HOCHTIEF UK CONSTRUCTION

SNOWDONIA VISUAL IMPACT PROVISION PROJECT

PLAN OF ADVANCE – TBM drive

C0233-HUK-GES-ZZ-PL-W-0001

Project No: **9.100.1.233**	Issue: **Rev P01**
	Date: **13/03/2023**

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Revision	Date	Prepared	Checked	Approved	Reason for Issue
P01	13/03/2023	M Gohlke	D. Grantham	L Bayer	For Information

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1.0 Introduction

The Snowdonia VIP (SVIP) Project will enable a visually intrusive 3.5km section of National Grid's (NG) 400kV (and 132kV) overhead line (OHL) to be buried underground within a cable tunnel.

The new cable tunnel will stretch from a location close to Sealing End Compound (SEC) at Garth on the western side of the Dwyryd Estuary to the eastern side of the estuary at Cilfor (see Figure 1 below).

The Project will include the construction of:

- a tunnel with shafts at either end of the tunnel;
- tunnel head houses (THH) with permanent access at either end of the tunnel;
- SEC at the eastern side of the Dwyryd estuary;
- electrical infrastructure laid within the tunnel;
- new high voltage cables connecting the Garth SEC to the new SEC at Cilfor.

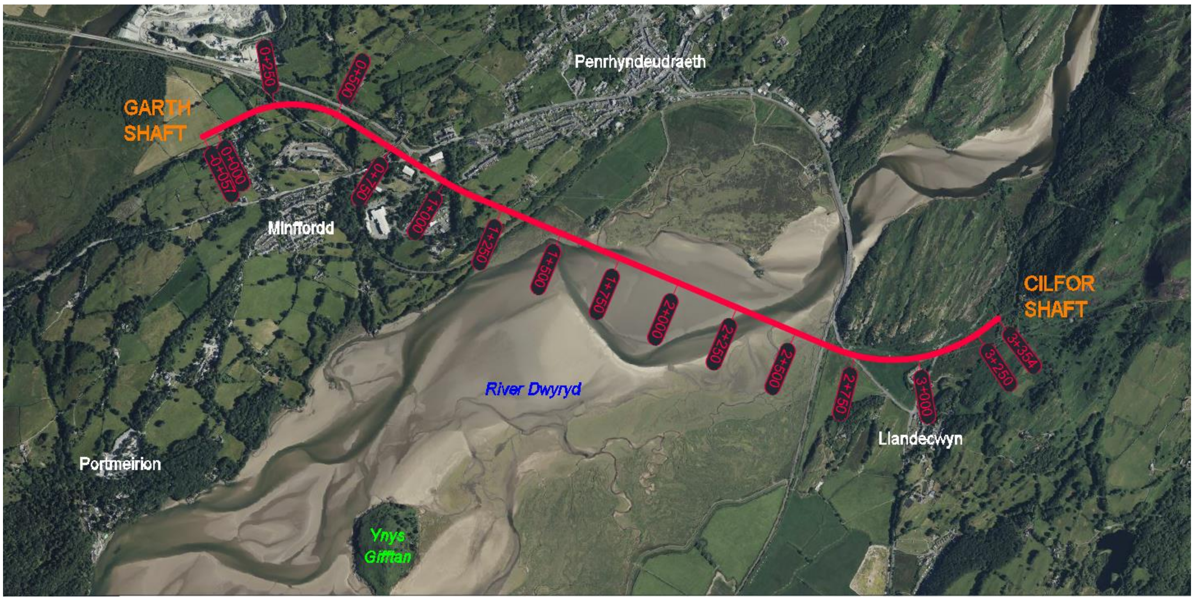

Figure 1: Overview Snowdonia Visual Impact Provision Project

The SVIP Project is led by NG as the Client, with HOCHTIEF (UK) Construction Ltd. appointed as the Design and Construction Contractor for the tunnel works. The SVIP Project obtained planning permission in December 2021 from both Gwynedd Council (GC) and Snowdonia National Park Authority (SNPA).

The existing SEC at Garth and the western construction compound is within GC's planning jurisdiction. The new SEC at Cilfor and the eastern construction compound is within SNPA's planning jurisdiction.

2.0 The Tunnel Boring Machine

The tunnel will be excavated using a refurbished Slurry Pressure Balance Tunnel Boring Machine (TBM) with the following characteristics:

- Cutting Diameter 4295mm
- Tunnel Diameter 3500mm
- TBM type Slurry TBM
- Manufacturer Herrenknecht AG / Germany

- Average advance rate 15.1m/day
- 24/7 regime
- Maintenance carried out on the 7th day

Figure 2: Slurry TBM

3.0 Outline description of the TBM's tunnel construction process

The TBM's rotating cutter head will be propelled forward by rams thrusting against the previously installed precast tunnel ring. Each 1.2m wide section of tunnel ring will be made of six tunnel segments.

There will be an annular gap of 150mm between the outside of the tunnel segments and the cut diameter. The annulus will be filled using a two-component grout. This grout will be pumped through grouting ports located in the rear tailskin and grouting of the annulus will occur during the TBM excavation advance.

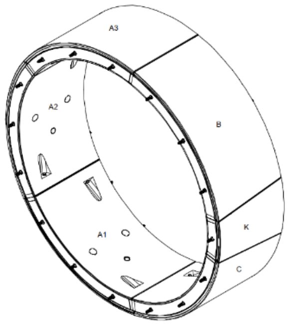

Figure 3: 3D Isometric View on Ring from Trailing Edge

Excavated material will be mixed with water pumped into the TBM to create a slurry. The slurry will be pumped back to a slurry treatment plant (STP) in the Garth construction compound. The STP will separate the slurry's water from the excavated material. The water will be reused in the TBM and the excavated material will be transported off site. Four booster pump stations will be installed at 1000m intervals to pump the slurry as the tunnel progresses

4.0 Expected Geology

The TBM will pass through several distinct ground conditions:

- Ch. 0+022 – Ch. 0+075 – Tidal Flat Deposits
- Ch. 0+075 – Ch. 1+300 – Dol-Cyn-Afon Formation
- Ch. 1+300 – Ch. 1+450 – Dolgellau Formation
- Ch. 1+450 – Ch. 3+165 – Ffestiniog Flags Formation
- Ch. 3+165 – Ch. 3+354 – Maentwrog Formation

Figure 4 and 5 below summarise the geology of the SVIP tunnel drive.

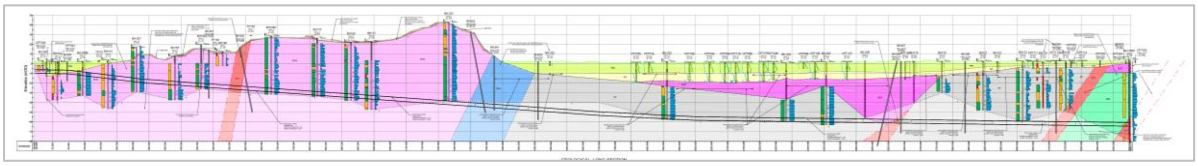

Figure 4: Geological Longitudinal Section

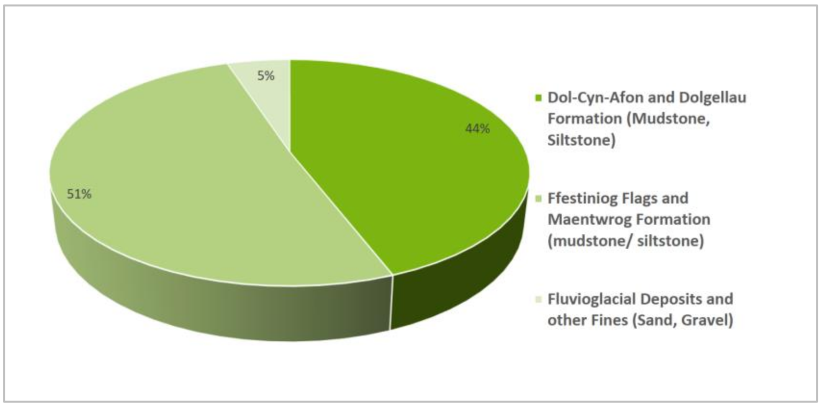

Figure 5: Proportion of geological formation to be excavated

5.0 TBM Plan Of Advance

A mix-shield TBM can be used as a slurry-shield or a compressed air shield. The mix-shield TBM consists of a steel cylinder which is a few centimetres larger than the outer diameter of the tunnel lining (see Figure 6). At the front of the TBM is the cutter head. Behind the cutter head is the pressure chamber or excavation chamber which is divided by a submerged wall. The slurry rises behind the submerged wall and a compressed air cushion applies the necessary pressure onto the slurry to compensate for pressure fluctuations in this part of the machine. The excavated soil is mixed with the slurry and is pumped out at the bottom of the excavation chamber for separation at the slurry treatment plant outside the tunnel. For compressed air support, the pressure chamber is partly or fully filled with compressed air.

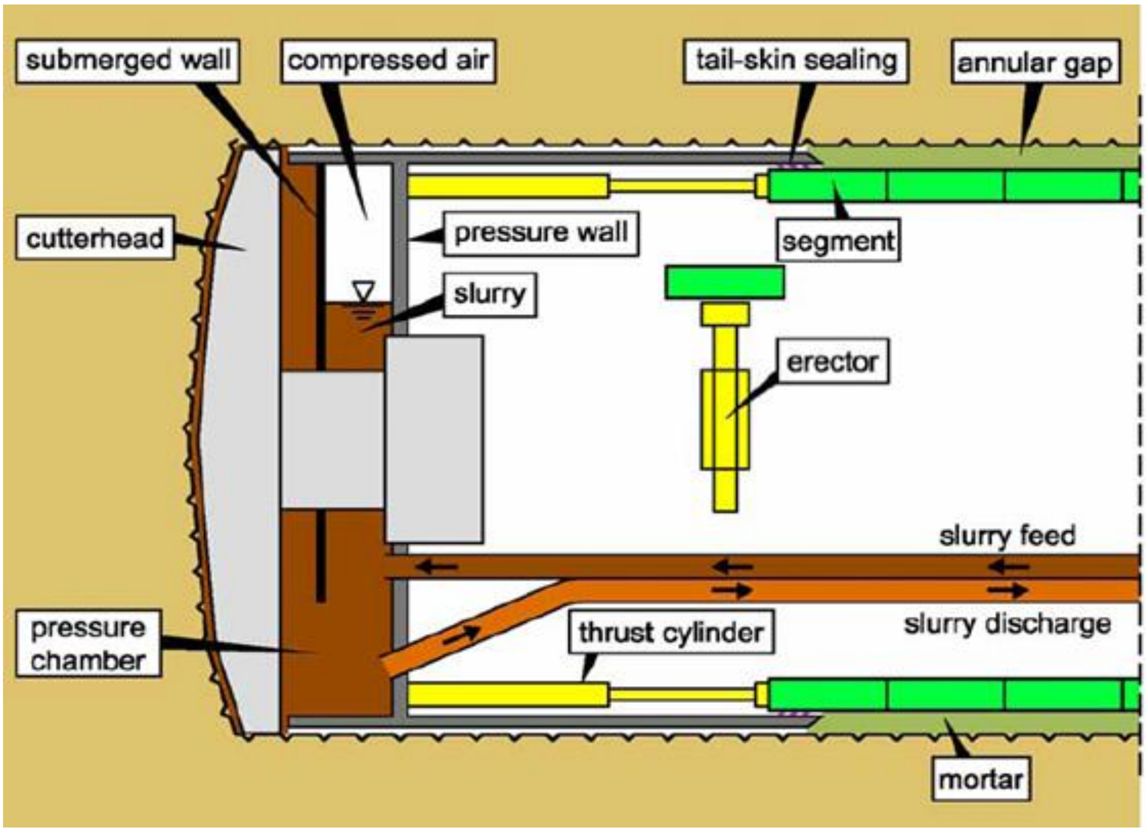

Figure 6: Schematic of Slurry TBM Operation

Behind the pressure wall are the thrust cylinders which jack against the previously placed segmental ring. For the TBM launch the thrust cylinders will push against a temporary support until the first permanent ring is built.

Face Support Pressure

A Slurry TBM maintains the stability of the tunnel face with a combination of compressed air and the level of slurry in the working chamber. The slurry filled working chamber and a compressed air cushion are moderated to balance the external forces at the tunnel face. This prevents groundwater entering the tunnel via the tunnel face.

The slurry volume in the cutting face can be reduced to enable maintenance. This is done by increasing reliance on compressed air pressure. This shown schematically in Figure 6 below.

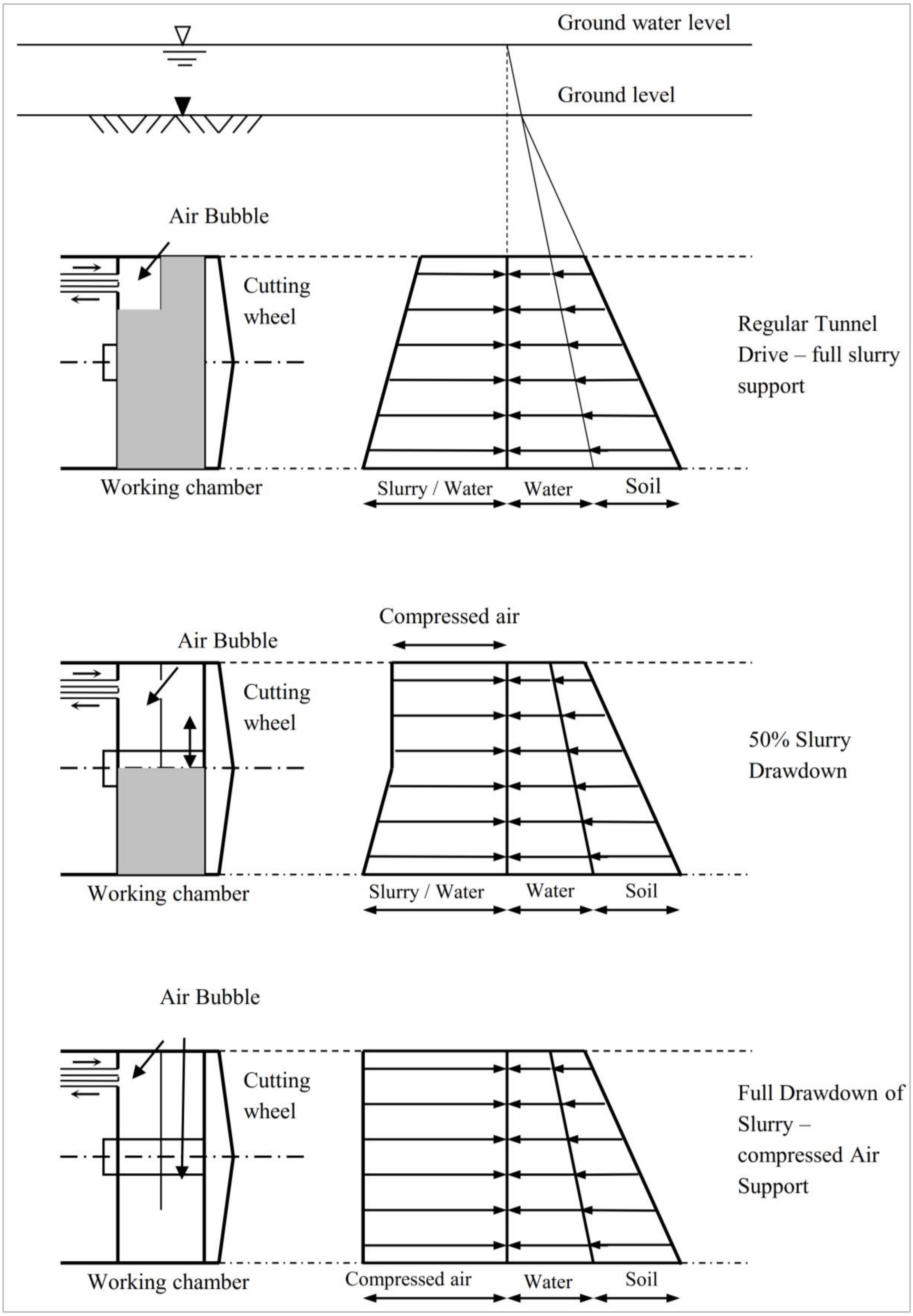

Figure 7: Operational Stages for the support of the tunnel face showing regular drive and maintenance phases.

Annulus Grouting

A+B component grouting will be adopted. Component A consists of: cement; bentonite; water and admixtures mixed to a liquid state and Component B, sodium silicate, acts as an accelerator for quick hardening.

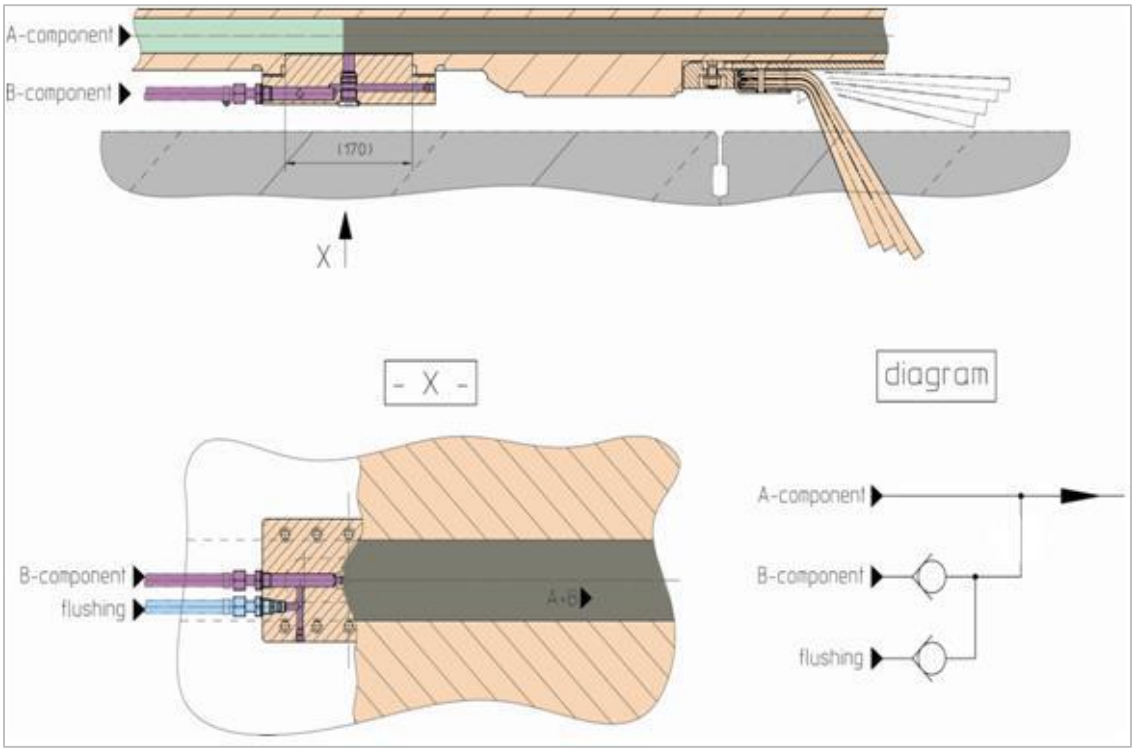

Figure 8: Principle of the grouting in the tail skin

The injection of grout is essential to prevent settlement of ground within annular tail void which could otherwise displace tunnel segments. The theoretical grout volume to fill the gap between bored diameter and outer ring diameter is 2.4 m^3 per advance of 1.2 m (one complete ring). The grout is injected into the annulus via four grout ports in the tail shield. Each grout port is served an independent grout pump.

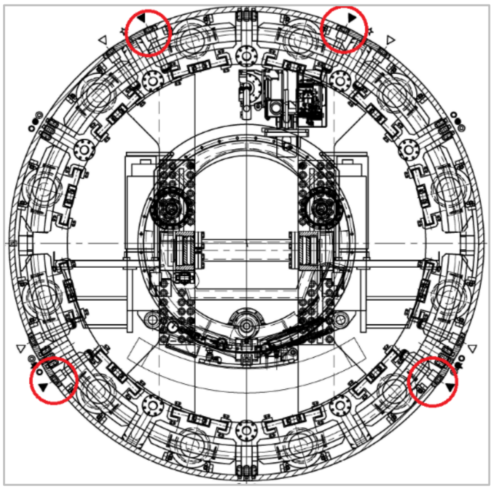

Figure 9: View of grout line positions

Tailskin Sealing

During the advance of the shield, the tail skin has to be sealed against the tunnel rings to avoid slurry and grout coming into the pressurised working area.

The seal is made with four parallel rows of steel wire brush elements sandwiched between two steel plates. The brushes and the openings between them are filled up with special sealing grease. A row of spring plates prevents ingress of grout between the tail skin and the surrounding earth.

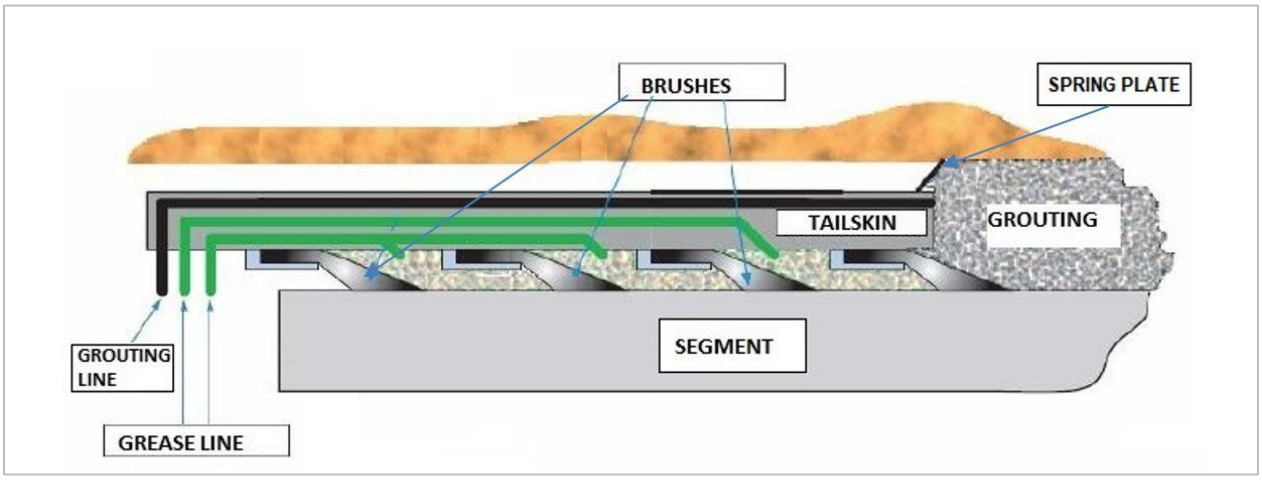

Figure 10: Schematic View of Brush/Spring Plate Arrangement

When sliding over the built-in segments, the brushes and the grease come into contact with the rough outer surface of the segments so that the grease sticks to the concrete and seals it. A proportion of the grease will be lost and is refilled automatically by a grease pumping system in the TBM.

Figure 11: Picture of Tail Skin Sealing Element