Project Chiren Gas Storage Facility Project - Bulgaria

Supplementary Environmental Impact Assessment –

Ogosta river crossing by the connecting pipeline of UGS Chiren to the village of Butan.

(Preliminary version)

July 2023

Table of Contents

List of Tables

List of Figures

List of Abbreviations

UGS	Underground gas storage
AGRS	Automated Gas Regulation Station
bcm	Billion cubic meters
BTG	Bulgartransgaz EAD
CPSs	Cathodic Protection Stations
CS	Compressor station
CS BGS 2005	Coordinate system of Bulgarian geodesic system 2005
DN	Diameter Nominal
DSP-PP	Detailed spatial plan - parcelling plan
EAD	Single-member joint-stock company
EIA	Environmental impact assessment
ESIA	Environmental social impact assessment
GMS	Gas metering station
GTCUs	Gas turbine compressor units
HDD	Horizontal Directional Drilling
HDPE	High-density polyethylene
IFC	International Finance Corporation
km	Kilometer
kV	Kilo volt
LVA	Line valve assembly
mcm/d	Thousand cubic meters per day
MD	Measured distance
MGS	Magnetic Guidance System
mm	Millimeter
MPa	Megapascal
NPP	Nuclear Power Plant
pH	Potential of hydrogen
PS	Performance Standards

SCADA	Supervisory control and data acquisition

Definitions

(HDD) Horizontal Directional Drilling: trenchless technology enabling pipelines' run-in operation by pulling them into underground drilling, created by a predetermined trajectory by using special equipment.

Rig (Drilling Unit): special machine to make an HDD drilling. It works by applying a pull or push force on the drill pipe string, combined with rotation as required. Special tools (drill bits, reamers) are used to open or enlarge the hole. Drilling operations are supported by a system for drilling mud injection, with flow and pressure control.

Drilling rig or entry site: area where the Drilling rig is located, and HDD drilling conventionally starts.

Pipeline site or exit site: area where the pipes are positioned and prepared to compose the pipestring to be pulled back into the drilling; it's the area where conventionally HDD drilling ends.

Drilling mud: water-based mixture containing bentonite and some additives (if necessary). The drilling mud is used in HDD and play important role, in particular by facilitating the excavation by hydraulic loosening, stabilization of the hole, lubrication of drilling tools and pipestring during pullback.

Cutting: material dug by HDD excavation. This is composed by the ground crossed by the drilling removed by the hydraulic action of drilling mud and mechanical effect of drill head or reamers, carried out from the hole through the circulation of drilling mud.

Pilot bore: materialization of projected profile by drilling a hole that connects the point of entry and exit of the drilling following the planned trajectory.

Drill head (drill bit): tool used for the pilot bore drilling.

MGS (Magnetic Guidance System): tracing and steering system, used typically during the execution of the HDD pilot bore. It allows identifying the position of a probe inserted near the drill head, thanks to its interaction with a magnetic field. Through this system is possible to measure the progress of drilling and correspondence between real trajectory and planned one and guide the drilling in order to achieve the drilling project. The data transmission can be made through cable or wireless.

Reaming: enlargement of the pilot bore by pulling in it special tools called reamers.

Overcut: % difference between the diameter of the pipe to be installed and the size of larger reaming.

Clean run: cleaning of drilling channel carried out by repeating the larger reamer passage, to remove any residual cutting.

Pullback: laying of the pipeline into the hole created by HDD. The pipeline, welded in a single piece (pipestring) is connected with appropriate devices (swivel, pulling head) to drill pipes at the exit site, and is set on an appropriate curvilinear configuration (to avoid any permanent deformation) by the use of rollers or roli cradles (on cranes, sideboom or excavator arms). The Rig pulls the pipe towards entry point, putting it completely into drilling hole.

Overbend: curve according to which the pipe is ready for pullback, it is calculated to avoid inadmissible stresses.

Frac-out: hydraulic fracturing, or more generally, increased permeability of the soil, creating an alternative circulation flow for drilling mud in the ground, that sometimes brings to superficial leakage.

SMYS (Specified Minimum Yield Strength) is the value of the maximum allowable stress for steel and pipeline features.

Buoyancy: hydrostatic lifting force (according to Archimedes principle) exerted on the pipeline by drilling mud inside HDD hole.

Residual buoyancy: the lifting force resulting from the combined effect of drilling mud buoyancy and pipeline weight.

1. Introduction

This document is the Supplementary Environmental Impact Assessment related to the Ogosta river crossing by the new connecting pipeline from Chiren UGS to the village of Butan which is part of the Project for expansion of the Chiren underground gas storage (UGS) facility from 550 mcm to up to 1 bcm. (In the following "the Project") in Bulgaria, Region Vratsa. The Proponent of the Project is Bulgartransgaz EAD, Republic of Bulgaria, Sofia ("Bulgartransgaz", "BTG" or "Project Company").

This Supplementary EIA is part of the documents' package which has been produced to upgrade the local ESIAs prepared for the local permitting process and align them with the International Finance Corporation (IFC) ("the Lenders Group") requirements and Performance standards.

It must be noted that currently the activities for detailed design of the pipeline and the river crossing are ongoing and this EIA is based on the information available at this time. As soon as the detailed design is finalized this Supplementary EIA report will be reviewed and complemented.

2. Project description and objective

2.1. Project objective

Chiren UGS Capacity Expansion Project (the Project) covers three aspects:

1. Design, construction and commissioning of new above ground facilities – a compressor station with all of the auxiliary equipment to ensure a reliable and continuous operation for natural gas injection and withdrawal and a new gas metering station (GMS).
2. Design, construction and commissioning of a new gas pipeline in the section VA Butan - Chiren UGS
3. Design, construction and commissioning of underground facilities - ten new high flowrate exploitation and three observation wells, as well as new gatherings (gas pipelines) connecting the exploitation wells with the above ground facilities, including the compressor station.

Figure 2.1 *Project Map*

<u>The project in its integrity has the following objectives:</u>

- a technical possibility will be created for increasing the working volume (expansion) of Chiren UGS, with the possibility to store up to 1 bcm of active gas;
- the necessary new, highly efficient and highly reliable compressor equipment meeting all modern requirements for environmental protection (low level of harmful emissions and noise) will be provided, ensuring the possibility to inject natural gas of up to 8.0 mcm/d;
- the operational safety, security and reliability of Chiren UGS, as a whole will be increased.
- In the context of the storage facility expansion and its transformation into a commercial storage facility of regional importance, the construction of a connecting gas pipeline will increase the capacity abilities of the storage from a commercial perspective, contribute to a greater flexibility, reliability, safety and opportunity for maneuvers as regards the routes of trade and processes of withdrawal and injection. The construction of a new connection to the gas transmission system will further contribute to better integration of the gas storage facility into the overall gas transmission system of Bulgaria and the region.
- The envisaged gas pipeline branch will provide a possibility for gas supply of neighboring regions in case of financial, economic and commercial interest. Creating a possibility to use natural gas will allow the replacement of currently used solid fuels, thereby contributing to the reduction of harmful emissions.

- The staged drilling of the new wells will increase the natural gas injection and withdrawal capacity of the gas storage facility. This will enable 8-10 mcm of natural gas to be withdrawn daily.

2.2. Project description

The implementation of the Project component "Gas pipeline connecting Chiren UGS to the existing gas transmission network of Bulgartransgaz EAD in the area of Butan village" is directly related to the possibilities for storage capacity expansion of the storage facility itself, thus increasing the safety of operation and security of natural gas transmission to and from Chiren UGS.

The major crossing of a water body for the pipeline will be the Ogosta river crossing. The estimated technology for installation of the gas pipeline here is by using the HDD procedure. In addition, pipes for protection of electrical cables or fiber optics are estimated to be laid by using HDD technology as well.

Design, construction and commissioning of gas transmission infrastructure from VA Butan to Chiren UGS will be carried out within the framework of the activity, which includes a gas transmission pipeline, together with the main facilities and an optical cable network for operational data transmission. The envisaged length of the gas pipeline is approximately 42 km, Dn 700 (711 mm outer diameter), maximum operating pressure 7.5 MPa.

Characteristics of the gas transmission pipeline route:

- Start: the existing site of valve assembly VA Butan of Bulgartransgaz EAD gas transmission network.
- End: Underground Gas Storage Chiren.

Technological sites and an optic cable line are envisaged to be constructed in the easement of the gas pipeline. Envisaged technological sites:

- Pigging Facility, Dn 700 at VA Butan.
- Valve assembly with a branch to provide an opportunity to supply adjacent areas in case of a financial, economic and commercial interest.
- Pigging Facility, Dn 700 at Chiren.

The major crossing of a water body for the pipeline will be the Ogosta river crossing km 8+689 along the gas pipeline route. The gas pipeline here will be installed by using the HDD procedure. In addition, pipes for protection of electrical cables or fiber optics will be laid by using HDD technology.

Location of activities: The route of the section from VA Butan to Chiren UGS runs through northern Bulgaria and the territory of Vratsa District as shown on Figure 2.2. below. The gas pipeline design route starts from an existing DN1200 gas pipeline at КМ 414+945.86 (point coordinates 4839886.067 m, 358281.054 m in CS BGS 2005), reaches to ПК 406+28.48 of the approved DSP-PP (with Order No РД-02-15-51/01.04.2015), follows its trail until it reaches the area of Chiren UGS. The new gas pipeline design runs through the lands of the villages of Chiren, Deven and Tri kladentsi in Vratsa Municipality, the lands of the village of Osen in Krivodol Municipality and the lands of the villages of Malorad in Borovan Municipality, the lands of the villages of Manastirishte, Rogozen, Botevo, Barzina and Hayredin in Hayredin Municipality, the lands of the village of Sofronievo in Mizyia Municipality and the lands of the villages of Butan and Kriva Bara in Kozloduy Municipality.

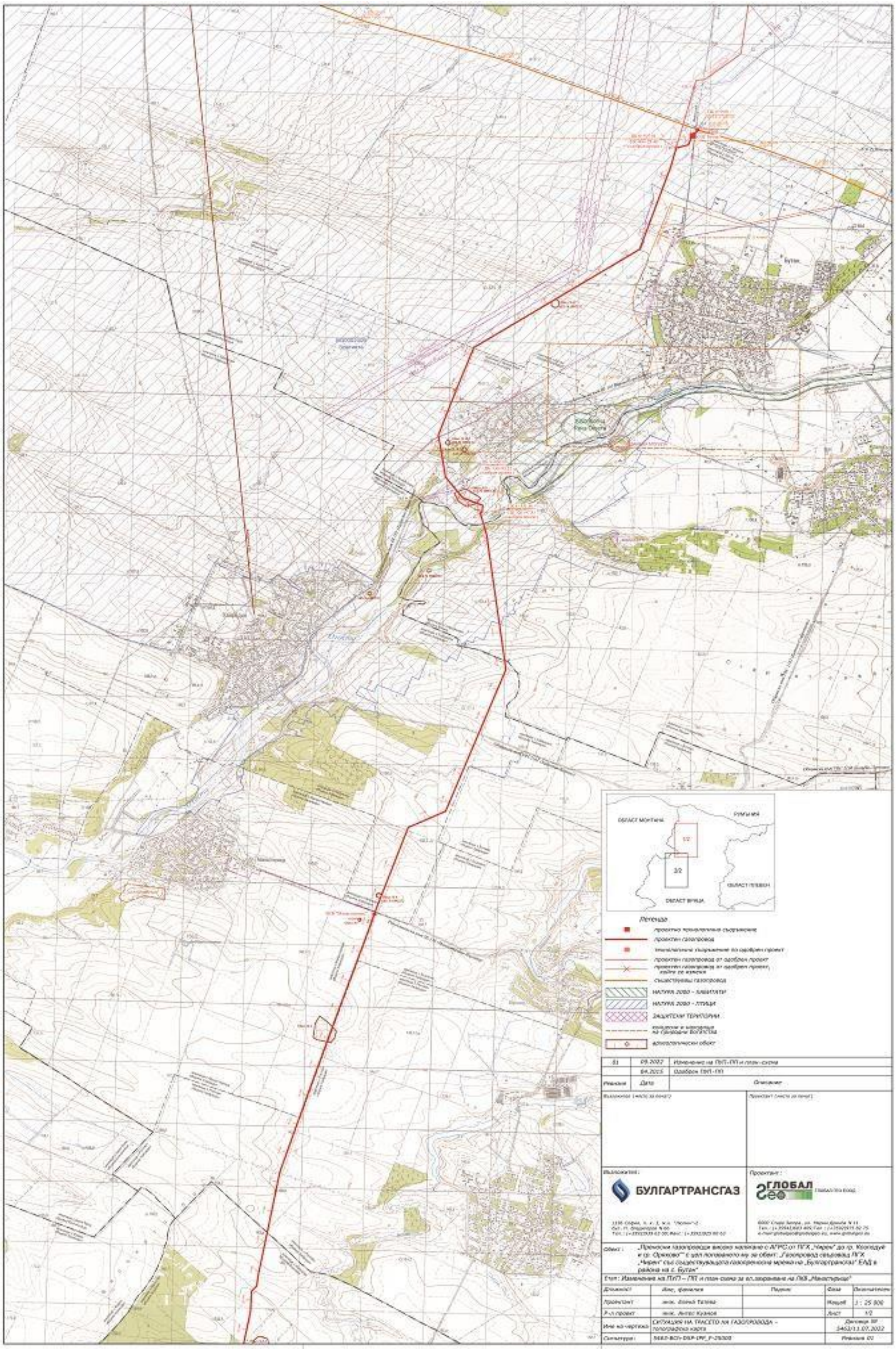

Figure 2.2 *Layout of the gas pipeline from VA Butan to Chiren UGS*

3. Brief overview of HDD technology and its' advantages

The technology to be used is horizontal directional drilling which will be performed at Ogosta River km 8+689 along the gas pipeline route. The Horizontal Directional Drilling (HDD) technique is used when the standard installation methods (trench excavation, horizontal straight drilling, etc.) would be difficult or impossible to use, due to the particular morphology of the soil or the presence of irremovable obstacles or when the surface of the site must be safeguarded due to historical or environmental interests.

The horizontal directional drilling method provides the following advantages:

- alteration of the surface of the terrain limited to the preparation areas at the entrance and exit of drilling.
- minimum environmental impact.
- the pipe can be laid at a considerable depth, even when it would not be possible or economical with traditional techniques; in this way the pipelines laid are protected from future surface works (foundations and excavations) and possible erosion of the coverage by surface waters.
- a safe distance can be maintained from existing obstacles.
- works do not require as much time as standard techniques; - the activities are affected to a lesser extent by weather conditions.
- no interruptions to naval, rail, air or automobile traffic are necessary.
- In many cases, using HDD may be the least expensive of the possible alternatives (in particular in terms of site restoration).
- HDD is the most non-destructive method of crossing water bodies that does not affect the borders of the water body, and accordingly does not affect the animal species inhabiting the river, as well as the plant species.
- By implementing the Ogosta River crossing, Bulgartransgaz EAD commits that there will be.

no net loss or disturbance of any animal and plant species part of the river's ecosystems.

4. Baseline data and information

4.1. Ogosta river description, geology, hydrogeology, biological conditions

The Ogosta river is one of the 6 large tributaries to the Danube River (Ogosta, Iskar, Osam, Vit, Yantra, Russe Lom). Most often, they are wide slow-flowing rivers with a predominant fine substrate (loess, clay, sand, organic sediments), but in some cases there may also be semi-rock, gravel sections.

Figure 4.3. *Ogosta downstream near the planned river crossing point.*

Hydro-morphological characteristics of the river type:

- River valley: Wide-developed River terraces
- Location: Accumulation area
- Longitudinal slope: Moderately steep
- Plan form: Meandering
- Character of the riverbed: Broad, associated with the river terraces.
- Character of current: Mostly slow
- Predominant substrate: Gravel, sand, silt
- Bottom sedimentary forms: Possible stabilized islands
- EP/Sub-EP:12-2
- Altitude: <80 m (varies)
- Size: >2500 km2, large
- Distance to source:> 70 km
- Slope / Flow Energy: <0.5%; very slight slope; Flow E is low.
- Valley shape: Wide River valley
- Dominant bottom substrate: Sands (0.064 - 2), silt (<0.064), clay, loess
- Salinity: Freshwater; <0.5‰

Geology and hydrogeology: The Ogosta River has formed one to two accumulation terraces with the presence of porous (by type) and non-pressurized (hydraulic nature) groundwater. The latter are in direct hydraulic connection with the river and participate in the formation of the surface runoff. Resource formation in alluvial deposits is generally from drainage of groundwater from Pleistocene and Neogene aquifers. Geology of river terraces: gravels, sands and sandy clays. Aeolian formations (loess) cover everywhere the Pleistocene deposits and pre-Quaternary sediments (sands, gravels, limestones).

The biological conditions typical for the river type of Ogosta river (large tributaries to the Danube River) are given in the table below:

Macrophytes	Phytobenthos
Angiosperms completely dominate higher aquatic plants (hydrophytes - submerged and floating; amphiphytes, helophytes). Water mosses (Bryophyta) are rare. Typical submerged/floating hydrophytes: Myriophyllum spicatum (abundance often >2) Potamogeton nodosus (>1) Najas marina (>1) Potamogeton crispus Potamogeton pectinatus Lemna minor, L. gibba Spirodela polyrhiza Macrophyte flora is rich, as sometimes exceeds 10 species (together with the helophytes). In the sections with many slow flow develop weakly and typical floaters (Lemna, Spirodela). Typical Littoral (Helophytes): Sparganium erectum - most often with abundance 1-2; Lithrum salicaria – 2 Persicaria – often with abundance Butomus umbellatus Lycopus europaeus The weak presence of Typha and Phragmites is noticeable.	Indicator flint algae (Bacillariophyta) for this type are: Achnanthidium eutrophilum Achnanthidium pyrenaicum Achnanthidium subatomus Amphora pediculus Cocconeis placentula var. euglypta Cocconeis placentula var. placentula Cymbella excisa Fragilaria ulna Gomphonema minutum Gomphonema parvulum Navicula capitatoradiata Navicula cryptotenella
Macrozoobenthos	**Fish**

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The weak presence of Typha and Phragmites is noticeable.	

Table 1. Biological conditions Ogosta river

4.2. Baseline data for verification of HDD technology feasibility for the Ogosta river crossing

In planning an HDD it is necessary to gather information about the boundary conditions. This is the only way to assess the feasibility of HDD and, only afterward, prepare a project for its successful performance.

The following preliminary activities are essential and were taken into careful consideration by BTG:

- selection of the crossing site.
- hydrogeological study of the area.
- definition of the drilling profile;
- selection of the pipe material.

4.2.1. Selection of crossing location

For an objective evaluation of the feasibility of a crossing by HDD technique, it is necessary to value accurately all aspects of the situation which is being done currently by BTG and its Contractor when preparing the detailed design.

Above all, it is important to consider that equipment must be moved, from both sides of the drilling channel, using exceptional weight trucks, and adequate access routes will be necessary for this purpose. Not infrequently, the only possible access to job site is the strip of land on which the pipeline under construction will be laid.

As for most construction jobs, also for HDD it is advantageous to dispose of as much space as possible. The minimum space requisite depends on the size of the drilling rig and equipment necessary. In general, as regards the area of initial drilling, a maxi-rig requires an area of about 40 m x 50 m (2˙000 m^2).

Much of the equipment can be arranged to adapt to particular conditions, so that a worksite appropriate to local conditions can be set up.

In general, the ideal conditions are a flat site with solid terrain and freedom of construction above soil level (for example, no aerial metrical lines), without underground services.

On the arrival side of the drilling site the space must be sufficient for installation of the screening equipment and preparation of pit for collection of the drilling mud, as well as for handling drilling pipes and excavators or sidebooms and cranes). In general, an area 30x40 m is sufficient. In continuity with the exit area, it is necessary to provide for a corridor for the preparation of the final pipe, aligned with the drilling line.

The width of the area necessary for assembly corresponds to that of a normal working strip for the classical pipeline laying process. Preparation for pullback of the pipe in a single section serves to ensure that pull-back insertion can be done without interruption. Tie-in of several sections of the pipeline during pullback greatly increases the risk due to the need for consequent stops and should be avoided if possible.

After deciding the sites of starting and ending of the HDD, an accurate topographic survey of the area is made, on drilling axis. In case of river crossings, it is necessary to measure the water level and geometry of the riverbed accurately. The accuracy of the measurements is an indispensable factor for successful project management and performance of HDD.

In performing the works it is also necessary to provide large quantities of water for mixing the drilling mud, so a good source (waterway or aqueduct) should be available, and it is important to determine whether the characteristics are adequate, especially as regards hardness, salinity and pH, to product suitable mud mix.

All these considerations are being taken into account by BTG when planning the project implementation and selecting the contractor to perform the detailed design. The estimated crossing point of the Ogosta river is km 8+689 along the gas pipeline route. The location of the drilling sites is estimated to be in flat area which is located mostly in agricultural land and is not in immediate vicinity of the riverbanks. In the process of coordinating the route with the state and municipal administrations and operating companies, it was established that in the transition area no other communications are crossed except the river. More concrete details (including maps) can be given once the detailed design is finalized.

4.2.2. Hydrogeological study of the area

Information of fundamental importance for assessing the feasibility of HDD comes from the geotechnical and geological studies of the soil involved.

In general, for application of the HDD method, the ideal soil consists of dense clay and sand, even completely saturated. The available baseline data on Ogosta river shows that the soil composition is suitable for HDD technology. According to the data of the engineering-geological studies, the pipeline will pass at designed depth in semi-rock and rock tuffs.

The banks at the location of the borehole entrance consist of alluvial clays with a thickness of 6m and alluvial gravels with a thickness of 4 m, and in the place of the exit of the well consist of alluvial gravels with a thickness of 2 m and alluvial clays with a thickness of 2.5 m.

After defining the area subject to crossing, however, boreholes must be made in the zone of operations foreseen.

The number and depth of the boreholes will depend essentially on the length and depth of horizontal drilling and on the geological context (foreseeable formations). Sufficient information must be gathered in order to generate a geological profile of the precise strata along the drilling line.

Core samples should be taken with a spacing of about 100 m and reaching a depth that exceeds by a few meters the deepest point of the potential drilling line. In case of unfavorable soil conditions, the drilling profile must be changed to reduce the construction risks, and involve, for most of its length, the formations more favorable for the HDD process.

All the data available, such as general geological data relative to the region involved, the precise indication of the borehole position, the detailed stratigraphy, the mode of collection and characteristics of the samples, tests made on site (SPT, Torvane test, pocket penetrometer, etc.) and in the laboratory (granulometric analysis, evaluation of geotechnical parameters such as friction angle, cohesion, modulus of Young and Poisson, etc.) as well as the hydrogeological characteristics (level of aquifers intercepted), should be written up in a geological-technical report.

All these considerations are being taken into account by BTG when planning the project implementation and selecting the contractor to perform the feasibility studies and detailed design and a detailed geological survey of the geological structure of the Ogosta River has been carried out, including laboratory samples testing. The results of these will be updated to this report once the feasibility and detailed design phase of the project is finalized.

4.2.3. Definition of the drilling profile

An essential point in the project and performance of an HDD procedure is the definition of an adequate drilling profile.

Using the MGS measurement technique, it is possible to reproduce three-dimensional drilling layouts, however in most cases HDD procedures are carried out with a two-dimensional profile, in particular on a vertical plane containing the drilling line.

The drilling profile depends on a number of factors such as:

- local conditions.

- drilling length.
- drilling depth.
- soil stratigraphy.
- minimum coverage necessary.
- safe distance from surface or underground structures.
- position of existing installations.
- admissible bending radius (for drill string and / or pipeline); possible entrance/exit angle.

The drilling profile bending radius is usually determined on the basis of the piping to be installed.

In the case of HDPE piping the radius is the one admissible for the drill pipes string.

Such factors as the entry and exit angle, drilling depth and admissible bending radius, combined, indicate a minimum length necessary for the pipeline and the characteristics of the equipment. The entry angle depends on the capability of the rig and may vary from 5° to 15°. The exit angle depends on pipeline features. Angles between 5° and 15° are recommended.

Detailed information on this is currently not available. It will be described for the Ogosta river crossing after finalization of the detailed design.

4.2.4. Selection of pipe material

The pipe to be installed with the HDD procedure is subject to various stresses during pullback and in use. Accurate measurement and appropriate selection of the pipe, particularly in terms of the characteristics of material resistance and thickness, do not serve only to ensure installation without damage, but contribute in a decisive way to ensuring satisfactory future use as well.

The calculations for selection of the pipes must take into consideration the following factors, among others:

- pulling and traction tension during installation.
- additional tension during to bending of the pipe in the drill hole.
- buoyancy caused by the drilling mud; pressing-flexing stresses.

With these considerations it is possible to define the minimum characteristics that a pipe must have in accordance with HDD project:

- nominal pressure.
- thickness.
- type of material.
- quality of material.

However, the pipeline conditions are usually aligned with as project parameters (for example, HDD crossings considering the general pipeline construction: the characteristics of the HDD pipeline are the same as those of the entire gas transmission line).

In this case, the characteristics of the pipeline and the surrounding conditions (surface, structures and soil), become binding for definition of the project profile.

The pipeline will be steel straight joints 12m, Φ711x11,9, X60 ME, API SPEC 5L with coating.

Φ – diameter of the pipe

11,9 - thickness of the pipe

X60 ME – type of steel/ carbon content

API SPEC 5L – Standard Specification 5L, Line Pipe of American Petroleum Institute

5. Definition of the main HDD stages

The HDD procedure to be used for the Ogosta river crossing consists of the following main stages:

- establishment of the drilling sites on both sides of the river.
- preparation of the pilot bore hole.
- reaming of the pilot hole.
- any necessary clean runs.
- pull back and laying of the pipeline.

All details related to the size and location of the drilling sites, the method of drilling, the materials used, etc. will be part of the river crossing detailed design.

5.1. Establishment of the drilling sites

This stage includes the preparation of the mud pits, work area, fences as needed, etc. The sites for the Ogosta river crossing sites will be located outside the vicinity of the riverbed in flat terrain, mostly used as agricultural land. Thus, they are not expected to affect the riverine vegetation, incl. trees. The drilling sites are planned to be accessed by any (heavy) machinery via the existing dirt farm roads.

The length of the section to be drilled is 241 meters. On both ends the boreholes will be located. The method consists in pushing a borehole along a set trajectory and subsequent sliding of the pipeline in the borehole. For the production work according to the method of the HDD of the two sides there are platforms on the riverbank, one of which is used for the deployment of the drilling equipment and the other for the installation of the docker.

The minimum radius of the elastic curve in the construction conditions is determined in view of the Recommendations of the high pressure (HP) "Construction of underwater transitions of gas pipelines through directed probing" by the formula:

$$R \geq 1200xDN = 1200x0{,}953 = 1144 \text{ m.}$$

R- radius
DN – diameter of the pipe (m)

The radius of the elastic curve under the service conditions was determined by the results from pipeline calculations for strength and resistance and is 850 m. The design radius of the elastic bend in oblique-directional drilling is assumed to be R=1200 m.

The location of the entry and exit points of the borehole are determined with regard to the radius of the elastic curve, the topography of the area, the permissible angle of the entrance to the borehole, and also with regard to the possibility of carrying out the drilling works and the location of the equipment.

The equipment to be used during performance of the activities includes:

- Rig station.
- hydraulic power unit.
- steering cabin.
- drill bit.
- MGS – Magnetic Guidance System.
- steering tool system.
- drill collar (non-magnetic drill pipe).
- drill pipe.
- reamer (barrel reamer, fly cutter, hole opener, as necessary).
- swivel.
- pulling head.
- drilling mud injection system (high pressure pump/s).
- bentonite mixture recycling system (electrical submerged pump/s).
- mixing unit.
- recycling unit.
- screener.
- de-sander.
- piping and fittings.
- spare parts container.
- compressor.
- water tank and pump.
- excavator.
- crane and/or side-boom for pipes laying.
- roller and roll cradle.

The information on this point will be reviewed and complemented once the detailed design is finalized.

5.2. Preparation of the pilot bore hole.

The pilot bore hole is the execution of the drilling profile defined in the project, connecting the entrance area (Drilling rig site) with the exit area on the other side (pipe site).

In order to make the pilot bore hole, in addition to the surface equipment (Rig, high pressure pumps, mixing and recycling units, etc.), a particular sequence of underground equipment called the “drill string” is also necessary.

The drill string is selected and defined starting from the characteristics of the pilot hole perforation plan and soil.

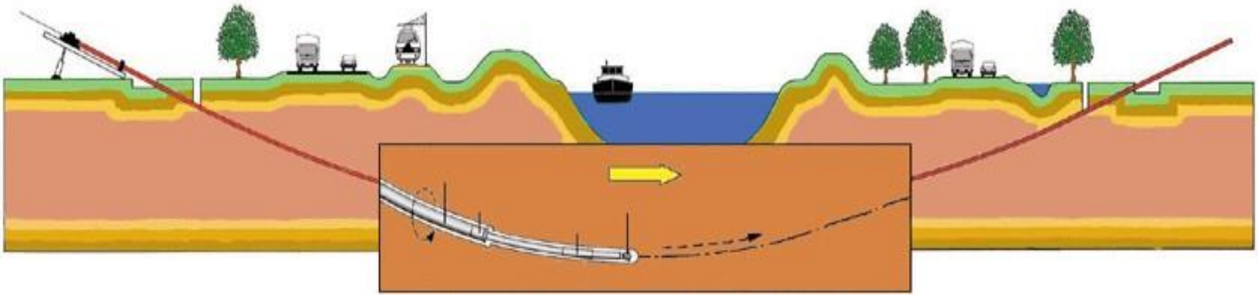


Figure *5* **4.** *Preparation of the pilot bore hole.*

The first component of the string is the drill bit, which serves to excavate and/or loosen the soil to be drilled, creating the cavity that will form the pilot bore hole.

Depending on the soil conditions, it may be possible to use a jet bit, with main function of hydraulic loosening, a tricone drill bit, if it is necessary to combine loosening and excavation, or a rock drill bit with mud motor when the mechanical action is prevalent.

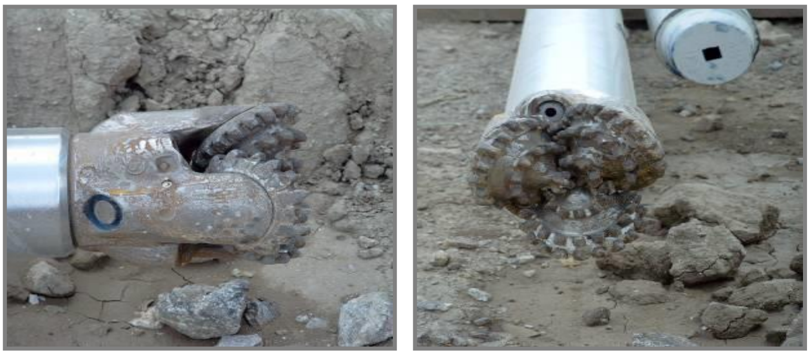


Figure 5.5 *Tricone drill bit*

Behind the drill bit, connecting joints and adapters (crossover, saver sub) are installed, if needed, then there is an angular element (bent-sub), which is a bent joint with a specific angle (1.7° - 2.5°). It is just this component that serves to direct the drilling process, by rotating the bent sub, using the rods, into the appropriate position of the tool face: by pushing the drilling battery, without rotation, it will be possible to change drilling direction.

The bent-sub serves, with the combination of rotation and thrust, to get the correct direction to drill the projected pilot bore.

To set and monitor the drilling process underground, it is necessary to know the exact position of the drilling bit. A probe housing behind the bent-sub in the bit contains a special measurement probe for this purpose.

The reading system to be used is MGS – Magnetic Guidance System: a highly sensitive probe in the probe housing, consisting of a set of magnetometers and triaxial accelerometers, connected by a transmission cable to the outside receiver system. It is necessary to install it in a special housing, followed by non-magnetic Drill Collars so that it will not be disturbed by the magnetic effect of drill pipes.

Figure 5.6 *Bottom Hole Assembly*

The elements listed above are the first portion of the drill string, known as the Bottom Hole Assembly, and consisting, of the following parts: drill bit, bent sub, non-magnetic drill collars, drilling rig holder and other joints and adapters.

The Rig only transmits a forward thrust movement to the rods and rotation to the bent-sub necessary to direct the tool face in the correct position and proceed with perforation, while the mud motor and drill bit perform the action of mechanical excavation and loosening of the soil.

The last element of the drill string consists of the drill pipes, made of special steel in accordance with API specification, being the same equipment used in oil drilling.

The drill pipes are fitted on the ends with tool joints with enlarged diameter, fastened to the body of the pipes by friction welding. The tool joints are threaded with conical male-female joints to facilitate and speed coupling, and a flat portion where the rig clamps or special drill pipe tongs can grip during screwing/unscrewing operations.

Normally, pipes with a 5” body are used, about 9.2 m long with external diameter of the tool joint 6.5/8” and thread 4.1/2” IF pin-box.

The drill pipes serve the main function of transmitting the rotation torque and compression/traction forces from the Rig to the bottom hole assembly. Also, since they are hollow on the inside, they convey the mud mix pumped by high pressure pumps to the bit nozzles.

The cable for transmission of the values measured by the measuring probes is housed inside the drill pipes and transmits this information to the parameter interpretation system on the surface.

Whatever drill bit is used, it must have a larger diameter than the tool-joint of the drill pipes and leave a ring – shaped opening between the pipes and hole sufficient to ensure circulation of the drilling mud containing the cuttings.

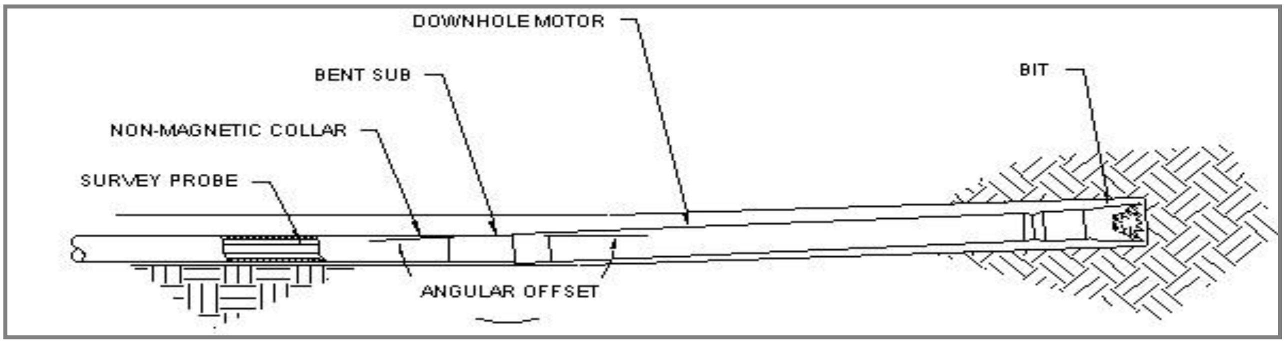


Figure 5.7 *Bottom hole assembly*

Figure 5.8 *Completion of pilot bore hole – Exit Point*

After perforation has started with the bottom hole assembly, the drilling pipes are screwed on, one by one. Every pipe takes the perforation farther, in the direction controlled by the guidance system and with the combined action of thrust and rotation provided by the Rig.

The position is measured by the probes in the hole and transmitted along the cable inside the pipe, to the external control station, where the data are processed with the aid of computers or to the wireless receiver. On the basis of the data collected, the project profile is compared with the effective drilling and the trajectory is recalculated to provide the information for the Rig operator to make any corrections in case of deviation (usually due to the soil characteristics).

During drilling, the remote control displays the data transmitted by the probe. In this way the operator of the remote guidance system always knows:

- Azimuth (the direction of the bit relative to magnetic north),
- Inclination (the tilt of the drill string),
- Tool face (rotation angle of the bit),
- Measured distance (MD – progress since the start of drilling),
- Elevation (height of the drill bit with respect to the reference height of 0),
- Displacement (horizontal projection of the reference line of the MD),
- Left – right (lateral deviation respect to drilling axis),
- Dog Leg Severity (DLS coefficient representing the three-dimensional shift) and determine the position of the bit three-dimensionally respect to the project line.

Depending on these data it is possible, pipe after pipe (on the polygonal principle) to make the changes and settings necessary to ready specific values in relation to the project outline.

For control measurements during drilling of the pilot hole, the MGS system is used (in particular, the Paratrack system by VectorMagnetics used by Inrock).

An electric wire is stretched along the surface on drilling axis between entrance and exit points and, parallel to it, about 30 meters far, to form a closed coil. After accurate topographic measurement of the wire position, an electric current of known intensity is passed through it, generating an artificial magnetic field. The underground probe is calibrated on the intensity of this field and measures its variation, providing an accurate position indication in real time.

The magnetic field generated by the system is stronger than the natural one: in this way it is not affected by the anomalies and interferences of the earth's magnetic field, nor by interferences of local disturbance (the presence of structures and elements in ferrous magnetic metal, electric wires, etc.)

The excavating works are aided by the jet of mud pumped through the drill pipes to the nozzles at controlled pressure that serves to:

- facilitate excavation by hydraulic loosening the soil.
- removal of cuttings.
- stabilization of the walls of the drilling hole.
- cooling the drilling tools.
- maintaining the cuttings in suspension in case of interruption of circulation.

- reducing friction and wear on all parts;
- avoiding corrosion of tools and drill pipes;
- keeping the mud motor (if any) in action.

Perforation advances as the battery is extended by adding more pipes, consequently, at every addition the measuring cable is also prolonged (the wire is cut, the pipe is added, wired and sheathed with head-to-head connector and a heat shrinkable sleeve around the ends of the cable).

Usually, at every pipe replacement, before cutting and prolonging the wire, a measurement is taken of the bit position.

Drilling of the pilot hole continues until the bit reaches the exit point on the surface of the soil, bringing the bottom hole assembly completely out of the pilot hole.

5.3. Reaming

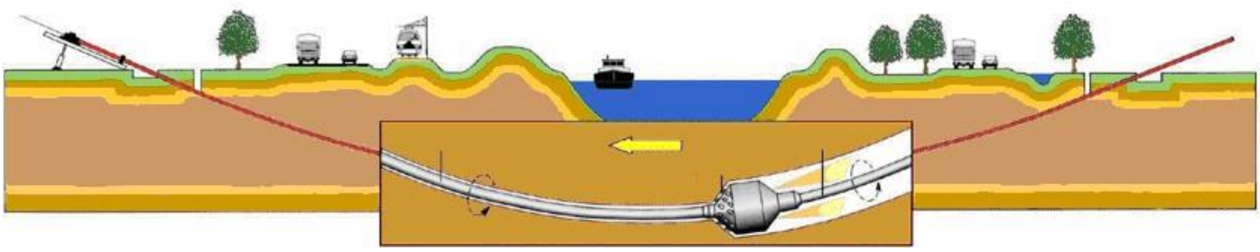


Figure 5.9 *Reaming scheme*

The second HDD stage is the enlargement of the pilot hole (*pre-reaming*).

After the pilot hole has been drilled, the bottom hole assembly is removed at the exit point and a special tool called reamer is installed on the drill pipes.

Depending on the soil conditions, this may be a *Barrel Reamer* (normally used for unconsolidated or semi consolidated sandy clay soil), *Fly-Cutter* (normally used for semi consolidated-consolidated clay soil) or a *Hole Opener,* also known as a *Rock-Reamer* (for rocky soil).

The reamer, coupled with threaded joints called crossovers, when necessary, to the drill pipes, is pulled (*back –reaming*) and simultaneously rotated by the drilling rig. The pipes guide the reamer along the line of the pilot hole that is enlarged to the diameter of the tool used.

A pipe is fastened to the end of the reamer so as to connect the battery with the entrance and exit points. For each drilling pipe removed at the hole entrance, a new one is added at the exit. In this way, regardless of the position of the reamer, the entrance and exit are always connected by the drill string in the hole.

To maintain hydraulic and mechanical soil loosening and cuttings removal, some injection nozzles are installed on the reamer, through which the drilling mud is discharged.

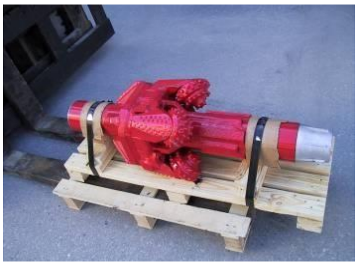


Figure 5.10 *Fly Cutter* **Figure 5.11** *Barrel Reamer* **Figure 5.12** *Rock reamer*

After reaming the pilot hole, the reamer is removed at the site of the drilling rig.

Depending on the dimensions of the pipeline to be installed, further reaming steps are performed to enlarge the hole using larger reamers until the necessary final diameter is reached and the drilling channel is as defined in the project.

Normally, the final diameter is over cut by a factor of 1.3 – 1.4 with respect to the diameter of the pipe to be installed.

After completing the reaming stages and obtaining the final overcut diameter, usually the drilling channel is cleaned, by performing a second run (cleaning run) of the largest reamer.

This also serves to verify the stability of the hole walls and complete removal of the cuttings so that it is filled with bentonite only, and thus reach the final stage with ideal conditions.

Figure 5.13/*14 Final reaming stage with barrel reamer and Installing the Barrel Reamer*

5.4. Pull-back.

The last stage in the HDD procedure consists of laying the pipeline (previously prepared in a single unit, called pipestring) inside the drill hole, using the pull-back method.

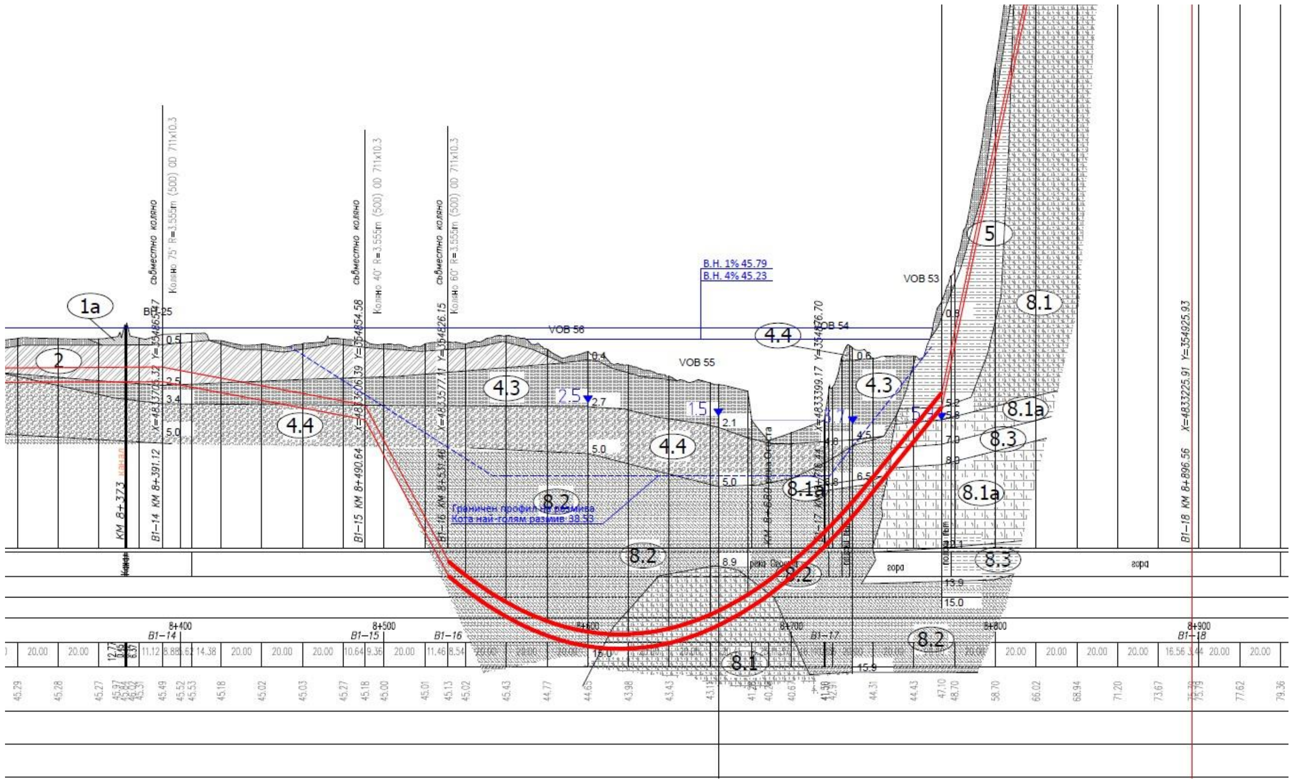


Figure 5.15 River crossing trajectory and elevations.

On the picture the crossing section between the pipeline Butan-Chiren and Ogosta river is presented. The picture shows geological conditions on the crossing, the trajectory of the gas pipeline during drilling and the design elevations.

The HDD will start from the high band (right side of Section above) of the river and then the pipe will be pulled back.

A special assembly method is used for pull back, fastened to the drill pipes at the exit point, consisting of:

- a reamer (the same one used for the last reaming and cleaning run).
- a swivel which prevents transmission of rotation to the pipe sections.
- a pull head/grip. This is a bullet-shaped element, welded to the pipeline that serves as a protection for the pipeline during installation, and is fitted with support on the front for assembly to the swivel.

The elements are connected by other high resistance elements (crossovers, clevis pins or handles), if necessary.

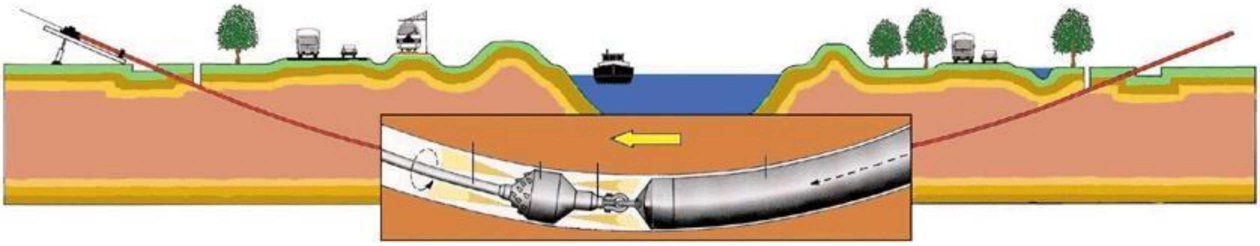


Figure *5.16 Pull-back scheme*

During pull back, the drill pipe string is withdrawn through the combined movement of pulling and rotation, toward the Rig, where the drill pipes are disassembled one by one.

Also, during this operation, the drilling mud is pumped through the battery of drilling pipes and exits from the reamer through nozzles, to ensure the lubricating effect of the drilling mud, while reducing the friction between the pipeline and the hole walls.

Inside the drilling channel produced using the HDD technique, not only single pipes, but also pipe bundles of different diameters or materials can be inserted.

Figure *5.17 Pull head and swivel.*

Figure 5.18 Swivel

Figure 5.19 Pull back assembly: pipeline.

pull head/grip – swivel - reamer.

5.5. Recording of control parameters.

While the pilot hole is being drilled, all the parameters of measurement and guidance provided by the MGS system shall be recorded:

- Number of drills pipes;
- Distance measured (progressive).
- Distance calculated (partial).
- Inclination.
- Azimuth.
- Horizontal distance (progressive - away).
- Horizontal distance calculated (partial).
- Elevation.
- Elevation calculated (partial).
- Right (deviation respect the project line), Degree of accuracy (DLS – Dogleg Severity).

During the drilling stages the following parameters are systematically measured, recorded and monitored:

- time.
- number of drills pipes;
- pull-push forces applied to drill battery.
- rotation torque.
- drilling mud injection pressure; drilling mud injection capacity.

In the same way, it's controlled the drilling mud parameters, with periodical measurements of:

- time.
- amount of bentonite and any additives used for preparation.
- density.
- viscosity (Marsh-funnel); cutting content.

6. Key risks identification and Impact Assessment

Risk management of horizontal directional drilling is an important part of decision-making in the construction process and is widely acknowledged as a vital factor in project management. Risk identification, as an initial step of risk management, is to establish what is exposed at risk in the context of the project's objectives and to generate a comprehensive risk description based on the threats and events that could prevent, worsen, delay or improve the achievement of objectives. For this study, different risk identification methods are used to identify and investigate different risk categories to support project managers with comprehensive checklists for their plan for a risk response and mitigation strategy. They can use this check list to develop and improve their program in order to avoid any damage during pipeline installation through the HDD method. Furthermore, these risks can be analyzed and assessed to develop a risk response plan.

The following risk categories were identified:

- risks related to environment - loss of habitat, protected areas, riverine vegetation and animal life, tree cuttings.
- risks related to soil structure - presence of cracks, caverns, high abrasiveness, obstacles, inappropriate soil composition.
- risks related to equipment.
- risks related to drilling fluid – damage to the filtration system, loss of circulation; incorrect amount and quality of bentonite; fluid loss; insufficient amount of fluid, incorrect pH of the fluid, etc.
- damage during operation of the gas pipeline.

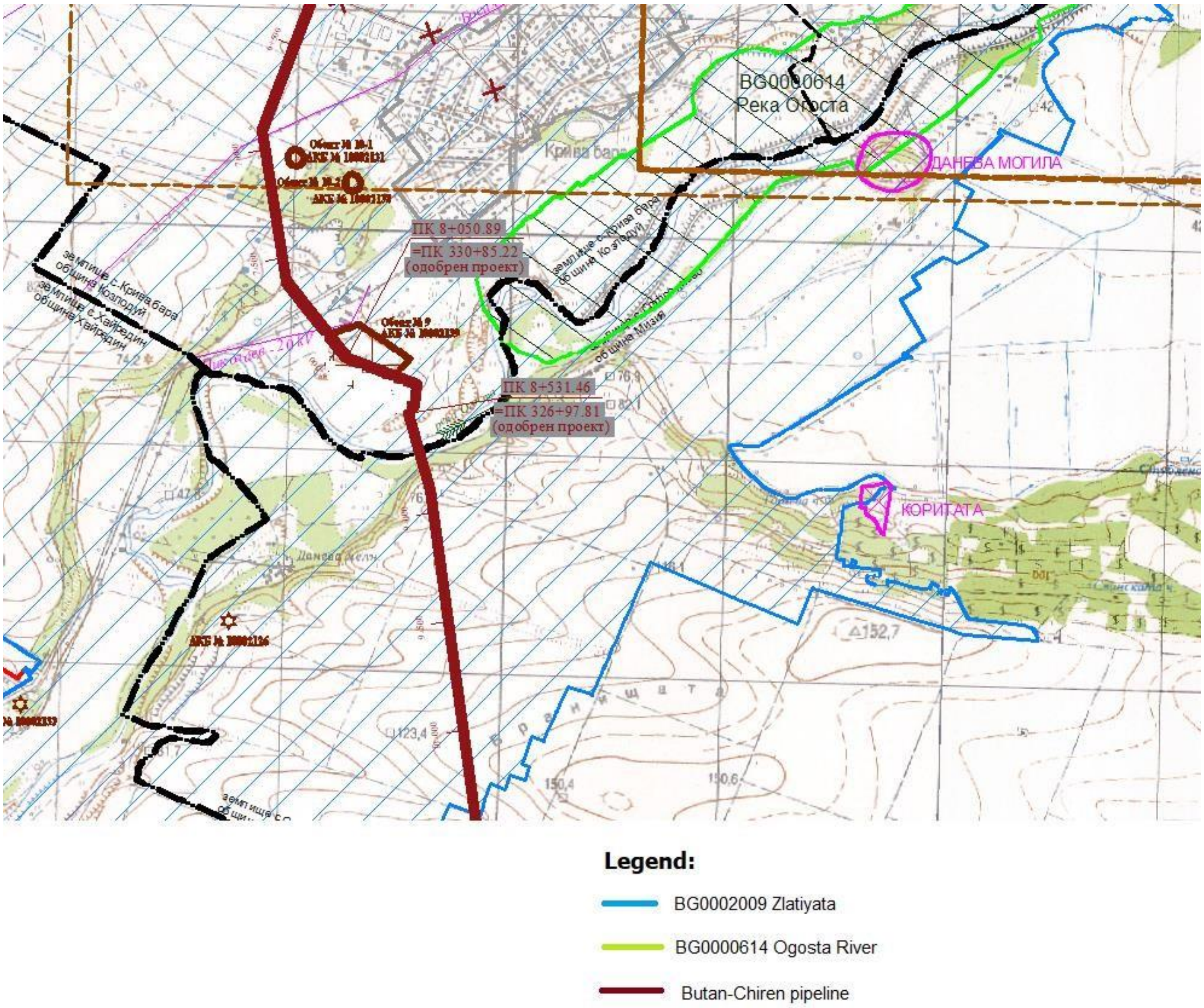
Storage and subsequent disposal of drilling mud is the most important of the essential obligations of the construction contractor in terms of environmental protection. In spite of the possibility of recycling the drilling mud during drilling operations, a large part of it must in any case be disposed of at the end of the job. To reduce the risk to a minimum and divide the responsibilities among the interested parties, it is necessary to identify as quickly as possible the potential future problems and request the necessary authorization for the use and disposal of drilling mud.

Other important issues in terms of environmental protection that will be considered at the preliminary stage, main or hollow transport pipes, underground dumps that contain hazardous materials and the risk of creating pathways for infiltration from contaminated areas.

The information included in this chapter is based on the available information so far and does not include information and specifics of the detailed design which is currently undergoing. It will be adapted (including schemes, maps) once the detailed design is finalized.

6.1. Impacts to biodiversity, riverine vegetation and protected areas.

The Ogosta river crossing of the gas pipeline route falls within the periphery boundaries of a protected area within the meaning of the PAA- BG0002009 Zlatiyata for protection of wild birds, announced by Order No. РД-548/05.09.2008 of the Minister of Environment and Water, amended by Order No. РД-69/28.01.2013 (promulgated SG, No. 83/23.09.2008 and No. 10/05.02.2013) and amended and supplemented by Order № РД-1039/03.11.2022 (promulgated SG, issue 89/08.11.2022) and is located about 600 m from the protected area BG0000614 Ogosta River for protection of natural habitats and wild flora and fauna, included in the list of protected areas adopted by the Council of Ministers by Decision No. 122/02.03.2007 amended by DCM No. 811 of 16.11.2010 (promulgated SG, No. 21/2007 and SG No. 96/2010);



During compatibility assessment within the meaning of Art. 40, para. 2 of the Ordinance on CA, it was established that Gas pipeline connecting Chiren UGS to the existing gas transmission network of Bulgartransgaz in the area of Butan village is compatible in relation to the regime of protected area BG0002009 Zlatiyata, determined by the announcement order of the Competent authority.

Considering the assessment of the likely degree of negative impact, the Gas pipeline project component, including the crossing of Ogosta river is unlikely to have a significant negative impact on natural habitats, populations and habitats subject to protection in the protected areas of the Natura 2000 network, as:

- The route of the gas pipeline connecting Chiren UGS to the existing gas transmission network at the crossing of Ogosta river is outside the boundaries of protected areas BG0000614 Ogosta River, therefore there is no probability of direct or indirect destruction or damage to natural habitats and habitats of species subject of protection in protected areas.
- The Project implementation will not violate the integrity, structure and functions of the protected areas as construction works will affect an insignificant percentage of the area of protected area BG0002009 Zlatiyata only. A small area of the start point of the gas pipeline route (incl. crossing of Ogosta river) falls within the periphery of protected area BG0002009 Zlatiyata in a minimum extent - respectively 29.120 ha or 0.066% of its area.
- Achievement of the conservation objectives of protected area BG0002009 Zlatiyata will not be hindered given that no changes will be induced in vital factors determining the functions of the habitats or ecosystems used by bird species subject to conservation. Such the construction activities will be executed only outside the breeding period of the birds (March-June).
- The route crosses protected area BG0002009 Zlatiyata in a peripheral section, so implementation of the Ogosta crossing will not lead to fragmentation of populations of bird species protected in the area.
- Implementation of the Project is unlikely to lead to fragmentation of migration corridors of species subject to conservation in protected areas, which may lead to a change in the number and structure of their populations, as during its implementation the removed humus layer will be temporarily deposited within the boundaries of the construction strip and after completion of the excavation works, formation of trenches for laying the gas pipeline, the technological communication connection and the site facilities, trenches will be backfilled and recultivation of the construction strip will be performed, i.e. almost all the affected area will be restored after finishing construction works;
- The temporary nature and the method of implementation of the activities of Project implementation do not imply eviction or permanent disturbance, which would lead to a change in the number, density and structure of the populations of animal species, including birds, subject to protection in the protected areas.
- The habitats of the species of birds, mammals, amphibians, reptiles and invertebrates subject to protection in the protected areas will not be affected by implementation of the gas pipeline, as after laying the pipes, the terrain will be completely restored to its original form.
- The implementation and operation of the Project will not result in generation of emissions and waste in types and quantities that have a significant negative impact on natural habitats, populations and habitats of species subject to conservation in the protected areas.
- It is unlikely the realization of the Project to lead to accumulation of cumulative impacts of negative effect on the protected areas and their subject of conservation.

According to the opinion of Basin Directorate Danube Region (Outgoing No. ПУ-01946(1)/20.12.2022), the Project implementation will not have a significant impact on water and aquatic ecosystems and is permissible in relation to the environmental protection objectives set out in the River Basin Management Plan (RBMP) 2016-2021 and the Flood Risk Management Plan (FRMP) 2016-2021.

In addition, the drilling sites will be located outside the vicinity of the riverbed and river banks in flat terrain, mostly used as agricultural land. The most significant environmental impact here results from the need to dispose the drilling mud and cuttings upon completion of the works. As a preliminary information it may be said that the expected cuttings are not to be expected of large volume and mainly of bushes.

7. Monitoring and Mitigation measures

BTG has committed to the following mitigation measures to avoid/ minimize risks to environment related to the Ogosta river crossing (to be reviewed after finalization of the detailed design):

Before start of drilling, a detailed geological survey of the geological structure of the Ogosta River will be carried out, which is part of the detailed design of the crossing.

- Laboratory samples of the geological material will be taken in order to guarantee that during drilling there will be no difficulties or impossibility of drilling due to unsuitable geological conditions.

- The restoration of the construction site will be done with native plant species only to avoid loss or disturbance of important animal and plant species part of the river's ecosystems.

- The drilling rig and all the equipment will be inspected and checked before commencement of drilling to ensure safe operation.

- Personnel induction and strict compliance with the drilling technology in order to avoid deviations from the established technology; - Development of an action plan in case of failure.

- Strict monitoring of drilling fluid parameters, pressure and possible loss of bentonite and undertaking immediate interruption of the process.

- Periodic inspection of the gas pipeline route in the process of operation to identify possible damages.

- A detailed briefing will be held of the participants in the construction works in order to prevent impacts, such as damage and destruction of plant and animal species within the drilling scope.
- The Ogosta River crossing will be carried out outside the breeding period of the birds (March-June).

- Following drilling completion, the two drilling sites shall be recovered to their original condition, the soil and humus layer will be restored, and they will be suitable for agricultural use again.

- Identify as quickly as possible the potential future problems for disposing the drilling mud and request the necessary authorization for the use and disposal of drilling mud. - At the end of the works, the Contractor will provide for clearing of the working area and its restoration to its original condition, by performing all the works of restoration and cleaning up of the areas involved in HDD operations to ensure no net loss of any natural habitat occurs.

8. Conclusion

HDD is the most non-destructive method of crossing water bodies that does not affect the borders of the water body, and accordingly does not affect the animal species inhabiting the river, as well as the plant species. Based on the preliminary available data and the ongoing efforts of the Project company to proceed with detailed design and its' commitment to adhere to best engineering practices and environmental legislation and protection according to national law as well as IFC PS and international standards for the project implementation NO NET LOSS of any natural habitat is expected to occur at the river crossing point of the Ogosta river by the gas pipeline from UGS Chiren to the village of Butan. This report and conclusion will be revised and integrated once detailed design information is available.