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Das Tapovan – Vishnugad Projekt – Maschineller Vortrieb unter extremen Bedingungen

Johann Brandl – Geoconsult ZT GmbH, Austria

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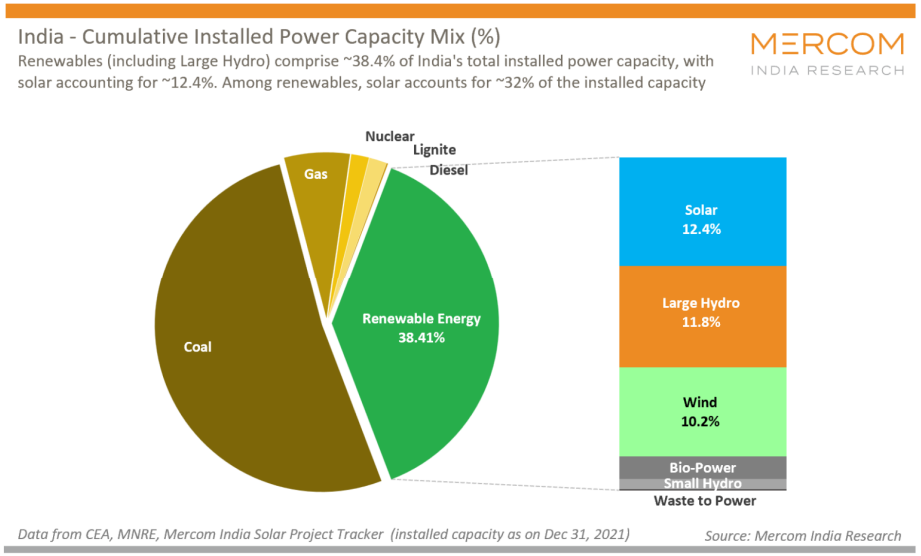
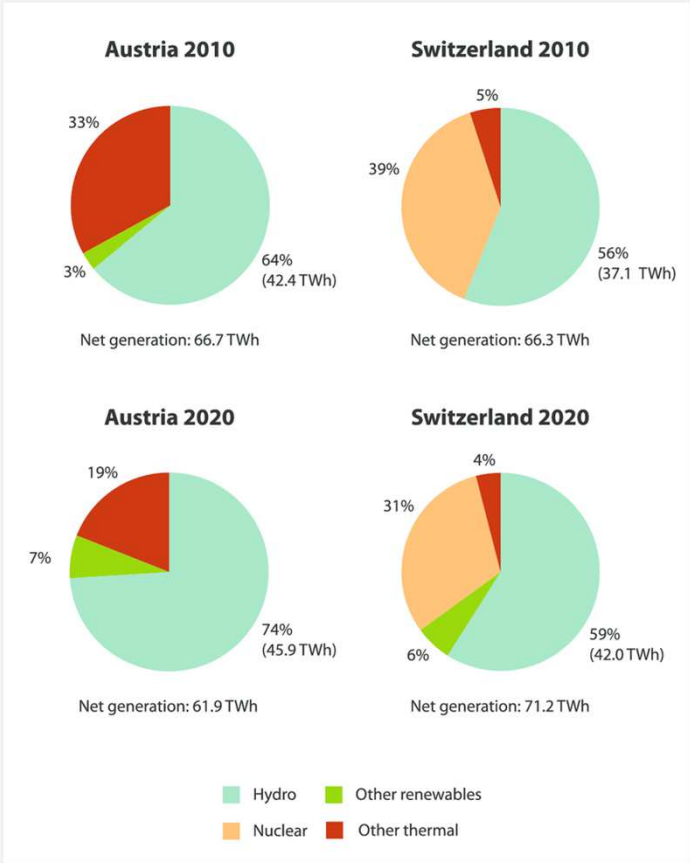
Energy Generation in India

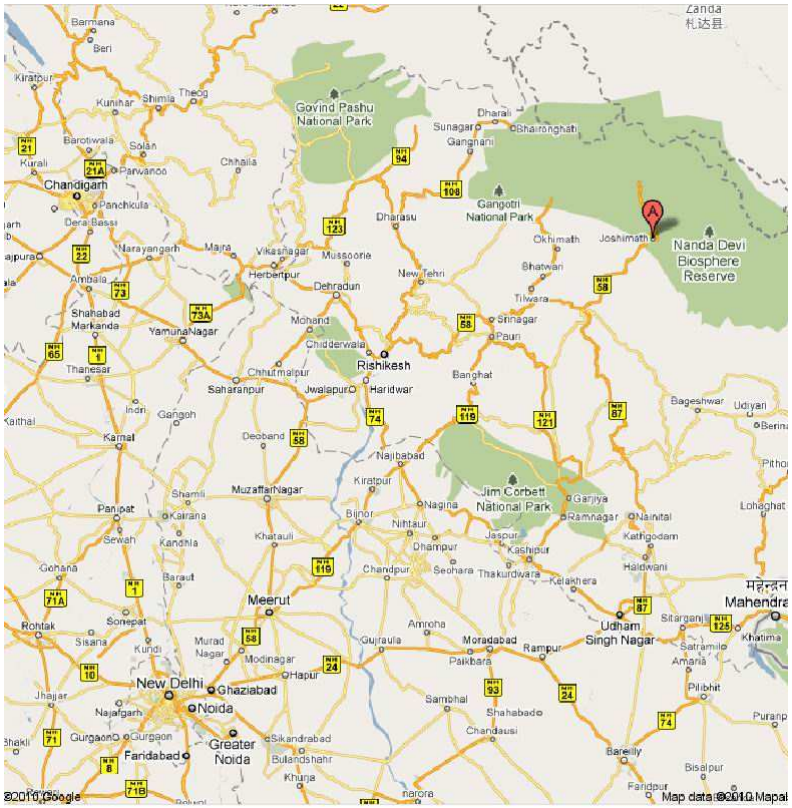


Estimated Hydropower Potential:
149.000 MW
Currently realised: 46.500 MW
Total Energy consumption:
482.000 MW (2022)



Source: https://www.researchgate.net/figure/Power-generation-mixes-for-Austria-and-Switzerland-in-2010-and-projected-for-2020_fig2_303904643

Projektsgebiet und Erreichbarkeit



Projektsgebiet und Erreichbarkeit

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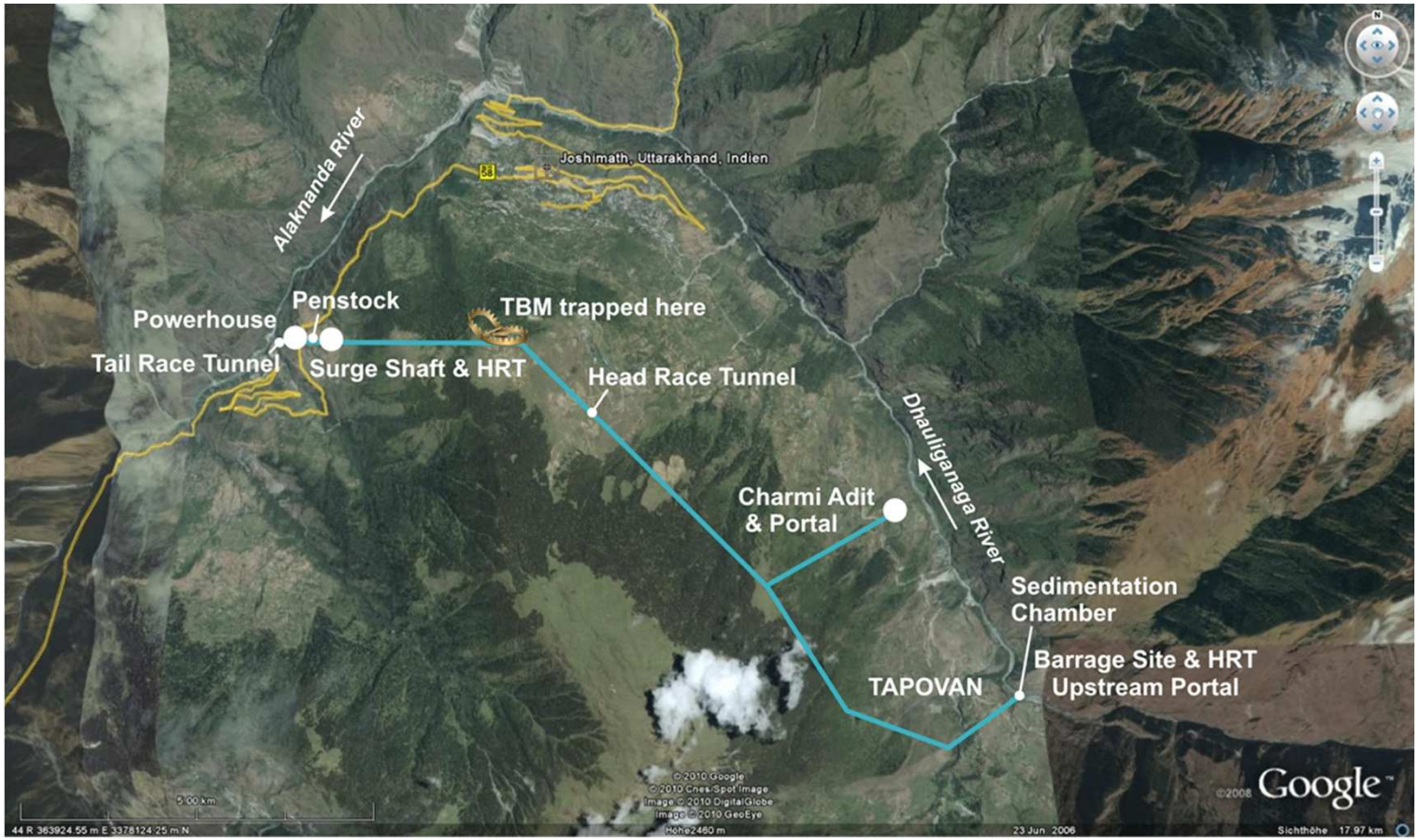
Projektslayout



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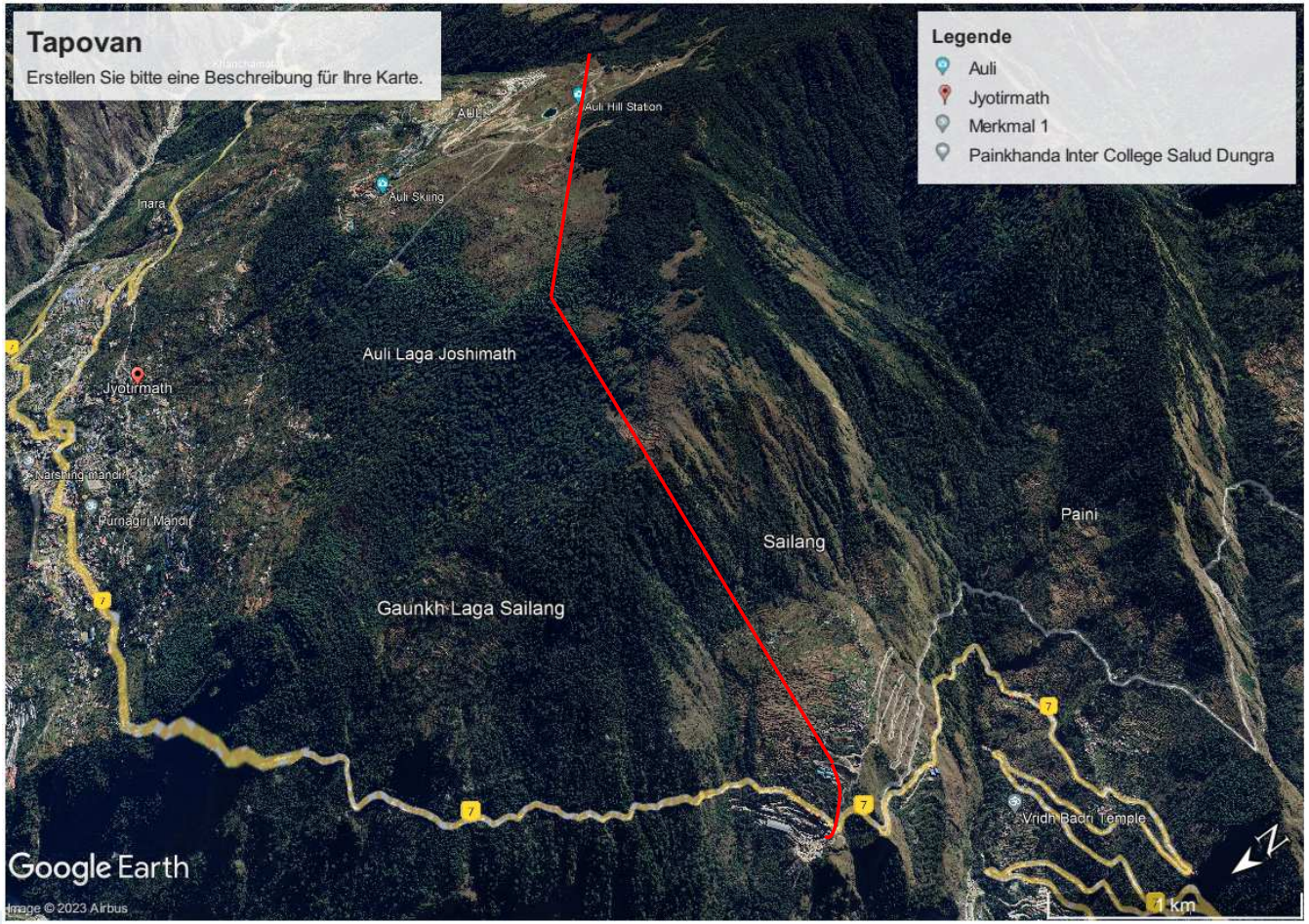
Tapovan
Erstellen Sie bitte eine Beschreibung für Ihre Karte.
Legende
Auli
Jyotirmath
Merkmal 1
Painkhanda Inter College Salud Dungra
Auli
Auli Hill Station
Auli Skiing
Inara
Auli Laga Joshimath
Jyotirmath
Narsing Mandir
Purnagiri Mandir
Sailang
Paini
Gaunkh Laga Sailang
Vridh Badri Temple
Google Earth
Image © 2023 Airbus
1 km


Tapovan TBM Adit
Legende
Auli
Jyotirmath
Merkmal 1
Painkhanda Inter College Salud Dungra
Google Earth
200 m

Technische Daten

- Capacity: 520 MW (4 x 130 MW)
- Headrace Tunnel: Internal Diameter 5.6 m, total length 12.1 km, 8.1 km with TBM , 4 km conventional excavation
- Powerhouse Cavern: Length 120 m, Width 22 m, Height 50 m
- TBM: Herrenknecht Double Shield TBM with 6.575 m Excavation Diameter

GENERAL	DATA
Machine type	TBM double shield
Total tunnel length	ca. 8.500 m
Installed power	3.581 kW
Length TBM + trailer	ca. 235 m
Weight TBM	502 t
Weight trailer	508t
Driveway	250 m

CUTTERHEAD / CUTTING WHEEL	DATA
Bore diameter	6.605 mm
Weight (with tools)	ca. 85 t
Disc cutters (individual)	38x
Disc cutters (double)	4x
Disc cutter diameter	432 mm
Track pitch	75 / 90 / 95 mm
Buckets	6x
Sprinkling	4x water

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Technical Data – Segmental Lining

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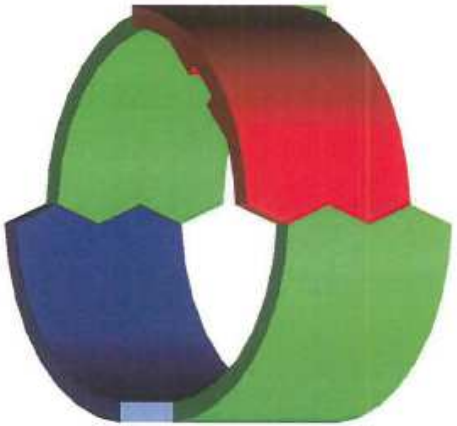
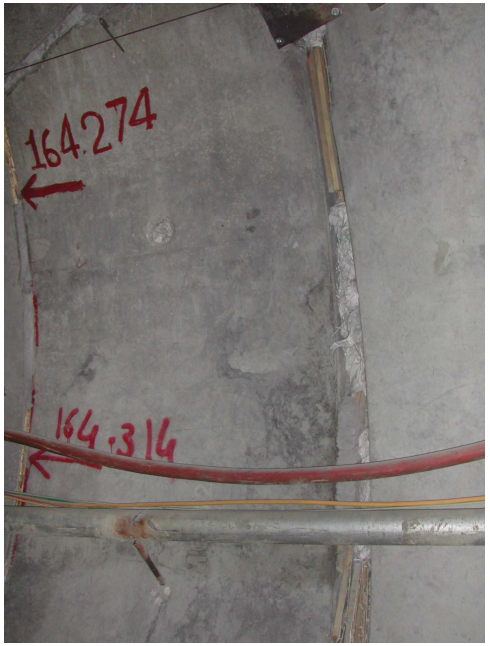
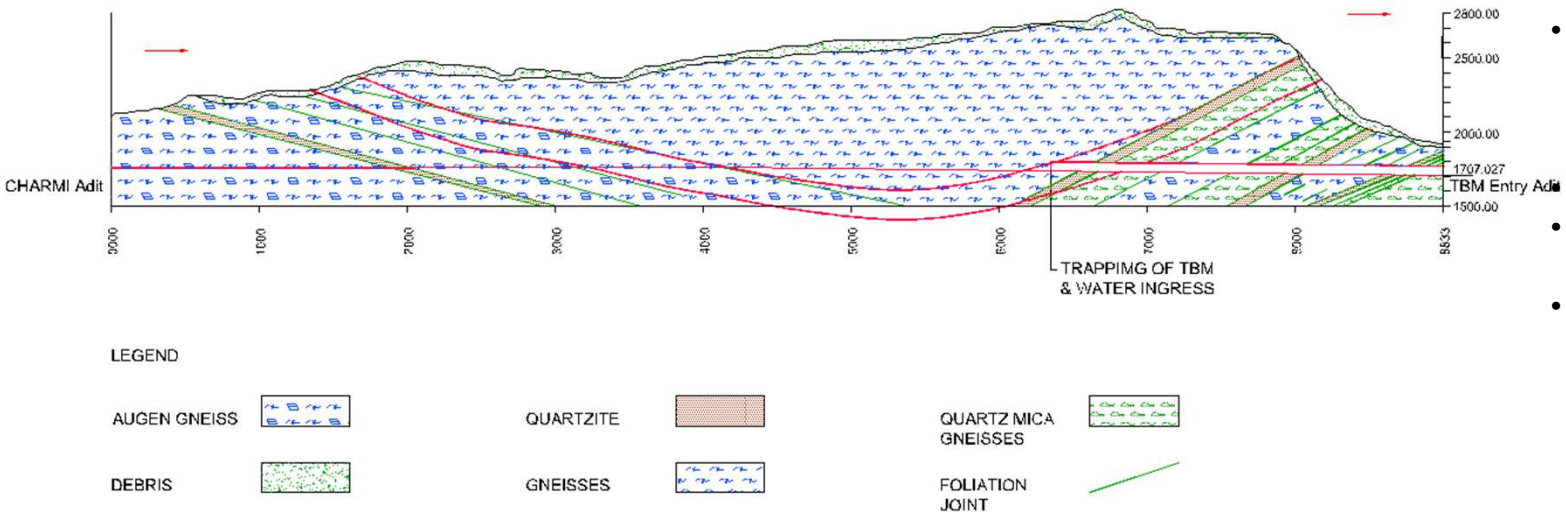




- Hexagonal Lining with thickness 300 mm
- Internal diameter 5640 mm
- Ring Length 1500 mm
- Concrete Quality M40
- Reinforcement Grade 90 – 100 kg/m³

Segmental Lining Impressions

Geological Conditions



- Highly metamorphic rocks such as Gneiss, Augengneiss, Quartztite Granatglimmergneiss, Augengneiss, Quartzite
  Overburden up to 1.100 m
- Only limited information related to fault zones
- Possibilities of rock burst and squeezing ground conditions

On the basis of limited surface and subsurface geological information, an attempt has been made to identify the tunneling conditions in different classes of rocks. About 80% of the head race tunnel is expected to be driven in very good to fair rock (i.e. Q-value >or = 4) conditions. The remaining 20% tunnel excavation may encounter poor to very poor rock conditions (i.e. Q-value < 4). The above classification is very preliminary in nature and is likely to change during excavation.

The geological investigations and study reports are indicative and for guidance only. If the contractor after visiting the project site feels need for additional investigations, the same may be done by the contractor at no extra cost to NTPC.

Squeezing Zones

Principle Idea: excavate through and „worry later“ (means any damages to the segmental lining is to be dealt with later but no stoppage of TBM!

			basis for design of segmental lining according to geotechnical report		not indicated at moment these are only hypothetic values	
		section	V		fault assumption 1 (20 % reduction of GSI+m+E)	fault assumption 2 (33 % reduction of GSI+m+E)
		chainage	km~9100-11400			
		rock mass description	foliated coarse grained garnet, gneiss with schist		schist / fault zone	schist / fault zone
	γ unit weight [kN/m^3]		27		27	
	h overburden < [m]		1100	150	1100	
	K_0 [-] lower bound		0,7		1,0	
	K_0 [-] upper bound		1,5			
	vertical in situ stress [kpa]		29.700	4.050	29.700	
	σ_c intact UCS [MPA]		65-75 (70)		56	46
	E intact [MPA]		15.000		12.000	10.000
	ν poisson ratio [-]		0,2		0,3	0,4
rock mass	Hoek-Brown criteria	GSI [-]	52		42	35
		m [-]	20		16	13
rock mass for structural analysis according to Hoek Brown criteria		friction angle [°]	39,2	54,16	32	27,5
		cohesion [MPA]	3,7	1,11	2,7	2,1
		UCS [MPA]	4,7	4,7	2,1	1,1
		global strength σ_{cm} [MPA]	15,6	6,9	9,7	6,9
		E [MPA]	5.000		2.200	1.100
squeezing potential according to Hoek		ratio σ_{cm}/p_0	0,52	0,23	0,33	0,23
		strain e [%]	0,73	0,07	1,85	3,60
		squeezing potential	minor	<minor	minor	severe

table 1 hypothetical rock mass values

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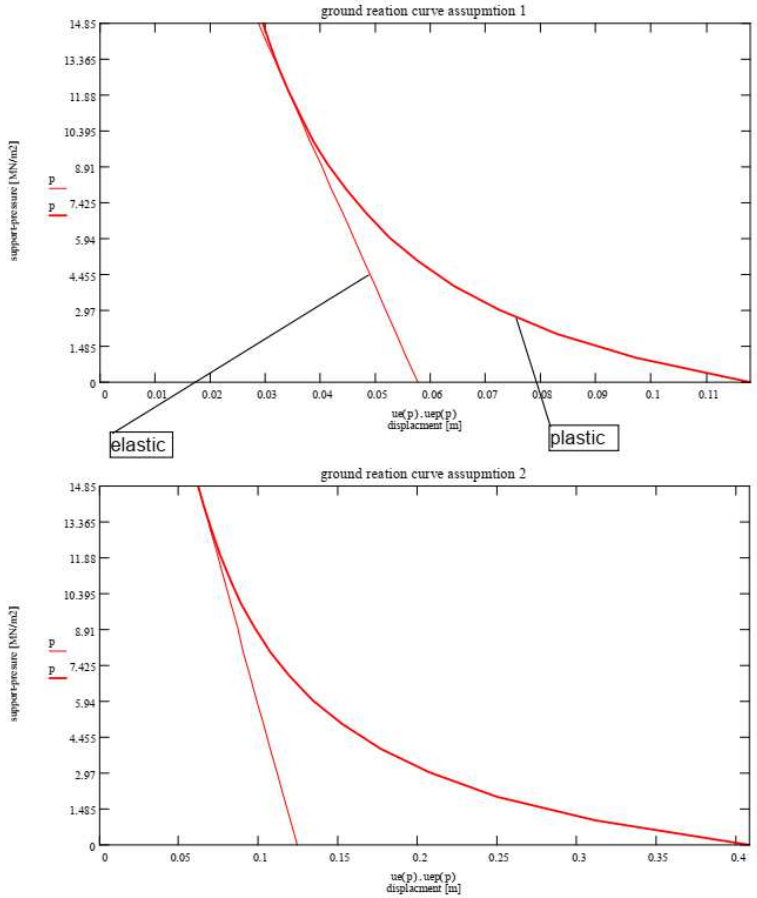
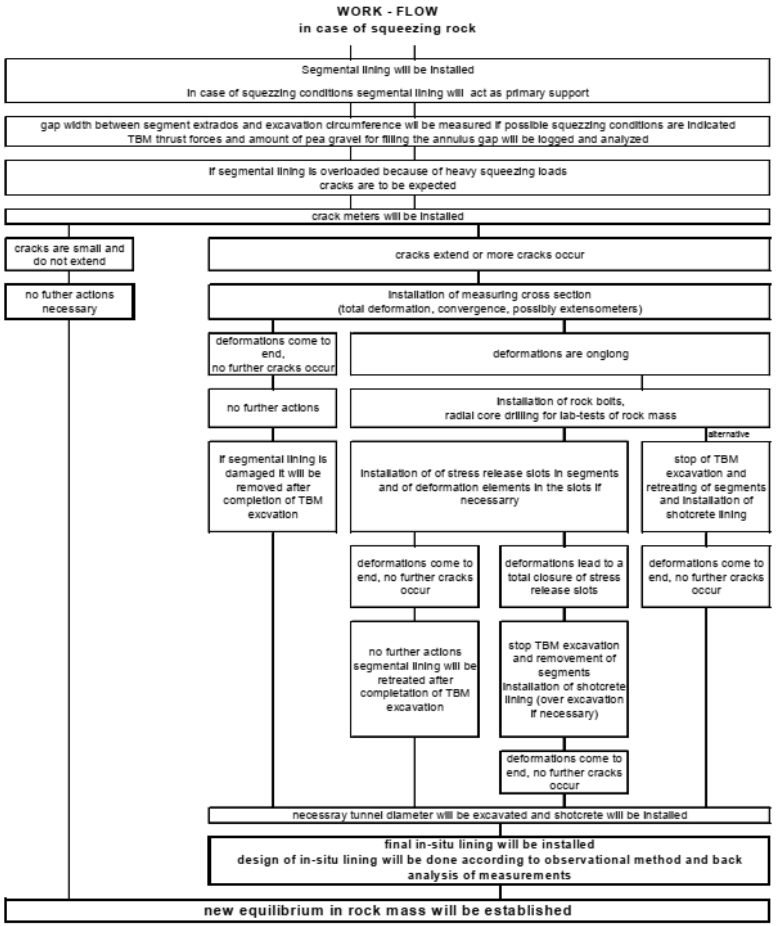
Squeezing Zones





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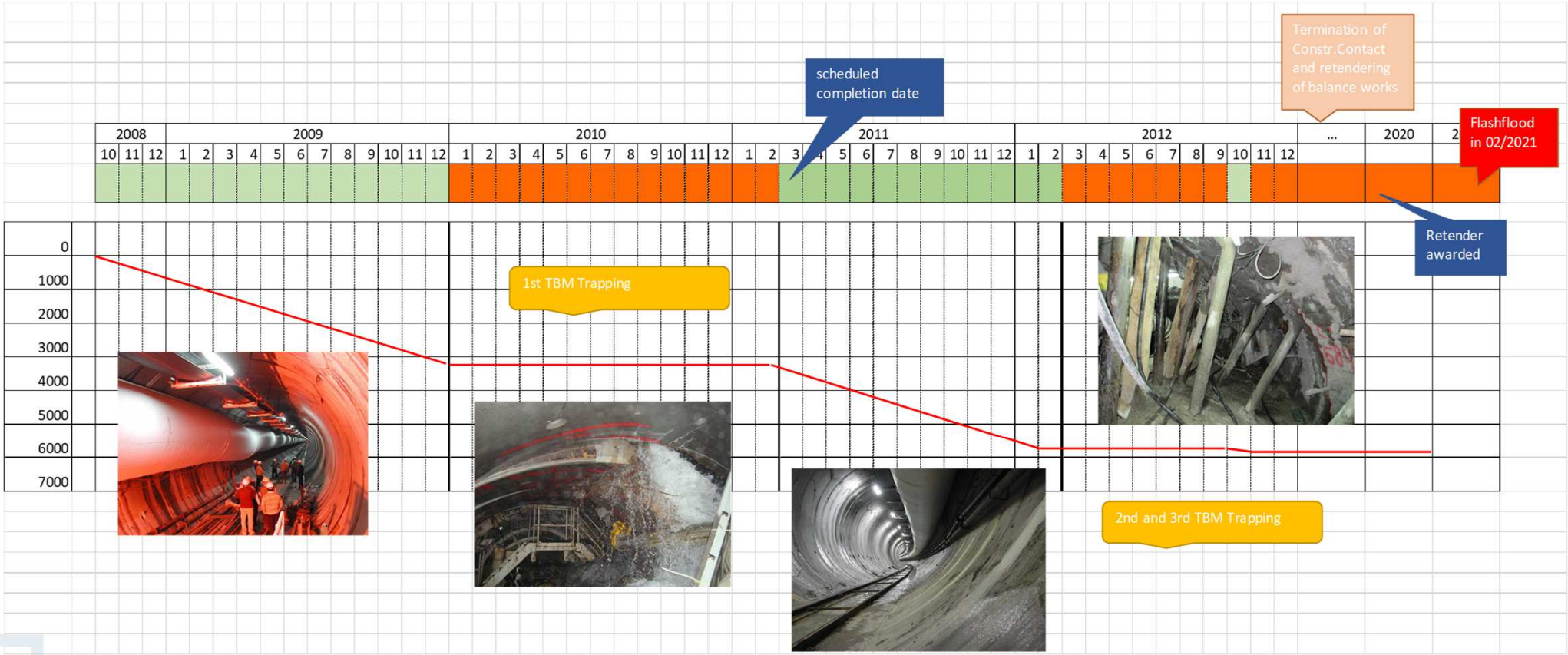
Summary of Project History



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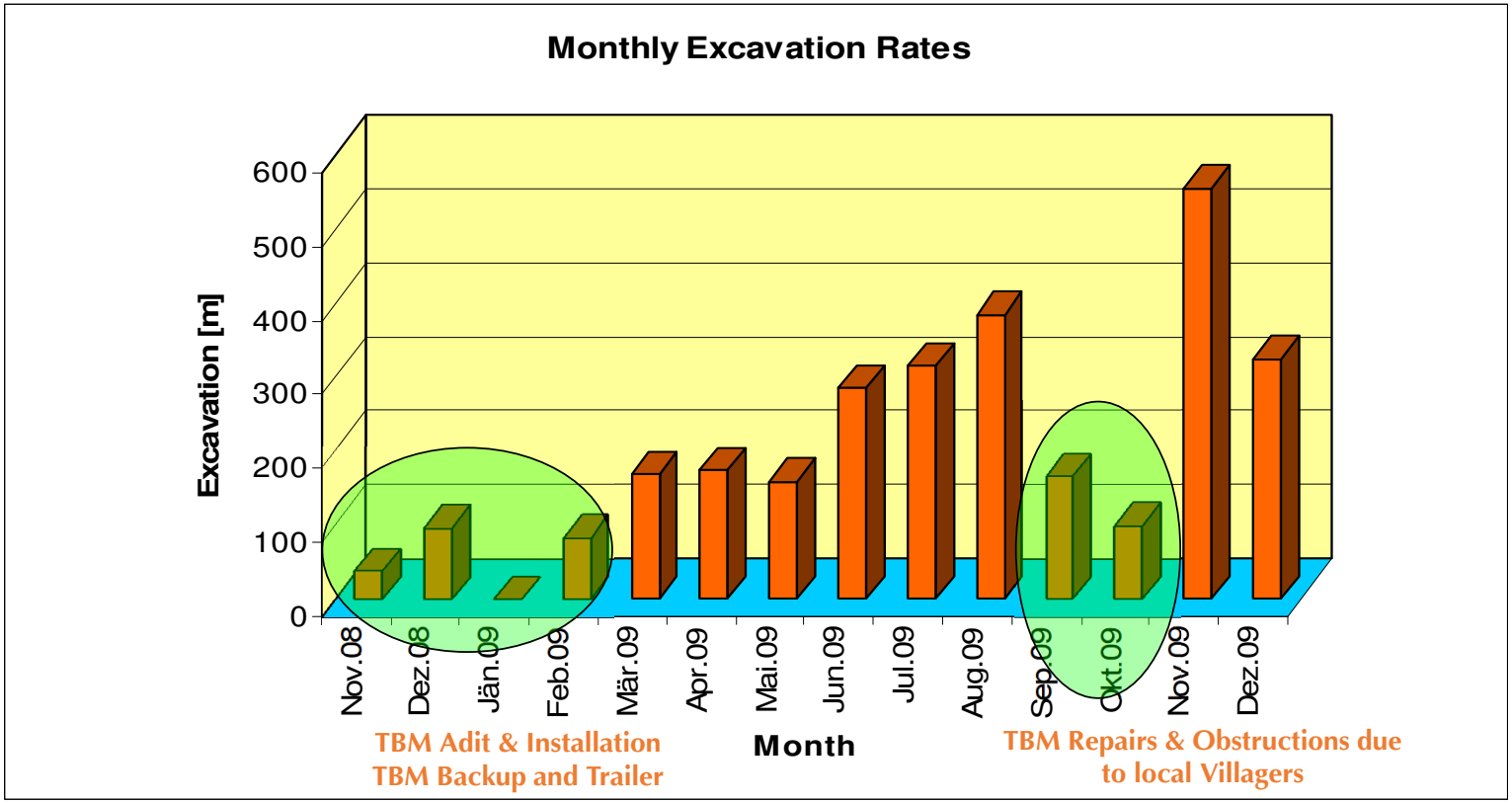
TBM Excavation Rates



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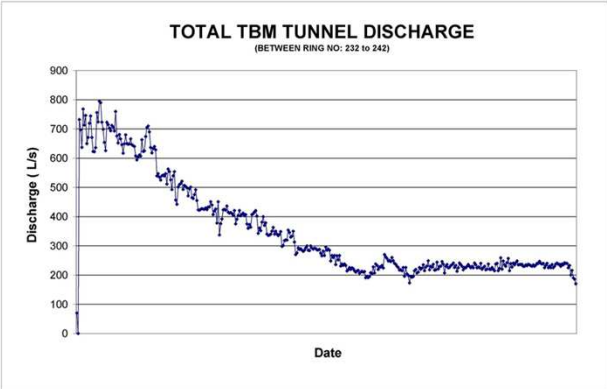
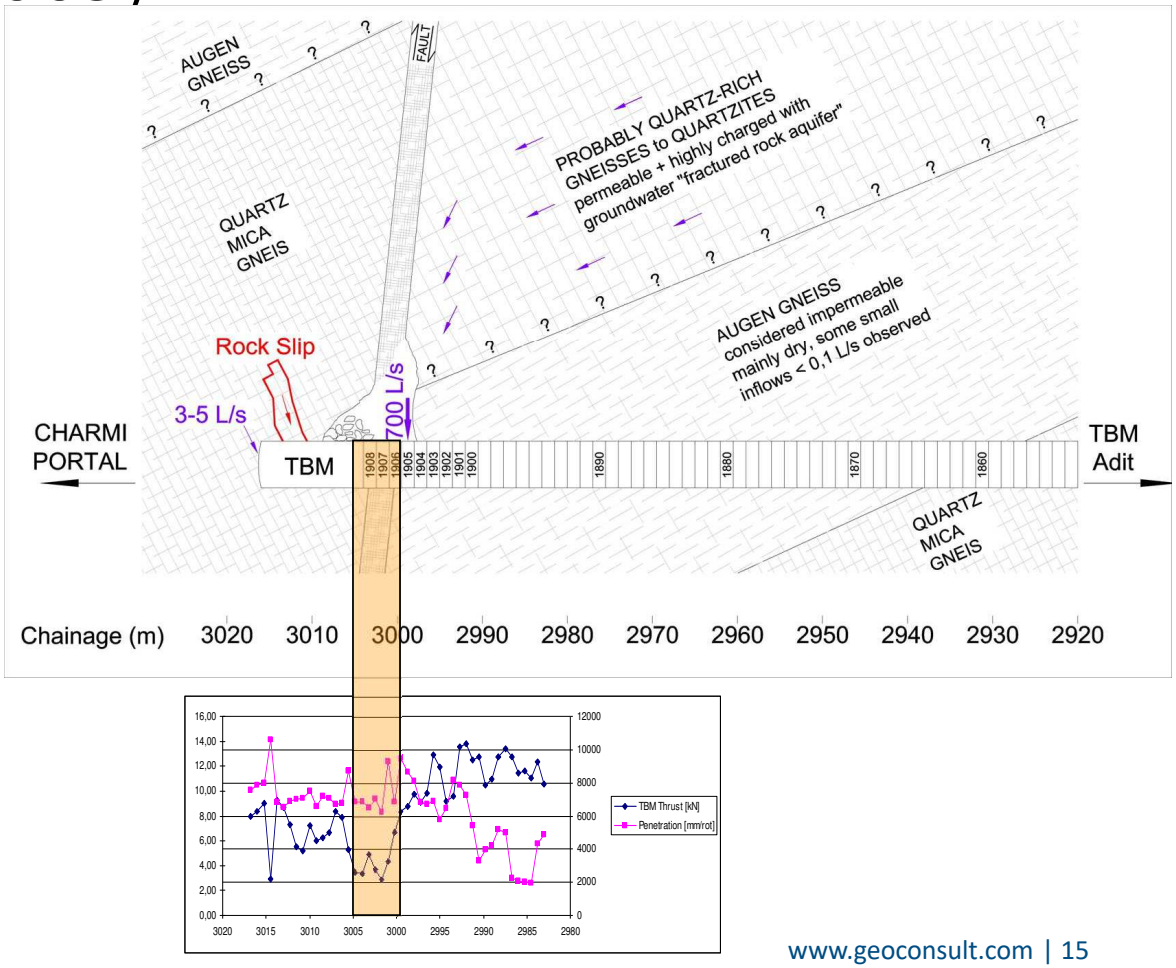
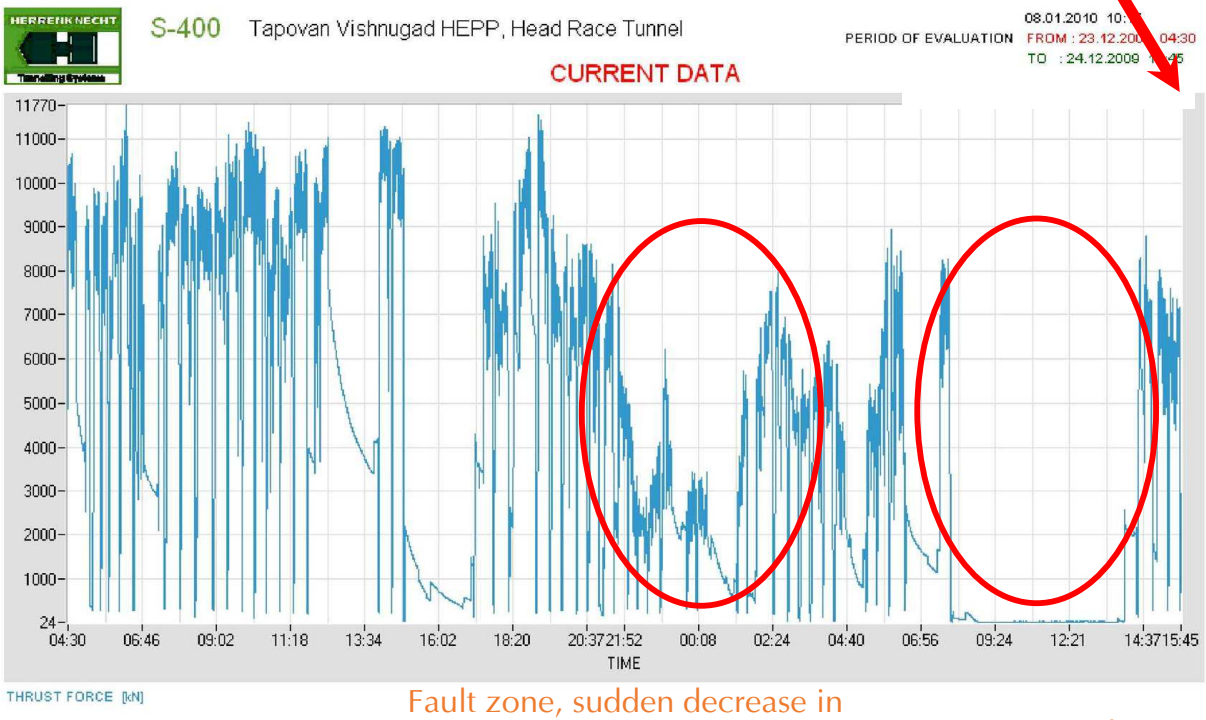
1st TBM Trapping (Dec. 2009)





1st TBM Trapping (Dec. 2009)

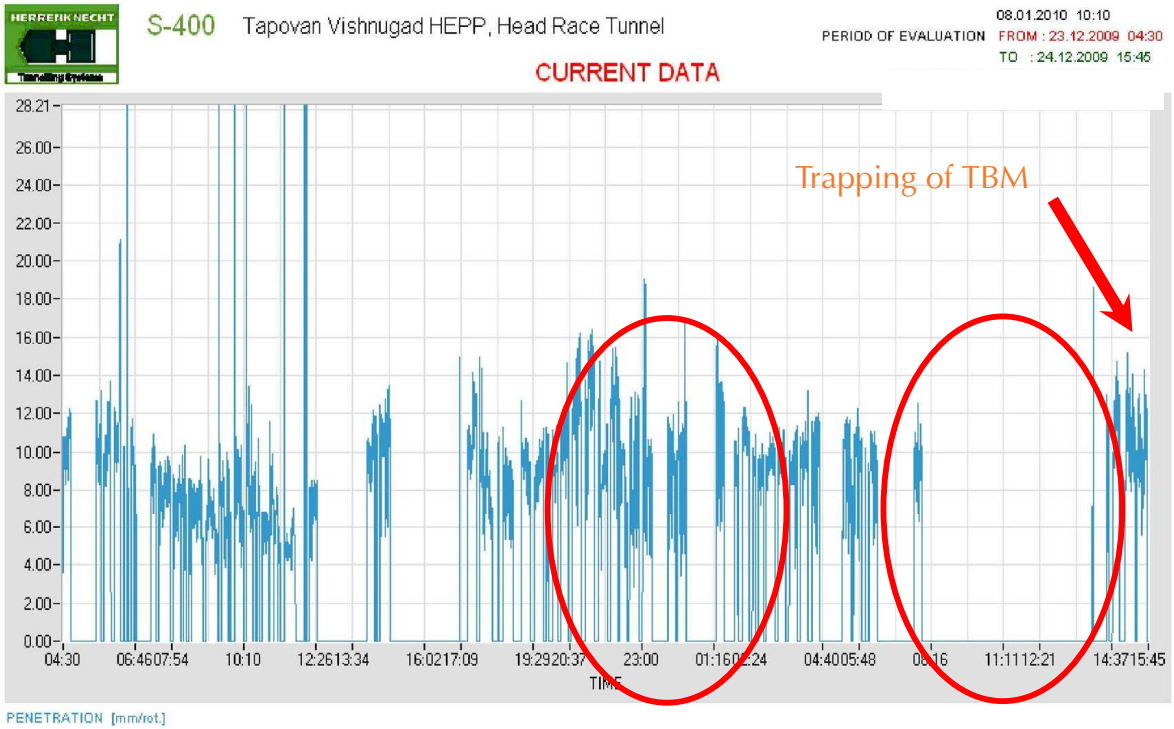
Trapping of TBM



Fault zone, sudden decrease in thrust to as little as 2000 kN

Cutter Change

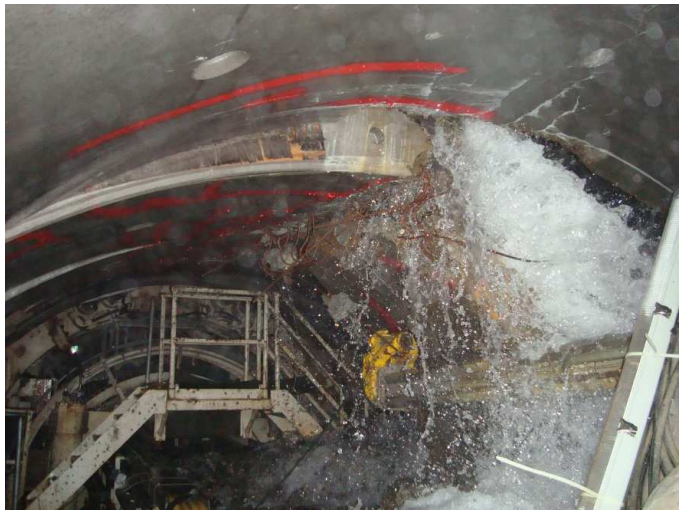
1st TBM Trapping (Dec. 2009)

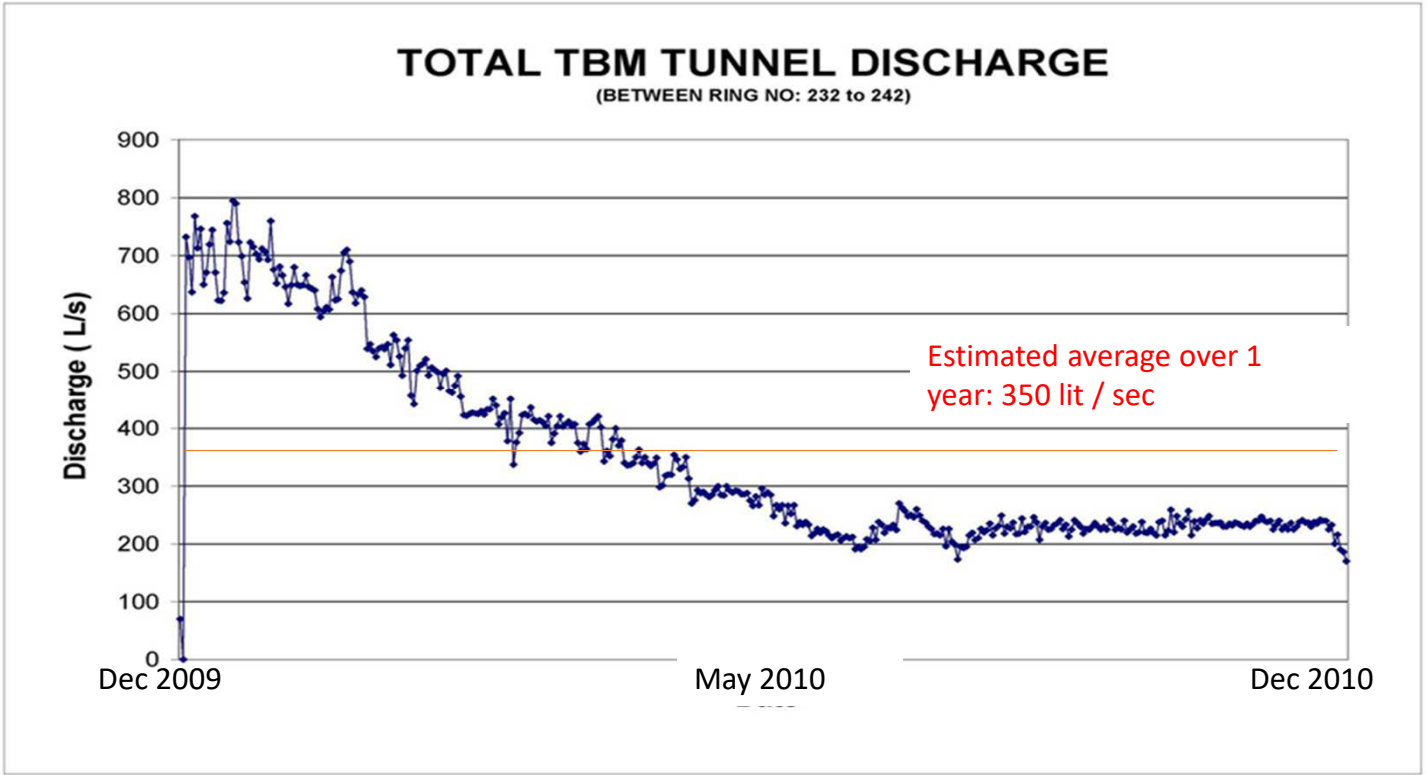


TBM penetration rate kept constant through fault zone

Cutter change

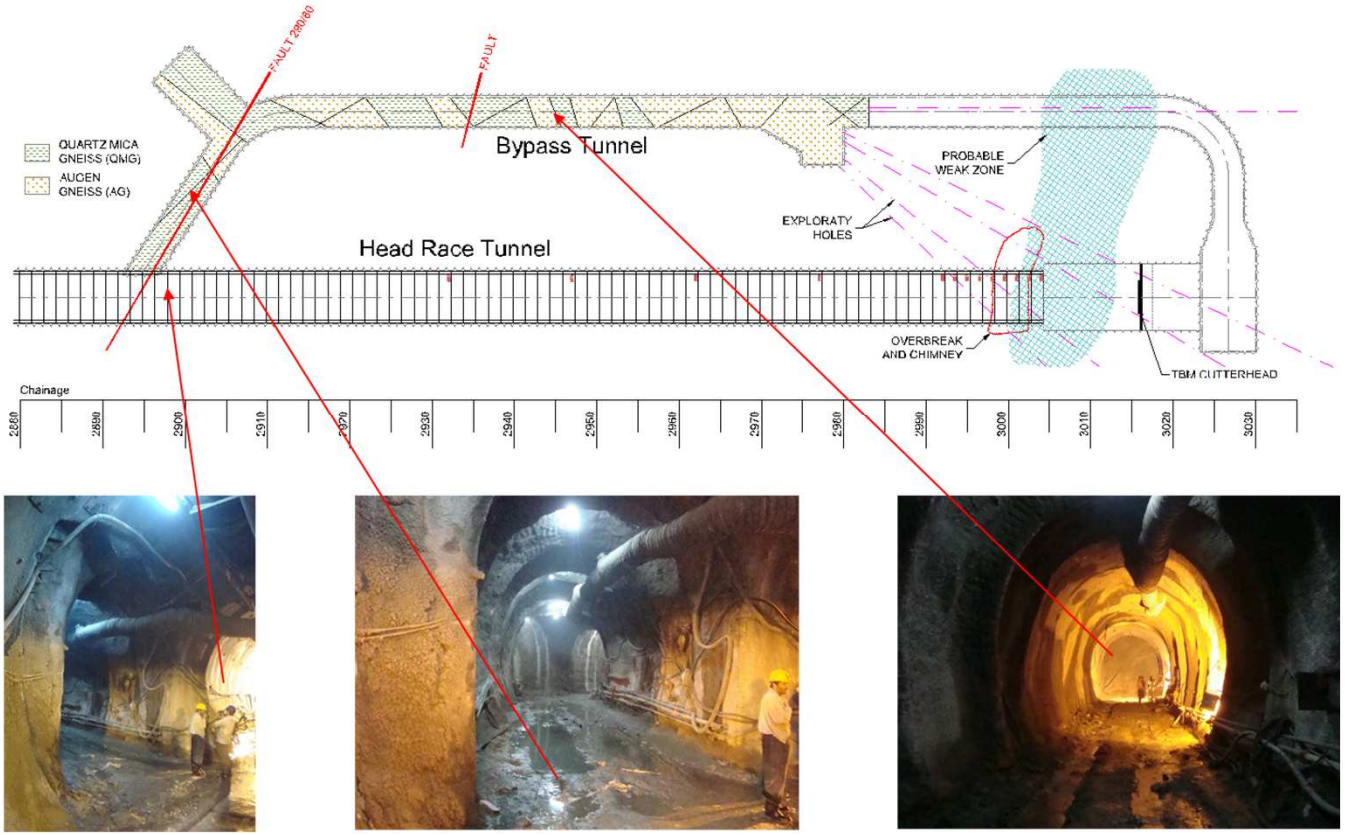
- Während des Durchörterns der Störungszone kam es zu einer massiven Überbruchbildung (Indikationen dafür: hörbarer Nachfall während Meisselaustausches sowie blockiges Ausbruchsmaterial mit Wechsel der Lithologie)
- Kernzone der Störung liegt zwischen Ringen 1904 und 1907
- Störungszone besteht aus tonreicher Brekzie, die aufgrund des Überbruches mobilisiert wurde und so den Schild verdrückte (braun gefärbtes, trübes Wasser in Verbindung mit Schlamm, Sand, Kies)
- Dadurch Freisetzung hochgespannten Wassers (> 80 bar Druck); Auswaschen des Perlkieses; nachfolgend Blockieren der Einblasöffnungen durch vom Wasser transportiertem kleinstückigen Gebirgsmaterial
- Versagen des Firsttübbings bei Ring 1905 durch aufliegendes Verbruchsmaterial sowie Wasserdruck (vorherige Wasseraustritte aus Einblasöffnungen blockiert)



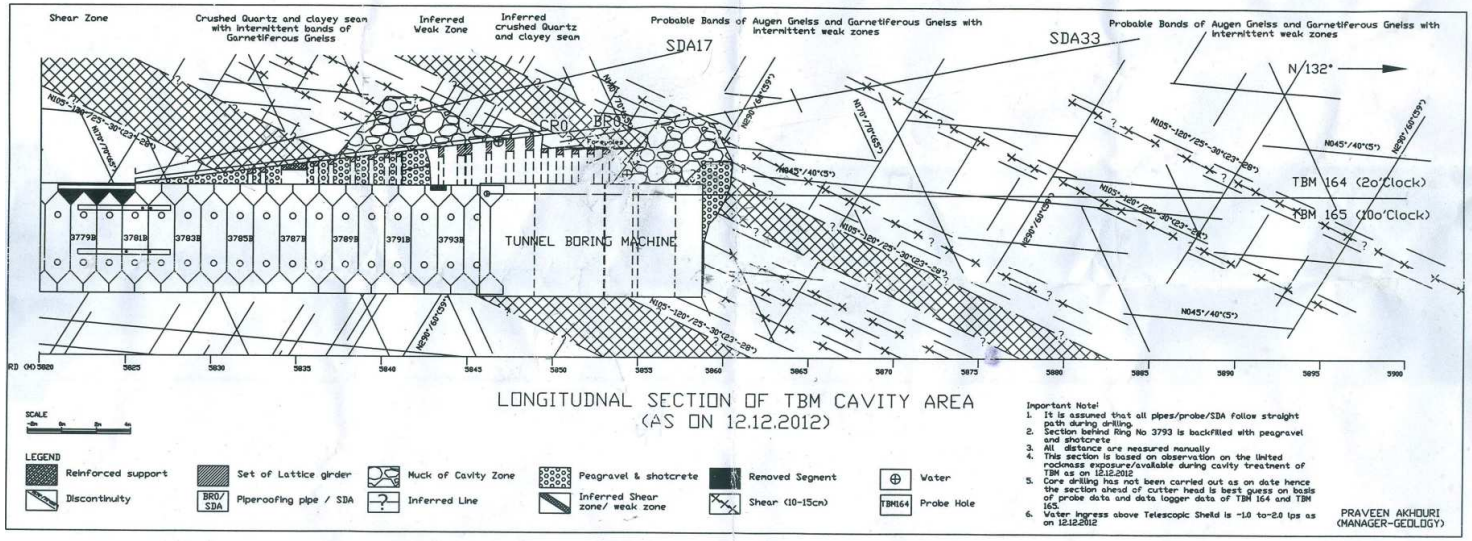


Total discharge in 1 year: 11 mio m³ water

1st TBM Trapping - Bypass Tunnel



2nd and 3rd TBM-Trappings (Feb 2012)



- Low strength fault zone with soil like material
- Installation of double pipe roof (was not foreseen in contract and in BoQ)
- Excavation of working chamber to free the shield again
- Further advance of approx. 18 m

Conclusion / Mitigation Measures

- **Geological / Geotechnical Investigations**
  for a project of this magnitude the geolog. / geotech. Investigations may be considered as insufficient
- **Contractual Setup / Risk Sharing and Risk Management**
  fair contractual relationship with clear definition of spheres of responsibilities; definition of risk and risk management plan; BoQ and specifications to allow for dealing with „unexpected“ conditions and situations
- **Organisational Setup / Responsibilities**
  requirement of experienced and trained personnel on all sides, willingness to take quick decisions, clear „chain of command“
- **TBM Specification and TBM Selection / Selection of Excavation Method**

  Advance Probing
  advance probing and proper evaluations has to be mandatory with no exceptions
- **Continuous Check on Volume Balance**
  correlation of theoretical to actual excavated volume for detection of overbreaks

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NATURGEWALTEN

Ein indisches Dorf versinkt im Erdboden

Im Himalaja bricht der Ort Joshimath buchstäblich auseinander, hunderte Menschen mussten in Sicherheit gebracht werden. Die Notlage wäre vielleicht vermeidbar gewesen

11. Jänner 2023, 20:06, 86 Postings

Foto: AFP/BRIJESH SATI

Durch das eine Wohnzimmer geht ein Riss. In einem anderen bröckelt die Wand ab. Auch in der lokalen Badminton-Halle klafft eine riesige Erdspalte. Und der Straßenasphalt ist an vielen Stellen zerrissen. Vor allem in den vergangenen zwei Wochen haben sich die Risse und Spalten überall in Joshimath rasant vermehrt.

NTPC denies project link to subsidence, records show a long history of breaches

Boring machine set off water surges that experts red-flagged

JAY MAZOOMDAAR
NEW DELHI, JANUARY 8

ON January 5, the day work was stopped at NTPC's 4x130 MW Tapovan Vishnugad hydel project following angry protests by residents of Joshimath in the wake of cracks appearing across the town, the company claimed its 12.1-km-long tunnel had nothing to do with the latest land subsidence.

"The tunnel built by NTPC does not pass under Joshimath town. This tunnel is dug by a tunnel boring machine (TBM) and no blasting is being carried out presently," NTPC said in a statement Thursday. The tunnel is meant to carry river water to the plant's turbine.

What the company did not mention is that its TBM has a history of breaches. In fact, official records accessed by *The Indian Express* show that since December 2009, there have been

CONTINUED ON PAGE 4

The Indian EXPRESS Mon, 09 January 2023
https://epaper.indianexpress.com/c/713

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Thank you for your Attention!