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ROCK - SOIL TECHNOLOGY AND EQUIPMENTS

WATERPROOFING

PORTLAND (OREGON - U.S.A.)

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PROJECT:

Jet Grouting treatment – Installation of a waterproof diaphragm (cut-off) underneath bulkheads in reinforced concrete, arriving and departing roadbeds (break-ins) of the TBM shafts and works of stabilization as part of the Willamette River Combined Sewer Overflow Control Project.

PERIOD:

January 2003 – september 2004

CLIENT:

Environmental Services of City of Portland.

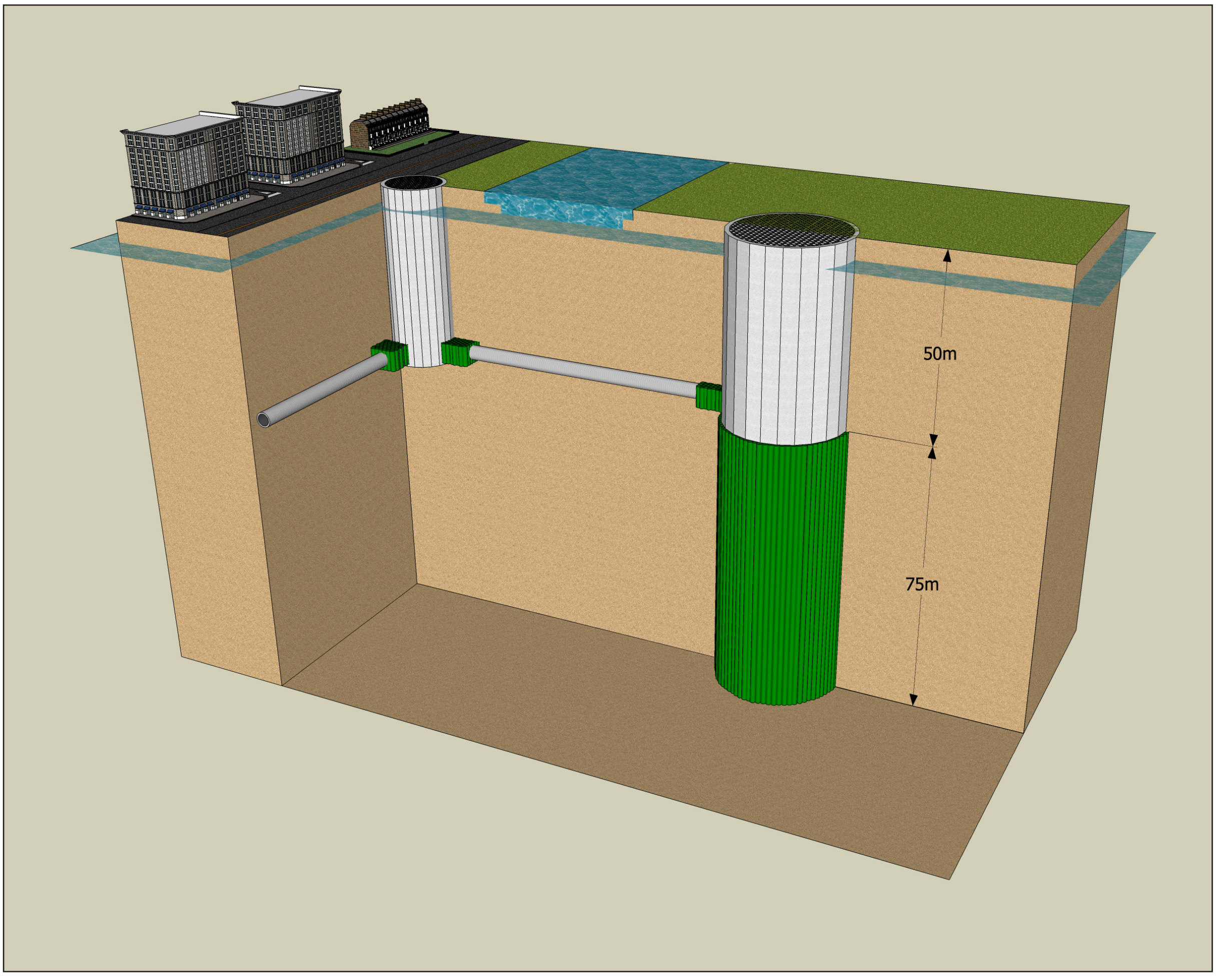

Fig. 1. 3D drawing of the work with portion of the pipeline and shafts and detail of the works.

Introduction.

The “Combined Sewer” is a mixed sewer system that uses the same channels for both foul and surface waters; the system is in need of expansion and must be integrated with the construction of a large new sewer pipe (West Side Big Pipe). This will have a diameter of 4.25 m and length of about 5.63 km, between Clay Street (Clay Shaft) and the Swan Island pump station (Pump Station Shaft), where the treatment plant is located to treat the waters collected (Fig. 2). The tunnel system includes five collection shafts for the different sections to the point where they change direction. These functions as departure and arrival stations of the TBM that will be used to construct the new pipeline. The layout of the tunnel involves the structures on the west side of the Broadway, Steel and Burnside bridges.

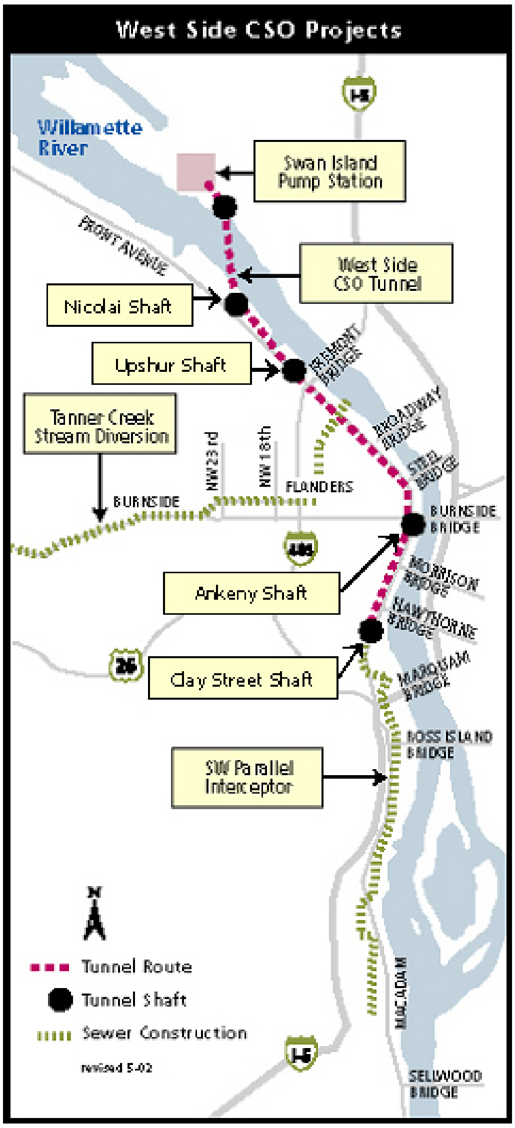

Fig. 2. Route of the pipeline under the banks of the Willamette River.

Geology.

The Portland area is located on the western edge of the basin of the same name. This structure, excavated in a northwesterly direction is bordered by the Portland West Hills on the west and the foothills of the Cascade Mountains on the East. The Portland basis consists, at the base, of basalt from the Columbia river (mid-Miocene period), the surface depth of which has undergone the profoundly altering effects of climatic conditions to form thick deposits of altered basalt. Above this base are fluvial deposits left by the ancestral Columbia river. These :consist of mudstone, siltstone and sandstone with lesser portions of gravel (Troutdale Formation). Above the fluvial deposits are glacial deposits and, lastly, silty sand and silt, deposited along the Willamette river in more recent times.

Lithology (Fig. 3).

As far as –30m from ground level there were silty and sandy alluvial deposits of fluvial origin, and at 32m below ground level fluvial gravel was encountered. This was followed by a thick layer of gravel in a silty-sandy matrix. At about 88m the mudstone began.

Fig. 3. View of the contact between the clay and gravel from core samples

Description of works.

Break-in e Break-outs

Construction of uniform beds of consolidated soil having variable dimensions case by case, under safe, dry conditions, starting from departure from the shafts or arrival in the shafts (which are circular and constructed with bulkheads in reinforced concrete) of the TBM used for construction of the new pipeline.

Nicolai Shaft (Fig. 4).

Three break-ins were built (one of which also included a waterproof wall around a box structure).

Toward Upshur Shaft

Located at a depth between 20 and 30 m is a parallelepiped of 27 columns with a base measuring 9.7 x 2.6 m. It consisted of a partial column that, if complete, would have a diameter of over 6 m.

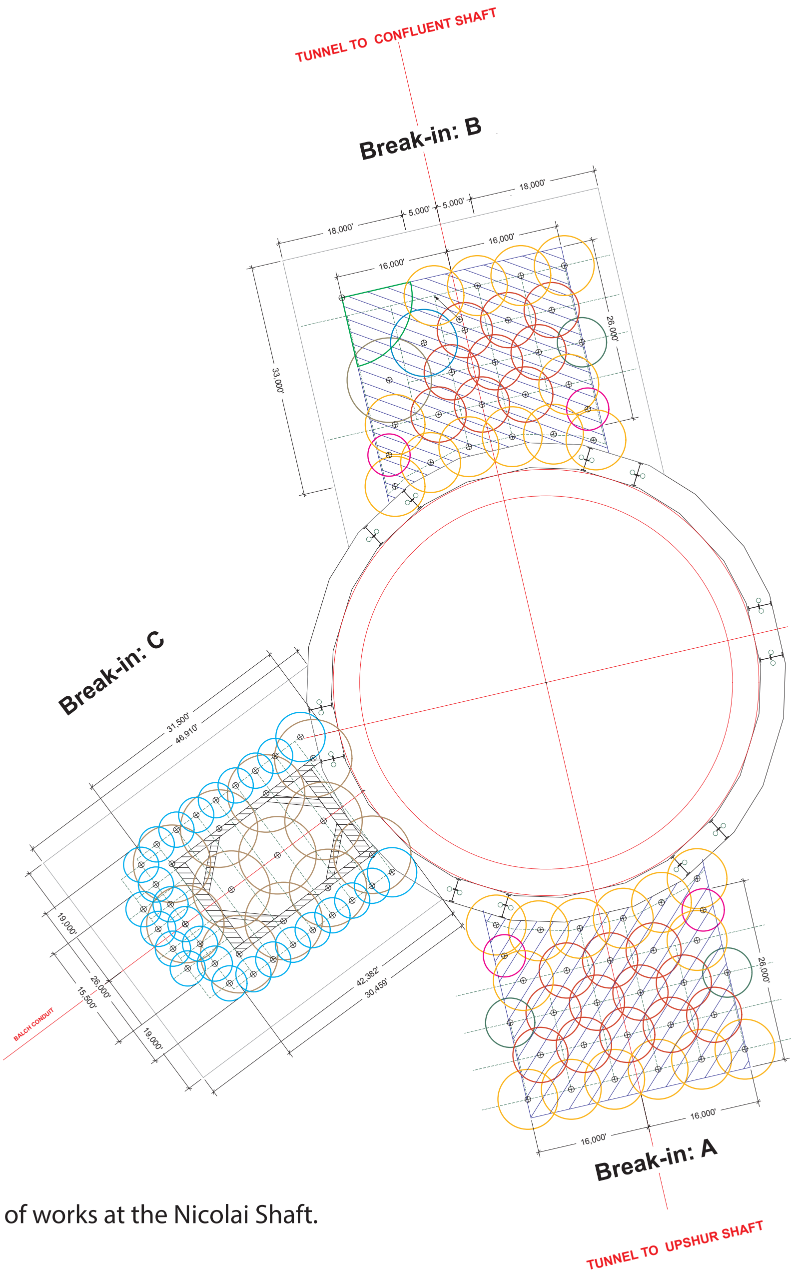

Fig. 4. Diagram of works at the Nicolai Shaft.

Toward Balch Conduit

For communication with the Balch Conduit a roadbed base was built at a depth of 12 m with a thickness of 2.7 m, consisting of 12 columns; on this structure 27 columns were headed, with a height of 18 m to form the waterproof wall.

Verso Balch Conduit

For communication with the Balch Conduit a roadbed base was built at a depth of 12 m with a thickness of 2.7 m, consisting of 12 columns; on this structure 27 columns were headed, with a height of 18 m to form the waterproof wall.

Confluent Shaft (Fig. 5).

Two break-ins were built.

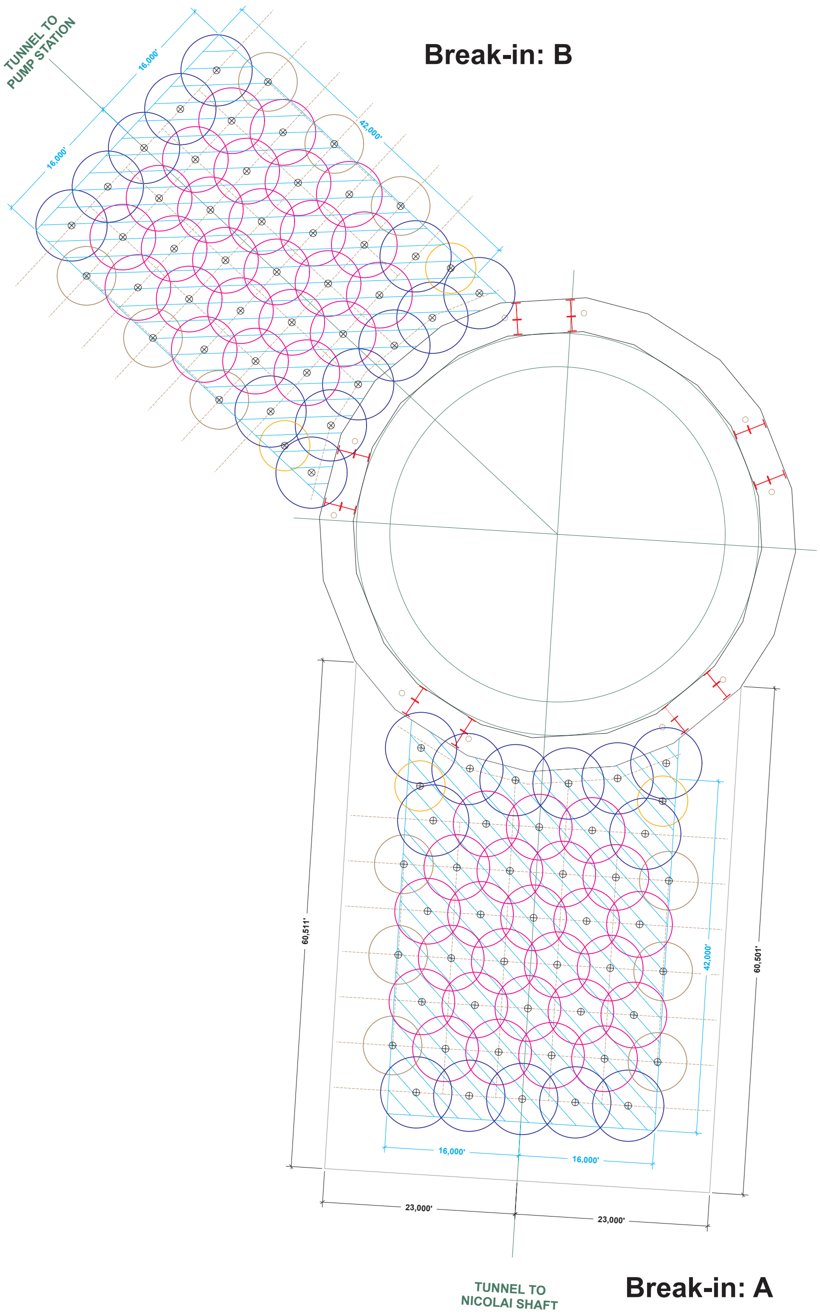

Fig. 5. Drawing of works at the Confluent Shaft..

Toward Nicolai Shaft

A parallelepiped with a base measuring 9.7 x 12.8 m was installed at a depth of 30 m, having a thickness of 9.7 m and consisting of 46 columns.

Toward Swan Island

A parallelepiped measuring 9.7 x 12.8 m was installed at a depth of 30 m, having a thickness of 9.7 m and consisting of 48 columns.

Consolidation and stabilization

Construction and treatment with largely linear arrangement for the purpose of improving the soil characteristics and/or bordering the soil around the foundations of the pile/ends of bridges that, at the time of passage of the TBM in the vicinity, would risk collapsing.

Steel Bridge (Fig. 6).

The tunnel route at Steel Bridge is in the vicinity of the pillars supporting the viaduct. It was therefore necessary to stabilize and consolidate the soil at the base to prevent movement or variations in the forces acting on the foundation soil. Four types of action were implemented:

Four are the interventions executed:

- Area A: 46 columns at a depth of 23 m, with a height of 8 m
- Area B: 28 columns at a depth of 25 m with a height of 9 m
- Area C: 17 columns at a depth of 25 m with a height of 9 m
- Area D: 16 columns at a depth of 25 m, with a height of 9 m

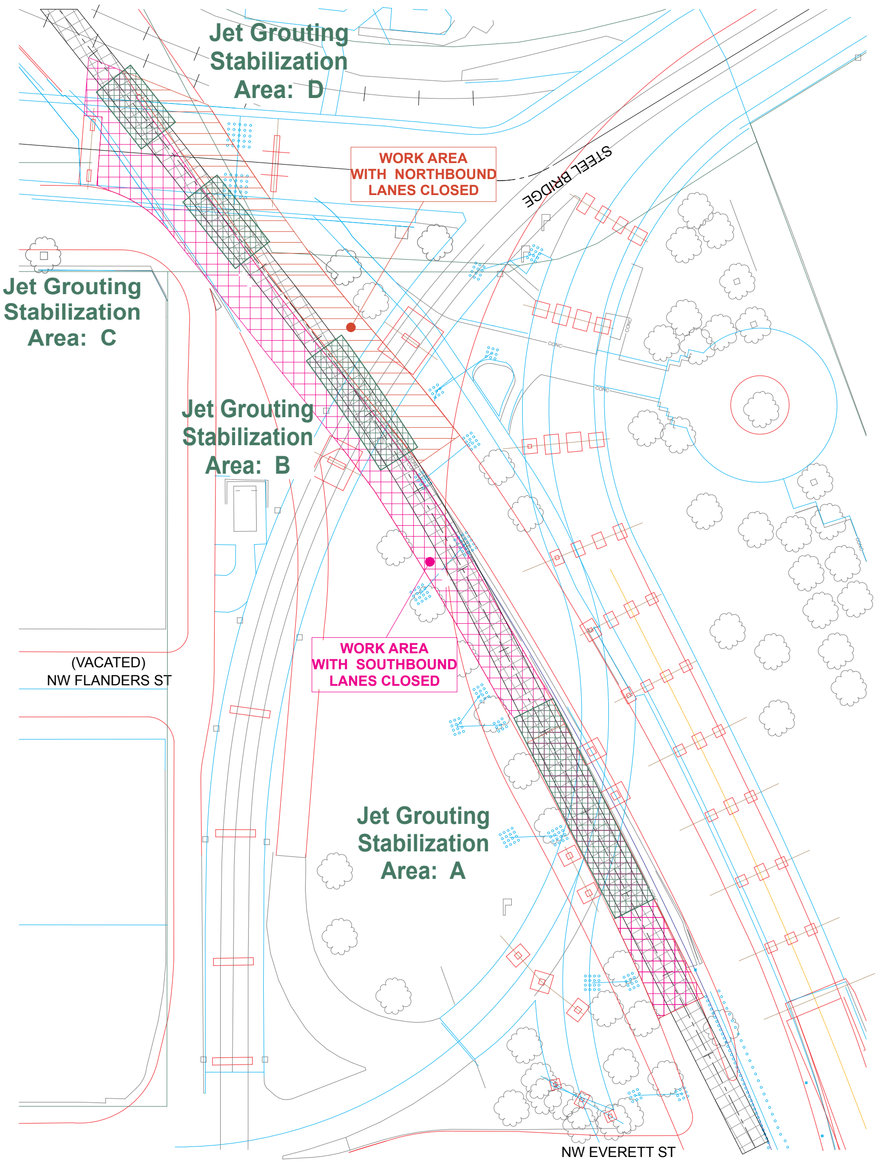

Fig. 6. Topography of works at Steel Bridge.

Burnside Bridge (Fig. 7).

At Burnside Bridge the tunnel passes near the foundation pillars of the viaduct. This made it necessary to stabilize the foundation soil to eliminate the risk of damage to the bridge during excavation of the tunnel. A structure with a thickness of 2.5 m was erected, consisting of 104 columns, to create an insulating layer between the soil involved in the tunnel excavation and the soil on which the bridge is based.

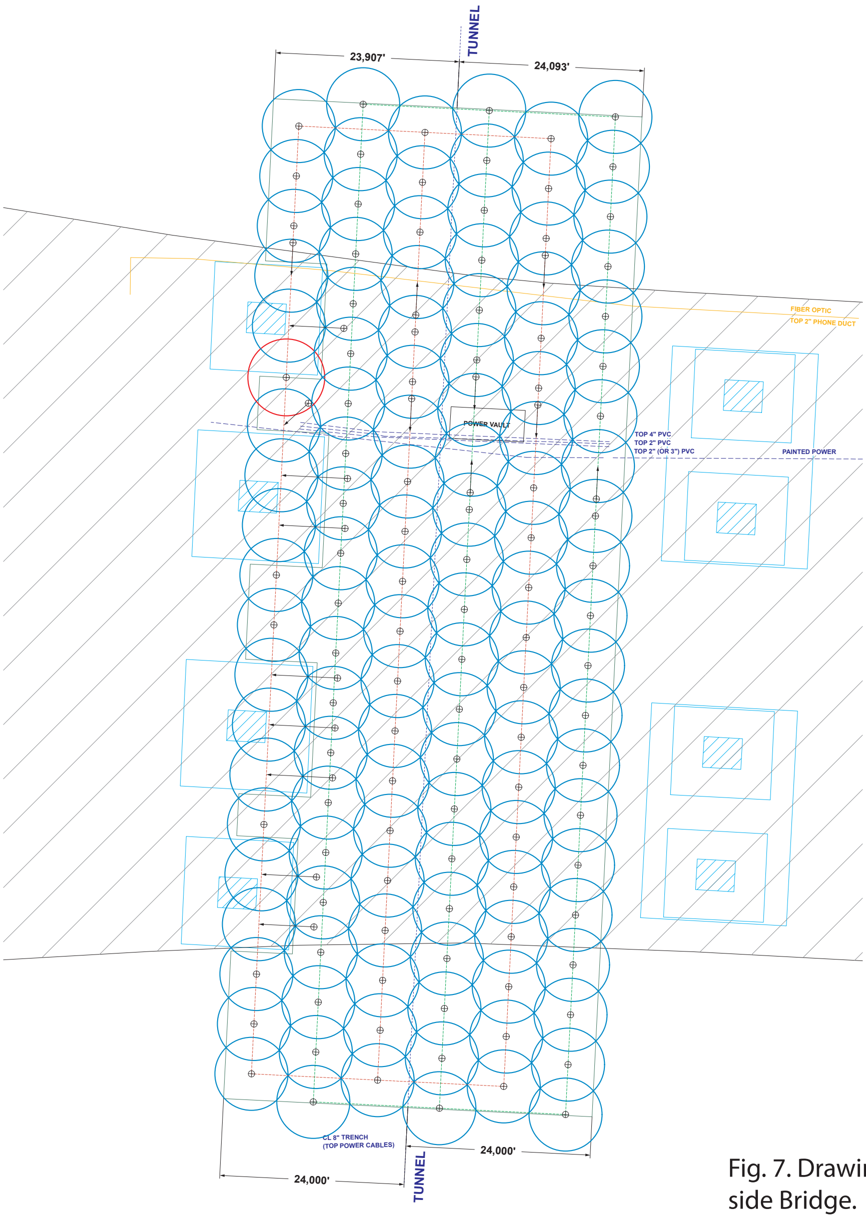

Fig. 7. Drawing of works at Burnside Bridge.

Broadway Bridge (Fig. 8).

In this zone the tunnel route passes in the vicinity of one of the foundation pillars of the viaduct. To prevent damage to its stability during tunnel excavation, a linear consolidation was performed, consisting to all effects of a reinforcing wall. The wall is composed of 28 columns 21.6 m high and placed at a depth between about -32 and –10 m.

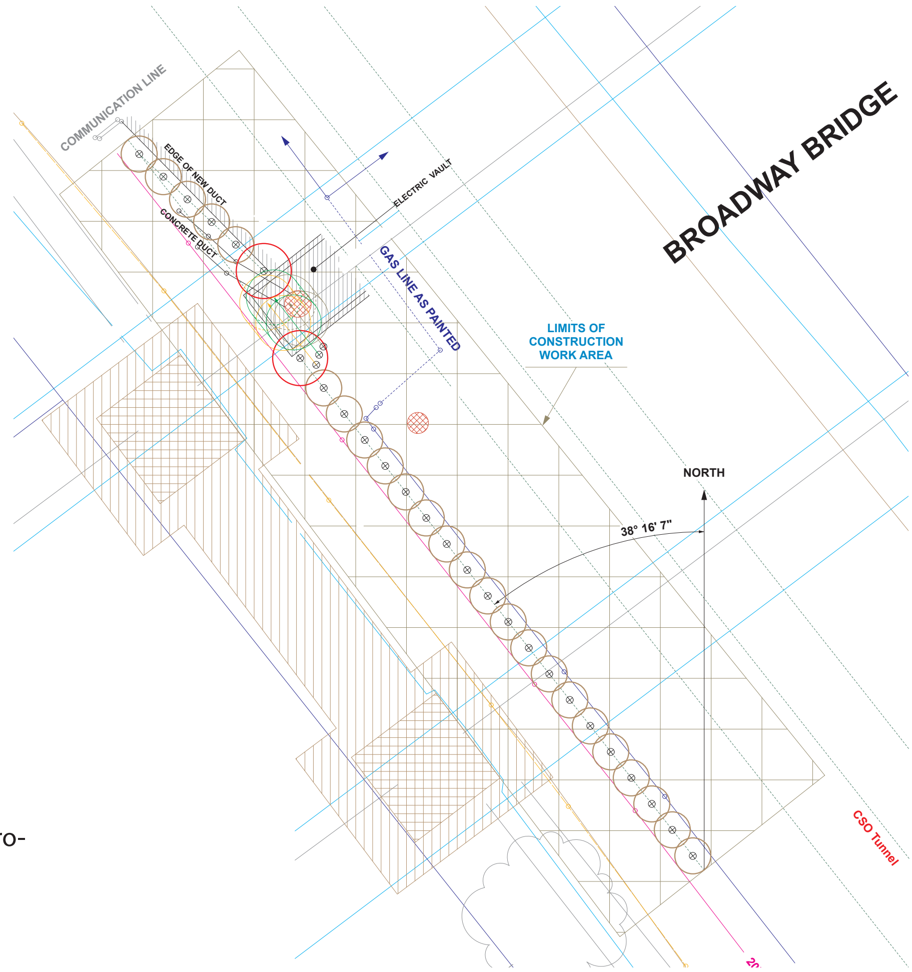

Fig. 8. Drawing of works at Broadway Bridge.

Diaphragm

Construction of a waterproof circular diaphragm below the bulkhead in reinforced concrete consisting of the Pump Station shaft, in view of the topology of the soil and because of the great depth of the rock bank on which it had to stand.

Fig. 9. View of circular excavation of the Pump Station shaft..

Pump Station su Swan Island (Fig. 10).

3 installations were made: two break-ins and a waterproof diaphragm. The first break-in (parallelepiped at the depth of 33 m) is 9.7 m high with a base of 9.7 x 12.8 m and consists of 46 columns. The second break-in, toward Portsmouth, is 7.6 m high with a base of about 8.5 x 2.5 m, and consists of four columns. The waterproof diaphragm (fig. 10÷11) was installed below the bulkheads in reinforced concrete used for the upper part of the shaft; it consists of 168 columns in a single circular row, passing with the perforation battery through pipes previously laid in the bulkhead panels; it is about 40 m high for a depth of –125 m to –50 m;

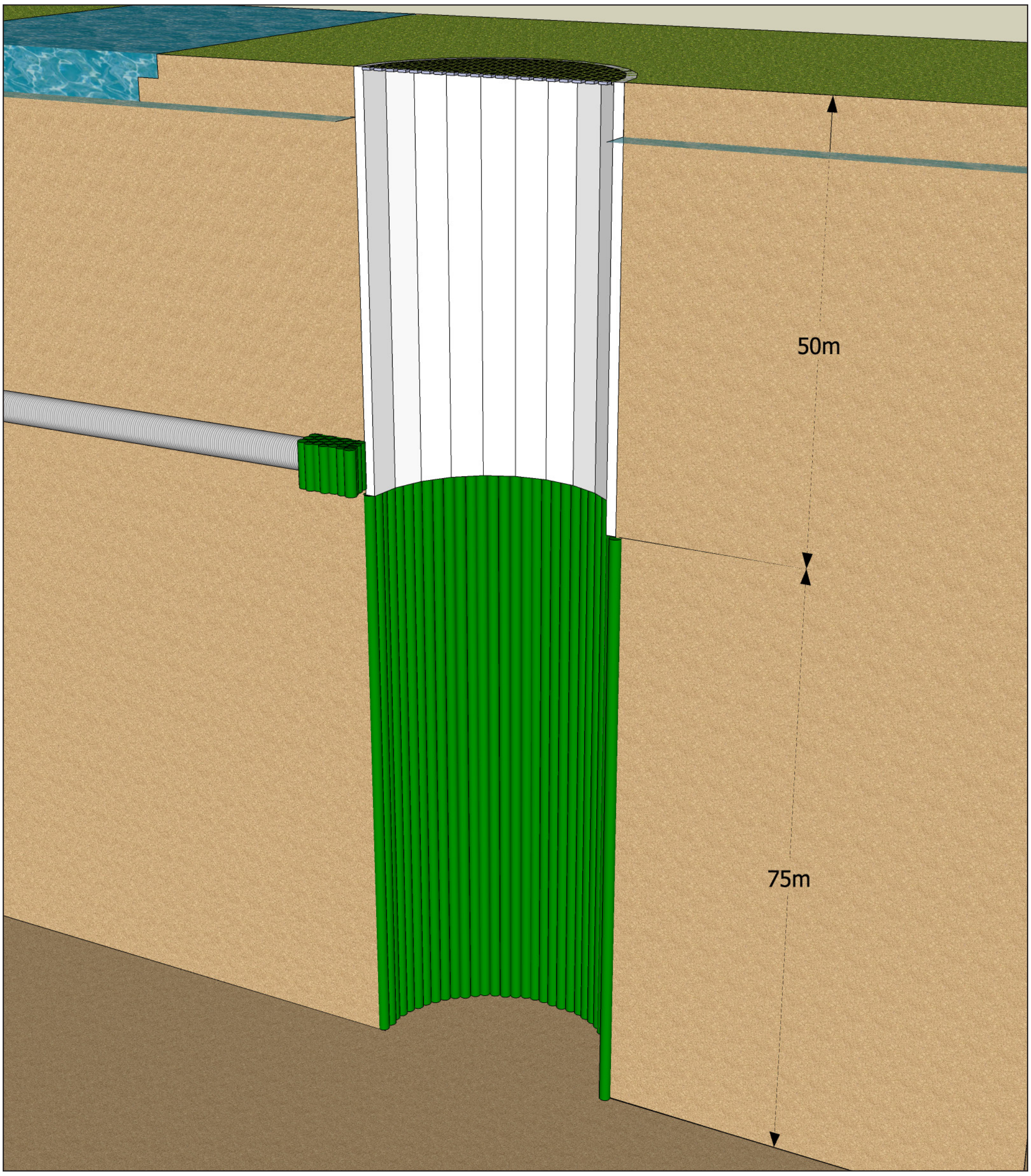

Fig. 10. Drawing of the Pump Station shaft.

Characteristics

Preliminary testing was done during production, and samples were drawn with video control of the inside of the core samples, to verify on the spot the quality and uniformity of the treatments. The main difficulties encountered were:

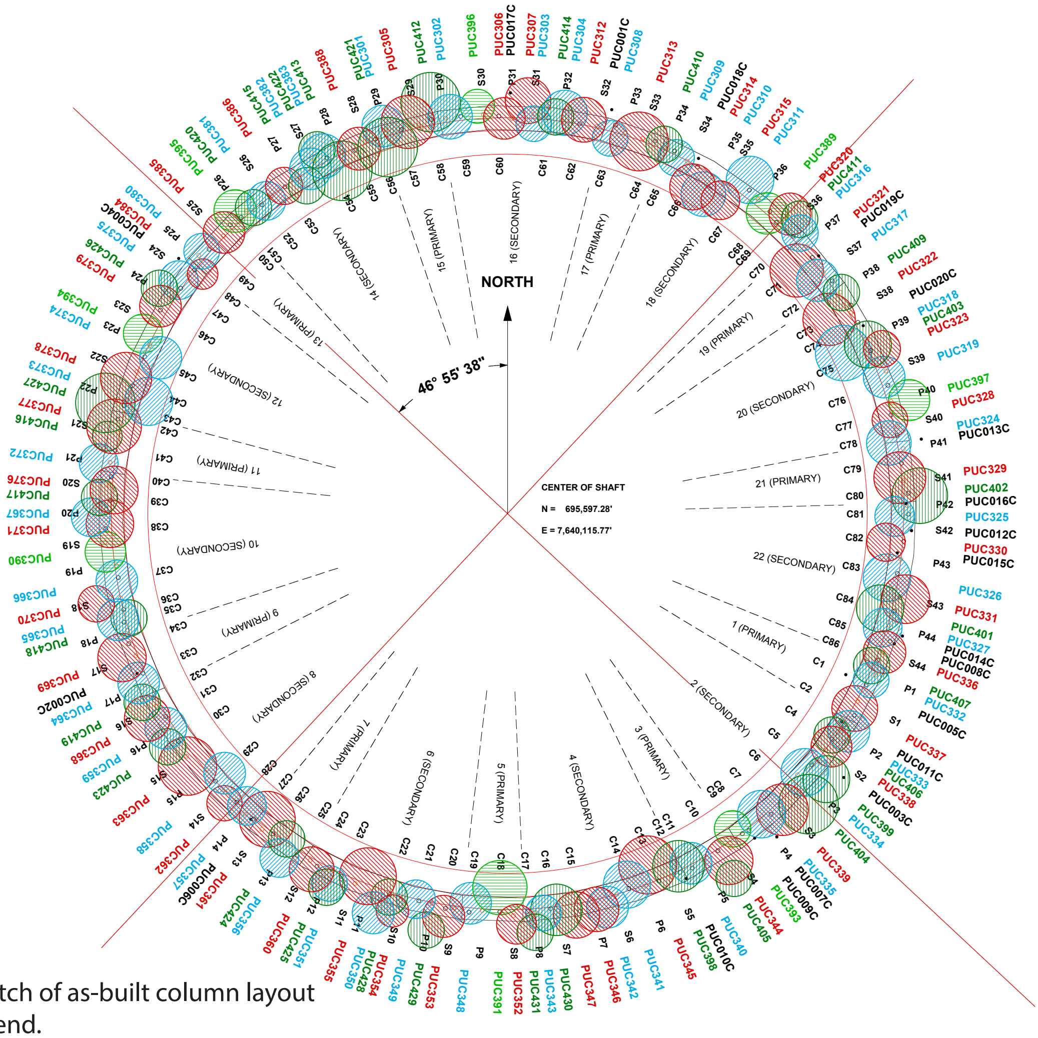

Fig. 11. Sketch of as-built column layout at bottom end.

- type of soil encountered, often densely packed and frequently containing rocks and blocks,

- great depth of the works, with the danger of significant risks of deviation and risk of blockage of the perforation and injection batteries.

Systematic use was made of a special measuring device to monitor the deviation of the perforation, prior to starting the injection stage, to ensure automatic adjustment of the working parameters and adaptation of the diameters to the Jet Grouting treatment in order to compensate the deviations measured. Graphic registrations were made and reported (using the PACCHIOSI PRS3 system) to keep track of the working parameters during both the perforation and injection stages. The triple-fluid PACCHIOSI PS3 technology was used. The resistance to compression (after 28 days) obtained for the Jet Grouting treatment samples drawn by core sampling was tested between 1.5 and 3.5 Mpa; the value of coefficient K of permeability for the treated soil was 1x10-6 cm/sec. The diameter of the columns varied from 2 to 4m, at depths of over 120 m.

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