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ACQUE SPA LAID 240 METERS OF DUCTILE IRON SEWAGE PIPES DN900 BY USING "HORIZONTAL DIRECTIONAL DRILLING"

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OVERVIEW

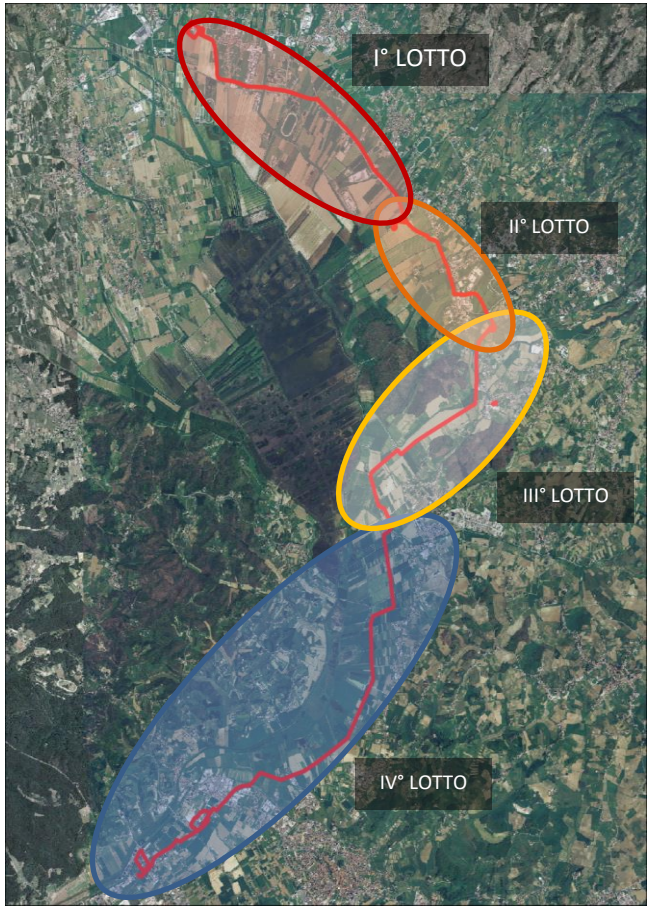
As part of Acque's work on the so-called “Tubone” (The Big Pipe) (the sewage collector that will convey waste water from the entire Valdinievole, Cerreto Guidi, and part of Fucecchio to the wastewater treatment plant of Santa Croce sull'Arno), an unprecedented operation took place in the history of water service in Italy.

This involved the “Horizontal Directional Drilling” laying of a section of pipeline. The special feature of the work is precisely that it is possible to use ductile iron systems for pressure sewers by means of trenchless techniques even for large piping.

On the border between the municipalities of Larciano and Cerreto Guidi, a 900 millimetre diameter section of the pipeline was in fact laid, for a length of approximately 240 metres and a total weight of around 50 tonnes, at a depth of about 8 metres below the road level.

FRAMEWORK OF THE ENTIRE INFRASTRUCTURE

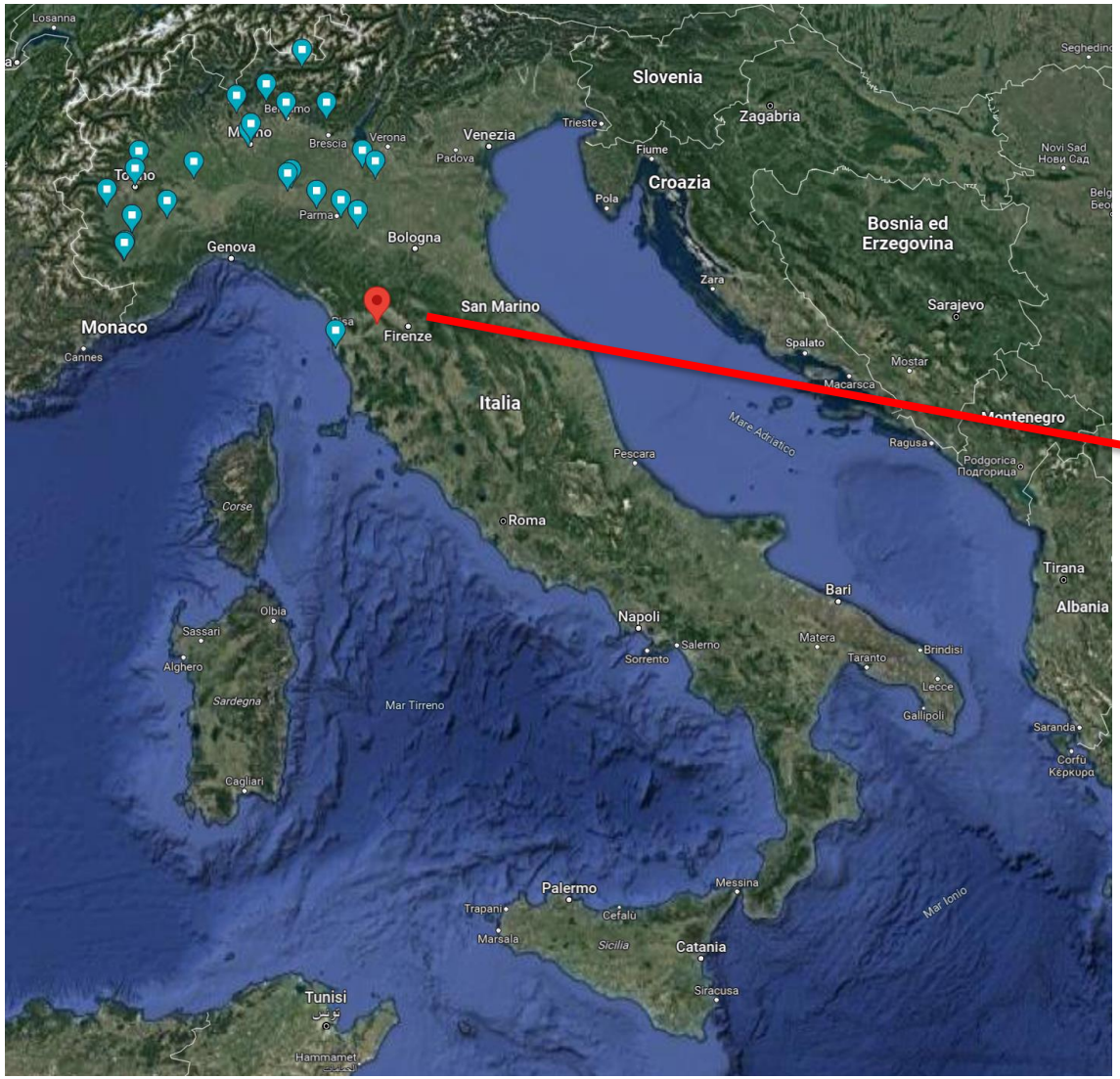
Based on the hydraulic scheme of the overall work, a main pumping station at the Pieve a Nievole purification plant will push the wastewater directly towards the final collection in Santa Croce. Along the way, three purification plants will be converted into pumping stations connected directly to the "Tubone". The peculiarity of the route is that it runs alongside the largest inland wetland in Europe, the Padule di Fucecchio, which is subject to environmental protection measures, therefore the design phase took into account the possible impacts on this sensitive area, both in the implementation and commissioning phase.



Main design features

ND900 ductile iron sewer
total length approx. 24 kilometers
maximum flow rate: 2,270 m3/h
expected maximum capacity: 120,000.00 p.e.

LOCATION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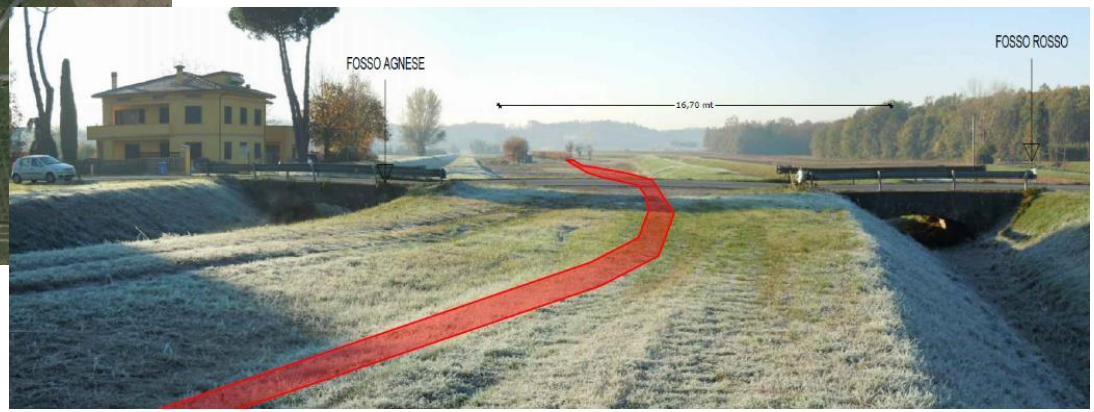
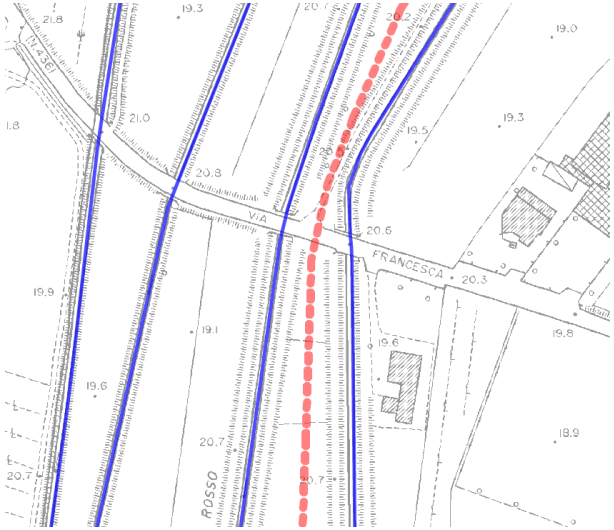
LOCATION

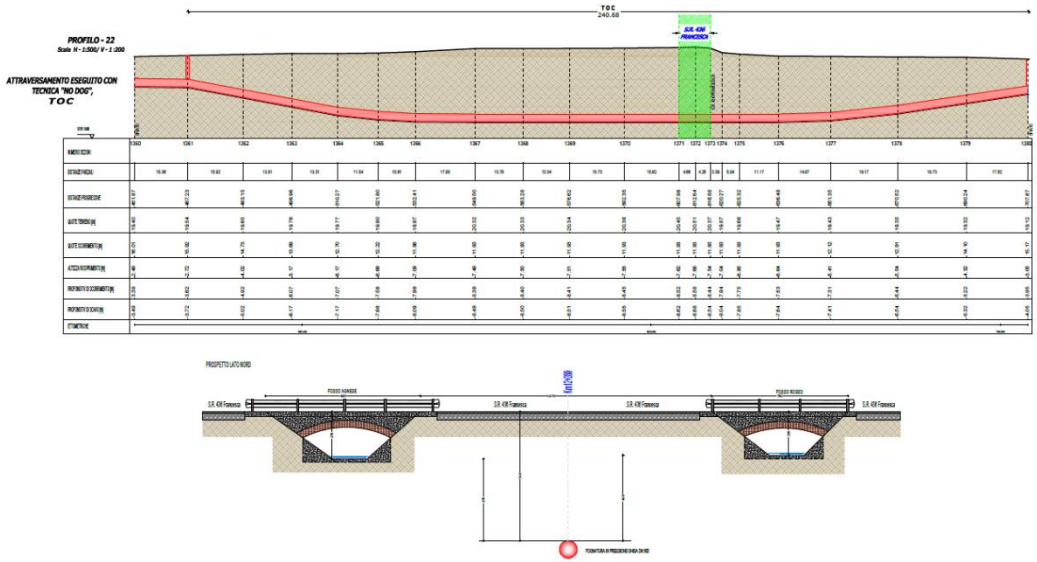
The ambitious project was necessary in light of the particular context in which the company commissioned by Acque SpA for the work on Lot 2 of the “Tubone” was called upon to intervene, given the simultaneous presence of the “Francesca Nord” regional road, the two ditches perpendicular to it, and their embankments. This is where it became indispensable to apply horizontal directional drilling, instead of the more traditional “thrust boring” technology. Unlike the latter, the “HDD” technology involves drilling into the ground with the use of rods, guided by a “milling head” that prepares the path for the pipeline.



Layout of the pipeline with watercourses and the interfering provincial road highlighted

The HDD made it possible to avoid deep excavations for any thrust pits necessary for other “NO DIG” “thrust boring” technologies and to keep due distances from interfering watercourses.

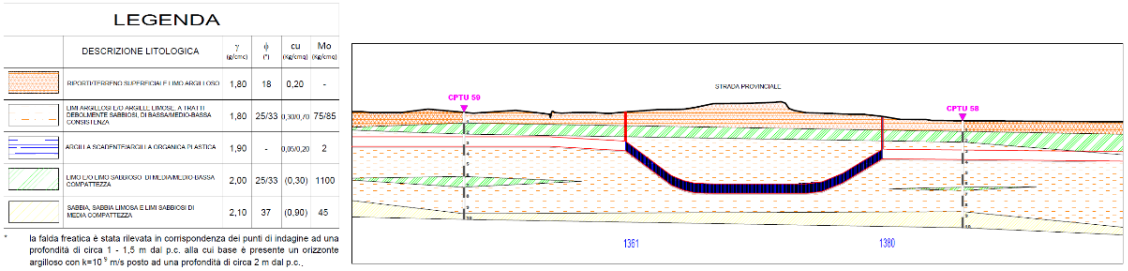




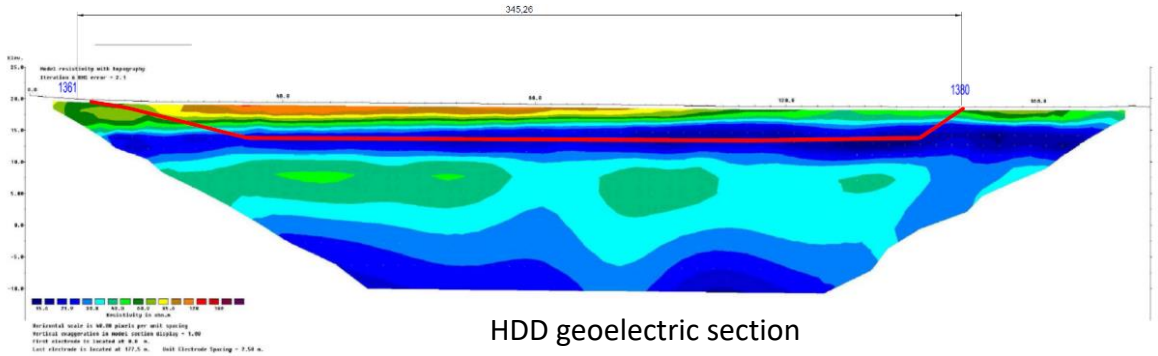
PRELIMINARY INVESTIGATIONS

The subsoil in the involved area is made of by clayey-loamy material. The preliminary analyses carried out during the design phase were:

- static electrical penetrometric tests upstream and downstream of the HDD
- geoelectric investigation along the axis of the tunnel.



Geological Section - HDD Technique



HDD geoelectric section

DESIGN LAYOUT

The design layout of the drilling includes a curved layout in addition to the usual height contour map. Taking into account the characteristics of the pipeline, in particular the allowed angular deviation of the restrained joints, the drilling profile was designed ensuring sufficient safety margins in the height and curved layout bending radii, assumed to be 650 m and 800 m respectively.

Characteristics of the equipment used:

- ✓ Drilling rig Vermeer D 220×500 S3:
  - Pulling force: 1,070 kN
  - Rotary maximum torque: 73,200 Nm
  - Power: 310 kW
  - Mud pump: 1,323 l/min at 83 bar
- ✓ desanding plant with hydrocyclones;
- ✓ centrifugal decanter;
- ✓ generator set;
- ✓ available excavator.

Regarding the definition of the maximum pull applied by the drilling rig when launching the pipeline, many factors are involved. The formula adopted is based on empirical data

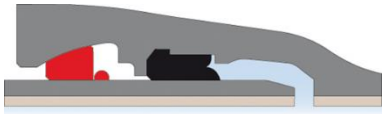
$$F[kN] = L \cdot D \cdot f \cdot \pi$$

In the present case, f=0.5 was assumed due to the type of material. Using table data from the Drilling Contractors Association's publication “Information and Recommendations for the Planning, Construction and Documentation of HDD projects” we obtain the value of F equal to

$$F = 241{,}5 \cdot 0{,}95 \cdot 0{,}5 \cdot \pi = 360{,}2\ kN$$

DESCRIPTION OF THE DUCTILE IRON PIPES USED

The Saint-Gobain PAM ductile iron pipes used, which are specifically for installation by HDD, are of the TT PUX type, namely with an external coating made of an adherent layer of reinforced polyurethane applied by projection on the surface of the pipe in accordance with standards EN 598 and EN 15189. The jointing system is of the UNIVERSAL STANDARD VE automatic elastic restrained type with pipe angular deflections and longitudinal shifts while the hydraulic seal is kept uninvolved. It is equipped with a double chamber socket made from a single casting: the inner chamber houses the gasket with dovetail profile according to UNI 9163 in NBR, in compliance with standard EN 681-1, which ensures the hydraulic seal, while the outer chamber houses the ring which ensures resistance against slipping thanks to the weld seam on the smooth end of the pipe.



DESCRIPTION OF THE DUCTILE IRON PIPES USED

The elastic joint, which it is known to allow cast iron being laid in soils characterised by differential settlements with no modification to the pipe tensional state (such settlement events are absorbed by the angular deflection allowed by the joint), in the case of laying by HDD allows for the considerable bend radius values shown in figure below.

The joint has been designed to withstand the high maximum allowed tensile stresses that characterise HDD laying. The figure below shows the maximum allowed pulling forces defined based on the maximum acceptable pressures of Saint-Gobain PAM's UNIVERSAL STANDARD Ve® restrained joints. The system also makes it possible to pre-test the pipe before it is pulled into the hole.

Angular deflection and curve radius

DN	Joint	Angular deflection	PFA (bar)	Allowable curve radius (m)
100	Uni Ve	3°	64	115
150	Uni Ve	3°	55	115
200	Uni Ve	3°	50	115
250	Uni Ve	3°	45	115
300	Uni Ve	3°	40	115
350	Uni Ve	3°	38	115
400	Uni Ve	3°	35	115
450	Uni Ve	3°	32	115
500	Uni Ve	3°	30	115
600	Uni Ve	2°	27	172
700	Uni Ve	2°	25	172
800	Uni Ve	2°	25	364
900	Uni Ve	1.5°	25	445
1000	Uni Ve	1.2°	25	572

Allowable pulling forces (kN)

	Pulling lengths (km)					
DN	0 to 0,4	0.5	0.7	0.9	1	1.2
100	87	84	77	70	66	59
125	114	109	100	91	87	78
150	136	131	120	109	104	93
200	201	193	177	161	153	137
250	271	260	239	217	206	184
300	342	329	301	274	260	233
350	426	409	375	341	324	290
400	506	486	445	405	384	344
450	579	556	510	463	440	394
500	667	640	587	533	507	453
600	855	821	752	684	650	581
700	1000	961	881	801	761	681
800*	1225	1177	1078	981	932	834
900*	1473	1415	1297	1179	1120	1002
1000*	1725	1657	1519	1381	1312	1174

PRELIMINARY STEPS

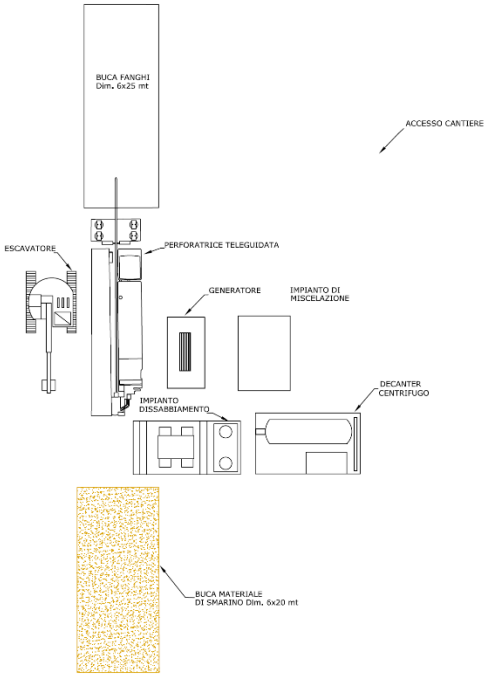
Drilling and pipeline launching procedures were developed as follows:

1. Pilot drilling with 5" oil-type drill rods being 9.75 m long driven with Digitrak Falcon F5 type radio instrumentation and high-power probe.
2. Subsequent hole enlargement steps with the following diameters:
   a) 32” DN800
   b) 40” DN1000
   c) 48” DN1200
   d) 54” DN1350
   e) No. 3 bore cleaning operations with “barrel” type boring equipment DN1200
3. Preliminary assembly and testing of the pipeline before pulling and positioning it inside a flotation trench which was flooded to allow the pipeline to float during the pulling phase.
4. Once the bore was ascertained to be clean, the pipe was hooked up using the pull head, which was specially made for this work, and the pipe was launched.

After the initial pulling effort of around 50 tons, no particular problems were encountered and the applied effort was constant from 15 to 20 tons and addition of around 500 l/min of bentonite. In about three hours, the launch was successfully completed.

AERIAL VIEW OF THE PIPE TRAIN BEING LAUNCHED WITH FLOODED TRENCH

VIEW OF THE SITE FROM THE SIDE WHERE THE DRILLING MACHINE WAS POSITIONED



CONCLUSIONS

This work of laying of DN900 ductile iron pipeline using the Horizontal Directional Drilling (HDD) technique, which set a record for the largest DN ever laid with this technique and this material, represents a worldwide case history made possible by the combination of far-sighted and courageous design by the Network Owner, professionalism in laying by the assigned company, and the quality of the pipes used. All this has resulted in a truly eco-sustainable project, both because of the trenchless non-invasive laying technique and the use of a material - the ductile iron of the chosen pipes - which, according to countless empirical references, ensures an expected service life of more than 100 years. Therefore, this can be defined a low environmental impacting work, to be benefited by several future generations.