two fixed locations within the Balch basin. The two intercept points are referred to as Shafts GLI and B. Additionally, Shaft M, the Balch Conduit Receiving Shaft (BCRS) is also fixed and will be the only relief point for the Balch basin while also being a relief point for the Westside tunnel. The Balch Consolidation Conduit is a combined sewer overflow pipe, and is not intended to carry any sanitary or other base flow. The project configuration is shown graphically in Figure 1.

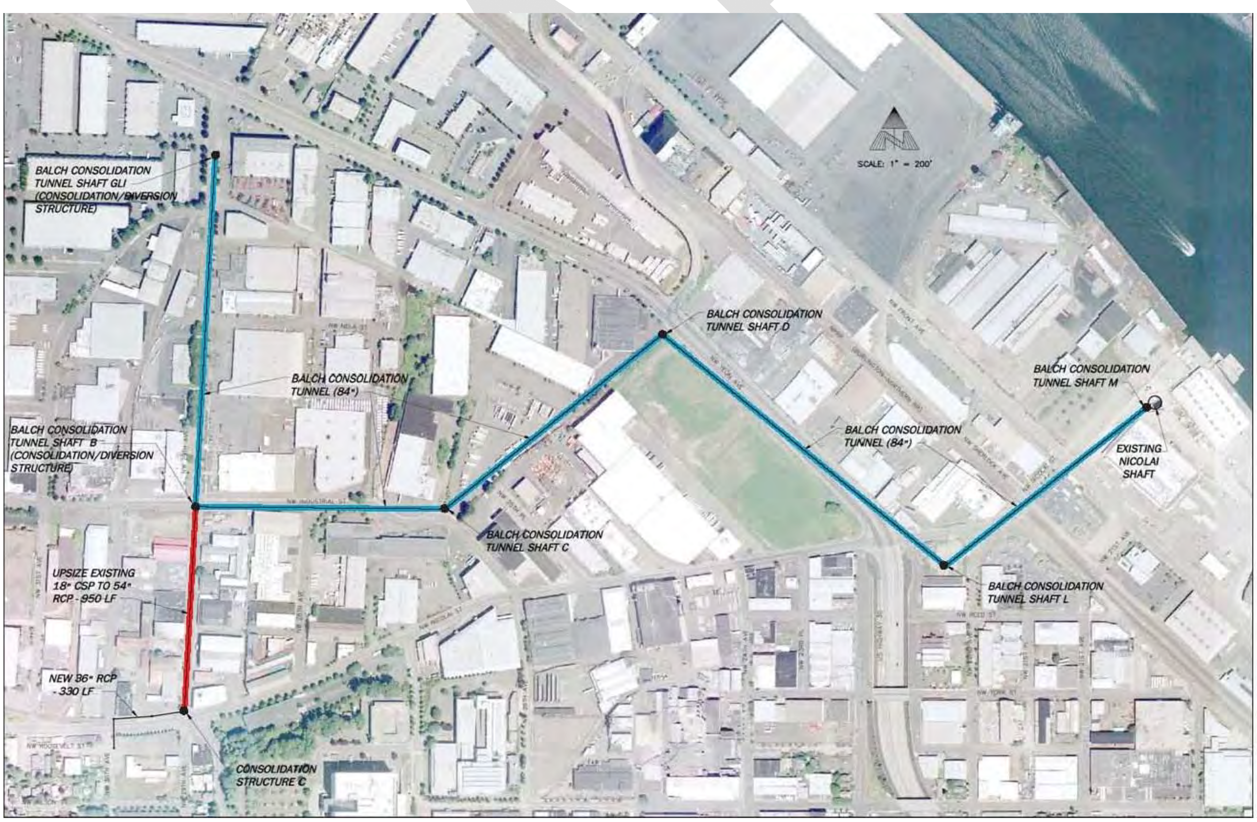

Figure 1. Balch Consolidation Conduit – Alignment Plan View

2. SCOPE OF PROJECT

The Balch Consolidation Conduit, Shafts and Pipelines Project is part of a group of improvements that BES intends to make over the course of the next two years to reduce the discharge of combined sewer overflows to the Willamette River.

The Project includes the construction of gravity pipelines, shafts, and deep tunnel that will collect and intercept overflows from existing combined sewers that discharge to the Willamette River from the Northwest Industrial Neighborhood (Guilds Lake area). The area is bound by the Willamette River to the north and the Tualatin Mountains to the south.

The Project will convey combined sewer overflows from the Balch Drainage Basin in Northwest Portland to the existing Nicolai drop shaft on the Westside Combined Sewage Overflow tunnel. The Balch Consolidation Conduit (BCC) will be concrete pipe with an inside diameter of eighty four inches (84-inches), and will be approximately six thousand nine hundred (6,900) feet long. It will be constructed at depths ranging between twenty four (24) to seventy five (75) feet beneath the ground surface. A series of six (6) shafts will be constructed along the conduit route to provide access to conduct the work and two (2) shafts will connect to the existing combined sewer. The purpose of this project is to reduce the frequency and volume of combined sewer overflows from the Balch Basin on the west side of the Willamette River.

BCC Micro-Tunnels and Shafts: The BCC and associated shafts are the central element of this project. The conduit will collect and intercept flows mid-basin rather than at Outfall seventeen (17). The intercept points are located at the intersection of NW 29th & NW Industrial, and approximate 220 feet north of the intersection of NW 29th and NW 31st Avenues. The micro-tunnel will extend for approximately one thousand five hundred ninety five (1,595) lineal feet from the vicinity of NW 29th & NW 31st (Shaft GLI), south to the intersection of NW 29th & NW Industrial, then approximately one thousand one hundred thirty six (1,136) feet east along NW Industrial, then NE approximately one thousand two hundred and ninety four (1,294) feet, then SE approximately one thousand six hundred and eighty six (1,686) feet to the SW corner of NW Nicolai and NW 22nd, then NE one thousand one hundred and ninety eight (1,198) feet to the Nicolai shaft. Total length of the micro-tunneling is approximately six thousand nine hundred (6,900) feet.

Connecting Pipelines: Another major aspect of the Project is the construction of new and modification of existing facilities to send sanitary and storm flows to the Balch Conduit. These items include modification of diversion structures, construction of approximately one thousand one hundred and fifteen (1,115) feet of microtunneled 54-inch diameter pipeline from NW 29th and NW Industrial to NW 29th and NW Roosevelt, approximately three hundred twenty feet (320) of 36-inch diameter pipeline from NW 29th and Roosevelt to NW 30th and NW Roosevelt, and miscellaneous short lengths of connecting pipelines from 12-inch to 54-inch diameters.

3. PROJECT GOALS

The Balch Consolidation Conduit Project established multiple project goals during project initiation and preliminary design. These goals and objectives are:

- Comply with the mandated Amended Stipulated and Final Order (ASFO) administered by the DEQ
- The Balch Consolidation Conduit must be in place and operational by the December 2011 deadline to meet requirements of the ASFO
- Provide subsurface characterization with respect to geologic units, soil properties and chemical characteristics
- Identify means by which risks will be shared for microtunneling construction work
- Minimize environmental risk and ensure worker health and safety
- Ensure collaboration and coordination among multiple project disciplines and affected businesses

4. ALIGNMENT OPTIONS AND SELECTION FACTORS

The alignment evaluation and selection process incorporated the following key considerations:

- An extensive alignment selection process took place involving the design team, BES Staff and independent review through a formal Value Engineering process.
- The selection process considered geotechnical and environmental exploratory data, construction risks, third party impacts and costs.
- The selection process used a comparison by pairs approach in a workshop setting.

The Balch Consolidation Conduit (BCC) microtunneling alignment selection process consisted of a four-step process for evaluation of alternative alignments.

1. Initial Alignment Alternatives Evaluation
2. Selected Alignments Evaluation
3. Value Engineering Process
4. Refinement of Selected Alignment Design

Figure 2 shows multiple alignments initially considered. Hydraulic functioning of the pipeline was not a distinguishing factor in the alignment selection process, although the shortest overall pipeline alignments were the most hydraulically effective.

Figure 2. Balch Consolidation Conduit – Initial Alignments

5. SYSTEM ANALYSIS AND HYDRAULIC DESIGN BASIS

The current BES sewer design manual provides design guidelines, two of which were important for the hydraulic design and operation of the Balch Consolidation Conduit:

- *"Designing a sewer to surcharge is acceptable engineering practice."*
- *"Storage facilities are part of the citywide CSO management control strategy. They operate by temporarily storing excess combined sewer flow for later controlled release and treatment. During normal operation, a facility could exceed the maximum surcharge height limits, however, it must never cause or exacerbate basement flooding."*

While the BCC will surcharge on an annual basis and act as a storage facility, it must not cause flooding in the contributing basin. The BCC will experience a peak hydraulic grade line of approximately elevation 22 feet when the tunnel fills. Boundary conditions for the existing system analysis include:

- Flow input near 29th and 31st Avenues Shaft (GLI Shaft)
- Flow input at Industrial Street and 29th Avenue Shaft (Shaft B)
- Flow discharge at Nicolai Shaft on WSCSO tunnel

These input and discharge points are fixed as required to comply and coordinate with the BES predesign for tributary projects (flow input points) and design of the Westside Combined Sewage Overflow project (discharge point). Hydraulic design data was established and verified consistent with changes in design plan and profile drawings, as follows:

<u>HYDRAULIC DESIGN DATA</u>
BES Standard 6-Hour, 25-Year CSO Design Storm, 2040 Condition

<u>CONSOLIDATION DIVERSION GLI</u>
Dry Weather Flow – 5.5 cfs (out to Yeon Pump Station by way of 21-inch sanitary line)
Peak Wet Weather Flow – 18 cfs (out to Yeon Pump Station by way of 21-inch sanitary line)
Dry Weather Flow – 0 cfs (out to Shaft GLI, BCC Tunnel)
Peak Wet Weather Flow – 190 cfs (out to Shaft GLI, BCC Tunnel)

<u>CONSOLIDATION DIVERSION B</u>
Dry Weather Flow – 1.5 cfs (out to Yeon Pump Station by way of 21-inch sanitary line)
Peak Wet Weather Flow – 14 cfs (out to Yeon Pump Station by way of 21-inch sanitary line)
Peak Wet Weather Flow – 92 cfs (in from West)
Peak Wet Weather Flow – 106 cfs (in from South)
Peak Wet Weather Flow – 122 cfs (in from East)
Peak Wet Weather Flow – 295 cfs (out to Shaft B, BCC Tunnel)

<u>BCC TUNNEL</u>
At Shaft GLI – 190 cfs (to BCC Tunnel)
At Shaft B – 295 cfs (to BCC Tunnel)
Downstream of Shaft B – 490 cfs (in BCC Tunnel)

BCC Tunnel Segment (Shaft GLI TO Shaft B) Diameter = 84-inch, Slope = 0.0100 ft/ft
BCC Tunnel Segment (SHAFT B TO SHAFT C) Diameter = 84-inch, Slope = 0.0104 ft/ft
BCC Tunnel Segment (Shaft C TO Shaft M) Diameter = 84-inch, Slope = .00160 ft/ft

BCC Tunnel submerged to 27.1 feet maximum water surface elevation at Shaft GLI during Westside CSO Design Storm Event
BCC Tunnel submerged to 26.8 feet maximum water surface elevation at Shaft B during Westside CSO Design Storm Event

BCC Tunnel submerged to 20.2 feet maximum water surface elevation at outfall to Nicolai Shaft during Westside CSO Design Storm Event

6. SUMMARY OF PROJECT DESIGN ISSUES

Following alignment selection and hydraulic design, the pipeline and shaft structure design was advanced considering key project issues including the contracting method for construction, need for ground modification, presence of contaminated media, dewatering, settlement monitoring, permits/easements acquisition, public interaction and utility relocation.

Contracting Method

Because of general risks associated with microtunneling and specific risks related to the BCC Project, a well conceived and managed approach to construction contractor procurement was important. This included a responsible level of risk-sharing between the contractor and City. During the time period from December 2007 to January 2008, BES representatives evaluated various methods for construction contractor selection and project execution. In mid-January 2008, BES decided to pursue a qualifications-based competitive proposal; contractor selection process and a Cost Reimbursable Fixed Fee (CRFF) form of contract for project construction.

Upon contractor selection through the Competitive Proposal Process, the contractor and City entered into a Pre-Construction Services Agreement. During this preconstruction period, the contractor participated in the project's final design and an Estimated Reimbursable Cost (ERC) was negotiated between the contractor and City. The construction contract also was negotiated between the City and contractor with the contractor compensation based on the ERC and Fixed Fee.

This form of contract and process allowed the following:

- Ability to develop an equitable risk-sharing approach and method between the contractor and City.
- Contractor selection occurring concurrently with design, thus reducing overall project schedule requirement.
- Contractor participated in the final design process and decision-making relative to materials and equipment selection, construction means and methods (particularly for shafts), and construction schedule/sequencing.
- Facilitated early procurement of long lead time equipment and materials (particularly microtunneling machine).
- Fostered cooperative working relationship among contractor, design team and BES during design and construction.
- Ability to work concurrently on inter-related elements of work including value engineering, constructability review, evaluation of risk and development of estimated reimbursable cost.

Value Engineering and Constructablility Review – A formal value engineering evaluation was conducted in November 2007 and focused on alignment alternatives and shaft construction methods. In addition, as a result of the form of contract, the construction contractor was involved in review of the work-in-progress (60%-90%-100%) design documents (drawings, specifications, construction schedule, and project cost estimates). During this time, the contractor worked collaboratively with BES staff and the design consultant in evaluation of cost saving proposals and conducting constructability reviews.

Project Risk – Project risks were initially identified during the design phase during a BCC Risk Workshop held on February 19, 2009, with the Bureau of Environmental Services, Contractor and Design Consultant staff representatives. The risk workshop identified risks with project construction along with frequency, probability, and magnitude of occurrence. Design actions were taken and decisions made to minimize these risks, while also establishing appropriate levels of construction allowances to provide for any remaining risks. Some of the project risks include ground modification, contaminated media handling, dewatering, ground settlement and permit/easement acquisition, public interaction and utility relocation. These risks and mitigation measures are described in the following sections.

Ground Modification

Due to the presence of highly variable soft soils, an extended zone of microtunnel break-out ground modification is recommended around shaft B, and for the microtunnel drive between B and GLI. The modified zone should extend for a distance of 60 feet in the direction towards Shaft GLI. Along the drive from GLI to B, ground modification is recommended in the form of grout column panels for support of the microtunneling machine throughout this zone. The recommended panel spacing is 15 feet clear space between each panel. This spacing is based upon the machine proposed for the BCC project that includes a secondary steering joint and an air lock cylinder. In addition, ground modification is necessary for successful break in/break out (BI/BO) at all BCC shafts. It is a standard industry practice and should not be eliminated.

Contaminated Media

A Contaminated Media Management Program was implemented to facilitate the efficient construction of the BCC Project and to properly manage contaminated media encountered during construction. The Contaminated Media Management Plan (CMMP) identifies the processes and procedures to be used in the handling of contaminated media (soil and groundwater) encountered during construction. The CMMP was submitted to the Oregon Department of Environmental Quality (DEQ) to obtain agency concurrence that contaminated media will be handled in a manner that is protective of human health and the environment and does not exacerbate existing environmental conditions.

The objectives for the BCC Contaminated Media Management Program included:

- Minimize the cost to the BCC Project in addressing contaminated media issues during the design and construction;
- Minimize decisions related to contaminated media management required during construction;
- Address long-term environmental risk to the City in a manner consistent with City policies and philosophies;
- Manage contaminated media in a manner that is protective of human health and the environment;
- Protect the BCC Project construction workers from adverse exposure to hazardous substances during construction by identifying, to the extent feasible, location, concentrations, and quantities of contaminated media likely to be encountered during construction activities;
- Prevent exacerbation of existing environmental conditions and hindrance of potential future remediation activities.

Dewatering

Dewatering methods and issues were identified and coordinated among BES, the Contractor, BCC Design team and DEQ, along with the possible effects of dewatering on existing groundwater contamination. Based on the results of those discussions, field and office activities were initiated to characterize the lateral extent of a known groundwater plume that exists in the vicinity of Shaft B. This groundwater contamination plume is related to historical releases on private properties, located southwest of the Shaft B location. Those subject private property sites were under evaluation by others. Additional field and office evaluation by the BCC Project team was undertaken to determine the effects of various dewatering methods and withdrawal rates of on potential groundwater plume migration.

Settlement Monitoring

An overall settlement monitoring program was prepared with respect to baseline determinations, monitor spacing, frequency of recording, information to be recorded, and lead entity for conducting the program. Surface and utility settlement estimates were prepared. The BES Materials Testing Lab managed the settlement monitoring program with PBOT survey assistance. This work was conducted in coordination with building video survey and project public involvement staff.

Permits and Easements

To facilitate the timely acquisition of permits, responsibilities were divided among those which could be undertaken by BES and the Design team during design, versus those that were more related to means and methods and to be undertaken by the Contractor. This division of responsibility is shown in the following Table 1.

Table 1. Division of Responsibilities for Permits/Approvals

Provided by Portland Bureau of Environmental Services	**Provided by Contractor**
Street Opening/Utility Permits	Utility services connections
Railroad Crossing/Encroachment and Easement Permits	NPDES Construction Stormwater Permit
Greenway Permit/Land Use Approval	Discharge Permits
Non-park use permits	Excavation Disposal Permits
Urban Forestry approval/Tree permits	Noise Variance Permit
Clearing permit	Permits for pumping water from the Willamette River
	Building, site grading, and demolition permits related to construction staging areas
	Contaminated media disposal

In addition, five temporary construction easements, six permanent tunnel easements, four permanent shaft easements and three permanent sewer easements were acquired for completion of the work. Early coordination with affected property owners enabled construction activities to proceed as scheduled.

Public Interaction

Each of the Bureau's Combined Sewer Overflow projects has included general public information and education on the City's 20-year CSO program, as well as a tailored approach for providing timely information and coordination with the parties directly affected by the individual construction activities. The BCC project was similar, addressing a broader stakeholder area as well as individual stakeholder issues.

The focus of outreach prior to and during construction of the Balch Consolidation Conduit was to convey site specific construction information and build working relationships with the businesses and property owners most affected by construction activities. Thoughtful and continuous outreach during construction helped to minimize community impact and disruption. The outreach effort prepared stakeholders for the various phases of construction, allowed the project team to quickly identify and resolve stakeholder issues, and provide a collaborative venue to find ways to minimize impact to stakeholders.

The following key stakeholder issues became evident during design and construction:

- Ability to conduct business
  - Access to/from individual properties for businesses – employees, customers, deliveries, large trucks, etc
  - Movement of traffic and ability to move goods; ease of travel through and around construction areas via simple alternate routes and good signage
  - Accommodate special shipments, special events, etc.
- Accessibility and safety for alternate transportation modes – bikes, pedestrians, bus
- Area parking
- Maintaining utilities during construction – water, electrical, phone
- Noise
- Vibration, building settling
- General safety around the area
- Being kept updated on the project

The outreach efforts during construction:

- Informed businesses and residents with information materials and mailings
- Maintained good working relationships and two-way communication with the businesses and residents along the project alignment and around construction locations (small group meetings, scheduled one-on-one meetings, and door-to-door site visits)
- Responded to individual citizen or business concerns

Utility Relocation and Coordination

Utilities in the project area were investigated to establish locations and types of utilities in order to determine impacts and utility relocation needs for construction. Utility impacts/relocations pertinent to each shaft location are discussed in this section. Early utility identification and coordination with Portland Water Bureau, Northwest Natural Gas, Portland General Electric, QWEST and Burlington Northern Railroad enabled waterline, gas pipelines, overhead power, underground telecommunications, and railroad lines to be adjusted or protected in advance of temporary shaft and pipeline construction.

7. CONCLUSION

The alternative contracting method chosen by Portland BES allowed the owner, design team and contractor to work collaboratively during the pre-construction/final design phase to meet the project goals and objectives, while concurrently addressing project technical, constructability, budgetary and schedule risks. Table 2 summarizes key project goals and objectives along with the means that have been used to meet those goals and minimize project risks.

Table 2. Summary of Project Goals and Objectives

Goal/Objective	**Means by which accomplished**
Comply with the mandated Amended Stipulated and Final Order (ASFO) administered by the DEQ	Provide Design Drawings and Specifications for CSO control using 84-inch tunnel and consolidation/diversion structures
The Balch Consolidation Conduit must be in place and operational by the December 2011 deadline to meet requirements of ASFO	Use an alternate form of Contract Method to allow concurrent design and constructability reviews, and also to initiate equipment procurement for long lead time items, including microtunnel boring machine (MTBM)
Provide subsurface characterization with respect to geologic units, soil properties and chemical characteristics	Prepare thorough Geotechnical and Environmental Data Report
Identify means by which risks will be shared for microtunneling construction work	Prepare Geotechnical Baseline Report. Conduct detailed risk analysis, risk workshop and mitigation plans
Minimize environmental risk and ensure worker health and safety	Prepare and implement a Contaminated Media Management Plan
Ensure collaboration and coordination among multiple project disciplines and affected businesses	Use a single Balch Consolidation Conduit Project Office within the project area for design, construction and public interaction

8. REFERENCES

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