Annual symposium on the theme
“Post-mining risk management in the Netherlands”:

Dealing with Post-Mining-Hazards

From theoretical approach to practical remediation

Stichting I.A.E.G. 1990

Werkgroep Ingeokring

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The Netherlands

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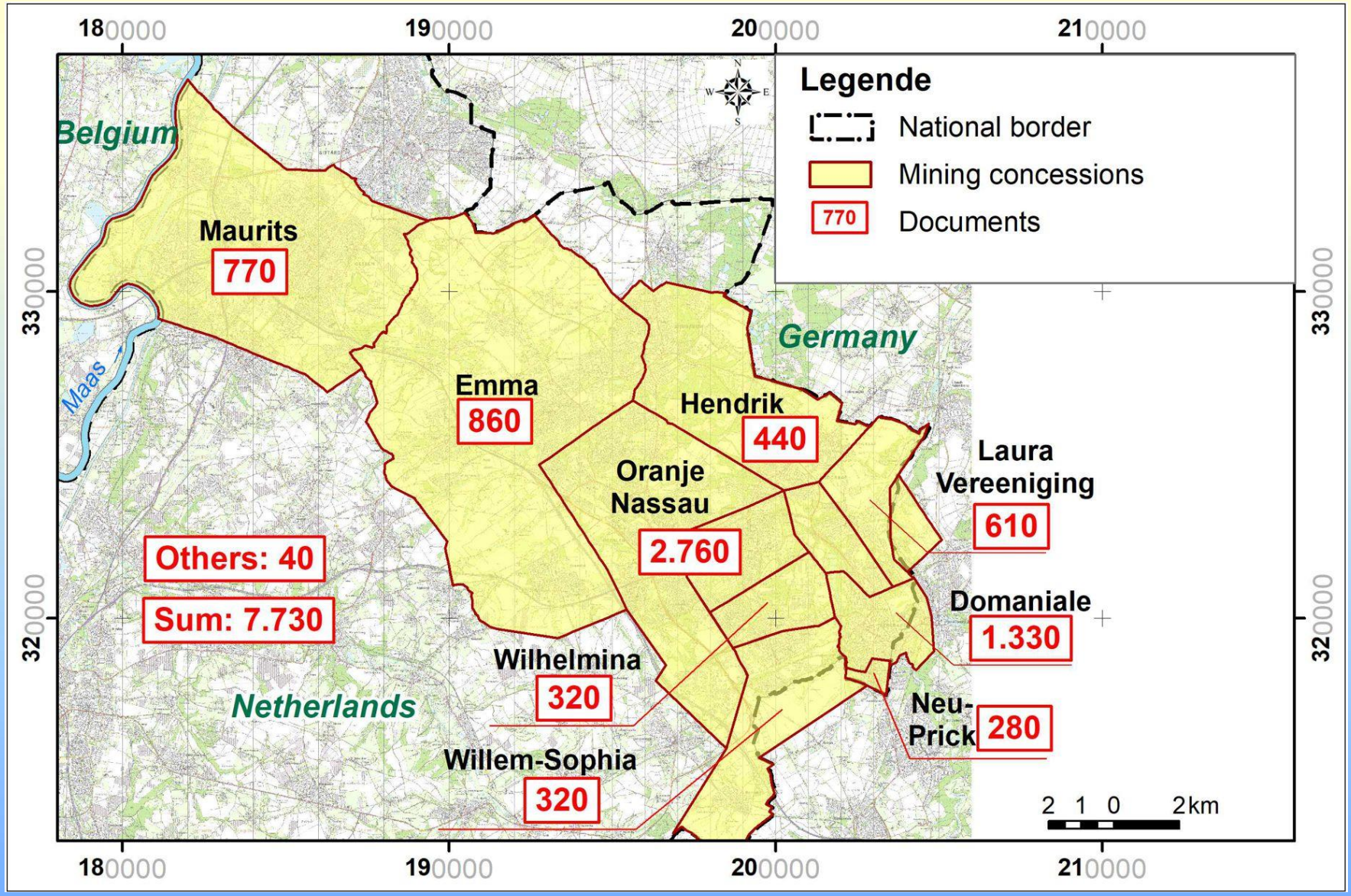
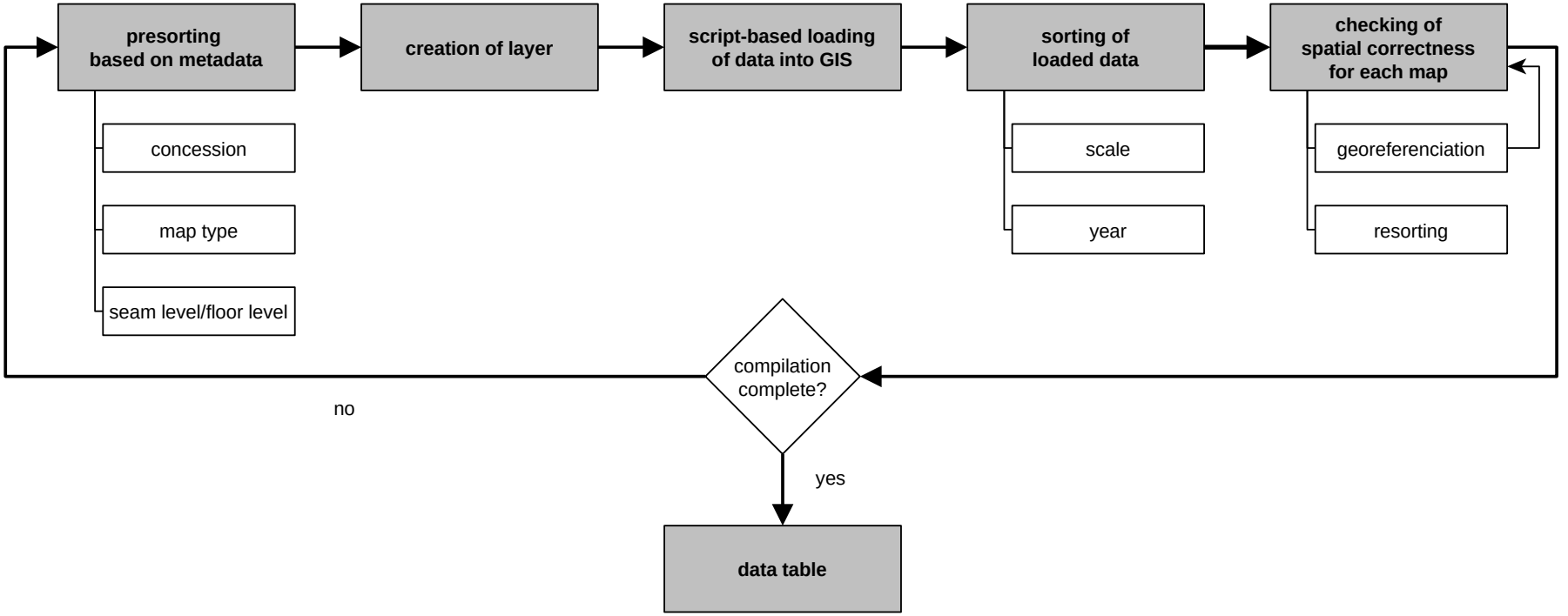
Na ijlende gevolgen steenkolenwinning Zuid-Limburg (GS-ZL)
Collected documents



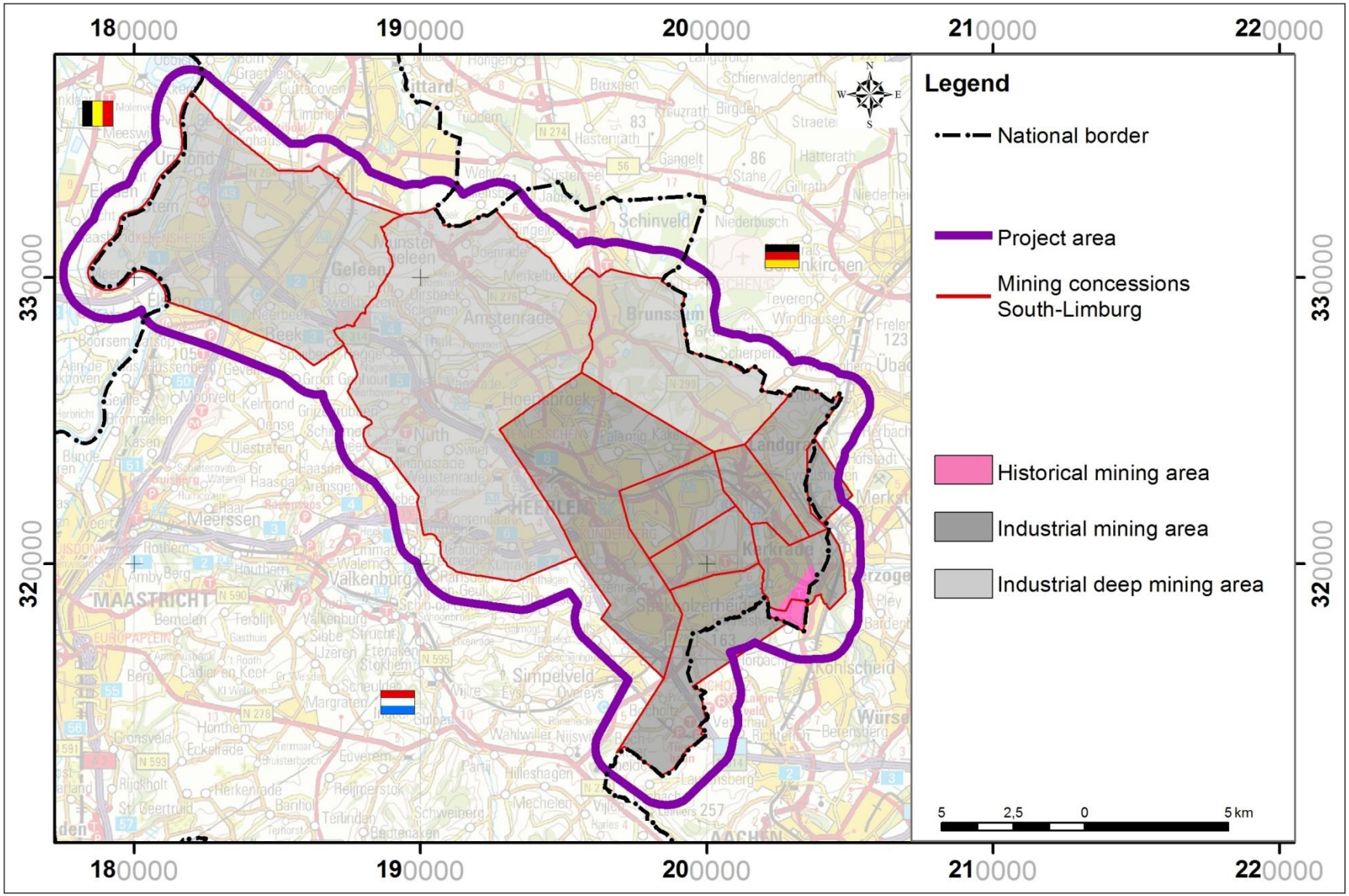
Compilation of mining maps



Effects not dependent on mine water rise

- Effect 1: Historical mine shafts
  Industrial mine shafts
- Effect 2: Voids due to historical near-surface mining
  Voids due to industrial mining near top of Carboniferous and Upward Drillings
- Effect 3: Change of groundwater quality/quantity
- Effect 4: Differential ground heave
- Effect 5: Accumulation of mine gas
- Effect 6: Induced earthquakes

General map of the project areas



Examples of historical mine shafts filled with loose soil material

Main results and proposals concerning historical mine shafts

- **Identification of 59 historical shafts in the area of Kerkrade, all impact category EK 1 („red“)**
- **For all shafts depiction of the „Accuracy of position“ and of the „Shaft-Protection-Zone“**

➢ **Awareness-raising**

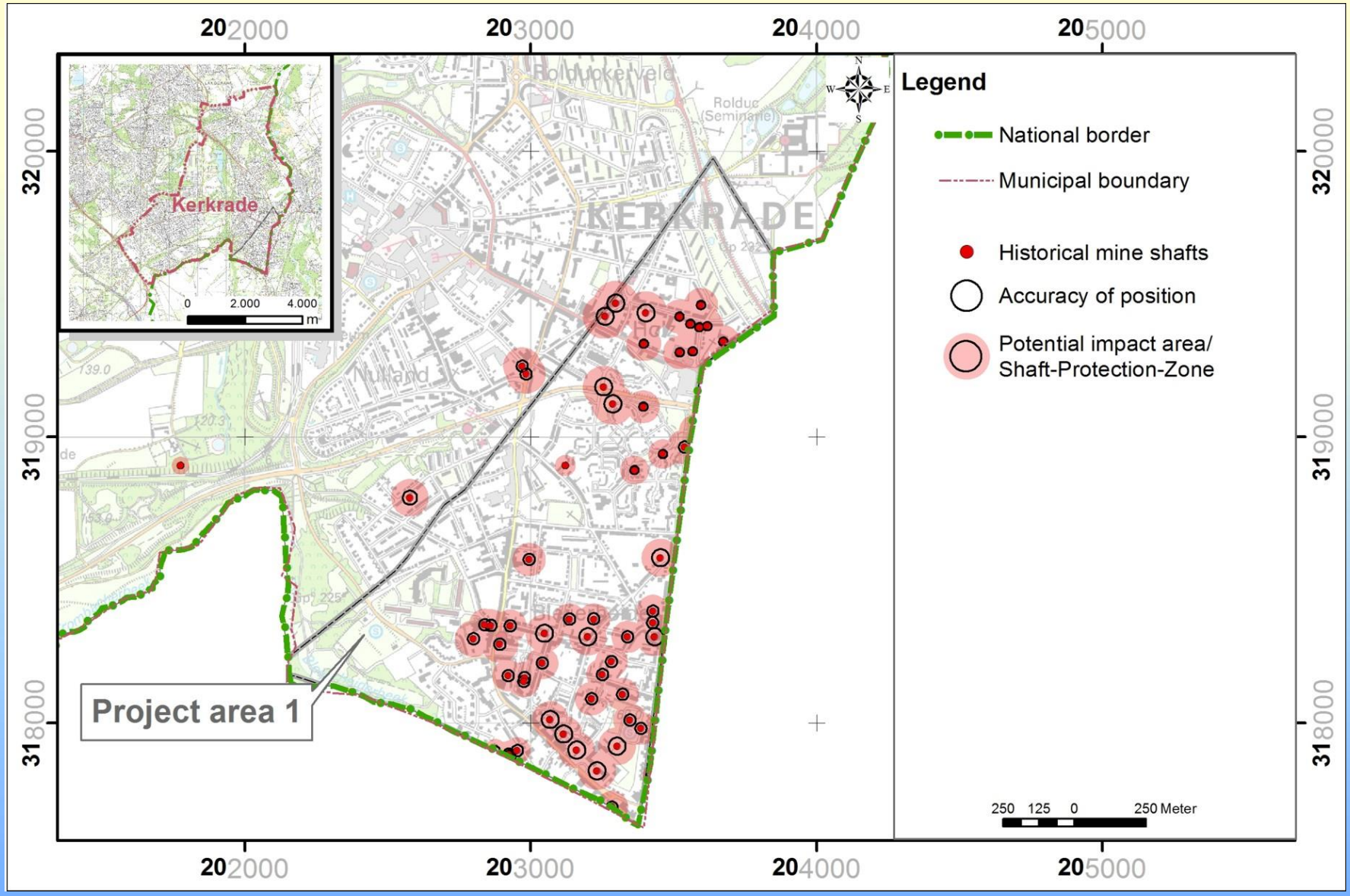
➢ **Management of existing risks and avoid the creation of new risks**

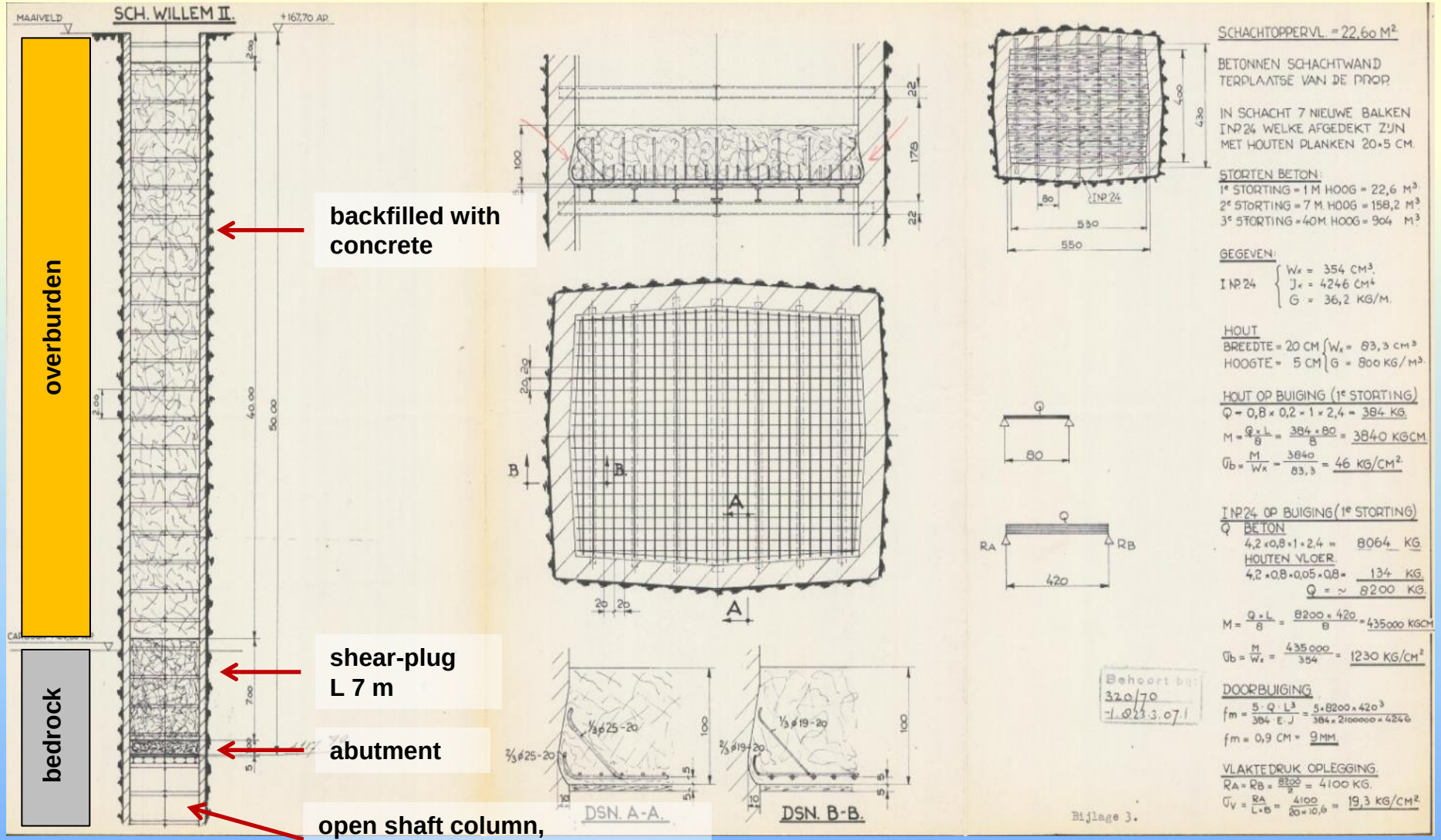
➢ **Strict regulations on new construction buildings**

➢ **Prospecting and investigating of all 59 shafts**

➢ **Remediation measures as far as necessary**

Shaft-Protection-Zones in Kerkrade

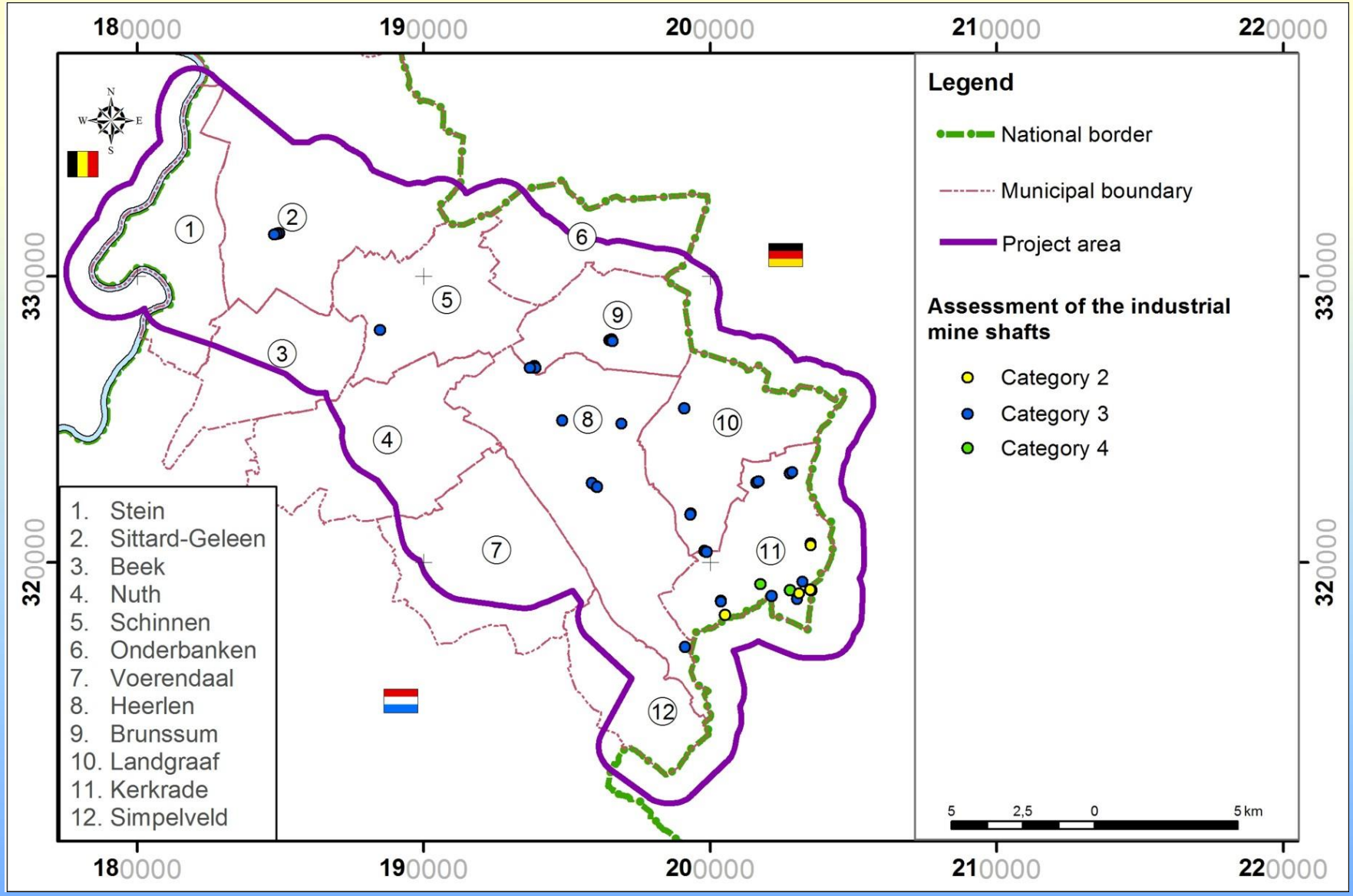



overburden
bedrock
backfilled with concrete
shear-plug L 7 m
abutment
open shaft column, 750 m deep → 23.000 m³
SCH. WILLEM II.
MAAIVELD
+167,70 AP
DSN. A-A.
DSN. B-B.
SCHACHTOPPERVL. = 22,60 M²
BETONNEN SCHACHTWAND TERPLAATSE VAN DE PPOR
IN SCHACHT 7 NIEUWE BALKEN INP 24 WELKE AFGEDEKT ZIJN MET HOUTEN PLANKEN 20×5 CM.
STORTEN BETON:
1e STORTING = 1 M HOOG = 22,6 M³
2e STORTING = 7 M. HOOG = 158,2 M³
3e STORTING = 40M HOOG = 904 M³
GEGEVEN:
INP 24 Wx = 354 CM³. Jx = 4246 CM⁴ G = 36,2 KG/M.
HOUT
BREEDTE = 20 CM HOOGTE = 5 CM Wx = 83,3 CM³ G = 800 KG/M³
HOUT OP BUIGING (1e STORTING)
Q = 0,8 × 0,2 × 1 × 2,4 = 384 KG
M = Q×L/8 = 384×80/8 = 3840 KGCM
σb = M/Wx = 3840/83,3 = 46 KG/CM²
INP 24 OP BUIGING (1e STORTING)
Q BETON
4,2×0,8×1×2,4 = 8064 KG
HOUTEN VLOER
4,2×0,8×0,05×0,8 = 134 KG
Q = ~ 8200 KG
M = Q×L/8 = 8200×420/8 = 435000 KGCM
σb = M/Wx = 435000/354 = 1230 KG/CM²
DOORBUIGING
fm = 5·Q·L³/384·E·J = 5×8200×420³/384×2100000×4246
fm = 0,9 CM = 9 MM
VLAKTEDRUK OPLEGGING
RA = RB = 8200/2 = 4100 KG.
σv = RA/L×B = 4100/20×10,6 = 19,3 KG/CM²
Behoort bij: 320/70 -1.023.3.07.1
Bijlage 3.

Assessment of industrial mine shafts

Impact cate-gory	Relative proba-bility of occur-rence	Shaft	Suggested action
EK 1	High	-	
EK 2	Medium	Melanie	Investigation of current situation and remediation measures in the short-term
		Buizenschacht, Willem I/II (Domaniale), Beerenbosch I, Neuland	
EK 3	Low	Willem I (Willem Sophia), Julia I / II, Louise	Periodic monitoring of the backfilling collumn based on the current surface use
		Willem II (Willem Sophia), Baamstraat, Sophia, Oranje Nassau (7 shafts), Wilhelmina I / II, Emma I-IV, Hendrik I-IV, Maurits I-III, Catharina, Laura I / II	
EK 4	None	Nulland, Ham II	Periodic monitoring
		Beerenbosch II	

Map of industrial mine shafts



Main results and proposals concerning industrial mine shafts

- **Identification of 39 industrial shafts**
- **Status concerning safety is mostly sufficient**
- **Only 6 industrial shafts do not completely comply with the actual state of the art**

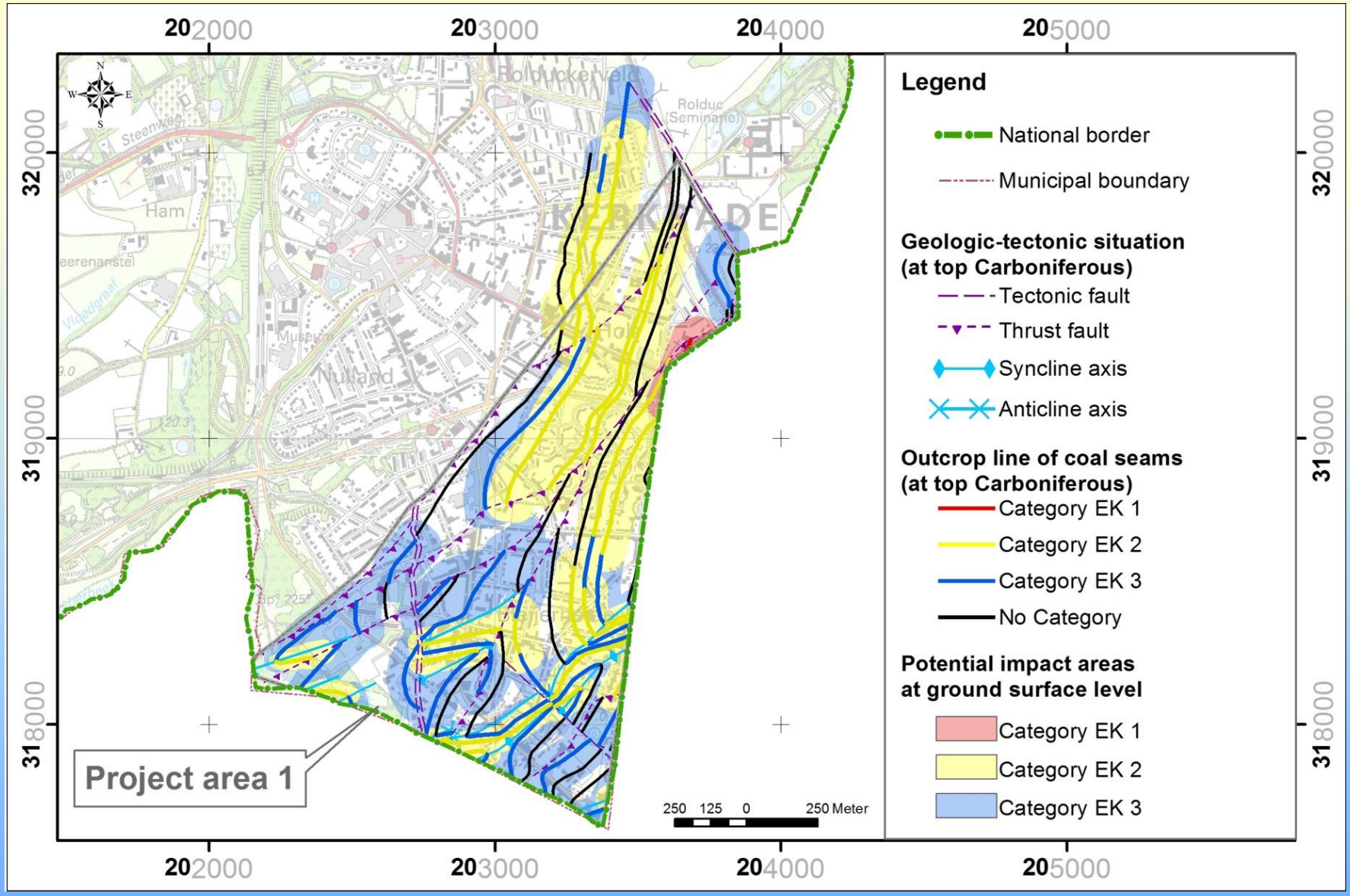
➢ **Monitoring is necessary, partly a facility/access for monitoring has to be (re-)established**

➢ **6 industrial shafts need investigation and maybe enhanced remediation**

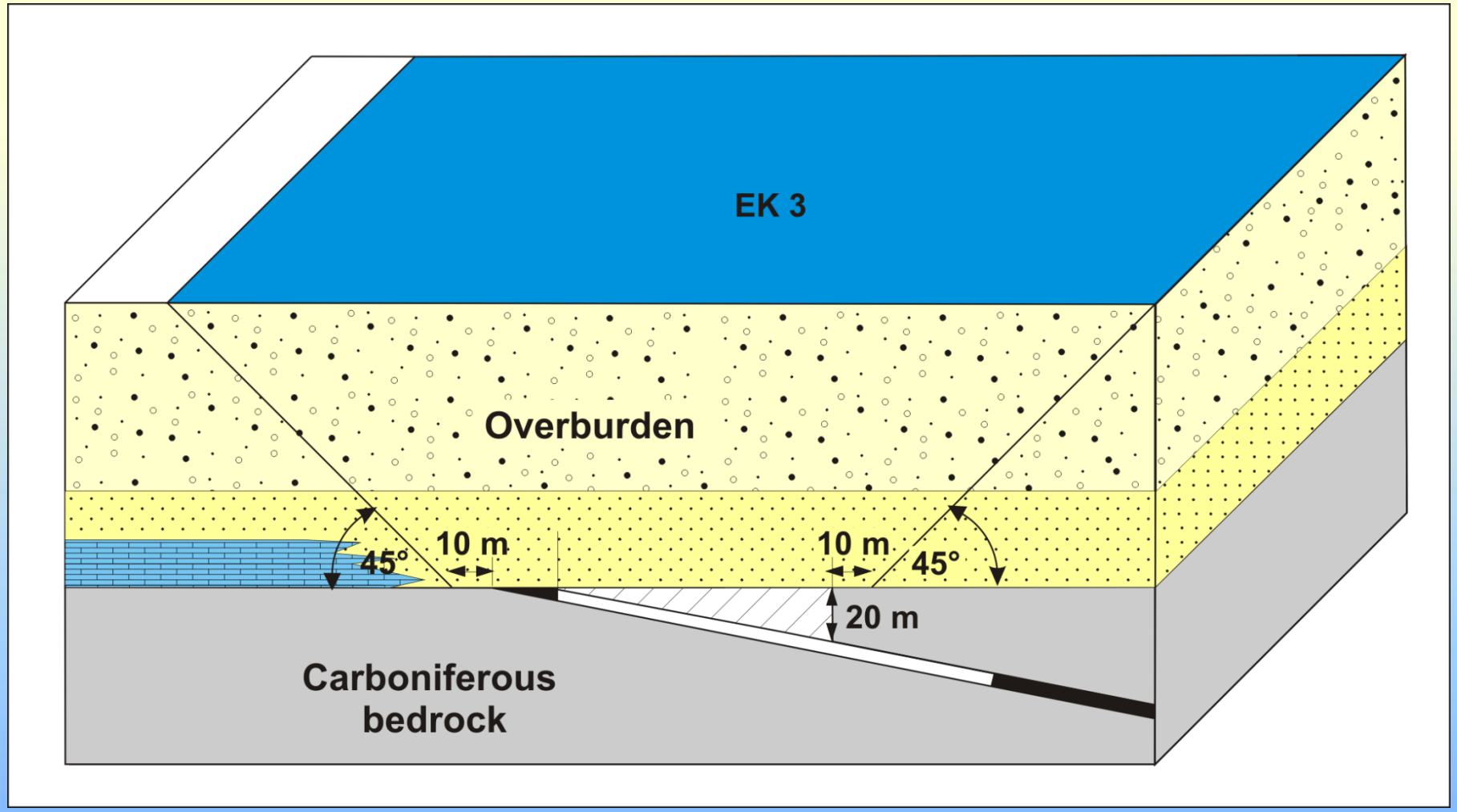
Historical near-surface mining
Several criteria for classification in impact categories

- **Main coal seam, mineable coal seam or not mineable coal seam**
- **Dip at high angle (≥ 40 gon) or low angle (≤ 40 gon)**
- **Evidence of near surface mining in documents**
- **Indication of mining activities above the uppermost gallery**
- **Documentation of sinkholes in the past**

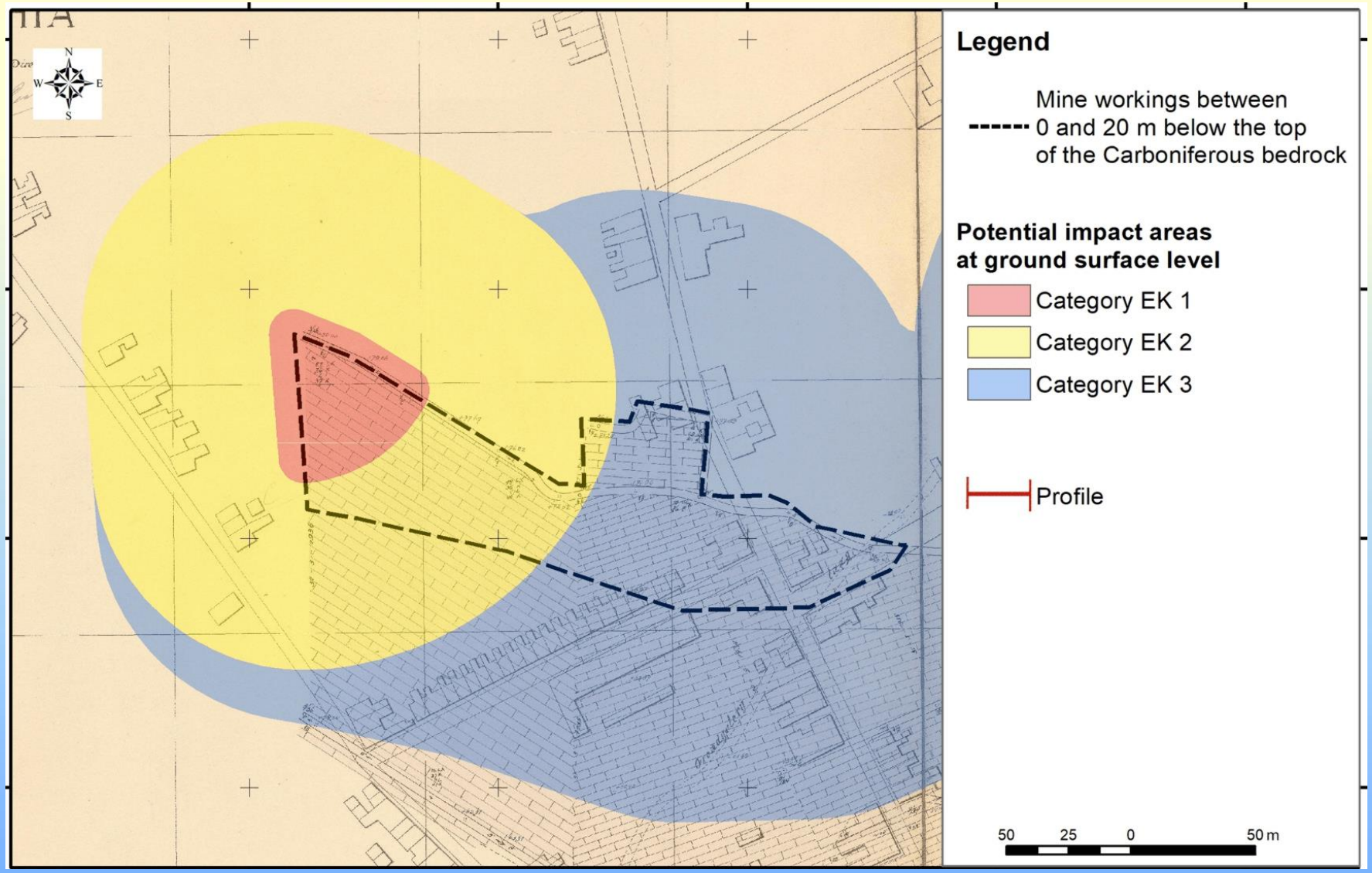
Potential impact areas from near-surface mining in the historical mining area



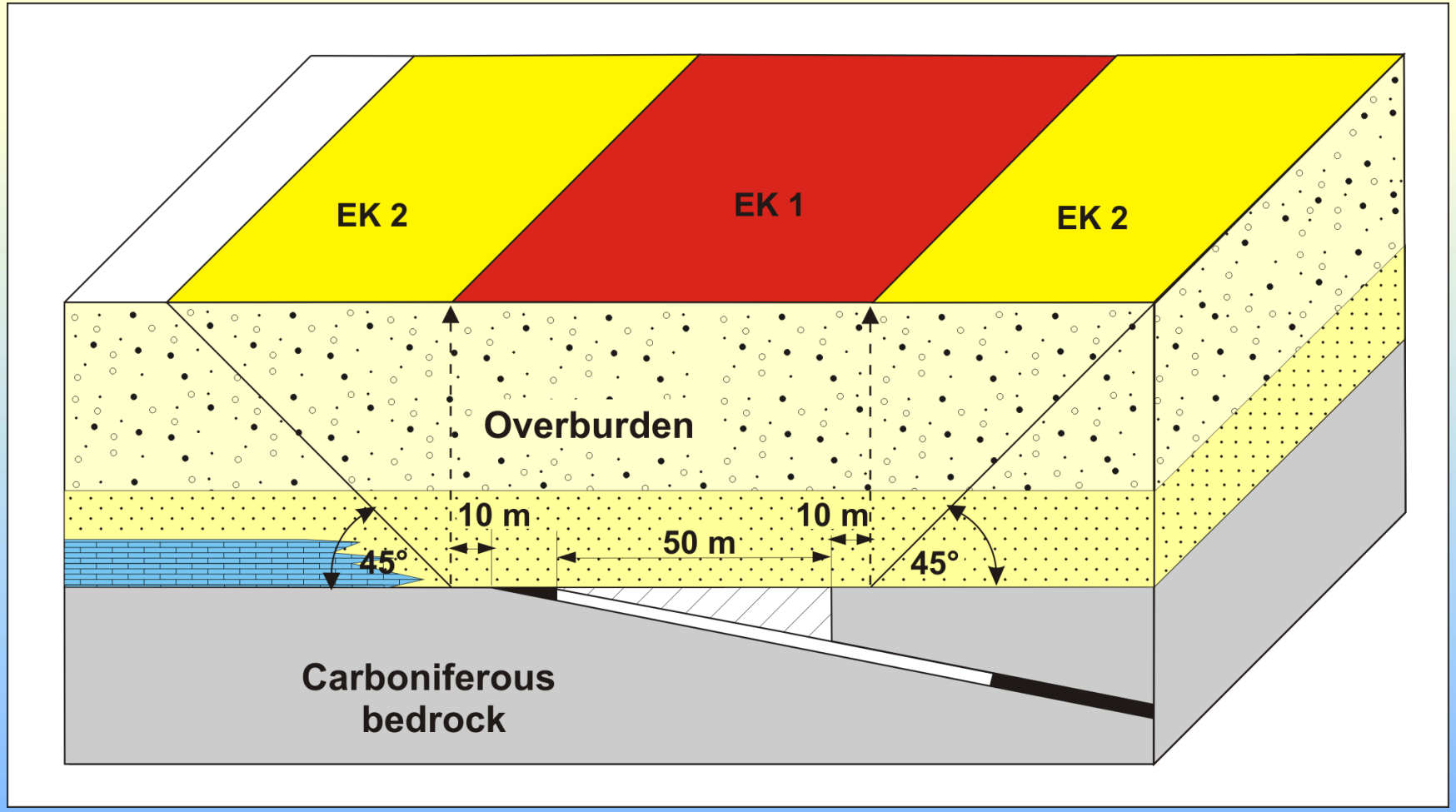
Potential impact areas (EK 3) from mining near the top of the Carboniferous bedrock in project areas 2/3



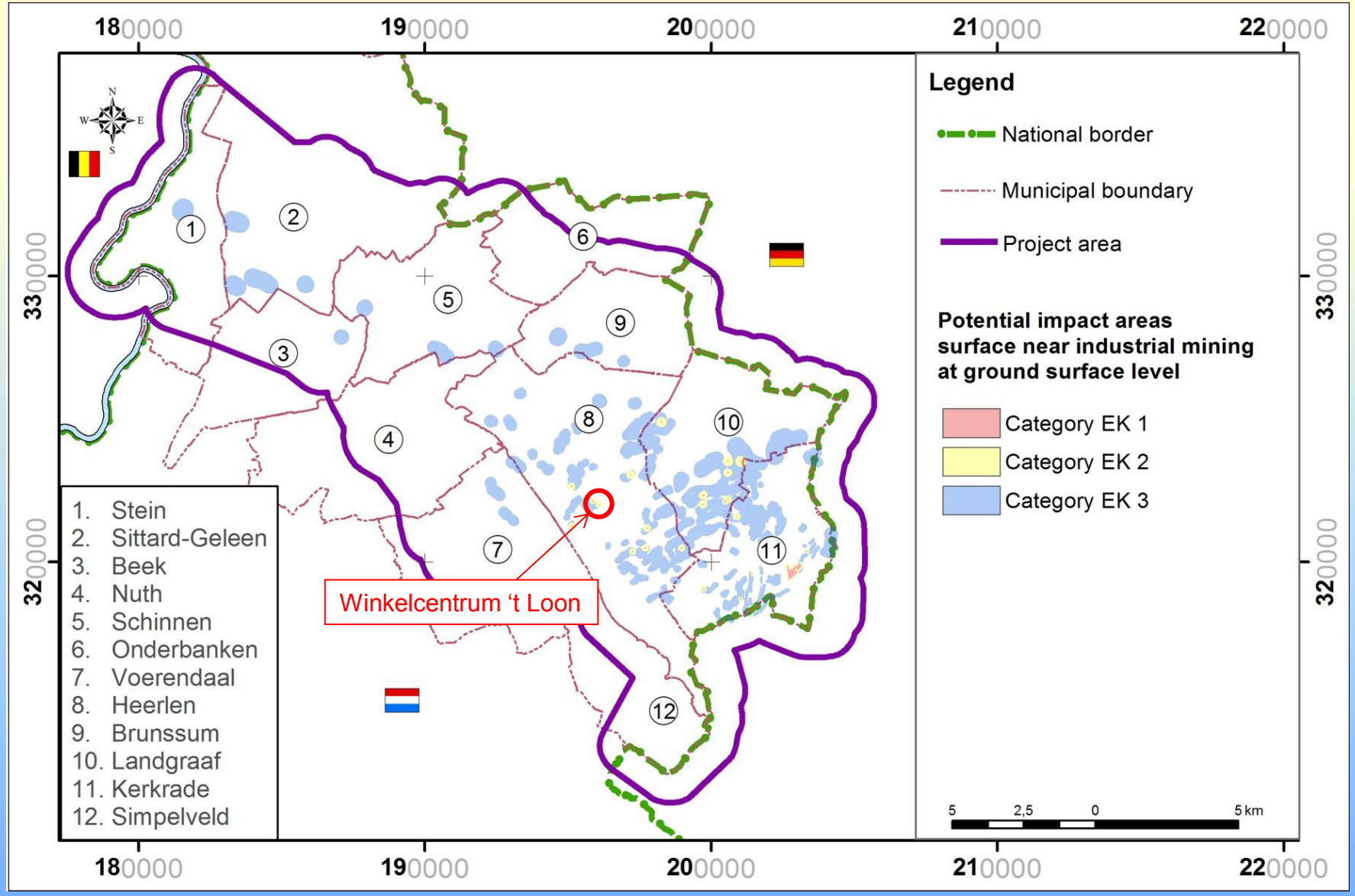
Industrial near surface mining
Definition of potential impact areas



Potential impact areas (EK 1 and EK 2) from mining near the top of the Carboniferous bedrock in project areas 2/3



Voids due to industrial near-surface mining
Map of the potential impact areas in project areas 2/3



- **Historical mining in the area of Kerkrade mostly of impact category EK 2 („yellow“) and EK 3 („blue“)**
- **Industrial mining mostly of impact category EK 3 („blue“)**
- **26 patches of impact category EK 1 („red“) and EK 2 („yellow“)**

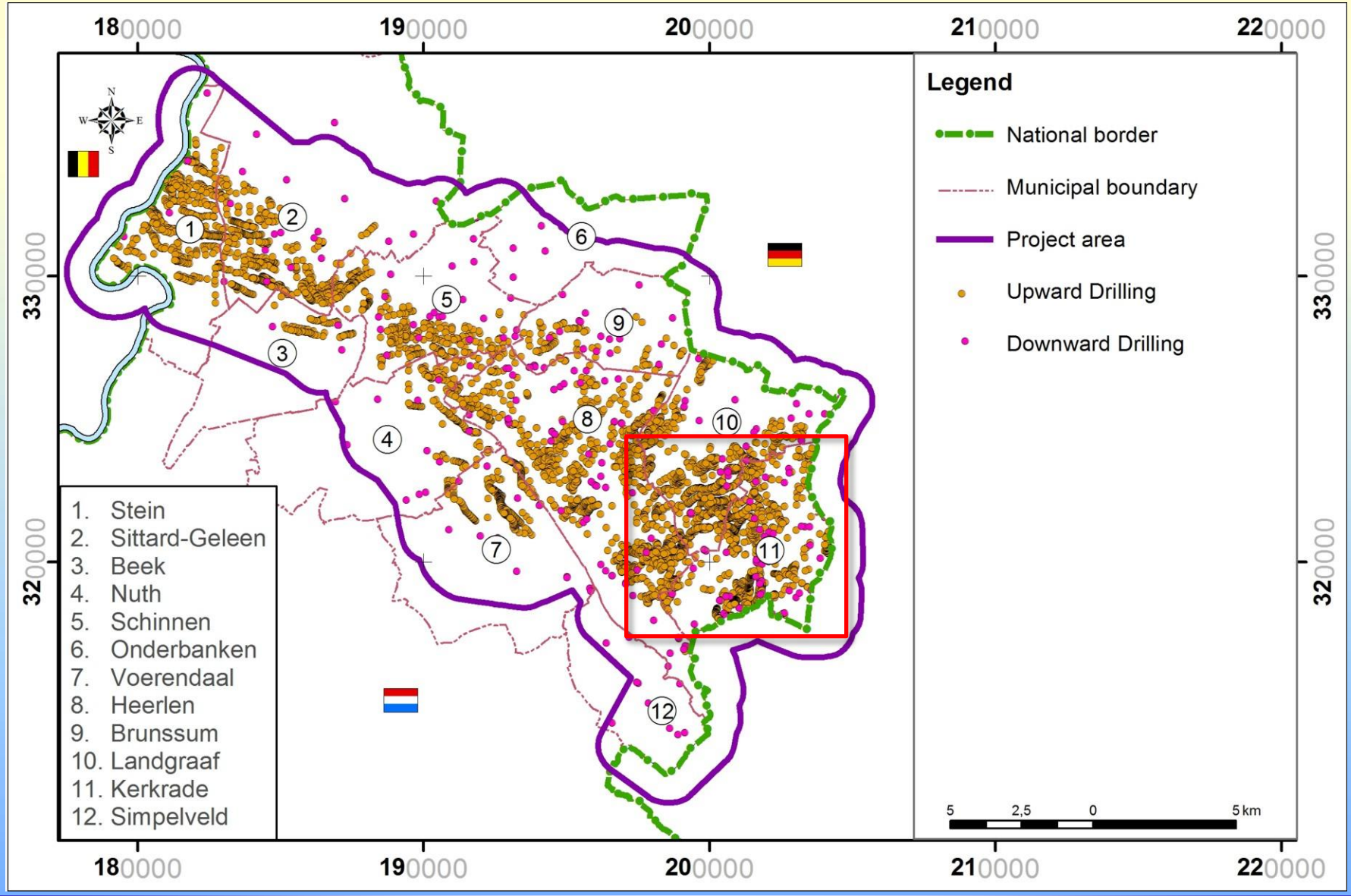
➢ **Pre-active measures on existing situation are disproportional**

➢ **Awareness-raising**

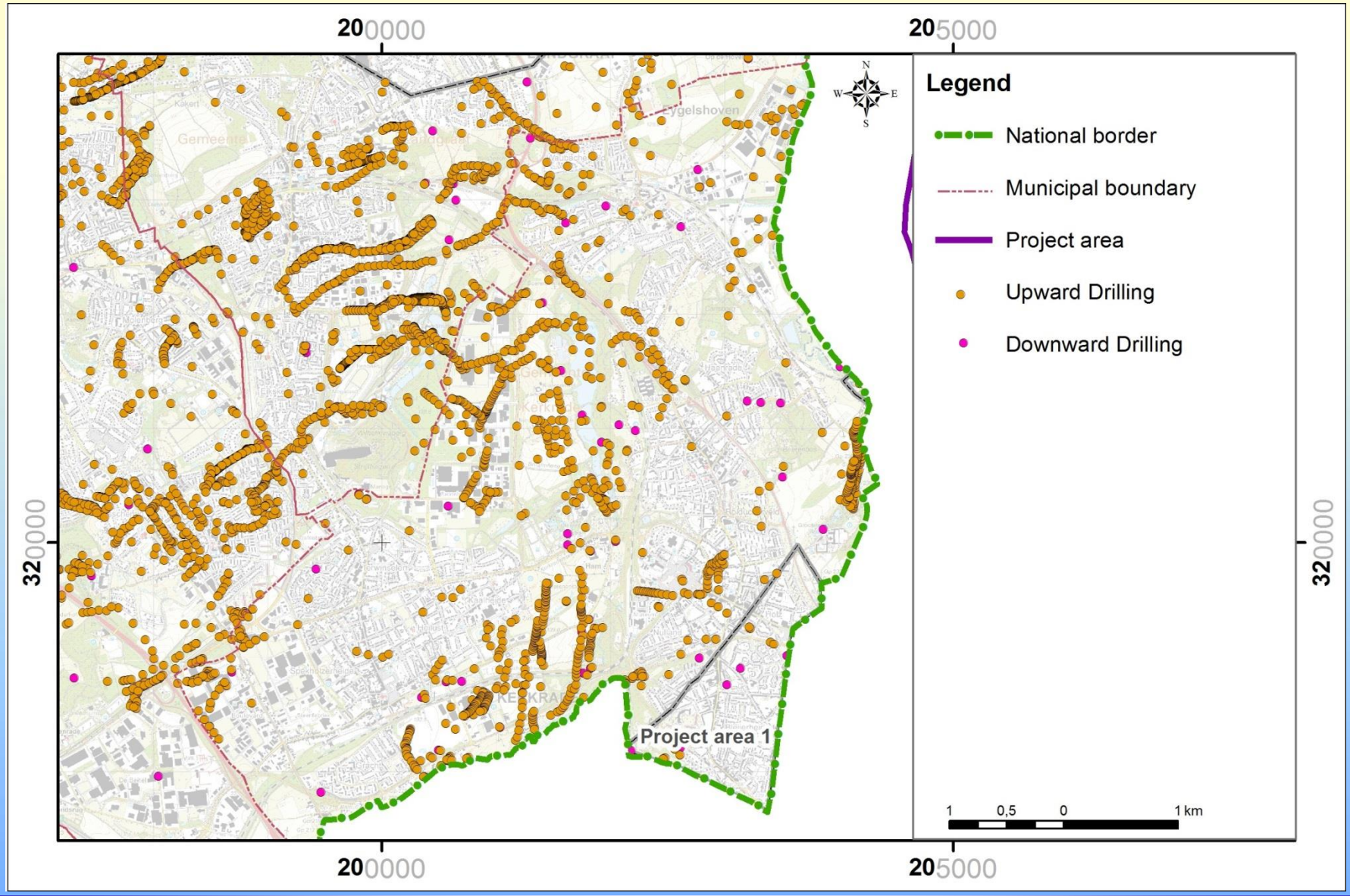
➢ **Management of existing risks and avoid the creation of new risks**

➢ **Strict regulations on new construction buildings**

General map of Upward and Downward Drillings



Detailed map of Upward and Downward Drillings



Step 1:

- **Detailed georeferentiation of mining maps on actual topography**

Step 2

- **Preliminary investigations by small hammer drivings**
- **Vertical small hammer drivings in a grid pattern of i.e. 3 x 3 m**
- **Meanwhile first test of inclined small hammer drivings**

Investigation of shaft location by inclined hammer drivings

Core material out of an old shaft in small hammer drivings

Step 3

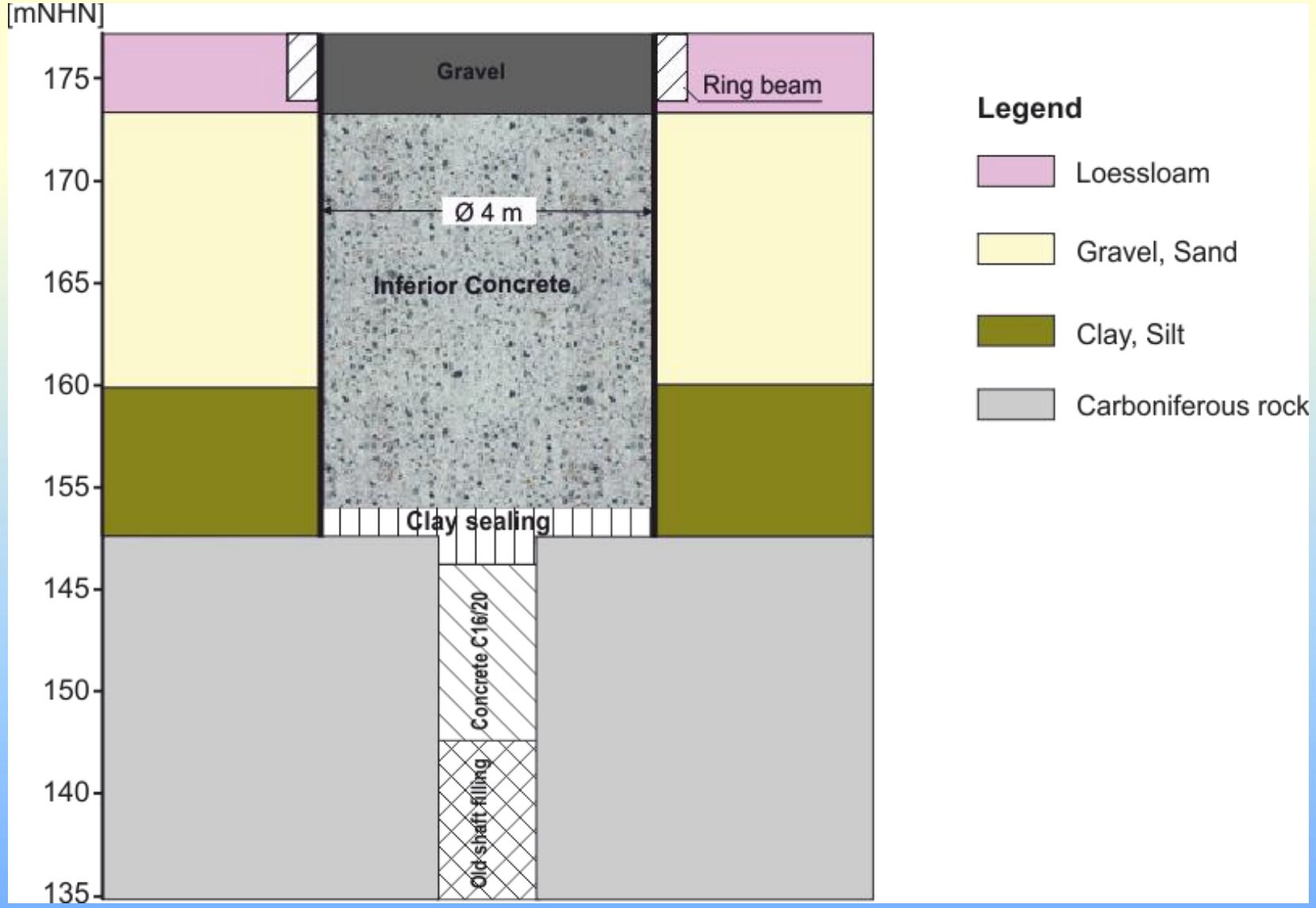
- **Investigation of larger depths by inclined core drillings**

Core drilling rig inside a courtyard

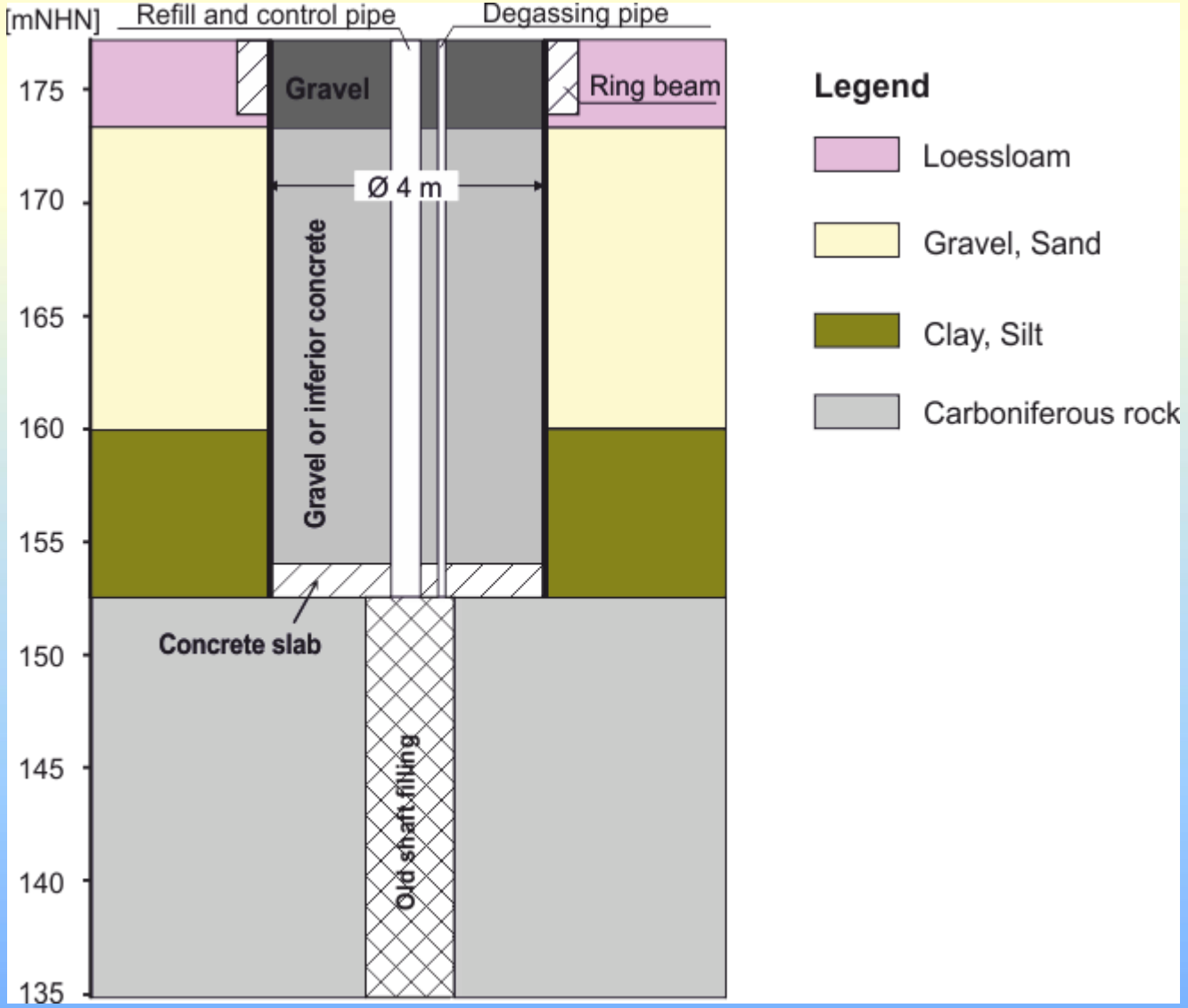
Positioning of core drilling rig behind buildings

Investigation of old shaft near train line

Shaft remediation by re-filling partially with cohesive material

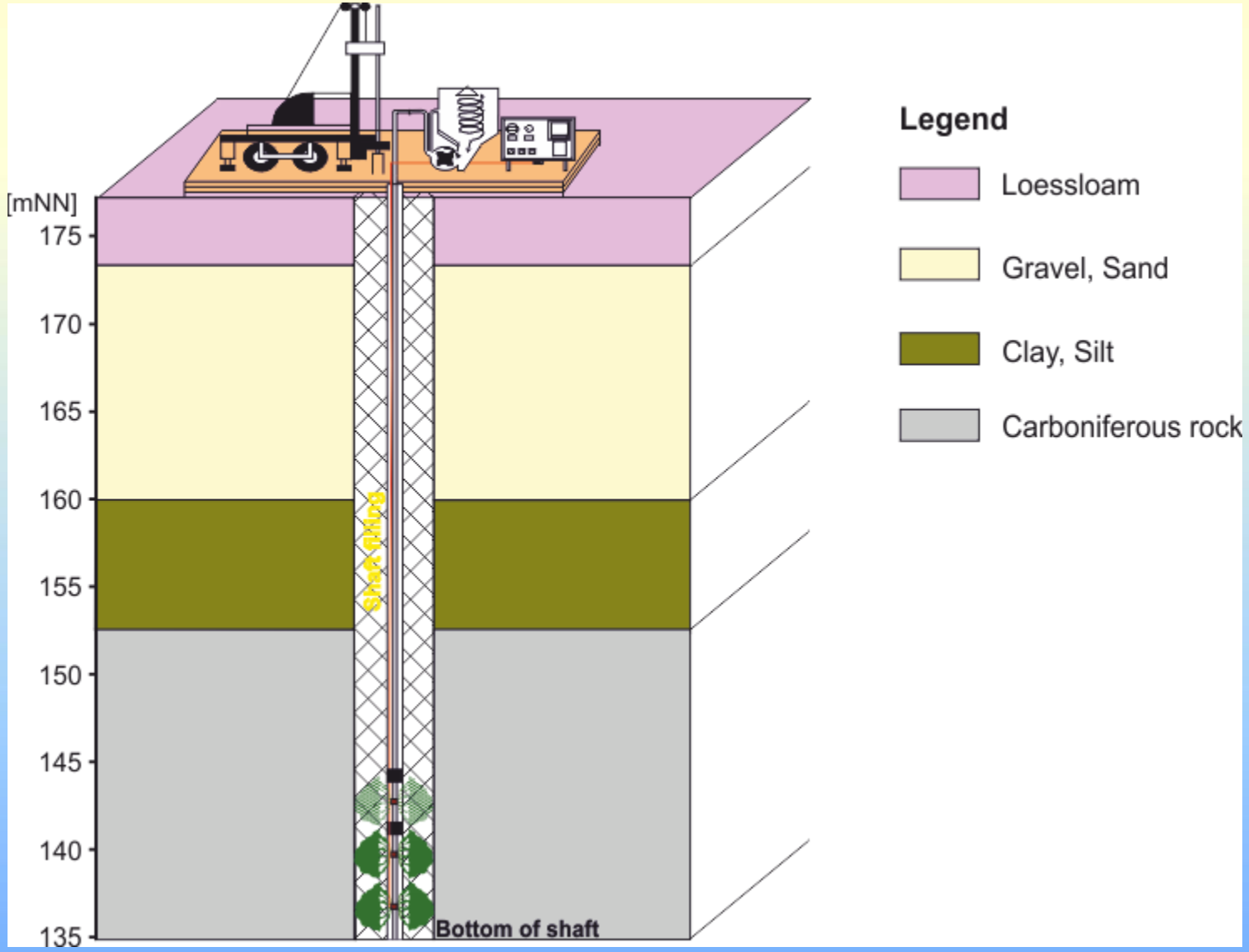


Shaft Remediation by concrete slab on rock surface



Shaft remediation by re-filling partially with cohesive material (including clay sealing)

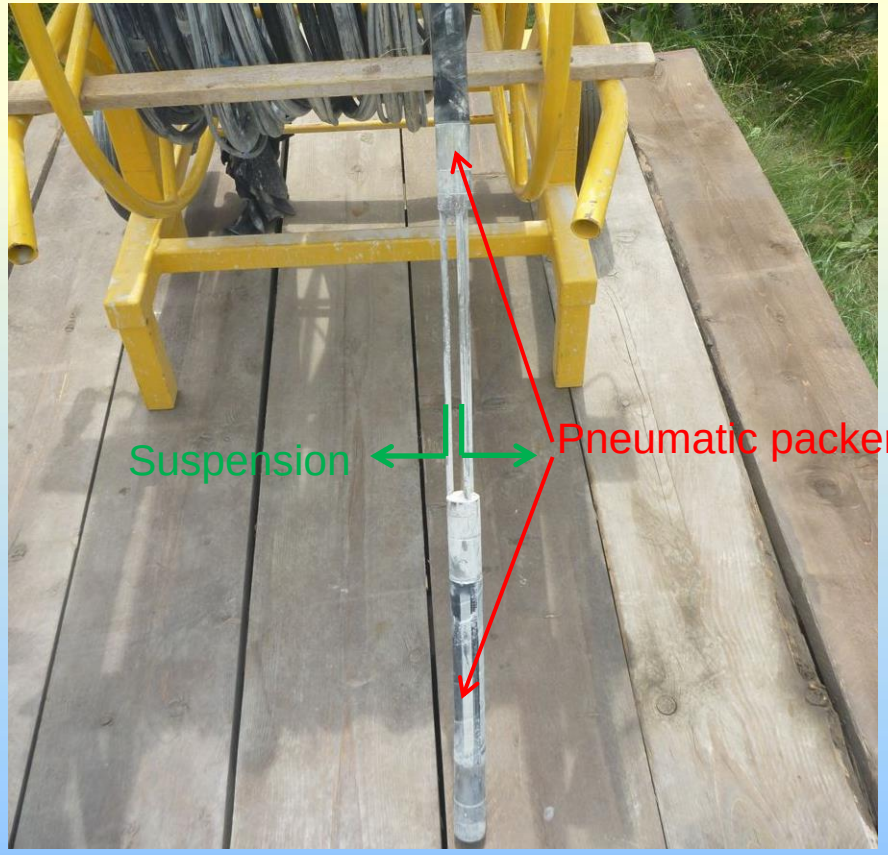
Shaft remediation by injection of the loose shaft fill material



Shaft remediation by injection of loose shaft fill material

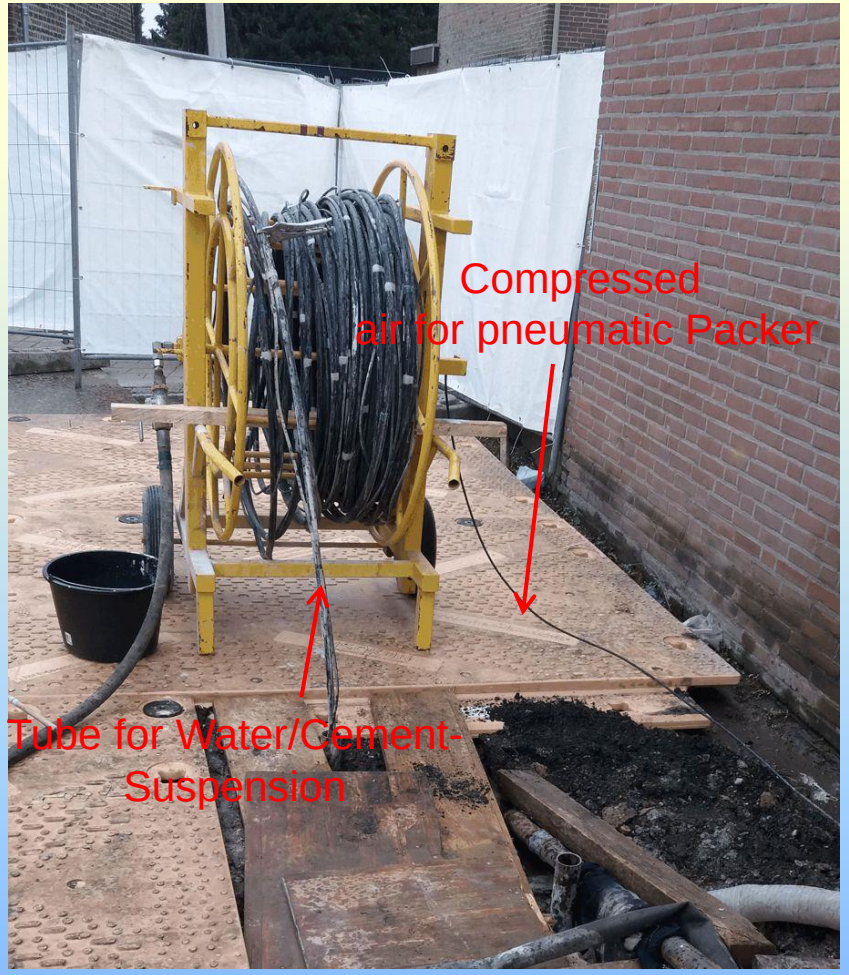
Setting up the construction site for remediation measures at DOM 27 and DOM 28

Equipment for cement injections

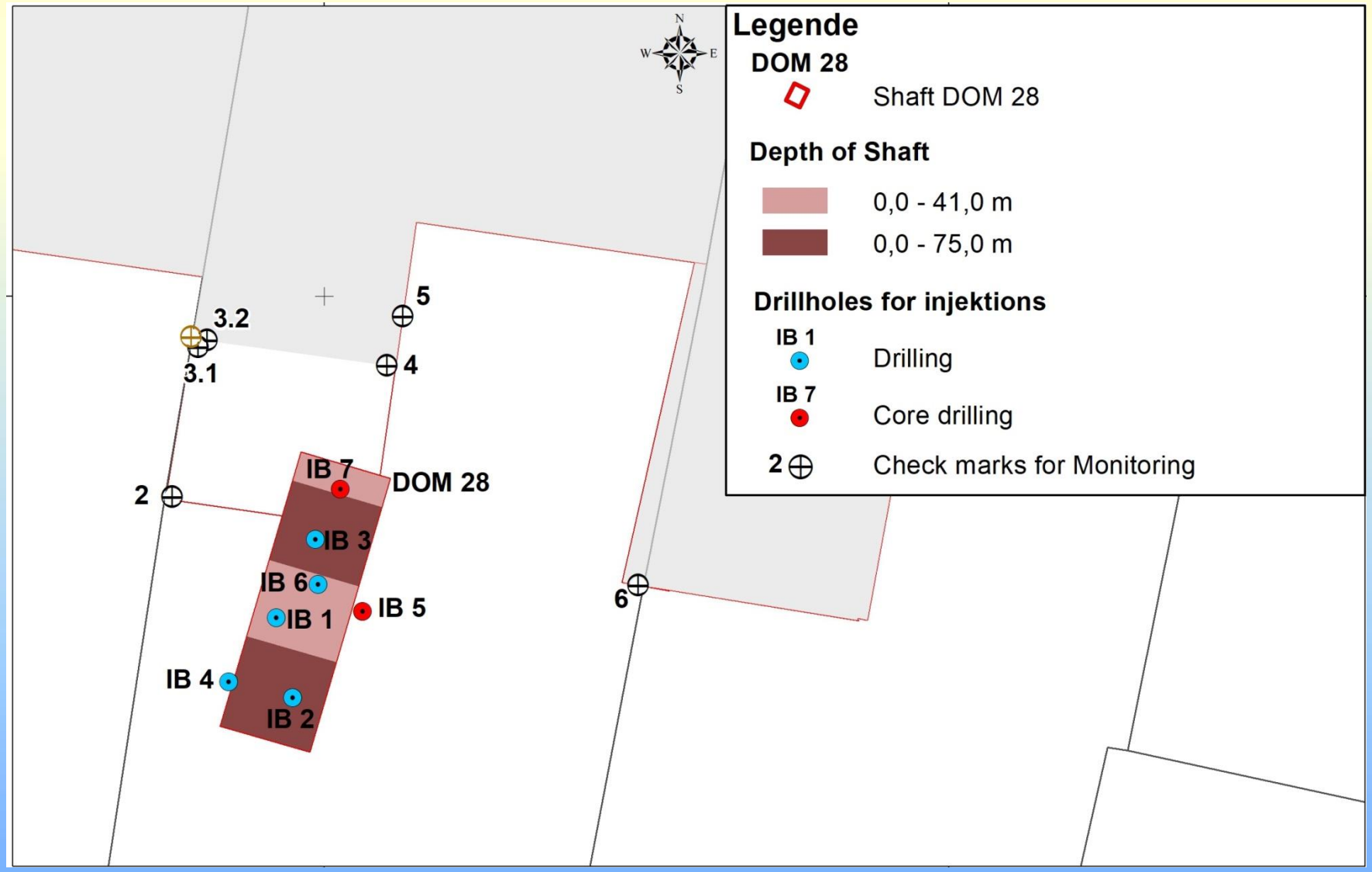


Equipment for cement injections

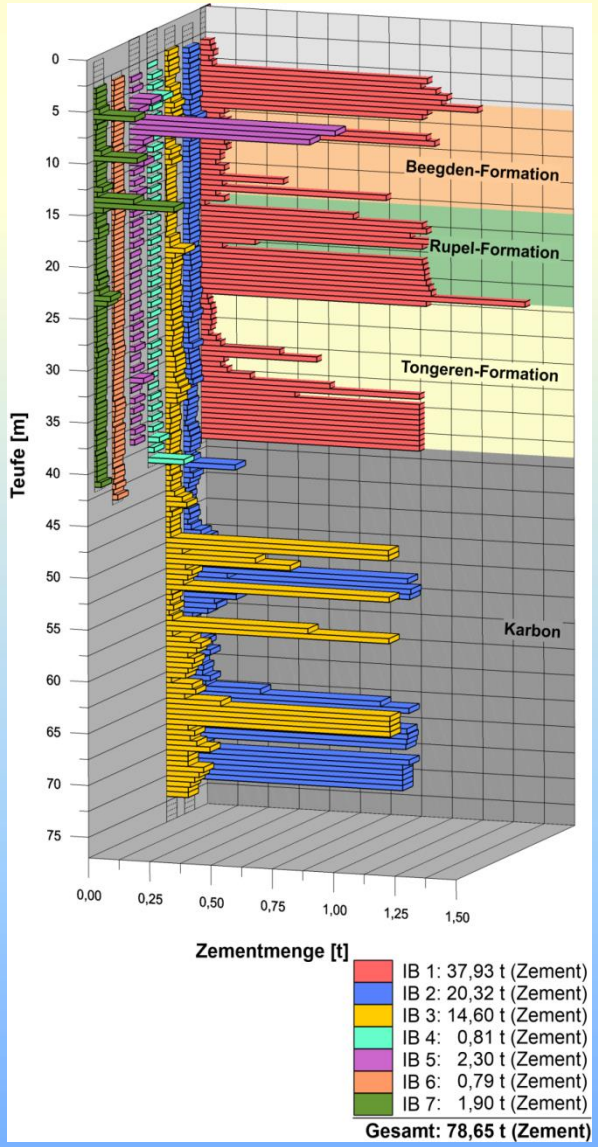
Mixer and Injection pumps



Site map of remediation measures at DOM 28



Injected cement [t solid weight] vs depth [m]



Injected cement vein