

EXPLORATORY ADIT AND RELATED INVESTIGATION ACTIVITIES IN THE EXCAVATED SECTION OF THE JAROV TUNNEL OF THE PRAGUE CITY RING ROAD

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ABSTRACT: The Jarov Tunnel is part of the planned Prague City Ring Road construction project No. 0094 in the Balabenka–Rybníčky section. As part of the design preparation of this major transport structure, a detailed geotechnical investigation is being carried out, including the design of an exploratory adit.

The exploratory adit has a total length of 790 m and is located in the top heading of the future road tunnel on alignment MO-A. It passes beneath several important urban structures in the Jarov area, particularly under the campus of the Metropolitan University Prague, the Zelené Město residential development, and the Třešňovka hill.

Construction of the exploratory adit will allow refinement of the geological and geotechnical model along the alignment of the future tunnel, verification of excavation technologies, and acquisition of essential data for the optimisation of the tunnel design and reduction of geotechnical risks during construction.

1. INTRODUCTION

The Jarov Tunnel exploratory adit is part of the detailed geotechnical investigation ensured within the documentation for zoning proceedings (DÚR) for the Prague City Ring Road project No. 0094 in the Balabenka–Rybníčky section. The entire adit lies within Prague 9. The site facilities and the excavated portal are located in the Hrdlořezy cadastral area north of Českobrodská Street on undeveloped land between SOŠ Jarov and Horní Hrdlořežská Street, i.e. in the location of the future Českobrodská grade-separated interchange. The exploratory adit is positioned within the profile of the future excavated Jarov Tunnel on alignment MO-A. It passes below the Metropolitan University Prague, residential areas of Zelené Město, and the Třešňovka hill. The adit terminates at the location of the future northern portal of the Jarov Tunnel, situated southwest of the Spojovací–Pod Šancemi intersection, without daylighting at the surface.



Figure1: Exploratory adit – wider context

The detailed geotechnical investigation includes, in addition to the design of the exploratory adit, extensive geotechnical monitoring, surface and underground exploratory works, and long-term monitoring of groundwater levels and chemistry in the area of project No. 0094. This paper presents the basic technical parameters of the access excavation, portal, and adit, the site facilities, the jet-grouting trial field, geotechnical monitoring, and related exploratory works.

1.1 INDICATIVE CONSTRUCTION SCHEDULE

Construction of site facilities including preparatory works:	2 months
Construction of access ramp (construction pit):	7–8 months
Excavation of the exploratory adit:	1.5–2.0 years
Reduction of site facilities after completion:	1 month
Removal of the adit and construction pit and reinstatement:	16 months

2. EXPECTED ENGINEERING–GEOLOGICAL CONDITIONS

2.1 GEOLOGICAL CONDITIONS

According to the regional geological classification of the Bohemian Massif, the area of interest for the exploratory adit of the Jarov Tunnel belongs to the Barrandian Paleozoic unit and, within it, to the regional geological subunit of the Barrandian Ordovician. The bedrock along the entire alignment is formed almost entirely by Ordovician sedimentary rocks. In the narrower area of interest, from Třešňovka towards Štěrboholy, Ordovician formations appear progressively in the subsurface, starting with the oldest units represented by the Šárka Formation, followed by the Dobrotiv, Libeň, Letná, Vinice, Zahořany, and finally the Bohdalec formations. On the northern slope of Třešňovka, the line of the Prague Fault causes repetition of the stratigraphic sequence.

The Quaternary cover is composed of colluvial, eolic-colluvial, fluvial, and colluvial-fluvial sediments. The uppermost layer of the cover is often formed by anthropogenic deposits—fill material.

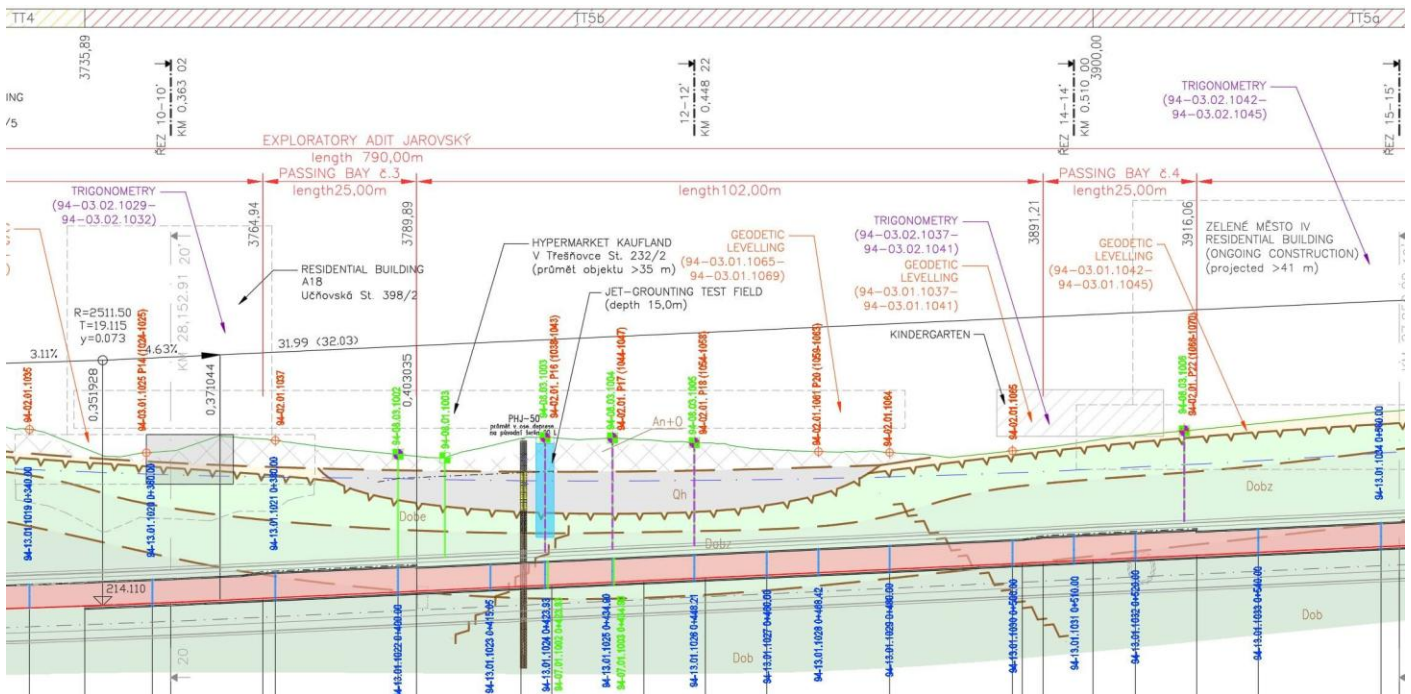


Figure 2: Longitudinal profile of the exploratory adit in the area of the Hrdlořezy Creek valley depression, including survey points and geotechnical monitoring sections

2.2 HYDROGEOLOGICAL CONDITIONS

The adit alignment crosses several valley and washout depressions through which permanent or intermittent streams used to flow in the past. Today, these streams are either piped (the Vackov Creek along Českobrodská Street; and probably also the Hrdlořezy Creek in the Zelené Město area in Jarov) or

drained by the sewer system. The main aquifer environment along the alignment consists of fissured, permeable rocks of the pre-Quaternary basement. Groundwater circulation is bound to the near-surface weathered zone, which usually extends to depths of 30–50 m. Additional groundwater is expected in washout or valley depressions. Here, the aquifer is of a pore-water type, which may be hydraulically connected to the aquifer bound to the upper weathered zone of the pre-Quaternary basement. The aquifer associated with washout depressions is characterised by significant fluctuations of the groundwater level over time and a strong dependence on current rainfall totals. In the chainage section km 4.2–3.4 of project MO No. 0094, excavation inflows of up to 0.1 l/s/100 m are generally expected based on individual quasi-homogeneous units. Only in km 3.9–3.7 (the Zelené Město residential area) is an increased inflow of up to 6.1 l/s/100 m expected due to more significant fissured aquifers associated with weathered and tectonically disturbed rocks of the Dobrotiv Formation within the axis of the valley depression.

2.3 GEOTECHNICAL CONDITIONS

In the alignment of the exploratory adit, complex engineering-geological conditions and geotechnical excavation constraints are expected. The portal and the first approximately 190 metres of the adit lie within weathered to sound Libeň shales. This is followed by excavation through a section of Řevnice quartzite. In this area, difficult breakability of high-strength quartzites must be anticipated, along with increased groundwater inflows into the excavation and reduced stability of the rock mass at the face. Additionally, buildings of the SOŠ campus and the Metropolitan University Prague at Jarov are located in the overburden.

In the section km 3.74–3.9, where the alignment passes beneath the erosional depression of the former Hrdlořezy Creek, significantly tectonically disturbed and deeply weathered Dobrotiv shales occur. Near the surface, these rocks are substantially decomposed into clayey material. Here, the weathered shales extend almost down to the tunnel invert. The base of the depression also contains a substantial fill of Quaternary washout and alluvial sediments, causing the rock cover above the tunnel crown to decrease to as little as 1 m. The passage beneath the former Hrdlořezy Creek depression therefore represents one of the critical points of the project, requiring great attention in further investigation phases and in the design of pre-excavation measures to ensure excavation stability and to minimise the effects of tunnelling on existing structures.

From km 3.9 to 4.0, the tunnel alignment enters Dobrotiv shales, which in their sound state generally provide very favourable conditions for excavation. This is followed by a zone of Skale quartzites forming much of the Třešňovka hill, and subsequently by Šárka shales. The Prague Fault and nearby cross-faulting along Spojovací Street result in a relatively high degree of tectonic disturbance of the rock mass, as documented in several preliminary investigation boreholes and expected to be encountered to an even greater extent. North of the Prague Fault, Šárka shales are separated from Bohdalec shales.

3. TECHNICAL DESIGN

Access to the construction site of the exploratory adit will be provided at the location of the existing entrance from Českobrodská Street. Access to the excavated portal of the exploratory adit will be ensured by a drive-in ramp with a longitudinal gradient of up to 12.5%. The excavation of the adit is designed in accordance with the principles of the NATM. A jet-grouting trial field is proposed as part of the investigation works to verify the performance of this technology under in-situ conditions.

3.1 CONSTRUCTION SITE FACILITIES

The future construction site facilities are located in Hrdlořezy, in an undeveloped area between the Secondary Police School of the Ministry of the Interior of the Czech Republic and SOŠ Jarov. The proposed site facilities include a welfare and administrative building, an emergency and safety storage facility, paved areas and internal roads, a water supply connection, a 22 kV high-voltage connection, a transformer station, low-voltage site distribution, and site lighting. For wastewater management, a pumping sump with a rising main, a settling and sedimentation tank, and a sewer connection are

proposed. No explosives storage is planned within the site facilities; explosives for daily use are expected to be delivered from a central depot.

3.2 ACCESS EXCAVATION AND EXCAVATED PORTAL OF THE ADIT

Due to the spatial constraints of the construction site, the inclined access ramp is designed with a longitudinal gradient of up to 12.5%. The roadway width along the entire length of the ramp is designed to be at least 6.0 m. In front of the portal, the roadway structure is widened by 3.0 m on the left side to allow for vehicle parking and placement of excavation equipment, including the ventilation unit.

The construction pit for the inclined ramp is a deep cut (up to 21.5 m at the portal), with its side walls supported using soil-nailed slopes covered with 150 mm thick shotcrete SB25, reinforced with two layers of 8×150×150 mm welded mesh. The slope face is graded at 5:1 with three berm levels, and the upper part of the slope is designed at a 1:1.5 gradient.

The portal face of the excavated adit is supported by a combination of a piled wall with a reinforced-concrete waling beam and two levels of micro-pile retaining walls. The portal is anchored using three-strand anchors through reinforced-concrete and steel walers across a total of eight anchor levels.

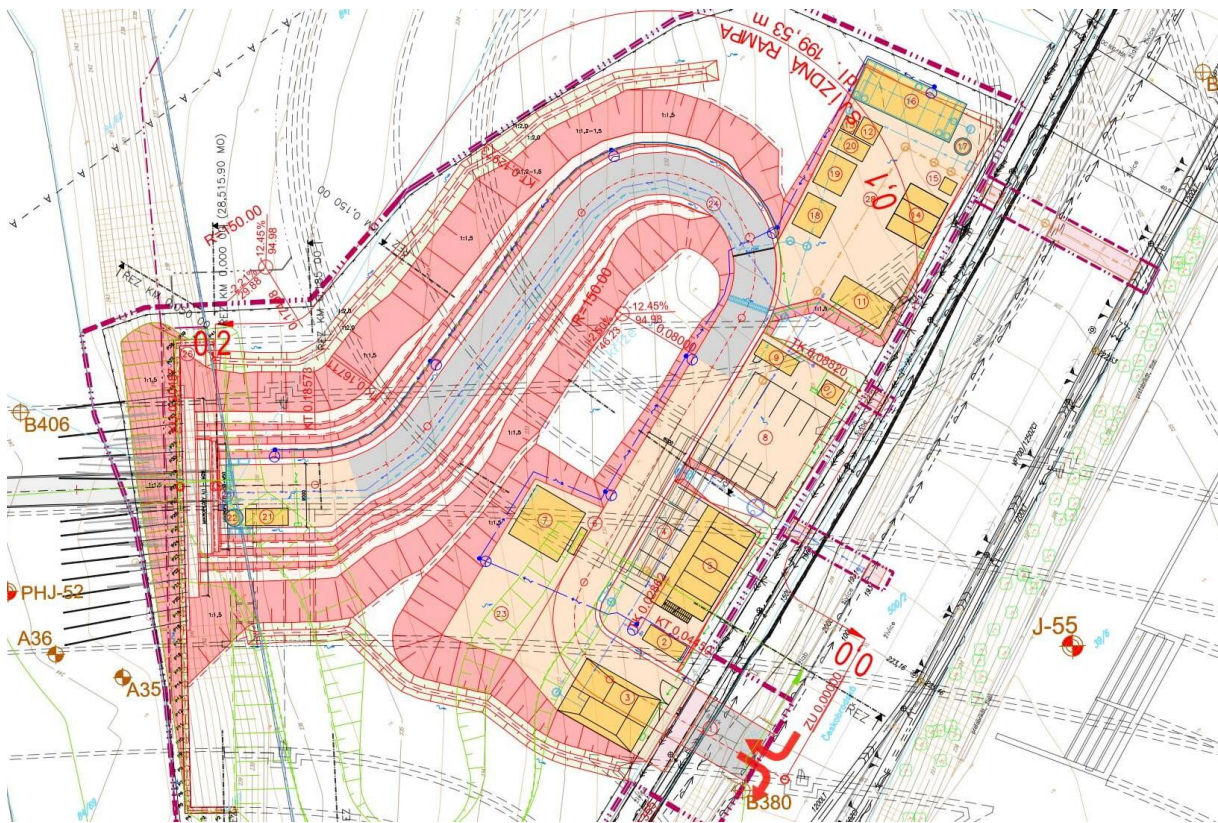


Figure 3: Layout of the access excavation with the excavated portal of the adit and the construction site facilities

3.3 EXPLORATORY ADIT

3.3.1 Basic Information

The exploratory adit is designed along alignment MO-A of project 0094, within the excavated section of the Jarov Tunnel. Horizontally, the adit axis is located in the tunnel crown, positioned on the left side, 6.1 m above the tunnel invert. Up to chainage 38.93 m, the alignment descends at a gradient of 2.3%. This section is followed by a vertical sag curve with a radius of 2,500 m, the centre of which lies at chainage 265.61 m. This point represents the lowest elevation of the adit. From there, the remaining section ascends continuously at gradients of up to +4.6%.

The trial field will verify the effectiveness of this technology and its applicability under local in-situ conditions. The jet-grouting field is designed to consist of 20 columns located in the valley depression of the Hrdlořezy Creek, where the most challenging geotechnical conditions are expected due to the shallow tunnel overburden and the nature of the encountered rock mass.

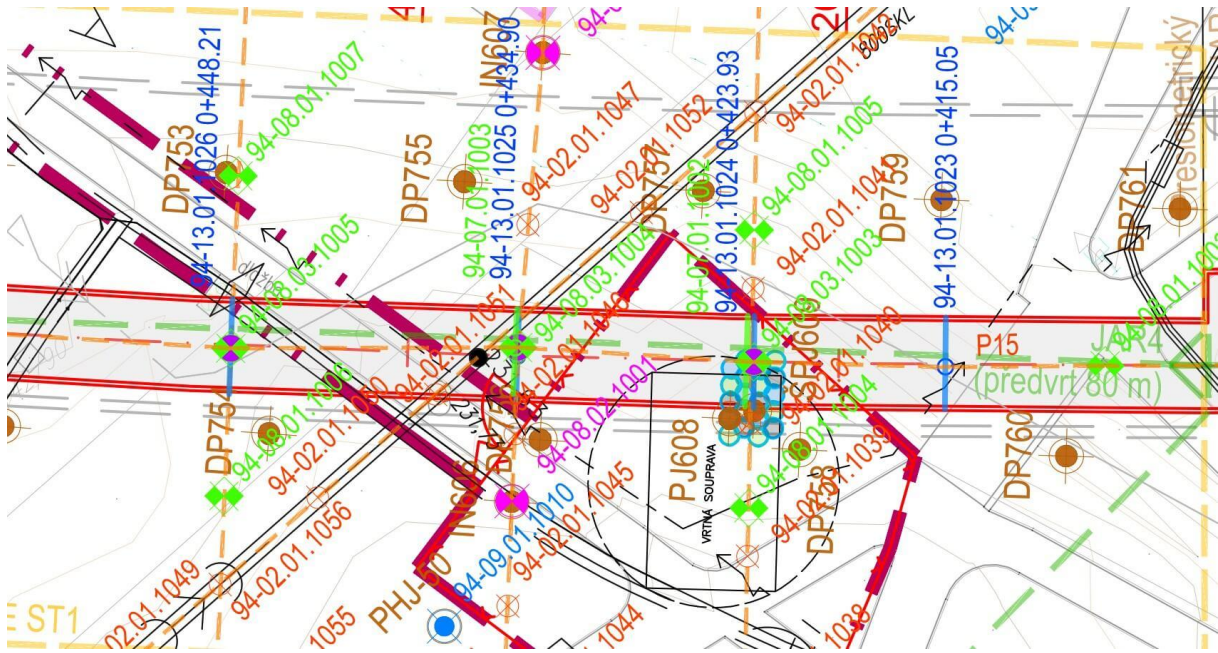


Figure 7: Jet-grouting trial field and related geotechnical monitoring measurements

4. GEOTECHNICAL MONITORING

The geotechnical monitoring of the Jarov Tunnel exploratory adit and the construction pit comprises an extensive set of measurements and observations. This chapter describes only some of them. Among the selected measurements related to the observational method of adit excavation using the NATM are the proposed convergence measurements of the excavation profile, surface deformation measurements by precise geodetic levelling, and trigonometrical surveys of points on the ground surface as well as on structures and utilities within the area influenced by the works. An integral part of the monitoring is the measurement of rock-mass deformation in boreholes using extensometers and inclinometers, supplemented by sliding deformaters.

Particular emphasis is placed on measuring the effects of excavation on the surroundings, especially residential buildings and utility networks. The geotechnical monitoring therefore includes initial condition surveys and re-surveys (pasportizace) of buildings and utilities, together with tracking and measurement of any defects that may occur. The impact of blasting-induced dynamic and acoustic effects on structures within the area of interest will also be monitored. The scope of monitoring is defined based on the blasting works design, which specifies the fundamental parameters and limiting conditions for the use of explosives. As part of the investigation, extensive hydrogeological monitoring is planned, with continuous observation of groundwater levels in hydrogeological boreholes and wells, complemented by relevant hydrological data needed to evaluate seasonal influences. The effects of the works on the water regime and water quality will be substantiated by continuous measurement of mine-water inflows into the excavation, inflows into construction pits, and by recording rainfall totals. Control laboratory analyses of the quality of drainage and wastewater will also be carried out.

Geotechnical and engineering-geological monitoring and excavation documentation, construction-pit passporting, and engineering-geological monitoring and documentation of boreholes and core pre-drilling are part of the related investigation works.

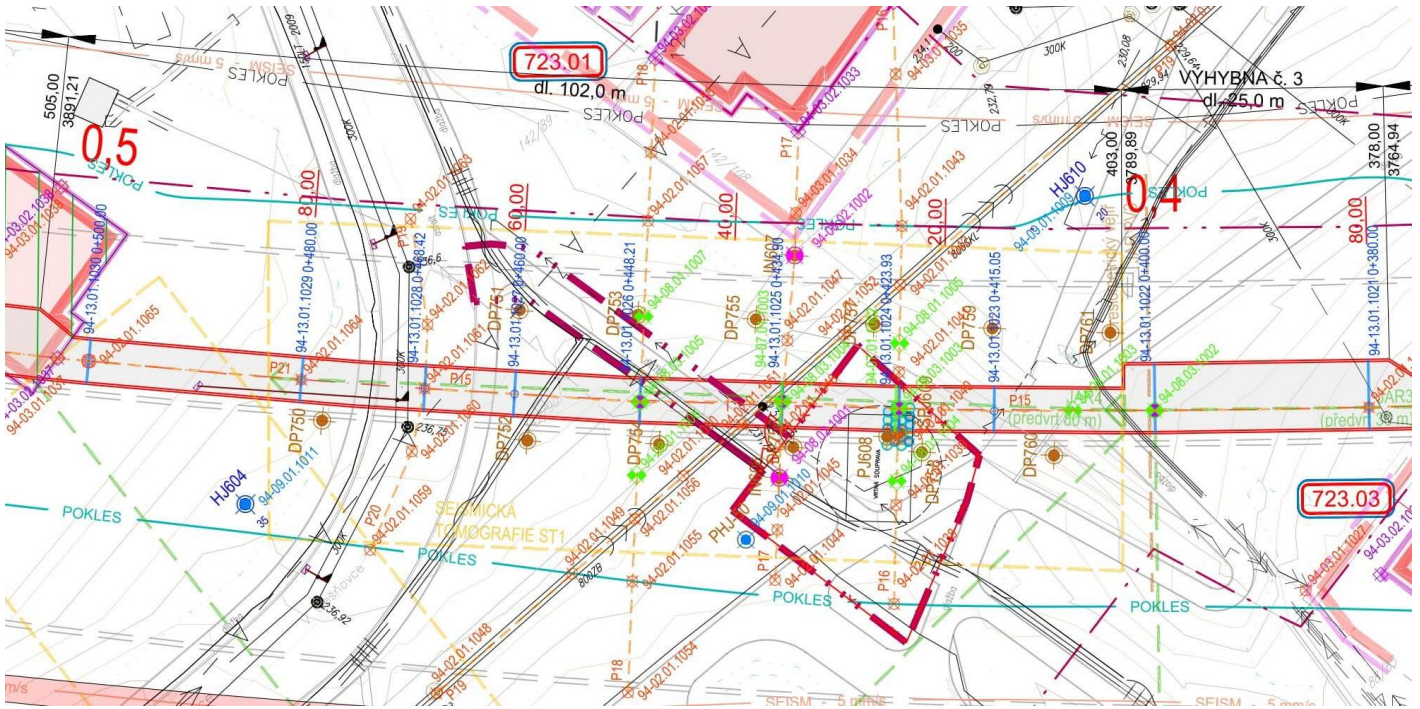


Figure 8: Coordination layout of the comprehensive geotechnical monitoring near the Zelené Město residential development – excerpt from the site plan

5. RELATED EXPLORATORY WORKS

In the area Pod Šancemi – Českobrodská, extensive exploratory works are planned both from the surface and from underground. The programme of the proposed investigation works consists of the following activities:

- **Surface exploratory works:** drilling and trial pits, field tests, geophysical works, laboratory testing of soils and rocks, geodetic surveying, hydrogeological works, corrosion surveys, and other engineering and geological service activities.
- **Underground exploratory works:** engineering-geological and geotechnical monitoring of the excavation of the exploratory adit, exploratory boreholes drilled from the adit towards the second tunnel tube and to the adit end, pressuremeter test fans from the adit, probe drilling from the adit (performed during excavation), and geo-electrical corrosion surveys.

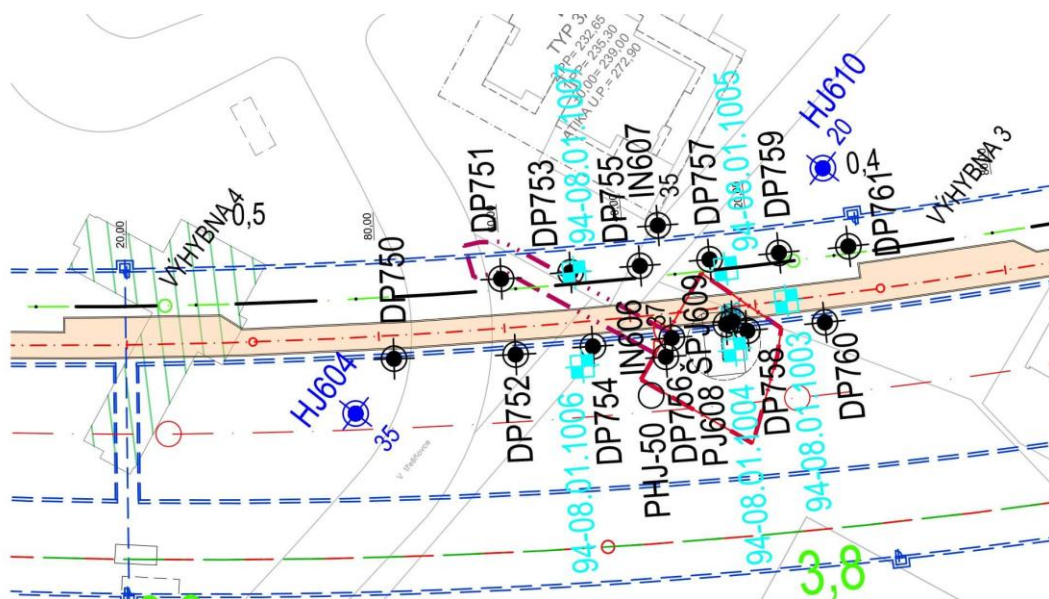


Figure 9: Layout of the surface exploratory works in the area of the Hrdlořezy Creek valley depression

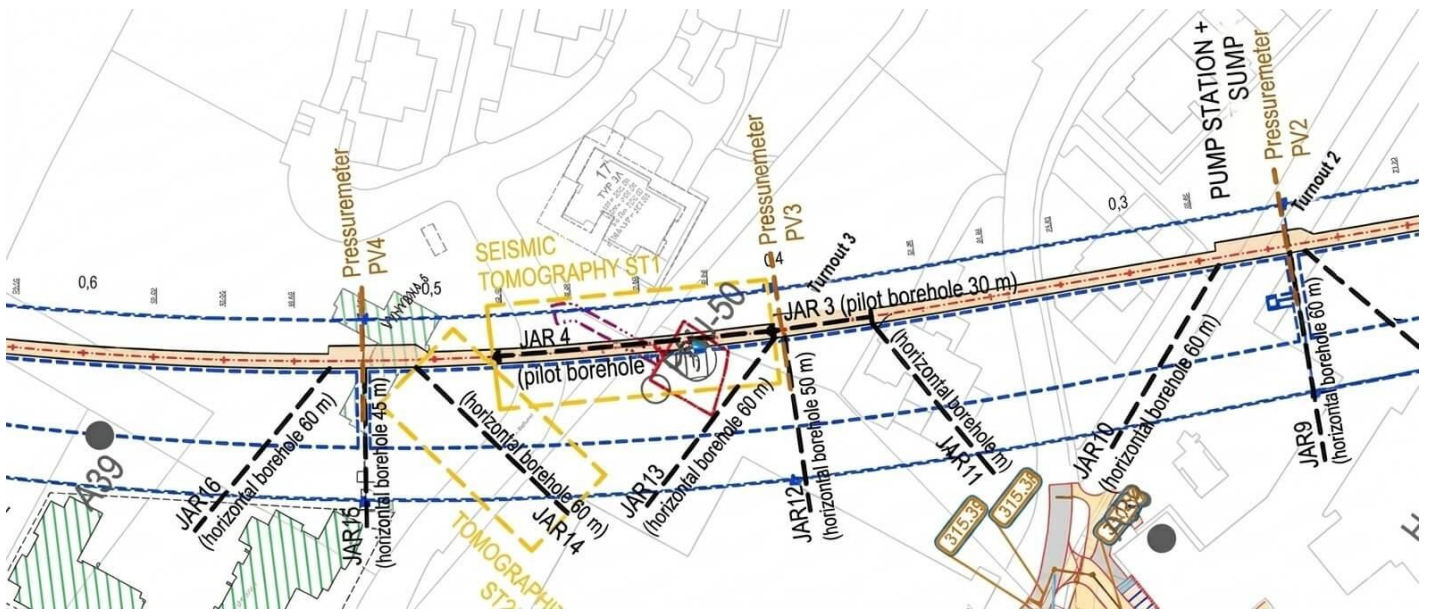


Figure 10: Layout of the underground exploratory works of the Jarov Tunnel exploratory adit in the area of the Hrdlořezy Creek valley depression

6. CONCLUSION

The exploratory adit of the Jarov Tunnel and the related investigation works will provide detailed and verified information on the overall geological, hydrogeological, and geotechnical conditions of the area of interest. The results of the geotechnical investigation and monitoring will supply the essential data for the next stages of preparation of project No. 0094 of the Prague City Ring Road. Their comprehensive evaluation will also make it possible to optimise the excavation technology of the main tunnel and significantly reduce geotechnical risks during construction.

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