Example site

GROUNDWATER · SEEPAGE AND DEWATERING ANALYSIS REPORT

Example — supported excavation, staged (spring-beam input)

2D finite element seepage · dewatering · shoring water pressure · heave

Information	Value
Report date	10.11.2026
Module · version	YeraltiSuyu 0.2.9 · input stamp A5418CA93069
Project author	—
Client	—
Province / district	Example site
Block / parcel	—
Data source	GeoteknikPro example file — parameters are representative
Source of identity information	stand-alone use — manual entry

Table 1: Report identification

APPROVALS

Project author	Structural inspection	Public authority

Table 2: Approval fields (left blank for signature)

> This report was produced with GeoteknikPro Studio · Groundwater module. The seepage analysis is a two-dimensional (section plane, unit length) finite element analysis; well rows are represented as equivalent trenches perpendicular to the section and the three-dimensional well layout must be assessed separately. Results depend on the entered permeability, storage and compressibility parameters; their interpretation and the final engineering decision are the responsibility of the engineer issuing the report.
>
> MISSING IDENTIFICATION INFORMATION: author

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SYMBOLS USED

Symbol	Note	Unit
h	Hydraulic head (as elevation)	m
u	Pore water pressure, $\gamma_w \cdot (h - y)$	kPa
k_x, k_y	Horizontal / vertical permeability	m/s
q	Section-plane (unit length) discharge	$m^3/s/m$
Q	Discharge per well	m^3/s
i_{exit}	Maximum upward hydraulic gradient at the pit base	—
i_{cr}	Critical hydraulic gradient, γ'/γ_w (Terzaghi)	—
FS_kabarma	Heave/piping factor of safety, i_{cr} / i_{exit}	—
S_s	Specific storage (confined)	1/m
S_y	Specific yield (free surface)	—
$\Delta\sigma'$	Effective stress increase (drawdown)	kPa
E_s	Oedometric (elastic) modulus	kPa
C_c, C_r, e_0, σ'_p	Compression / recompression index, void ratio, preconsolidation pressure	—, —, —, kPa
s	Drawdown-induced settlement	mm
β	Angular distortion (slope − rigid tilt)	—
Δ/L	Deflection ratio	—
ε_{lim}	Limiting tensile strain (Burland)	%
γ_w	Unit weight of water (= 9.807)	kN/m^3

Table 3: Symbols, descriptions and units used in the report

Throughout the report lengths are in m, discharges in $m^3/s/m$ (section plane) and L/s, stresses in kPa and settlements in mm. Elevations refer to the project datum (upward positive); depths are written downward positive from the ground surface.

1. INTRODUCTION AND SCOPE

This report covers the groundwater seepage analysis, the dewatering (excavation / well) assessment, the wall water pressure at the shoring excavation stages and the excavation base heave check for the Example — supported excavation, staged (spring-beam input) project at Example site. Topics that were not computed are NOT included; the omitted sections and the reasons are listed below.

Sections omitted from the report and the reasons: Wells — no well defined in the section; Well group in plan — input missing/invalid, not computed; Transient solution — steady-state flow regime selected; Drawdown-induced settlement — set to not computed in the Settings; Adjacent building damage assessment — no adjacent building defined; Benchmark comparison — no reference solution defined (verification projects only).

Kapsam: steady seepage · base heave

1.1. Summary of Results

Quantity	Result
Section type · width	flat ground (pit / sheet pile) · 124 m
Groundwater level (left / right)	-2 m / -2 m
Pit · wall	width 16 m · base level -11 m (depth 11 m) · water in pit -12 m (below the base — drain line) · pit sides: impermeable wall
Total inflow Σq^{+}	1.156E-04 $m^3/s/m$
Dewatering (drain / well) discharge	1.156E-04 $m^3/s/m$ = 0.116 L/s/m
Mass balance difference	0.00 %
Base heave FS	— (no upward flow at the base (heave not applicable))
Maximum drawdown settlement	—
Adjacent building worst category	—

Table 4: Summary of results

2. SOIL PROFILE AND PARAMETERS

Layers are assumed horizontal; permeabilities and compressibility parameters are given below with their sources. The program never generates a parameter by itself; values from literature or manual entry are flagged as USER ASSUMPTION.

Layer	Top elevation [m]	Bottom elevation [m]	Material	k_x [m/s]	k_y [m/s]	γ_{sat} / γ_{moist} [kN/m³]	Source
Sandy gravel (GW-GM)	0	-13	Sandy gravel (GW-GM)	3E-04	1.5E-04	21 / 19.5	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s

Layer	Top elevation [m]	Bottom elevation [m]	Material	k_x [m/s]	k_y [m/s]	γ_{sat} / γ_{moist} [kN/m³]	Source
Silty sand (SM)	-13	-24	Silty sand (SM)	2E-05	1E-05	20 / 18.5	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s
Clay (CL)	-24	-34	Clay (CL)	1E-09	5E-10	19.5 / —	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s

Table 5: Soil profile and permeabilities

Material	S_s [1/m]	S_y [—]	E_s [kPa]	C_c	C_r	e_0	σ'_p [kPa]
Sandy gravel (GW-GM)	—	—	—	—	—	—	—
Silty sand (SM)	—	—	—	—	—	—	—
Clay (CL)	—	—	—	—	—	—	—

Table 6: Storage and compressibility parameters (— = not entered; that calculation is skipped for that layer)

3. ANALYSIS MODEL AND BOUNDARY CONDITIONS

Section: horizontal layers, far-field fixed head at edges

Information	Value
Section type	flat ground (pit / sheet pile)
Width · ground level	124 m · 0 m
Groundwater level left / right (far field)	-2 m / -2 m
Initial (pre-drawdown) water level	-2 m
Excavation	width 16 m · base level -11 m (depth 11 m) · water in pit -12 m (below the base — drain line) · pit sides: impermeable wall
Wall / sheet pile	Left wall: x = 54 m, kot -11 → -18 m · Right wall: x = 70 m, kot -11 → -18 m
Flow regime	Steady-state, free surface (dry-element $k \cdot 10^{-4}$ + seepage-face iteration) (Bathe & Khoshgoftaar 1979)
Mesh	39445 nodes · 77637 triangles · target edge 0.35 m · triangles crossing the wall 0

Table 7: Model summary

Limit	Type	Value
B1 · K8 left	fixed head	-2 m
B1 · K2 right	fixed head	-2 m
B1 · K5 excavation base	seepage face (h = y)	—
B2 · K4 left	fixed head	-2 m

Limit	Type	Value
B2 · K2 right	fixed head	-2 m
B3 · K4 left	fixed head	-2 m
B3 · K2 right	fixed head	-2 m
Dewatering line (internal line)	fixed head	-12 m

Table 8: Boundary conditions (fixed head only on submerged nodes; dry nodes above water → no-flow)

4. SEEPAGE ANALYSIS RESULTS

Convergence: Conjugate gradient: 669 iterations · relative residual 9.0e-11 · converged.

Free surface / seepage face: saturated solution (no free-surface iteration)

Limit	h [m]	q [m³/s/m] (+ inflow)
B1 · K8 left	-2	5.372E-05
B1 · K2 right	-2	5.369E-05
B1 · K5 excavation base	h = y	0E+00
B2 · K4 left	-2	4.087E-06
B2 · K2 right	-2	4.085E-06
B3 · K4 left	-2	2.393E-10
B3 · K2 right	-2	2.392E-10
Dewatering line	-12	-1.156E-04

Table 9: Boundary discharges

Mass balance: inflow Σq^{+} = 1.156E-04 m³/s/m · outflow Σq^{-} = 1.156E-04 m³/s/m · difference 0.00 %.

Su indirme: total extracted from the pit base, drain line and wells 1.156E-04 m³/s/m (0.116 L/s per m of section length). This is the section-plane (unit length) discharge; the total pumping rate around the pit needs the perimeter length and 3D effects (corners, well layout).

4.1. Pore Water Pressure Along the Wall

The two wall faces are separate nodes in the mesh (shared tip); u(z) was read at 0.25 m steps on the back (soil) and front (pit) faces. At the tip: back u = 143.8 kPa, front u = 143.2 kPa.

Depth [m]	Back face u [kPa]	Front face u [kPa]
0	0.0	—
0.5	0.0	—
1	0.0	—
1.5	0.0	—
2	0.0	—
2.5	2.8	—

Depth [m]	Back face u [kPa]	Front face u [kPa]
3	7.7	—
3.5	12.6	—
4	17.5	0.0
4.5	22.4	0.0
5	27.3	0.0
5.5	32.2	5.0
6	37.1	9.9
6.5	42.0	14.9
7	46.8	19.9
7.5	51.7	24.9
8	56.6	29.8
8.5	61.5	34.8
9	66.4	39.8
9.5	71.3	44.7
10	76.1	49.7
10.5	81.0	54.7
11	85.9	59.7
11.5	90.8	64.6
12	95.6	69.6
12.5	100.5	74.6
13	105.4	79.6
13.5	109.7	85.5
14	113.9	91.5
14.5	118.1	97.6
15	122.3	103.6
15.5	126.5	109.7
16	130.6	115.8
16.5	134.6	122.0
17	138.4	128.4
17.5	141.8	135.2
18	143.8	143.2

Table 10: u(z) along the wall — diagram transferred to the Retaining module

5. PIT BASE HEAVE / PIPING CHECK

Criterion: i_{exit} / i_{cr} (Terzaghi). Maximum upward hydraulic gradient in the elements at the excavation base edge i_{exit} = 0, critical gradient $i_{cr} = \gamma'/\gamma_w$ = 1.141, factor of safety FS = — (required ≥ 1.50) → no upward flow at the base (heave not applicable).

6. EXCAVATION SUPPORT — EXCAVATION STAGES, WALL WATER PRESSURE, HYDRAULIC BASE FAILURE

Each excavation stage is solved separately as steady seepage; the wall toe level is the same in all stages (-18 m). Net water pressure = retained-side u − excavation-side u (u < 0 → 0). Hydrostatic assumption: retained side from the initial GWT (-2 m), excavation side from the water level inside the excavation. Hydraulic base failure: Terzaghi prism in front of the wall (width D/2, depth D = embedment); S = mean excess pore pressure at the prism base × b, G′ = b·∫γ'_{dz}; FS = G′/S; EN 1997-1 HYD (2.9b): $\gamma_{G,dst}$·S ≤ $\gamma_{G,stb}$·G′, $\gamma_{G,dst}$ = 1.35, $\gamma_{G,stb}$ = 0.90 (EN 1997-1 Annex A Table A.17 recommended values; the National Annex may differ). Criterion: i_{exit} / i_{cr} (Terzaghi) · prism verdict FS ≥ 1.50.

Stage	Base [m]	Inside water [m]	Inflow q [m³/s/m]	Max net u [kPa] (hydrostatic)	Net resultant [kN/m] (hydrostatic)	Prism FS	EN HYD ratio	Verdict
Stage 1 (4 m)	-4	-5	3.333E-05	27.3 (29.4)	331 (427)	13.92	0.11	ADEQUATE
Stage 2 (8 m)	-8	-9	7.898E-05	63.1 (68.6)	642 (858)	4.22	0.36	ADEQUATE
Stage 3 (11 m)	-11	-12	1.144E-04	89.3 (98.1)	776 (1079)	2.04	0.74	ADEQUATE

Table 11: Excavation stages — summary

Inflow to the excavation in the last stage 1.144E-04 m³/s/m × excavation length 45 m ≈ 5.15 L/s (2D section estimate; corner and end effects not included).

Input to the beam-on-springs (Winkler) model — final stage, Left wall (x = 60 m): water load net u(z); earth pressure $\sigma'_h = K \cdot \sigma'_v$, with σ'_v consistent with seepage (σ_v − u). Upward flow on the excavation side reduces σ'_v below γ′·z (lower passive resistance); downward flow on the retained side increases it.

Elevation [m]	Retained side u [kPa]	Excavation side u [kPa]	Net u [kPa]	Net u hydrostatic [kPa]	σ'_v retained [kPa]	σ'_v excavation [kPa]
0	0.0	—	0.0	0.0	0.0	—
-0.5	0.0	—	0.0	0.0	9.8	—
-1	0.0	—	0.0	0.0	19.5	—
-1.5	0.0	—	0.0	0.0	29.3	—
-2	0.0	—	0.0	0.0	39.0	—

Elevation [m]	Retained side u [kPa]	Excavation side u [kPa]	Net u [kPa]	Net u hydrostatic [kPa]	σ'_v retained [kPa]	σ'_v excavation [kPa]
-2.5	0.0	—	0.0	4.9	48.8	—
-3	2.0	—	2.0	9.8	56.8	—
-3.5	6.9	—	6.9	14.7	62.4	—
-4	11.8	—	11.8	19.6	68.0	—
-4.5	16.7	—	16.7	24.5	73.6	—
-5	21.6	—	21.6	29.4	79.2	—
-5.5	26.5	—	26.5	34.3	84.8	—
-6	31.3	—	31.3	39.2	90.5	—
-6.5	36.2	—	36.2	44.1	96.1	—
-7	41.1	—	41.1	49.0	101.7	—
-7.5	45.9	—	45.9	53.9	107.4	—
-8	50.8	—	50.8	58.8	113.0	—
-8.5	55.6	—	55.6	63.7	118.7	—
-9	60.4	—	60.4	68.6	124.4	—
-9.5	65.3	—	65.3	73.6	130.0	—
-10	70.1	—	70.1	78.5	135.7	—
-10.5	74.9	—	74.9	83.4	141.4	—
-11	79.7	0.0	79.7	88.3	147.1	0.0
-11.5	84.5	0.0	84.5	93.2	152.8	9.8
-12	89.3	0.0	89.3	98.1	158.5	19.5
-12.5	94.1	5.2	88.9	98.1	164.2	24.8
-13	98.8	10.4	88.5	98.1	170.0	30.1
-13.5	101.7	18.8	82.9	98.1	177.2	31.8
-14	104.3	27.5	76.8	98.1	184.6	33.0
-14.5	106.9	36.3	70.7	98.1	192.0	34.3
-15	109.4	45.1	64.3	98.1	199.5	35.5
-15.5	111.8	54.0	57.8	98.1	207.1	36.5
-16	113.9	63.2	50.7	98.1	215.0	37.4
-16.5	115.6	72.6	43.0	98.1	223.3	38.0
-17	116.8	82.6	34.2	98.1	232.1	38.0
-17.5	116.5	93.8	22.7	98.1	242.4	36.7
-18	111.6	109.6	2.0	98.1	257.3	31.0

Table 12: Water pressure along the wall and seepage-consistent vertical effective stress (final stage)

7. SETTINGS AND SOURCES

Method selections used in the analysis and their sources are listed below. Rows deviating from the default carry the USER ASSUMPTION label.

Setting	Selected	Assumption	Source
Flow regime	Steady-state, free surface (dry-element k·10^{-4} + seepage-face iteration)	USER ASSUMPTION	Bathe & Khoshgoftaar 1979
Linear solver	Conjugate gradient (Jacobi-preconditioned, sparse)	default	—
Mesh generator	Delaunay (unconstrained, boundary-sampled)	default	Bowyer–Watson
Well dewatering	Finite element (in section plane)	default	—
Base heave / piping criterion	i_{exit} / i_{cr} (Terzaghi)	default	Terzaghi 1943
Drawdown-induced settlement	Not computed	default	—
Adjacent building damage criterion	Burland categories (limiting tensile strain; deep beam) + Boscardin–Cording ε_h + Bjerrum β limits	default	Burland & Wroth 1974; Boscardin & Cording 1989; Burland 1995; Bjerrum 1963
Target edge length	0.35 m	USER ASSUMPTION	—
k — Sandy gravel (GW-GM)	3E-04 m/s	USER ASSUMPTION	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s
k — Silty sand (SM)	2E-05 m/s	USER ASSUMPTION	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s
k — Clay (CL)	1E-09 m/s	USER ASSUMPTION	literature — USER ASSUMPTION: Example — Terzaghi–Peck–Mesri 1996 Table 3.1 range; Ss = γ_w/E_s

Table 13: Settings and kaynaklar

8. CONCLUSIONS AND EVALUATION

The section-plane seepage solution gives a total inflow of 1.156E-04 m³/s/m; the dewatering discharge is 1.156E-04 m³/s/m = 0.116 L/s/m. Base heave factor of safety FS = — (no upward flow at the base (heave not applicable)). CAVEAT — BOUNDARY EFFECT: a fixed-head side boundary lies within the estimated radius of influence of the dewatering (see the decision lines). Since the boundary feeds water, the discharge may be

over- and the drawdown and settlement under-estimated; the results above should not be taken as final until a widened section shows no change.

8.1. Program Decision and Remark Lines

The lines below are the decision and warning texts produced by the calculation branches themselves; they show which assumption was made where.

Note
Wall x = 54 m, level -11…-18: 21 nodes split.
Wall x = 70 m, level -11…-18: 21 nodes split.
TRIANGULAR MESH: 39445 nodes · 77637 triangles · target edge 0.35 m · coverage 100%.
22 boundary node(s) above the water level (dry) → treated as no-flow.
Conjugate gradient: 669 iterations · relative residual 9.0e-11 · converged.
Free-surface / seepage-face iteration: 6 outer steps · 0/47 seepage-face nodes active · 5367 dry elements.
Capillary fringe: Clay (CL) ψ_a = 73.6 kPa (hc = 7.5 m) — PROGRAM ASSUMPTION: from the soil class, lower bound of the capillary rise range (Das). Change it on the Material tab.
Flow lines: 9 lines, tube discharge between neighbours Q/N = 1.156E-05 m³/s/m (particle tracing on the node-averaged velocity field; display only).
⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head left boundary is 54 m; estimated radius of influence R ≈ 3000·s·√k = 520 m (s = 10 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head right boundary is 54 m; estimated radius of influence R ≈ 3000·s·√k = 520 m (s = 10 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
EXCAVATION BASE: i_{exit} = 0 · $i_{cr} = \gamma'/\gamma_w$ = 1.141 · FS_heave = — (required ≥ 1.50) → no upward flow at the base (heave not applicable)
Left wall: at the tip back u = 110.8 kPa · front u = 112.0 kPa (tip level -18).
Right wall: at the tip back u = 112.1 kPa · front u = 110.6 kPa (tip level -18).
SUPPORT · Stage 1 (4 m) (base -4 m): inflow 3.333E-05 m³/s/m · max wall net water pressure 27.3 kPa (hydrostatic assumption 29.4 kPa)
SHORING · Stage 1 (4 m): Left wall · HYDRAULIC BASE (Terzaghi prism D = 14 m, b = D/2 = 7 m): S = 80.4 kN/m · G′ = 1120.1 kN/m · FS = G′/S = 13.92 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.11 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 1 (4 m): Right wall · HYDRAULIC BASE (Terzaghi prism D = 14 m, b = D/2 = 7 m): S = 80.5 kN/m · G′ = 1120.1 kN/m · FS = G′/S = 13.92 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.11 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 1 (4 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head left boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 156 m (s = 3 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section

Note
and check that the result does not change.
SHORING · Stage 1 (4 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head right boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 156 m (s = 3 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
SUPPORT · Stage 2 (8 m) (base -8 m): inflow 7.898E-05 m³/s/m · max wall net water pressure 63.1 kPa (hydrostatic assumption 68.6 kPa)
SHORING · Stage 2 (8 m): Left wall · HYDRAULIC BASE (Terzaghi prism D = 10 m, b = D/2 = 5 m): S = 136.6 kN/m · G′ = 576.2 kN/m · FS = G′/S = 4.22 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.36 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 2 (8 m): Right wall · HYDRAULIC BASE (Terzaghi prism D = 10 m, b = D/2 = 5 m): S = 136.6 kN/m · G′ = 576.2 kN/m · FS = G′/S = 4.22 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.36 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 2 (8 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head left boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 364 m (s = 7 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
SHORING · Stage 2 (8 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head right boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 364 m (s = 7 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
SUPPORT · Stage 3 (11 m) (base -11 m): inflow 1.144E-04 m³/s/m · max wall net water pressure 89.3 kPa (hydrostatic assumption 98.1 kPa)
SHORING · Stage 3 (11 m): Left wall · HYDRAULIC BASE (Terzaghi prism D = 7 m, b = D/2 = 3.5 m): S = 140.3 kN/m · G′ = 285.8 kN/m · FS = G′/S = 2.04 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.74 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 3 (11 m): Right wall · HYDRAULIC BASE (Terzaghi prism D = 7 m, b = D/2 = 3.5 m): S = 140.4 kN/m · G′ = 285.8 kN/m · FS = G′/S = 2.04 · EN 1997-1 HYD: 1.35·S / (0.90·G′) = 0.74 (≤ 1) → ADEQUATE [verdict: FS ≥ 1.50]
SHORING · Stage 3 (11 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head left boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 520 m (s = 10 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.
SHORING · Stage 3 (11 m): ⚠ BOUNDARY EFFECT: distance from 'Dewatering line' to the fixed-head right boundary is 60 m; estimated radius of influence R ≈ 3000·s·√k = 520 m (s = 10 m, k = 3.0E-04 m/s; Sichardt, empirical). The boundary may be feeding water and limiting drawdown and settlement — widen the section and check that the result does not change.

Table 14: Decision and remark lines of the calculation arms

9. REFERENCES

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APPENDICES — FIGURES

The figures below are diagrams produced by the program. No figure is added for an analysis that was not computed.

FIGURES

> The figures below are generated from CALCULATED results; no figure is included for a branch that was not calculated (empty axes would suggest it was calculated). The axes and the source of each figure are stated below it.

Seepage

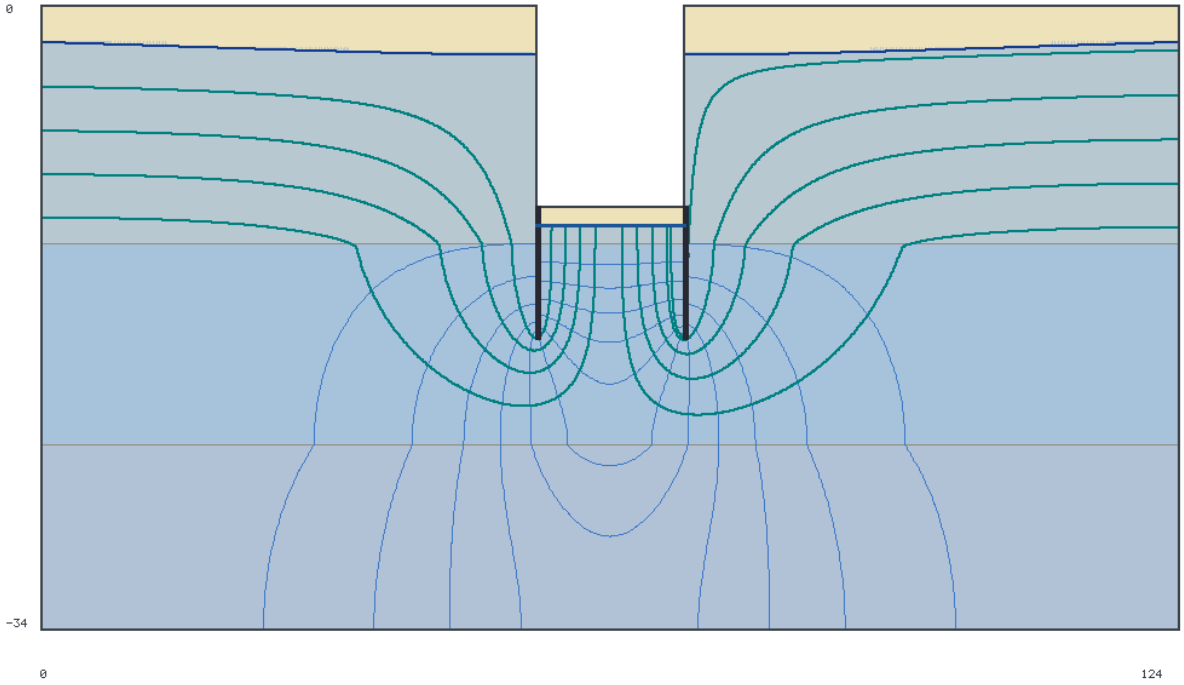


Figure 1: Section, saturated zone, equipotentials and flow lines (vertical scale ×2)

> Section plane; x to the right, elevation upward. Coloured areas are layers; light blue is the saturated zone (u > 0); thin blue lines are equipotentials (constant h, interval 12); teal lines are flow lines (equal-discharge tubes, Q/N = 1.156E-05 m³/s/m); dark dashed line u = 0 (computed water table); thick dark line impermeable wall; red lines well screens. The figure is exaggerated ×2 VERTICALLY; slopes and flow-line angles are flatter in reality.

Colour maps

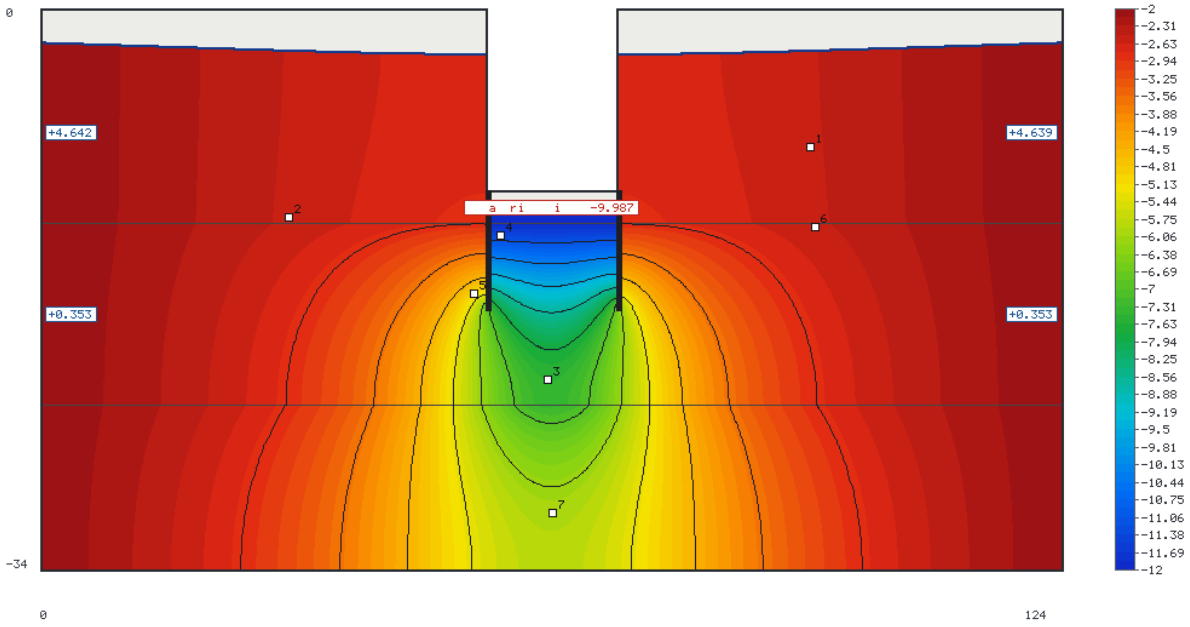


Figure 2: Total head h

> Total head h [m], 64 colour bands (-12 … -2); the bar on the right is the scale. Dark thin lines are equipotentials; numbers in boxes are boundary flows [m³/day/m] (+ into the model, − out of it). Only the saturated zone (u ≥ 0) is coloured. Vertical scale ×2. Monitoring points (numbered in the figure): 1 N1 (x = 93.42; -8.38): h = -2.49 m, u = 57.7 kPa, i = 0.016 · 2 N2 (x = 30.12; -12.64): h = -2.50 m, u = 99.4 kPa, i = 0.017 · 3 N3 (x = 61.63; -22.47): h = -7.48 m, u = 147.0 kPa, i = 0.117 · 4 N4 (x = 55.79; -13.76): h = -11.38 m, u = 23.4 kPa, i = 0.759 · 5 N5 (x = 52.64; -17.28): h = -5.04

m, u = 120.0 kPa, i = 0.723 · 6 N6 (x = 93.97; -13.2): h = -2.51 m, u = 104.8 kPa, i = 0.053 · 7 N7 (x = 62.09; -30.53): h = -5.99 m, u = 240.7 kPa, i = 0.084.

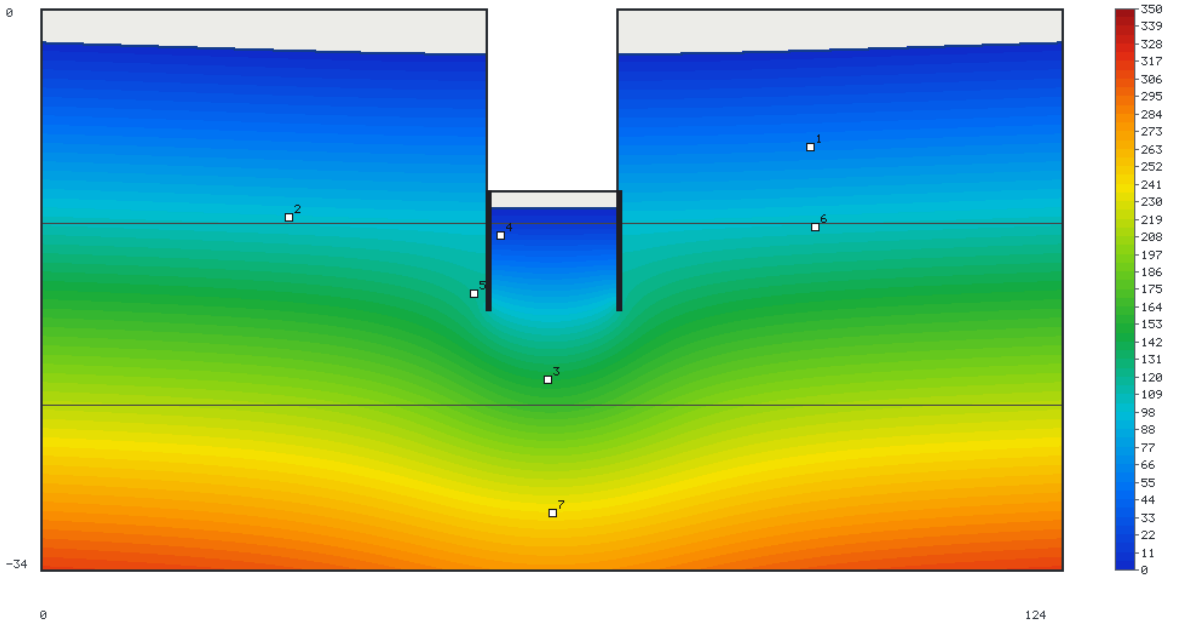


Figure 3: Pore water pressure u

Pore water pressure u [kPa], 64 colour bands (0 … 350); the bar on the right is the scale. Only the saturated zone (u ≥ 0) is coloured. Vertical scale ×2.

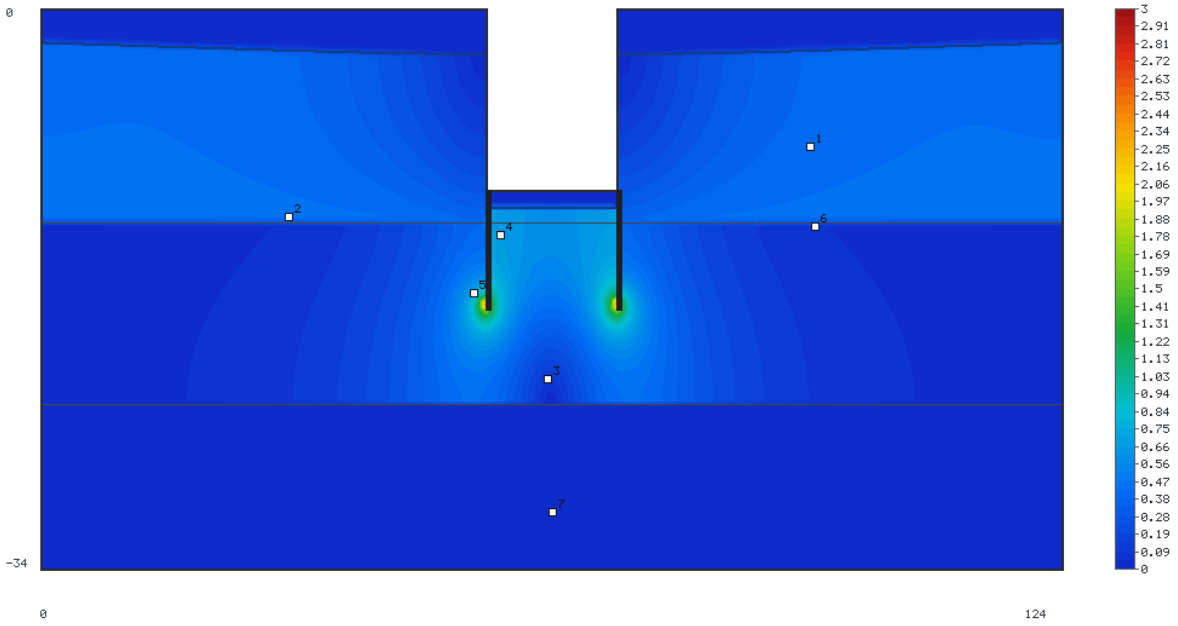


Figure 4: Flow velocity |v|

Flow velocity |v| [m/day], 64 colour bands (0 … 3); the bar on the right is the scale. Vertical scale ×2.

Excavation stages

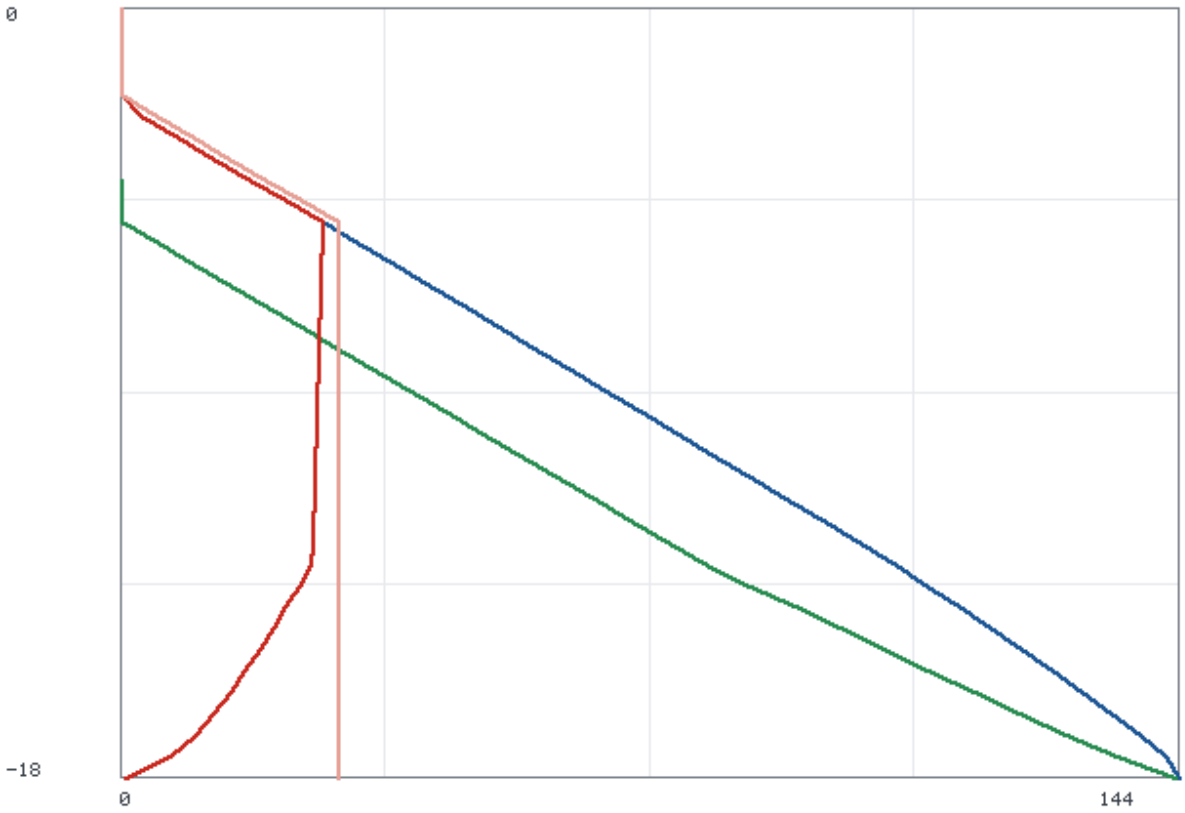


Figure 5: Stage 1 (4 m) — Left wall: water pressure u(z)

> Horizontal axis u [kPa], vertical axis level [m]. Blue: back face; green: front (excavation) face; red: NET water pressure (seepage solution, beam-on-springs input); light red: net, hydrostatic assumption. Maximum net 27.3 kPa (hydrostatic 29.4 kPa); net resultant 330.9 kN/m (hydrostatic 426.6 kN/m).

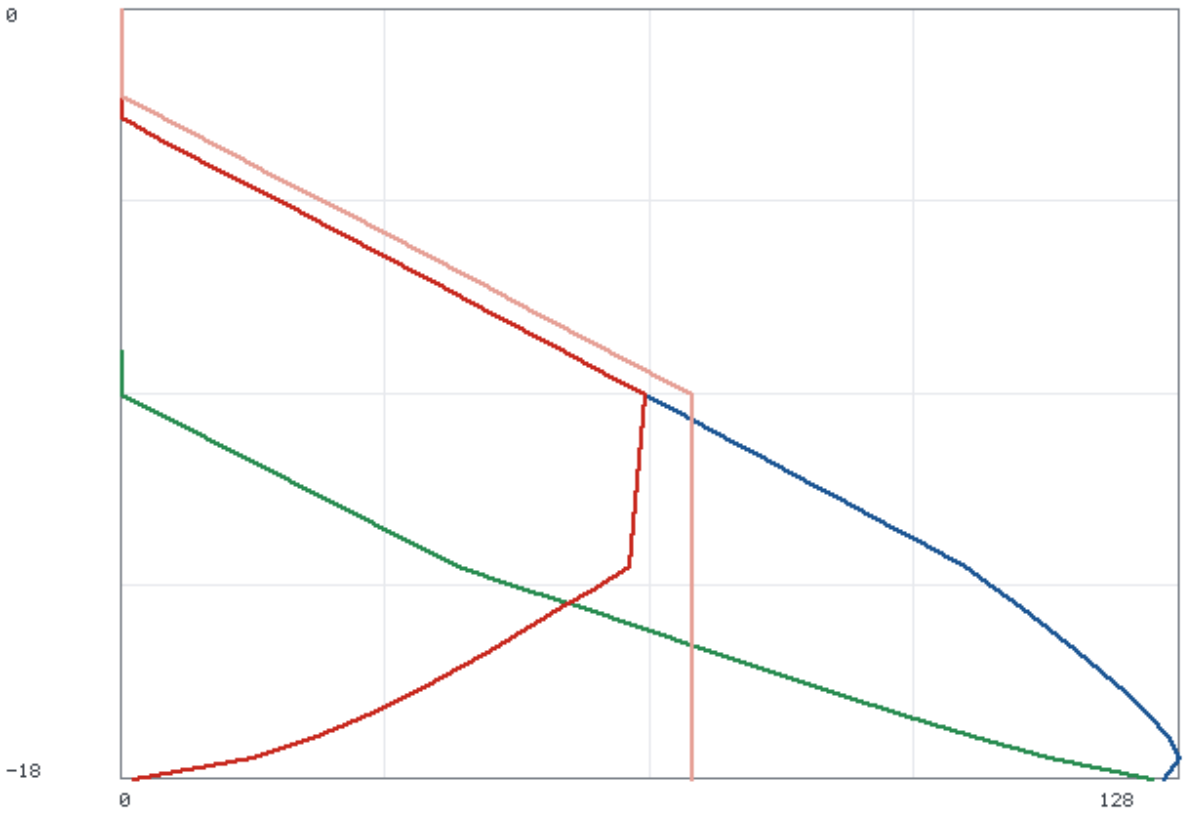


Figure 6: Stage 2 (8 m) — Left wall: water pressure u(z)

> Horizontal axis u [kPa], vertical axis level [m]. Blue: back face; green: front (excavation) face; red: NET water pressure (seepage solution, beam-on-springs input); light red: net, hydrostatic assumption. Maximum net 63.1 kPa (hydrostatic 68.6 kPa); net resultant 642 kN/m (hydrostatic 858.1 kN/m).

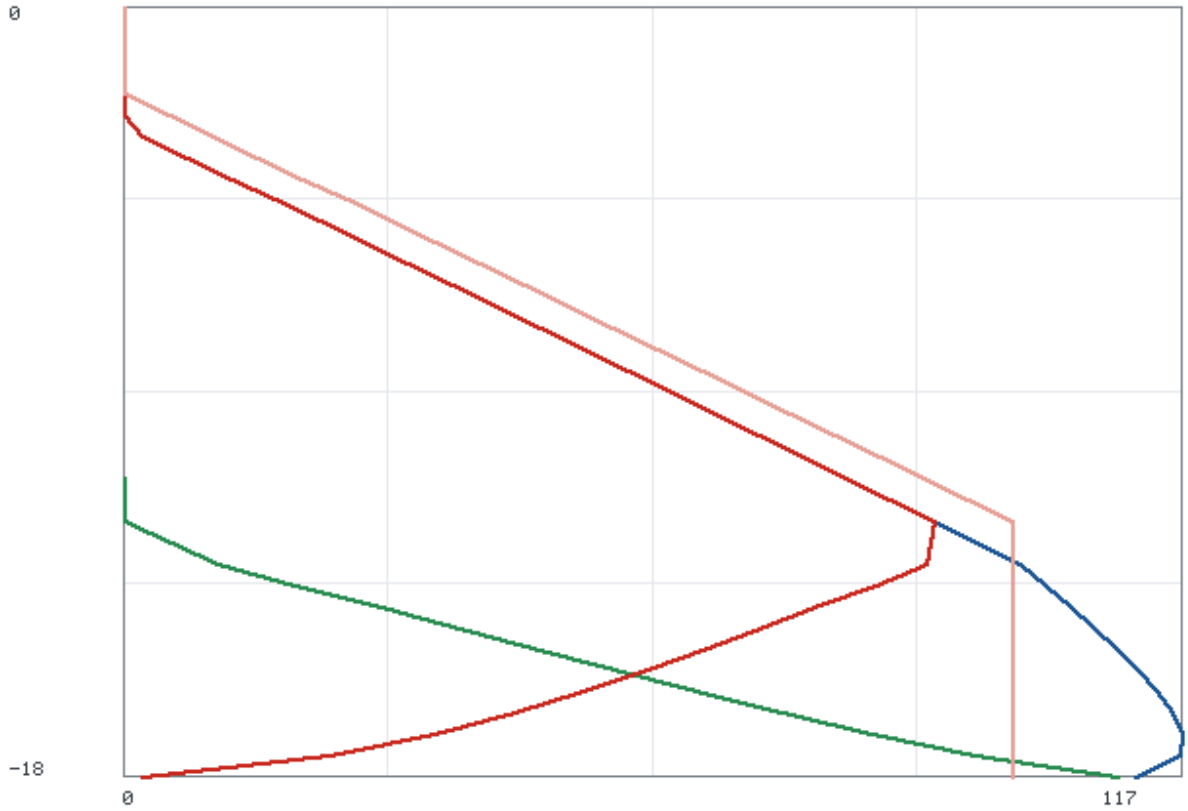


Figure 7: Stage 3 (11 m) — Left wall: water pressure u(z)

> Horizontal axis u [kPa], vertical axis level [m]. Blue: back face; green: front (excavation) face; red: NET water pressure (seepage solution, beam-on-springs input); light red: net, hydrostatic assumption. Maximum net 89.3 kPa (hydrostatic 98.1 kPa); net resultant 776 kN/m (hydrostatic 1078.8 kN/m).

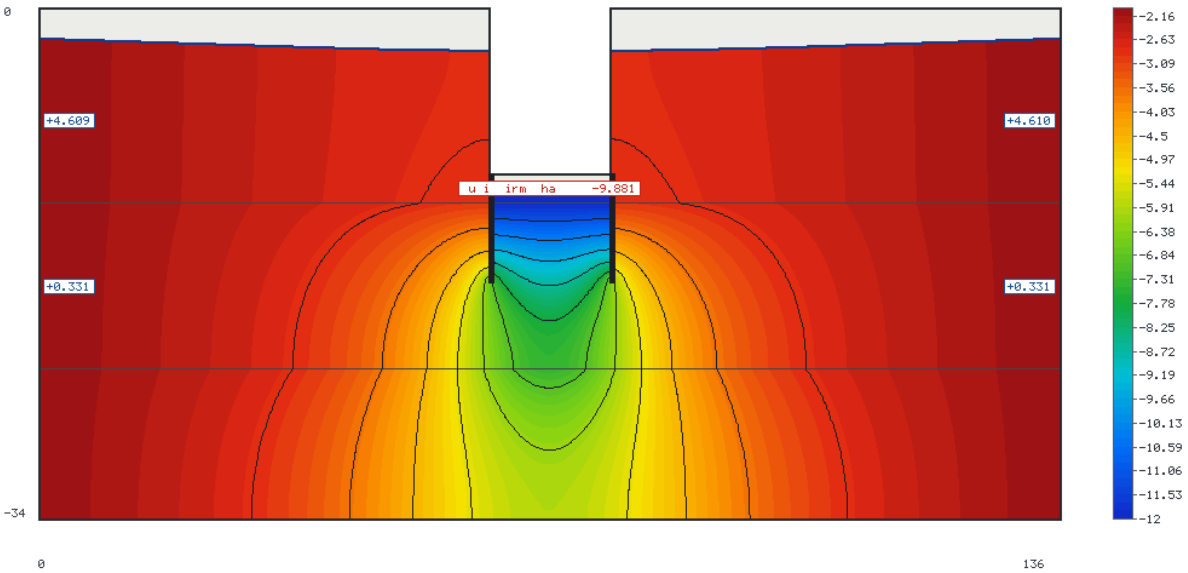


Figure 8: Stage 3 (11 m): total head h and boundary flows

Final excavation stage (base -11 m, water inside the excavation -12 m). Numbers in boxes are boundary flows [m^3/day/m]; total inflow to the excavation 9.881 m^3/day/m.