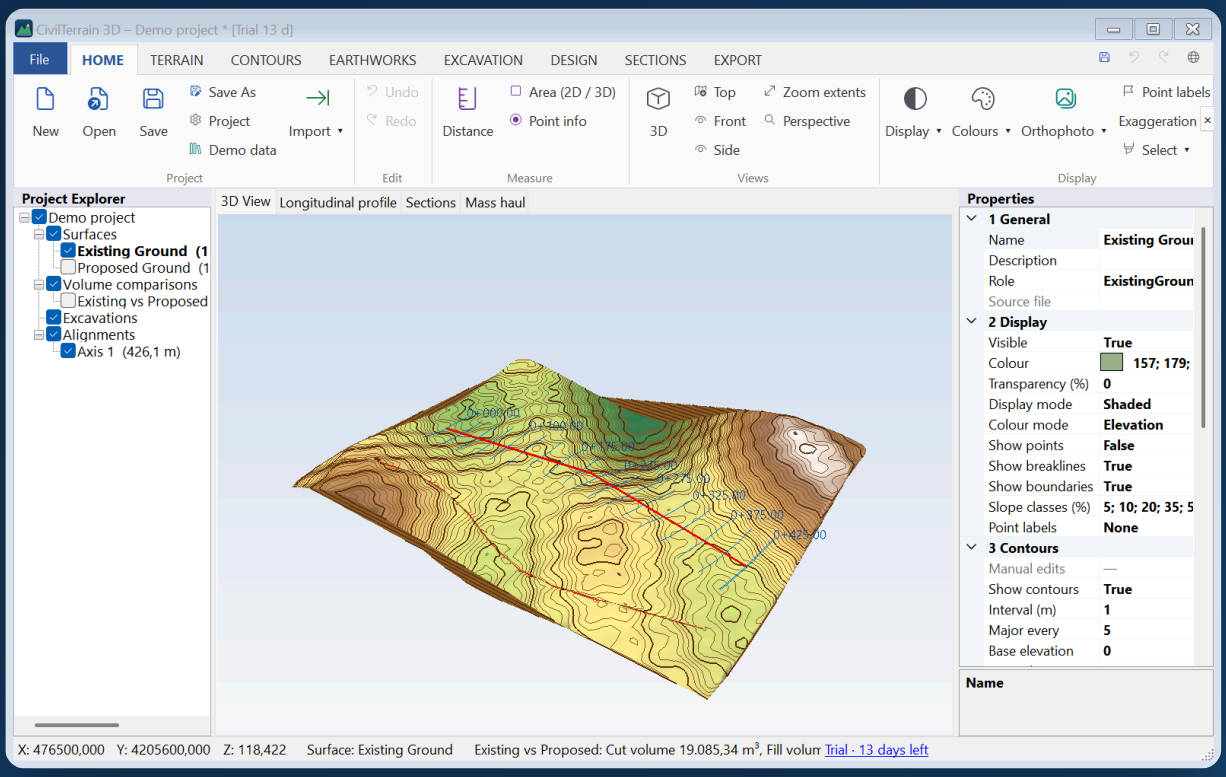
CivilTerrain 3D

User Manual · Version 1.6.14

Digital terrain models, contours, earthwork volumes, dynamic excavation design, cross sections and longitudinal profiles

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1. Introduction

CivilTerrain 3D creates and edits digital terrain models (TIN) and computes earthworks. It is intended for land surveyors, civil engineers, construction companies, earthwork and road contractors, and LiDAR/drone survey professionals.

With CivilTerrain 3D you can:

- import points from CSV/TXT/XYZ, DXF, LAS/LAZ, PLY/OBJ, LandXML and DEMs (GeoTIFF, ASCII Grid, SRTM, BIL / FLT);
- build a triangulated terrain model with breaklines, boundaries and holes;
- generate labelled and smoothed contours;
- compute cut/fill volumes between surfaces or against an elevation;
- design excavations whose slopes intersect the real ground;
- produce longitudinal profiles and cross sections, and re-create them at the same positions for re-measurement;
- export drawings and reports to DXF, PDF, Excel, LandXML, GeoTIFF and more.

New in version 1.6.14: triangles and contours from the spot grid (section 5.4): one option turns the grid points (e.g. every 20 m) into a surface of the project, with triangles and contours only inside the perimeter, over the survey or the orthophoto; it is updated with the grid. **Centroids** of the cut volume and of the fill volume, with the distance between them, in polygon earthworks and volume comparisons: in the window, the Properties, the reports and, if you wish, the drawing; and the command **Surfaces inside the perimeter** (section 12.6). In the ground filter, the option **Leave out low noise**, for clouds with points under the ground (section 8.1); in following a road / channel, “Suggest points” finds the crest and the toe correctly, the options of the result are always in view and the point codes are in English in the English interface (section 8.4). In surface imports, points with invalid coordinates are left out, with a message (chapter 7).

New in version 1.6.13: routes without a surface (section 15.7). The 3D polylines of a DXF / DWG (roads, networks, cables several km long) are imported as 3D lines, without making a surface, and **one click** on a line shows its **weighted slope** in the Properties. All the routes together in **one table**, with sorting, totals and export to Excel / CSV. Small improvements: in the Greek interface the Properties show their values in Greek («ναι / όχι» instead of True / False, display mode, colour mode, surface role and more); the tree menus and the item list have **Zoom to** (instead of “Zoom extents”) for zooming to one object; a status bar message that does not fit is shown in full when you rest the pointer on it.

New in version 1.6.12: three tools for drone surveys and orthophotos of earthworks sites. The **spot grid** (section 5.4): points every so many metres inside a perimeter with their elevations (e.g. "48.62 m") and, optionally, the Δz to a second surface, exported to CSV, TXT, DXF / DWG, Excel and PDF. **Remove objects** (section 10.4): machines, trucks and other objects come off the ground, found automatically or drawn, and the ground under them is made from the ground around them. **Replace terrain** (section 10.5): debris or a deposit inside an outline comes down to the ground around it.

New in version 1.6.11: themes (section 3.3): Light, Dark, CivilShop or "As Windows", in **File → Theme**. A new About window and a start screen with the CivilShop logo.

New in version 1.6.10: sloped design (section 14.5). Inside a perimeter you draw sub-areas with a grade on each side as you draw, and get at once the design surface with side slopes and its cut / fill against the ground. Also the **elevation offset** of the whole surface or inside an outline, with a transition band and a comparison into a copy (section 10.3). A rare triangulation fault that could count the volumes of an excavation or platform twice is also fixed.

New in version 1.6.9: hydrology, in the new **WATER** tab (sections 9.7 – 9.8): where the water runs and where it **stays** on a surface, with the depth and volume of each pool, and **drainage basins** from one click at the outlet, with area, longest flow path, time of concentration (Kirpich, Giandotti) and peak flow by the rational method. The ribbon also **scrolls** in narrow windows (laptops), section 3.1.

New in version 1.6.8: grading optimization inside an outline (section 14.4). It finds the surface with the least earthworks for a largest grade (e.g. 5%), with drainage where you draw water paths and outlets, points of given elevation, cut / fill and elevation limits, balance and side slopes.

New in version 1.6.7: sections with a **width and interval of up to 15 000 m** (e.g. sections over a large DEM), and the **grade line can be hidden** with a check box, so that the profile and the sheets show only the ground (sections 15.1 – 15.2).

New in version 1.6.6: contour labels (section 11): you choose which contours get labels and every how many metres. The choices are major, minor, all, every N-th, every X m of elevation or given elevations, with the shortest contour labelled and the decimals, for one or all surfaces.

New in version 1.6.5: following a road / channel in a LiDAR / drone cloud (section 8.4). From a rough line and the typical section at its start, the program follows the feature by itself and gives the **crest, toe, edges and ditches** as coded breaklines. It also separates the **ground from vehicles and vegetation** in the corridor without cutting off the edges.

New in version 1.6.4: DEM import in more formats (section 7.6) — GeoTIFF and BigTIFF (strips or tiles, LZW / Deflate / PackBits), **ESRI ASCII Grid (.asc)**, **SRTM (.hgt, also inside a .zip)** and **ESRI BIL / FLT**; the coordinate system from the file, its `.prj` or the tile name, and a **transformation** into the project's system (e.g. WGS 84 → GGRS87); **only the project area** of large DEMs and keeping every n-th cell; TIFFs without georeference through their world file (`.tfw`); surface export as an **ESRI ASCII Grid**.

New in version 1.6.3: the **Project Explorer** becomes the place to manage the whole project (section 3.2). It includes: the definition of every surface in the tree (point groups, breaklines, boundaries, edits with check boxes); the parts of every alignment, opened by double-click; ⚠ **out of date** marks and "Update all"; "Used by" and a warning on deletion; an **item list** as a table; **selection by clicking in the drawing**; search.

New in version 1.6.2: Δz labels on a grid over the cut / fill map at a node spacing you give (e.g. every 10 m), on screen, in the PDF / Excel report and in DXF / DWG (section 12.13); **a point cloud in its RGB colours** as a gridded surface at a sampling you type, with no orthophoto, in every display mode (section 8.3); **weighted slope by clicking** a 3D polyline, breakline or feature line of the drawing, without an ASCII file (section 15.6).

New in version 1.6.1: merging surfaces and point clouds (section 9.6) — two or more surfaces into a new one, with priority in the common area, height alignment and thinning; the About box shows the version.

New in version 1.6: section grid and volumes — parallel sections every d m inside a boundary, nodes with Δh, areas and volumes by the average end area method, checked against the exact TIN volume and the grid method (section 12.12); bathymetric colours and Greek labels in the 3D view.

New in version 1.5: final ground levels check of the Greek building code (NOK) — final against natural ground at every point of the uncovered area (±1.50 m, steep plots −2.00 / +1.50 m, permit above 0.80 m), with excluded areas (building, ramps, cours anglaises, pools), a map, the worst points and **permit sections at true scale** for the coverage diagram.

New in version 1.4: **polygon earthworks** — pick a zone, a closed line or a DXF outline (or draw it) and get cut / fill to a level or an inclined plane (also from 3 points or best fit), another surface or a depth, **balanced** or with a required surplus, with vertical edges or side slopes; **topsoil**, **swell / compaction factors**, truckloads and a **waste (ΣΔA) table** in the reports; volumes per zone with a choice of comparison, % outside the surfaces and an overlap check.

New in version 1.3: **depth lines below the profile** (cable/pipe trenches with indications every N m, volumes and setting-out table), **weighted slope** of a route, **volume zones from DXF/DWG** (named from the drawing's texts), cut-and-fill level from a 3D polyline and many accuracy fixes.

New in version 1.2: direct **DWG** reading and writing (no AutoCAD needed), feature lines with elevations and grades, graded platforms with **automatic cut/fill balance**, automatic linework from **point codes**, multiple typical sections with widenings, **superelevation** with diagram, dynamic labels and automatic **plan-profile sheets**.

New in version 1.1: contour editing (delete, masks, labels), measuring tools, points table and point labels, stockpile/pit volumes, volumes per zone, road design (horizontal alignment with arcs and clothoids, grade line with vertical curves, typical section, road surface), mass-haul (Bruckner) diagram, scaled drawing sheets, ground filter for LiDAR/drone clouds, orthophotos draped on the terrain and faster editing of large surfaces.

System requirements

Operating system	Windows 10 (1809 or later) or Windows 11, 64-bit
Memory	4 GB (8 GB+ recommended for point clouds)
Graphics	Graphics card with OpenGL support (all modern cards)
Disk	~150 MB for the installation
Internet	Only for license activation/validation and updates

2. Installation and licensing

2.1 Installation

1. Download `CivilTerrain3D-Setup-x.y.z.exe` from www.civilshop.gr/demos.aspx.
2. Run it. If Windows SmartScreen appears, click **More info** → **Run anyway**.
3. Accept the license terms, choose a folder and optionally a desktop icon and the association of `.ct3d` project files.
4. The program starts at the end. The Start menu also contains a shortcut to the **sample data**.

No other software is required. Uninstall from Windows **Settings** → **Apps**.

2.2 Free 14-day trial

From the first start you have **14 days of full functionality** without a key. The remaining days are shown in the window title and in the status bar (bottom right). After the trial the program runs in **viewer mode**: you can open and view projects, but saving, exports, reports, excavation and sections are disabled until a license is activated. Your projects are kept.

2.3 License activation

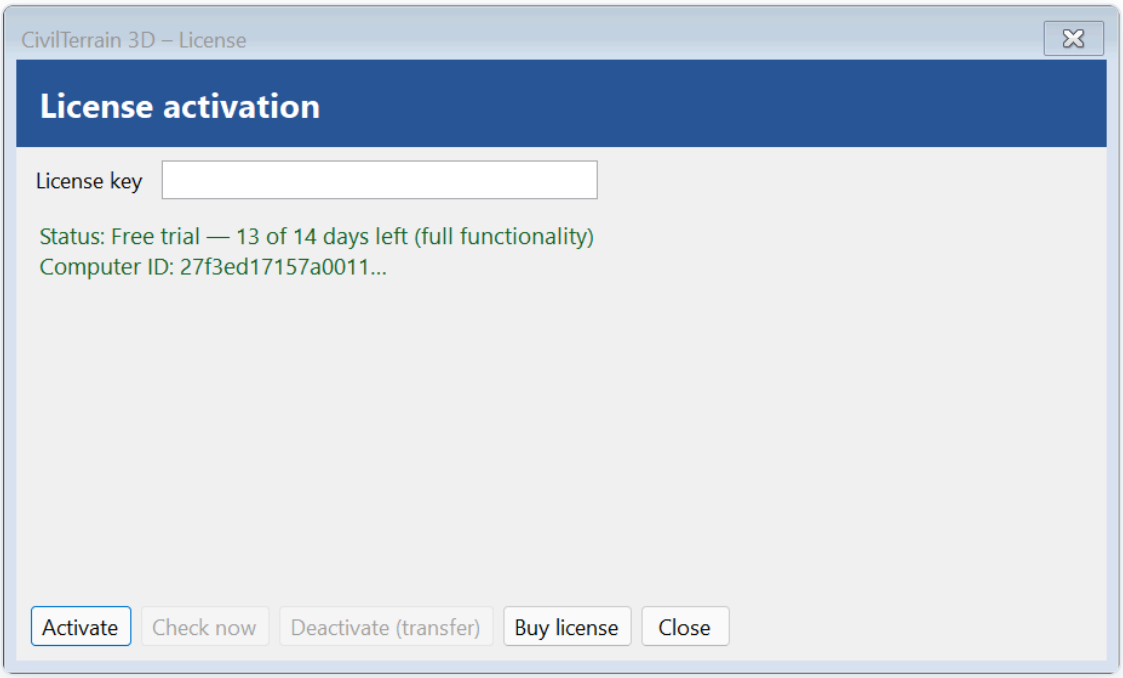


Figure 2.1 – The License window

1. Open **File** → **License...** or click the license indicator in the status bar.
2. Type or paste your **license key** (e.g. `CIVILTERRA-XXXXX-…`).
3. Click **Activate**. An Internet connection is required.

Button	Function
Activate	Binds the license to this computer.
Check now	Checks the license status on the server immediately.
Deactivate (transfer)	Releases the license from this computer so it can be activated on another one.
Buy license	Opens the shop in your browser.

> **Offline use:** the license is checked at every start. Without a connection the program keeps working normally for **7 days** based on the last successful check.

Possible messages: *license expired*, *revoked*, *suspended*, *all activations are used by other computers* (deactivate one first), *key does not exist*. If your license contains specific modules, the other functions show a notice.

2.4 Updates

At every start and from **File** → **Check for updates** the program looks for a newer version. Updates are provided while the license's update subscription is active; after it expires, the installed version keeps working.

3. The user interface

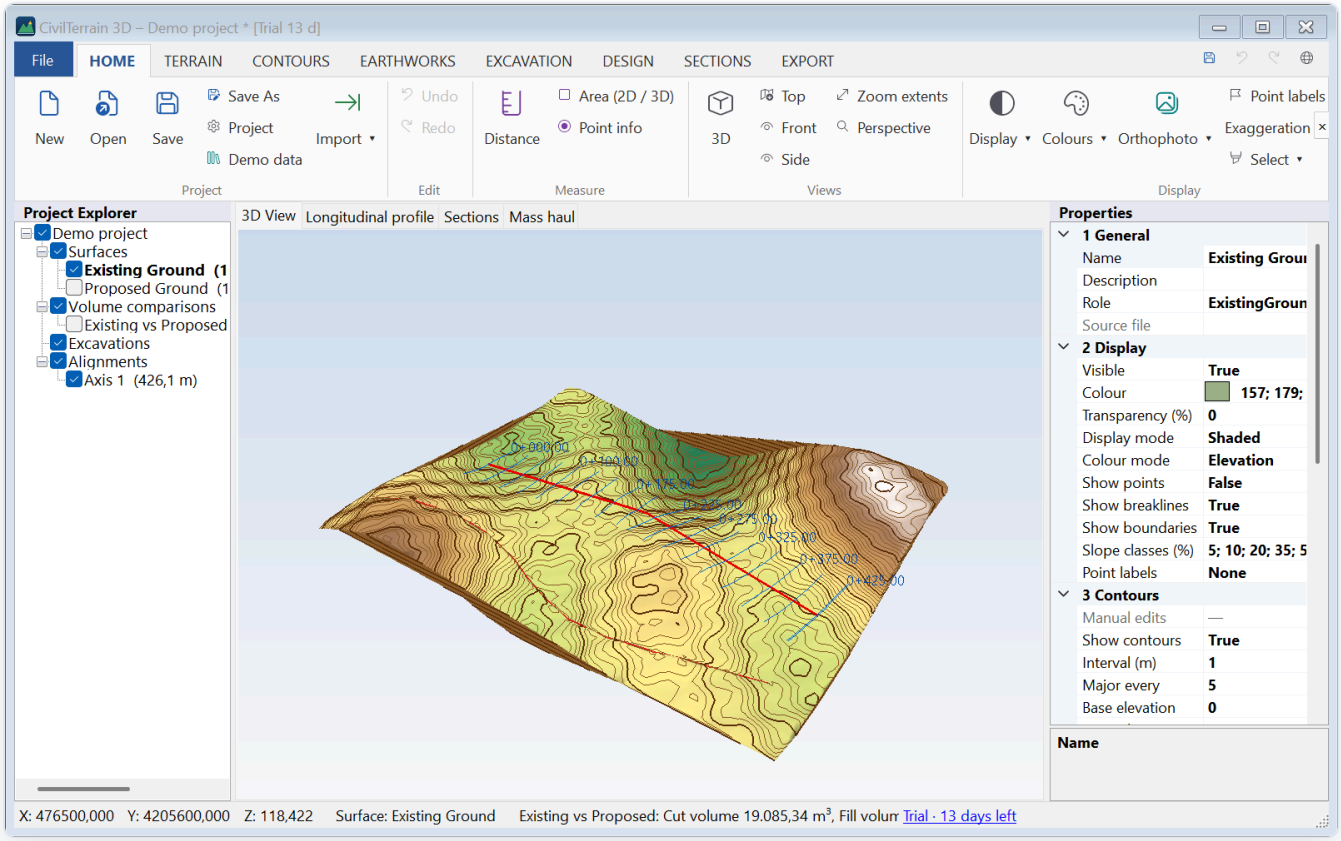
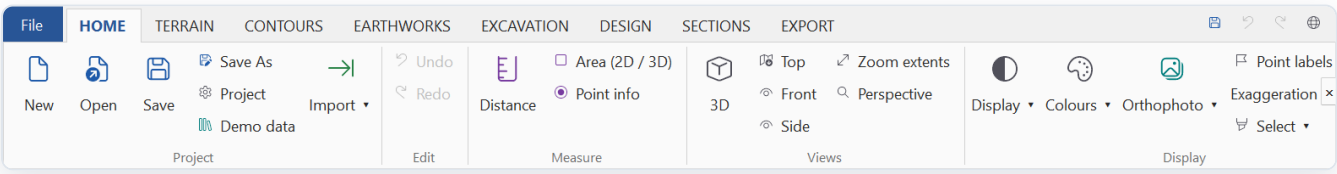


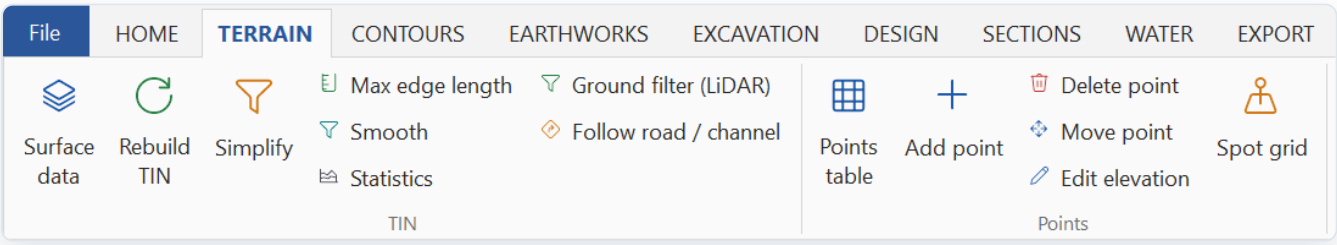
Figure 3.1 – Main window: ribbon (top), Project Explorer (left), 3D view (centre), Properties (right), status bar (bottom)

Area	Description
Ribbon	Commands organised in tabs: HOME, TERRAIN, CONTOURS, EARTHWORKS, EXCAVATION, DESIGN, SECTIONS, WATER, EXPORT. Double-click a tab to collapse/expand the ribbon.
File (blue button)	New, Open, Save, Save As, Project settings, Recent projects, License, Check for updates, Classic toolbars, Theme (section 3.3), About, Exit.
Quick access (top right)	Save, Undo, Redo, switch language Ελληνικά/English.
Project Explorer	Tree of every object of the project (section 3.2). The check box shows/hides. Click selects (the selected surface becomes the **active** one, in bold). Double-click zooms to it. Right-click opens a menu (Rebuild, Duplicate, Statistics, Delete…).
Centre	Tabs **3D View**, **Longitudinal profile**, **Sections**, **Mass haul** (mass-haul diagram, section 17.5).
Properties	Settings of the selected item (display, contours, TIN, statistics, volume results…). Changes apply immediately.
Status bar	X, Y, Z under the cursor, active surface, messages/tool prompts, progress, license status and coordinate system.

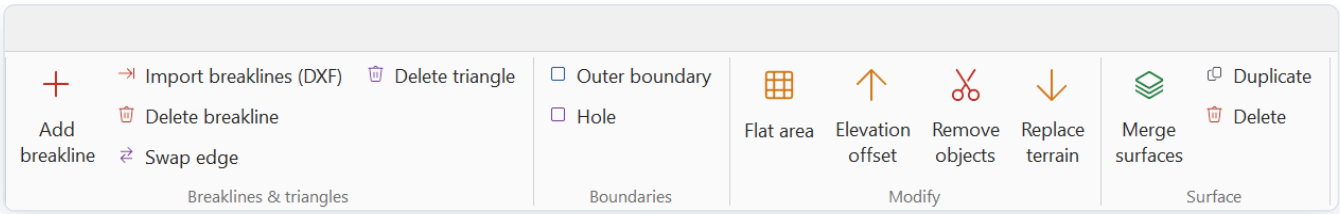
3.1 Ribbon tabs



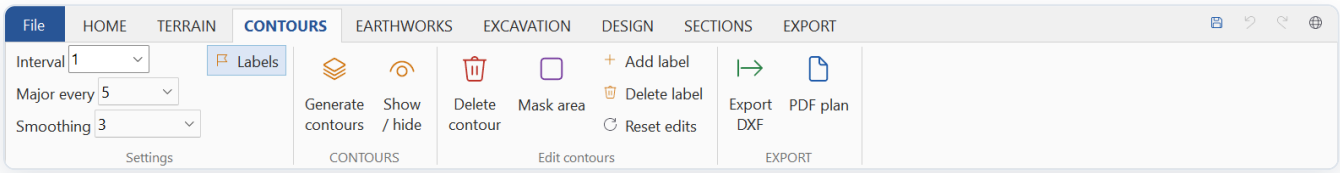
HOME – project, import, undo, views, display



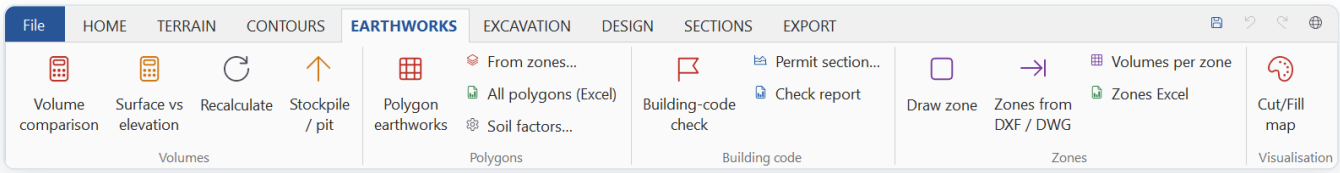
TERRAIN, left part – TIN (with the ground filter and Follow road / channel), points and spot grid



TERRAIN, right part – breaklines, triangles, boundaries, modify (elevation offset, remove objects, replace terrain), merge surfaces



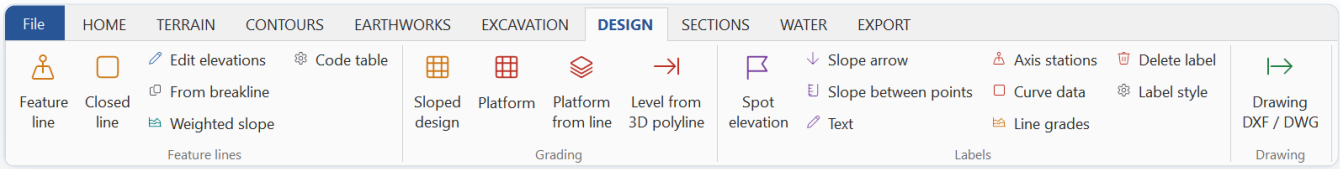
CONTOURS – interval, major, smoothing, labels, export



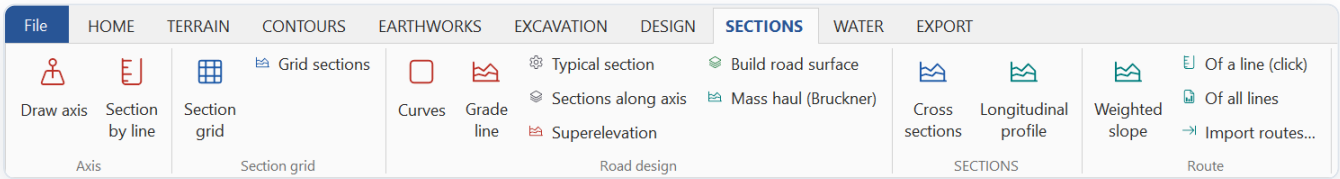
EARTHWORKS – volume comparisons, cut/fill map, reports



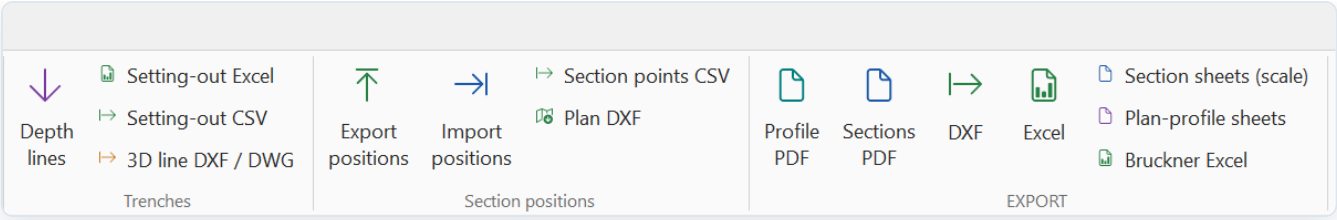
EXCAVATION – new excavation, designer, create surfaces, report



DESIGN – feature lines, platforms, labels, DXF/DWG drawing



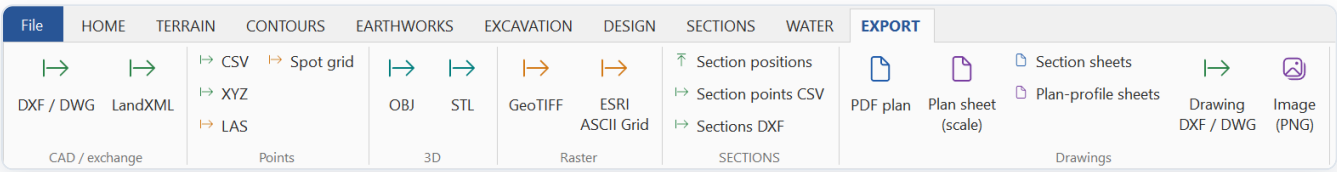
SECTIONS, left part – axis, section grid, road design, sections, profile, route (weighted slope, import routes)



SECTIONS, right part – trenches (depth lines), section positions, exports



WATER – water on the surface, pools, drainage basins



EXPORT – CAD, points (and spot grid), 3D, raster, sections, drawings

In a narrow window (e.g. a laptop), when the groups of a tab do not fit, the ribbon **scrolls**: with the ‹ › arrows at its ends or with the mouse wheel over it. If the tabs do not fit beside the quick-access buttons, they get narrower.

> **Tip:** if you prefer simple toolbars choose **File → Classic toolbars**. Switch back with the **Ribbon view** button on the HOME tab. The choice is remembered.

3.2 Project Explorer

The **Project Explorer** tree shows every object of the project with icons and a count per collection. Above the tree are a **Search** box and two buttons: **Update all** and **Item list**. When the tree is rebuilt, it keeps which nodes are open and which one is selected.

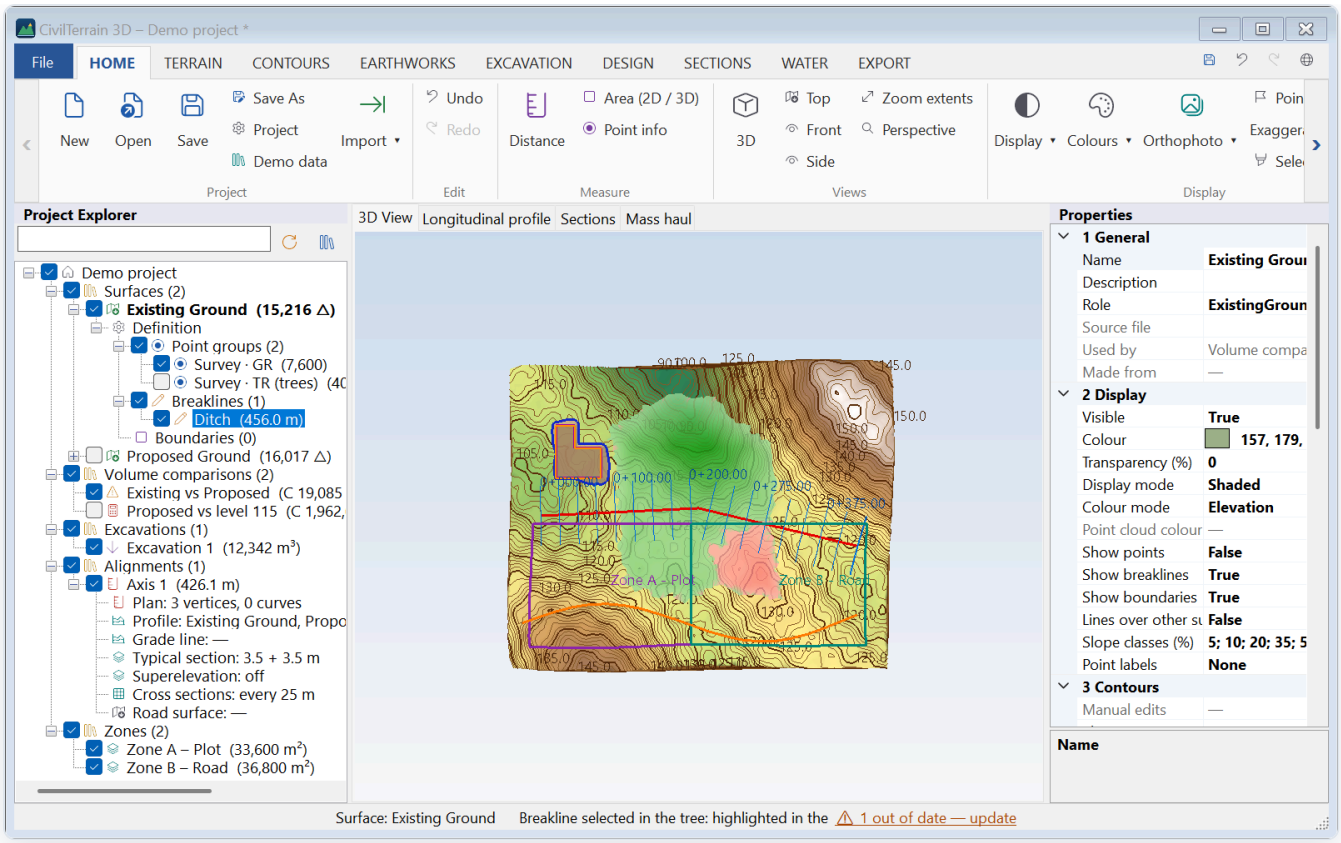


Figure 3.2 – The definition of the surface and the parts of the alignment in the tree; the selected breakline is highlighted in the drawing; a comparison "⚠ out of date"

The definition of every surface

Below every surface, the **Definition** node shows what takes part in its TIN (and the maximum triangle edge, if set):

- **Point groups** – the check box switches each group on or off (e.g. the "trees") and the TIN is rebuilt at once. The folder check box changes all groups together.
- **Breaklines** – each with its length. Selecting one highlights it in the drawing. Right-click: zoom, rename, delete, import breaklines from DXF / DWG. Above 60 they are grouped by name (e.g. the DXF layer).
- **Boundaries** – outer, holes and show boundaries, with an on / off check box.
- **Edits** – swapped edges and deleted triangles. Each can be removed on its own (right-click), or all together.

Every change made from the tree can be undone with **Undo**. Double-clicking **Definition** opens **Surface data**.

The parts of an alignment

Below every alignment are its parts, each with a short summary:

- plan (vertices, curves);
- profile (surfaces);

- grade line;
- typical section and typical sections along the axis;
- superelevation;
- cross sections;
- depth lines;
- road surface.

Double-click a part to open its window, e.g. “Grade line” opens the grade line, while “Road surface” builds or updates it.

Out of date and dependencies

When a surface changes, whatever is computed from it updates automatically: comparisons, excavations, polygon earthworks, building-code checks, section grids. Automatic update can however be switched off in the Properties. The road surface is also built by a command. In these cases the object is marked ⚠ **out of date**:

- with an icon in the tree;
- with an explanation when you hover over it;
- in the Properties (**State**);
- in the status bar, as a link “⚠ N out of date — update”.

The same holds for a **road surface** if the alignment, grade line, typical section, superelevation or ground changed after it was built.

- **Update:** right-click → **Update** on one object, or the **Update all** button above the tree, or click the message in the status bar.
- ⚠ **surface missing**: a surface the object is computed from was deleted.
- **Used by**: the Properties of every surface (and its tooltip in the tree) list the objects that use it. When a surface is **deleted**, the program names them before asking for confirmation.

Item list

Clicking a collection, e.g. **Surfaces**, opens the **item list** under the 3D view, a table with the key figures of every object:

- **surfaces:** points, triangles, Z min/max, area, maximum edge, what uses them;
- **comparisons:** base, comparison, cut, fill, net volume, state and centroids (X, Y, Z of the cut and of the fill, CG distance); polygon earthworks have the centroids too;
- **alignments:** length, stations, curves, grade line, road surface etc.

Working with the table:

- click a header to sort;

- rename in place (F2);
- the check box shows or hides;
- with several rows selected: **Show**, **Hide**, **Zoom to**, **Update**, **Copy (Excel)** and **Delete** (one question for all).

Objects that are out of date are shown in orange. Selecting a row also selects the object in the tree. Clicking the project itself shows a **summary** of every collection.

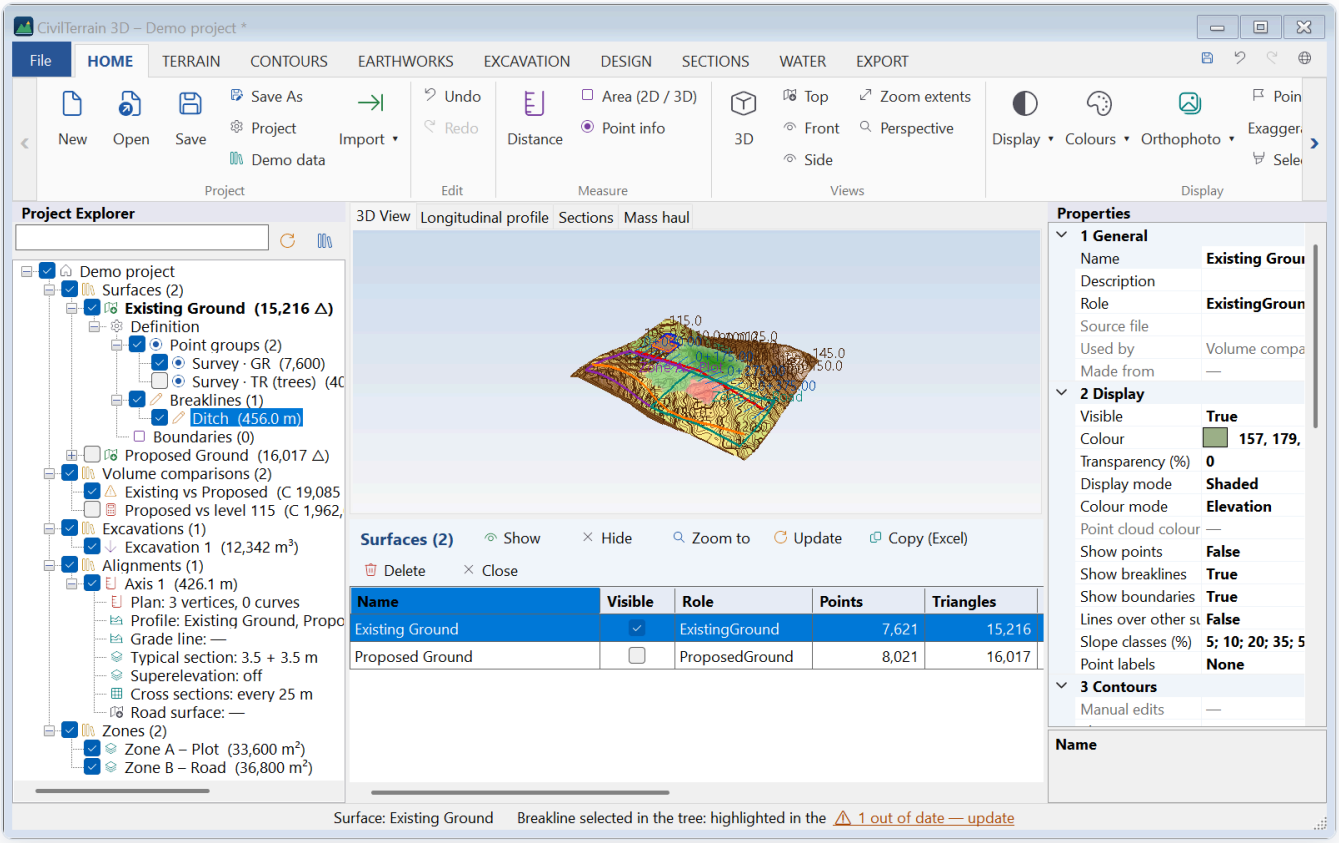


Figure 3.3 – Item list: the surfaces of the project

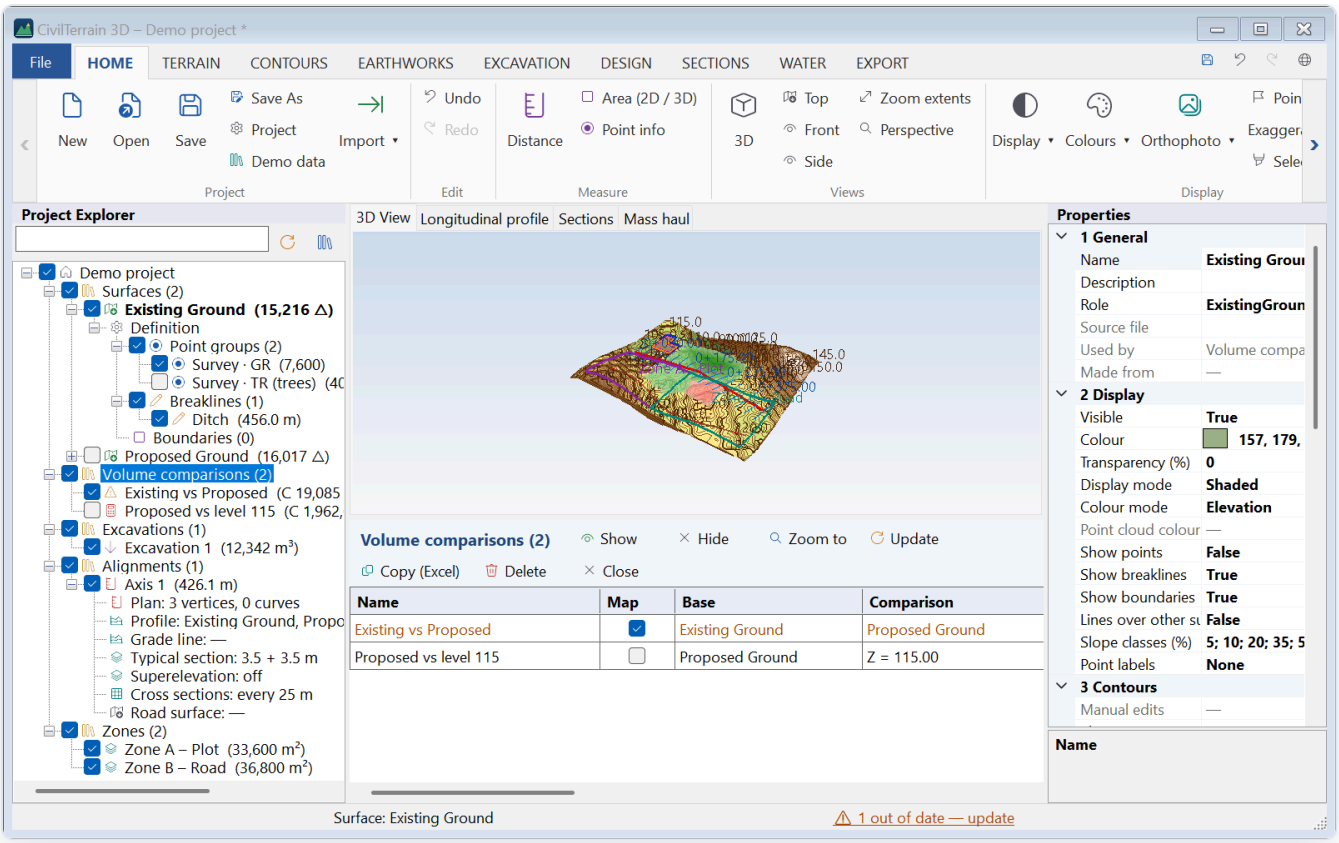


Figure 3.4 – Item list: the volume comparisons, the first one out of date; the columns of the volumes and the centroids follow on the right (horizontal scroll)

Many feature lines

Up to 500 feature lines are shown one by one under **Feature lines**. With more (e.g. a network of routes from a DXF, section 15.7), the tree groups them per code / layer, with their count and length, e.g. “ROADS (1,250 lines, 84.3 km)”. When you open the node of a layer, its first 300 lines appear, followed by a “… and N more (Item list)” node. The check box of the node shows or hides every line of the layer. A line you select in the drawing or in a table is added to the tree and selected. Right-click **Feature lines**: **Weighted slope of all lines…** and **Import routes (DXF / DWG)…**.

Selecting by clicking in the drawing

A plain click in the 3D view (without dragging) selects the object under the cursor, in this order:

1. lines and outlines (alignments, feature lines, excavations, zones, polygons, building-code checks, section grids, spot grids, breaklines);
2. the area the point is in, or a marker of a spot grid (section 5.4);
3. the cut / fill map.

Its node is selected in the tree and its Properties open, as in a CAD program. A click on bare terrain changes nothing (the active surface stays the same; surfaces are selected in the tree). Drawing tools, the double-click that ends a line and the vertex / edge / triangle selection are not affected. If the object is hidden by the search, its name is shown in the status bar.

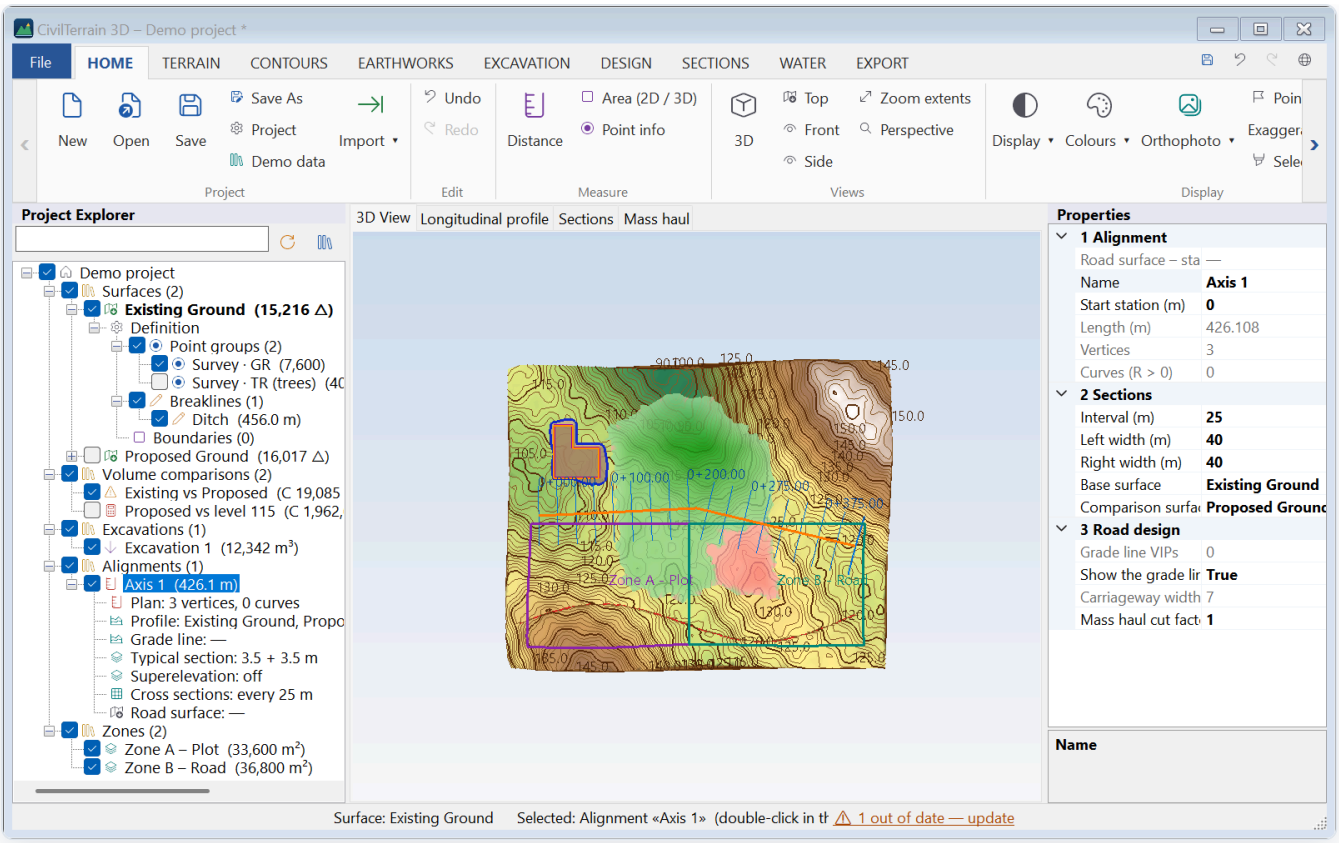


Figure 3.5 – A click on the alignment: it is selected in the tree with its parts and its Properties open

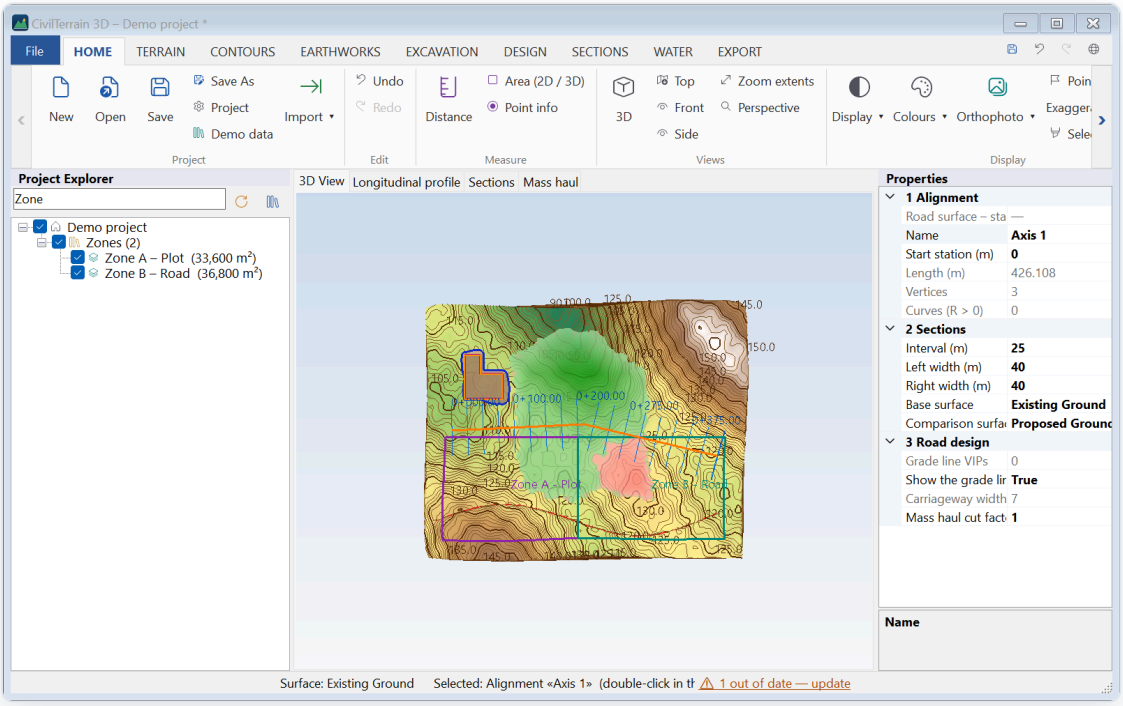


Figure 3.6 – Searching the tree

3.3 Theme

In **File → Theme** you choose how the program looks. The choice is remembered.

Theme	Description
Light	The default. It looks the same as earlier versions.
Dark	Dark windows, ribbon, tree, tables and drawings (profile, cross sections, mass haul diagram) with light text, and a dark background in the 3D view. It suits long working hours or low light. Available on Windows 11.
CivilShop	Light, in the CivilShop colours: a dark title bar and tab strip, a yellow line under the selected tab and blue headings.
As Windows	Dark or light, following the Windows setting for apps (Settings → Personalization → Colors). The menu shows which of the two applies now. On Windows 10 it stays light.

The theme changes when the program **restarts**. After you choose a theme, the program asks whether to restart now. If the project has unsaved changes, it first asks you to save them, and then opens the project again. If you answer "No", the new theme applies at the next start. With "As Windows", a message in the status bar tells you when the Windows setting changes while the program is open.

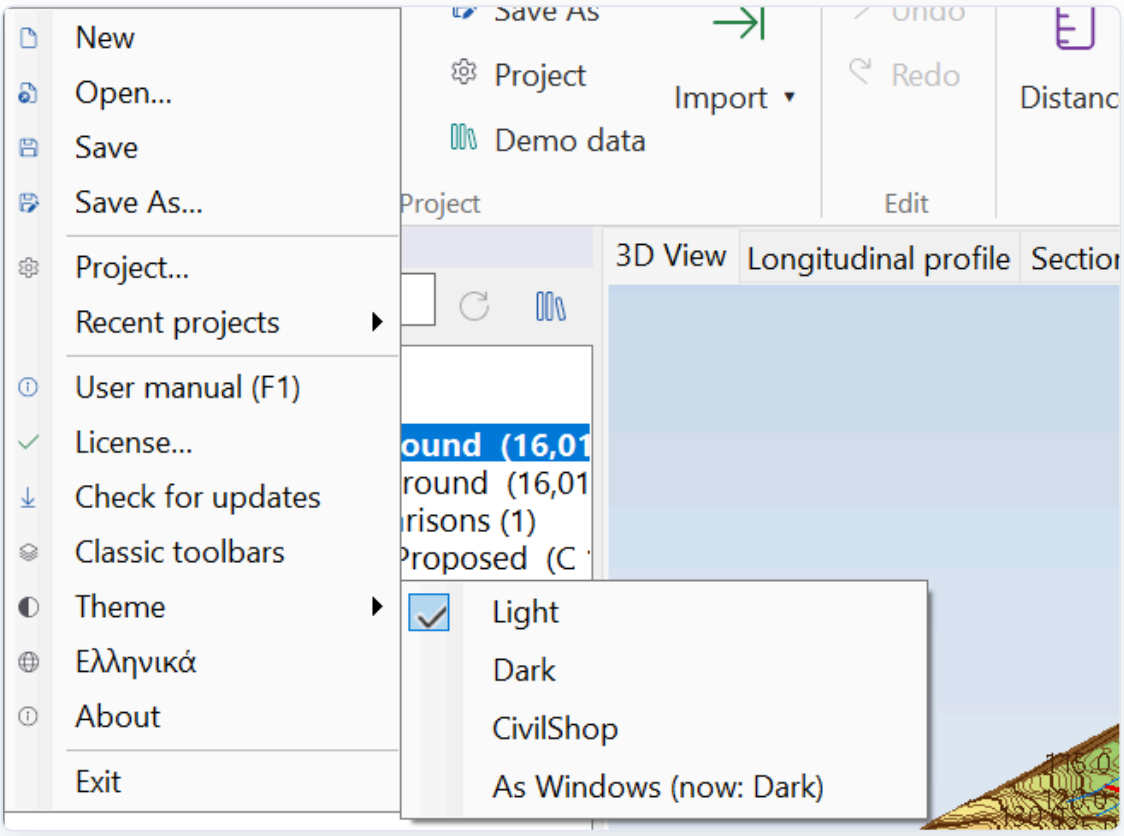


Figure 3.7 – File → Theme

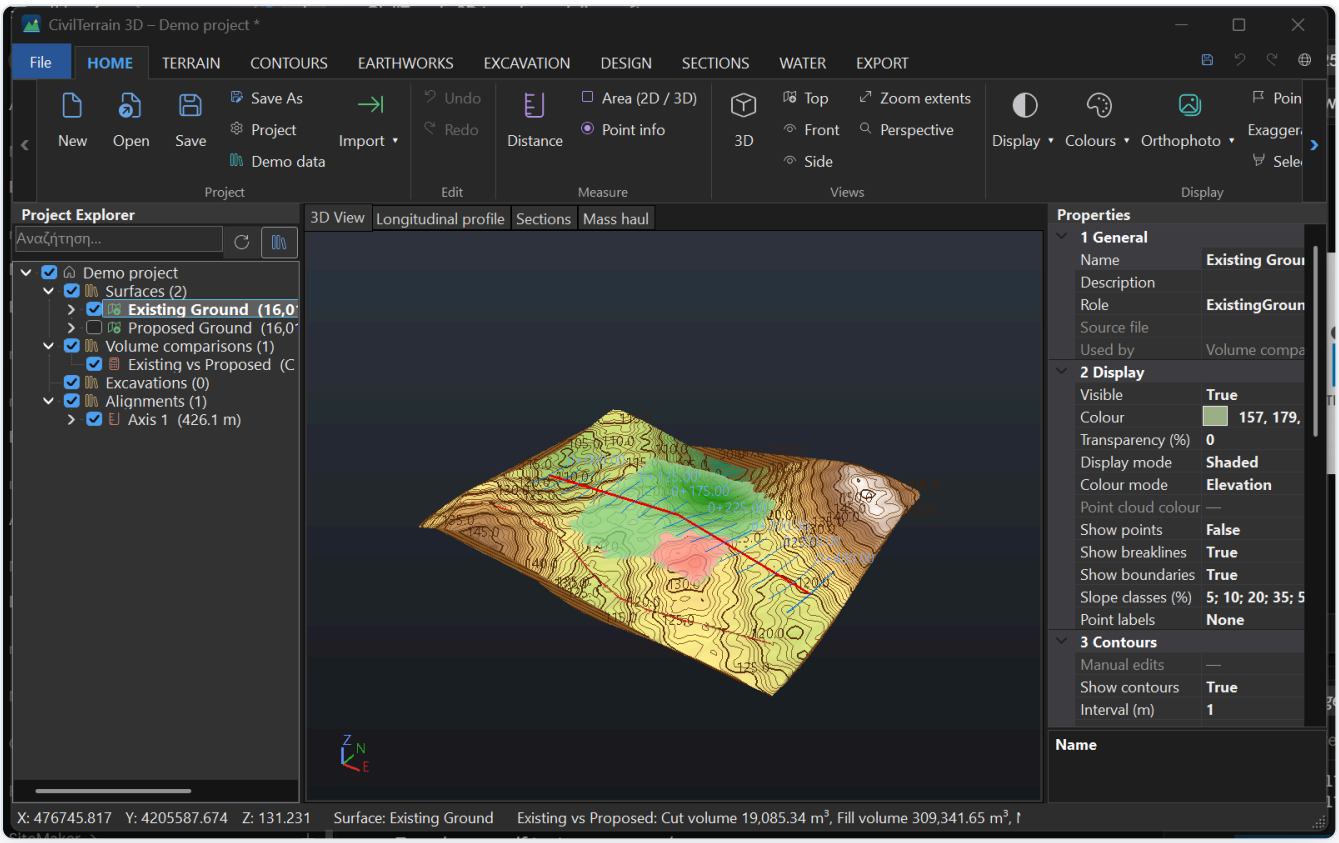


Figure 3.8 – The Dark theme

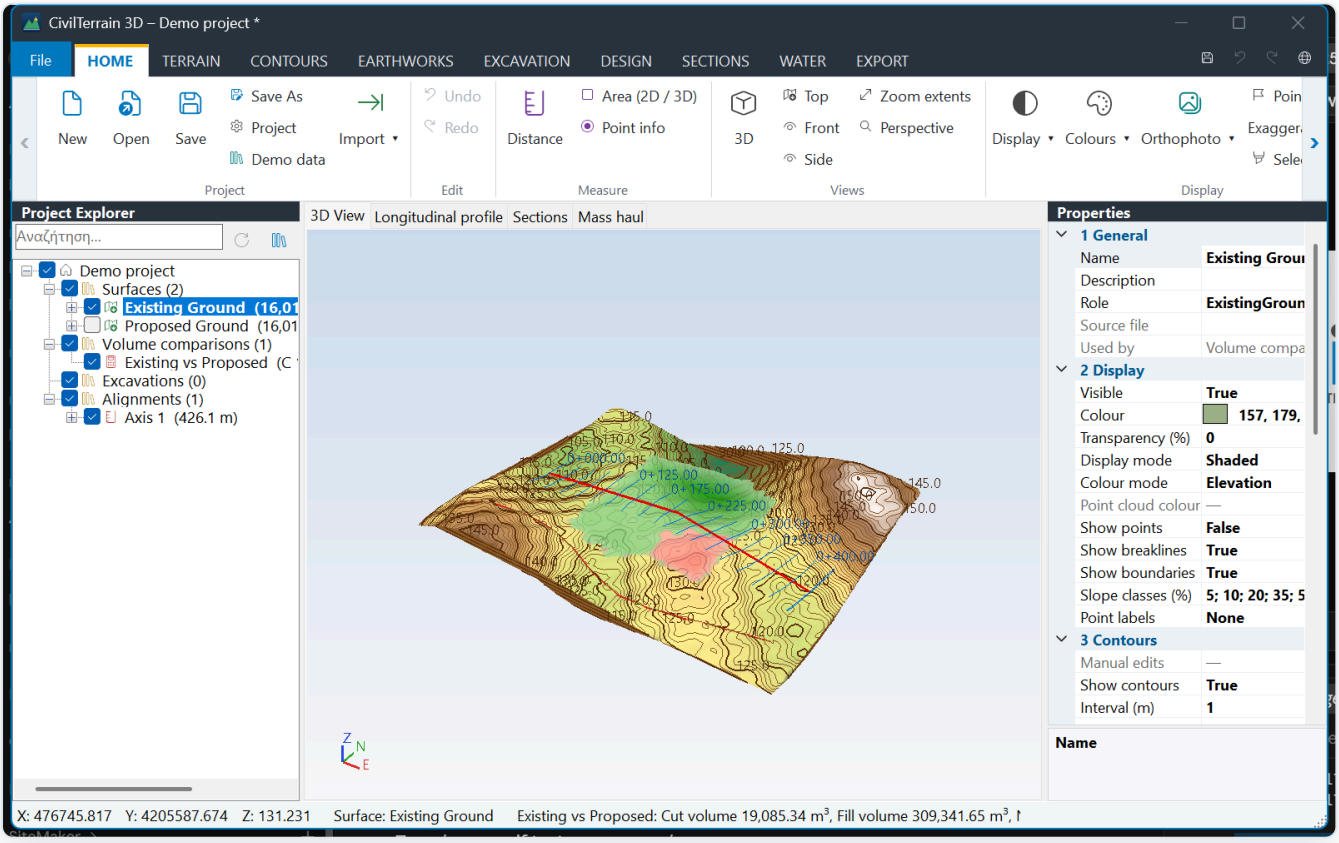


Figure 3.9 – The CivilShop theme

> Exported images (PNG of the 3D view, report pictures) and PDF reports always have a **white background** , whatever the theme, so they print correctly. With Windows high contrast on, the program keeps the system colours.

The **File** → **About** window shows the version and a link to the CivilShop store. The CivilShop logo appears there and on the start screen.



Figure 3.10 – About

4. 3D navigation and display

Action	Control
Orbit	Drag with the left mouse button
Pan	Drag with the right or middle button, or `Shift`+left
Zoom	Mouse wheel — zooms towards the point under the cursor
Views	**3D**, **Top**, **Front**, **Side**, **Zoom extents**
Projection	**Perspective** or **Orthographic** (toggle with the same button)

4.1 Display modes and colouring

From **HOME → Display**: **Shaded**, **Wireframe**, **Shaded + Wireframe**, **Points**. From **Colours**: **Elevation colours** (hypsometric ramp), **Slope analysis**, **Solid colour**. Settings apply to the active surface; details (colour, transparency, slope classes) are in Properties.

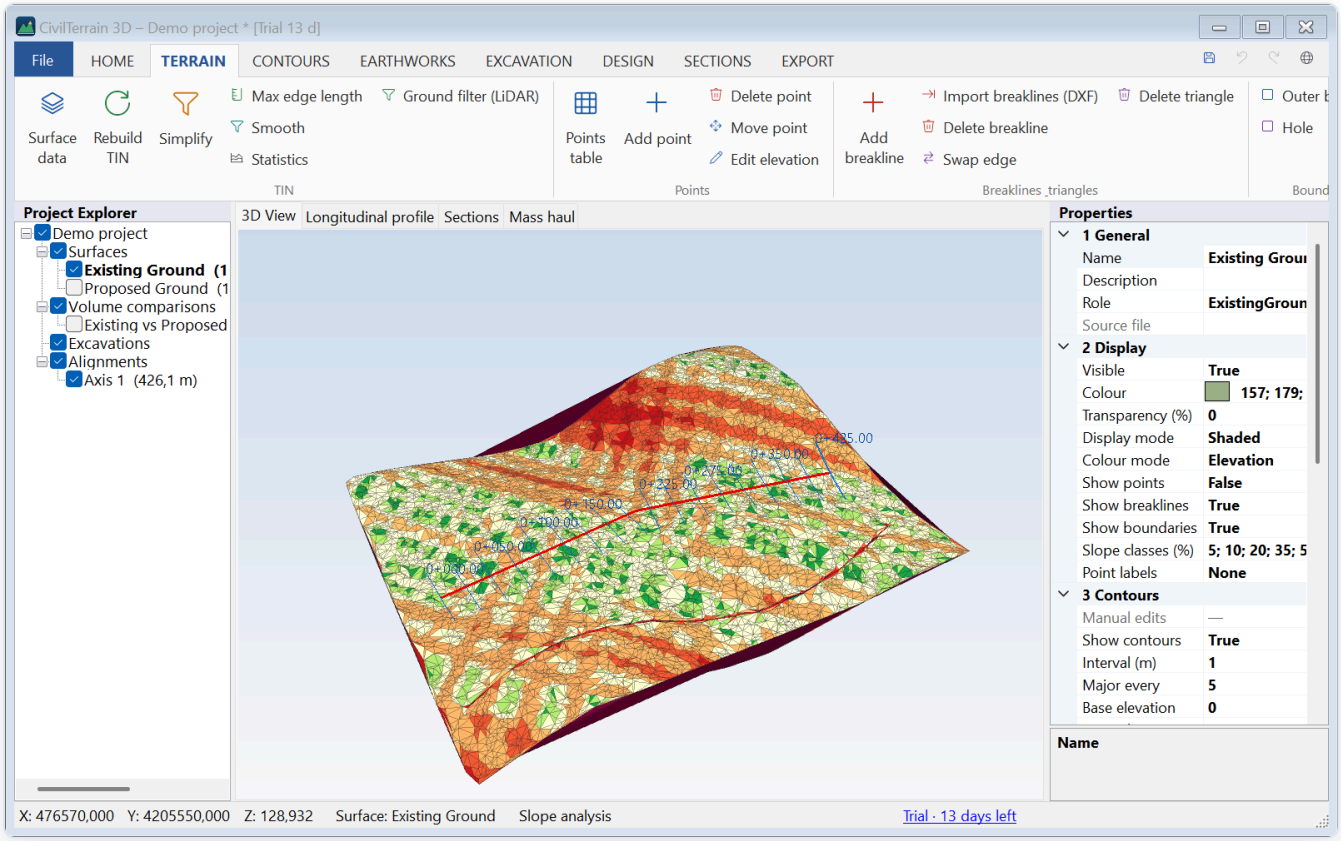


Figure 4.1 – Slope analysis with triangles

Slope classes (e.g. `5; 10; 20; 35; 50; 100` %) are defined in the surface Properties. **Vertical exaggeration** (×1 to ×10) stretches the display only, not the data. **Transparency** lets you see two surfaces at the same time. With **Lines over other surfaces** (Properties → Display) the triangles,

contours and lines of a surface also show where another surface lies above them (e.g. the surface of the points of a spot grid, section 5.4); while such a surface is not the active one, the pointer reads the elevations of the surface below it. A **Duplicate** of a surface keeps this option; the other surfaces made from it (merge, smoothing, simplification and so on, section 5.4) start without it.

4.2 Selecting vertices, edges, triangles

From **HOME** → **Select** choose **Vertices**, **Edges** or **Triangles** and click on the active surface. The status bar shows coordinates, 2D/3D lengths, slope and areas. `Esc` clears the selection.

5. Measurements, points and spot grid

5.1 Measurements

On **HOME → Measure**:

Tool	Result
Distance	Draw a polyline (2 or more points). Gives horizontal length, slope length, **length on the surface** (following the terrain), ΔZ, average grade and azimuth (grad) for 2 points.
Area (2D / 3D)	Draw a closed polygon. Gives plan area, perimeter, the **true 3D surface area** and min / mean / max elevation. A warning appears if part of the polygon lies outside the surface.
Point info	Click points (repeating): X, Y, the Z of every visible surface, the slope at the point and the WGS84 geographic coordinates.

Results are collected in the **Measurements** window and can be copied (**Copy**) to Word or Excel.

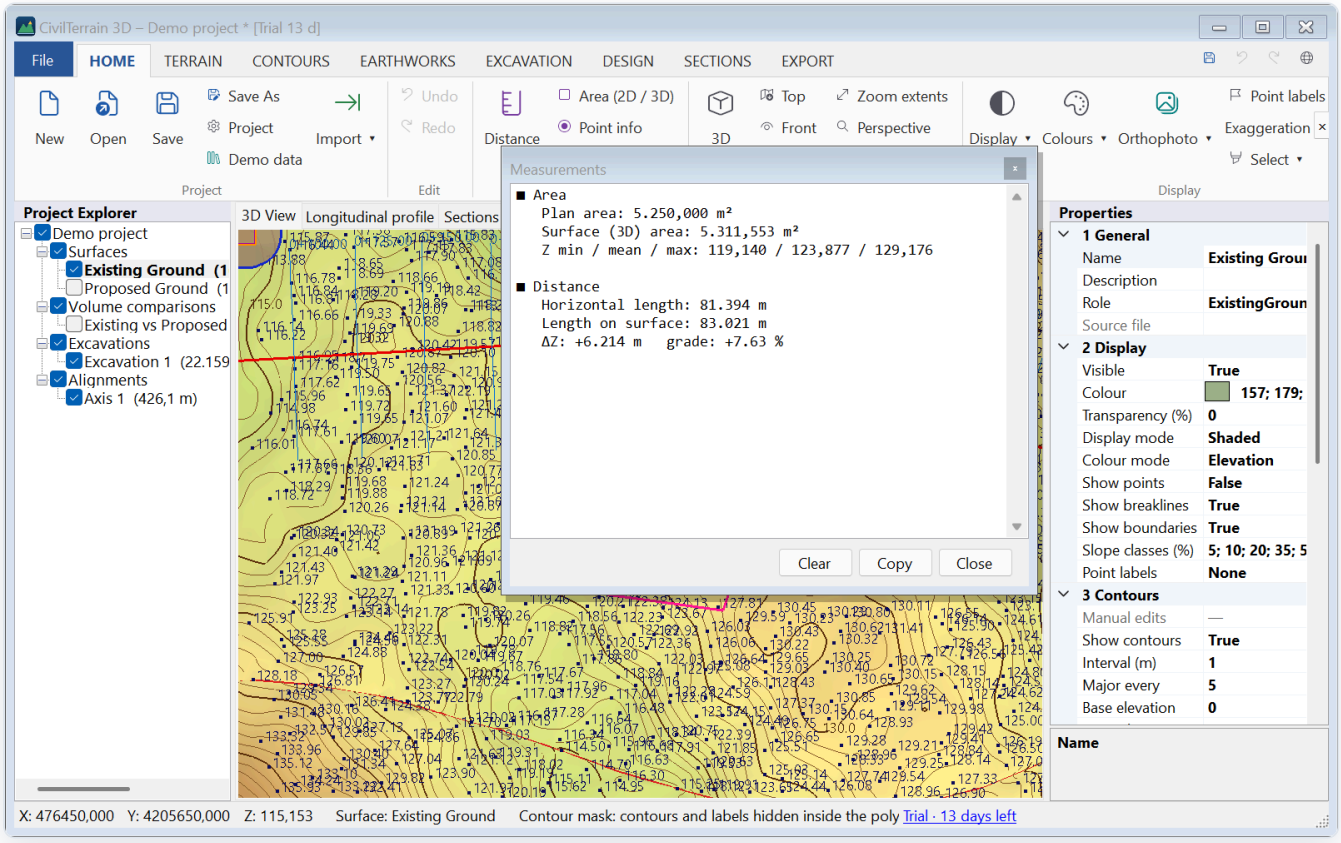


Figure 5.1 – 3D area measurement and point labels (number + elevation)

5.2 Point labels

HOME → Point labels (or Properties → Display → Point labels): **None**, **Number**, **Elevation**, **Number + elevation**. The number is the point id from the CSV/TXT file ("No." column). In dense areas only the

labels that fit are drawn — zoom in to see more.

5.3 Points table

TERRAIN → Points table lists every point of the active surface by group, even for millions of points (virtual list).

- **Search** by point number or group name.
- **Edit** X, Y or Z directly in the cell — the surface updates immediately and the change can be undone with `Ctrl` + `Z`.
- **Double click** or **Zoom to**: the drawing moves to the point.
- **Delete selected** and **Export CSV**.

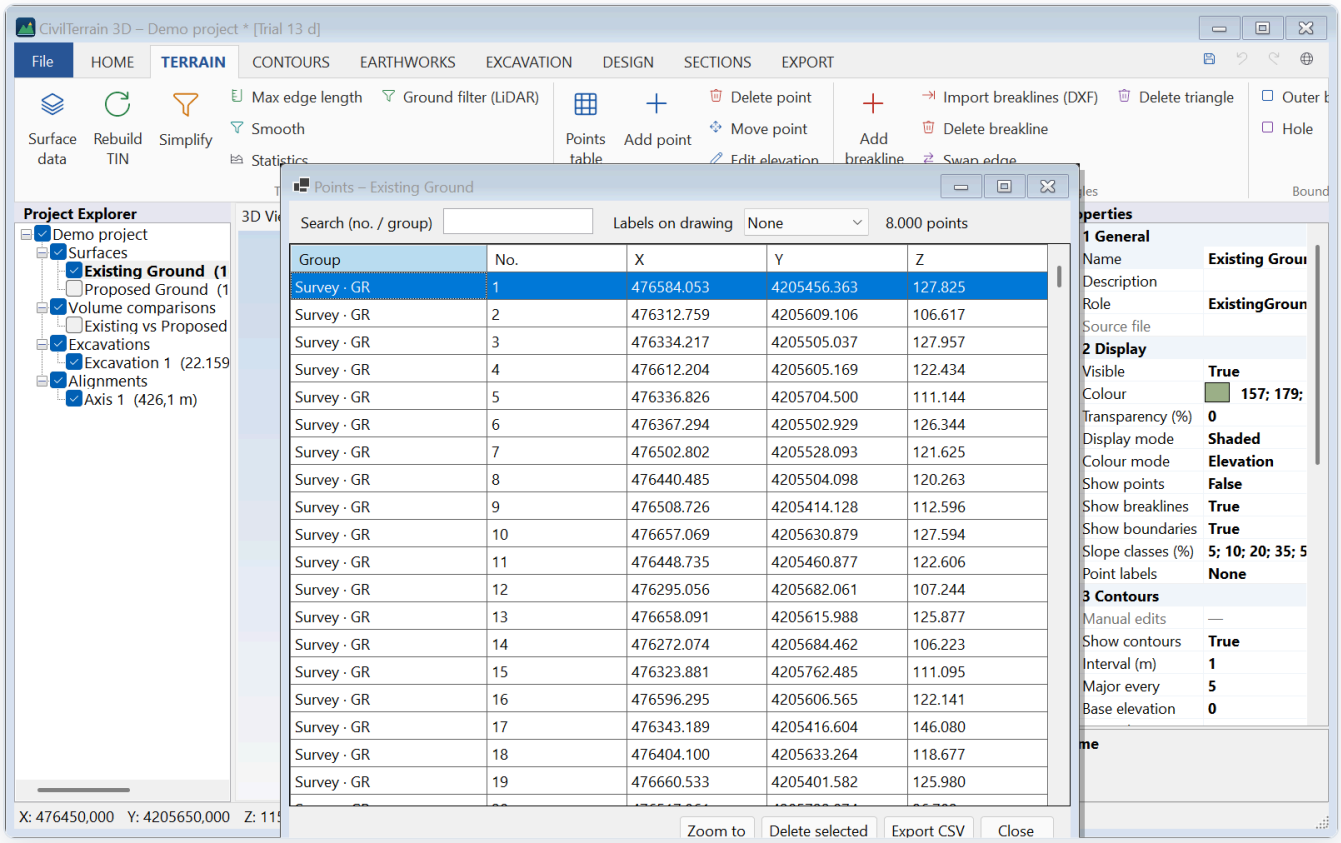


Figure 5.2 – Points table with groups, numbers and coordinates

5.4 Spot grid

A **spot grid** gives points every so many metres (e.g. every 5 m) inside a perimeter, with the elevation of the surface at each point. The points are numbered (S1, S2 …) and shown in the view with a marker and a label, e.g. “48.62 m”, on the surface or on the orthophoto. Use it for the spot elevations of a layer once it is laid (checking, measurement, as-built survey), for setting out, and to check a drone survey against the design: with a **second surface** every point also gets its **Δz**.

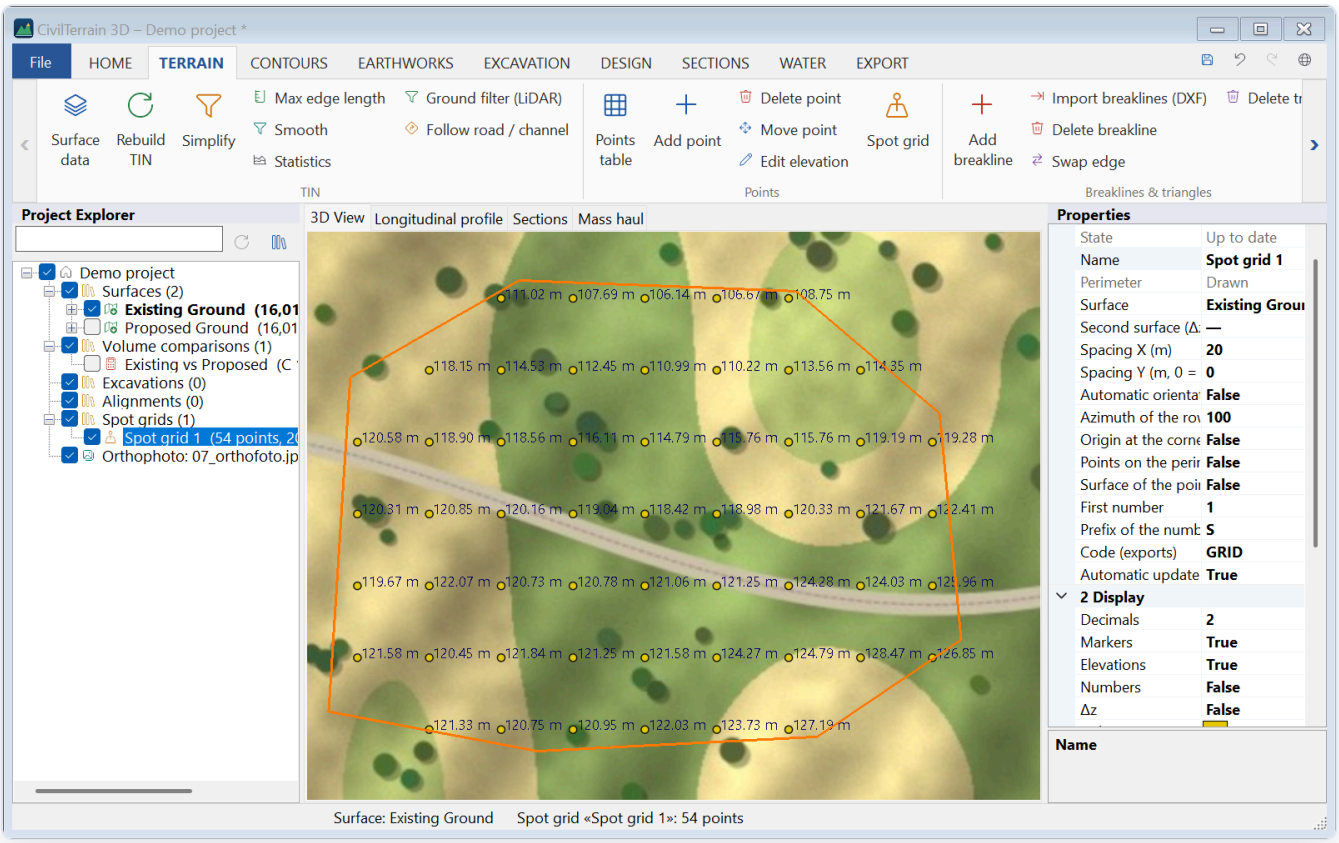


Figure 5.3 – A spot grid on the survey: yellow markers with the elevation of every point

1. Make the surface active (e.g. the drone survey). If the perimeter already exists, select it in the tree: a zone, a closed line, the outline of polygon earthworks, a grading optimization, a sloped design, a building-code check or a section grid, a closed breakline or a boundary.
2. **TERRAIN → Points → Spot grid**. The selected outline becomes the perimeter. Otherwise you choose where it comes from: **Outline of the surface «…»** (the whole survey; the default), **Click an existing outline** (zone, closed line, breakline, boundary, excavation), **Draw the polygon**, **From a DXF / DWG** or **Type / paste coordinates**.
3. In the **New spot grid** window set the spacing and the other settings (table below) and press **Create**.

When a spot grid is selected in the tree, the same command opens its window to edit it. The table and the exports of a grid open from its menu in the tree (right click, below); the exports also from **EXPORT → Points → Spot grid**.

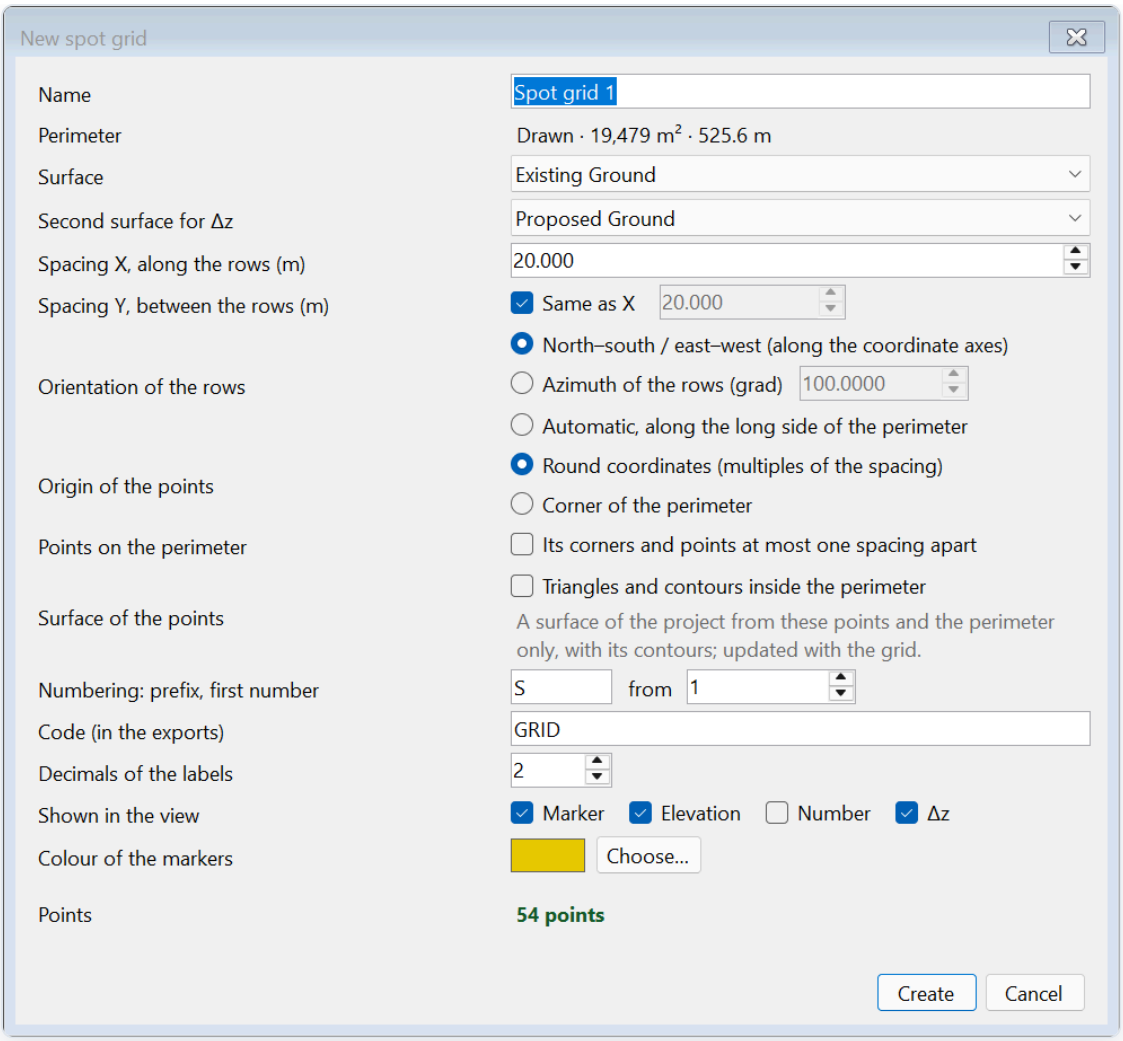


Figure 5.4 – The “New spot grid” window, with the option “Surface of the points” (off by default)

Setting	Description
Name	The name of the outline it comes from is proposed (a zone, a line …), otherwise “Spot grid N”.
Perimeter	Where it came from, its area and length. When editing, **New perimeter…** takes it again (from the same sources) and comes back to the window.
Surface	The surface that gives the elevation Z of the points. The active one by default.
Second surface for Δz	Optional (“— none —” by default). Every point also gets its elevation Z2 and the difference **Δz = Z2 − Z**: positive = fill, negative = cut.
Spacing X, along the rows (m)	The distance between the points of a row. The first grid proposes a spacing for about 2,000 points; the next ones start from the settings of the last one.
Spacing Y, between the rows (m)	**Same as X** (default) or another value, for a rectangular grid (e.g. 10 × 5 m).
Orientation of the rows	**North–south / east–west** (along the coordinate axes, default); an **Azimuth of the rows (grad)** that you type (100 = west to east); or **Automatic, along the long side of the perimeter**, e.g. for a platform or a road that is not parallel to the axes.
Origin of the points	**Round coordinates** (multiples of the spacing, default): the points fall on the same positions in every survey. Or the **Corner of the perimeter**.
Points on the perimeter	Adds points at the corners of the perimeter and along it, in equal parts not longer than the spacing. They are numbered after the grid points. A point of the perimeter (a corner too) closer to a grid node than 2% of the spacing, and at most 5 cm, is that node and is not added twice (e.g. a side a few centimetres off a row of a 5 m grid).
Surface of the points	**Triangles and contours inside the perimeter** (off by default): makes a surface of the project from the points of the grid and the perimeter only, with triangles up to the perimeter and never outside it, and their contours (below). It adds no points to the exports.
Numbering: prefix, first number	Prefix `S` from `1` by default: S1, S2 …
Code (in the exports)	The point code in the CSV, TXT and Excel files (`GRID` by default).
Decimals of the labels	Decimals of the elevation and Δz in the view, in the DXF / DWG and on the plan of the PDF (0–4, default 2). The tables and point files always have 3 decimals.

Shown in the view	**Marker** and **Elevation** (ticked), **Number**, and **Δz** when there is a second surface. The same labels are written on the plan of the PDF.
Colour of the markers	Yellow by default; **Choose...** for another colour (the view only).
Points	How many points the settings give, as you type. Above 250,000 the number turns red, the window says “Too many points (more than 250,000): increase the spacing.” and the grid is not created.

In the view

Each point is shown with a round marker in the colour of the grid and, to its right, its elevation (e.g. “48.62 m”), with the number above and Δz below (red in cut, blue in fill). The perimeter is drawn on the surface. As many labels are written as fit without overlapping one another or the markers of the labelled points: every few rows and columns from far away, more densely as you come closer (in perspective, near points more densely than far ones). Zoom in to see every label. Where the points crowd on the screen (far away, or the far part of an oblique view) the markers become small, faint dots, so that the ground shows through. The markers are drawn over the surface, so in an oblique view they also show behind hills.

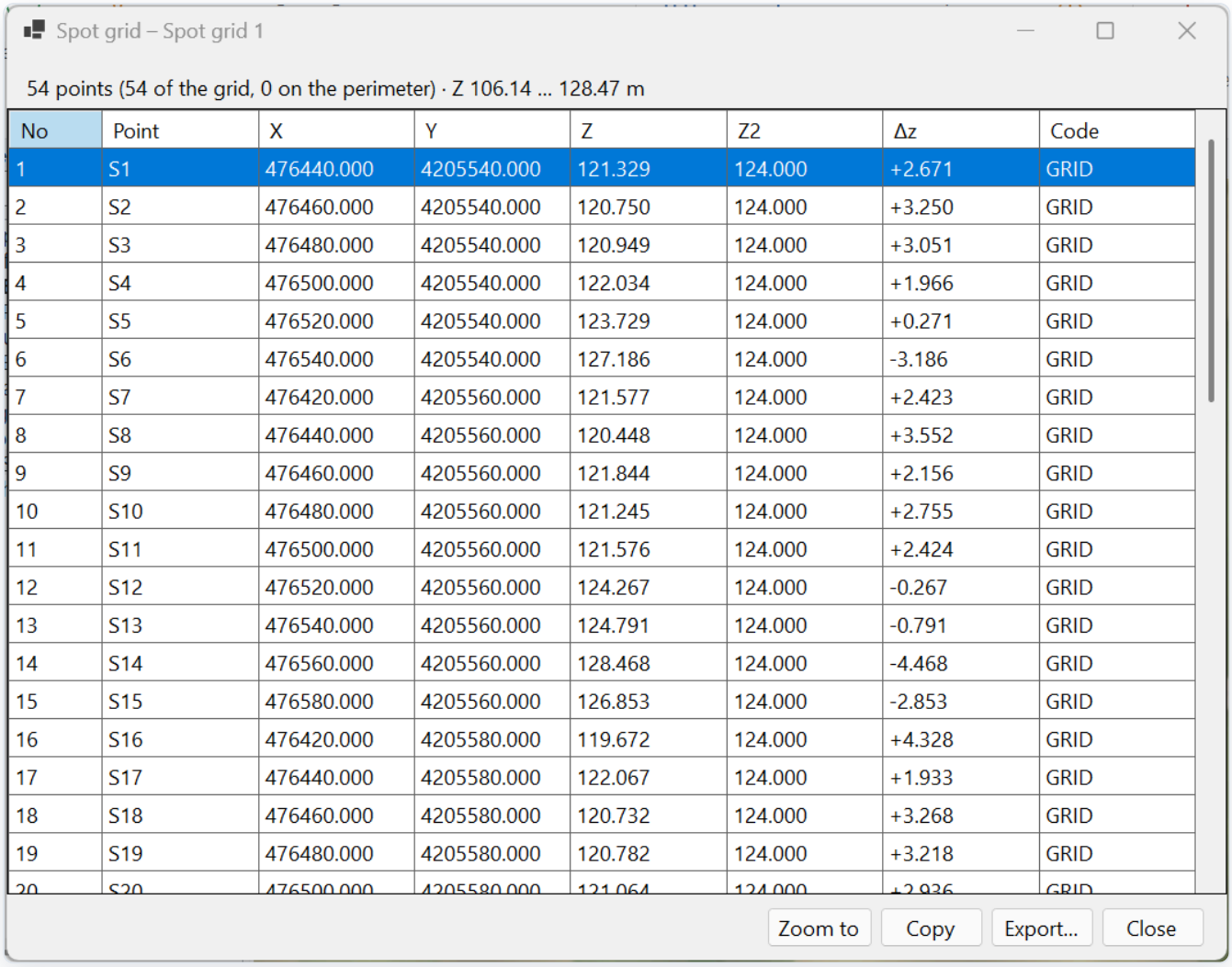
The grid goes into the tree, in the **Spot grids** collection, with its number of points and spacing (and “with surface” when it has a surface of the points) and a check box to show / hide it. A click in the view on its perimeter, on one of its markers (where they stand apart) or inside it selects it; if it was made from a zone, the line and the inside select the zone and a marker the grid. Creating it, editing it in its window and deleting it are undone with `Ctrl`+`Z`. Right click: **Edit...**, **Table...**, **Export...**, **Surface of the points** (turns the option on or off), **Go to the surface of the points** (when there is one), **Recalculate**, **Delete**. In the Properties you change the same settings (a spacing that would give more than 250,000 points is refused), the **Surface of the points** too, and see the results: points of the grid / on the perimeter, points off the surface, Z and Δz min / mean / max, points in cut / fill / no change, direction of the rows, area and length of the perimeter and, with the surface of the points, its triangles.

The points table

Right click on a grid in the tree → **Table...** shows its points: **No, Point, X, Y, Z**, with a second surface also **Z2, Δz**, and **Code**. Above it you see how many points there are (of the grid and on the perimeter) and the range of Z. The numbers are in the number format of Windows (e.g. a decimal comma with Greek regional settings), so that they paste into Excel as numbers.

- **Double click** or **Zoom to**: the view goes to the point and marks it with a cross; its coordinates are shown in the status bar.
- **Copy**: the selected rows, with the column headings, to paste into Excel; all the rows when one row or every row is selected. `Ctrl`+`C` copies just the selected rows, even a single one.
- **Export...**: as below.

The table stays open beside the drawing and is updated when the grid is computed again; the rows you are looking at stay in place.



No	Point	X	Y	Z	Z2	Δz	Code
1	S1	476440.000	4205540.000	121.329	124.000	+2.671	GRID
2	S2	476460.000	4205540.000	120.750	124.000	+3.250	GRID
3	S3	476480.000	4205540.000	120.949	124.000	+3.051	GRID
4	S4	476500.000	4205540.000	122.034	124.000	+1.966	GRID
5	S5	476520.000	4205540.000	123.729	124.000	+0.271	GRID
6	S6	476540.000	4205540.000	127.186	124.000	-3.186	GRID
7	S7	476420.000	4205560.000	121.577	124.000	+2.423	GRID
8	S8	476440.000	4205560.000	120.448	124.000	+3.552	GRID
9	S9	476460.000	4205560.000	121.844	124.000	+2.156	GRID
10	S10	476480.000	4205560.000	121.245	124.000	+2.755	GRID
11	S11	476500.000	4205560.000	121.576	124.000	+2.424	GRID
12	S12	476520.000	4205560.000	124.267	124.000	-0.267	GRID
13	S13	476540.000	4205560.000	124.791	124.000	-0.791	GRID
14	S14	476560.000	4205560.000	128.468	124.000	-4.468	GRID
15	S15	476580.000	4205560.000	126.853	124.000	-2.853	GRID
16	S16	476420.000	4205580.000	119.672	124.000	+4.328	GRID
17	S17	476440.000	4205580.000	122.067	124.000	+1.933	GRID
18	S18	476460.000	4205580.000	120.732	124.000	+3.268	GRID
19	S19	476480.000	4205580.000	120.782	124.000	+3.218	GRID
20	S20	476500.000	4205580.000	121.064	124.000	+2.936	GRID

Figure 5.5 – The points table of the grid with Z2 and Δz

Exports

Right click on the grid in the tree → **Export…**, the **Export…** button of the table, or **EXPORT → Points → Spot grid** (for the grid selected in the tree, otherwise the one in the open table or the last one). A save window opens and the file type sets the format. If the grid is out of date, it is computed first. Excel and PDF files open as soon as they are saved.

Format	Content
CSV	Columns `PT,X,Y,Z,CODE` (with a second surface also `Z2,DZ`), 3 decimals with a decimal point, commas between the values. It reads back into the program with the point numbers.
TXT (PNEZD)	Number, northing (Y), easting (X), elevation, code, separated by spaces, with no header — for setting-out instruments and software.
DXF / DWG	Layers `SG_BOUNDARY` (perimeter), `SG_POINTS` (points at their elevation), `SG_MARKER` (cross), `SG_NUMBER` (number), `SG_ELEV` (elevation) and, with a second surface, `SG_DZ`. Markers and texts are in plan. A DWG is written for up to 50,000 points; above that the program suggests DXF (the same layers, in seconds) or CSV.
Excel	A **Summary** sheet (project, surfaces, perimeter, spacing, direction, origin, count, numbering, Z and Δz) and a **Points** sheet (No, Point, X, Y, Z, Z2, Δz, Code). With the surface of the points, the summary also gives its name, its triangles and the contour interval.
PDF	A summary with the method, the **plan on A3 at a standard scale** (1:N with a scale bar, contours, perimeter, points and labels where they fit) and the list of points on A4, two lists per page, with Δz in red / blue. The list is written for up to 10,000 points; above that, see the CSV or Excel file. With the **Surface of the points** on, the contours of the plan are those of that surface.

Surface of the points: triangles and contours

With the option **Triangles and contours inside the perimeter** of the window (row **Surface of the points**), or **Surface of the points** in the Properties and in the grid's menu in the tree, the points of the grid become a **surface of the project**, e.g. “Grid 20 m – surface”: a TIN of the grid points and the points of the perimeter only, with triangles up to the perimeter and never outside it, and its contours, also only inside the perimeter. Outside the perimeter the survey shows as before. By default no surface is made: a grid gives points only, as before.

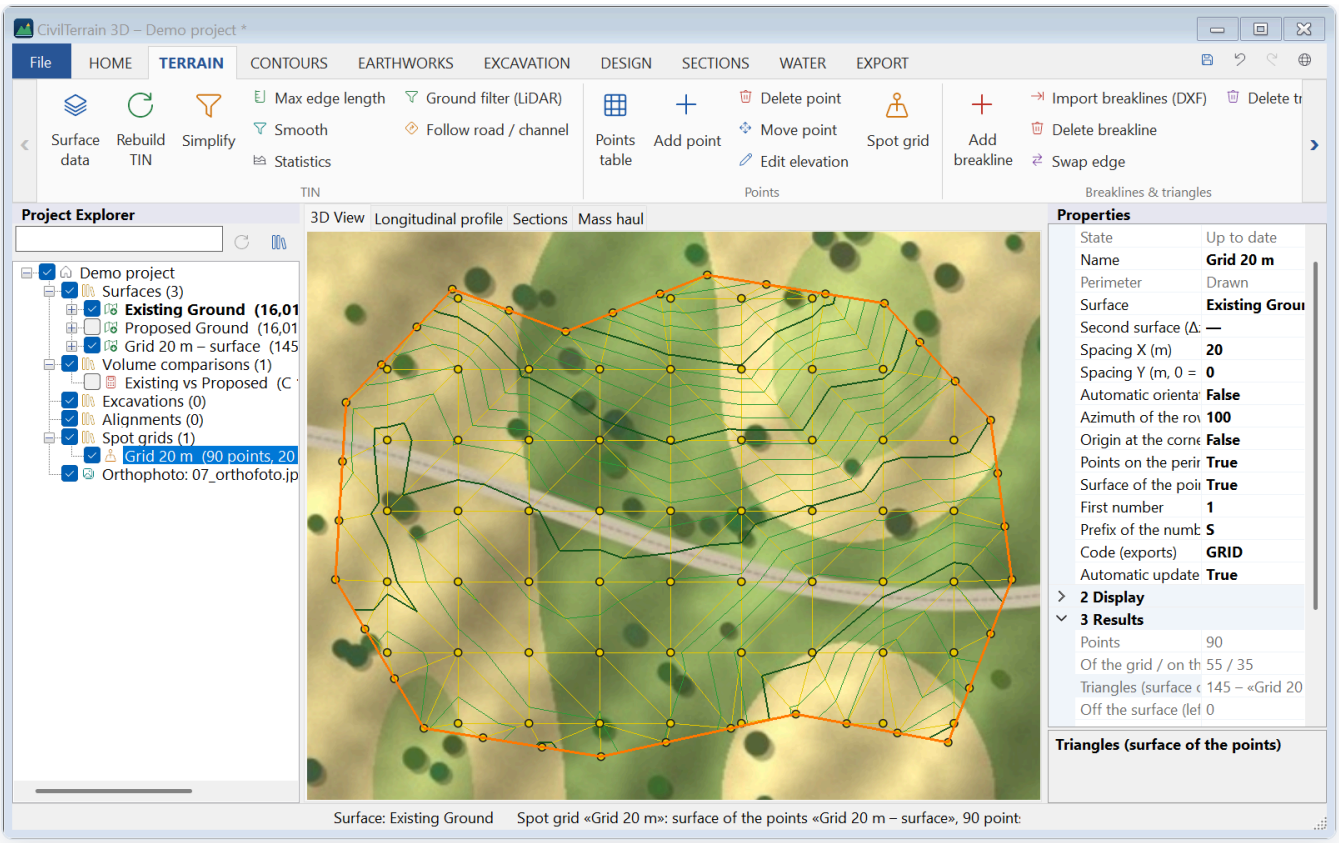


Figure 5.6 – The triangles and contours of the points of a grid every 20 m (90 points, with points on the perimeter; 145 triangles), only inside the perimeter, over the orthophoto; on the right the Properties of the grid

- The surface shows as a wireframe in the colour of the grid's markers, with green contours at the interval of the grid's surface. It is drawn **over the other surfaces** (surface Properties → **Lines over other surfaces**), so that it shows whole over the survey or the orthophoto; in an oblique view it also shows behind hills. While it is not the active surface, the pointer reads the elevations of the surface below it. Colours, interval and labels change in its Properties.
- Every point of the grid is a vertex of the surface, with its number (S1, S2 …). On the perimeter, besides the grid points that lie on it, the surface takes the elevations of the grid's surface at its vertices and at most one spacing apart. With **Points on the perimeter** these are set-out points too; without them they go into the surface only, not into the exports.
- Where the perimeter leaves the grid's surface (there are no grid points and no elevations there), the triangles stop at the last grid points and at the pieces of the perimeter that lie on the surface; no triangle goes outside the perimeter. Where the grid's surface has a hole inside the perimeter, the triangles join the points around it.
- A perimeter with many small vertices (e.g. the outline of a survey) gives many thin triangles along it and takes a few seconds; for a cleaner result draw a perimeter with few vertices.
- It is an ordinary surface (role "Other"): contours and TIN to DXF / LandXML, volume comparisons, sections (while visible it also shows in the profiles and sections of alignments). In its Properties, **Made from** names the grid. In the grid's PDF export the plan shows its contours.
- It is **linked to the grid**: it is made again with it (a change of the grid's surface, the perimeter, the spacing, the numbering and so on), only when the points change, and not when the project

opens. When you rename the grid, the surface is renamed too, as long as it keeps the name the program gave it.

- Its data are made from the grid and **cannot be edited**: the commands that change the data of a surface (e.g. the terrain tools, Surface data, the ground filter, adding data to the active surface, following a road) say so in a message and change nothing: most of them before their window opens, the imports as soon as you choose "Add to the active surface", Replace terrain and Remove objects as soon as you choose "In the same surface" (in a copy they work as usual). To edit it, make a **Duplicate** first: the duplicate keeps the look (wireframe, lines over other surfaces), becomes the active surface and can be edited as usual. The other surfaces made from it are ordinary surfaces, without "Lines over other surfaces": a merge, a smoothing, a simplification, an elevation offset, objects removed or terrain replaced in a copy, and the "Surfaces inside the perimeter" (section 12.6).
- When you turn the option off or delete the grid, the surface is removed (if another object uses it, e.g. a volume comparison, the program asks first); Undo brings it back. If you delete the surface, the grid's option is turned off.
- A grid cannot take its elevations (or Δz) from its own surface of the points, not even through another grid; another grid can. If an undo brings back such a source, the grid's node says "⚠ surface of the points not updated" until you change the source.
- Versions up to 1.6.13 open the project and show the surface as an ordinary surface, not linked to the grid.

Updates and numbering

- When the surface or the second surface changes (an edit, remove objects, new data), the grid is computed again by itself. With **Automatic update** off in the Properties it is marked **⚠ out of date** (section 3.2). The project saves the settings of the grid; the points are computed again when the project opens.
- The numbers follow the geometry only: row by row from the origin side (with north–south orientation, from the south-west) and then the perimeter points. So every point keeps its number when the surface changes. The numbers change only if you change the perimeter, the spacing, the orientation, the origin, the perimeter points or the first number.
- A point inside the perimeter but off the surface is left out together with its number, and the program says how many were left out. A point off the second surface is kept without Δz.

> **Tip:** to check a layer, make a grid on the survey after laying, with the design as the second surface. The Δz of every point shows how much material is missing (+) or in excess (−). With the same settings and round coordinates, the points keep the same positions and numbers in every new survey. For a cut / fill map with height differences, see also section 12.13.

6. Project and coordinate system

A project (`.ct3d`) contains all surfaces with their data (points, breaklines, boundaries, edits), volume comparisons, excavations and alignments. Coordinates are stored at full precision.

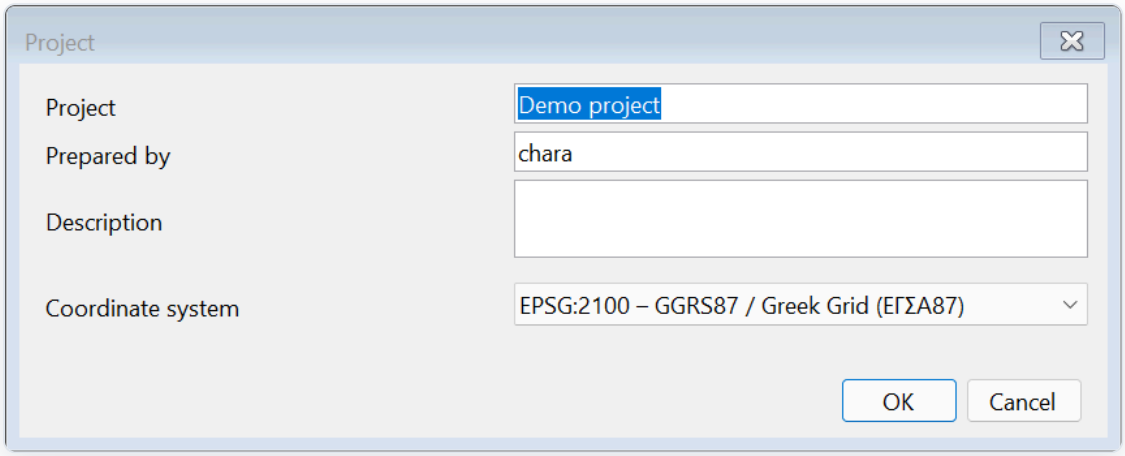


Figure 6.1 – Project settings

In **File → Project…** set the name, author, description and the **coordinate system** (default GGRS87 / Greek Grid). These appear in the reports.

> **Quick start:** **HOME → Demo data** loads a complete sample project (GGRS87) with existing ground, design surface, volume comparison and an axis.

7. Importing data

All imports are under **HOME → Import ▾**. Data go into a **new surface** or, with **Add to the active surface**, into the surface already selected (e.g. to add breaklines or a second point file).

After every import the **Surface data** dialog opens (section 9.2) so you choose what takes part before the TIN is built. Points are organised in **groups**: per code (CSV/TXT), per layer (DXF) or per file (LAS). Points and vertices with **invalid coordinates** (e.g. "nan" or "1e400" in the file, or out of the coordinate transformation) are left out of every surface import and of "Level from 3D polyline", and a message says how many before the dialog opens; if no valid point is left, nothing is imported.

7.1 CSV / TXT / XYZ

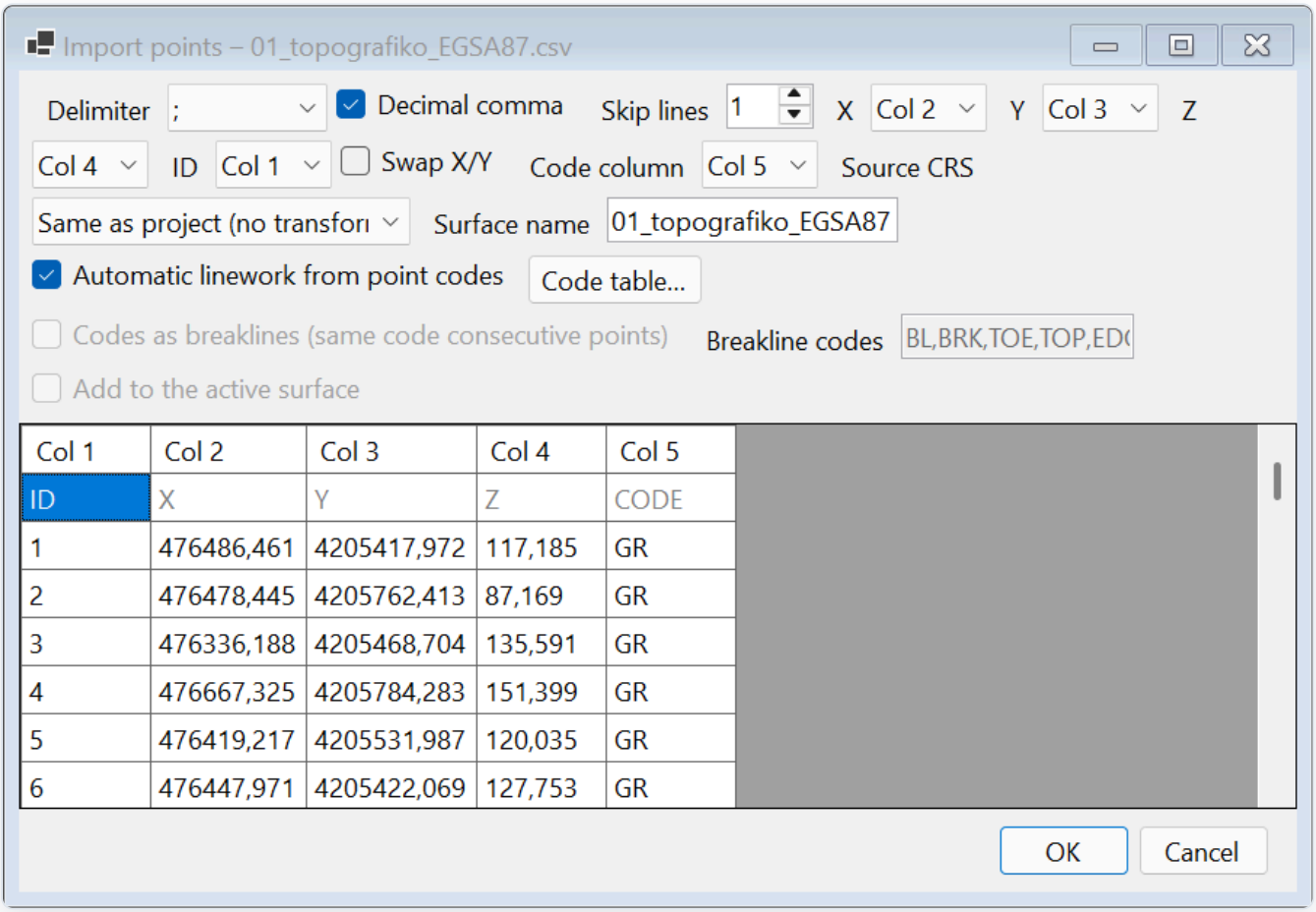


Figure 7.1 – Point import with preview

The **delimiter** (comma, semicolon, tab, space), **decimal comma**, header lines and the X, Y, Z, ID and code columns are detected automatically. Check the preview and correct if needed:

- **Skip lines**: header lines (shown grey).
- **Swap X/Y**: for files ordered Northing, Easting.
- **Source CRS**: if the points are in another system than the project (e.g. WGS84) they are transformed automatically.

- **Codes as breaklines**: consecutive points whose code starts with one of the **breakline codes** (e.g. `BL, BRK, TOE, TOP, EDGE`) are joined into a breakline.

7.2 DXF

POINT, LINE, LWPOLYLINE, POLYLINE (2D/3D/polyface) and 3DFACE entities are read from ASCII DXF of every version. In the dialog choose the **layers** and whether POINTs become points, polyline vertices become points, 3D polylines become breaklines and 3DFACEs a fixed TIN. 3D polylines with a spline fit are read by the points of their fitted curve; the control points of the spline frame are ignored.

With **3D polylines as 3D lines only (no surface)** no surface is made and the Surface data dialog does not open: every polyline of the chosen layers becomes a 3D line of the project (e.g. a route), and one click on it shows its weighted slope (section 15.7). In the normal import the option is **not ticked** at first: as before version 1.6.13, a drawing of 3D polylines is made into a surface. The program remembers your choice in this window and, if you ticked it, ticks it again when the drawing has 3D polylines with elevations and no POINT or 3DFACE. The remembered choice changes only when you tick the option or import such a drawing; another drawing (e.g. a survey with points) made into a surface does not change it. **SECTIONS → Route → Import routes…** always imports without a surface. When the option is ticked:

- the surface options (points, vertices, breaklines, 3DFACE, surface name, add to the active surface) are unticked and disabled; they come back as they were when you untick it;
- layers without any polyline with elevations (e.g. a frame or a title block) start unticked when another layer has routes; you can tick them again;
- files in longitude / latitude or Web Mercator are transformed into the project's system; in an empty project, the projected system of the file (e.g. GGRS87, UTM) that you set in **Source CRS** becomes the project's system;
- if the coordinates look like degrees (longitude / latitude) while Source CRS is “Same as project”, a warning appears; the lines are already imported: undo (`Ctrl` + `Z`), choose **WGS 84 (lon/lat)** in Source CRS and import again. A local drawing in metres near 0, 0 (e.g. a 150 × 80 m yard) does not give the warning;
- vertices with invalid coordinates (e.g. “nan” in the file) are skipped, and the import message says how many;
- the whole import is undone with one **Undo**.

The **Contents** line of the dialog also shows how many polylines have elevations, e.g. for the sample `13_diadromes.dxf` “0 POINT, 11 polylines (10 3D), 0 faces”: the 10 routes and a 2D frame.

> **DWG:** DWG files (AutoCAD R14 to 2018+) are read directly — **Import → DWG…** or choose DWG in the DXF dialog. The same layers and options as DXF apply; blocks (INSERT) are exploded, arcs and circles become polylines.

7.3 LAS / LAZ (point clouds)

LAS 1.0–1.4 is supported. The dialog shows point count, extent and EPSG. Options: **Ground only (class 2)**, **Leave out noise** (classes 7 and 18 – e.g. birds, reflections), **keep every N-th point**, **grid thinning** (keeps the lowest point per cell – suitable for ground) and **Gridded surface** in the RGB colours of the cloud (section 8.3). LAZ requires the free `laszip64.exe` in the program's `tools` folder or on the PATH. If the import fails (e.g. a LAZ file without `laszip64.exe`, or a file that is not LAS), the program says why; if the chosen classes leave no point, it says "No points with the selected classes."

> **Large clouds:** for millions of points use 0.25–1 m grid thinning. The terrain model remains very accurate and the program stays responsive.

7.4 PLY / OBJ, LandXML

- **PLY/OBJ**: with triangles they are imported as a fixed mesh, otherwise as points.
- **LandXML**: TIN surfaces (points and faces), breaklines, CgPoints and EPSG.
- **DEM** (GeoTIFF, ASCII Grid, SRTM, BIL / FLT): section 7.6.

7.5 Point codes – automatic linework

When the CSV/TXT file has a code column, points with the same code are joined automatically into lines. In the import dialog tick **Automatic linework from point codes**.

Field code	Result
`KP1` , `KP2`	Points of each code are joined in file order; the number keeps parallel lines apart (e.g. two curbs).
`KP1 B` (or `ΑΡ`)	Begin a new line.
`KP1 E` (or `ΤΕ`)	End the line.
`ΚΤ C` (or `ΚΛ`)	Close to the first point (buildings).

The **code table** (**DESIGN → Code table** or the button in the import dialog) defines for each code: whether it forms lines, whether they are terrain **breaklines**, whether its points take part in the surface (e.g. not buildings, trees) and the colour. Greek field codes (ΚΡ, ΑΞ, ΑΣ, ΦΡ, ΠΟ, ΤΑ, ΡΕ, ΤΟ, ΠΕ, ΚΤ, ΔΕ) are predefined; the table is kept for all projects.

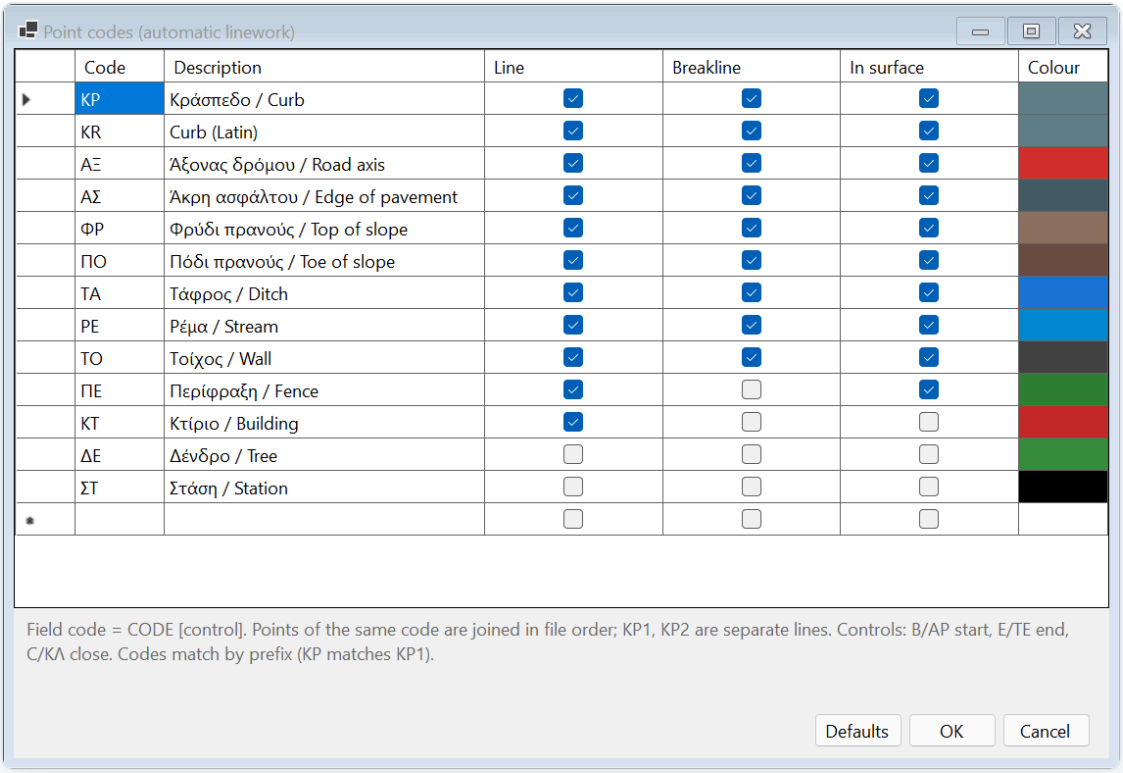


Figure 7.2 – Point code table

The lines become project **feature lines** (see "Feature lines and platforms"); those marked as breaklines also enter the TIN. Sample: `08_kodikopoiisi.csv`.

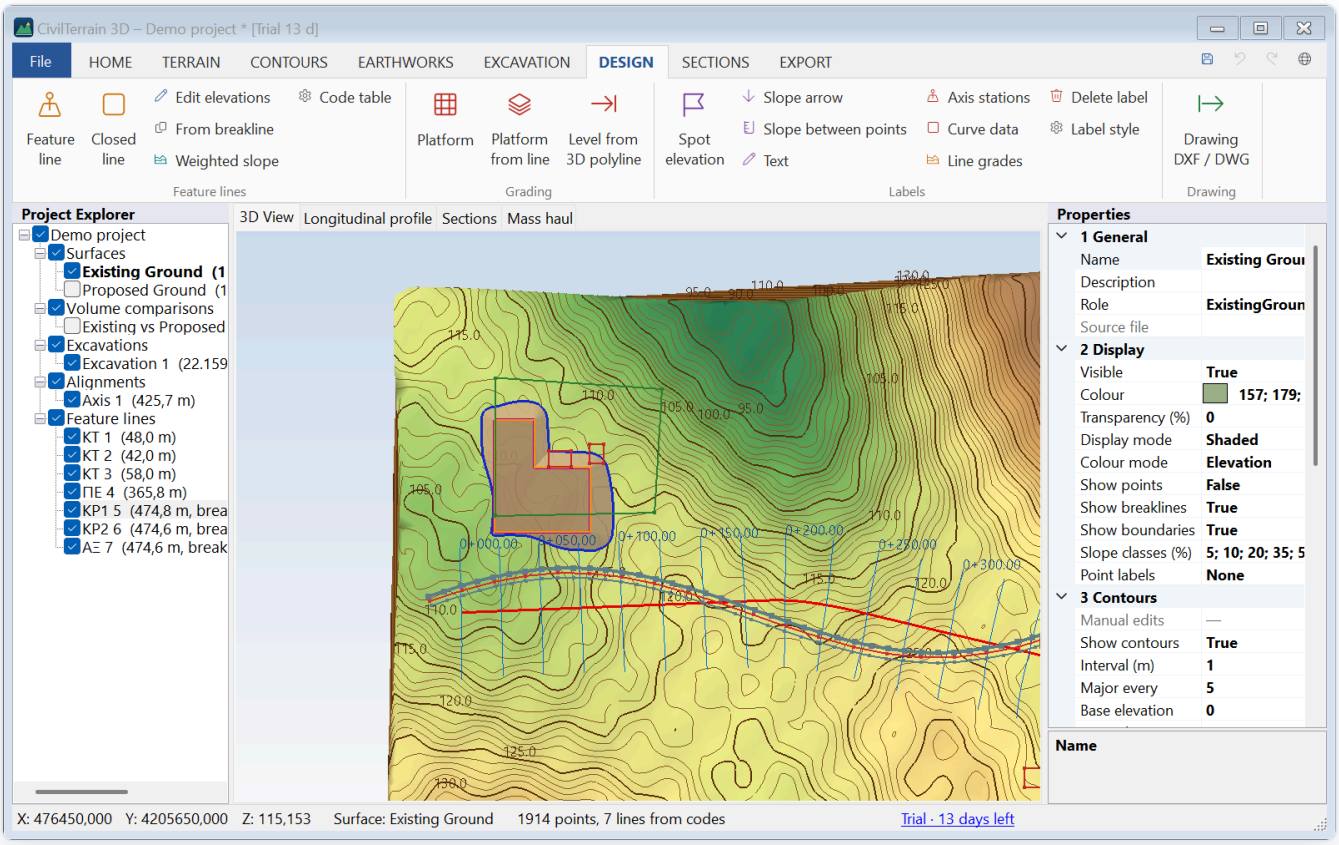


Figure 7.3 – Curbs, axis, buildings and fence from point codes

7.6 Digital elevation models (DEM)

HOME → Import → DEM (GeoTIFF, ASC, HGT, BIL)... reads gridded elevations and turns them into a surface (a fixed triangle mesh, one point per cell). Cells without a value (NoData) stay empty.

Format	Files	Notes
GeoTIFF	`.tif`, `.tiff`	Classic TIFF and BigTIFF (over 4 GB), in strips or tiles (also Cloud Optimized GeoTIFF); LZW, Deflate, PackBits compression; 8–64 bit integer or floating point values; NoData and value scale / offset. Georeference from the GeoTIFF tags or from a world file (`.tfw`).
ESRI ASCII Grid	`.asc`	Header ncols, nrows, xllcorner / xllcenter, cellsize, NODATA_value. An `.asc` chosen in the point import is recognised as a DEM automatically.
SRTM / NASADEM	`.hgt`, `.hgt.zip`	1″ (≈30 m) or 3″ (≈90 m) tiles; the position is read from the name (e.g. `N38E023.hgt`), WGS 84.
ESRI BIL / FLT	`.bil`, `.flt` with `.hdr`	Binary rasters with a header, as most GIS export them.

The dialog shows the format, size, cell and extent of the file and sets:

- **File coordinate system**: read from the file itself, from the `.prj` next to it or from the name of the SRTM tile (the source is shown in brackets). When it differs from the project's system the points are **transformed** — e.g. a DEM in WGS 84 degrees goes into GGRS87. For the first DEM of an empty project you also choose the project's system.
- **Only the project area**: from a large DEM (e.g. a 1° × 1° tile) only the area of the project's surfaces, alignments and zones is kept, with a margin. It is selected automatically when the DEM is much larger than the project.
- **Keep every n-th cell**: thinning for very large DEMs. The number of points and the resulting cell are shown; the suggested value keeps up to 4 million points (16 million at most).
- **File without georeference**: you give the cell size and the lower-left corner.

Large files are read row by row without loading the whole file into memory, so choosing an area or thinning also makes the import faster.

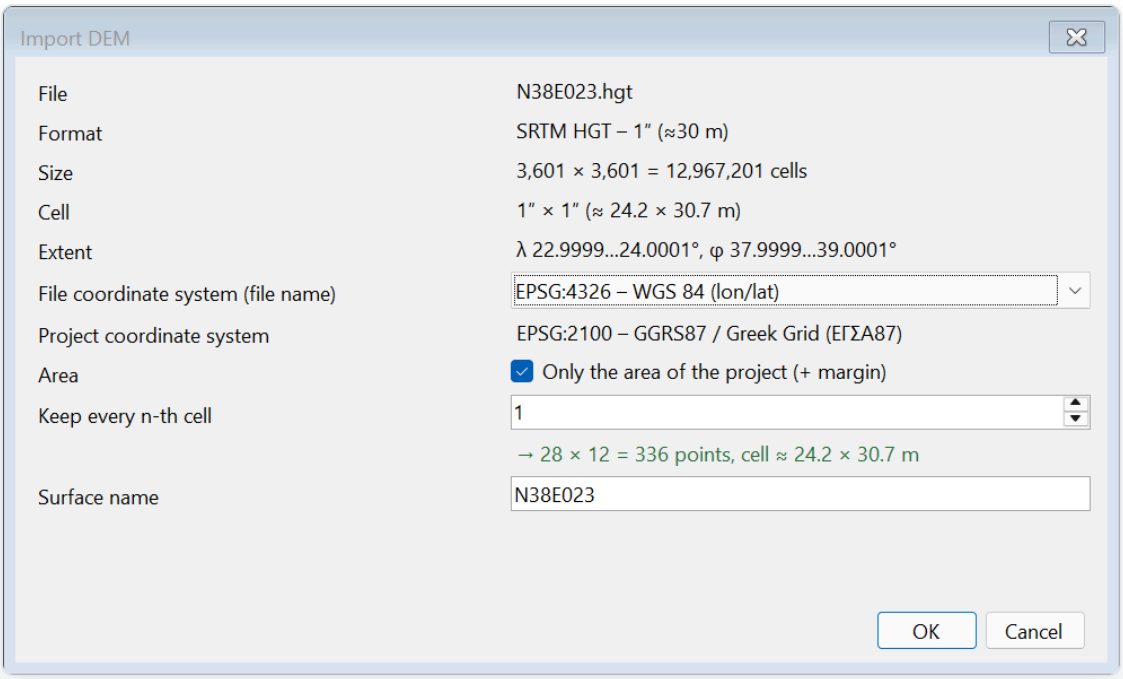


Figure 7.4 – Importing an SRTM tile in degrees: transformed into GGRS87, only the project area

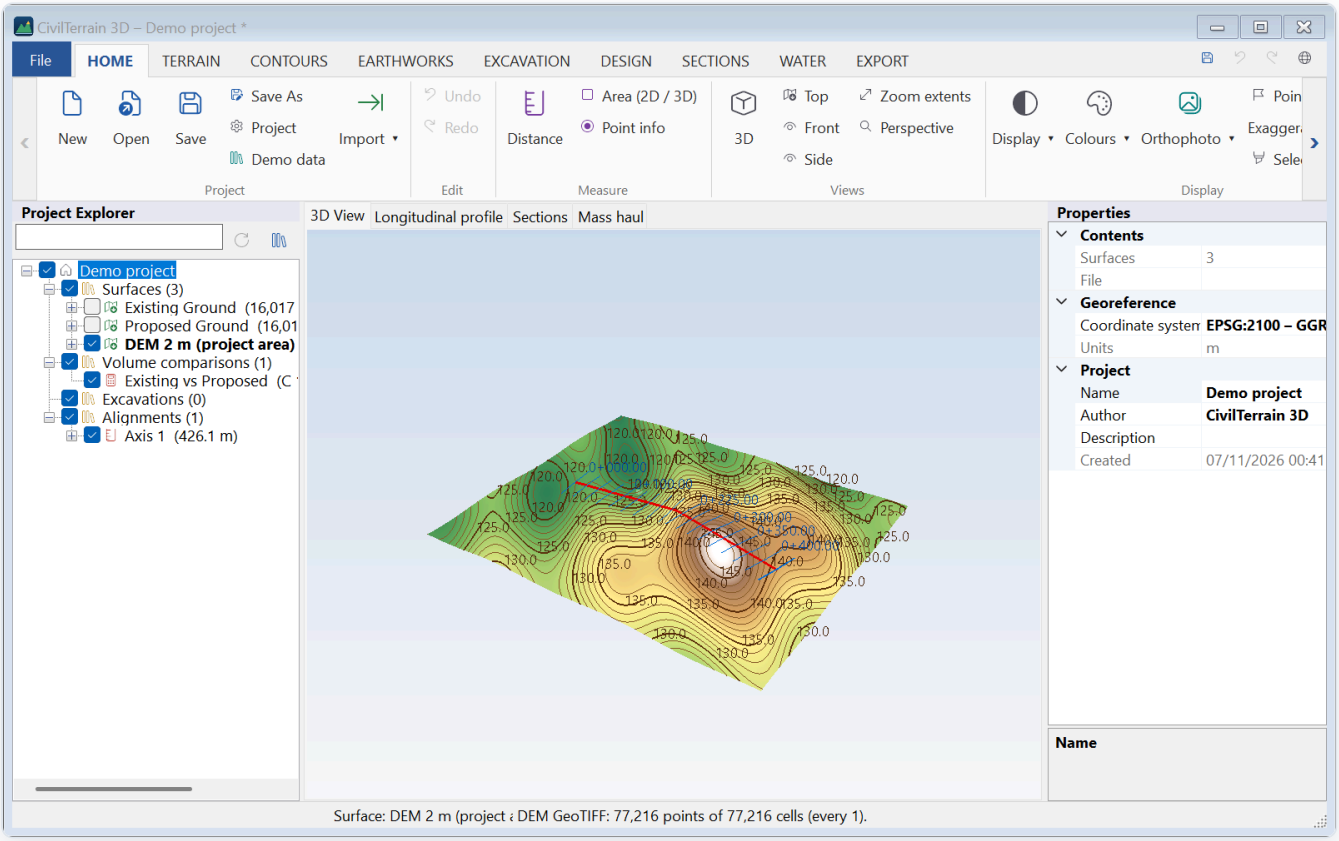


Figure 7.5 – A 3 × 3 km DEM with a 2 m cell: only the project area is imported

A picture, not elevations: a TIFF with colours (RGB or a palette — e.g. a coloured elevation map or a hillshade) holds no elevations and the program says so; it can be draped over a surface as an orthophoto instead (section 8.2). ERDAS IMG files or ZSTD / LERC compression are not read: save the DEM as GeoTIFF with LZW or Deflate (e.g. from QGIS).

8. LiDAR / drone point clouds and orthophotos

8.1 Ground filter

Unclassified drone or LiDAR clouds contain vegetation, buildings and vehicles. The **ground filter** (progressive morphological filter) separates them from the ground:

1. When a LAS file is imported without class filtering the program offers to run the ground filter, or later: **TERRAIN → Ground filter (LiDAR)**.
2. Adjust the parameters (the defaults suit most cases).
3. Points are split into a "ground" group (enabled) and an "objects" group (**disabled**) and the TIN is rebuilt. Any group can be re-enabled from **Surface data**.

Parameter	Meaning
Cell size	Density of the helper grid (≈ average point spacing, e.g. 0.5–1 m); “Leave out low noise” needs about one point per cell or more.
Largest object	The widest building/tree to remove (e.g. 20 m).
Terrain slope	Maximum expected slope of the natural ground. Larger for mountainous areas.
Initial height threshold	Height above "ground" already treated as an object (e.g. 0.3 m).
Distance to ground model	Final tolerance: points closer to the ground model than this are kept as ground.
Leave out low noise	For clouds with points **under the real ground** (reflections, multipath), which otherwise leave pits in the ground model. Single points or small groups (up to about 3 m across) more than 0.5 m + terrain slope × cell size under the ground around them (0.8 m with the defaults; cells under 1 m count as 1 m) are left out of the ground; long low ground (ditches, channels, streams) stays. The box is **not ticked** by default: the filter works as up to version 1.6.13. Your choice is kept for the next time and also applies to the general filter of **Follow road / channel** (section 8.4). See the limits below.

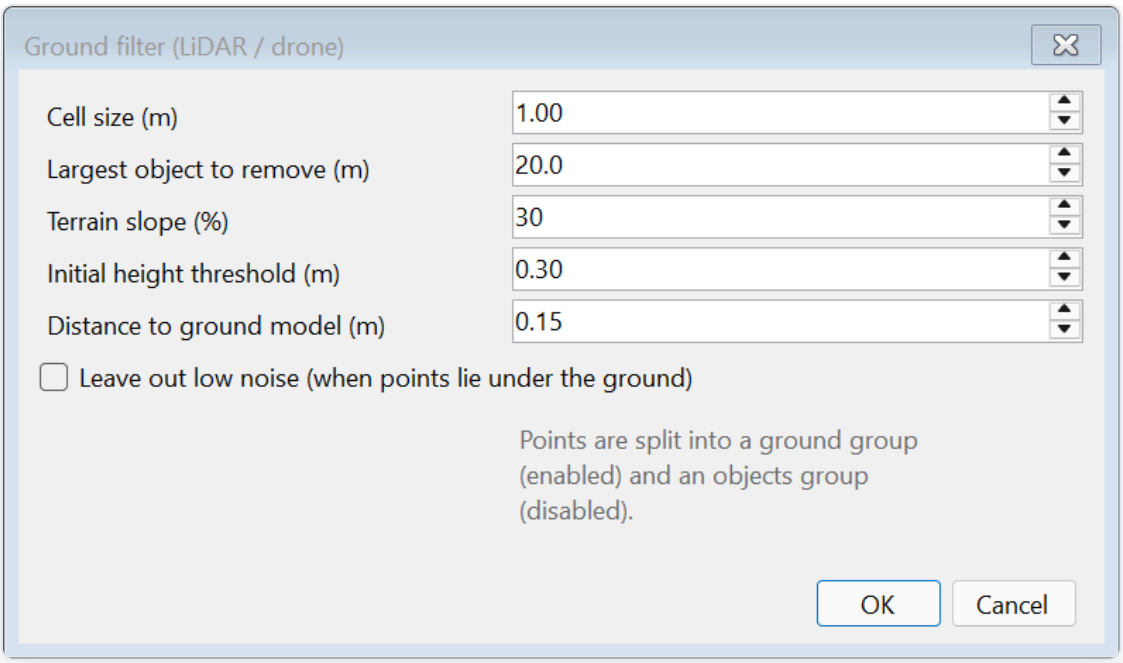


Figure 8.1 – Ground filter parameters with the defaults; "Leave out low noise" is not ticked

Leave out low noise: when and when not. Tick it only when the ground model of a cloud has pits from points under the real ground, and check the result (e.g. with sections). It can also take out real ground:

- real pits narrower than about 3 m and deeper than the threshold (0.8 m with the defaults), e.g. a manhole: they are bridged;
- narrow ditches and channels in a **sparse** cloud (few points per m^2) or broken by crossings every few metres: they may be filled in part or even whole; for a channel with water, where only a few points reach the bottom, leave it unticked;
- **low, dense vegetation** (shrubs, scrub), where few points reach the ground: those few ground points may be left out and the ground raised to the height of the shrubs;
- the **edges of the cloud**, where the ground around is not seen on every side: low ground points may be left out and the ground raised locally.

Below about one point per cell the option does little; in dense clouds with a small cell it changes few points or none. **TERRAIN → Ground filter (LiDAR)** says in its question, before it applies the result, how many of the points classified as objects are low noise. On large clouds the filter can take up to about twice as long.

DEM / DSM and other meshes: the ground filter works on point clouds. On a surface that is a triangle mesh it does not run and the program says: "This surface is a triangle mesh (e.g. a DEM / DSM, LandXML, OBJ / PLY or a smoothed surface): the ground filter works on point clouds." For machines or trucks use **TERRAIN → Remove objects** (section 10.4), which works on any kind of surface; for debris or deposits use **TERRAIN → Replace terrain** (section 10.5).

8.2 Orthophotos

HOME → Orthophoto → Load orthophoto: choose a JPG, PNG, TIFF or GeoTIFF image. The georeference is read from the GeoTIFF tags or from the **world file** next to the image (`.jgw` , `.pgw` , `.tfw` , `.wld`) as exported by Pix4D, Agisoft Metashape, DJI Terra, QGIS and most CAD programs. The image must be in the project's coordinate system.

The orthophoto is draped on the surfaces (colour mode **Orthophoto**). Use **Colours** to return to elevation colours; the image stays in the project. Contours, axes and excavations are drawn on top of it. Large images are resized automatically up to 4096×4096 pixels for display.

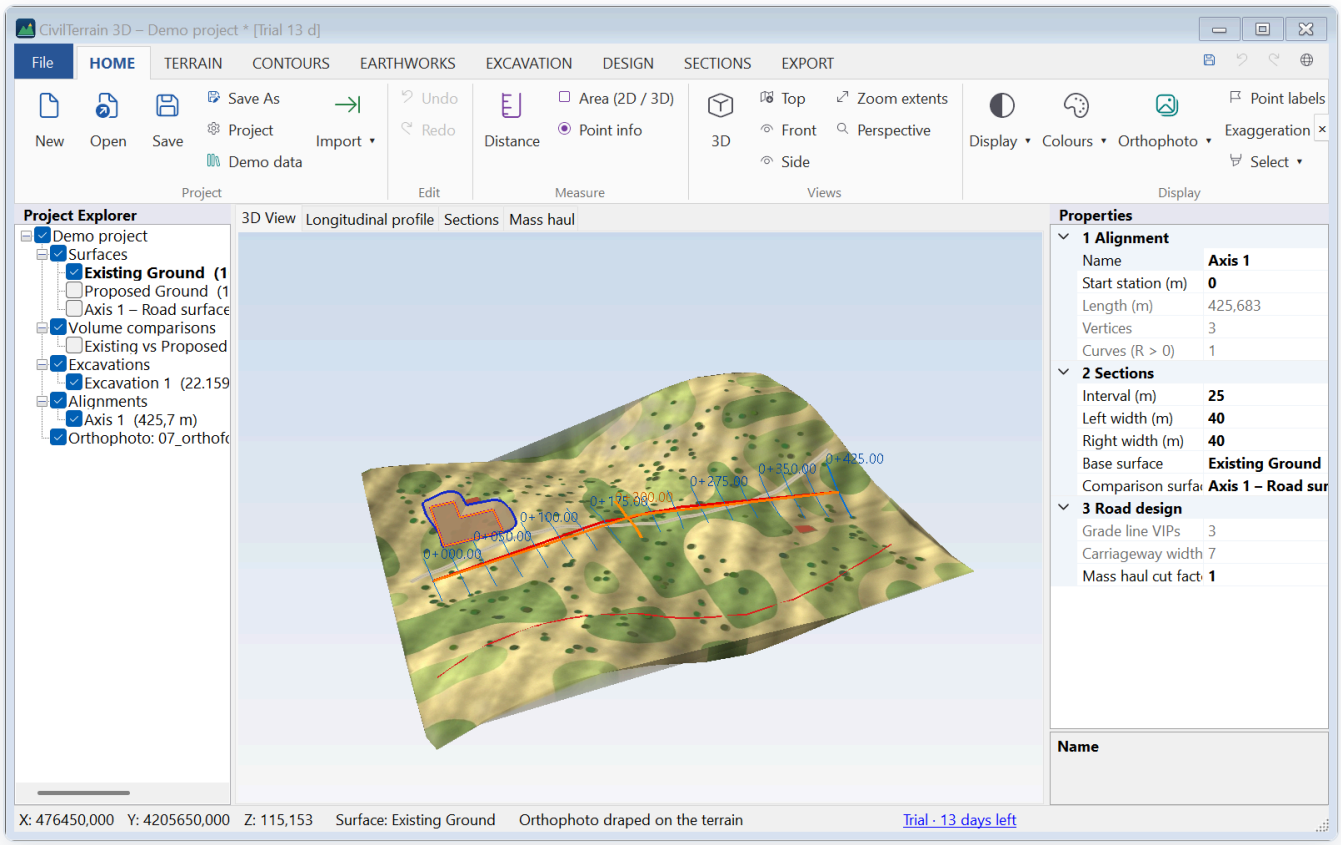


Figure 8.2 – Orthophoto draped on the terrain (sample 07_orthofoto.jpg)

8.3 A point cloud in its RGB colours as a gridded surface

Clouds from drones and photogrammetry (Pix4D, Agisoft Metashape, DJI Terra etc.) carry the colour (RGB) of every point. The program reads them as a **gridded surface**: one point per cell at the step you type and the average colour of the points in the cell. The surface is shown in the real colours of the site **without an orthophoto** and switches as usual between shaded, wireframe, shaded + wireframe or points (**HOME → Display**).

1. **HOME → Import → LAS / LAZ** and choose the file.
2. Tick **Gridded surface** (the default when the file has colours).
3. Type the **grid sampling** in m. The program suggests a value close to the density of the cloud and shows how many cells it gives over the extent.

4. Choose the **cell elevation** and whether the **RGB colours** are imported, and press **OK**.

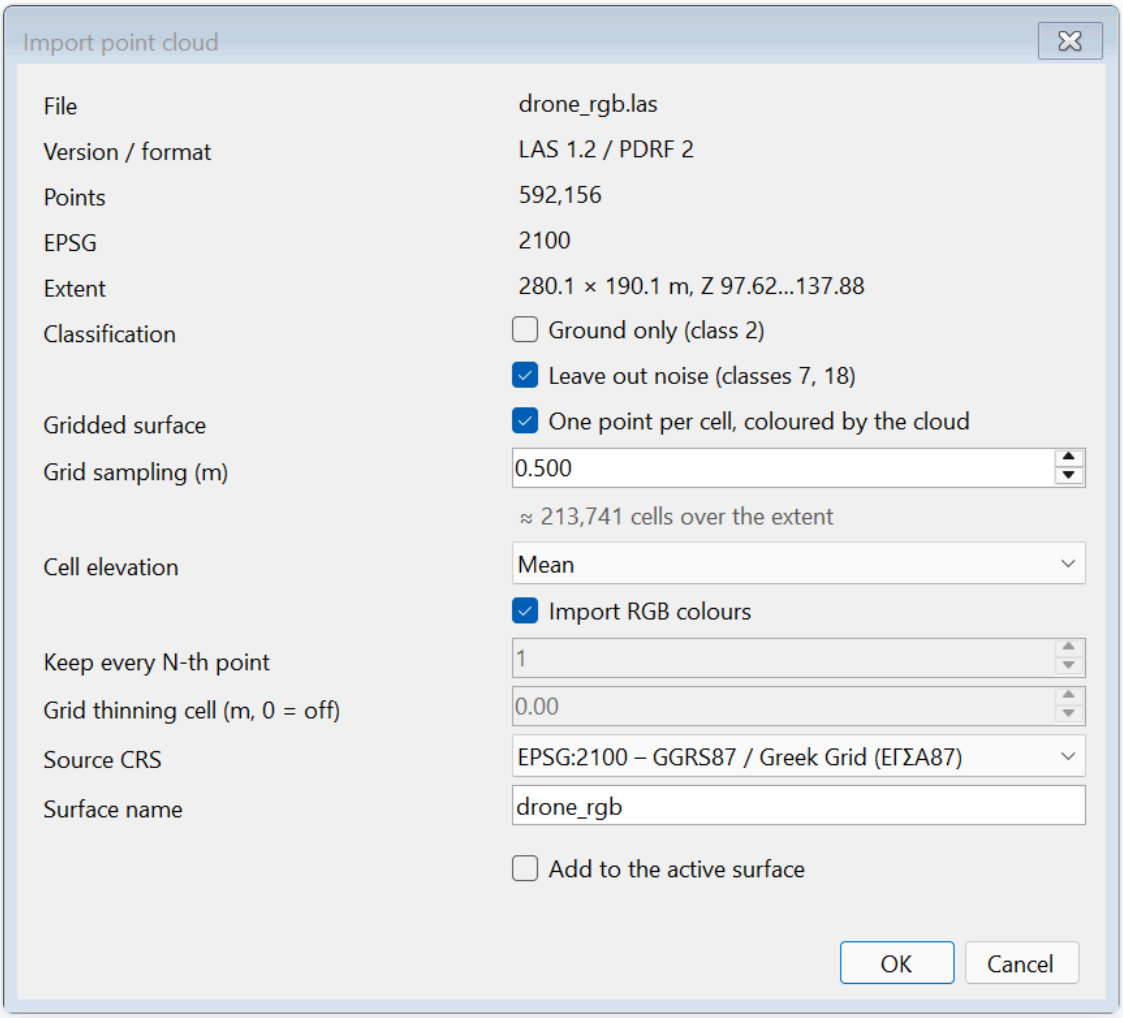


Figure 8.3 – Importing a point cloud as a gridded surface with RGB colours

Option	Meaning
Grid sampling	Cell size (m). A smaller step gives more detail and a heavier surface: about 1 million cells are built in a few seconds; above 3 million a warning is shown.
Cell elevation	**Lowest point** (ground), **mean** or **highest point** (roofs, trees – the surface as the camera sees it).
Import RGB colours	The average colour of the points of every cell. 8- and 16-bit colours are recognised automatically (point formats 2, 3, 5, 7, 8, 10).
Ground only / leave out noise	Apply here too: e.g. the ground in its colours for a terrain model, or all classes for the picture of the site.

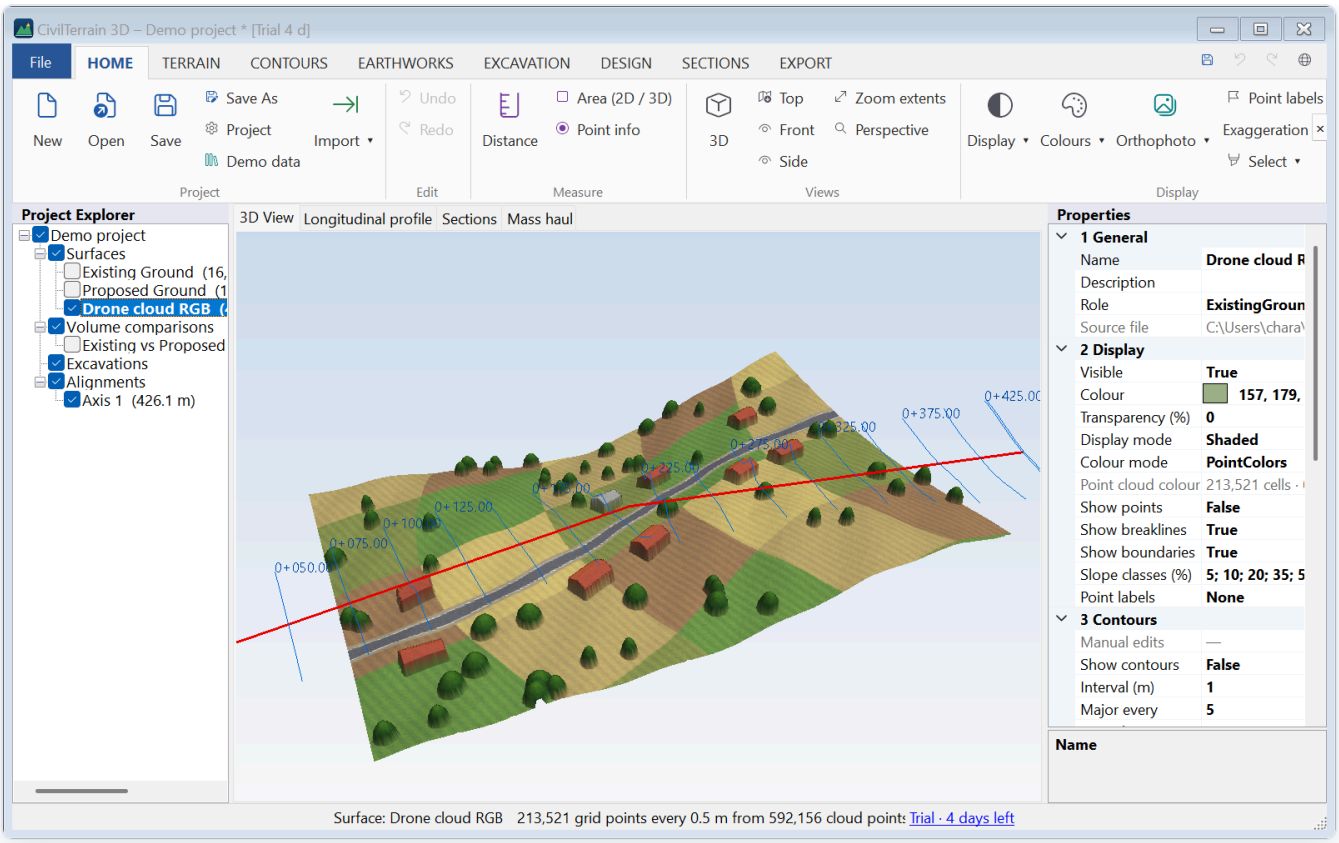


Figure 8.4 – A drone cloud as a 0.50 m gridded surface in its RGB colours, with no orthophoto

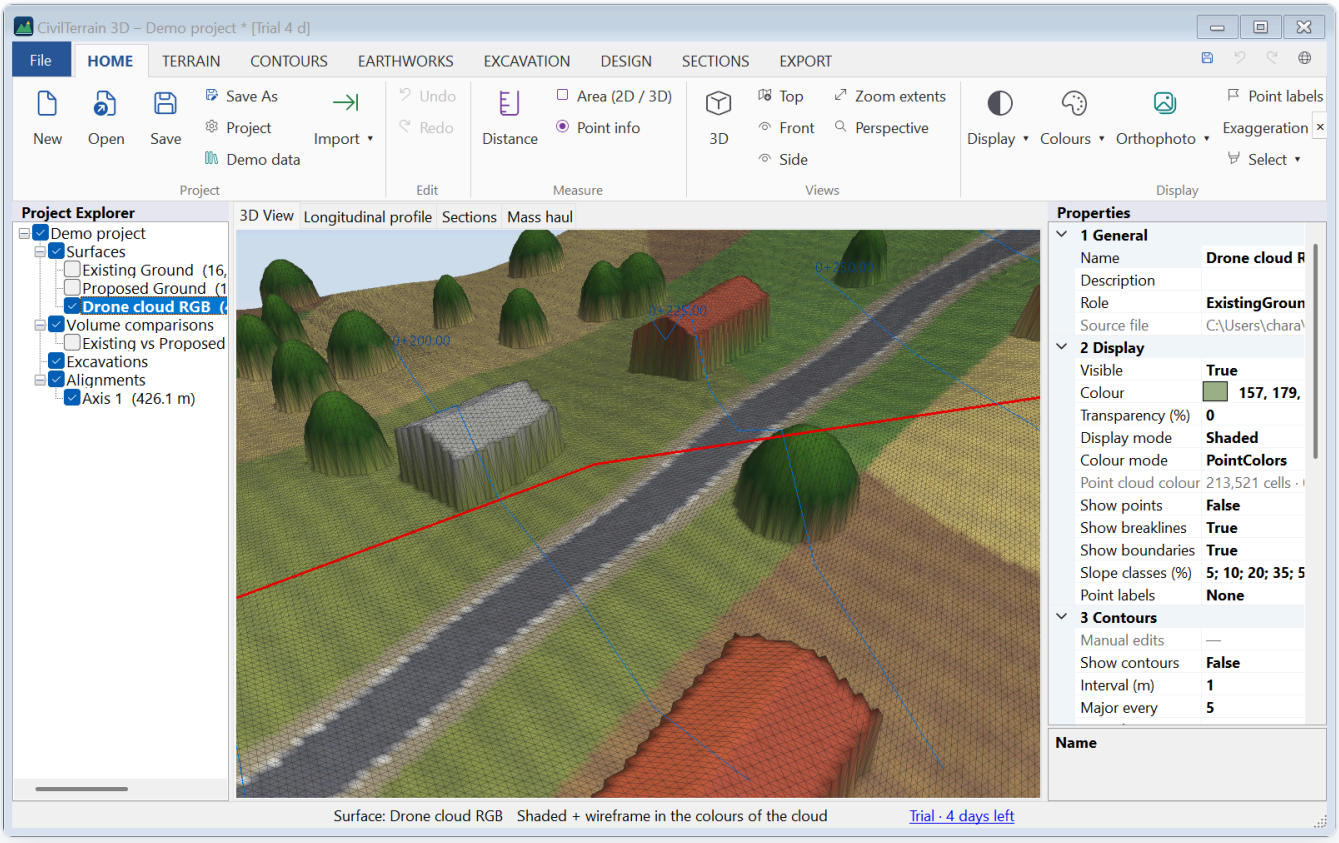


Figure 8.5 – The same surface shaded + wireframe

The new surface is coloured with **Point cloud RGB** (in the Properties: **PointColors**) and its contours are hidden at first. With **HOME → Colours** you switch to elevation colours, slopes etc. and back to the

colours of the cloud at any time. The maximum triangle edge is set to 4 × the step, so that the gaps of the cloud (water, shadows) stay open instead of being bridged; change it in **Surface data**.

- The colours are saved in the project file and follow the surface when it is copied, smoothed or **merged** (where surfaces overlap, the first one has priority).
- With **Add to the active surface** the colours are added to the existing ones.
- If the source coordinate system differs from the project's, the colours are transformed together with the points.

> **Tip:** for volumes keep a separate ground surface (**Ground only**, **lowest point**) and use the surface with the **highest point** and RGB for the picture of the site, measurements and presentations.

Machines and trucks can be cleaned off such a surface too, together with their colours, with **TERRAIN → Remove objects** (section 10.4).

8.4 Following a road / channel

In a LiDAR or drone cloud the general ground filter (8.1) often cuts off the sharp edges of a road or a channel: the crest of the cut, the toe of the fill, the edges and the ditches. **TERRAIN → Follow road / channel** (the road-sign icon) solves this with the **typical section**:

1. With the surface of the cloud active, draw a **rough line** along the road or channel, from its start. It does not need to be exact; it may be a few metres off. For **Suggest points**, draw it on the road (or in the channel): the two sides of the section are split at it.
2. The dialog shows the **first section** (the points of the slice and their ground) with points suggested at the changes of slope. The suggested points stop at the **crest** and the **toe**, the outer ends of the steep faces (diamonds, free points); points on the natural ground beyond them are not suggested. A rough line at an angle to the road is allowed for. It is a proposal: check it, especially between walls or hedges, where it may put a crest on their top. Adjust the **typical section**: drag a point, double click to add one, right click to delete. Place the fixed points exactly on their edge (zoom with the wheel; the offset and Z show while you drag): they keep that distance along the whole road. In the table give the **kind** of each point (crest, toe, ditch, edge of pavement, axis, curb, channel lip / bottom…), which gives its name and code (TOP, TOE, DCH, SH, EP, AX, KR, CH, WALL; in the Greek interface ΦΡ, ΠΟ, ΤΑ, ΑΣ, ΑΞ, ΚΡ, ΡΕ, ΤΟ). For a channel, the suggested top of each side is a “Top of slope”; for a lined channel change its kind to “Channel – lip” (fixed). The crest and the toe are **free** points: they follow the ground however the height of the slope changes. The others keep the distances of the typical section and move together as one body, which may also tilt (superelevation).
3. **Follow**: every few metres (e.g. 2 m) the program finds the typical section in the points, following the feature itself rather than the rough line. It ignores vehicles, vegetation and noise. It bridges gaps (e.g. no points under a bridge) and marks them as **uncertain** sections. The slider shows every section: green is the typical section found, blue the clean ground; the plan shows the lines.

4. OK creates **feature lines** with their codes, optionally as **breaklines** of the surface so that the TIN keeps the edges. It also splits the points of the corridor into **ground** and **objects** (a disabled group), optionally with the general filter for the rest of the cloud (**… and the general ground filter outside it**), with the default settings of the ground filter and your last choice of **Leave out low noise** (section 8.1). Everything can be undone. The options of the result are in the strip **Result (with OK):** above the buttons and are always in view; the window fits whole also on a 1920 × 1080 screen at 150 % scaling.

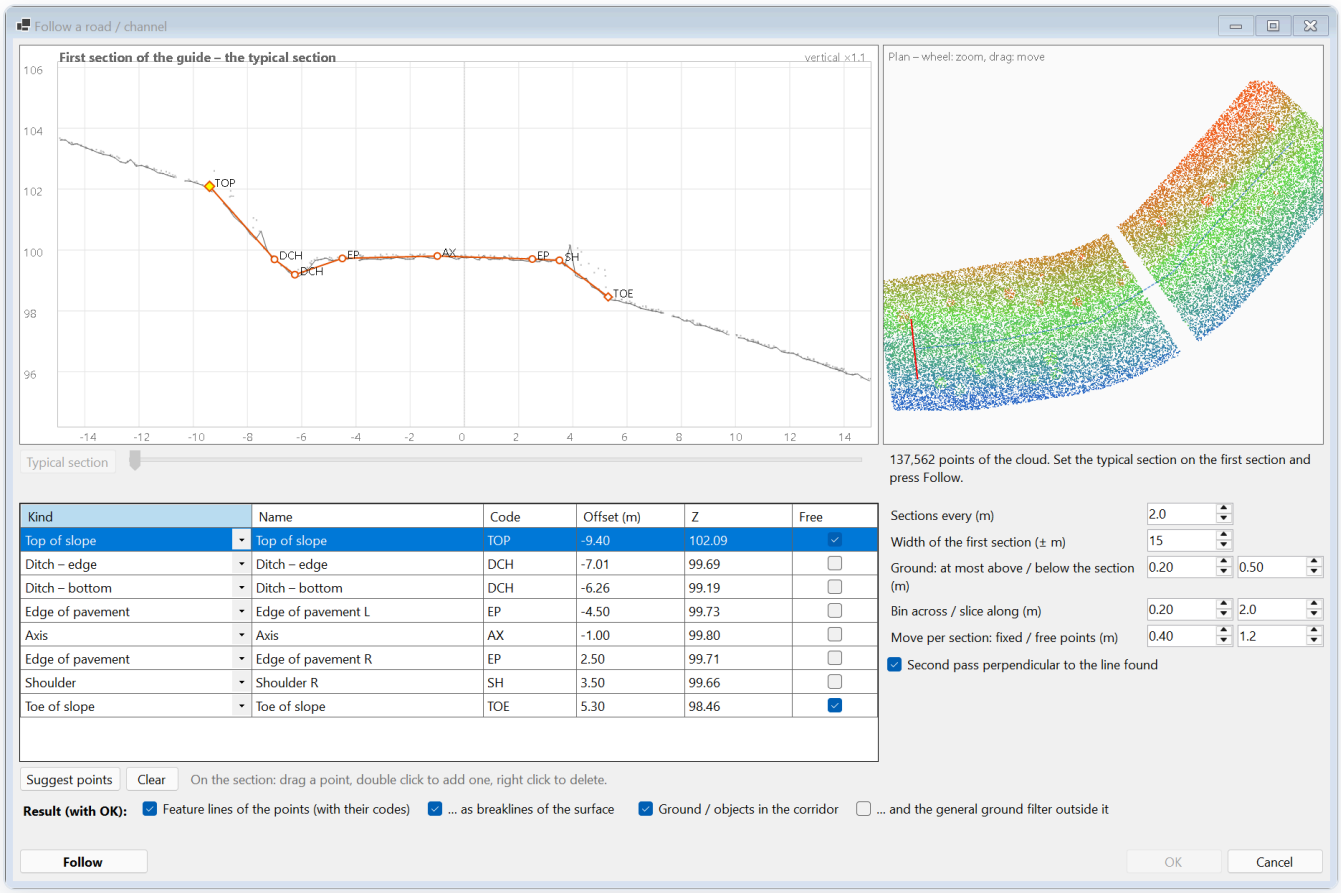


Figure 8.6 – The typical section on the first section of the rough line; below, the “Result (with OK):” strip

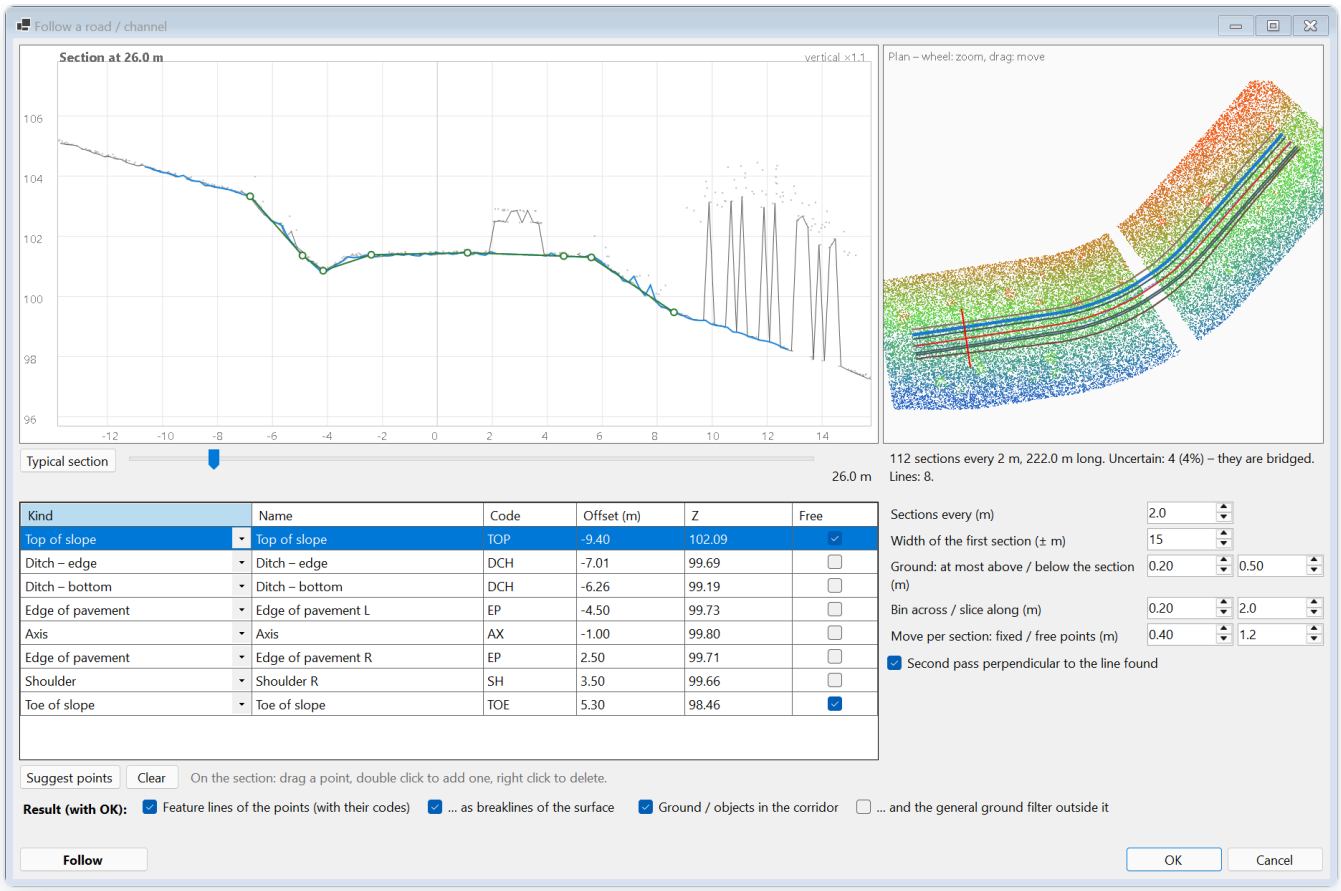


Figure 8.7 – A section of the result: the car on the road and the tree past the toe do not count

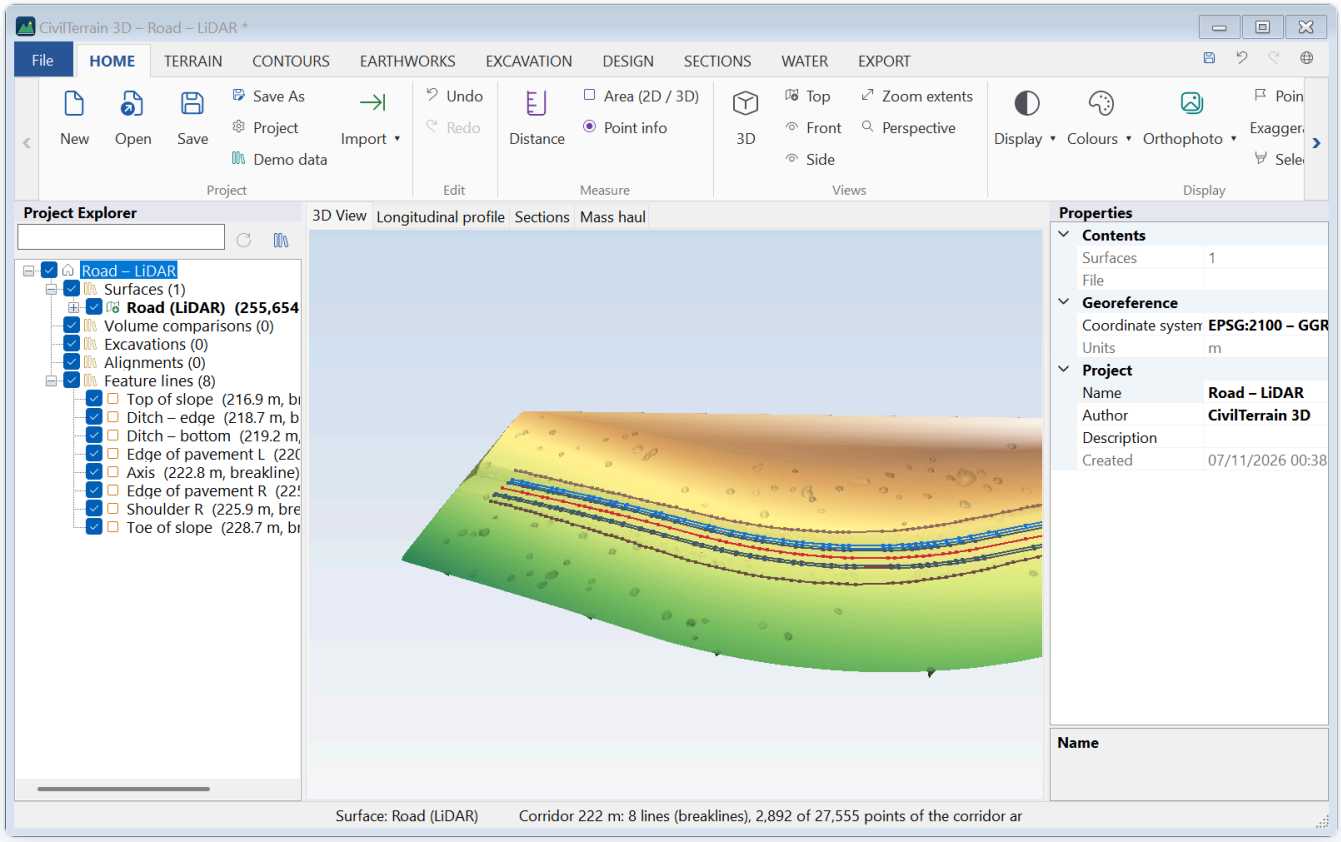


Figure 8.8 – Crest, ditch, edges, axis and toe as breaklines on the clean ground

Setting	Meaning
Sections every	Distance of the sections (1–5 m); smaller in tight curves.
Ground: at most above / below	How far above (e.g. 0.20 m) or below the ground of the section a point may be to count as ground.
Bin across / slice along	Resolution of the section (0.1–0.2 m) and length of the slice of points along it (2 m); make the slice longer in a sparse cloud. **Suggest points** reads a slice of at least 4 m (at most 6 m), straightened along the feature.
Move per section	How far the fixed and the free points may move from one section to the next. When the feature is lost the search widens by itself.

Codes and DXF layers: the codes are in the language of the interface when the typical section is made, and they are never changed later (nor in older projects). In **DESIGN → Drawing DXF / DWG** every feature line goes on the layer `FL_` + its code, in Latin letters: the English codes give e.g. `FL_TOP`, `FL_TOE`, `FL_DCH`, `FL_SH`, `FL_EP`, the Greek codes `FL_FR`, `FL_PO`, `FL_TA`, `FL_AS`. A project with typical sections made in both languages has two layers for the same kind of line (only `FL_AX` and `FL_KR` are shared).

> **Tip:** give the typical section its **strong** changes of slope (crest, ditch, edge of the shoulder, toe). Points with a very small change of slope, such as an axis with 2.5% crossfall, follow their body; they do not need to show in the points. Sample: `12_dromos_lidar.las` (a road with a cut, a ditch, a fill, vehicles and trees; an unclassified cloud, class 1, as it comes from the scan).

9. Terrain model (TIN) and water flow

The TIN is built by **Delaunay** triangulation; breaklines and boundaries are inserted as mandatory edges (**constrained Delaunay**). The model is **non-destructive**: it keeps the source data and every edit and is rebuilt automatically after each change (**TERRAIN → Rebuild TIN** or `F5`).

9.1 Multiple surfaces

A project can hold any number of surfaces, e.g. *Existing Ground, Proposed Ground, Excavation Surface, Final Construction Surface*. Each has its own name, role, visibility, colour, transparency and contour settings.

9.2 Surface data – what takes part in the TIN

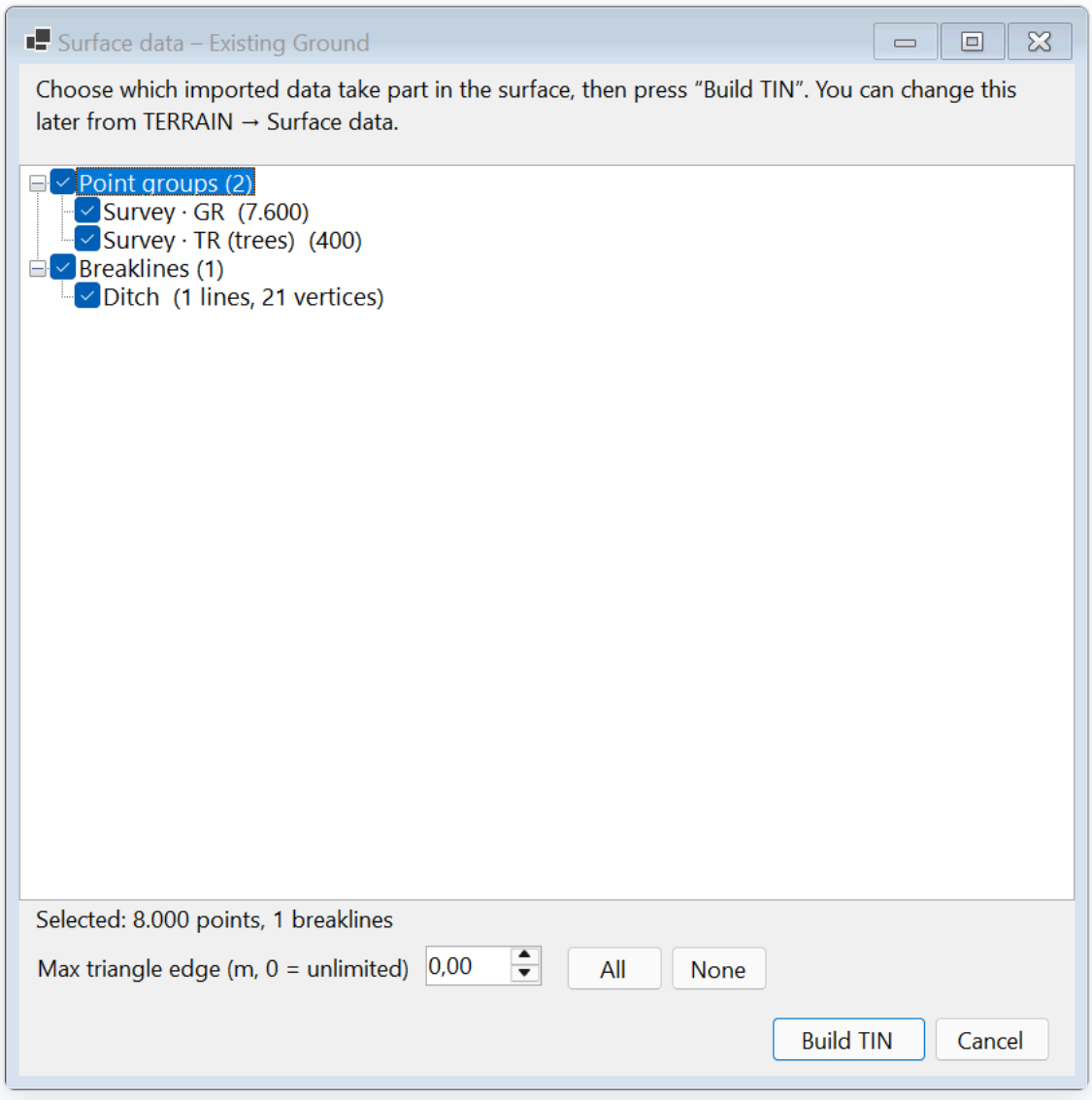


Figure 9.1 – Choosing point groups, breaklines and boundaries

From **TERRAIN → Surface data** (or right-click the surface) you see all the data of the surface and tick which are used:

- **Point groups** – e.g. "Survey · GR" (ground), "Survey · TR" (trees). Untick groups that are not ground.
- **Breaklines** – grouped by name / layer / code.
- **Boundaries** – outer boundaries and holes.
- **Max triangle edge** length.

Click **Build TIN**. Changes can be undone. Disabled data are not deleted; you can enable them again at any time.

9.3 Surface simplification

Point clouds (LiDAR, drone) produce very large models. **TERRAIN → Simplify** reduces the points while keeping the **maximum vertical difference** you set (e.g. **0.05 m = 5 cm**):

- only original points with their real elevations are kept;
- every original point is within the tolerance of the new surface;
- the outline, holes and breaklines are kept exactly;
- flat areas keep few large triangles, slope changes keep more.

A **new** surface is created (the original is kept hidden) and a summary is shown: points and triangles before/after, maximum and RMS difference, time.

> **Simplify or smooth? Simplification** reduces the model size without changing elevations beyond the tolerance. **Smoothing** changes elevations to remove noise. For large point clouds simplify first.

9.4 TIN settings (Properties → 4 TIN)

Setting	Description
Max edge length	Removes triangles with an edge longer than the value (cuts long "bridge" triangles at the edges). 0 = unlimited.
Duplicate tolerance	Points closer than the tolerance (default 1 mm) are treated as the same point.

9.5 Statistics

TERRAIN → Statistics: number of points and triangles, plan and surface area, elevation range, mean slope, edge lengths, build time and any breaklines that could not be inserted.

9.6 Merging surfaces and point clouds

When an area is covered by several files (e.g. two drone flights, a LiDAR cloud with a supplementary GPS survey, an old and a new survey), **TERRAIN → Merge surfaces** (or right-click a surface → **Merge with…**) builds a **new surface** from the points, breaklines and boundaries of two or more surfaces. The original surfaces are not changed.

Option	Description
Order of the surfaces	The order in the list (▲ ▼ buttons) is the **priority**: the first one wins where they overlap.
Common area	Only the points of the surface higher in the list are kept. Points of later surfaces that fall where it has **data** are left out. Its data means its triangles, without the long ones that only bridge empty space, such as the bay of an L-shaped survey. Their breaklines are cut exactly at the edge. Without this option all points are kept.
Height alignment	Every later surface is shifted vertically by the **median** difference from the first one in their common area (robust to vegetation and noise). The shift and its spread are reported at the end.
Grid thinning	One point per cell (nearest to the centre, lowest – for ground from a cloud – or mean). Breakline vertices are not thinned.
Longest triangle edge	For the new surface. The automatic value is the largest of the ticked surfaces; if one of them has no limit, the value is 0 (no limit). A mesh (LandXML, GeoTIFF etc.) counts with 1.5 × its longest edge. The value follows your selection until you type your own.

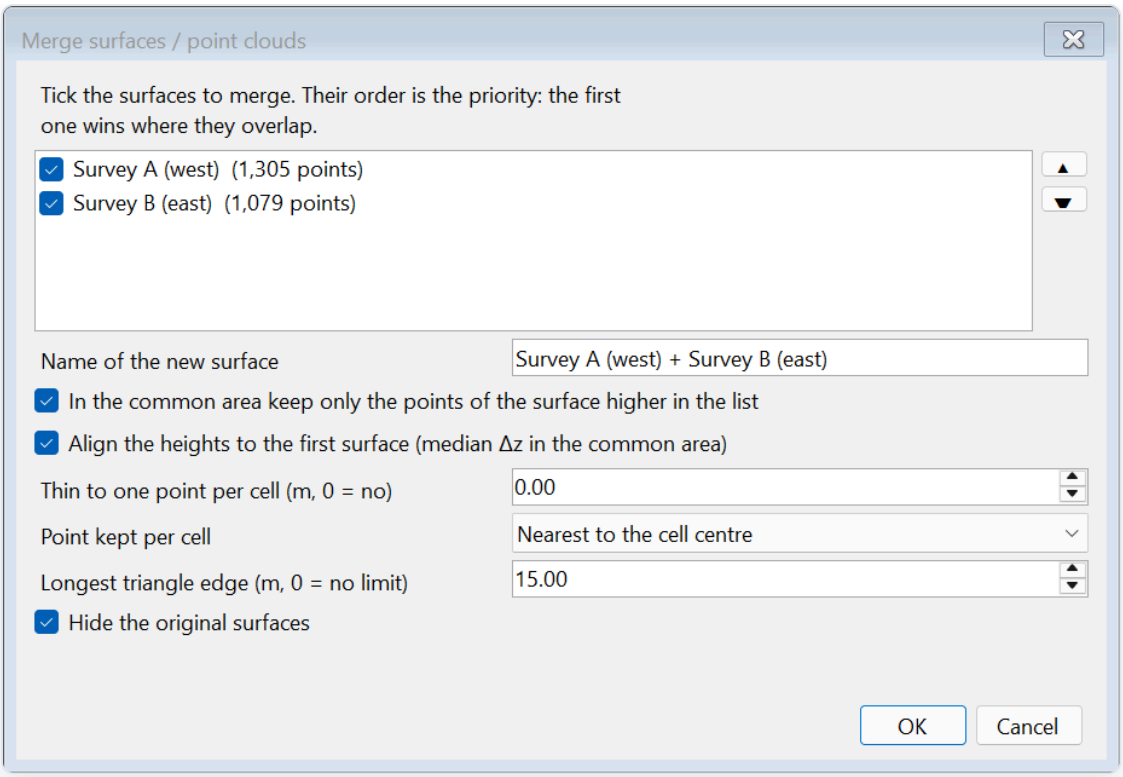


Figure 9.2 – The merge window: priority order, common area, height alignment, thinning and longest triangle edge

The points of every original surface become separate point groups with their numbers, so you can switch them on / off in **Surface data**. A mesh gives the vertices of its triangles.

Boundaries are handled as follows:

- Whatever a surface had cut away with its own boundaries (outer boundary, holes) stays out of the new one.
- Outer boundaries are kept only if every surface has one, so that none is cut away. A mesh counts with its outline.
- A hole hides only the data of its own surface. Where the other surfaces have data inside it, their data stays visible (show areas); if they cover it whole, the hole is left out. The report says so.
- The voids of a mesh (no data) become holes the same way, with the islands inside them as show areas.

At the end a report opens that shows for every surface:

- how many points were kept, cut away or left out in the overlap;
- the height shift.

The report stays open while you look at the new surface.

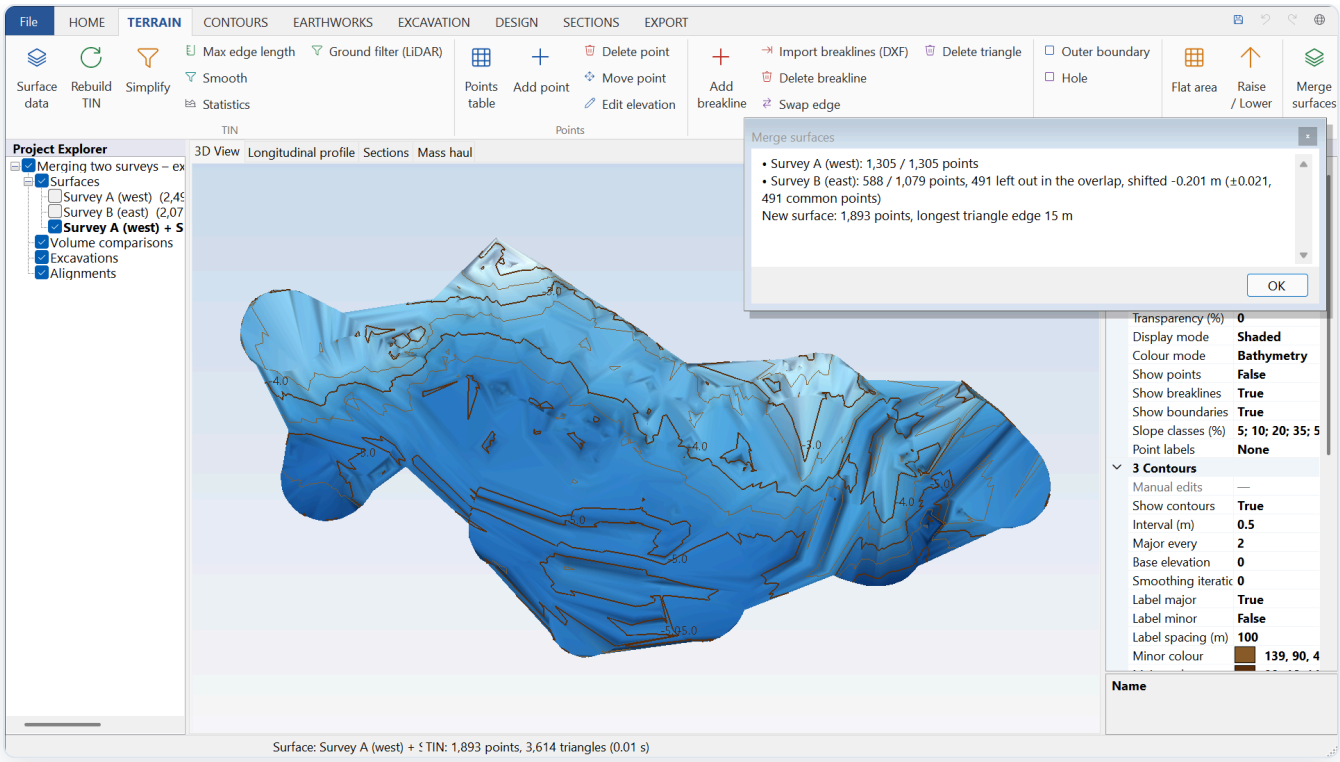


Figure 9.3 – Two bathymetric surveys with a common strip merged into one surface: the second one was aligned by −0.20 m and its points in the common strip were left out

Tip:

- If two surfaces do not touch, a longest triangle edge stops the gap between them from being bridged.
- A topographic survey that surrounds a lake or a river also “covers” the water with its triangles. For the bathymetry to count there, put the bathymetry first in the list or draw a hole in the topographic survey. The merge report points this out when points are left out far from the points of the earlier surface.
- To simply add a second file to an existing surface there is also **Add to the active surface** when importing.

9.7 Water on the surface: water courses and pools

WATER → Water on the surface: for the active surface the program shows **where the rain water runs** (water courses) and **where it collects and stays** (pools, with depth, area and volume of water). Use it to check a grading design before it is built, to find where manholes or culverts are needed, and to spot puddles on roads, squares and plots.

Setting	Description
Grid spacing	The surface is sampled on a square grid. 0 = automatic (about 1.5 million cells, at a round spacing; the dialog shows the value). A finer grid shows smaller puddles and takes longer.
Water course from a drained area of	A line of the grid becomes a water course when its water comes from an area of at least this many m^2. The automatic value is about 0.5% of the surface. A smaller value gives more, smaller water courses.
Pools deeper than	Shallower pools are left out (e.g. 0.05 m).
Show the water courses / pools	What is drawn on the surface.

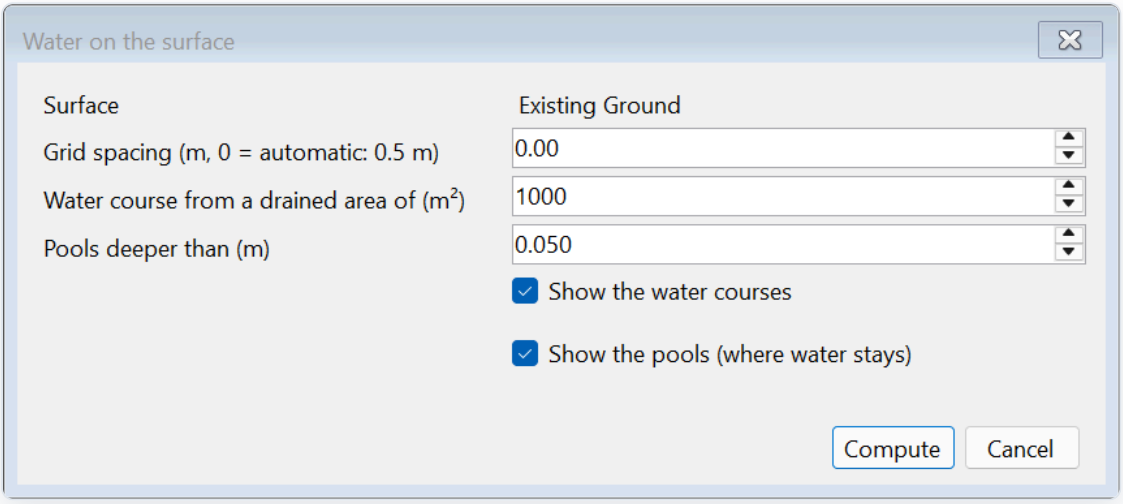


Figure 9.4 – The settings of the water analysis

The **water courses** are drawn in blue, reach by reach from junction to junction, thicker and darker the larger their basin. Where the ground falls towards the edge of the surface, the water leaves there and does not run along the edge. Through the **holes** of the surface (hidden areas, deleted triangles, e.g. the opening of a culvert under a road) the water passes at the level of their edge: it is neither lost in them nor dammed by them, at whatever angle they lie. The **pools** are coloured blue, darker where the water is deeper, up to their spill level, that is up to where the water rises before it overflows. A list of the pools also opens, largest first. For each pool it shows the lowest point, the depth, the area and the volume of water. Clicking a row zooms to the pool in the drawing. Clicking a header sorts the column. **WATER → Pools** opens the list again.

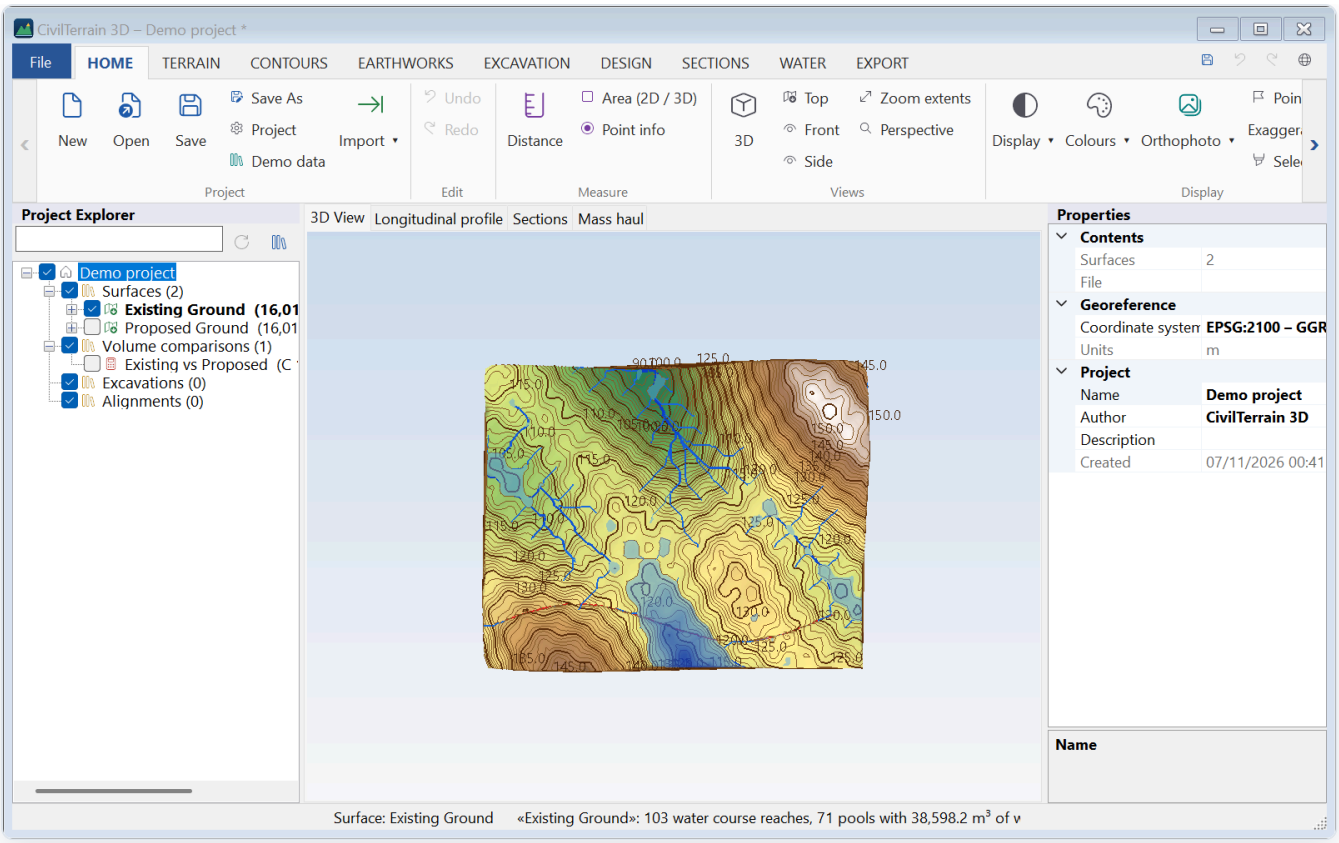


Figure 9.5 – Water courses and pools on the ground surface

The computation runs in the background and `Esc` cancels it. The water picture goes with **Hide the water**, when the surface changes or when another project opens. It is not saved in the project: run the command again whenever you need it.

> **Tip:** run the water analysis on the **design surface** of a grading as well (e.g. after the grading optimization, section 14.4). A pool there shows where water will stay after construction.

9.8 Drainage basin

WATER → Drainage basin: click the point where the water leaves (culvert, manhole, lower end of a water course). The program finds the whole area upstream, from where the water ends up there, and adds it to the project tree as a **drainage basin**. The click snaps to the water course with the largest basin within a short distance, so it does not need to be exact. A click inside a hole of the surface (e.g. on a hidden culvert) takes as outlet the point where the water leaves the hole.

For each basin the program computes:

- the **area** (m^2, ha, km^2), the perimeter and the outline;
- the **longest flow path** L, from the farthest point to the outlet, and its grade;
- the outlet elevation, the mean and the highest elevation, and the mean grade of the ground;
- the **time of concentration** by **Kirpich** ($t_c = 0.0195 \cdot L^{0.77} \cdot S^{-0.385}$ min, with L in m) and by **Giandotti** ($t_c = (4\sqrt{A} + 1.5\ L) / (0.8\ \sqrt{(H_m - H_0)})$ hours, with A in km^2 and L in km);

- the **peak flow** by the rational method, Q = C · i · A / 3.6 (m^3/s, with i in mm/h and A in km^2). You give the runoff coefficient C and the rainfall intensity i in the Properties; the peak flow updates at once.

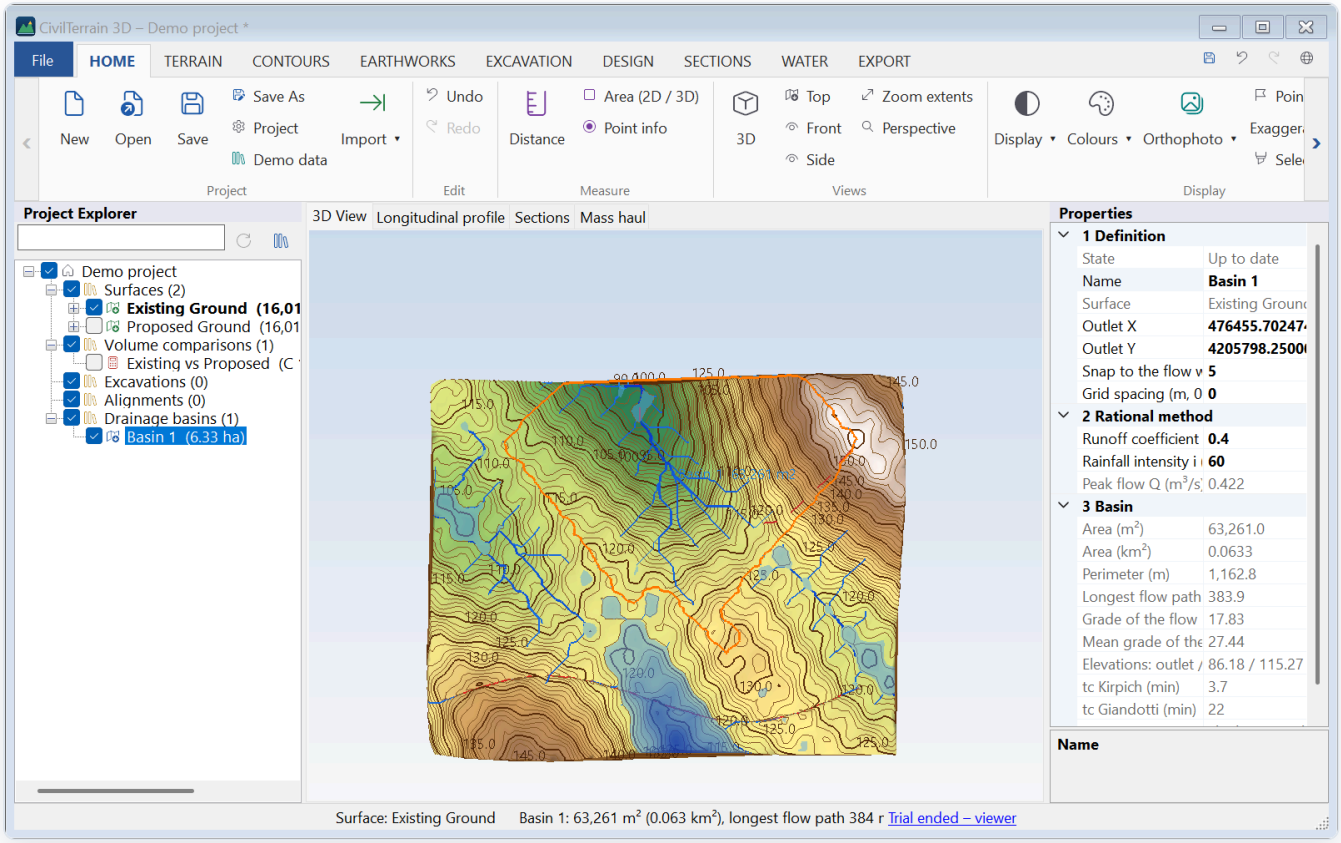


Figure 9.6 – A drainage basin: outline, longest flow path (dashed), outlet and its figures in the Properties

In the Properties you can also change the outlet (X, Y), the snap distance and the grid spacing. After such a change, or when the surface changes, the basin shows as **out of date** (⚠) until you **Recalculate** it (right-click the basin). The right-click menu, and the buttons of the **Drainage basins** group for the selected basin, also have **Results…** and the export to **Excel** and **DXF / DWG**. The DXF has the outline on the ground (layer BASIN), the longest flow path (FLOW_PATH), the outlet (OUTLET) and, if the water courses are shown, their reaches inside the basin (STREAMS). Basins are saved in the project and computed again when you open it.

> If the basin reaches the edge of the surface, the program says so, because it may go on beyond it. A very small basin usually means that the click was not on a water course; a larger snap distance helps. The times of concentration and the peak flow are estimates for preliminary design and checking. For the drainage design use the intensity–duration–frequency curves of the area.

10. Terrain editing

The **TERRAIN** tools act on the **active surface**. Every edit supports **Undo** (`Ctrl`+`Z`) and **Redo** (`Ctrl`+`Y`).

10.1 Drawing on screen

- Click = vertex. The cursor snaps to TIN vertices.
- `Enter`, double-click or right-click = finish the line/polygon.
- `Backspace` = remove the last vertex, `Esc` = cancel.
- Each tool's prompt is shown in the status bar.

The **Add / Delete point**, **Edit elevation**, **Delete breakline**, **Swap edge** and **Delete triangle** tools stay **active** after each click so you can edit many items in a row. Press `Esc` to finish.

10.2 Tools

Tool	Usage
Add point	Click the position and type the elevation (the surface elevation is suggested).
Delete point	Click on the point (or a breakline vertex).
Move point	Click the point, then click the new position (elevation is kept).
Edit elevation	Click the point and enter the new Z.
Add breakline	Draw a polyline; elevations are taken from the surface (or asked outside it).
Delete breakline	Click near the line.
Import breaklines (DXF)	Adds the polylines of the selected layers as breaklines to the active surface.
Swap edge	Click an edge: flips the diagonal of the quadrilateral (only if convex).
Delete triangle	Click inside the triangle.
Outer boundary	Closed polygon: everything outside is removed. The boundary is inserted exactly into the TIN.
Hole	Closed polygon: everything inside is removed (e.g. buildings, ponds).
Flat area	Closed polygon and elevation: creates a level pad.
Elevation offset	Δz on the whole surface or inside an outline, with a transition band, in place or into a copy (section 10.3).
Remove objects	Machines, trucks and other objects off the ground, found automatically or drawn; the ground under them is made from the ground around them (section 10.4).
Replace terrain	Debris or a deposit inside an outline comes down to the ground around it (section 10.5).
Smooth	Creates a **new** smoothed surface; the original is preserved. Breaklines and boundaries are kept fixed.
Duplicate / Delete	Copies or deletes the active surface.

> **Fixed meshes:** surfaces imported as triangles (DXF 3DFACE, LandXML, OBJ, PLY, GeoTIFF) are converted to a point-based TIN when you add points or breaklines; the program asks for confirmation.

> **Large surfaces:** edits run in the background, the program stays responsive and quick consecutive clicks are processed in order. Swap edge and delete triangle are applied instantly without re-triangulation, and undoing the latest edits is immediate. A save while a surface is being rebuilt (or an edit is running) waits for it: a small window says “Please wait – the surface is still being rebuilt. When it is done, the project will be saved.”, closes by itself and the project is saved. The same holds for **Yes** to “Save changes to the current project?” before the program closes or another project opens. **Cancel** in that window saves nothing and closes nothing; the status bar says “Not saved – the surface is still being rebuilt.”

10.3 Elevation offset

TERRAIN → Elevation offset: moves the elevations of the active surface by Δz (positive: up, negative: down).

Setting	Description
Where	On the whole surface or inside an outline. If a zone, a closed line or an outline (of polygon earthworks, a grading optimization, a sloped design) is selected in the tree, that one is used; otherwise you draw it after OK.
Transition band	Beyond the outline the offset fades smoothly to zero over this distance, so that no step forms. 0 = an abrupt change right at the edge. On point surfaces, points are added along the outline and the band, so that the change follows the outline also where the survey points are sparse. Breaklines that cross the outline or the band get vertices there and follow too.
Result	In the same surface (undo with `Ctrl`+`Z`), or into a copy: the original is hidden and a volume comparison original → copy is made.

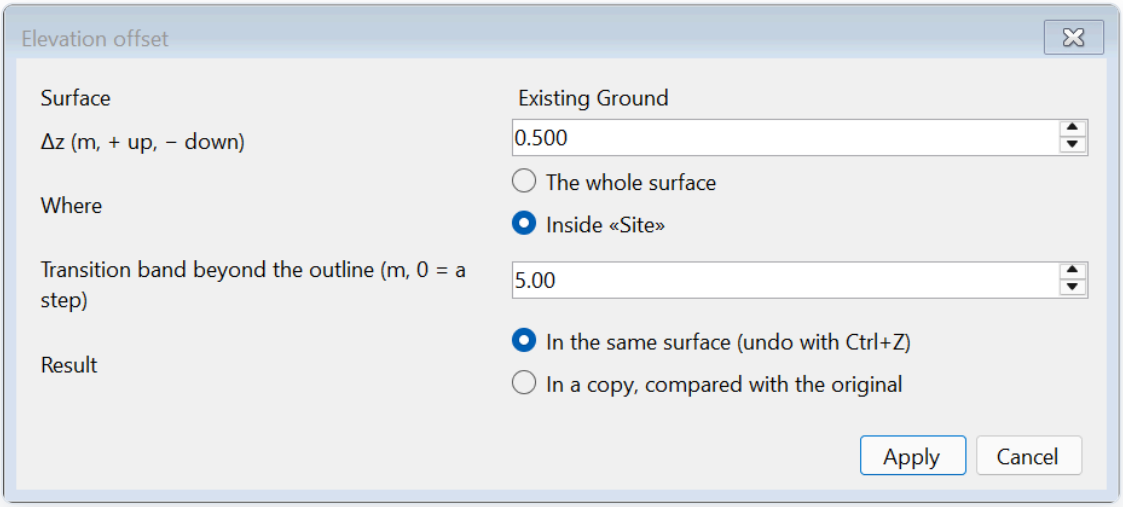


Figure 10.1 – Elevation offset inside a zone, with a 5 m transition band

> **Tip:** for a 0.30 m layer on a plot, give Δz = 0.30 inside its outline, into a copy. The comparison gives the volume of the material at once.

10.4 Remove objects

A drone or LiDAR survey of a site often keeps machines, trucks, cars or containers. The surface rises over them, and volumes, contours and cross sections count them as ground. **TERRAIN → Modify → Remove objects** takes them away: inside each outline the ground is made again from the ground around it. It works on point clouds, gridded RGB clouds (section 8.3) and DEM / DSM.

1. Make the surface active. To search only part of it, or to use an outline that already exists, select that outline in the tree: a zone, a closed line, the outline of polygon earthworks, a grading optimization, a sloped design, a building-code check, a section grid or a spot grid, a closed breakline or a boundary.
2. **TERRAIN → Modify → Remove objects**. In the window choose where the outlines come from, how the new ground is made and where the result goes. The button follows the source: **Search**, **Draw**, **Open...** (DXF / DWG) or **Apply** (selected outline).
3. Check the list of the objects found, or draw the outlines, and press **Apply**.

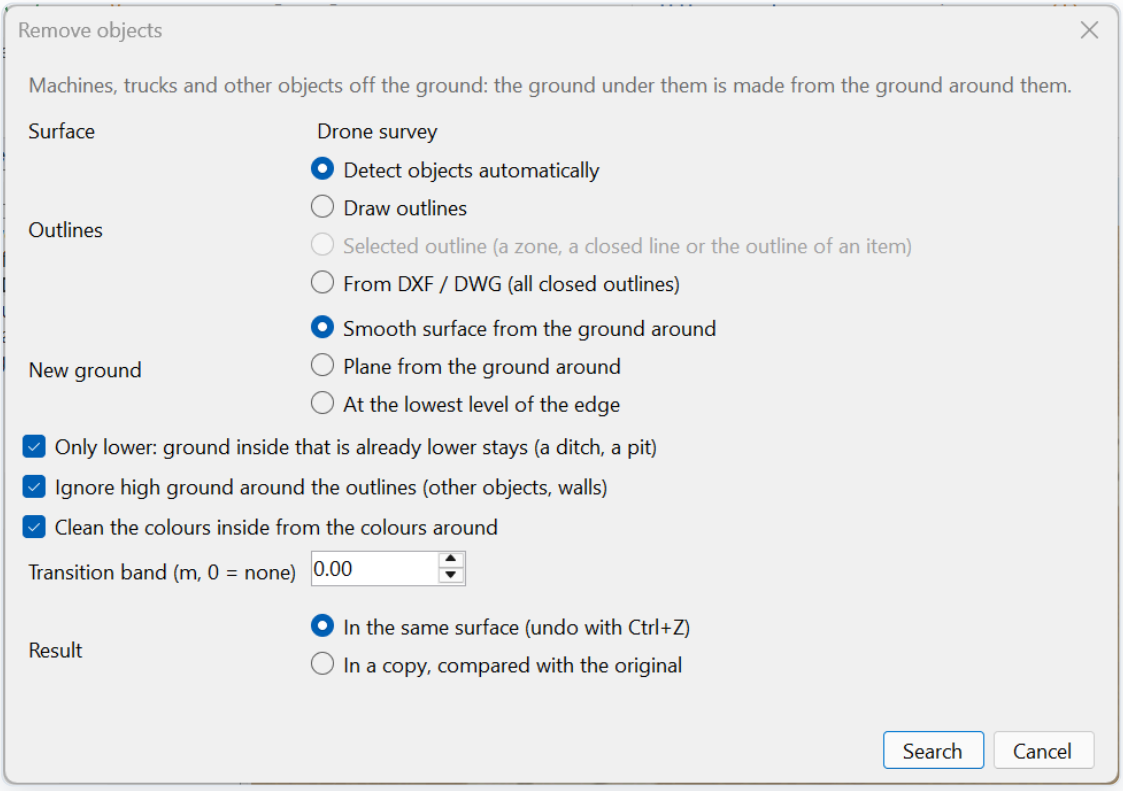


Figure 10.2 – The “Remove objects” window

Setting	Description
Outlines	**Detect objects automatically** (default): the program finds the objects and lists them for you to check. With an outline selected in the tree, **Search only inside «…»** keeps the objects whose centre is inside it. **Draw outlines**: draw as many as you like, one after the other. **Selected outline «…»**: applied at once. With nothing selected it reads **Selected outline (a zone, a closed line or the outline of an item)** and cannot be chosen. **From DXF / DWG (all closed outlines)** of the layers you choose: they are shown in the view and you can draw more before applying.
New ground	**Smooth surface from the ground around** (default): carries on the slopes of the ground around the outline smoothly; a sloping plane comes back exactly. **Plane from the ground around**: for each outline the plane that fits the ground around it best, without the values that stand out above it. **At the lowest level of the edge**: level, for each outline at the low ground around it (about its lowest 5%). Outlines that touch or overlap share one plane or level; outlines that only lie close (a deposit on the floor and one on the bench above it) each stand on their own ground.
Only lower	Ticked by default: the surface only comes down, and ground inside that is already lower than the new ground (a ditch, a pit) stays as it is. Without it, lower points are raised to the new ground too.
Ignore high ground around the outlines	Ticked by default for Remove objects. Ground around the outline that is much higher than the low ground next to it (more than about 0.30 m: another truck touching it, a wall) is not used, so it does not lift the new ground. The program says what share was ignored.
Clean the colours inside from the colours around	For surfaces with colours (a gridded RGB cloud): the colours of the ground around replace those of the machine. Disabled when the surface has no colours. An orthophoto, if any, does not change.
Transition band (m, 0 = none)	Beyond the outline the new ground joins the old one smoothly over this distance. 0 (default) = the change is right at the outline.
Result	**In the same surface (undo with Ctrl+Z)**, the default: all the outlines in one edit. **In a copy, compared with the original**: a surface "… (objects removed)" is made, the original is hidden and a volume comparison original → copy is added, whose cut is the volume taken away.

The choices are kept, separately for each command, until the program closes.

Automatic detection and the review list

With **Search** the program searches in the background (`Esc` cancels) for objects standing on the ground: at least 0.80 m higher than the ground around them, with a plan area of about 3 – 150 m² and up to 15 m long (up to 22.5 m for wide and high machines, e.g. an articulated dump truck). For each object it proposes an outline 0.75 m outside it. The list **Remove objects – …** with the name of the surface then opens at the bottom right inside the view, as large as its rows (at most 40% of the height of the view):

- The **suggested** objects are already ticked: they have the size and plan of a machine, steep sides, a flat top and lower, even ground all around them.
- The others are not ticked, and the **Note** column says why, e.g. “Sides not steep (stockpile?)”, “No flat top (stockpile, tree?)”, “Ground not lower all around (cut face, crest, edge?)”, “Long and narrow (berm, windrow?)” or “Smaller than 3 m²”. So stockpiles, berms and cut faces are not removed by mistake.
- Columns: No, Area (m²), Height (m) (of the body above the ground around it: a raised boom or mast does not count), Length × width (m), Note; a click on a header sorts. A click on a row shows the object in the view and zooms to it; a click on its check box or `Space` changes the tick. In the view the ticked ones are **red** and those left as they are **yellow**.
- **Tick suggested** and **Untick all** change all the ticks at once.
- **Draw more…**: draw outlines for anything not found. They go into the list ticked, with the note “Drawn”. In the small drawing window, **Back to the list** or `Esc` takes you back to the list; the outline being drawn goes into it if it has three vertices or more (`Esc` with one or two vertices starts it again). If another tool takes the view meanwhile, the drawing ends and the list stays; an outline cut short (three vertices or more) goes into the list unticked, with the note “Drawn, cut short by another tool: tick it to remove it”.
- **Apply (N)** removes the N ticked objects in one edit; **Cancel** closes the list without changes.

If no object is found, the program asks whether you want to draw their outlines.

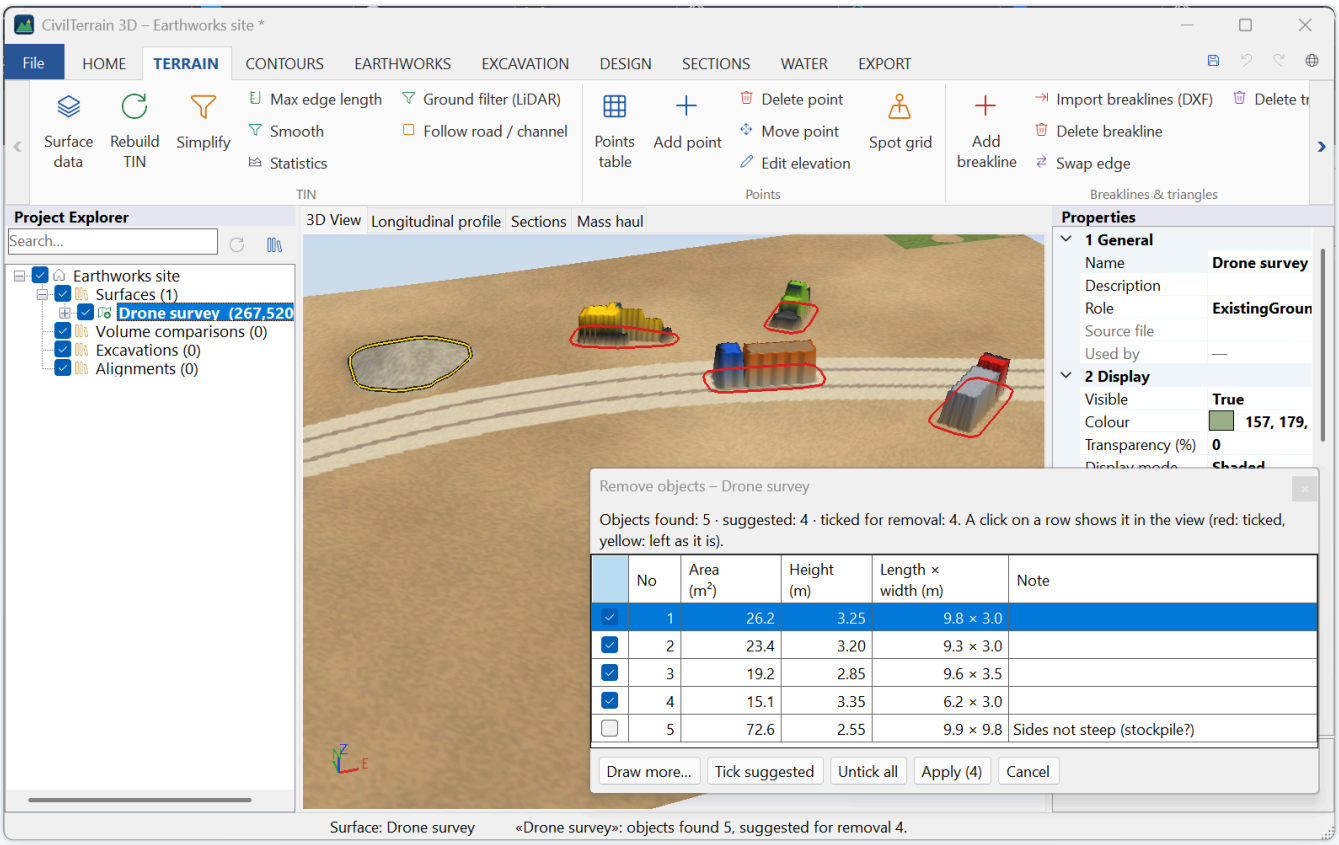


Figure 10.3 – The objects found, in the list and in the view: red when ticked for removal, yellow when left as they are

Drawing several outlines

With **Draw** (or after the DXF / DWG) you draw the outlines one after the other. A small window at the top right of the view shows how many outlines you have and how many vertices the current one has:

Key / button	Action
Click	A vertex. A click on a vertex or a side of another outline snaps to it (shared edges with no gaps).
`Enter` / double click	Outline done; the next one starts by itself.
`Backspace` / **Back**	Back one vertex.
Undo outline	Takes away the last outline.
Apply (N)	Applies all the outlines in one edit, and the current one if it has at least three vertices.
`Esc` / **Stop**	Ends the drawing. If there are outlines, the program asks: **Yes** = apply, **No** = discard, **Cancel** = go on drawing. The current outline counts if it has at least three vertices. `Esc` while the current outline has one or two vertices only starts that outline again.

An outline with one or two vertices is drawn again; an outline whose sides cross is not added. While a surface is being rebuilt, **Apply** is refused: the drawing goes on and you press **Apply** again when it is done.

If another tool takes the view while you draw (a measurement, another command), nothing drawn is lost: the drawing waits with its outlines in the view, the current outline is kept if it has three vertices or more, and the small window says “Paused: another tool has the view.” **Continue drawing** (in place of **Back**) goes on with the drawing; **Undo outline**, **Apply (N)** and **Stop** work as before. If nothing had been drawn, the command ends.

The result

The status bar says what was done, the volume first, e.g. “Remove objects: removed 110.3 m^3, outlines 1, area 68 m^2, points changed 147, colour cells cleaned 147”; “added … m^3” follows the removed volume when it is at least 0.05 m^3, and into a copy the line ends with the name of the copy. The volumes are measured on the surface itself, between the surface before and after, so into a copy they are the cut and fill of the comparison. What changes for each kind of surface:

- **Point cloud:** the elevations of the points inside the outlines (loose points and enabled groups; disabled groups, e.g. the “objects” of the ground filter, do not change). Enabled breaklines that cross the outlines get vertices and follow the new ground. On a sparse survey, with few points inside an outline, points of the new ground are added in a new point group “Remove objects”.
- **Gridded RGB cloud** (section 8.3): as a point cloud, and the colours are cleaned too, so that ground shows where the machine was.
- **DEM / DSM and other fixed meshes** (GeoTIFF, LandXML, OBJ, PLY): only the elevations of the vertices change; the triangles stay the same and the surface stays a mesh. The status bar says “vertices changed”.

When only elevations change, the TIN is updated without a new triangulation, and the result comes in a few seconds even on millions of points. In the same surface, one `Ctrl` + `Z` undoes all the outlines together. Anything computed from the surface (comparisons, spot grids etc.) is updated. If nothing changed (e.g. the outlines are off the surface, or with “Only lower” the ground inside is nowhere higher than the new ground), the program says so and why, with no undo step and no copy.



Figure 10.4 – Before and after: the trucks are removed and the ground under them is made from the ground around

After applying, warnings may be shown:

Message	What it means
"…% of the area inside the outlines is not on the surface: it is left as it is."	The outline goes off the survey; only its part on the survey changes.
"… part(s) of the area have no ground around them on the surface and were left as they were."	There is no ground around to give elevations (e.g. the outline covers the whole surface). Make the outline smaller.
"…% of the ground around the outlines is much higher than the ground next to it (another object, a wall) and was not used."	The effect of "Ignore high ground". If the share is large and there is a bank next to the outline, see the limits below.
"The colours were not cleaned: the outlines cover too many colour cells (…)."	More than 3 million colour cells; the elevations changed as usual. Apply to smaller outlines.
"The outlines are outside the surface: nothing was changed."	Check the active surface and the coordinate system of the DXF.

Always check the result.

- The automatic detection is tuned for machines and vehicles on open ground. Check the list before applying: a tree with a steep crown may be suggested, and an object of an unusual shape may not be.
- A machine against a wall or a cut face is not suggested ("Ground not lower all around…"): tick it in the list or draw its outline. Objects that touch each other are found as one; if together they are longer than 22.5 m they are not suggested ("Longer than …"), and a truck with a trailer may come out "Long and narrow". Draw their outlines then.
- With "Ignore high ground", a sharp bank, kerb or step right next to the outline is taken for an object too, and the new ground comes out lower. Draw the outline a little away from the bank, or untick the option.
- The new ground is an estimate from the ground around: it does not "know" what lies under a large object. On large outlines the computation spacing grows by itself (e.g. about 0.4 m on a 9 ha outline), so the new ground is coarser there; the volumes are still measured on the surface itself.

10.5 Replace terrain

Inside an excavation or on a platform there is often debris, a pile or a deposit of material that is not part of the ground you want to measure. With **TERRAIN → Modify → Replace terrain** you encircle it, and the ground inside the outline comes down to the ground around it (smoothing).

The window is the same as for Remove objects (section 10.4), without the automatic detection, and with two other defaults:

- the outlines are **drawn** (or come from the selected outline or a DXF / DWG);
- **Ignore high ground around the outlines** is not ticked: banks, benches and berms crossing the outline are ground and are used, so the new ground is not pulled down.

The **Smooth surface** carries on the banks and slopes around; **At the lowest level of the edge** gives a level floor, e.g. for material on the bottom of an excavation. With **Only lower** (default) lower points inside the outline (pits, ditches) stay as they are. The new ground takes its elevations from a strip about 1 m outside the outline: draw it so that it runs over clean ground.

You draw as many outlines as you like with the same small window (**Back**, **Undo outline**, **Apply (N)**, **Stop**) and they are applied together, with one undo. In a copy, the new surface is named "… (terrain replaced)".

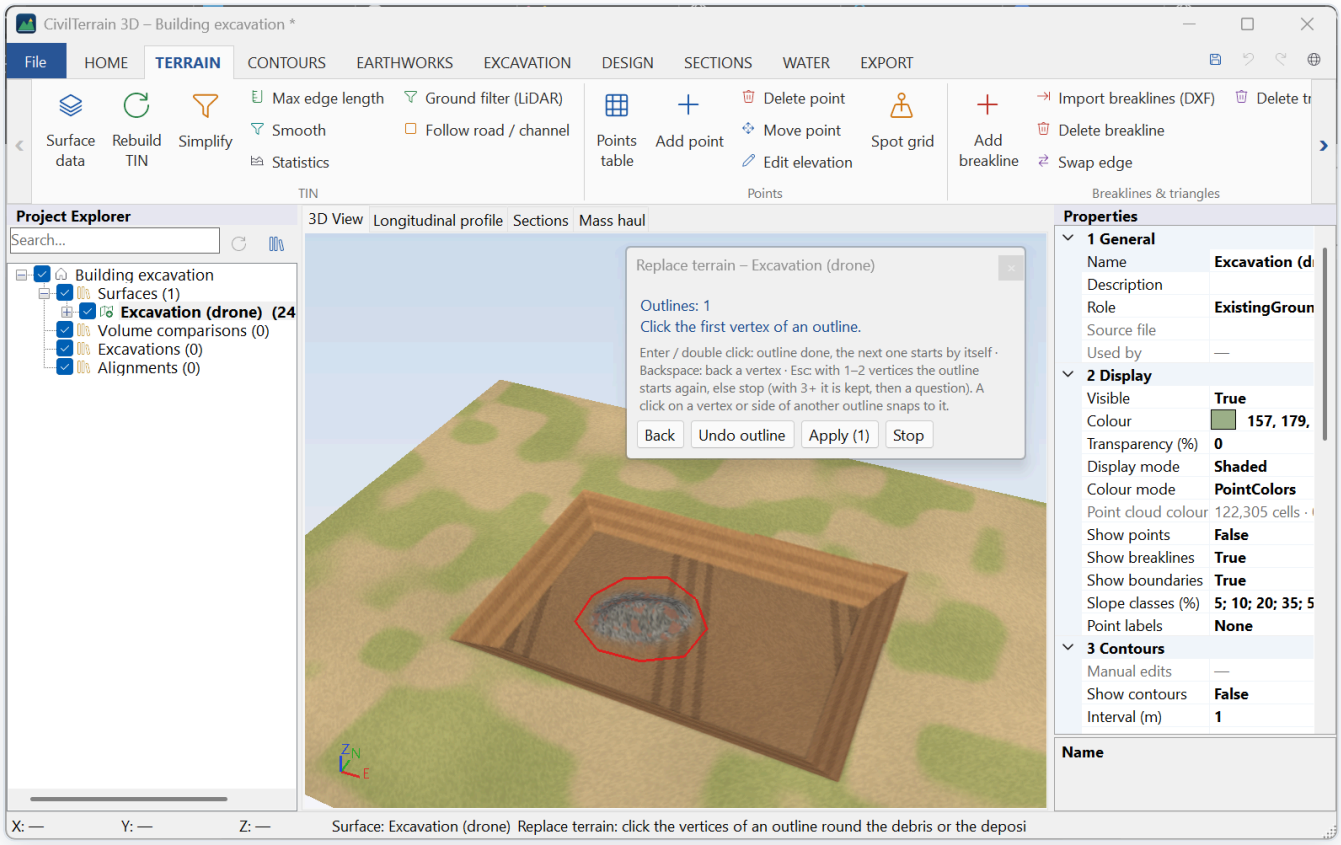


Figure 10.5 – Drawing an outline round a pile of debris in an excavation; the small drawing window at the top right

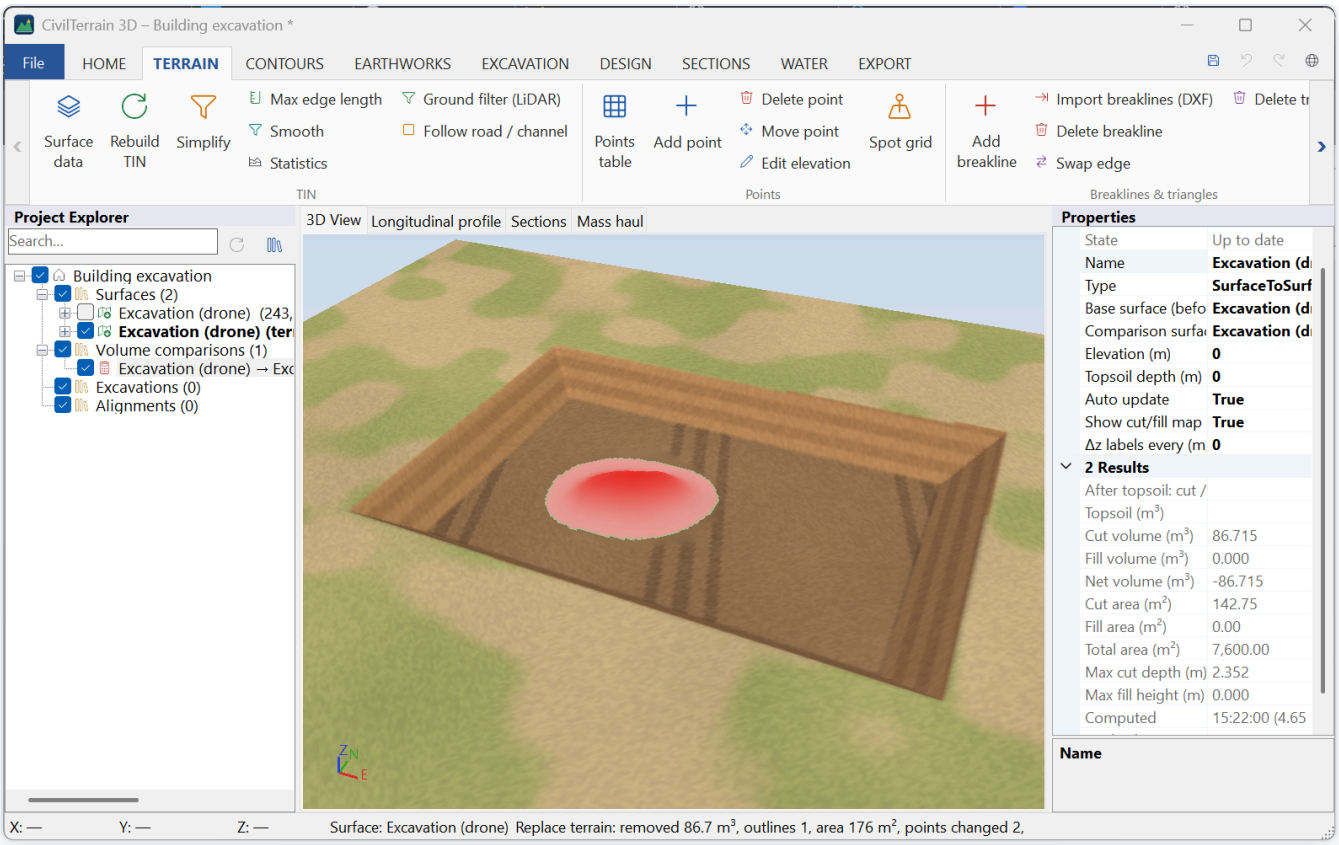


Figure 10.6 – Terrain replaced into a copy: the cut / fill map of the comparison shows the debris taken away

> **Tip:** for the volume of debris or a deposit, replace the terrain **into a copy**. The comparison original → copy that is made gives the volume of the material as its **cut** (section 12.2), with a cut / fill map and a PDF / Excel report.

11. Contours

Contours are computed **exactly from the TIN** and shown in 2D and 3D. On the **CONTOURS** tab set:

Setting	Description
Interval	Contour interval (e.g. 0.5 – 1 – 2 m). Type and press `Enter`.
Major every	Every how many contours a major (thicker) contour is drawn.
Smoothing	0 = exact TIN lines, 1–6 = progressively smoother curves. End points at the boundary do not move.
Labels	Switches the elevation labels on / off; **Labels…** sets which contours and every how many metres (below).

Changes apply **immediately** to the active surface. Colours, base elevation and labels are also in Properties → 3 Contours.

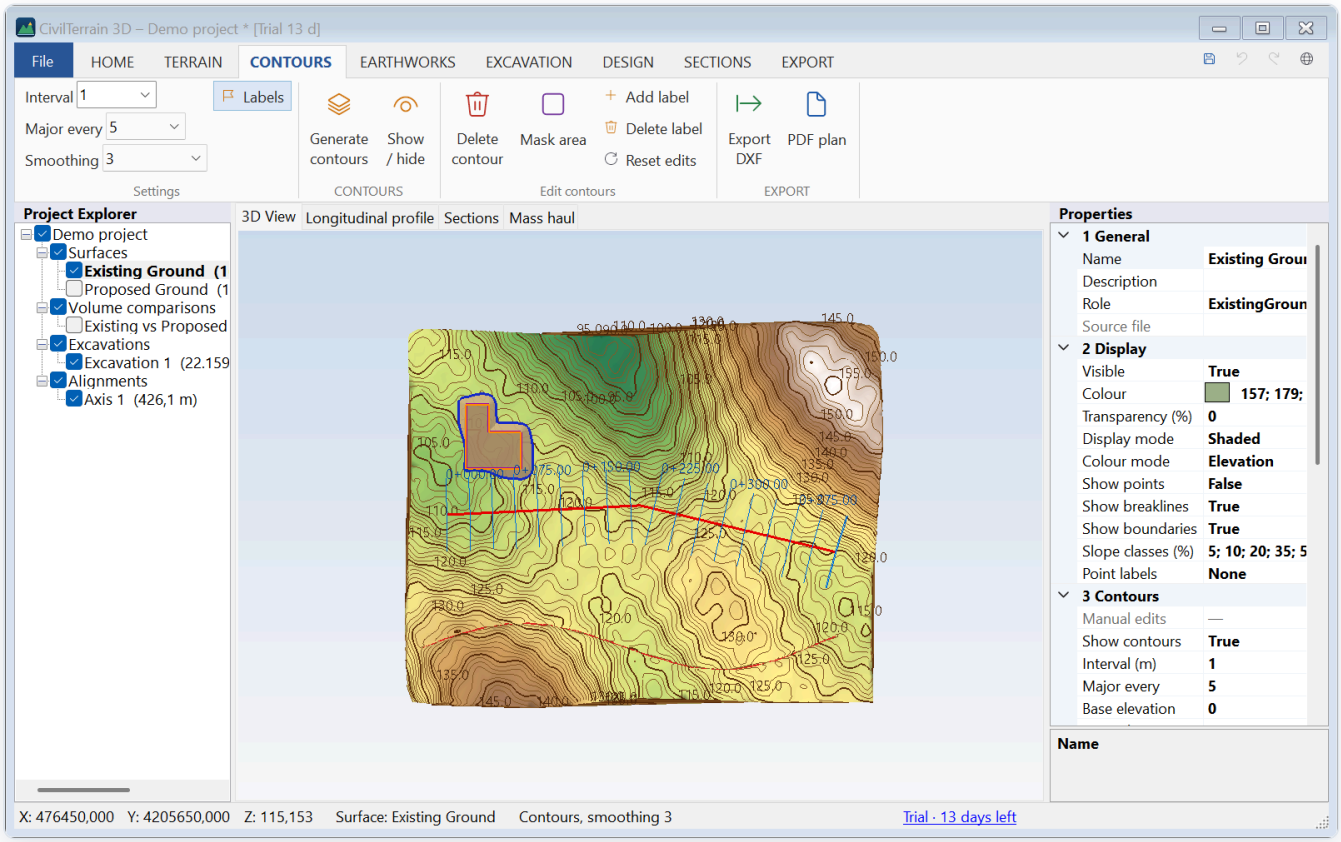


Figure 11.1 – Contours in plan with smoothing 3

> **Smoothing and accuracy:** smoothing affects display and drawings only. Calculations (volumes, sections) always use the TIN.

Export: **Export DXF** (layers CONT_MAJOR, CONT_MINOR, CONT_LABELS with the elevation on every polyline) and **PDF plan**.

Contour labels

CONTOURS → Labels… sets **which contours** get elevation labels and **every how many metres**:

Setting	Description
Labels on	**Major**, **minor**, **all** contours, **every N-th** contour, **every X m of elevation** (e.g. every 5 m: 100, 105, 110… whatever the interval) or **given elevations** you type (e.g. `100; 105; 112.5`).
A label every	Distance of the labels along the contour (m).
Shortest contour labelled	Shorter contours (e.g. small closed islands) get no label.
Decimals	0–3 decimals in the text.

The dialog shows at once how many levels and about how many labels you get. **Also on the other surfaces** applies the settings to all of them. The labels are used on screen, in DXF / DWG, PDF and the drawing sheets. The **Labels** button switches them on and off without losing the settings. The same settings are also under Properties → 3 Contours.

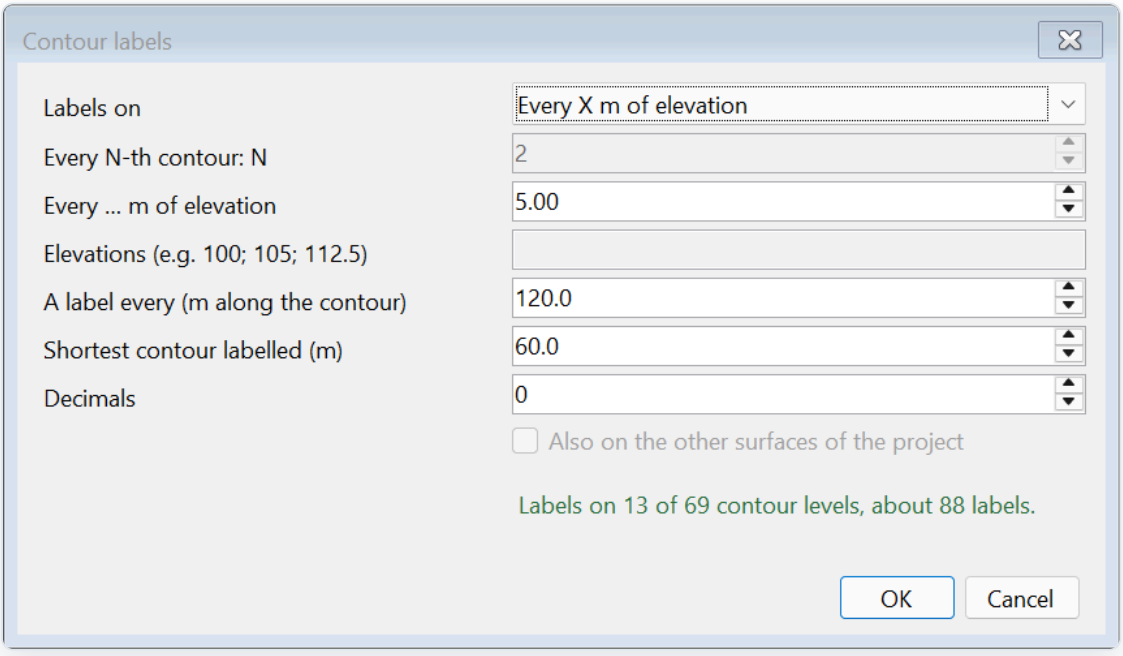


Figure 11.2 – Contour labels: every 5 m of elevation, one every 120 m

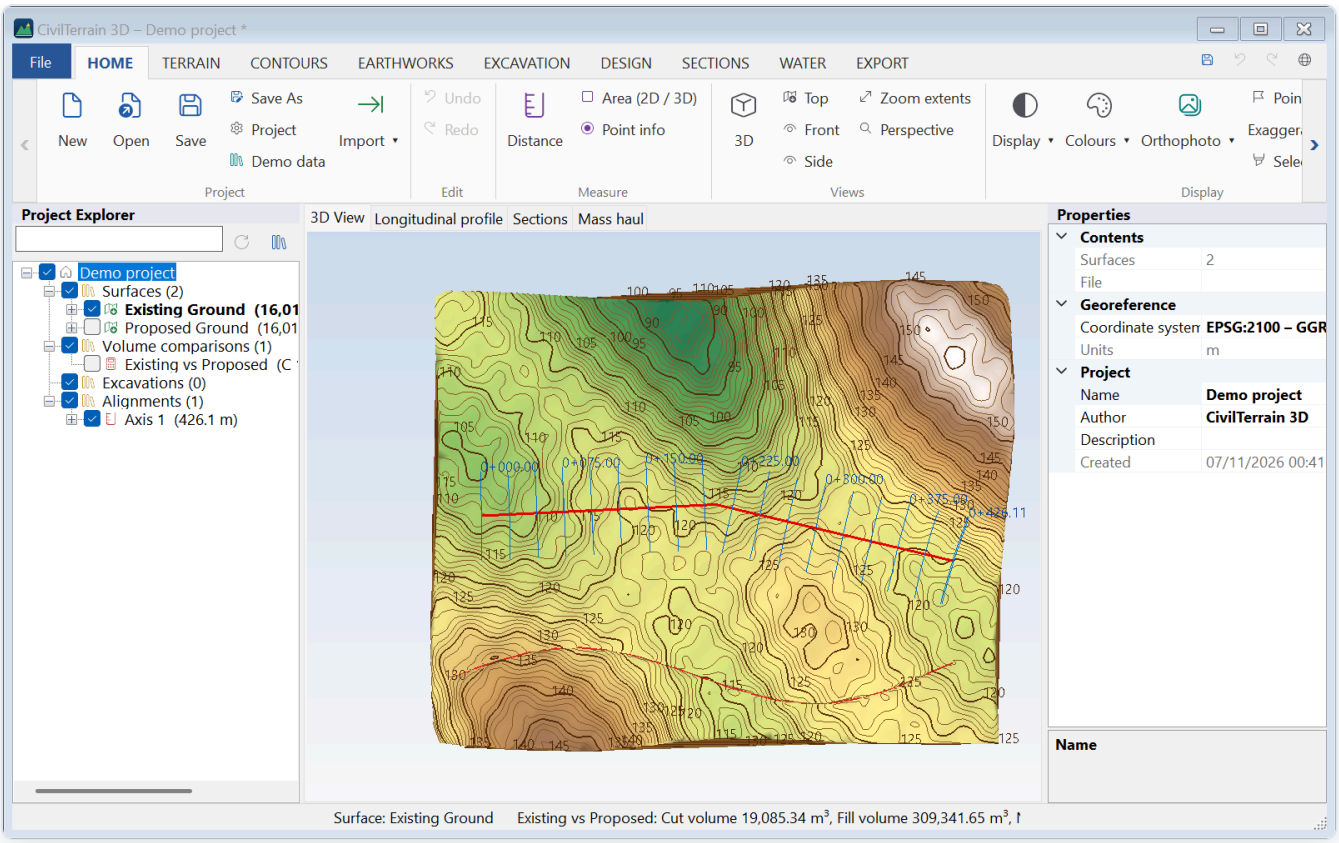


Figure 11.3 – A 1 m interval with labels only on 90, 95, 100, 105…

11.1 Editing contours

The **CONTOURS → Edit contours** group improves the drawings **without changing the terrain**. The edits are stored in the project, apply to DXF/PDF exports and can be undone with `Ctrl` + `Z`:

Tool	Use
Delete contour	Click a contour: that piece is removed (e.g. small "islands"). Repeating, `Esc` to finish.
Mask area	Polygon inside which contours and labels are hidden (buildings, roads, squares).
Add label	Click a contour: an elevation label is added there, aligned with the line.
Delete label	Click a label to remove it.
Reset edits	Removes all manual edits of the active surface.

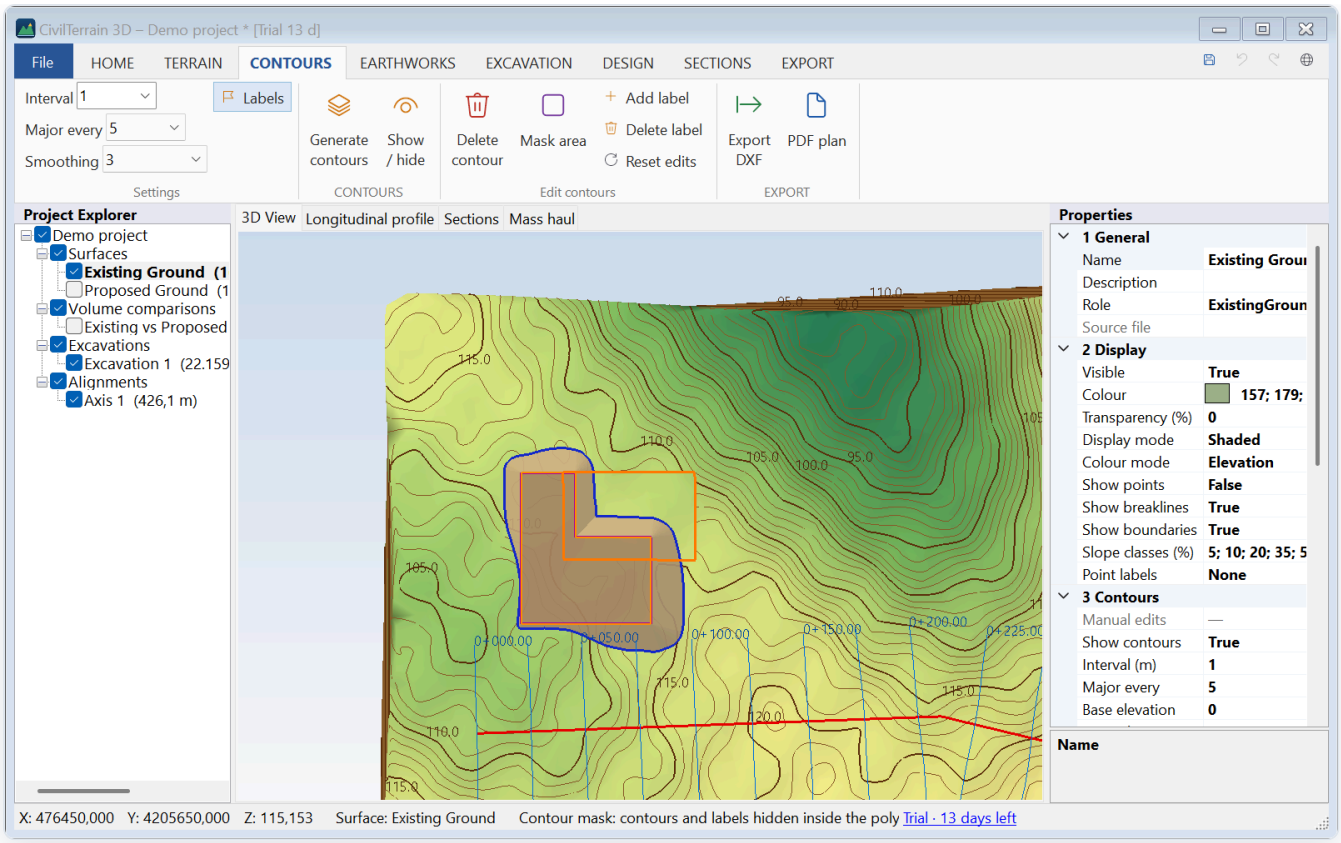


Figure 11.4 – Contour mask over buildings

> **Tip:** if the interval changes, deleted contours stay stored for their elevation; use **Reset edits** to start over.

12. Earthwork volumes

12.1 Comparing two surfaces

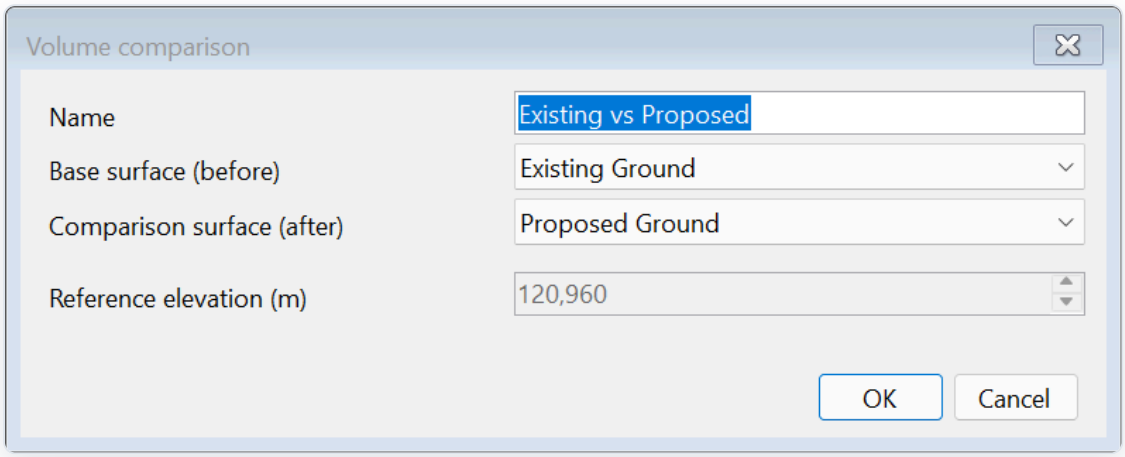


Figure 12.1 – New volume comparison

1. **EARTHWORKS → Volume comparison**.
2. Choose the **base surface (before)** and the **comparison surface (after)**. Examples: Existing → Proposed, Existing → Excavation, Before → After.
3. Results appear in Properties and in the status bar.

For **surface vs elevation** (e.g. a stockpile above a level) use **Surface vs elevation**.

12.2 Results

Quantity	Meaning
Cut volume	Where the comparison surface is **below** the base (m^3).
Fill volume	Where the comparison surface is **above** the base (m^3).
Net volume	Fill − cut (positive = excess fill).
Cut / fill / total area	Plan areas (m^2) – only the common valid area of both surfaces.
Max cut depth / fill height	Maximum elevation difference in cut and fill.
Centroids	In the Properties, category **3 Centroids**: Cut centroid X / Y / Z, Fill centroid X / Y / Z and the horizontal distance between them (Centroid distance). Z is the mean elevation of the volume. With topsoil, also the centroids after stripping it. See “Centroids of the volumes” in section 12.6.

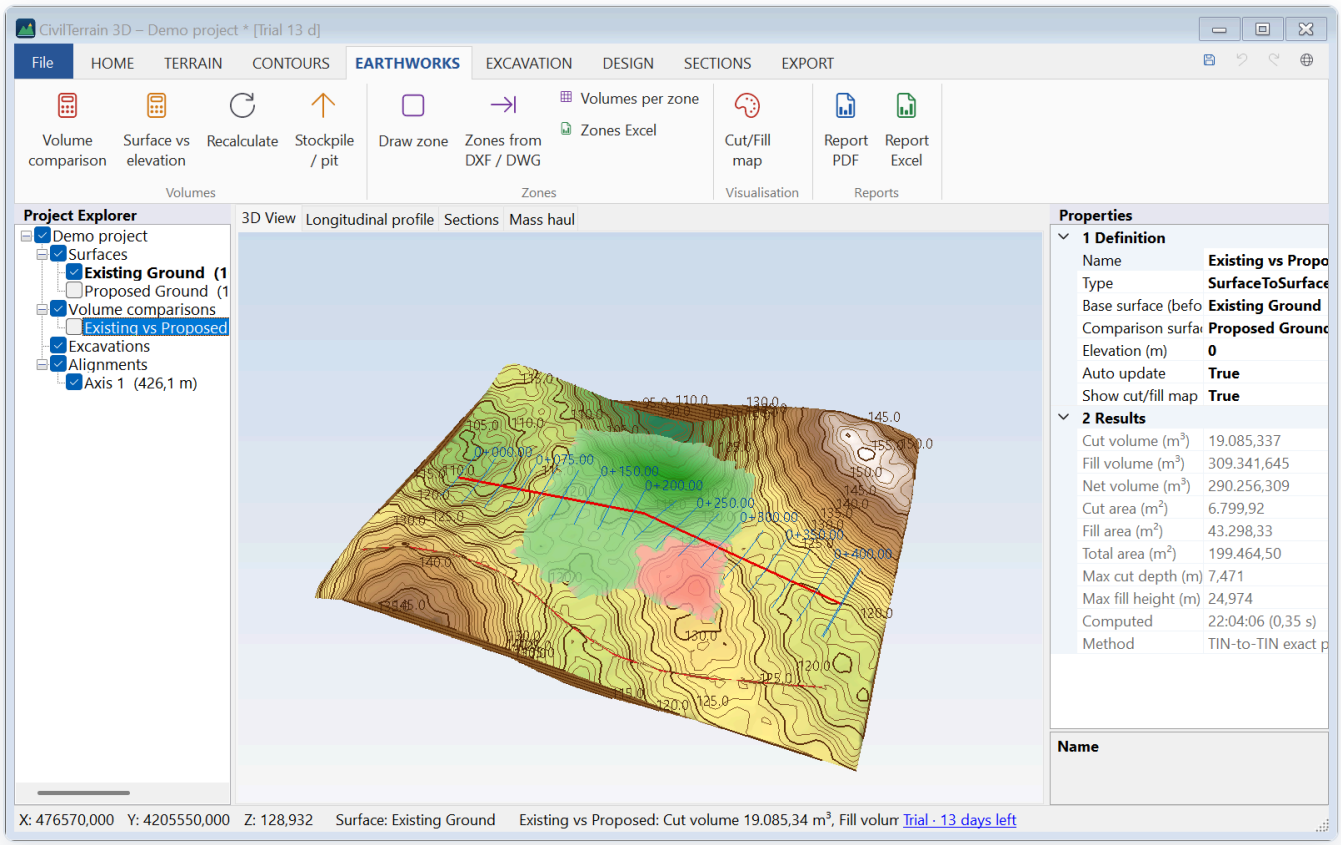


Figure 12.2 – Cut (red) / fill (green) map and results

The **cut/fill map** is toggled with its button or the tree check box: **red = cut**, **green = fill**, intensity shows the depth.

> **Automatic update:** when a surface is edited, the comparisons using it are recalculated automatically (configurable in the comparison Properties).

12.3 Stockpile or pit volume

EARTHWORKS → Stockpile / pit: draw the toe of the stockpile (or the rim of the pit) on the surface. Choose the **base**:

Base	When
Triangulated from the outline	The most common: the base follows the ground at the toe (stockpiles on sloping ground).
Best-fit plane	Least-squares plane through the outline points.
Lowest / mean elevation	Horizontal base at the lowest or mean outline elevation.
At elevation…	Horizontal base at a given elevation.

The dialog shows volume above/below the base, net volume, 2D/3D areas and maximum height. If part of the outline is off the surface, its shape is kept and the share that does not count is shown. **Add to project** creates the base surface and a **ground → base** comparison for PDF/Excel reports: cut = material above the base (stockpile), fill = the pit below it.

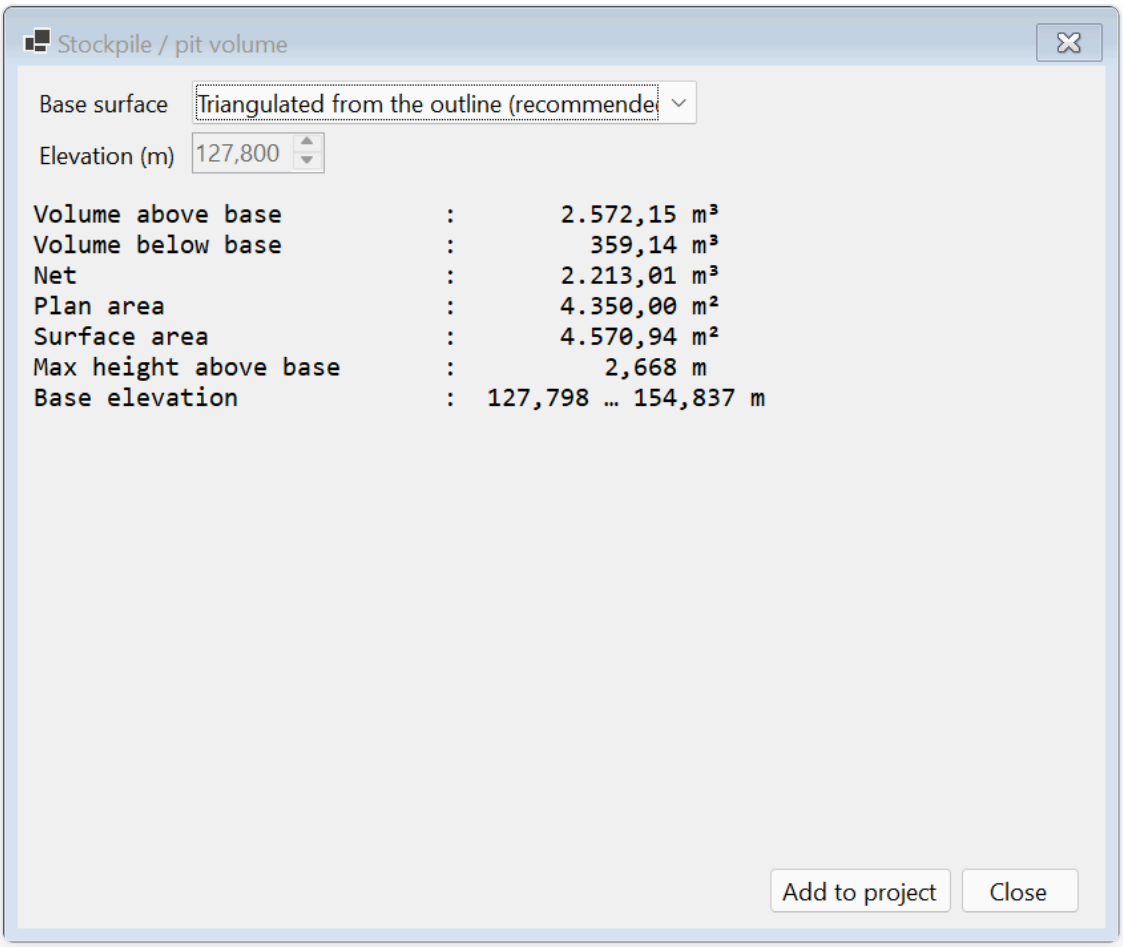


Figure 12.3 – Stockpile volume with triangulated base

12.4 Volumes per zone

To split volumes into parts (plots, phases, contracts): **EARTHWORKS → Draw zone** and give a name. Zones are drawn on the plan and listed in the project tree (rename / delete with a right click).

Volumes per zone gives, for the selected comparison, cut, fill, net volume and areas **exactly** for each zone (the computation pieces are clipped at the zone boundary). If no comparison is selected and there are several, the program asks which one. The **% outside** column shows the part of a zone without both surfaces, and **overlapping zones** are warned about (they count twice in the totals). With topsoil in the comparison a topsoil column is added. Zones are included automatically in the PDF (all of them, over as many pages as needed, and drawn on the plan) and Excel reports.

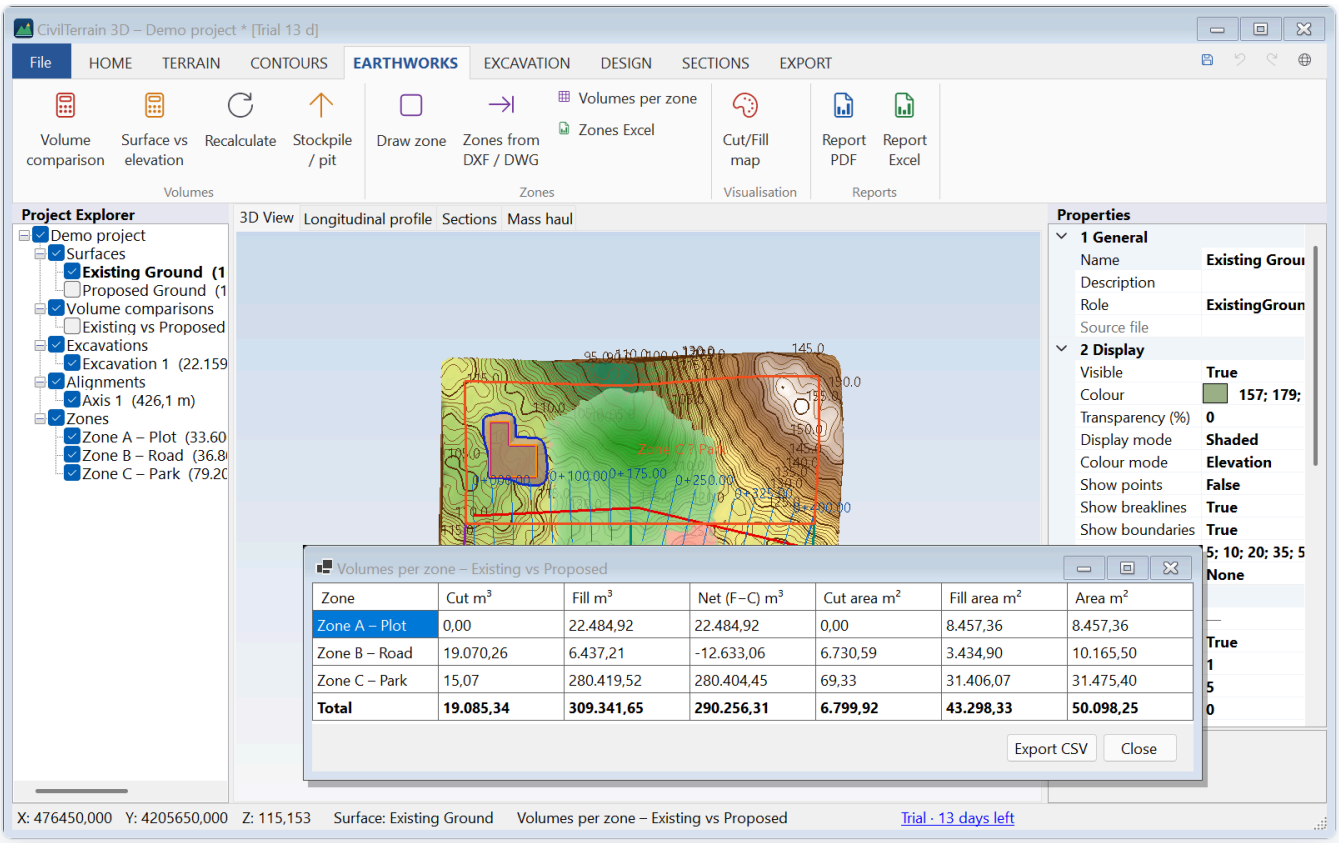


Figure 12.4 – Zones on the plan and volumes per zone table

12.5 Volume zones from DXF / DWG

When the outlines of the volume areas already exist in a CAD drawing, there is no need to draw them: **EARTHWORKS → Zones from DXF / DWG**.

- Choose the layer(s) with the **closed outlines**; a polyline whose first and last vertex coincide also counts as closed. Arcs and circles become polygons.
- The **name** of each zone comes from a text (TEXT/MTEXT) inside the outline — the smallest outline containing it, for nested areas — otherwise from the layer name.
- **Replace the existing zones** or add to them; the import can be undone with `Ctrl` + `Z`.
- If a computed volume comparison exists, the volumes-per-zone table is offered right away; zones are also included in the PDF/Excel reports.

Sample: `10_zones_kyvismou.dxf`.

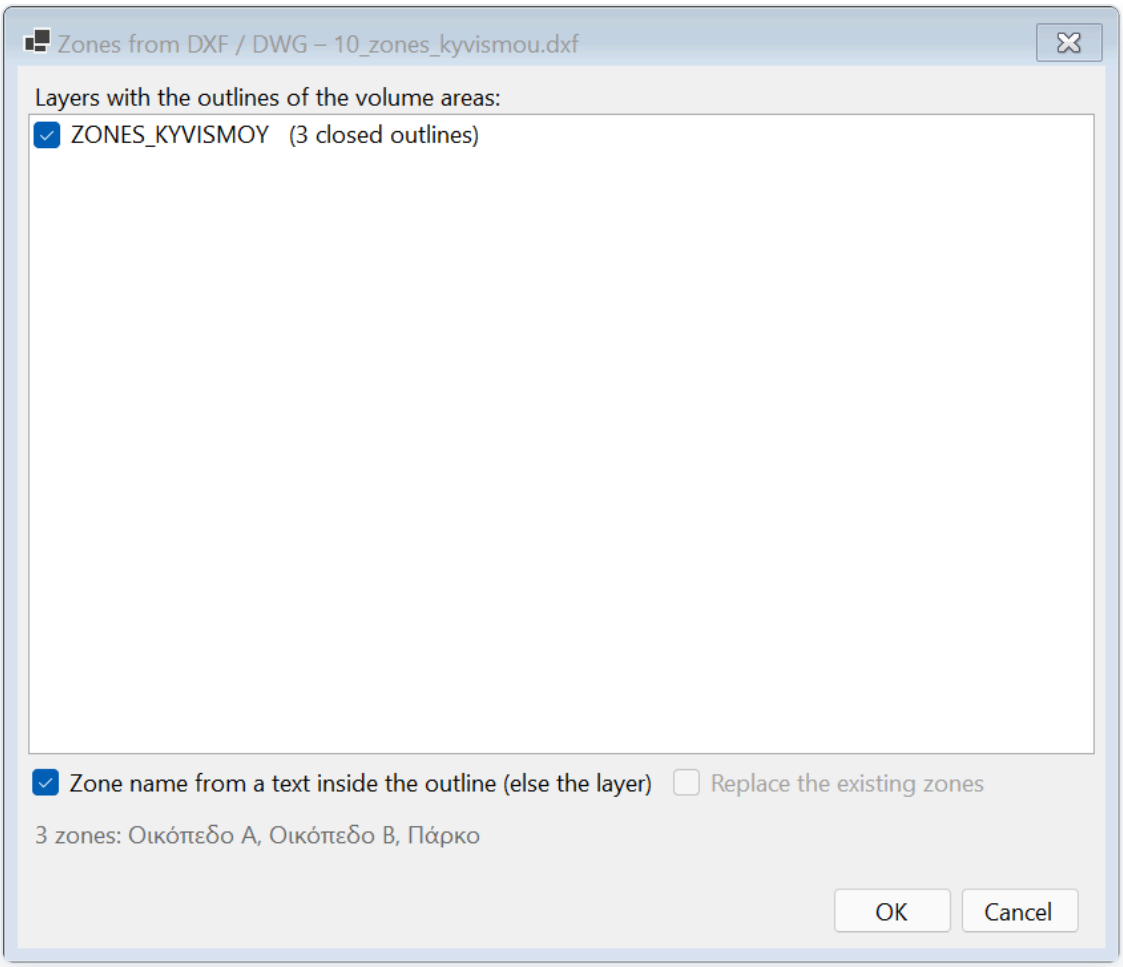


Figure 12.5 – Zones from a DXF named by the texts of the drawing

12.6 Polygon earthworks (plot, pad)

The most common question: "how many cubic metres to grade this plot to +102.50, at 2 %, or balanced?". **EARTHWORKS → Polygon earthworks** answers it in one step, without building surfaces and comparisons.

Choosing the polygon

- If a **zone** or a **closed feature line** is selected in the tree, it is used straight away (also with right click → **Polygon earthworks…**).
- Otherwise choose: **click an existing outline** (zone, closed feature line, closed breakline, surface boundary, excavation outline or daylight — a click inside a zone is enough), **draw**, **from DXF / DWG** (one or more closed polylines, named from the text inside) or **type / paste coordinates** (e.g. from Excel or the survey).

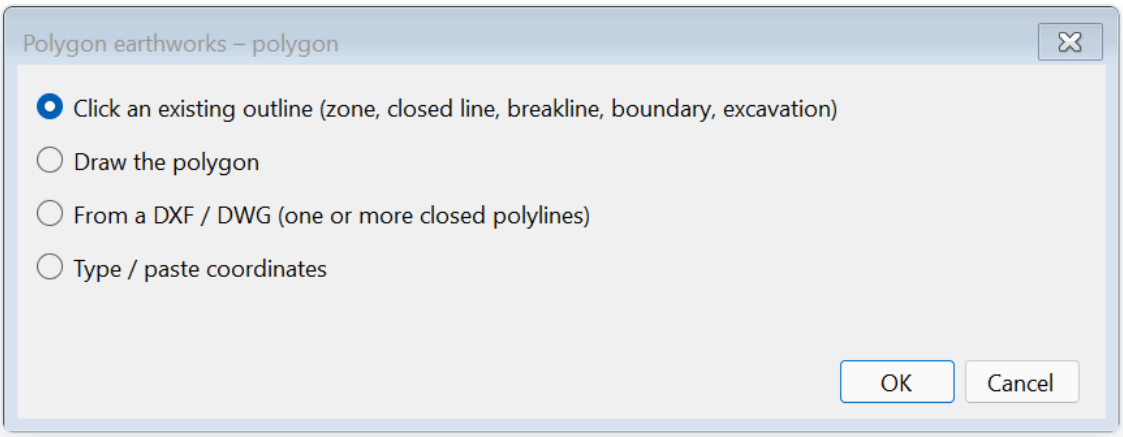


Figure 12.6 – Choosing the polygon

Design

Graded to	What is computed
Horizontal level	Cut / fill to elevation Z. **Lowest / Mean / Highest ground** give a starting value, and the slider changes Z with **instant** results.
Inclined plane	Plane with a **grade % falling towards an azimuth** (grads, clockwise from north) through the **reference point** at elevation Z. It can also be set **From 3 points…** (clicks on the surface) or as the **Best-fit plane** of the ground inside the polygon (least squares).
Other surface	Ground versus a design surface (or a later survey) inside the polygon only.
Depth below the ground	Uniform excavation, e.g. 0.50 m (stripping, sub-base).

Elevation: "Elevation I give", **Balance cut = fill** (the program finds the Z where cut × compaction = fill) or **Required surplus** (e.g. +500 m^3 to leave the site, or −300 m^3 of borrow). An inclined plane moves as a whole, keeping its grade.

Edges: vertical (volumes inside the polygon only — e.g. a plot with walls) or **side slopes to the ground** with cut / fill slopes; the results are then split into **inside the polygon** and **on the slopes**.

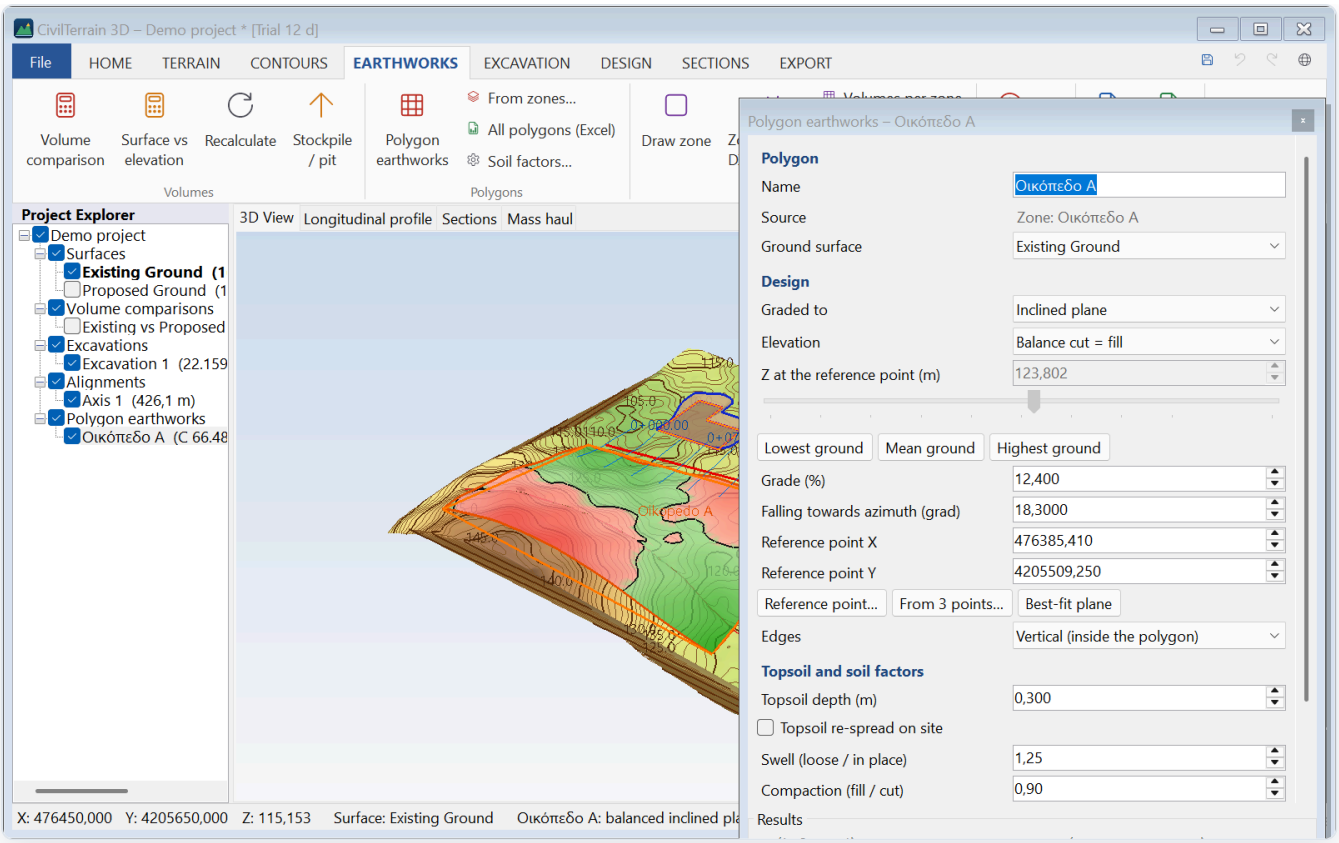


Figure 12.7 – Balanced plot: cut/fill map, zero line (black) and the polygon earthworks window

The plan shows the cut (red) / fill (green) map inside the polygon, the **zero line** and the daylight of the slopes. The item is saved in the project ("Polygon earthworks" node of the tree) and is **recomputed automatically** when the ground changes.

Buttons: **Design surface** (the plane as a surface for sections and comparisons; with slopes also the final ground), **Surfaces inside the perimeter** (below), **As zone**, **PDF**, **Excel**, **DXF / DWG** (outline with design elevations, zero line, daylight, texts) and **Setting-out CSV** (vertices and daylight with design Z, ground Z and ΔZ).

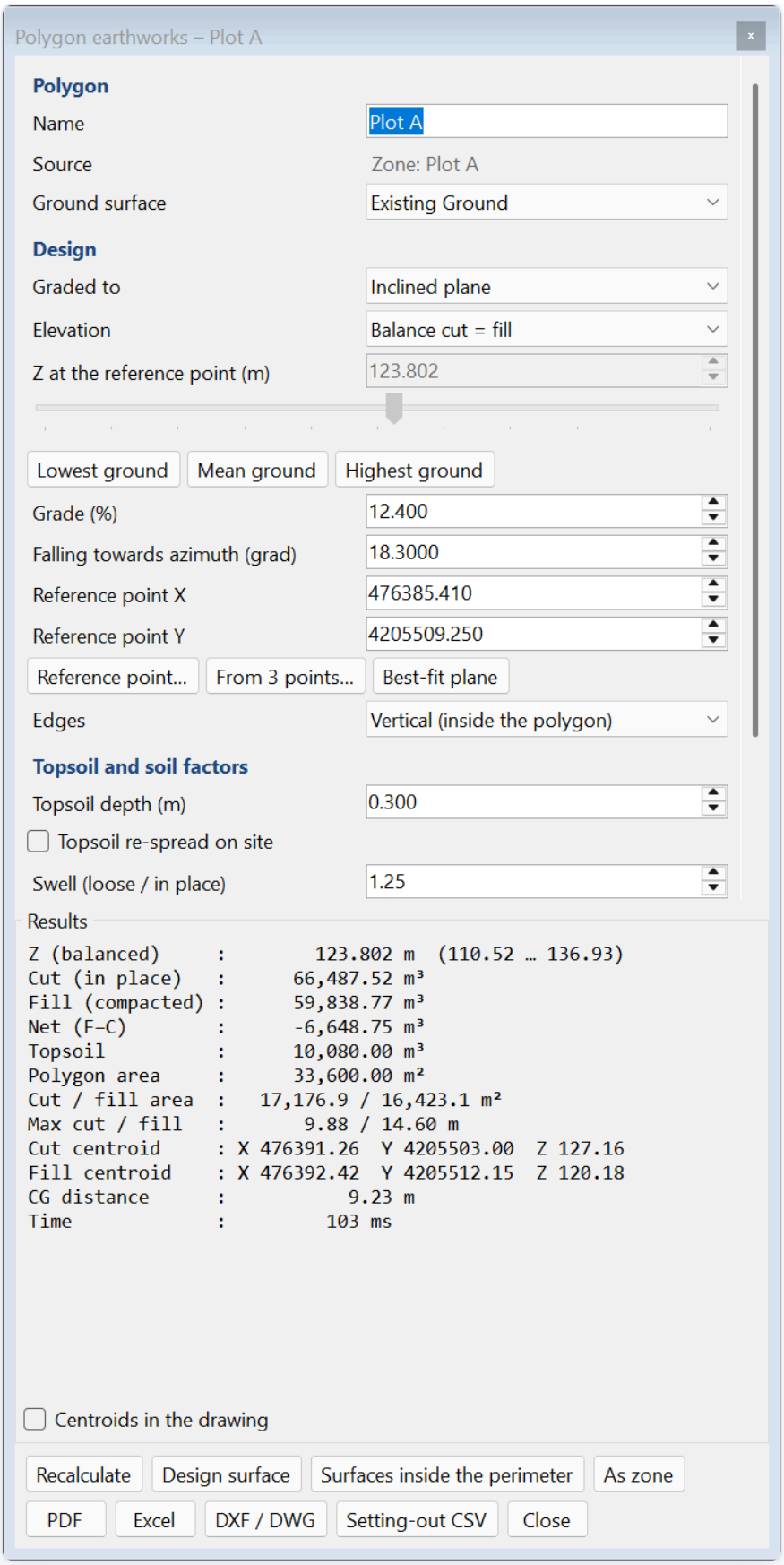


Figure 12.8 – The "Polygon earthworks" window for the plot of figure 12.7: the settings above, which scroll, and below the results with the centroids, the “Centroids in the drawing” check box and the buttons

The window always opens inside the screen; on a small screen (e.g. 1366 × 768) it moves up or takes the whole height of the screen. The settings scroll, the results show whole lines and scroll when they do

not fit, and the check box and the buttons are always in view.

Centroids of the volumes

The results also give the **centroids** (CG) of the cut volume and of the fill volume, e.g. for the haul distance of the excavated material:

- **Cut centroid** and **Fill centroid**: X, Y and Z. Z is the **mean elevation of the volume**, not a point of a surface: in an excavation of constant depth it lies at half the depth.
- **CG distance**: the horizontal distance between the two centroids, when both exist.
- They are the centroids of the volumes given as the result: **after stripping the topsoil** (the topsoil is a separate quantity and does not count in the cut centroid, while the fill also includes the stripped layer) and, with side slopes, **including the slopes**. The swell and compaction factors do not move them.
- Where there is no cut or no fill volume (up to 0.0005 m^3), or where one is negligible next to the other (up to 0.01 % of it, e.g. 0.02 m^3 of fill on the slopes of a 6,600 m^3 excavation), its centroid and the distance read "—" (in Excel and in the item list the cell is left empty); its volume is still shown.

With the check box **Centroids in the drawing** under the results (or in the Properties), the centroids are drawn in plan and in the 3D view, at their position and elevation, over the surfaces: a red cross "CG cut", a green cross "CG fill" and a thin line between them with the distance. The same crosses, line and distance also go on the plan of the PDF report. The box is not ticked by default and is saved with the item.

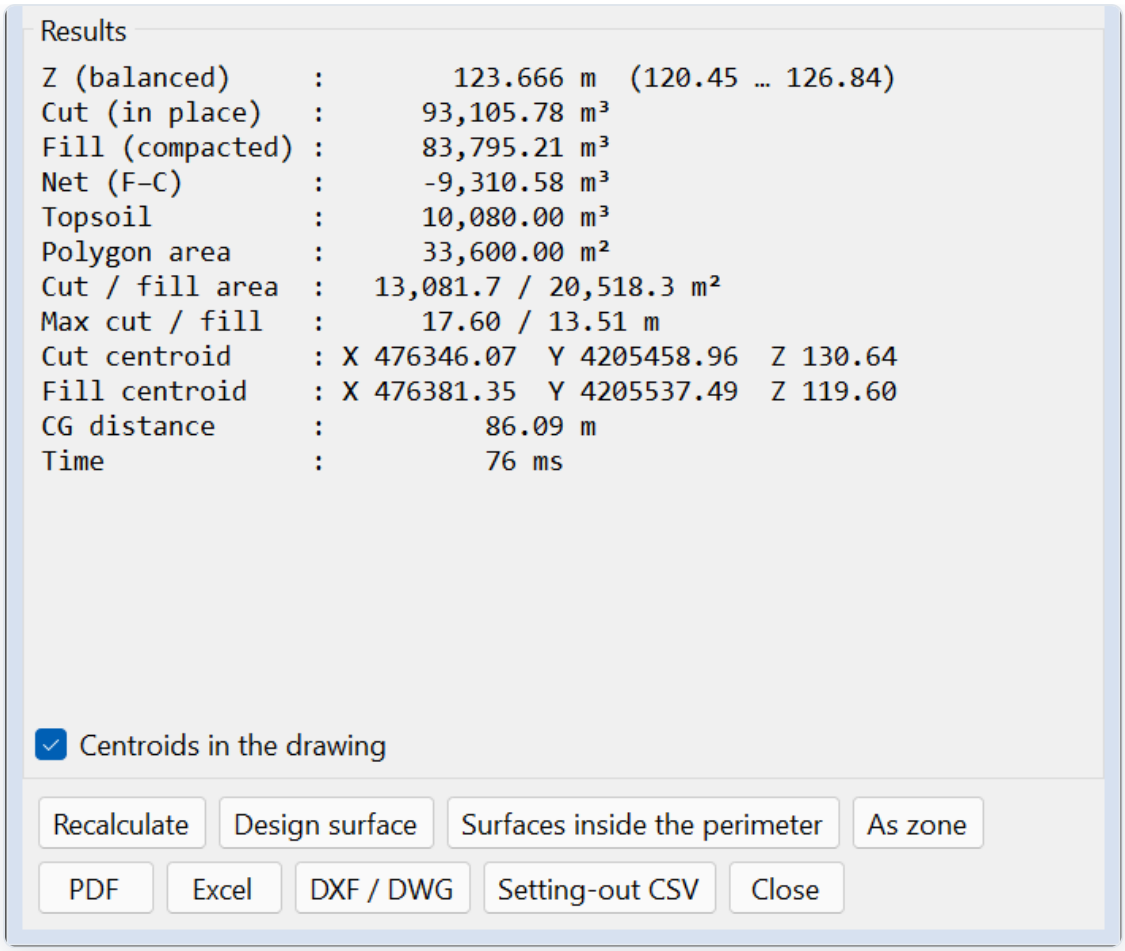


Figure 12.9 – The results of a platform at 3 % in balance: the cut and fill centroids and the distance between them (86.09 m), the “Centroids in the drawing” box ticked and the “Surfaces inside the perimeter” button

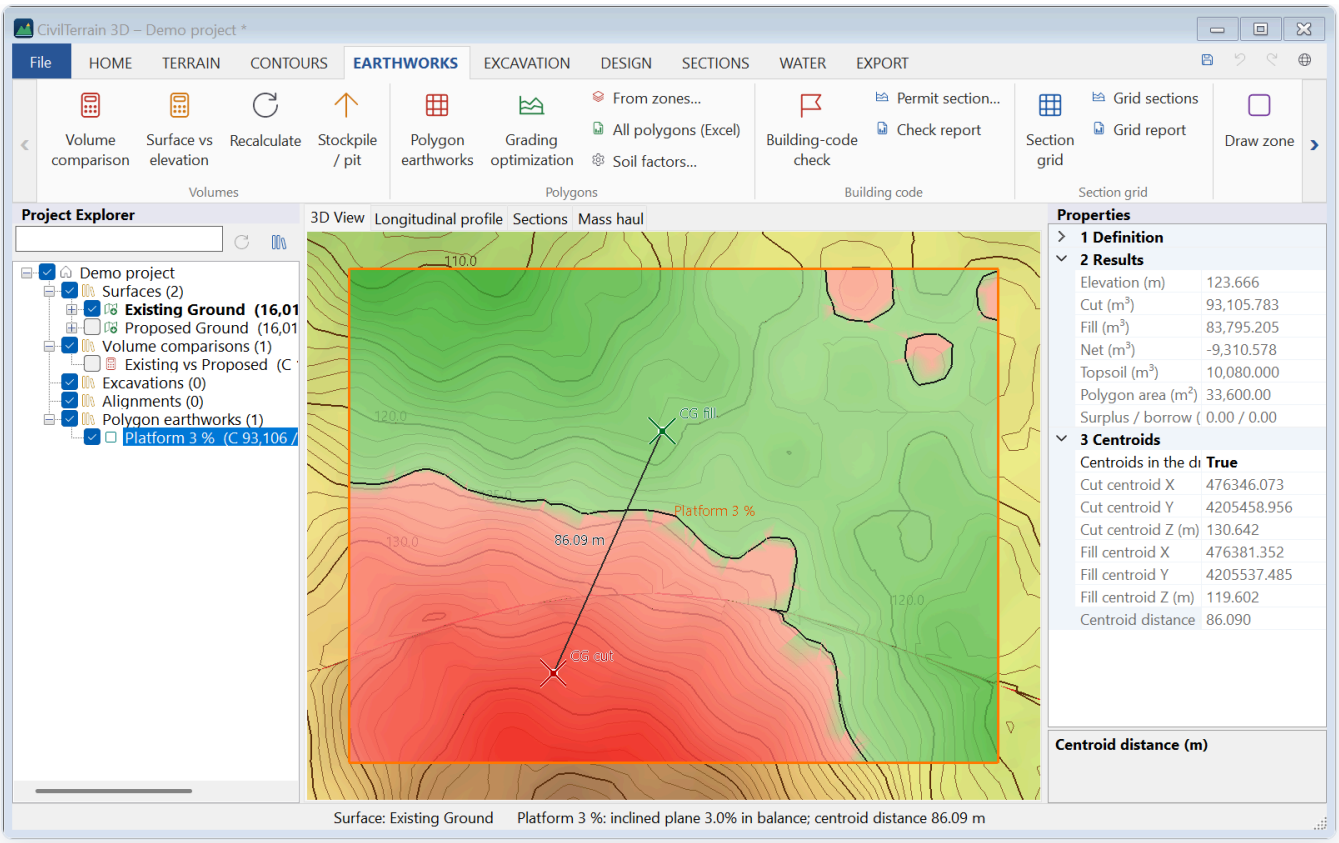


Figure 12.10 – The same platform in plan: the cut (red) and fill (green) centroids, the line between them and their distance; on the right the “3 Centroids” category of the Properties

In the **Properties** of the item, the category **3 Centroids** has the option “Centroids in the drawing” and the values Cut centroid X / Y / Z, Fill centroid X / Y / Z and Centroid distance. The PDF and Excel reports give them as “Cut centroid”, “Fill centroid” and “Distance between the centroids” (in Excel as numbers, X, Y and Z apart), with a paragraph on the method. The **All polygons (Excel)** table (section 12.9) and the item list (section 3.2) have them in columns.

Volume comparisons (section 12.2) give the same values, in the Properties, the item list and the PDF / Excel reports, with no drawing. With topsoil in the comparison, the Properties also give the centroids after stripping it, and the report, whose volumes are after the topsoil, gives those.

Surfaces inside the perimeter

The **Surfaces inside the perimeter** button (also in the right-click menu of the item in the tree) adds to the project two surfaces cut to the polygon: “… – ground inside the perimeter” and “… – design inside the perimeter”, with the name of the item in front. Depending on what the polygon is graded to, the design is the plane at the elevation of the result (e.g. after balancing), the piece of the other surface or the surface at the depth below the ground. A **volume comparison** of the two (section 12.1) gives the volumes and centroids of the item, and the surfaces serve for sections or exports of the polygon only.

- Both are added in **one** undo step.
- The copy of the ground is hidden, since it lies on the ground; so is the design when it is a piece of another surface. A plane or a depth shows in the colour of the “Design surface”.

- With side slopes the surfaces cover the polygon only: their comparison gives the part **inside the polygon**, without the slopes.
- With topsoil, the results of the item are after stripping the topsoil, while the comparison of the two surfaces gives them without stripping. The status bar says so.

12.7 Topsoil and soil factors

Topsoil: give a depth (e.g. 0.30 m). The topsoil is stripped over the whole works area **before** the earthworks, it is reported separately (a separate pay item that does not go into fills) and cut / fill are computed from the stripped ground. Topsoil can be set for polygon earthworks and for **volume comparisons** (Properties → "Topsoil depth"), so it also applies to the volumes per zone and the reports.

Soil factors (EARTHWORKS → Soil factors...):

Factor	Meaning
Swell	Loose / in-place volume (e.g. 1.25): for haulage and truckloads.
Compaction	Compacted fill obtained from 1 m^3 of cut (e.g. 0.90): for the balance.
Density	t per in-place m^3 (e.g. 1.80): for the weight.
Truck	Capacity in loose m^3 (e.g. 16): for the truckloads.

> There are no official tables of values: use those of the soil study. The values are printed in every report. Each polygon keeps its own factors (initially the project's; "Save as project factors" from its window).

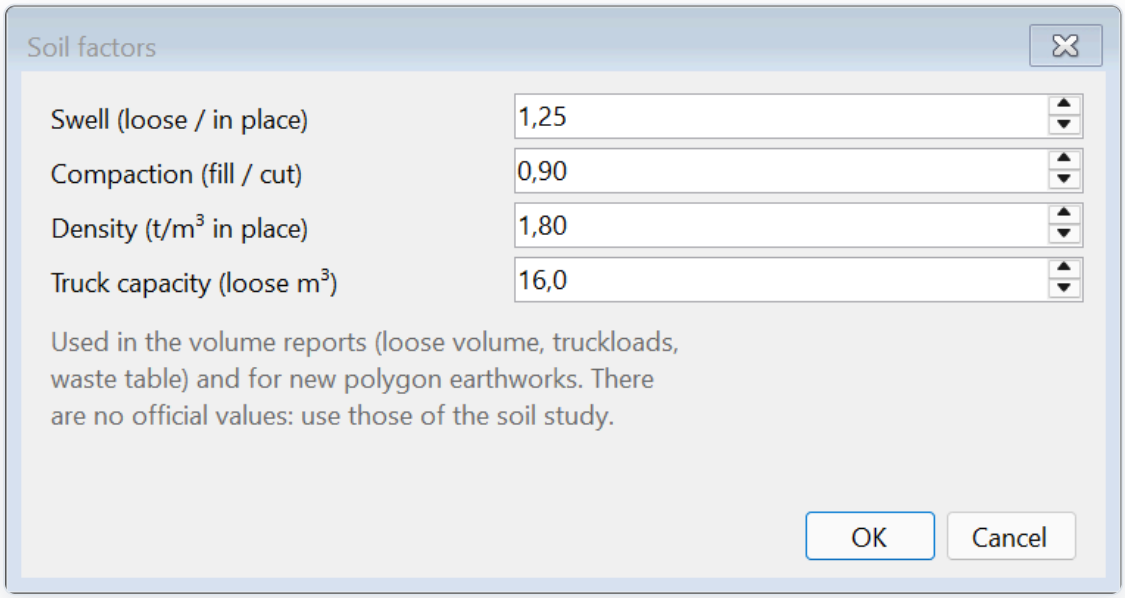


Figure 12.11 – Project soil factors

12.8 Balance, haulage and waste table

The reports of polygon earthworks and of volume comparisons contain a **Balance and haulage** table: loose volume and weight of the cut, material needed for the fill, cut reused on site, **surplus to remove** or **borrow** with loose volume and **truckloads**, and the topsoil.

A **construction-waste (ΣΔΑ)** table follows with category, EWC code (17 05 04 – soil and stones), in-place and loose volume, tonnes, reuse on site and removal — the data asked for in the waste management plan of a building permit. Check categories and quantities before submitting.

12.9 Several polygons at once

From zones… (or a DXF/DWG with several outlines): choose the polygons and a common design — level at the mean ground of each polygon, **balance in each polygon** or a common elevation — edges and topsoil. One item is created per polygon and at the end the **All polygons (Excel)** table is offered with volumes, topsoil, surplus / borrow, truckloads and totals. Overlapping polygons are warned about (the common area would count twice).

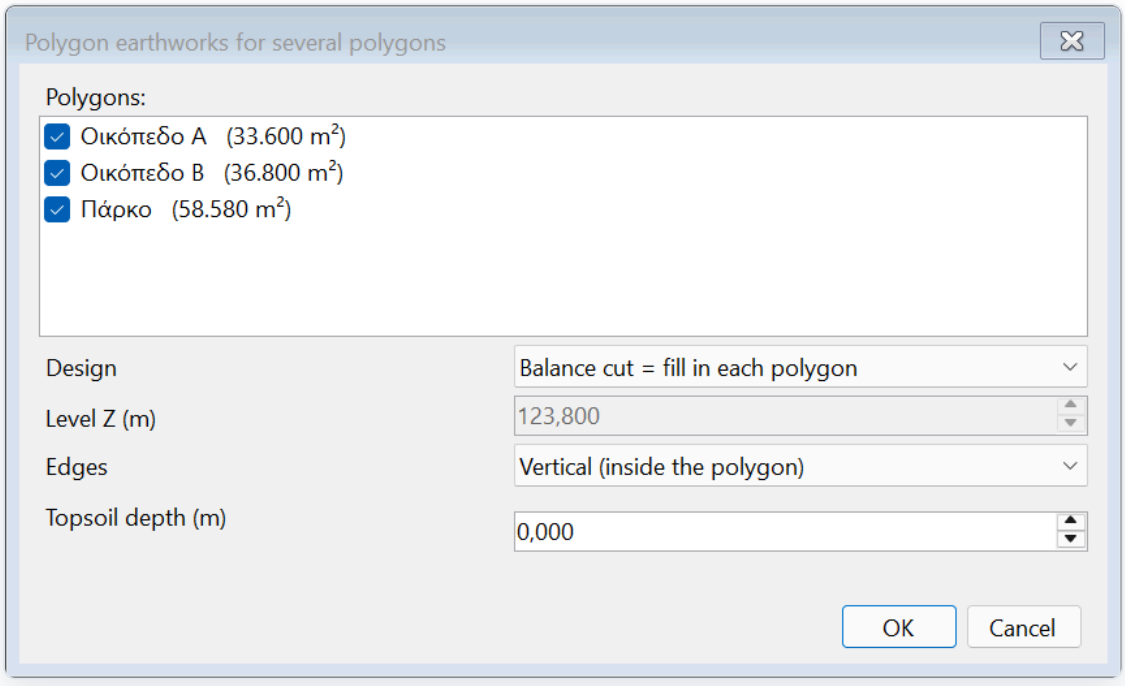


Figure 12.12 – Earthworks for several polygons

Sample: `10_zones_kyvismou.dxf` (plots A, B and a park).

12.10 Final ground levels check (Greek building code, NOK)

The Greek building code (**NOK**, ν.4067/2012, now codified in ν.5306/2026) states that in the **uncovered areas** of a plot the **final ground level at no point** may be higher or lower than the **natural ground** by more than **1.50 m** (art. 210 §4 and 212 §3a). On plots steeper than **20 %** the ground may be lowered by up to **2.00 m** and raised by up to **1.50 m**. Works beyond these limits need an opinion of

the **Architecture Council**. Excavations or fills of more than **0.80 m** need a building permit (art. 315 §1c).

EARTHWORKS → Building-code check: choose the plot (zone, closed line, DXF/DWG, drawing or coordinates, as for polygon earthworks). In the window:

- **Natural ground** and **final ground**: surfaces of the project (e.g. the survey and the design / final construction surface). Where there is no final surface the ground is taken as unchanged (optional).
- **Excluded areas**: the building (the rule concerns the uncovered area) and everything that is not ground — ramps, stairs, cours anglaises, pools.
- **Limits** (editable): ±1.50 m, steep above 20 % with −2.00 / +1.50 m, permit threshold 0.80 m. Steep is decided from the plot slope or by the engineer.
- **Plot slope**: the law defines no method; the program gives the **mean slope** of the natural ground, the slope of its **best-fit plane** and the slope from its **highest to its lowest point**, and warns when they disagree about 20 %.

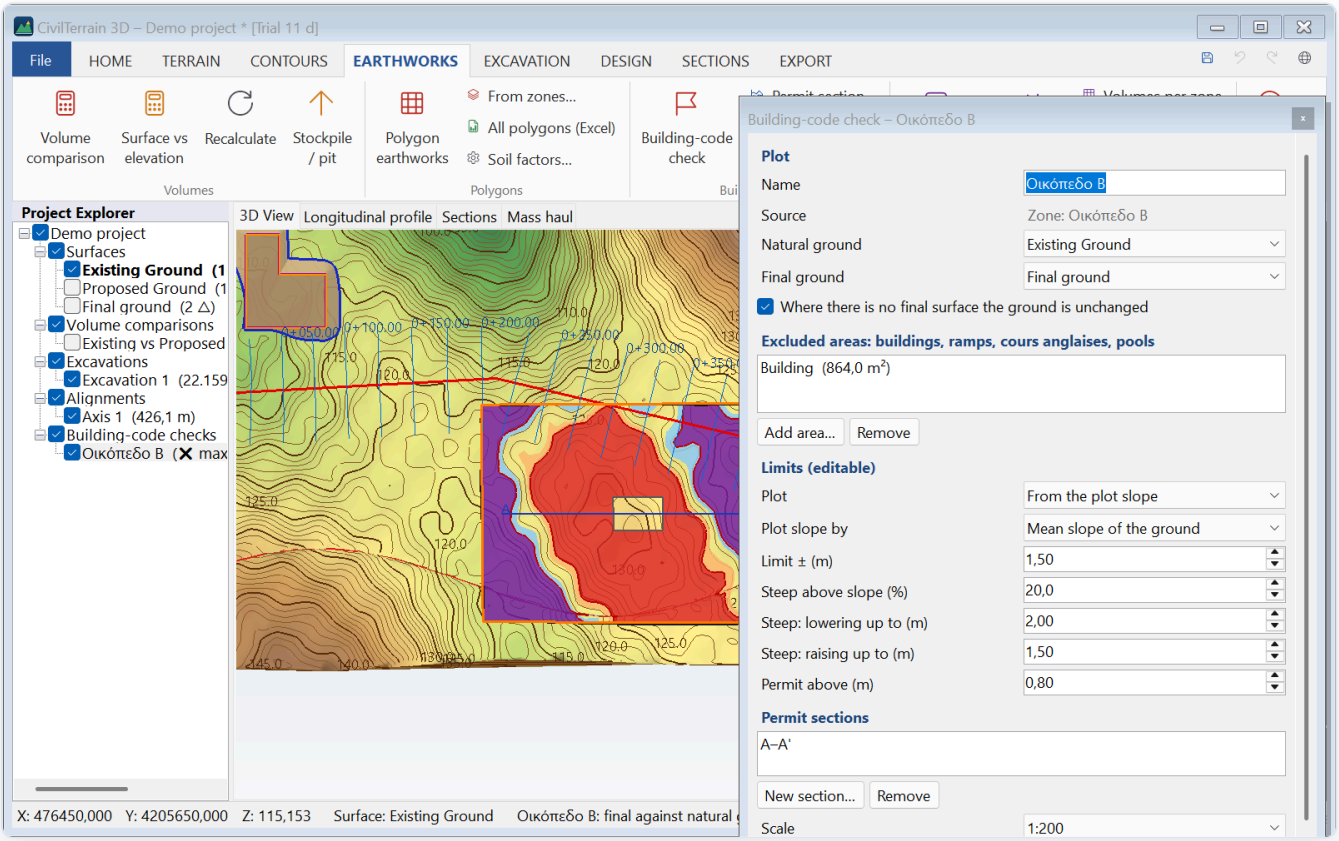


Figure 12.13 – Building-code check: beyond the limits red (lowered) / purple (raised), with permit orange / light blue, limit line red, building excluded

The result is **exact at every point**: both TINs are overlaid and every piece is split exactly at the limits. You get **COMPLIES** (green), **LIMITS EXCEEDED** (red) or **NOT FULLY CHECKED** (amber: part of the uncovered area has no natural or final ground — shown grey in the plan), whether a permit is needed, the largest lowering and raising with their coordinates, the areas per class, the volumes beyond the limits and the **worst points** (X, Y, natural Z, final Z, excess). Without a final ground surface (or if it is the

natural ground itself) no verdict is given. A design exactly at a limit (e.g. exactly +1.50 m) counts as within it.

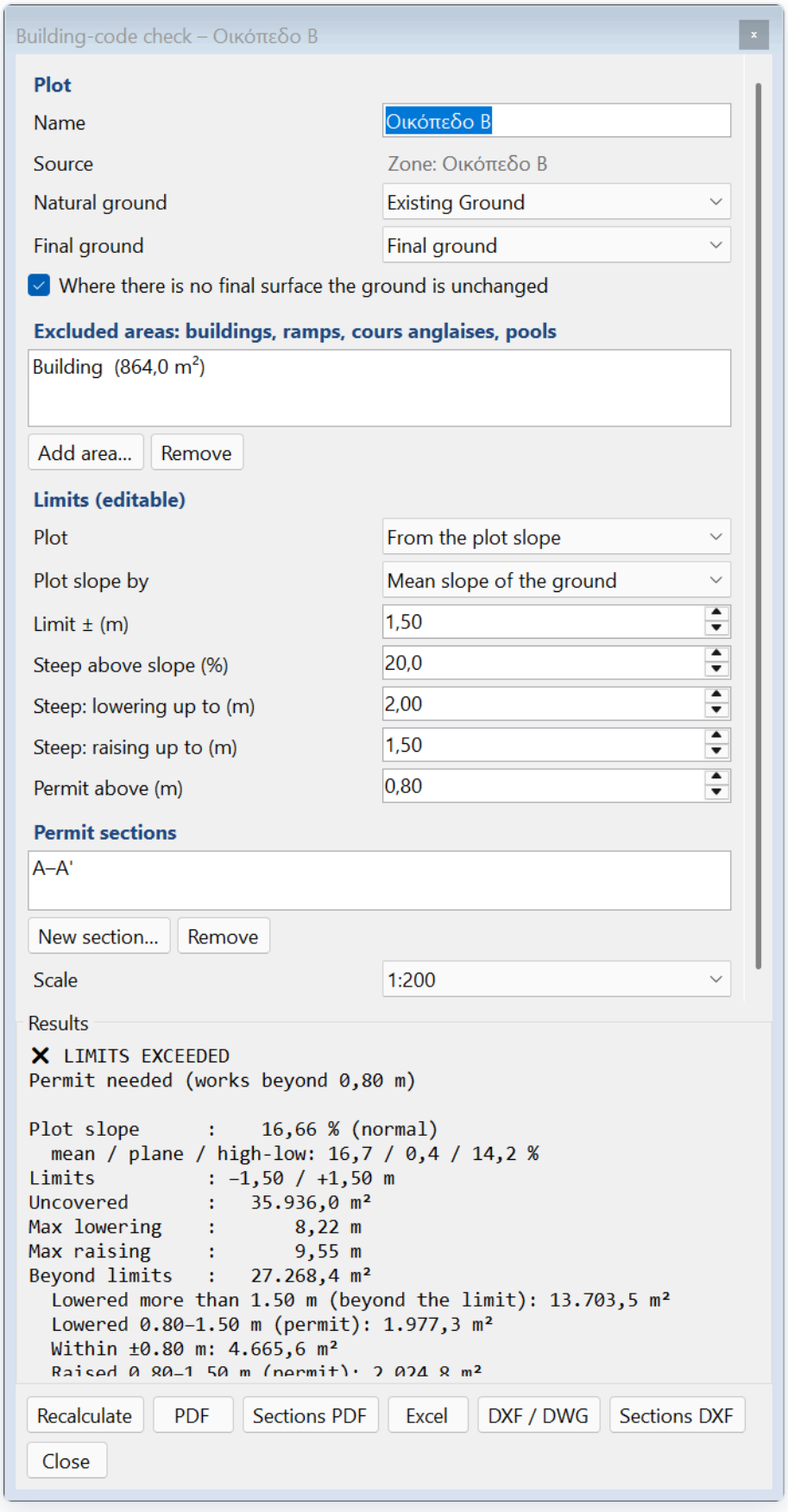


Figure 12.14 – The building-code check window

12.11 Permit sections

New section… (or **Permit section…**) draws the section line (two or more points; it may be bent). **Sections PDF** gives each section on its own page **at 1:100, 1:200 or 1:500** (same horizontally and vertically, as the coverage diagram requires — art. 325 §3ε), with the natural ground (dashed), the final ground, the allowed range, the parts beyond the limits in red (only inside the plot and outside the buildings), the building and the plot boundary. The scale is saved with the check and is also used for the sections in the PDF report. If a section does not fit at the chosen scale, the next one is used (paper up to A2). **Sections DXF** gives each section as a CAD drawing in real metres (X = station, Y = elevation) for the coverage diagram; with several sections one file per section is written ("<name> A.dxf", "<name> B.dxf" …).

The **PDF** report has the check data, the plan of the classes with the points and section lines, the text of the provision and all sections. **Excel** and **DXF / DWG** (plot, excluded areas, limit lines, points, sections) are also available.

> **Note:** the program checks the ground levels against the limits you set. It does not check the special cases of art. 212 (e.g. fill to the sidewalk level on plots steeper than 17 %, stepping behind front fences). Always confirm with the provision in force.

12.12 Section grid and volumes

The **section grid** gives the classic volume computation with parallel cross sections (e.g. for **dredging** to a design level, the excavation of a yard or a regrading): sections every *d* m inside a boundary, perpendicular to a baseline, grid nodes with the ground elevation and Δh, cut / fill areas per section and volumes by the **average end area method**.

1. **EARTHWORKS → Section grid** (or **SECTIONS → Section grid**). A selected zone or closed line becomes the boundary; otherwise choose the **outline of the surface**, click an outline, **draw** it, or take it from DXF/DWG or coordinates.
2. In the grid window set the **ground surface**, the **design level** (e.g. −5.00 m) or a **design surface**, the **distance between sections** and the **distance between nodes**. The baseline follows the long side of the boundary (smallest enclosing rectangle) or an azimuth in grads.
3. The grid is drawn on the plan: boundary, sections S1, S2 … with their names, node lines, nodes with Δh (+ = cut) and the cut / fill map. Every change is recomputed at once.
4. **Sections**: the sections appear in the *Sections* tab with their names; the current one is highlighted on the plan.

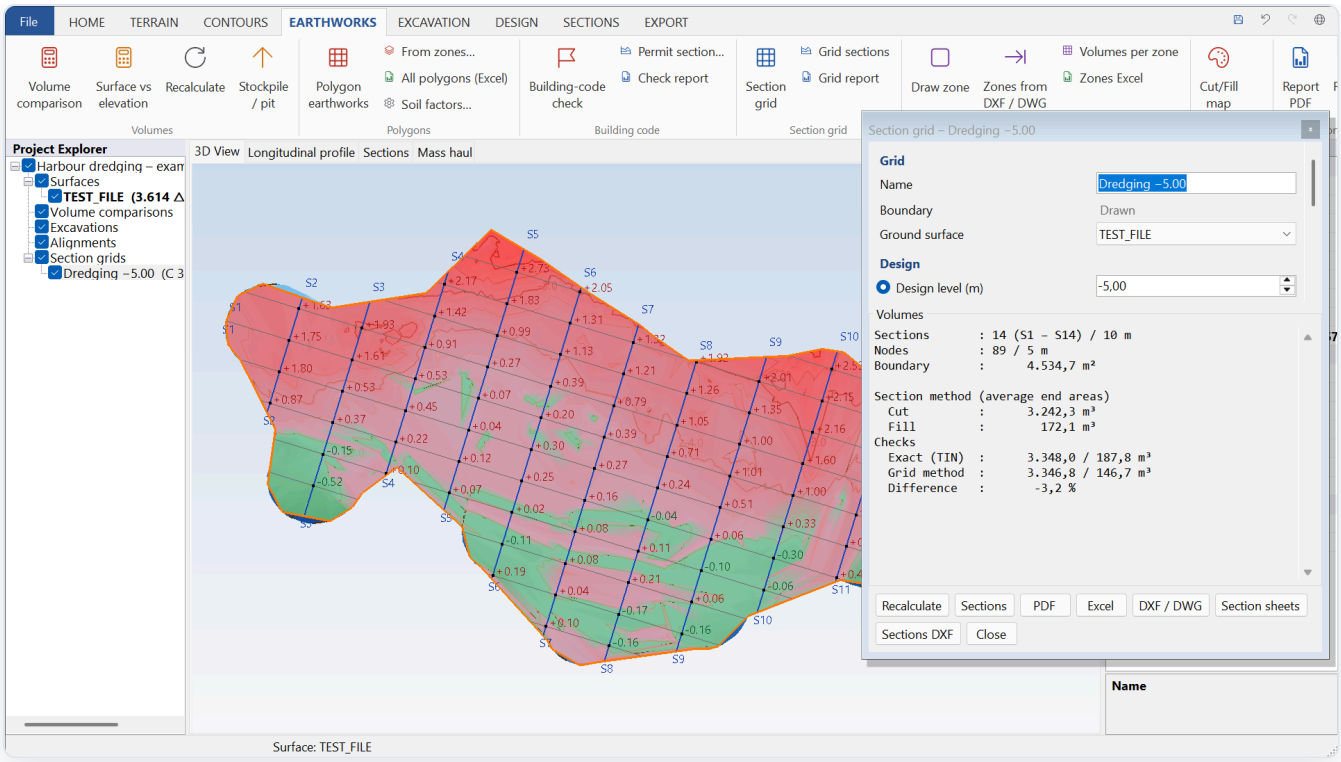


Figure 12.15 – Section grid on a bathymetric survey: dredging level −5.00 m, sections every 10 m, nodes every 5 m

The results are given in three ways, as checks:

Method	Description
Sections (average end areas)	The areas of every section are exact between the ground and the design line; the volume between two consecutive sections is half the sum of their areas times their distance. The first and the last section lie at the ends of the boundary.
Exact TIN volume	The volume of the TIN prisms inside the boundary (no approximation).
Grid method	The mean Δh of the four corners of each cell times its area; Δh at the centroid for the cells on the boundary.

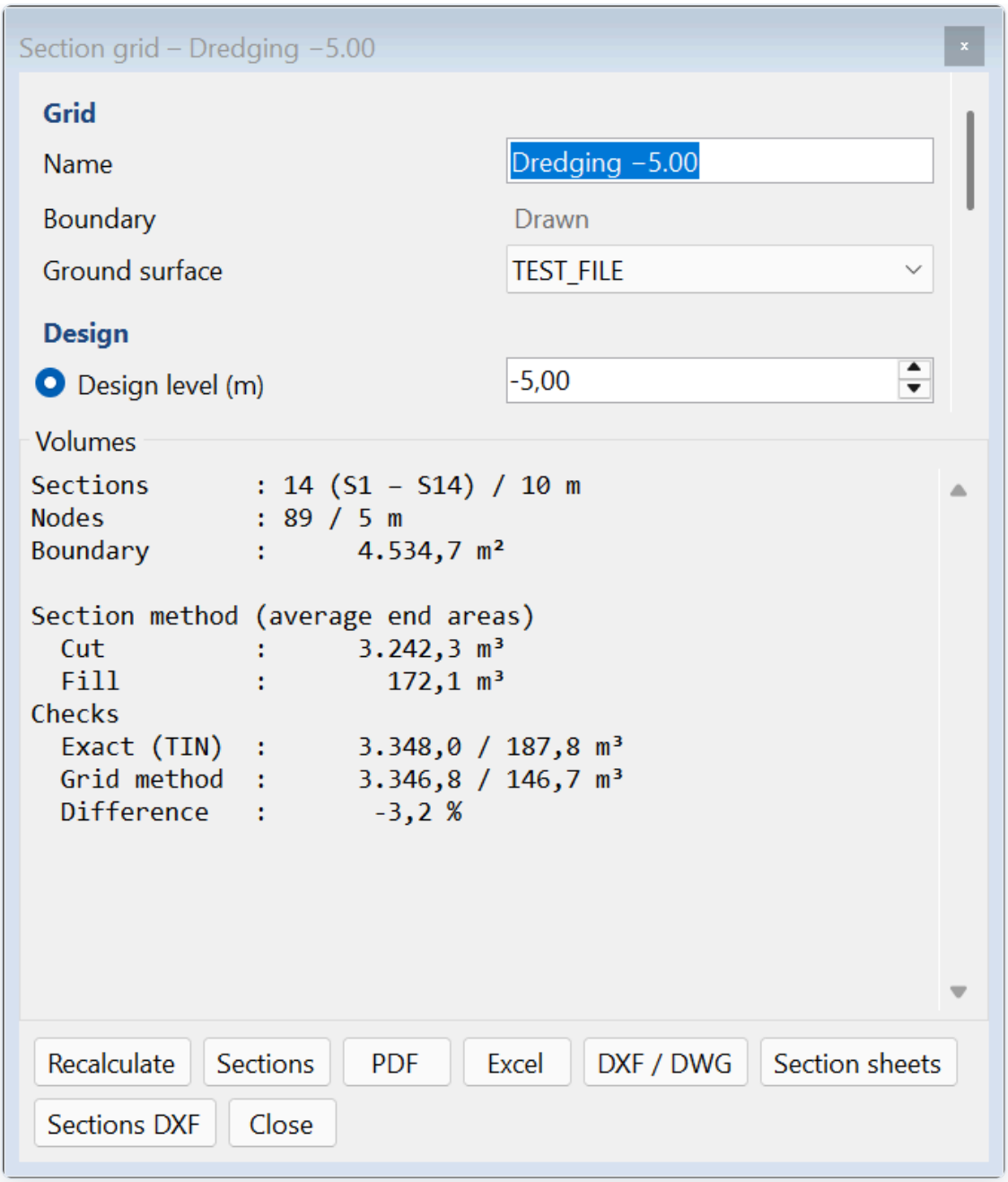


Figure 12.16 – The section grid window with the volumes

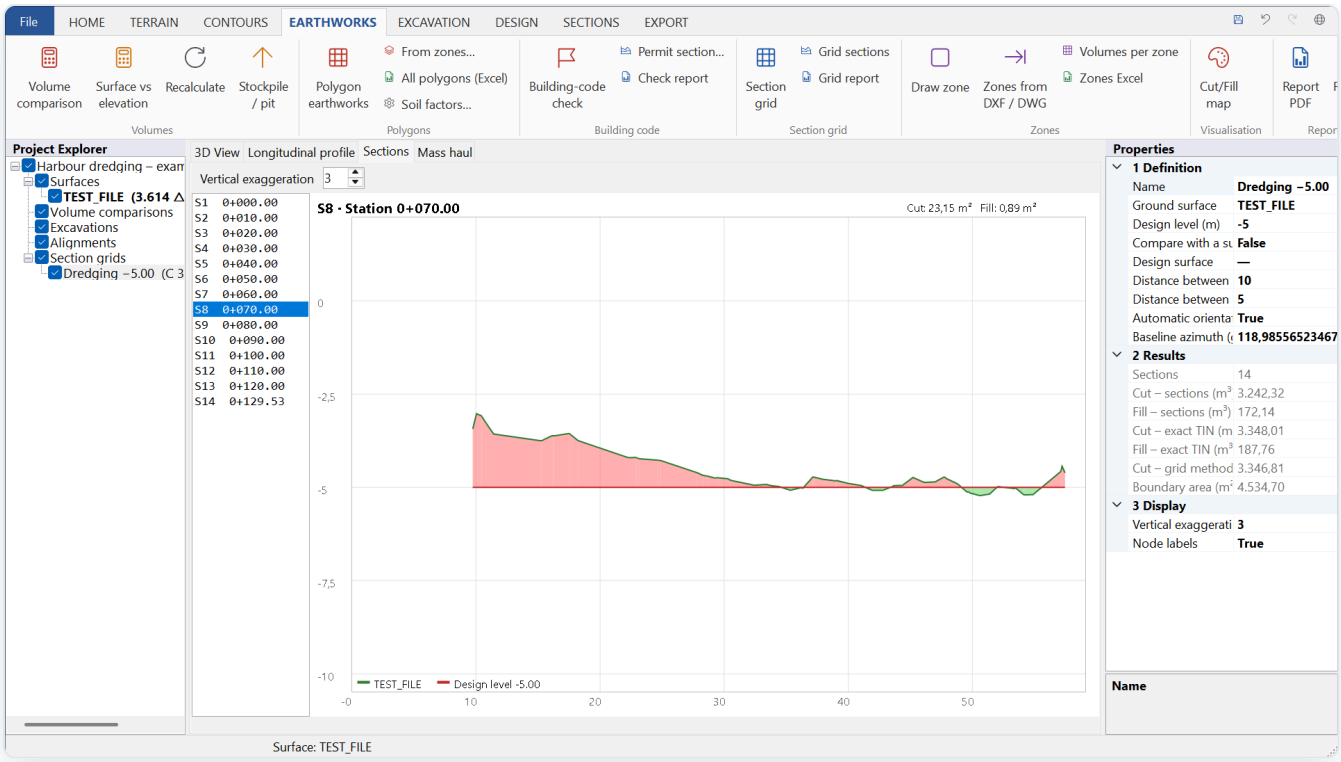


Figure 12.17 – Grid sections: ground, design level and cut / fill areas

Exports: **PDF** (summary, volume table, A3 plan with contours, all sections at a common scale and the node table), **Excel** (volumes, nodes, cells, section points), **DXF / DWG** (boundary, named sections, node lines, nodes with Z and Δh), **Section sheets** at scale and **Sections DXF**.

> **Tip:** for bathymetric data choose **HOME → Colours → Bathymetry (blue)**, depth contours every 0.50 m and exaggeration ×5. Set a **maximum triangle edge** (e.g. 15 m) so that the TIN does not bridge the gaps between the runs of the boat.

> **Note:** the average end area method approximates the volume; where the section areas change abruptly (e.g. at steps of the boundary), use denser sections. Always compare with the exact TIN volume given in the report.

12.13 Δz labels on a grid (cut / fill map with height differences)

The **height differences Δz** are written over the cut / fill map of a comparison at the nodes of a regular grid, at the spacing you give (e.g. every 10 m) — like the maps of height differences delivered in AutoCAD.

1. Select the comparison in the tree (otherwise the last one is used).
2. **EARTHWORKS → Visualisation → Δz labels on a grid…** and type the node spacing (m). 0 removes the labels.
3. The spacing can also be changed in the comparison Properties: **Δz labels every (m, 0 = none)**.

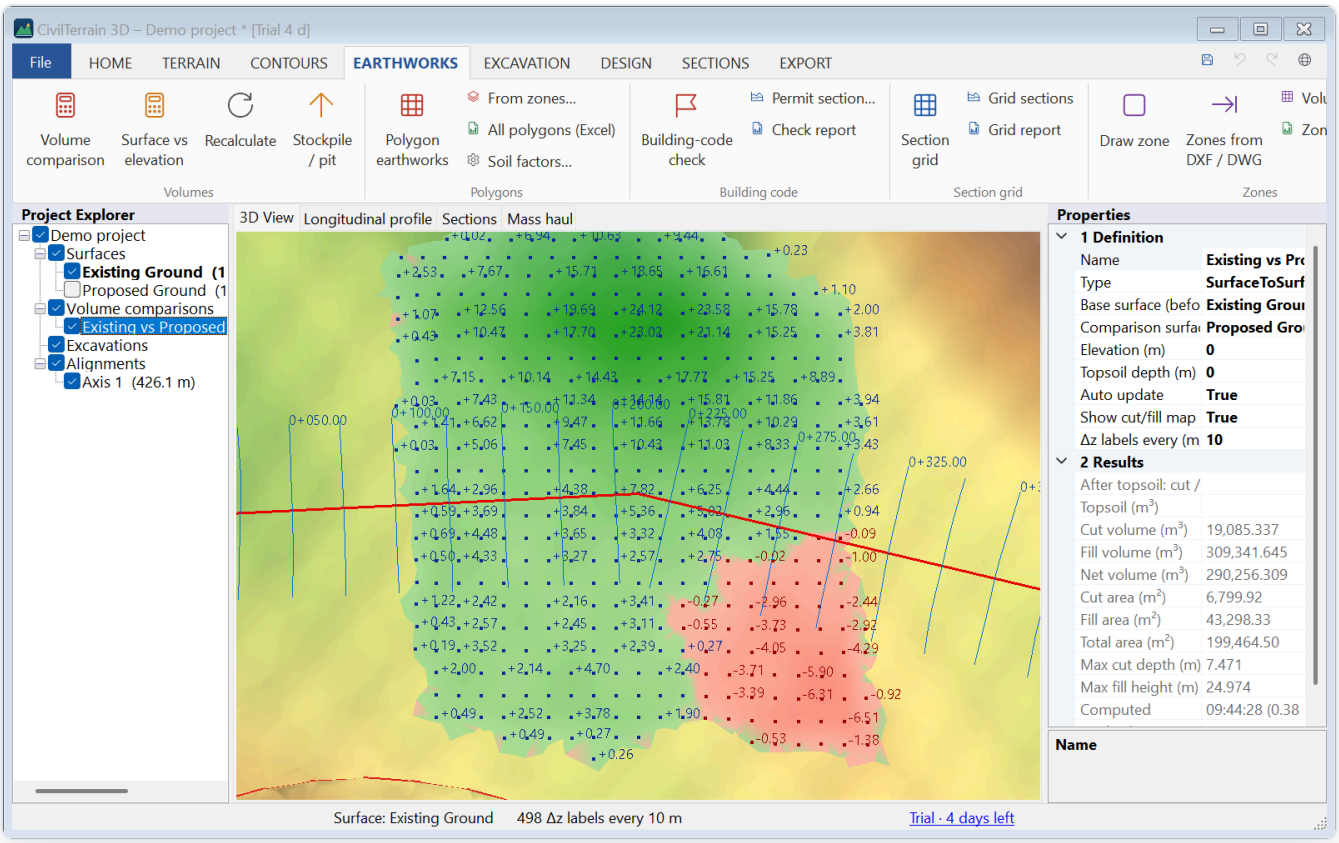


Figure 12.18 – Cut / fill map with Δz labels on a 10 m grid

- **Δz = after − before** (comparison − base surface, or elevation − surface): **+ fill** (blue), **− cut** (red), with two decimals.
- The nodes lie on round coordinates (multiples of the spacing), only where both surfaces exist. Where the surfaces coincide (Δz = 0.00) no label is written.
- On screen, labels that would overlap are left out and appear as you zoom in.
- The **Volume report** PDF writes the differences on the cut / fill plan, and the Excel file adds a **Δz grid** sheet with X, Y, base Z, comparison Z and Δz of every node.
- **EARTHWORKS → Δz map DXF / DWG**: cut / fill faces (layers CF_CUT, CF_FILL), nodes (CF_NODES) and Δz texts (CF_DZ_CUT, CF_DZ_FILL) with a text height in proportion to the spacing.

Tip: for large areas start with a coarse grid (e.g. 20 m); the program accepts up to 250,000 nodes and suggests a larger spacing if you ask for more.

13. Dynamic excavation design

Draw the outline of an excavation (or pad) and the program creates the 3D surface with slopes that **intersect the real ground geometrically**. The final top outline (daylight line) results from this intersection, not from a constant horizontal offset.

1. Make the ground surface active.
2. **EXCAVATION → New excavation** and draw a closed outline.
3. The **Excavation designer** opens.

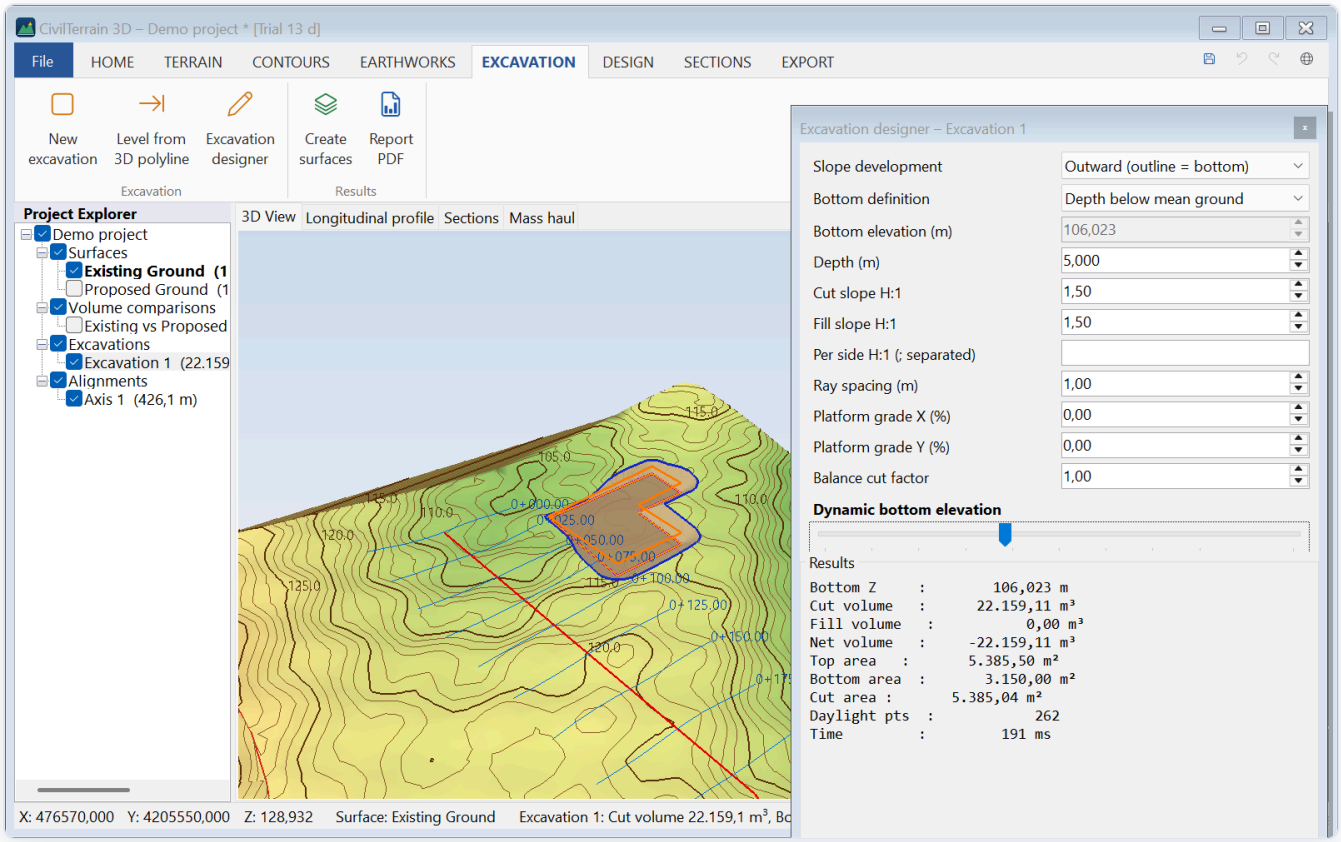


Figure 13.1 – Dynamic excavation: blue = daylight line, purple = bottom, orange = outline

Field	Description
Slope development	**Outward**: the outline is the bottom and the slopes rise outwards to the ground. **Inward**: the outline is the top edge on the ground and the slopes go down inwards.
Bottom definition	Absolute **bottom elevation** or **depth** below the minimum / mean / maximum ground elevation along the outline.
Cut / fill slope H:1	Horizontal to vertical (e.g. 1.5 = 1.5 horizontal to 1 vertical). Where the bottom is above the ground, an embankment with the fill slope is created.
Per side H:1	Different slope per side, separated by `;` (1st value for the side from vertex 1 to 2, etc.). Empty = same for all.
Ray spacing	Spacing of the computation points along the outline (smaller = more accurate).
Dynamic bottom elevation	Slider: while dragging you see a fast preview; when released the exact calculation is done.

Results (bottom elevation, cut/fill volumes, top/bottom areas, time) update immediately. **Create surfaces** adds the **Excavation Surface** and the **Final Construction Surface** (ground + excavation) to the project, plus a volume comparison. **Redraw outline** lets you draw a new outline.

> **Note:** if the slopes reach the edge of the ground surface a warning is shown; extend the ground data for a correct volume.

14. Feature lines, platforms and grading optimization

The **DESIGN** tab contains grading tools in a simple form.

14.1 Feature lines

3D lines with editable elevations: curbs, ditches, platform edges, walls. Create them with **Feature line** / **Closed line** (elevations from the active surface), **From breakline** or automatically from point codes. 3D lines also come from the 3D polylines of a DXF / DWG, without a surface (section 15.7). Click a line and its Properties show its weighted slope, name, colour and visibility (the last three can be changed there).

In **Edit elevations**:

- vertex table with distance, X, Y, **Z** and **grade to next** — edit Z or grade directly;
- **Elevations from surface**, **Interpolate between selected**, **Constant grade…**, **Raise / lower…**;
- a small profile of the line (orange) with the ground (green dashed);
- **Breakline of** a surface: the line enters the TIN and every elevation change updates the terrain automatically.

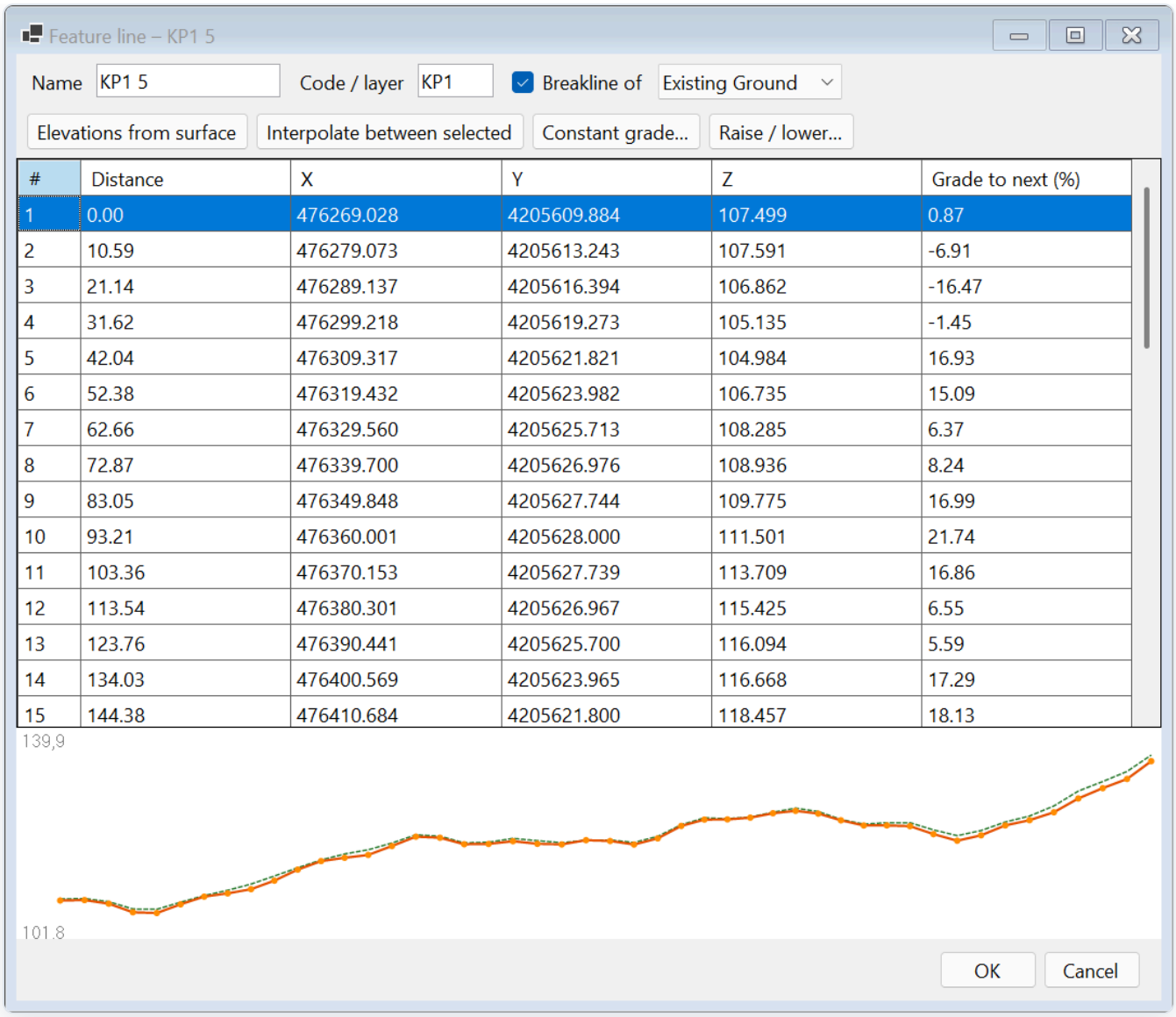


Figure 14.1 – Editing feature line elevations and grades

14.2 Platforms with earthwork balance

Platform: draw the outline; the designer opens with extra **platform grades X / Y (%)**. Cut/fill slopes develop outwards to the ground. **Platform from line**: the platform edge follows the elevations of a closed feature line (e.g. with drainage grades).

Balance cut = fill finds the elevation for which **cut × factor = fill** (zero balance, no import/export of soil). The factor expresses swell/shrinkage (e.g. 0.9) and is saved with the platform. Ideal for plots, solar parks, sports grounds and warehouses. For topsoil, an inclined plane by azimuth or a required surplus use polygon earthworks (with "side slopes to the ground").

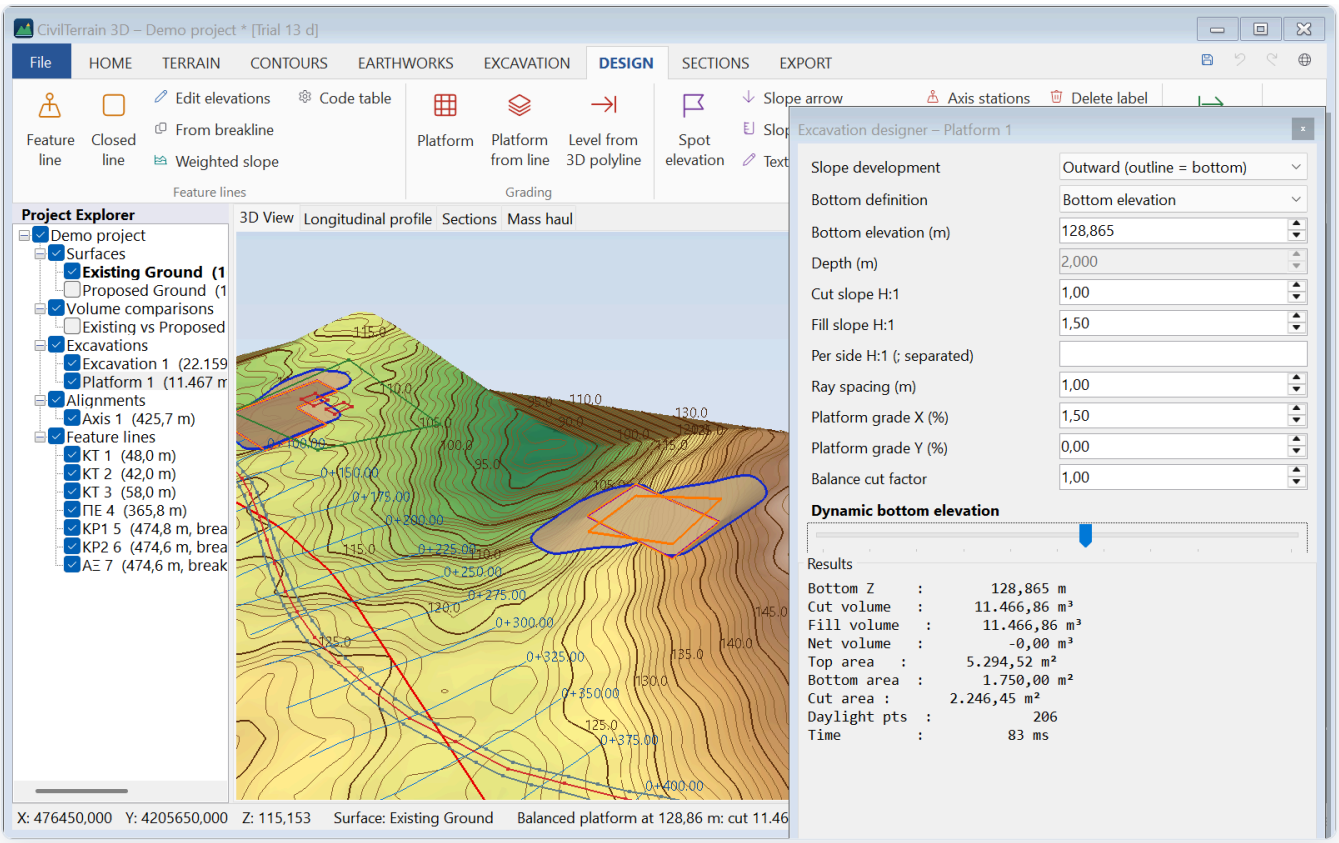


Figure 14.2 – Platform with 1.5% grade balanced between cut and fill

14.3 Cut-and-fill level from a 3D polyline

When the level is already drawn in CAD, import it directly: **DESIGN → Level from 3D polyline** (or **EXCAVATION**) and choose a **DXF or DWG** file and layer.

- The largest **closed 3D polyline (3DPOLY)** becomes the outline with the elevation of each vertex (grades, different levels).
- Polylines **inside** the outline become grade breaks of the level (ridges, valleys, grade changes).
- The level can be **above and below the ground at the same time**: where the ground is higher a cut slope is created, where it is lower a fill slope.
- In the designer the slider and **Balance cut = fill** move **the whole level** (outline and interior lines) keeping its grades.

Sample: `09_epipedo_3dpoly.dxf` (60×40 m platform with 2% grade and a ridge).

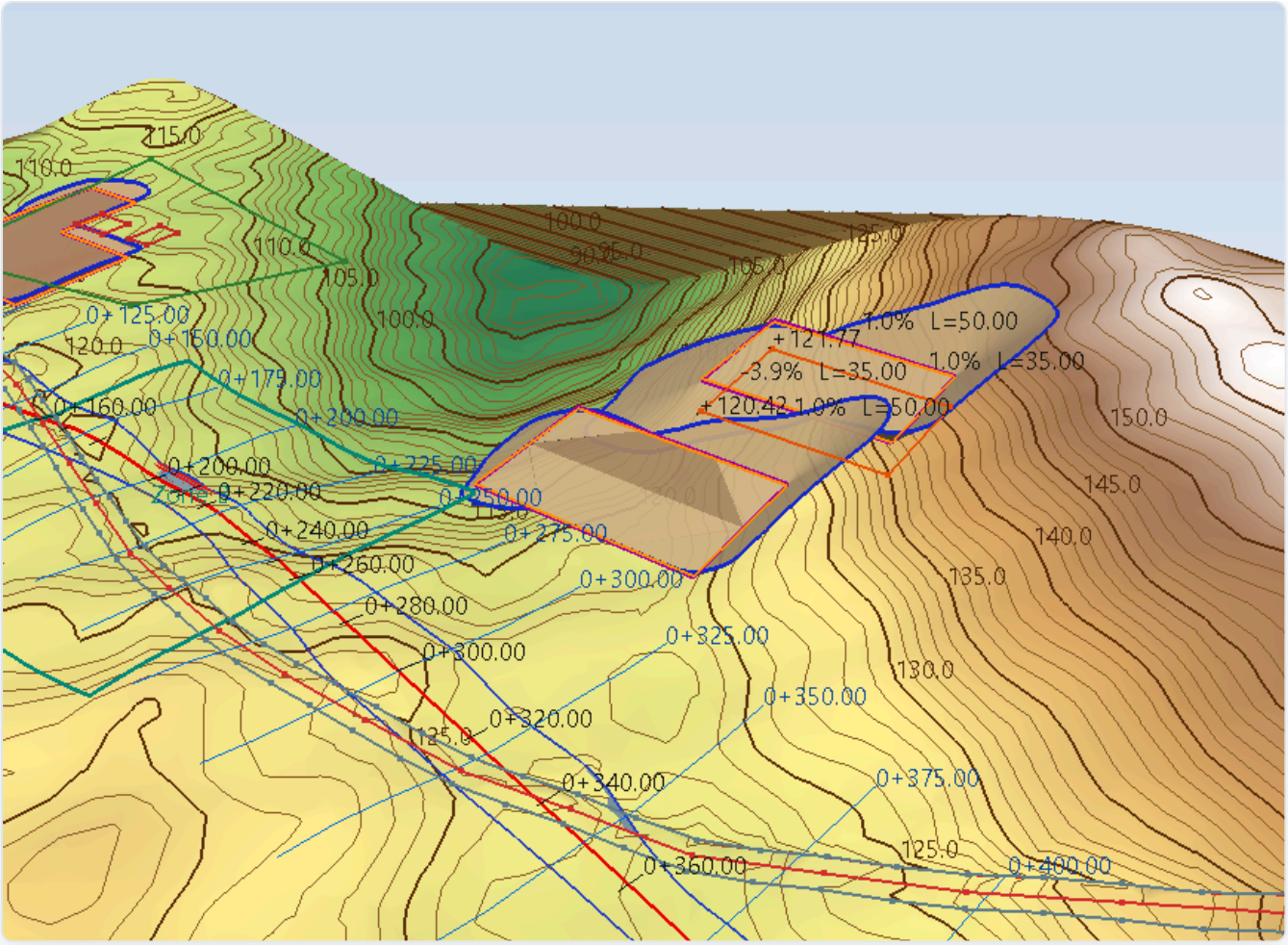


Figure 14.3 – Level from a 3D polyline with ridge, cut and fill

Level accuracy: outline vertices on a straight edge keep their elevation (e.g. a gable), interior lines are clipped exactly at the outline, and where a grade break touches the outline (or stops up to 5 cm short of it) it becomes an outline vertex, so the surface and the slopes have one elevation at every point. "Redraw outline" replaces the 3D level by a horizontal bottom at its mean elevation.

14.4 Grading optimization inside an outline

EARTHWORKS → **Grading optimization**: inside an outline the program finds the surface with the **least earthworks** that keeps your criteria. It needs only the largest grade (e.g. **not above 5%**) and, if you wish, where the water should go.

1. **Outline**: click a zone, a closed line or an outline, draw it, take it from a DXF / DWG or type coordinates, as for polygon earthworks. A zone or closed line selected in the tree is used directly.
2. **Criteria**: the criteria dialog opens at once (below).
3. **Compute**: in a few seconds you get the **design surface** and its **comparison with the ground**, with a summary of the results.

Criterion	Description
Largest grade (%)	The grade of every triangle, **in any direction**, stays within this value.
Water path	**Draw a water path…**: the dialog hides and you draw a line **from high to low** (Enter to finish). Around each of its segments the ground falls in its direction at least at the **smallest fall** (e.g. 1%). Draw as many paths as you need.
Outlet (manhole)	Click where the water is collected. All around it the ground falls towards it.
Points of given elevation	Click in the drawing and type the elevation, e.g. an entrance, a building threshold, a manhole.
Lowest / highest elevation	Optional limits for the whole surface, e.g. above a flood level.
Deepest cut / highest fill	How deep it may dig or how high it may fill (0 = no limit).
Balance	Fill = factor × cut, **side slopes included**.
Cut / fill side slopes	The slope (H:1) that ties the surface to the ground outside the outline.
Grid spacing	0 = automatic (about 20,000 nodes). A denser grid gives more detail and takes longer.
Accuracy	**Fast** (recommended, up to ~20 s), **Normal** (within 2% of the least earthworks, up to ~1 minute) or **High** (within 0.5%, up to ~3 minutes). In practice "Fast" gives volumes just above the least. `Esc` cancels the computation.

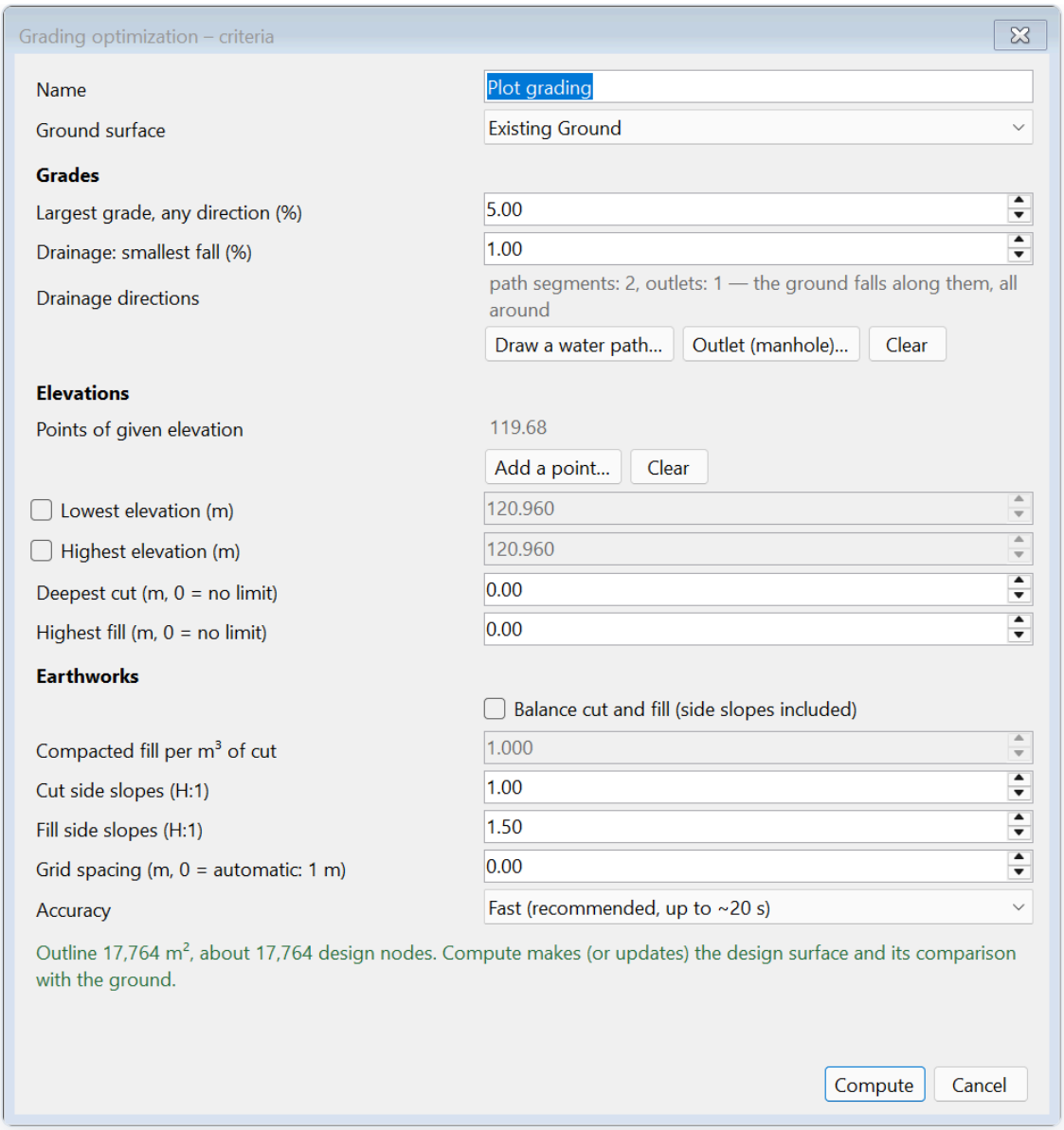


Figure 14.4 – The criteria of the grading optimization

Result. The design surface is coloured in grade classes that end at the largest grade and has contours every 0.25 m. The **blue arrows** show where the water runs. The comparison "ground → design" gives the cut / fill map, the reports and the Δz labels. The summary shows:

- cut, fill and net, exact between the two TINs;
- how they split between the inside of the outline and the side slopes;
- the largest grade reached, the share of the area that drains correctly, and the balance;
- how close the solution is to the least possible earthworks, with a bound certified by mathematical duality.

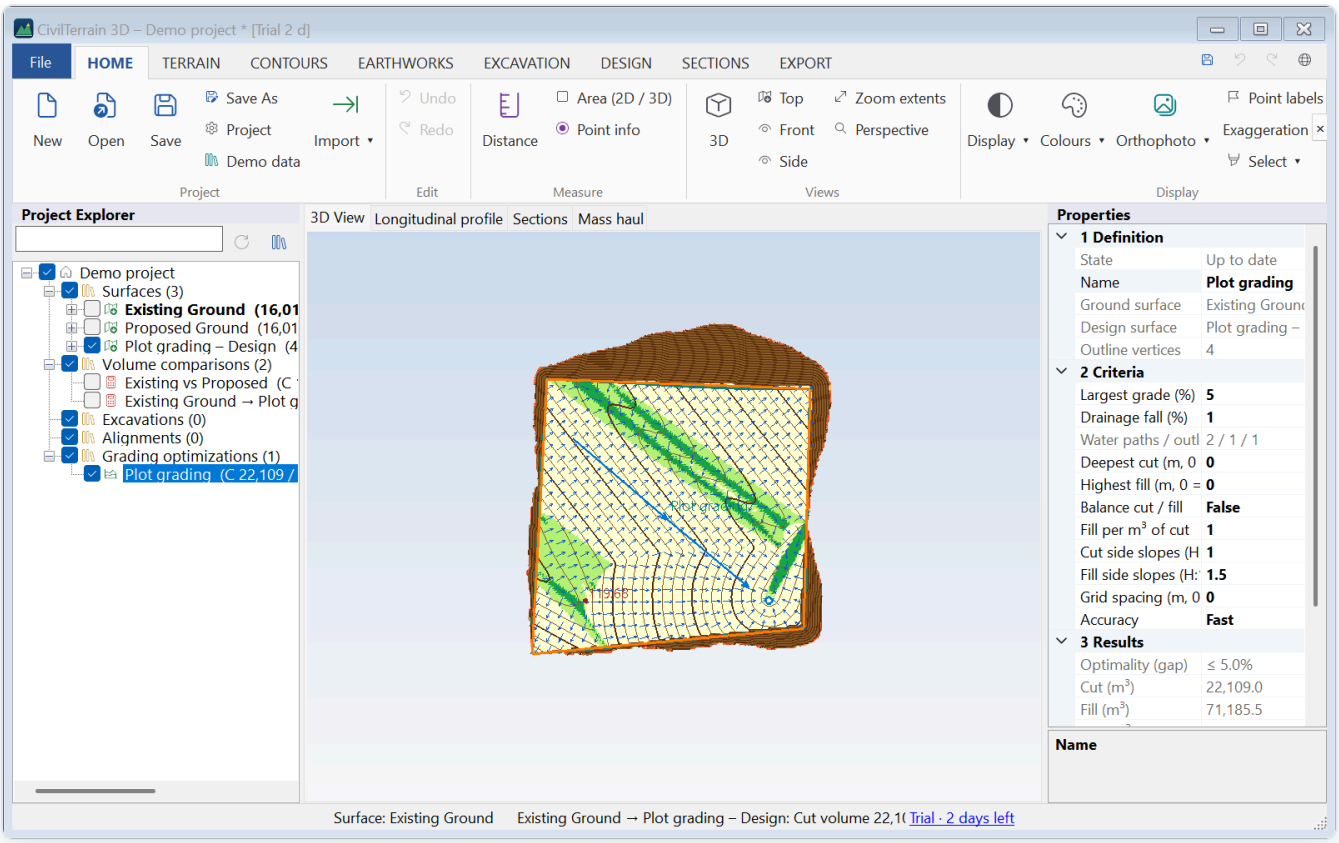


Figure 14.5 – Design surface ≤ 5% with a water path, an outlet and the drainage arrows

Changes. Change the criteria from the tree (**Criteria…**) or in Properties. After a change the optimization shows as **out of date** (⚠), as it also does when the ground changes. **Recalculate** updates the same design surface (with undo) and the same comparison.

> When the criteria contradict each other (e.g. two points 20 m apart, 3 m apart in height, with a 5% limit), the program says so. The result keeps the criteria as far as it can. Where the ground already keeps the criteria, it is left as it is.

14.5 Sloped design (sub-areas)

DESIGN → Sloped design: inside the perimeter of a site you draw sub-areas of any shape and give **each side a grade % as you draw**. They make a new **design surface**, with side slopes to the ground, and its **comparison with the ground**: volumes and cut / fill colours. Both update as soon as anything changes, so you see at once whether a layout pays off.

1. **Perimeter**: select a zone, a closed line or an outline in the tree before the command. It is shown dashed and vertices snap onto it. With nothing selected, the design starts without a perimeter.
2. **Drawing an area**: click its vertices.
    - In the small window you give the **grade of the next side** (+ uphill, − downhill, in the direction you draw) and you can change it before every click.
    - The 1st vertex takes the elevation of the ground, or one you type.

- For the point under the cursor, the window shows the length, grade and elevation of the side, and the closing side.
- `Enter` or a double click: the area is done; `Backspace`: back one vertex. A click on the first vertex again snaps onto it.
- In the grade box both a point and a comma are a decimal point; `Enter` there keeps the value and goes back to the drawing.

3. **Neighbouring areas**: a click on a vertex or side of another area makes a shared point at its elevation, so the areas join without steps. After each area the drawing goes on with the next one; `Esc` ends it.

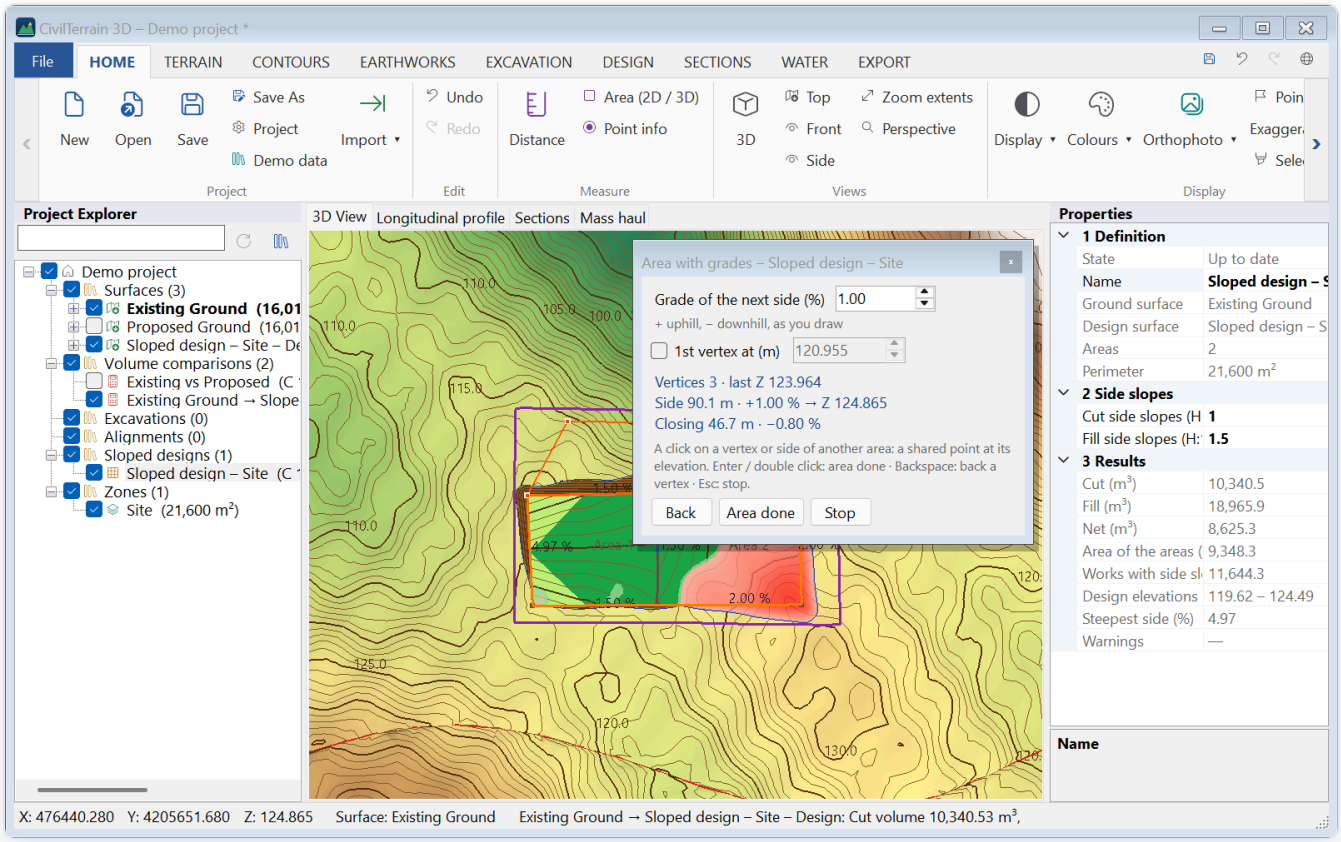


Figure 14.6 – Drawing an area: the grade of the next side in the small window, with the length, grade and elevation of the point under the cursor

Result. The areas join into one design surface. Its outer edge meets the ground with the cut and fill side slopes of the Properties (e.g. 1:1 and 1.5:1). The drawing shows:

- the grade of each side, with an arrow pointing downhill;
- the cut (red) and fill (green) colours.

The Properties and **Results…** give:

- cut, fill and net;
- the area, and the works area including the side slopes;
- the range of elevations and the steepest side;

- the **volumes per area**, and of the side slopes on their own.

A gap enclosed by areas (a courtyard, say) is designed from the areas around it; a warning tells so and its volumes are in the row «Gaps between areas». Areas that overlap or cross themselves (vertices out of order) are pointed out.

The Excel export contains the volumes and the vertices.

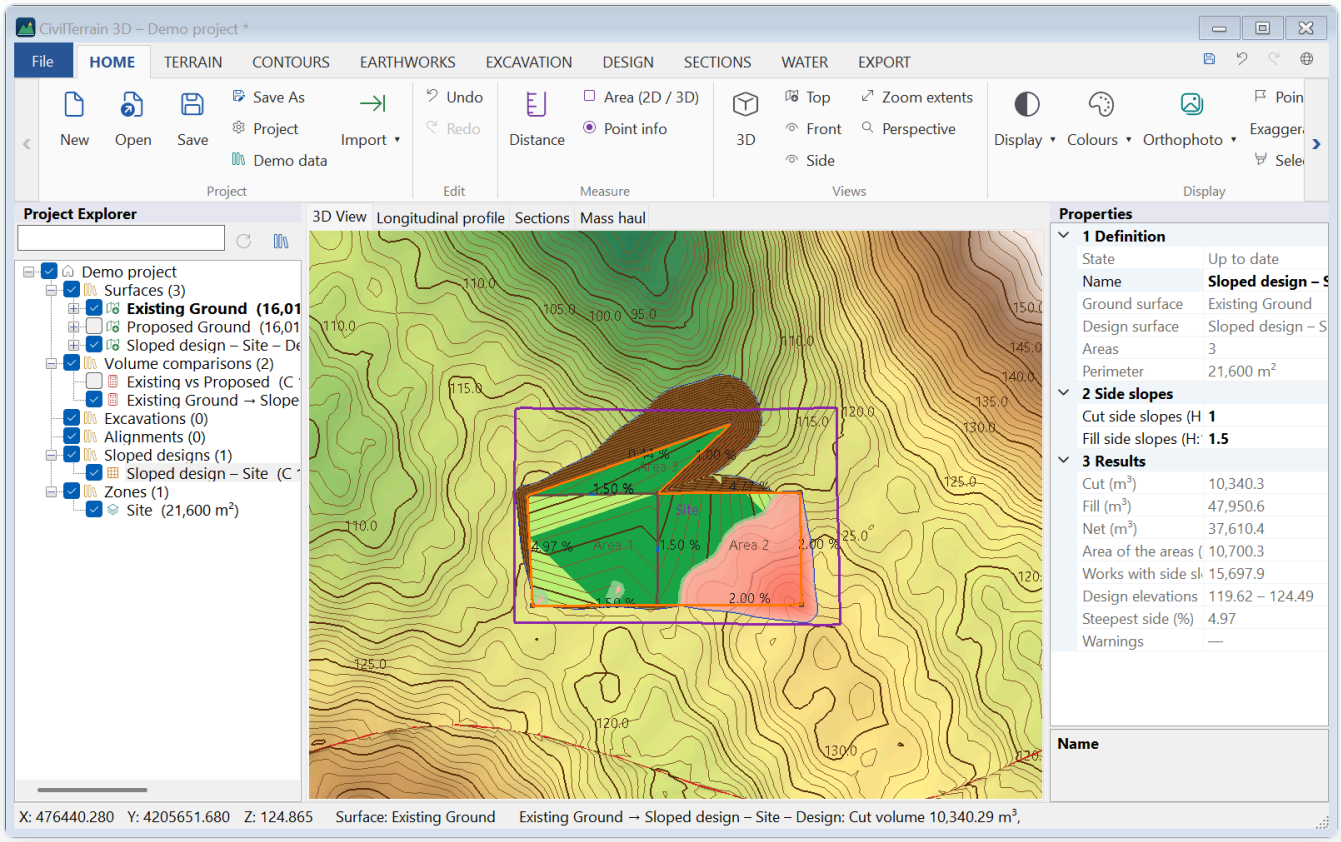


Figure 14.7 – Three areas with grades inside the perimeter, with their side slopes and the cut / fill colours

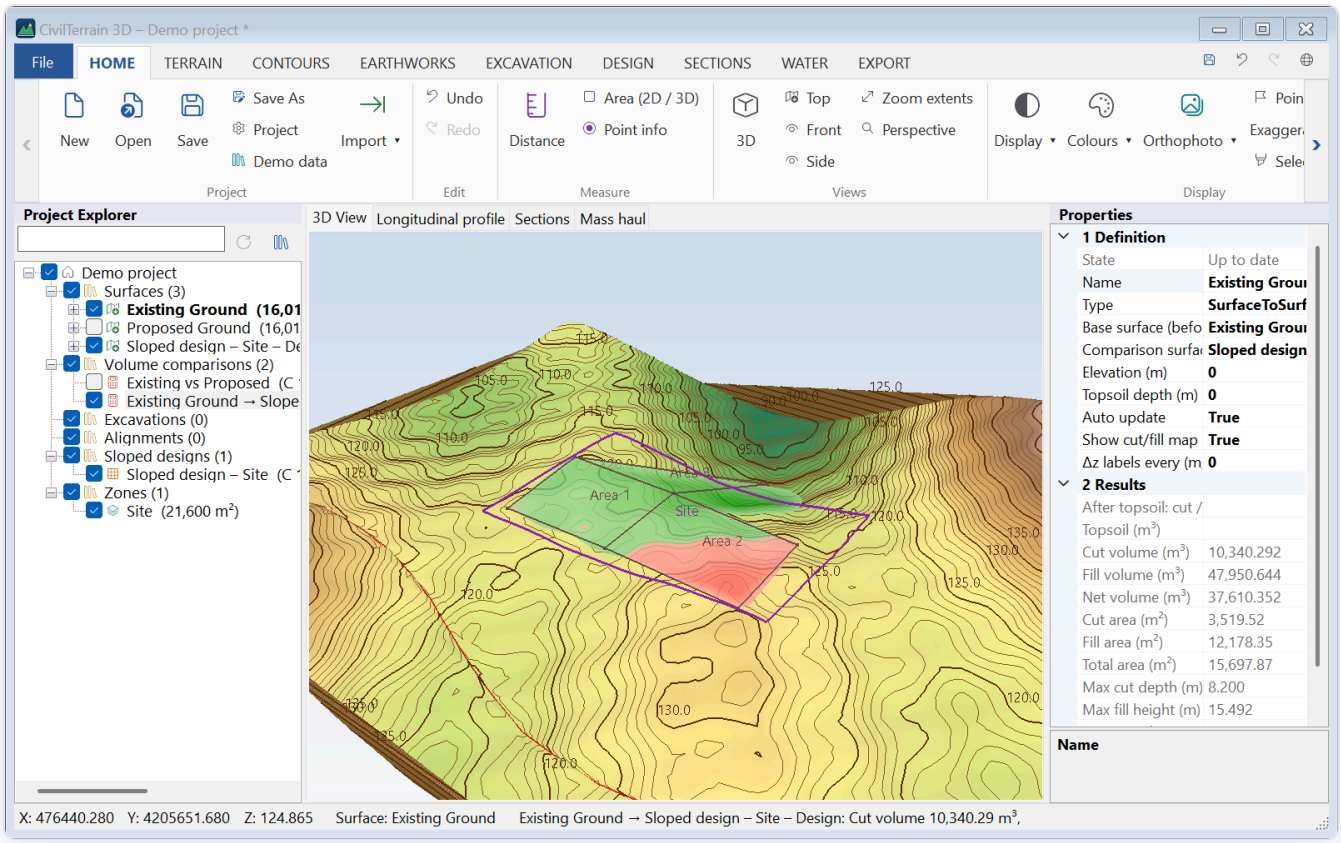


Figure 14.8 – The cut and fill of the design surface against the ground, in 3D

Changes. Right-click the design → **Areas (elevations, grades)…**: a table with the elevation of every vertex and the grade of every side, the closing side included.

- A changed grade moves the next vertex. With the box ticked, the vertices after it move too, so their own sides keep their grades.
- Points shared with other areas follow. A point lying on a side of another area (not on one of its vertices) does not follow; if it ends up at another elevation than that side, a warning says so and the side bends there.
- In the same table you rename or delete areas.

New areas are drawn with right-click → **Draw an area…**. Every change is undone with `Ctrl` + `Z`, and the design surface updates by itself.

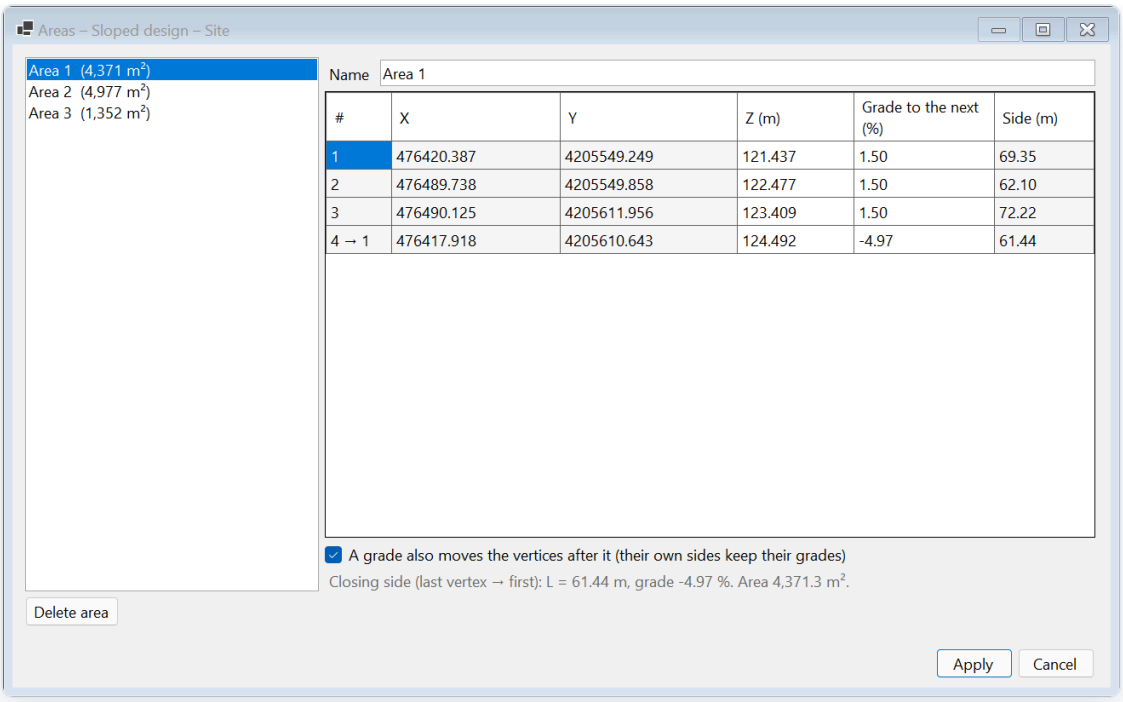


Figure 14.9 – The table of the areas: elevations of the vertices and grades of the sides

- The design surface belongs to the design: every change of the areas makes it anew, so manual edits on it are lost. Until then the design shows as out of date (⚠), since its figures no longer describe the surface.
- When the ground changes, the design shows as out of date (⚠) until you **Recalculate** it.
- If the vertices of an area do not lie in one plane, its surface folds along a diagonal.
- Areas reaching the edge of the survey keep their elevations up to it; side slopes and volumes are computed only where there is ground (a warning says so).

15. Axes, profiles and cross sections

15.1 Drawing an axis

SECTIONS → **Draw axis**: draw the axis polyline. The sections dialog opens immediately.

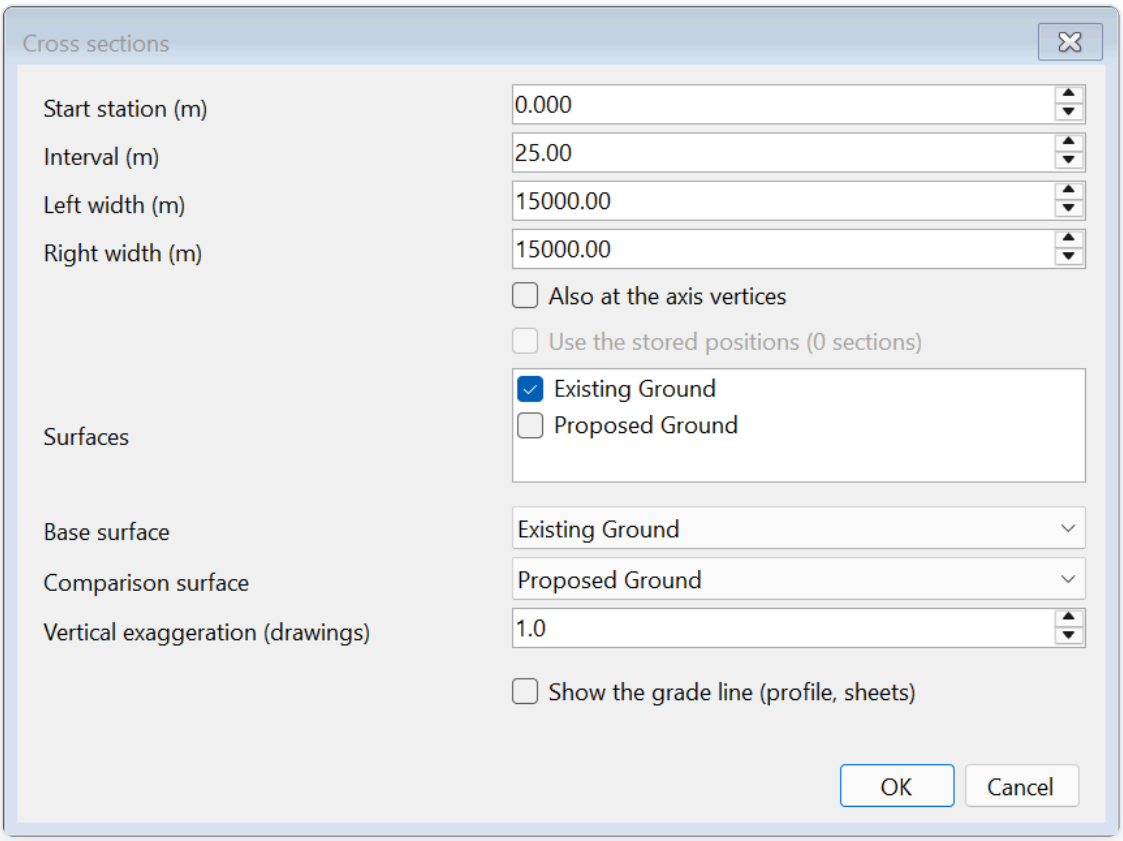


Figure 15.1 – Cross-section settings

Setting	Description
Start station	Chainage of the start of the axis.
Interval	Section spacing (e.g. 20 m, up to 15 000 m). Start and end are always included.
Left / right width	Length of the section on each side of the axis (up to 15 000 m).
Also at the axis vertices	Adds sections where the axis changes direction.
Use the stored positions	For axes imported from a positions file (chapter 16).
Surfaces / base / comparison	Which surfaces are drawn and between which the cut/fill areas are computed.
Show the grade line	Whether the grade line (design profile) is drawn on the profile and the sheets. Without it only the ground data remain; its VIPs are kept.

The sections are also shown **on the plan**: blue lines labelled with their chainage. The section selected in the list is highlighted in orange.

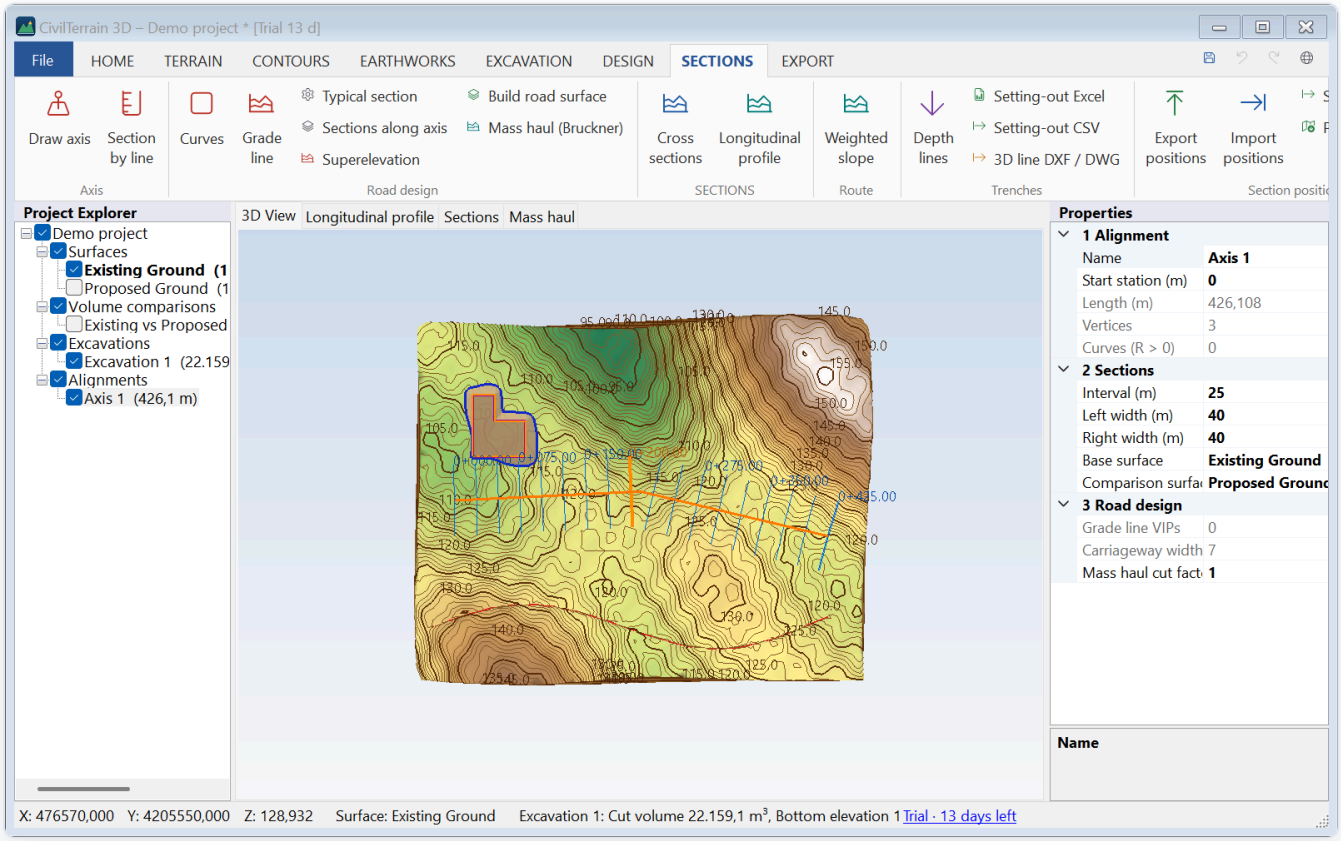


Figure 15.2 – Axis and sections on the plan with chainages

15.2 Longitudinal profile

The **longitudinal profile** has its own tab (**SECTIONS → Longitudinal profile**). It shows the surfaces along the axis, cut/fill shading, the axis vertices (V) and a **band table** with chainages, ground and design elevations and their difference. The band is written at the section stations or at a fixed spacing (**Band every**). Vertical exaggeration is set at the top left.

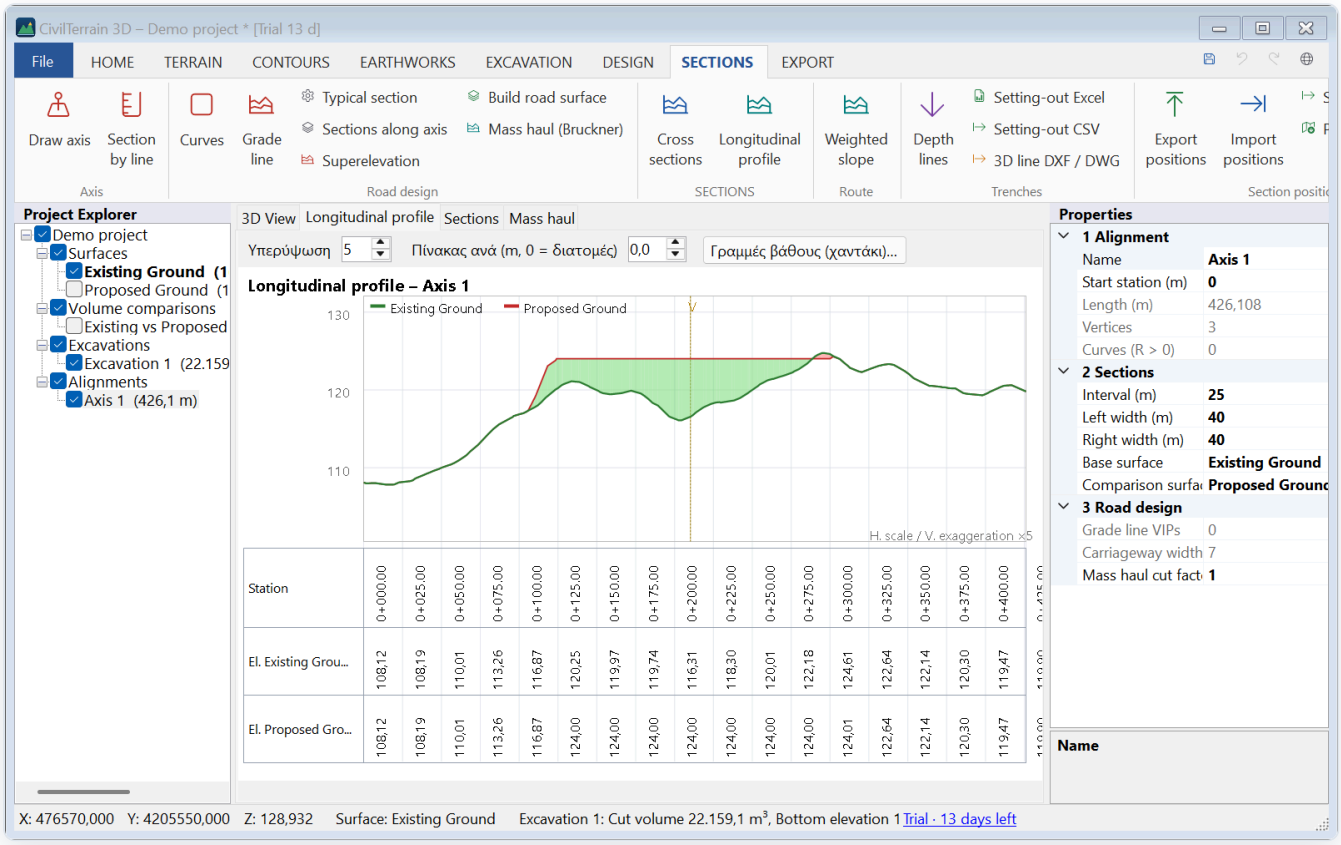


Figure 15.3 – Longitudinal profile with band table

When the axis has a grade line, the **Grade line** box above the profile shows or hides it. Hidden, it is not drawn on the plan-profile sheets either and its VIPs cannot be dragged; the band shows only the ground. The same option is in the sections dialog and in the axis Properties.

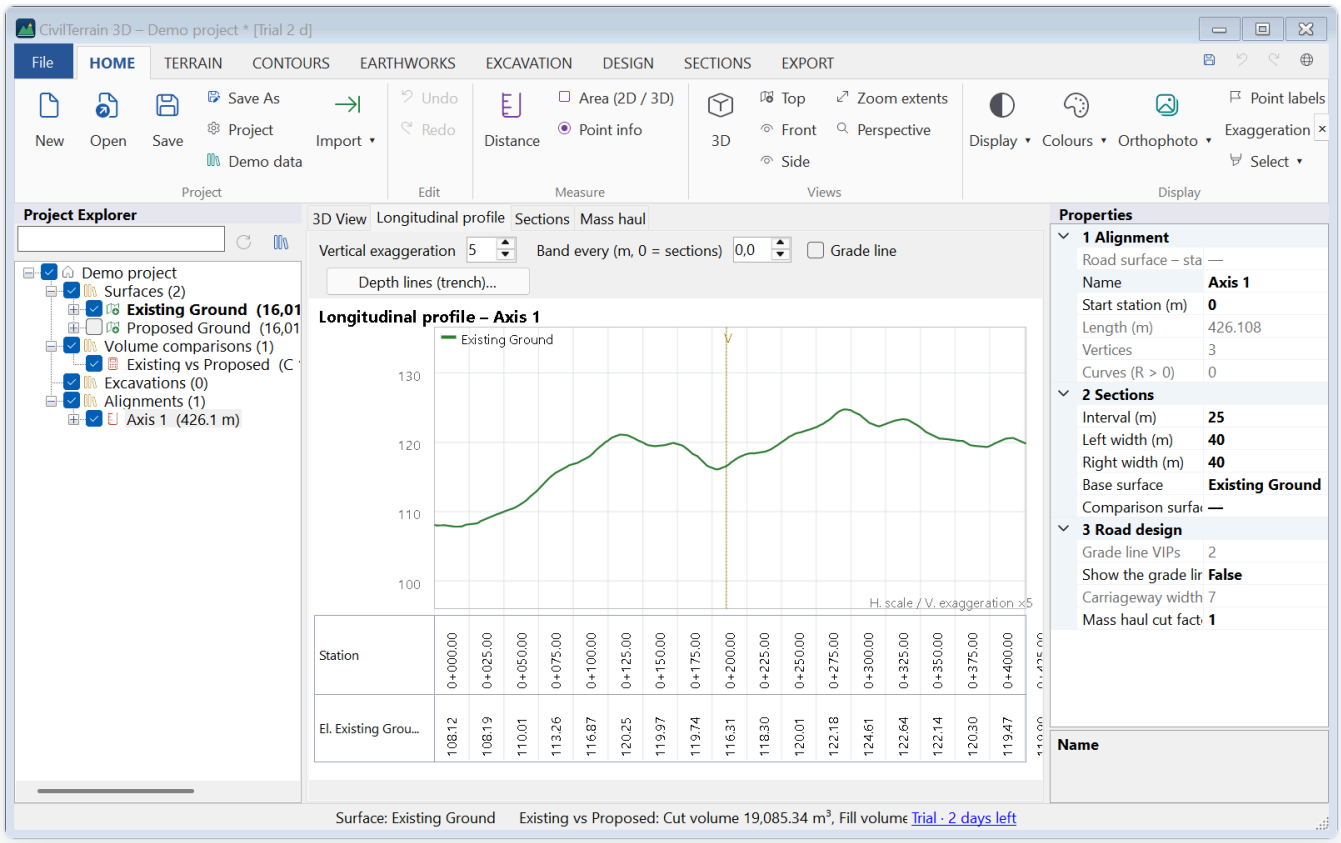


Figure 15.3a – Profile without the grade line: only the ground

15.3 Cross sections

On the **Sections** tab pick a chainage from the list. Each section shows the surface profiles, the axis (red dashed), cut/fill shading and areas. Move the cursor to read offset and elevations.

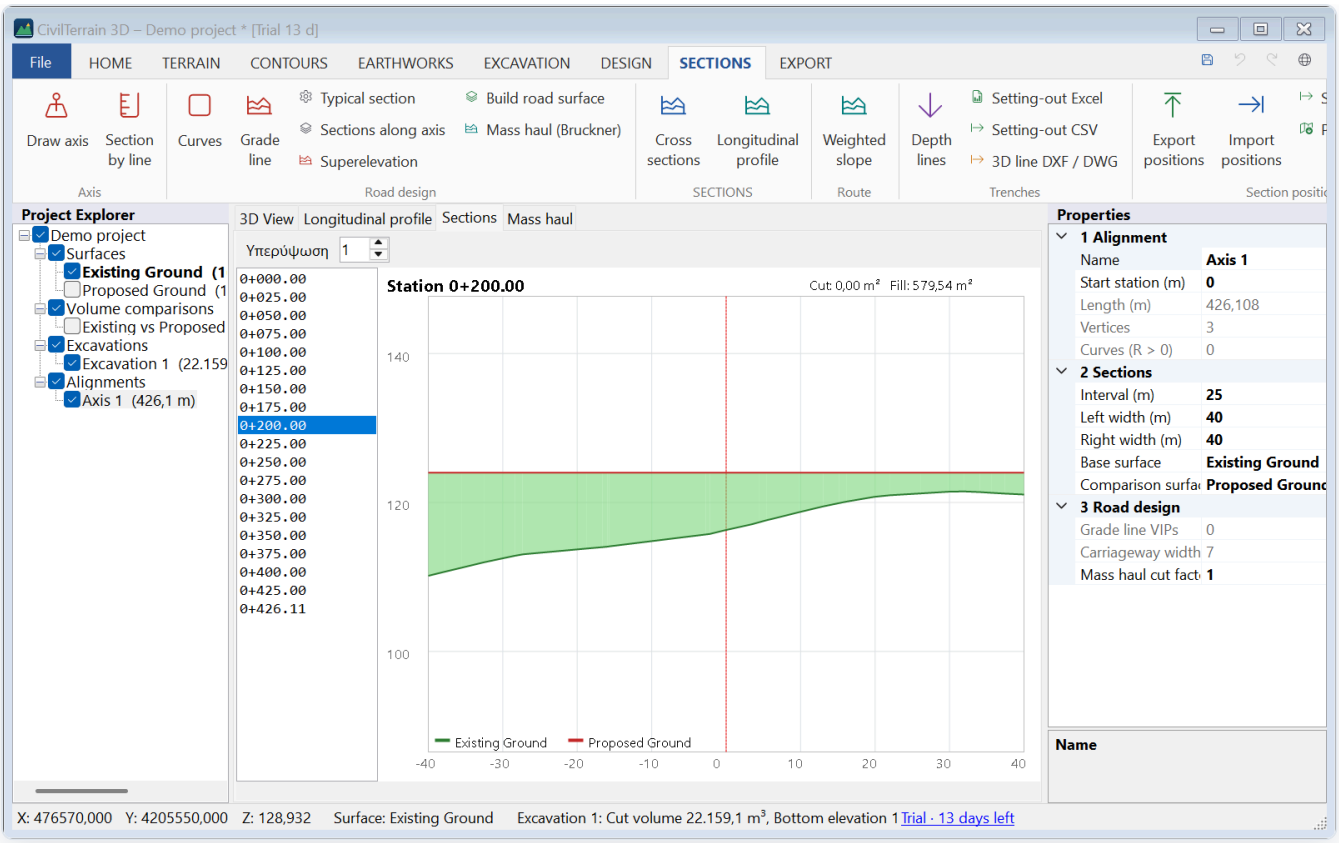


Figure 15.4 – Cross section with cut / fill areas

Volumes between sections use the **average end area method** and appear in the reports. For the exact volume also use the surface comparison (chapter 12).

15.4 Section by line

SECTIONS → Section by line: two clicks show the profile of all visible surfaces along that line.

15.5 Depth lines (cable and pipe trenches)

For cables, pipes and networks: **SECTIONS → Depth lines** (or the **Depth lines (trench)...** button above the profile). Each line has:

Item	Meaning
Depth	E.g. 1.20 m for the cable and 1.30 m for the trench bottom — as many lines as you need.
Below	**ground** (follows the terrain) or **grade line** (follows the design; the actual depth below ground is shown separately).
From / To station	Part of the axis (empty = all). For different depths in different parts define more lines.
Width, wall slope	Trench section (rectangular or trapezoidal) for the **excavation volume**, shown per line and in total.
Indications every (m)	How often a depth indication is shown (e.g. 10, 20, 25 m); always at the start/end of the line too.

In the profile the lines are dashed, with a vertical mark from the ground down to the line and the depth written next to it. The **band** under the profile gets the elevation and the depth of each line at the indication stations. The same appears in **Profile PDF** and **Plan-profile sheets**.

Exports: **Setting-out Excel** (length/volume summary and a setting-out table per line), **Setting-out CSV** (with X, Y of every indication for GPS) and **3D line DXF / DWG** (the trench bottom as a 3D polyline on the axis, with labels).

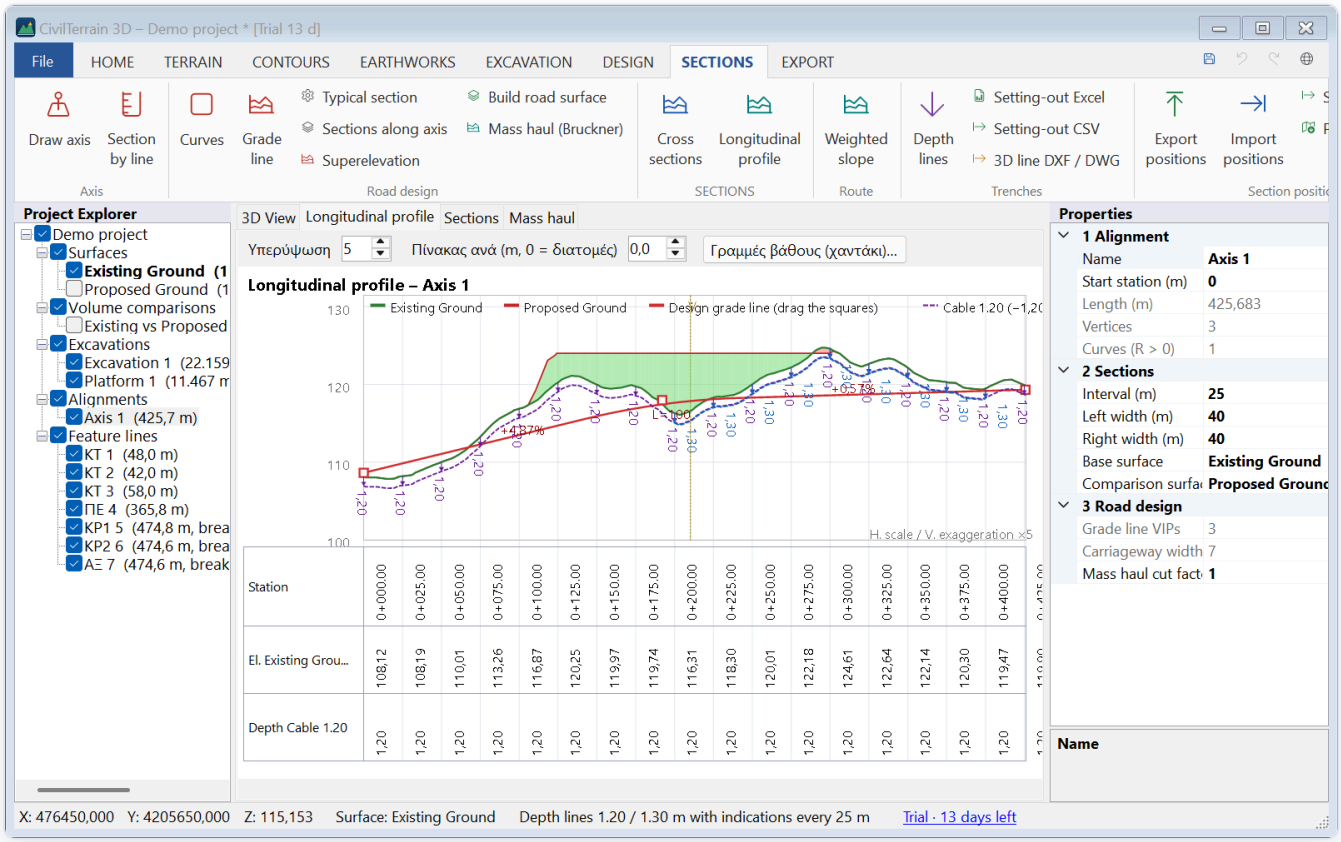


Figure 15.5 – Depth lines 1.20 / 1.30 m with indications every 25 m

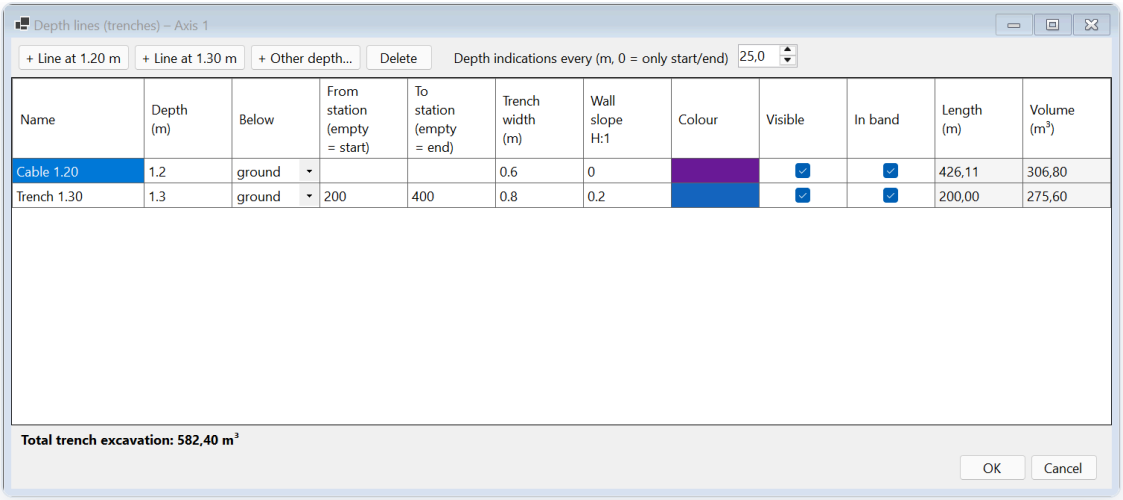


Figure 15.6 – Defining depth lines, ranges and trench volumes

15.6 Weighted slope of a route

SECTIONS → Weighted slope (also in DESIGN or the axis right-click menu). It computes the weighted slope of a route (road, network, cable) as in the classic spreadsheet:

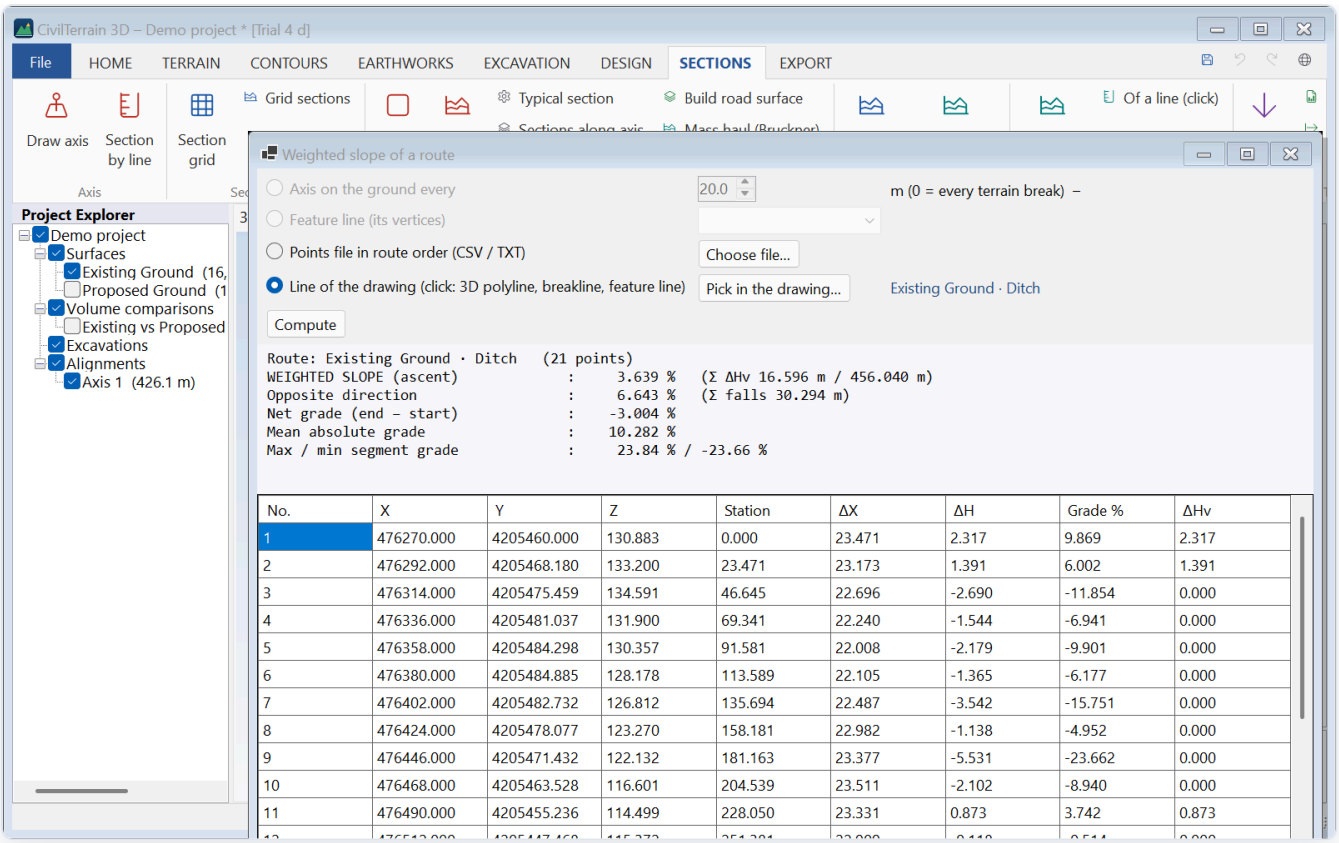
```
Weighted slope = Σ ΔHv / total horizontal length
(ΔHv = uphill height differences only)
```

Source of the points:

- **Axis on the ground every N m** (e.g. 20 m); with 0 every slope change of the terrain is used (exact value).
- **Feature line**: its vertices in order.
- **Points file** CSV/TXT in route order (No., X, Y, Z).
- **Line of the drawing (click)**: click a **3D polyline** you imported (from DXF / DWG, as a breakline of a visible surface) or a feature line, and the X, Y, Z of its vertices are taken directly — no ASCII file needed.

To pick by clicking: **SECTIONS → Of a line (click)**, or **Pick in the drawing…** in the weighted slope window. Click near the line; the window opens with its name, the line is highlighted in the drawing and the result is computed at once. Closed lines are computed back to their first point.

The line is found where it is drawn on the screen, so **Of a line (click)** also works **without a surface**, e.g. on routes imported as 3D lines only (section 15.7). Quicker still: right-click a feature line, in the tree or in the 3D view, → **Weighted slope…**, and the window opens for that line. The window starts with the first source available, in this order: the line you clicked, else the selected line, else the axis, else the first line of the project, else a points file.

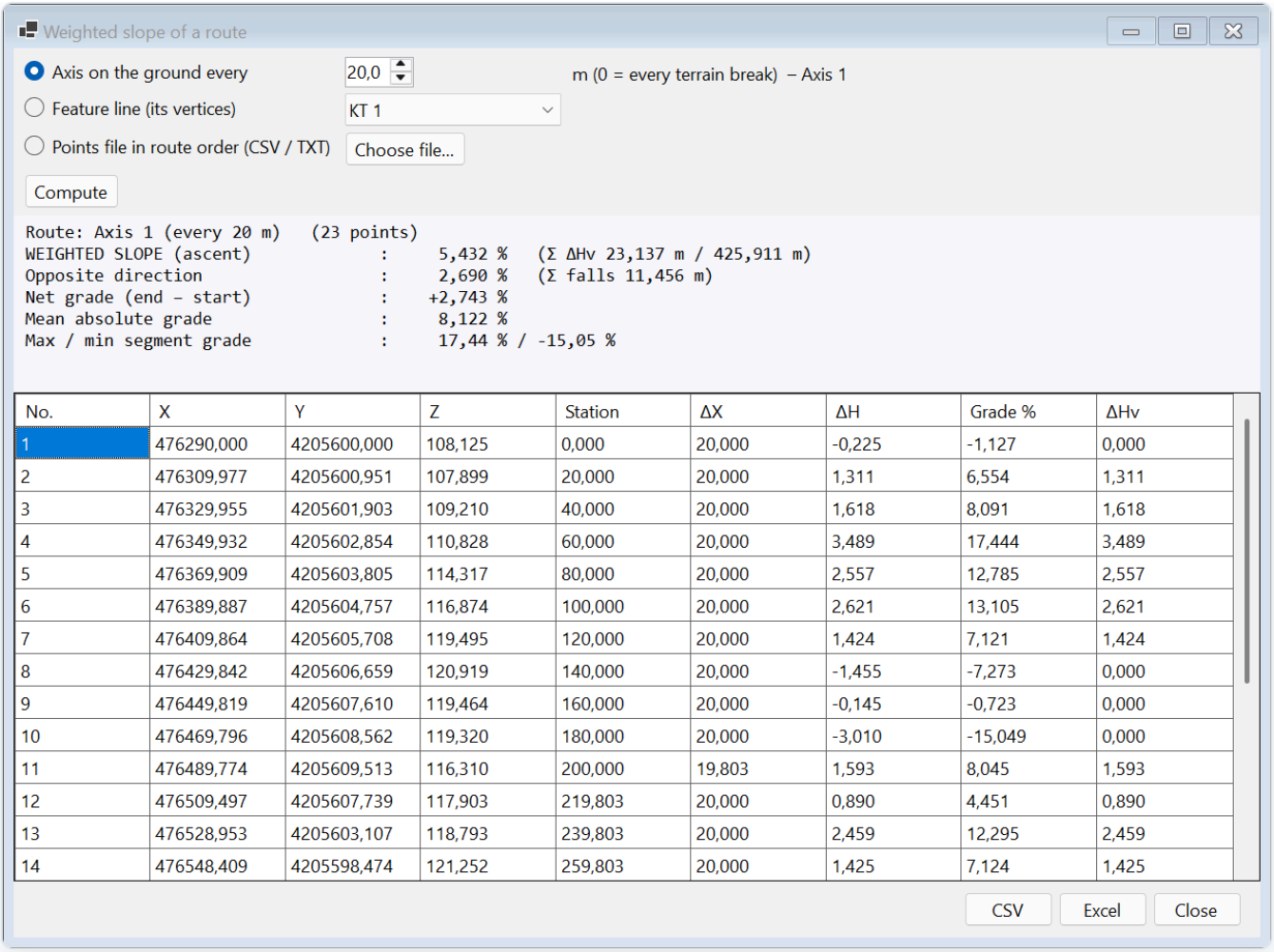


No.	X	Y	Z	Station	ΔX	ΔH	Grade %	ΔHv
1	476270.000	4205460.000	130.883	0.000	23.471	2.317	9.869	2.317
2	476292.000	4205468.180	133.200	23.471	23.173	1.391	6.002	1.391
3	476314.000	4205475.459	134.591	46.645	22.696	-2.690	-11.854	0.000
4	476336.000	4205481.037	131.900	69.341	22.240	-1.544	-6.941	0.000
5	476358.000	4205484.298	130.357	91.581	22.008	-2.179	-9.901	0.000
6	476380.000	4205484.885	128.178	113.589	22.105	-1.365	-6.177	0.000
7	476402.000	4205482.732	126.812	135.694	22.487	-3.542	-15.751	0.000
8	476424.000	4205478.077	123.270	158.181	22.982	-1.138	-4.952	0.000
9	476446.000	4205471.432	122.132	181.163	23.377	-5.531	-23.662	0.000
10	476468.000	4205463.528	116.601	204.539	23.511	-2.102	-8.940	0.000
11	476490.000	4205455.236	114.499	228.050	23.331	0.873	3.742	0.873

Figure 15.7 – Weighted slope of a breakline picked by clicking in the drawing

Shown: weighted ascent, the value in the opposite direction (Σ falls / length), net grade (end − start), mean absolute grade and max/min segment grade, with the table No., X, Y, Z, Station, ΔX, ΔH, Grade %, ΔHv. Export to Excel (same layout as the classic sheet) or CSV. Sample: `11_diadromi.csv`.

In the window, next to **Compute**, two buttons lead to the routes without a surface (section 15.7): **Import routes (DXF / DWG)…** and **Weighted slope of all lines…**.



No.	X	Y	Z	Station	ΔX	ΔH	Grade %	ΔHv
1	476290,000	4205600,000	108,125	0,000	20,000	-0,225	-1,127	0,000
2	476309,977	4205600,951	107,899	20,000	20,000	1,311	6,554	1,311
3	476329,955	4205601,903	109,210	40,000	20,000	1,618	8,091	1,618
4	476349,932	4205602,854	110,828	60,000	20,000	3,489	17,444	3,489
5	476369,909	4205603,805	114,317	80,000	20,000	2,557	12,785	2,557
6	476389,887	4205604,757	116,874	100,000	20,000	2,621	13,105	2,621
7	476409,864	4205605,708	119,495	120,000	20,000	1,424	7,121	1,424
8	476429,842	4205606,659	120,919	140,000	20,000	-1,455	-7,273	0,000
9	476449,819	4205607,610	119,464	160,000	20,000	-0,145	-0,723	0,000
10	476469,796	4205608,562	119,320	180,000	20,000	-3,010	-15,049	0,000
11	476489,774	4205609,513	116,310	200,000	19,803	1,593	8,045	1,593
12	476509,497	4205607,739	117,903	219,803	20,000	0,890	4,451	0,890
13	476528,953	4205603,107	118,793	239,803	20,000	2,459	12,295	2,459
14	476548,409	4205598,474	121,252	259,803	20,000	1,425	7,124	1,425

Figure 15.8 – Weighted slope of an axis every 20 m

15.7 Routes without a surface – weighted slope with one click

Many routes (roads, networks, cables, several km long) that you have as **3D polylines** in a DXF / DWG need neither a surface nor a points file each. Every polyline is imported as a **3D line** of the project with its own vertices, and **one click** on it shows its weighted slope (Σ ΔHv / horizontal length, section 15.6) in the Properties. All of them together give one table with totals and export to Excel / CSV.

Import

1. **SECTIONS → Route → Import routes...** and choose the DXF or DWG. The same command is the **Import routes (DXF / DWG)...** button of the weighted slope window and is also in the right-click menu of **Feature lines** in the tree. With the normal import (**HOME → Import ▾ → DXF...**) tick **3D polylines as 3D lines only (no surface)** to do the same (section 7.2).
2. In the **Import routes (DXF / DWG)** window choose the **Layers**. The surface options are not shown here. Layers without any polyline with elevations (e.g. a frame or a title block of 2D lines, like FRAME of the sample `13_diadromes.dxf` in Figure 15.9) start unticked when another layer has routes; tick them if you want them.
3. In **Source CRS** set the system of the file if it is not the project's (default “Same as project (no transformation)”). In an empty project, a projected system (e.g. GGRS87, UTM) becomes the

project's system. Files in geographic coordinates (longitude / latitude) or Web Mercator are always transformed into the project's system, because the lengths of the slope are measured in metres, in the plane.

4. Click **OK**. After "Import routes" the **Weighted slope of all lines** table opens at once as well (below).

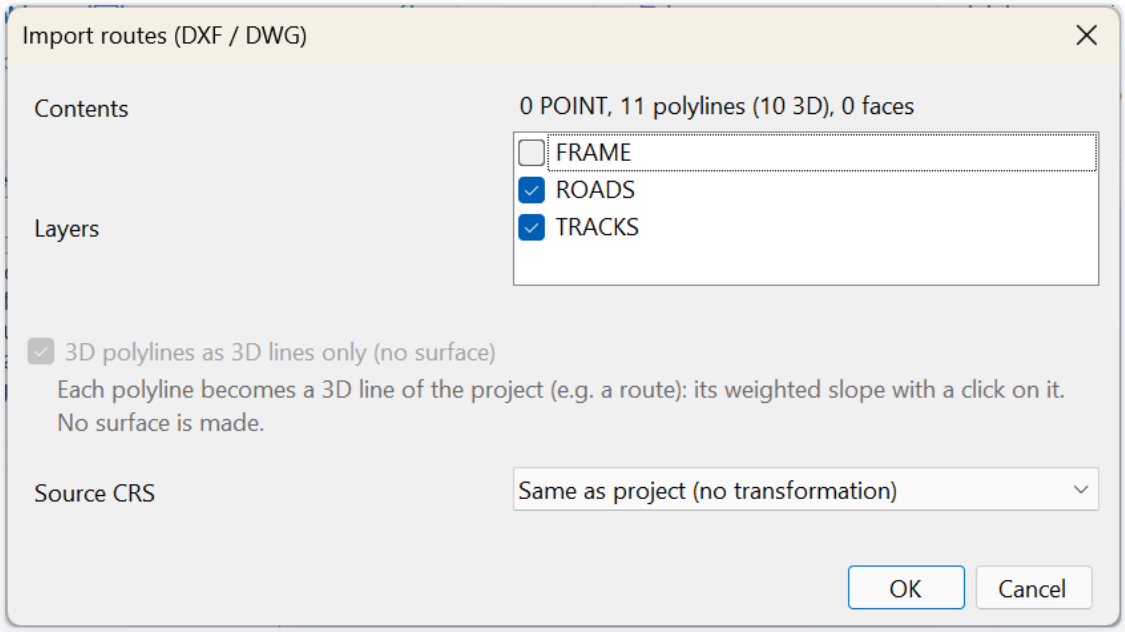


Figure 15.9 – The "Import routes (DXF / DWG)" window: layers and source CRS, without the surface options

No surface is made. Every polyline becomes a 3D line named after its layer with a running number, in the order of the file: for the layer ROADS, **"ROADS 1", "ROADS 2" …** (just "ROADS" when the layer has one line; for layer 0, the file name). A name already in the project gets "(2)". The code of the line is its layer, each layer has its own colour, and closed polylines stay closed. The view goes to the new lines, and the whole import is undone with one **Undo**.

The status bar says how many lines came in. Lines **without elevations** (every vertex at one Z, e.g. 2D polylines) have a weighted slope of 0 %: the program warns about them once, with their names. Polylines of a single point are left out. Vertices with invalid coordinates are skipped, and the message says how many. 3D polylines with a spline fit are read by the points of their fitted curve (the control points of the frame are ignored). If the project is in degrees (longitude / latitude), the message asks you to set a projected system (e.g. GGRS87) for lengths in metres. If the coordinates of the file look like degrees while Source CRS is "Same as project", a warning appears: undo (`Ctrl` + `Z`), choose **WGS 84 (lon/lat)** in Source CRS and import again.

One click: the weighted slope in the Properties

Click a route in the 3D view or in the tree. The line is selected and the **Properties** show the result in the **1 Weighted slope** group, from its vertices in order, with no surface:

Field	Meaning
Uphill (%)	The **weighted slope** in the direction of the line: Σ rises / horizontal length.
Opposite (%)	The weighted slope in the opposite direction: Σ falls / horizontal length.
Length (m)	The horizontal length of the line.
Σ rises (m)	Σ ΔHv: the sum of the rises along the line.
Σ falls (m)	The sum of the falls along the line.
Net grade (%)	(Z end − Z start) / horizontal length.
Mean |grade| (%)	Mean absolute grade: (Σ rises + Σ falls) / horizontal length.
Max / min (%)	The steepest grade of a segment uphill / downhill.
Z ends (m)	Elevation of the start / of the end.
Skipped points	Points left out: without an elevation, or at the position of the point before.
Note	"—" for a normal line. For a line without elevations: "⚠ No elevations: every vertex at one Z (a 2D polyline?) – the slope is 0 %".

The **2 General** group has **Name**, **Colour** and **Visible**, which you can change there, and Code / layer, Closed, Vertices and Breakline of. The explanation of the weighted slope fields (all but Note) and of Breakline of appears below the Properties when you select the field. After **Edit elevations** (section 14.1) the values are computed again. Closed lines are computed back to their first point.

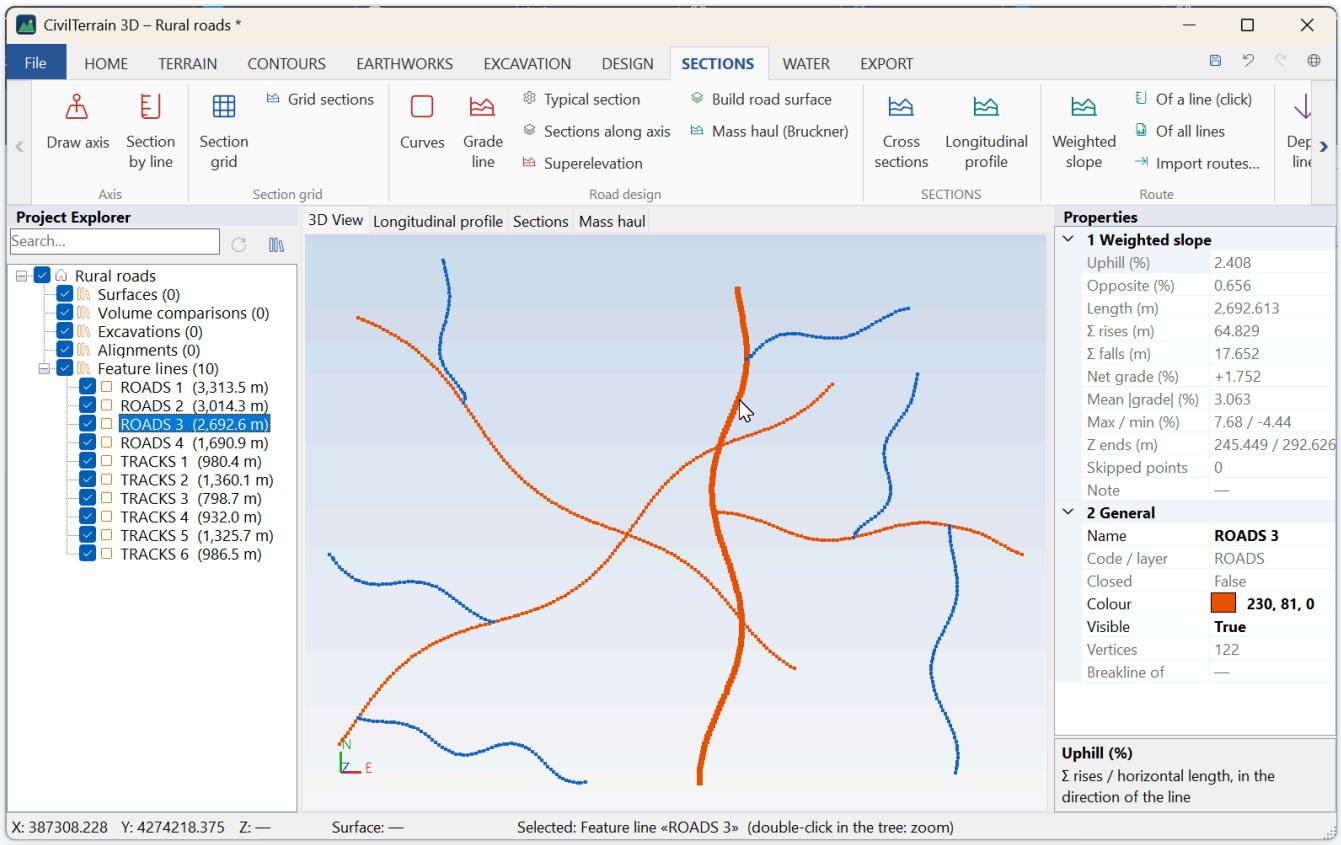


Figure 15.10 – A click on the route “ROADS 3” of the sample 13_diadromes.dxf: its weighted slope (2.408 %) in the Properties, without a surface

Weighted slope of all lines

SECTIONS → Route → Of all lines, or **Weighted slope of all lines…** in the weighted slope window and in the right-click menu of **Feature lines** in the tree. The table has one row for every **visible** 3D line of the project and stays open beside the main window. It follows the project: a new import, an edit, an undo, lines shown or hidden in the tree. If the project has no 3D lines yet, the program offers to import routes.

Columns: No., Route, Code / layer, Horizontal length (m), Σ rises ΔHv (m), Σ falls (m), **Weighted slope uphill %**, Opposite direction %, Net grade %, Max segment grade %, Min segment grade %, Points. The totals are shown above the table, e.g. for the sample `13_diadromes.dxf` (Figure 15.11) “10 routes · 17.095 km · Σ ΔHv 469.86 m · weighted slope of all 2.749 %”: the weighted slope of all is the Σ ΔHv of all routes divided by their total length.

- **Sorting:** click a header (again: the other way round). Names sort with their numbers as numbers (ROADS 2 before ROADS 10).
- **Click a row** (or move with the arrow keys): the line is selected in the tree, its Properties open and the view zooms to it; the **Zoom to** button does the same.
- **Details…**: the full window of the route (below).
- **Copy** (or `Ctrl` + `C`): the selected rows (when you have selected more than one), otherwise all of them, with the headers, to paste into Excel; numbers in the Windows format.

- **Excel**: a **Summary** sheet with one row per route and a **Total** row, and one sheet per route in the layout of the classic sheet of section 15.6. The sheets per route are written for up to 200 routes and 250,000 vertices in all; above that the Excel has the summary only and the program says so (the table of one route: **Details…** → Excel).
- **CSV**: the summary, with `;` as separator and a decimal point.

The exports follow the sorting of the table. Routes **without elevations** are shown in orange with 0 % and are **left out of the totals**, because their slope is not known: above the table it says "⚠ N without elevations (0 %): left out of the totals", and the same note is written below the Total row of the Excel.

The **Also the 3D polylines of the surfaces (breaklines)** check box adds the breaklines of the visible surfaces (e.g. 3D polylines imported into a surface, section 7.2), named "surface · line". It is ticked from the start when the project has no visible 3D lines of its own.

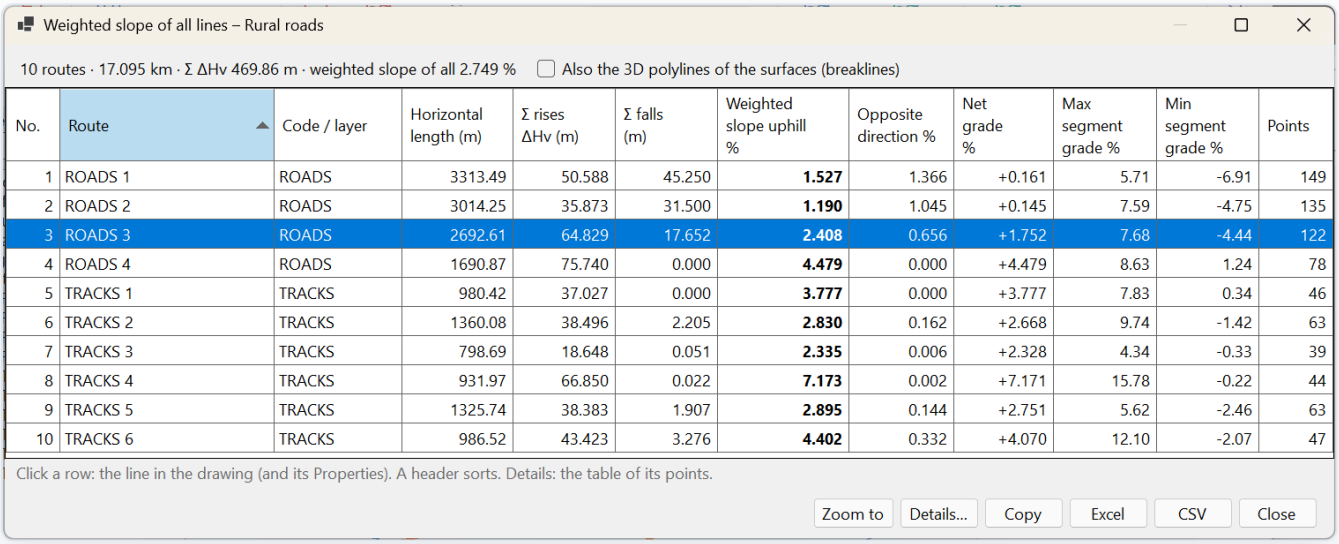


Figure 15.11 – Weighted slope of all lines (sample 13_diadromes.dxf): one row per route and the totals above the table

Right-click: the full window of one route

Right-click a line, in the 3D view or in the tree, and its menu opens: **Zoom to** (the view zooms to the line), **Weighted slope…** (in bold), **Edit elevations…**, **Grade labels** and **Delete**. **Weighted slope…** opens the window of section 15.6 for this line, with the table No., X, Y, Z, Station, ΔX, ΔH, Grade %, ΔHv and export to Excel or CSV. A closed line also has **Platform from this line**, **Polygon earthworks…** and **Zone from this line** in its menu. In the 3D view the right-click menu opens on feature lines only.



Figure 15.12 – Right-click on a route: “Zoom to” the line, and “Weighted slope…”, which opens the full window of the line

With more than 500 lines the tree groups them per code / layer (section 3.2). A project with 3D lines only is saved like any project, and the program asks whether to save it before closing.

Limits

- Every LINE entity of the DXF (a segment of two points) becomes a route of its own; the segments of an exploded drawing are not joined back into routes. Join the segments into polylines in the drawing before the import.
- Changes of name, colour and visibility in the Properties are not undone by **Undo**.
- Routes without elevations (2D polylines) give 0 % and do not count in the totals.
- The tree shows up to 300 lines per layer; the others are in the **Item list** or appear when you select them in the drawing or in the table.

16. Re-measurement with the same sections

To compare surveys from different phases (e.g. the initial survey and the survey after the works) the sections must be at **exactly the same positions**.

16.1 Exporting section positions

SECTIONS → Export positions saves a `.ctsec` file with the axis (vertices with mm precision), the widths and every section:

```
FORMAT;CT3D-SECTIONS;1
NAME;Axis 1
CRS;2100
START;0.000000
WIDTHS;40.000000;40.000000
VERTEX;476290.000000;4205600.000000
...
SECTION;Station;CenterX;CenterY;Azimuth(grad);LeftX;LeftY;RightX;RightY
SECTION;25.000000;476314.9940;4205601.1898;95.9604;476313.0911;4205641.1445;476316.8970;420
```

It is a plain text file that opens in Excel or other software (azimuths in grads).

16.2 Re-creating sections at the same positions

1. Import the new survey as a new surface and make it active.
2. **SECTIONS → Import positions** and choose the `.ctsec` file.
3. In the dialog keep **"Use the stored positions"** checked and choose base/comparison surfaces.
4. The sections are created at exactly the same positions, with the same chainages and widths.

> **Re-measurement:** use the initial survey as base and the final survey as comparison; cut/fill areas per section and average-end-area volumes are exported to Excel and PDF.

16.3 Other section exports

Command	Content
Section points CSV	For every section and surface: chainage, offset, X, Y, Z (real coordinates).
Plan DXF	Axis, section lines and chainages in real coordinates.
Sections PDF / DXF	Section drawings (3 per page in PDF, a grid in DXF) with areas.
Profile PDF	Longitudinal profile on A3 with band table.
Excel	Areas and cumulative volumes per section and the points of every section.

Note: a positions file without VERTEX records (only SECTION) is also accepted; the axis is rebuilt from the section centres.

17. Road design

For rural/forest roads, accesses, platforms and small road works, CivilTerrain 3D builds the **road surface** from the axis, the grade line and the typical section and computes earthworks and the mass-haul diagram. The tools are in **SECTIONS** → **Road design** and in the axis right-click menu.

17.1 Horizontal alignment: arcs and clothoids

Curves: for each vertex (PI) of the axis enter a radius **R** and a clothoid length **L** (0 = none). The deflection angle (grad) and the new axis length are shown. The geometry is checked: if the tangents of two consecutive curves overlap or a clothoid is too long, a warning appears.

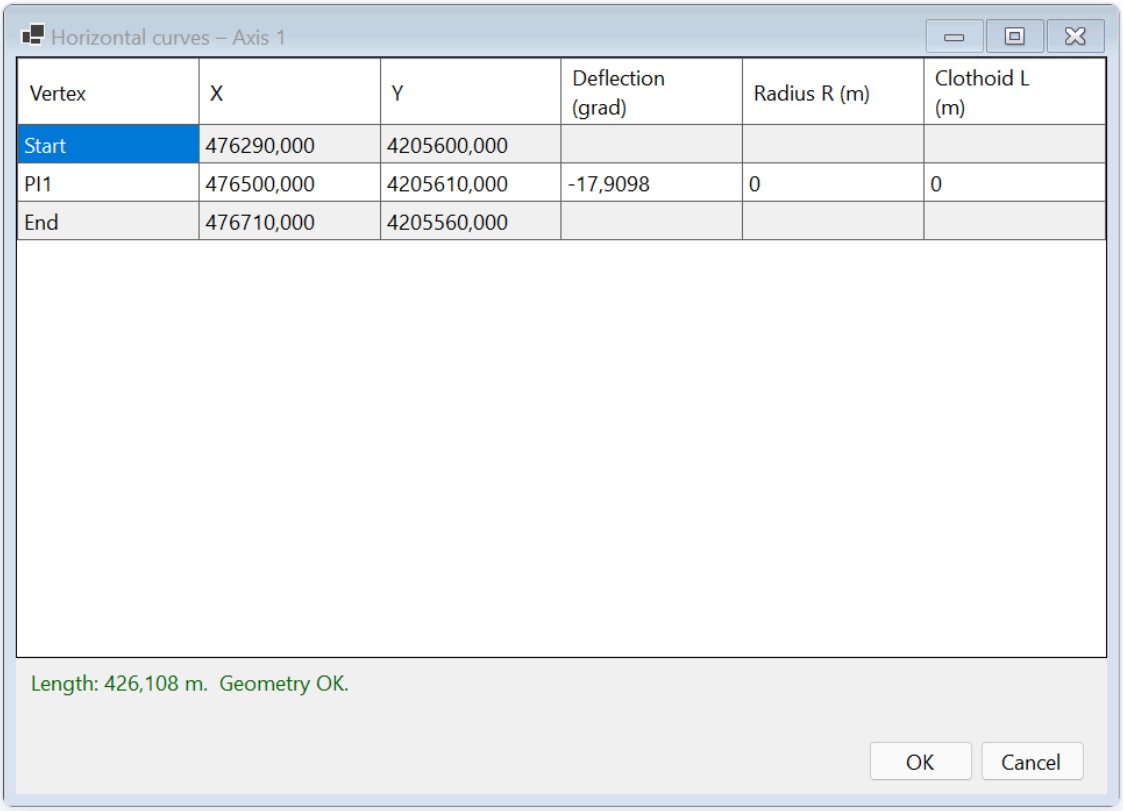


Figure 17.1 – Curves per vertex: radius and clothoid

Stations, cross sections, the profile, position exports and drawings now follow the curved geometry. The key points (TS/SC/CS/ST, BC/EC) are used by the "sections at vertices" option.

17.2 Grade line (design profile)

Grade line: table of VIPs with station, elevation and **vertical (parabolic) curve** length. Grades are computed and the ground elevation is shown. The buttons **Start/end on ground** and **Follow ground** give a quick initial grade line.

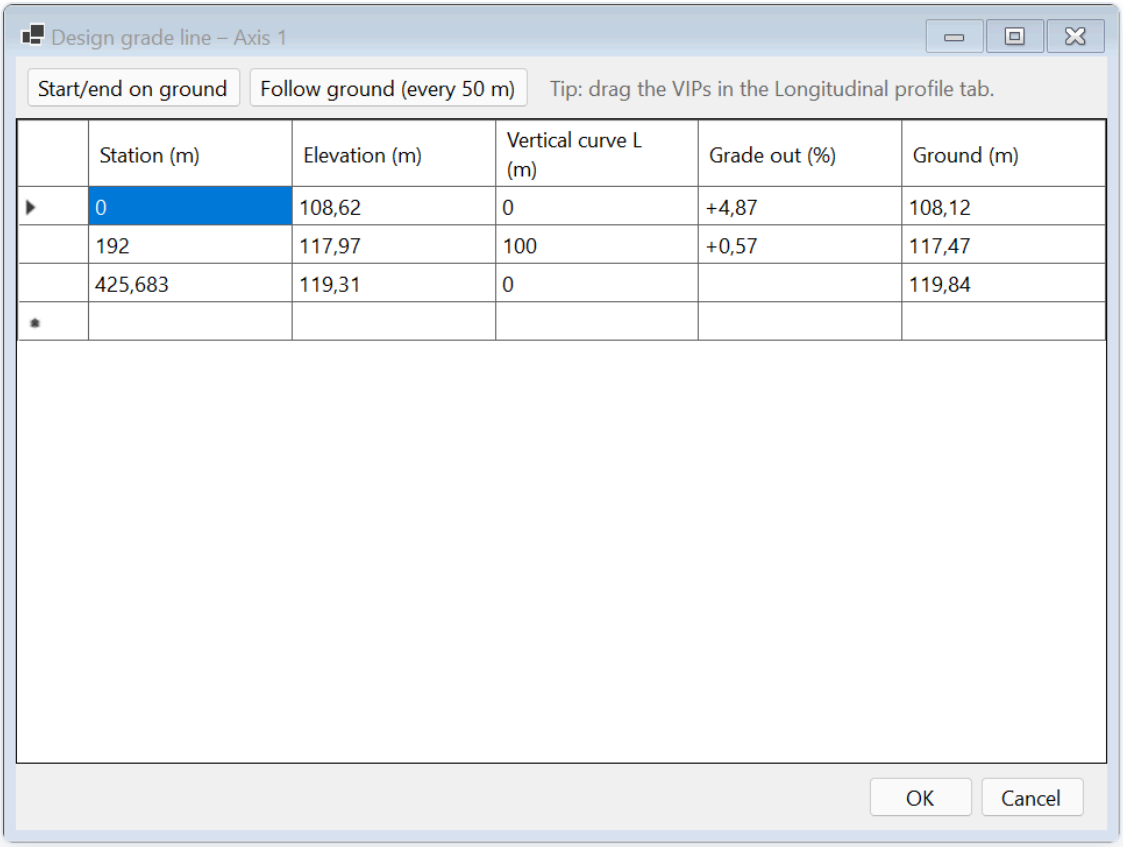


Figure 17.2 – Grade line table

In the **Longitudinal profile** tab the grade line is drawn in red with grades and curve lengths. **Drag the squares** with the mouse to move a VIP (`Shift` = vertical only). The band under the profile shows design elevations and design − ground difference.

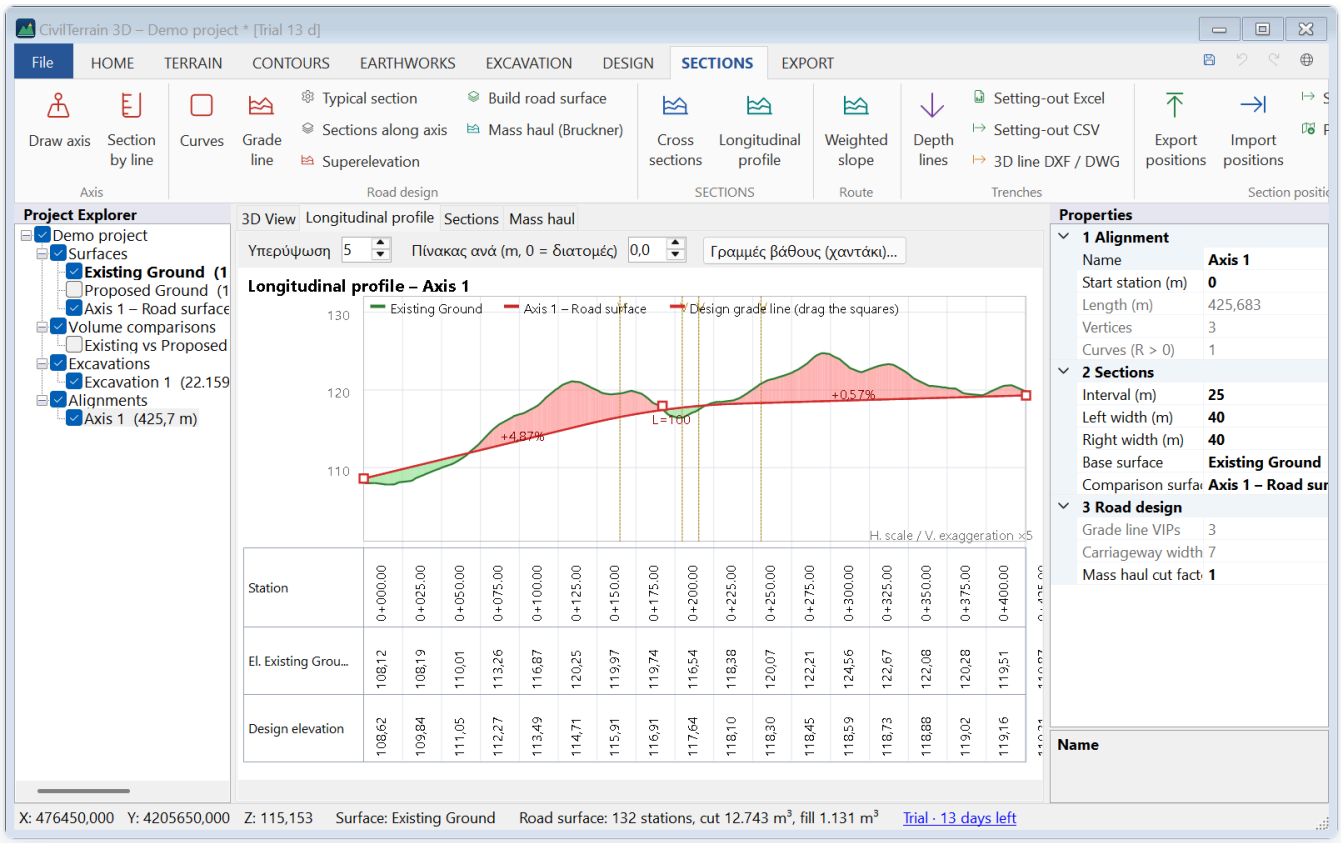


Figure 17.3 – Profile with grade line, grades and vertical curve

17.3 Typical section

Typical section: lane widths left/right, cross fall, shoulder width and fall, cut and fill slopes (H:1), maximum slope width and model station step. The sketch updates as you type.

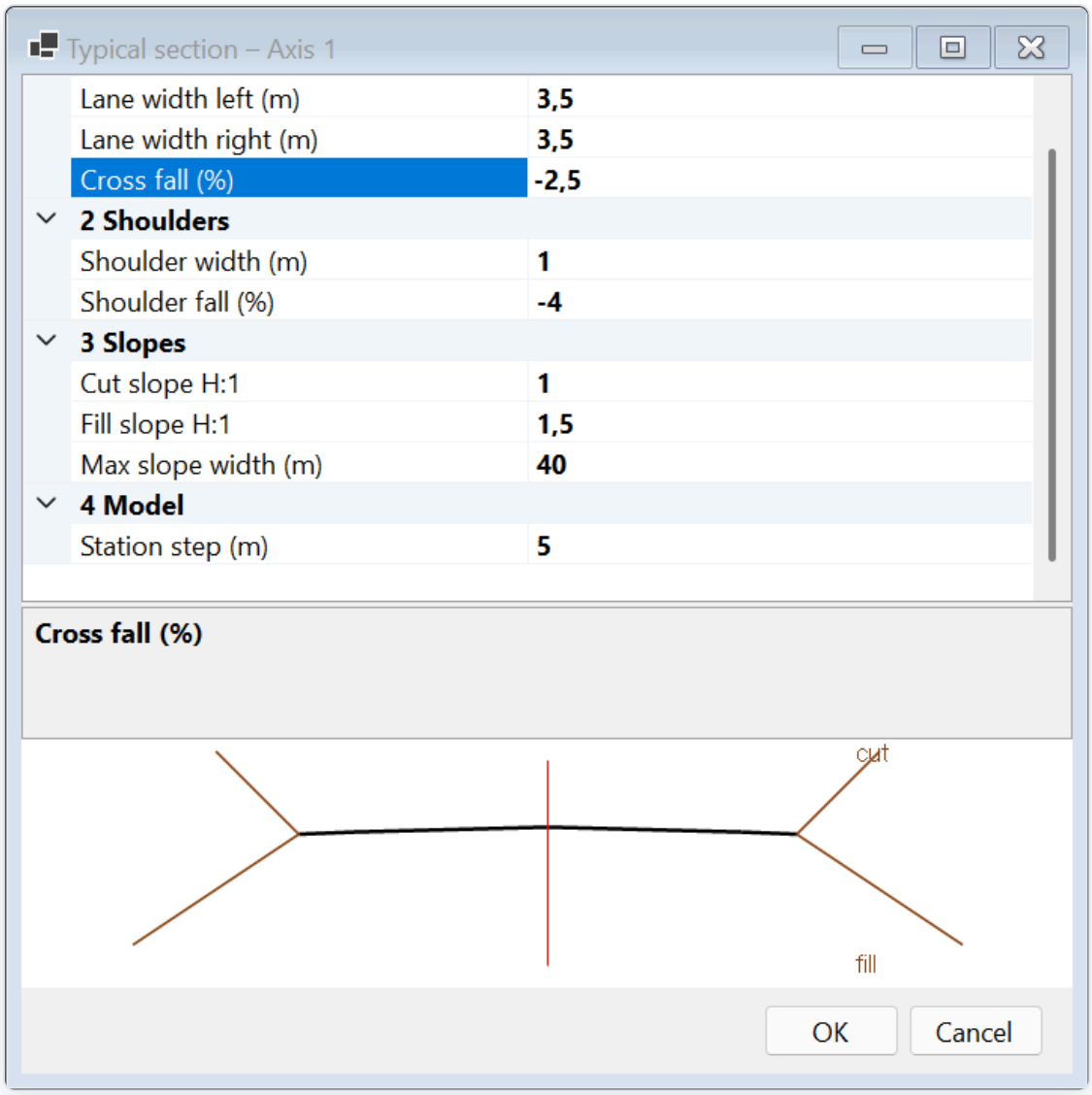


Figure 17.4 – Typical section

17.4 Road surface and earthworks

Build road surface: a 3D surface is created (carriageway + side slopes daylighting on the ground) together with a ground → road volume comparison. The axis is set so that the cross sections show ground and road, with cut/fill areas and volumes. After changing curves, grade line or typical section press **Build road surface** again to update.

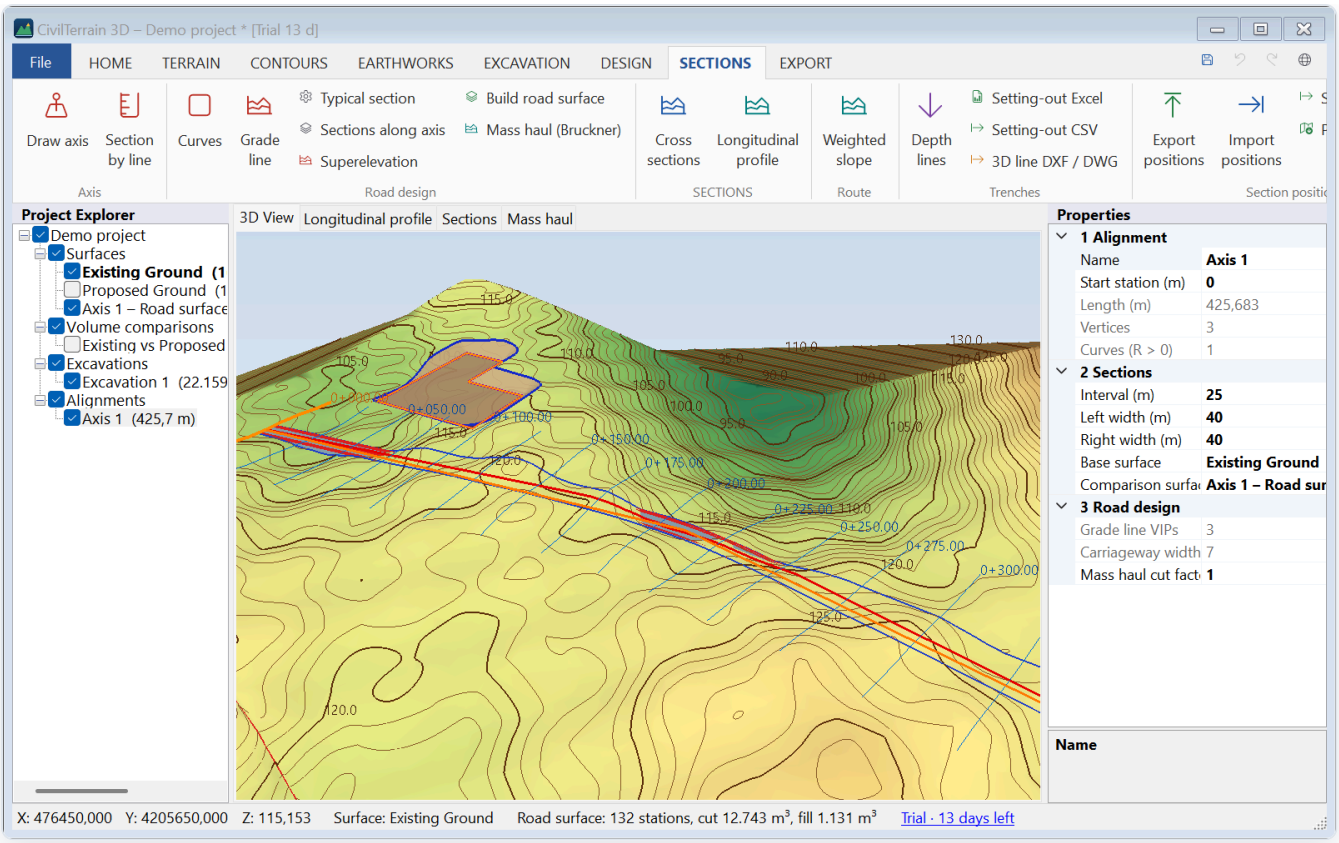


Figure 17.5 – Road surface with side slopes in the 3D model

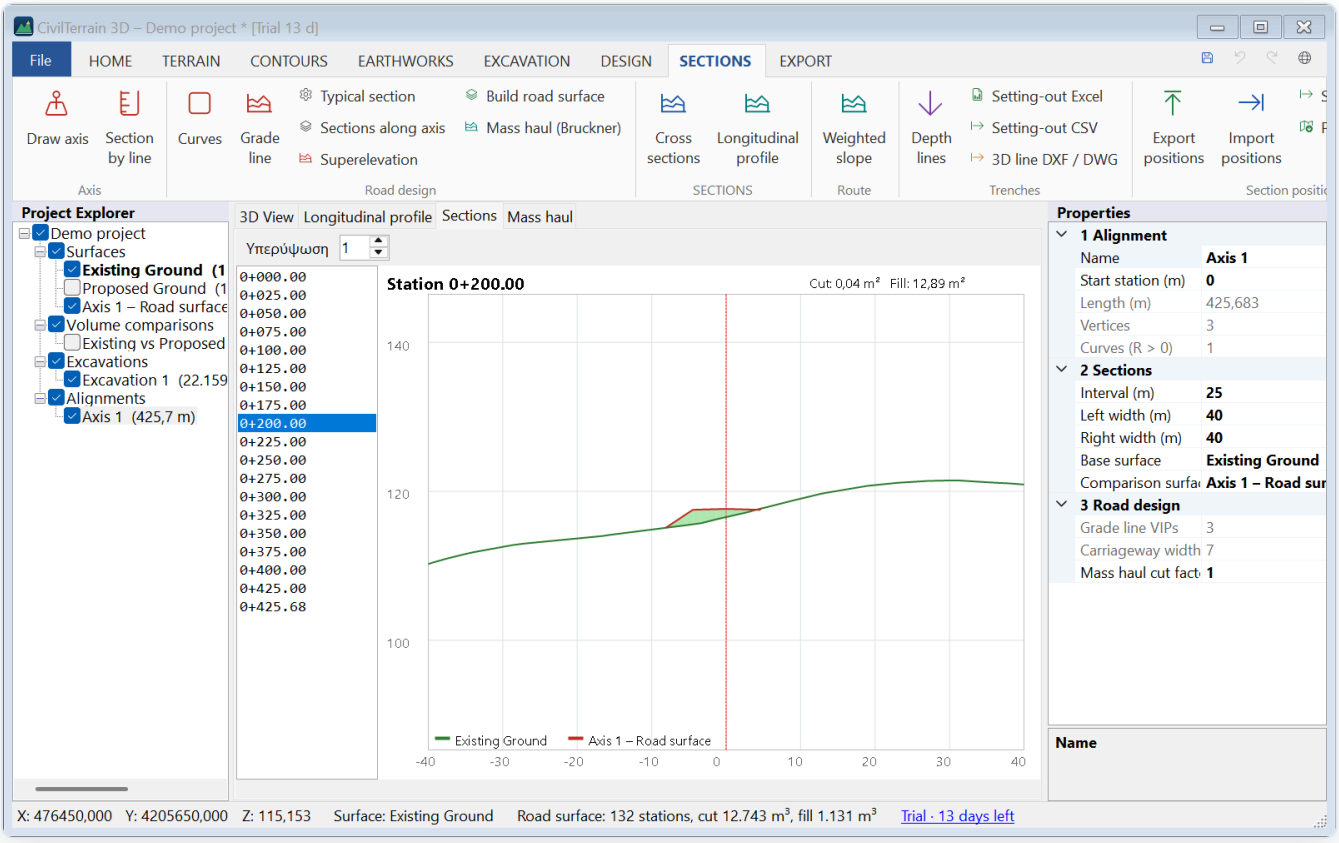


Figure 17.6 – Road cross section: ground, carriageway and slopes

17.5 Mass-haul (Bruckner) diagram

Mass haul (Bruckner): the cumulative volume curve (cut × factor − fill) is computed from the cross sections. The **cut factor** expresses swell or shrinkage (e.g. 0.9). Rising parts = surplus, falling parts = deficit; crossings of the zero line are balance points. Export to Excel with **Bruckner Excel**.

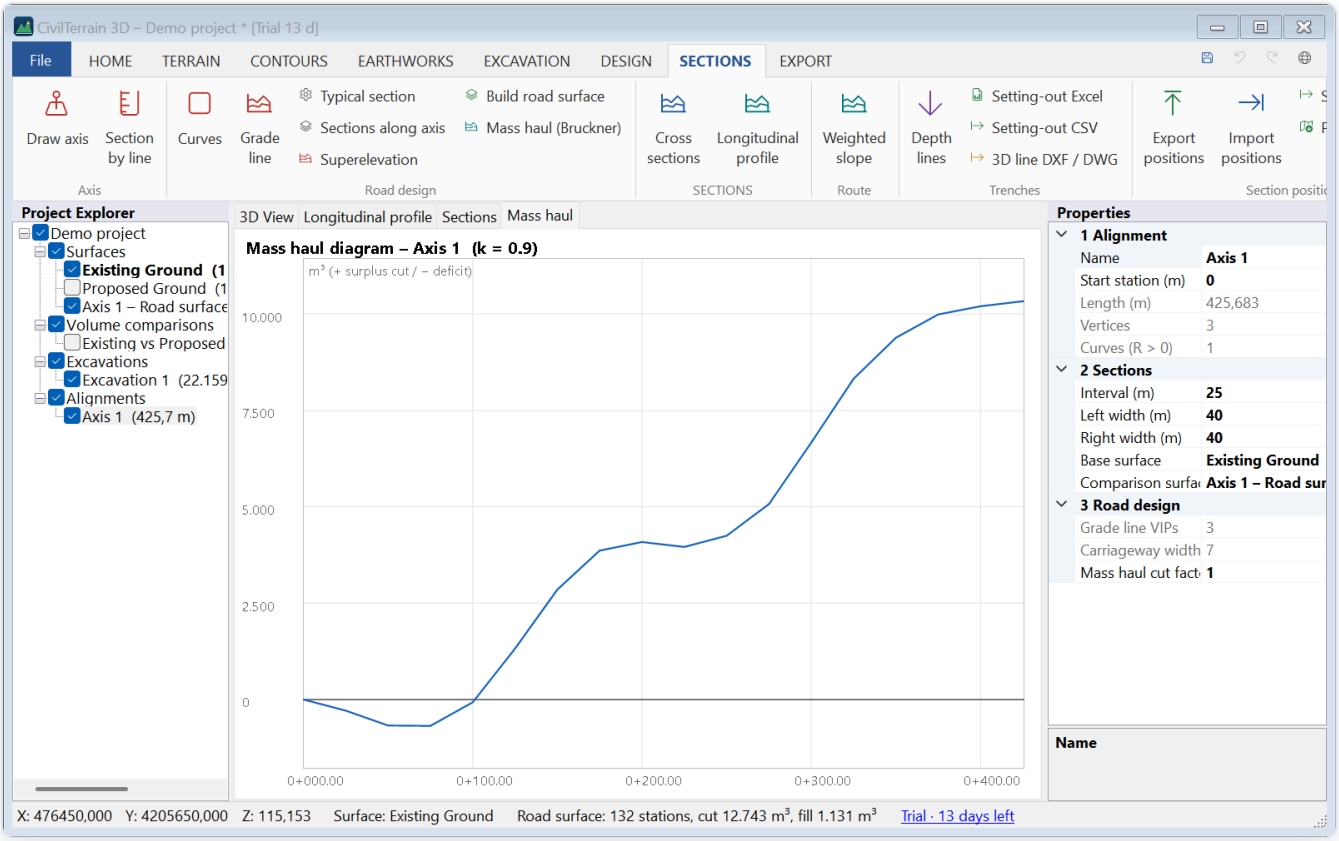


Figure 17.7 – Mass-haul diagram

17.6 Typical sections along the axis and widenings

Sections along axis: add typical sections that apply from a station onwards (e.g. widening in a bend, different carriageway width, other slopes). The change from one to the next is linear over the **transition length**.

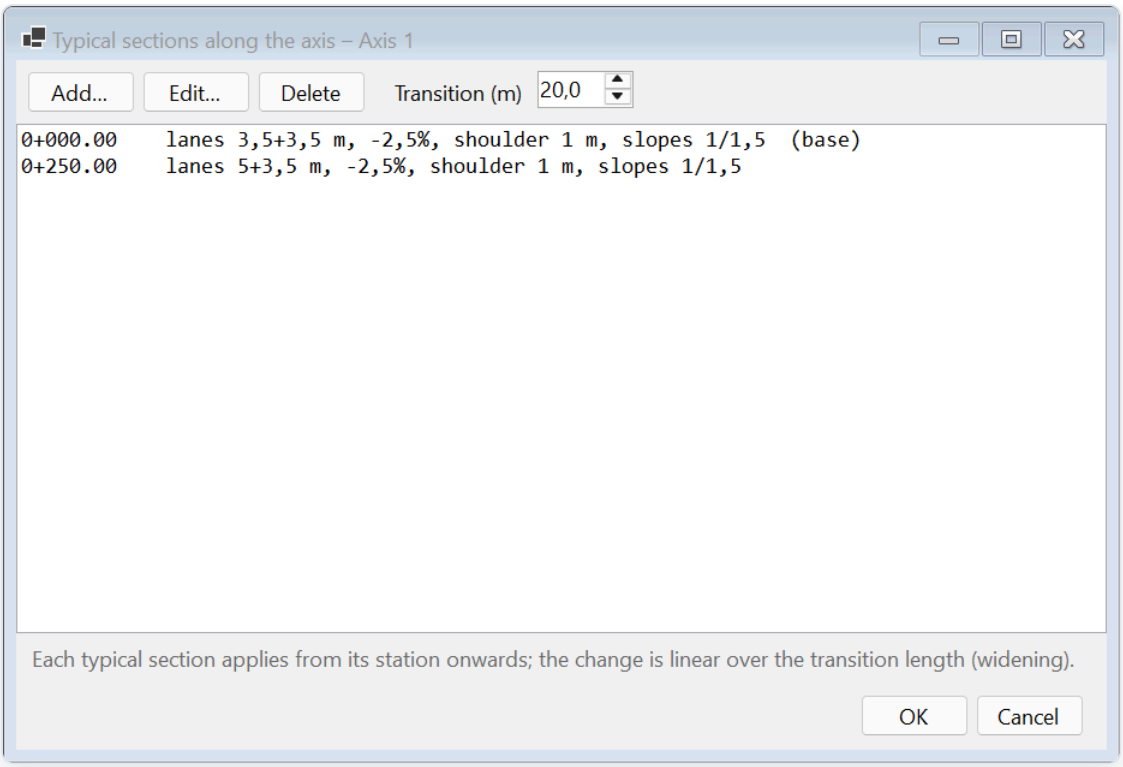


Figure 17.8 – Typical sections per station range

17.7 Superelevation

Superelevation: in curves the carriageway takes a single cross fall towards the inside. The rate is automatic from design speed and radius ($q = V^2/127R - f$, limited to the maximum) or entered per curve. The run-off follows the clothoid or, without clothoid, the run-off length (2/3 on the straight, 1/3 in the arc). The superelevation diagram shows left and right cross fall along the axis.

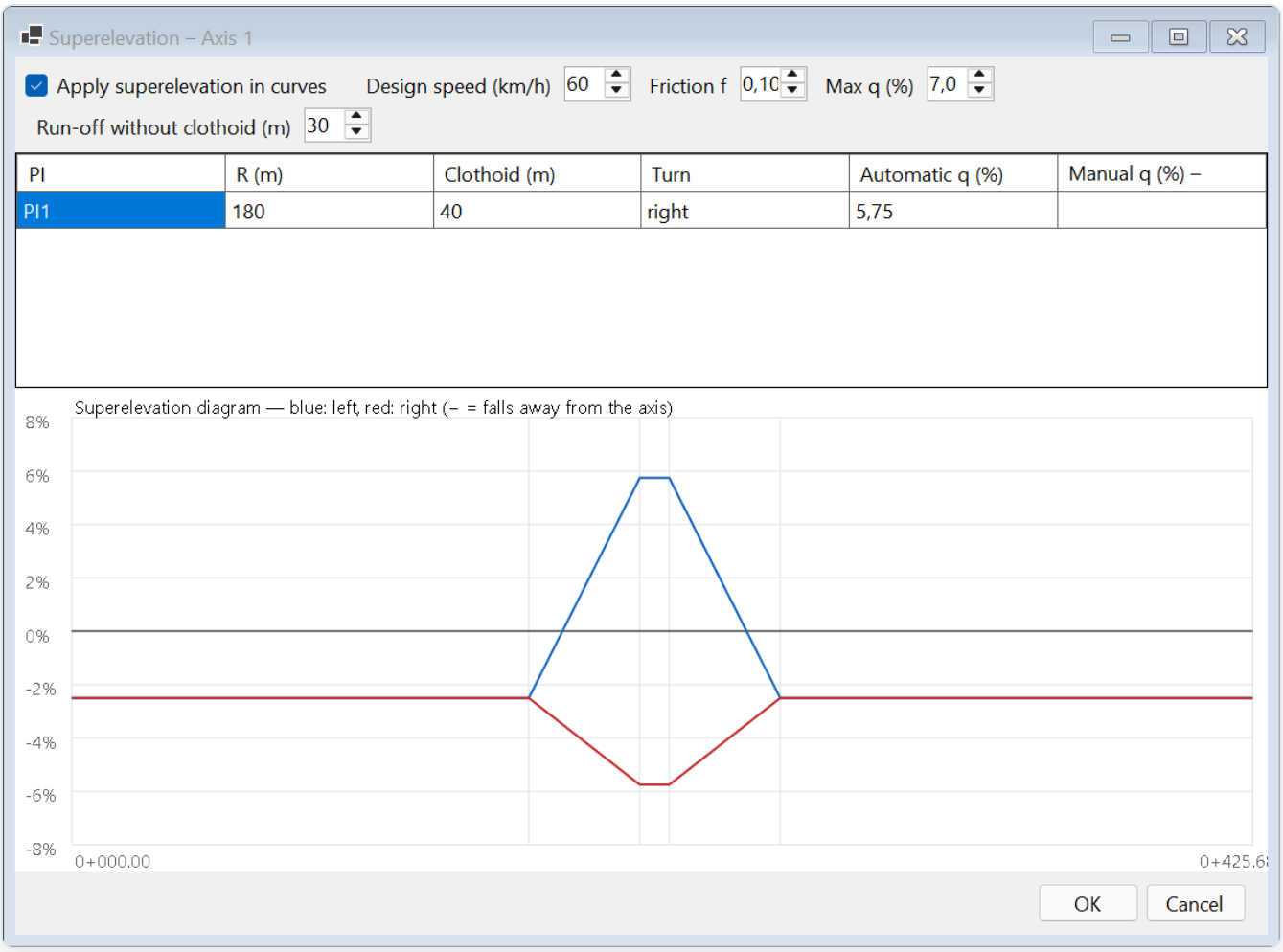


Figure 17.9 – Superelevation settings and diagram

18. Dynamic labels

The labels of **DESIGN → Labels** are **dynamic**: the text is computed from the geometry, so it updates by itself when the terrain, the axis or the line changes.

Label	Content
Spot elevation	Cross and elevation of the active surface (repeating).
Slope arrow	Downhill arrow with the surface slope at the point.
Slope between points	Surface slope between two points.
Axis stations	Stations at the label interval and key points (TS/ST, BC/EC).
Curve data	R, clothoid A and L, T, arc length and angle for each vertex.
Line grades	Grade and length of each segment and vertex elevations of a feature line.
Text	Free text.

Label style sets text height (plan metres), decimals, elevation prefix, slope as % or 1:n and station interval. Labels appear on screen (overlapping ones are hidden until you zoom in), on PDF sheets and in the DXF/DWG drawing.

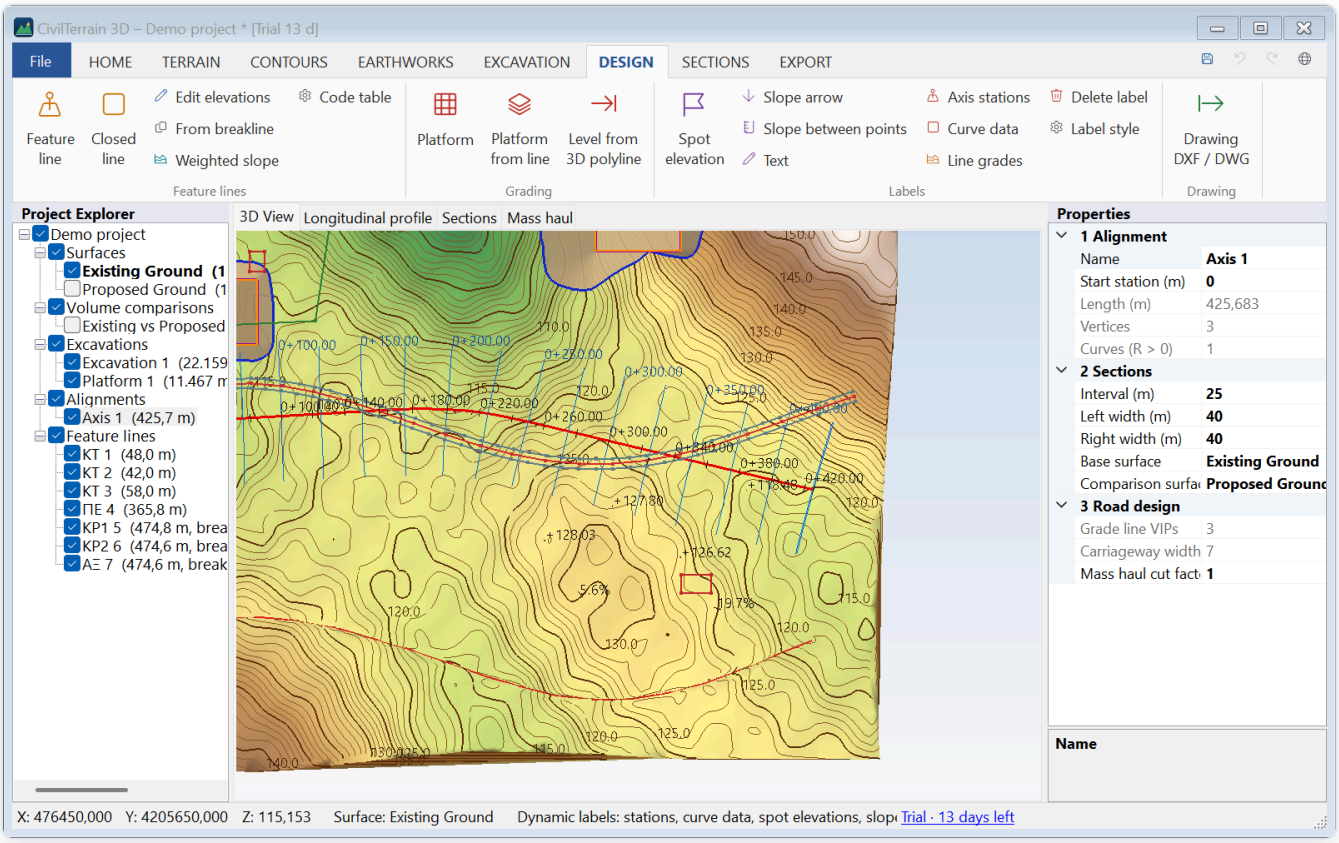


Figure 18.1 – Dynamic labels: stations, spot elevations and slopes

19. Technical reports

EARTHWORKS → Report PDF / Report Excel for the selected volume comparison (or **EXCAVATION → Report PDF** for an excavation). The PDF report contains:

- project name, date, author, coordinate system;
- the compared surfaces with points, triangles, areas and elevation range;
- the excavation data (if any);
- results: cut, fill and net volume, areas, maximum depths, cut / fill centroids and the distance between them, computation time (with topsoil: also the volumes without stripping);
- **balance and haulage** (loose volumes, weight, surplus / borrow, truckloads) and the **waste (ΣΔA)** table with the project factors;
- volumes per zone (all zones, continued on the next page);
- the calculation method and a page documenting it;
- a cut/fill plan with legend, scale bar, north arrow and an image of the 3D model (as currently shown on screen).

The Excel report contains sheets for results, balance – waste, surfaces, zones and, if computed, sections. The excavation report prints all parameters (cut / fill slopes, per side, platform grades, balance factor). Polygon earthworks (§12.6) and spot grids (§5.4) have their own reports.

> **Tip:** before creating the PDF, set the 3D view the way you want it to appear in the image.

19.1 Scaled drawing sheets

For deliverable drawings: **EXPORT → Plan sheet (scale)** and **SECTIONS → Section sheets (scale)** create PDFs on A4–A0 paper (landscape) with:

- frame, coordinate grid, north arrow and scale bar;
- a **title block** with title, drawing number, company/office, scale, coordinate system, date and **logo**;
- plan: triangles, contours with labels, axes with sections and zones (optional);
- sections: consecutive sheets with as many sections as fit, at the horizontal/vertical scale you choose (e.g. 1:200 / 1:100), with cut/fill areas.

Company and logo are stored in the project. Print the PDFs at actual size (no "Fit to page").

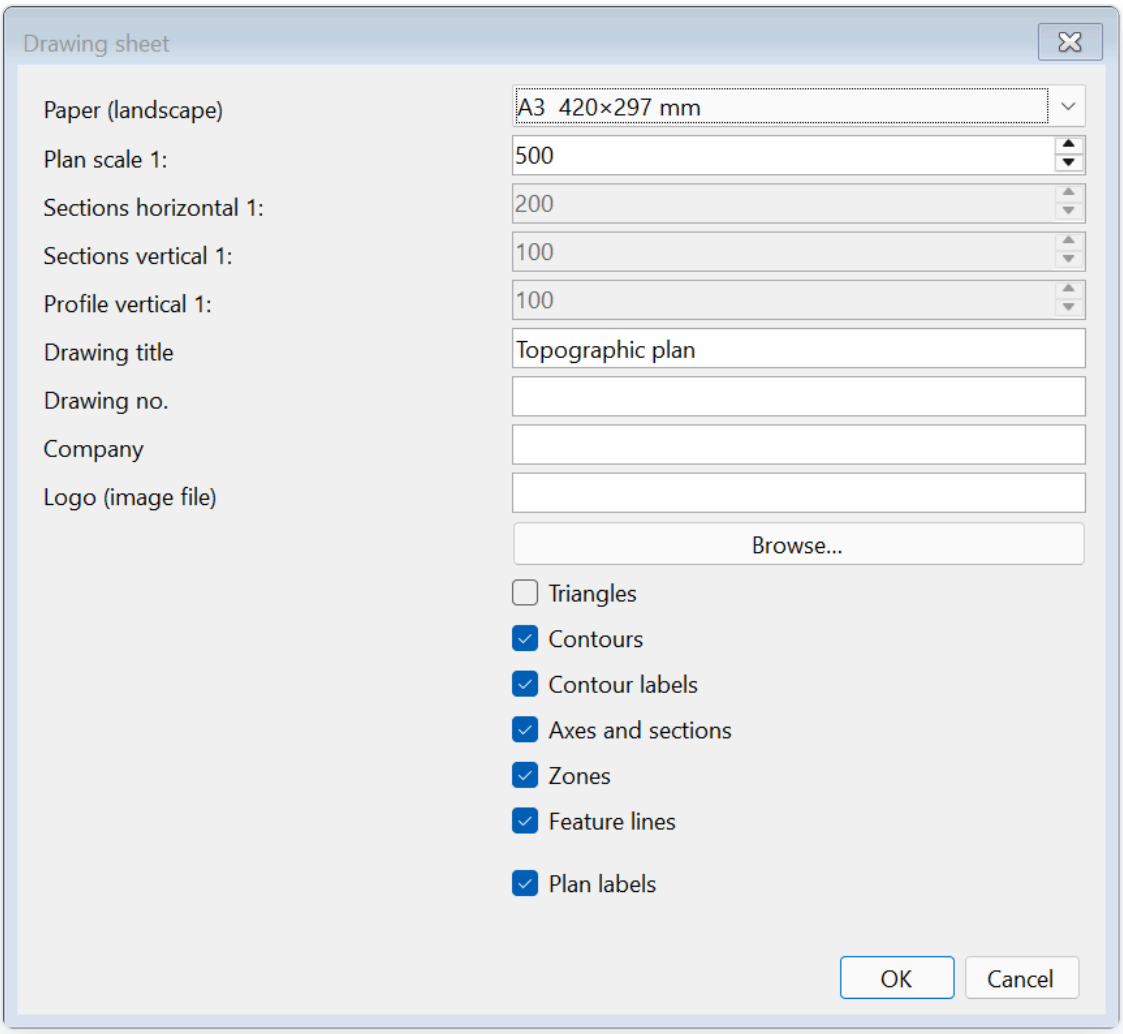


Figure 19.1 – Drawing sheet settings

19.2 Plan-profile sheets

SECTIONS → Plan-profile sheets: the axis is split automatically into parts that fit the paper at the chosen scale. Each sheet shows the plan **rotated along the part** (contours, axis with stations, lines, labels, north arrow, **match lines** to the neighbouring sheets) above the profile of the same stations with grade line, grades, cut/fill and data band. The profile vertical scale is set separately.

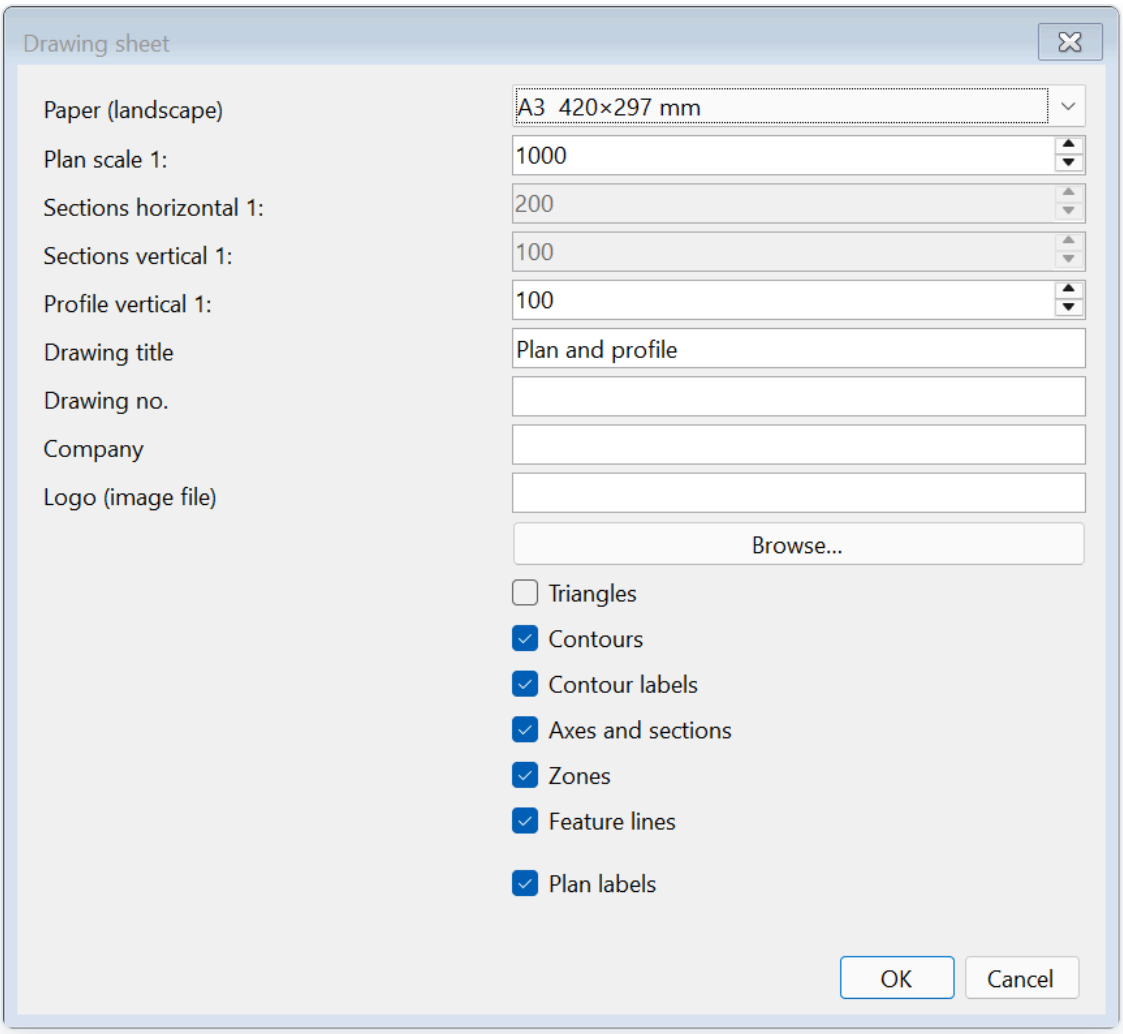


Figure 19.2 – Plan-profile sheet settings

20. Exporting data

The **EXPORT** tab exports the active surface:

Format	Content / notes
DXF	Triangles (3DFACE), contours, labels, breaklines, boundaries on separate layers. Compatible with all CAD (R12).
DWG	Every CAD export (surface, contours, sections, axis plan) can also be saved as DWG (AutoCAD 2013 format) — choose "DWG" as file type.
Drawing DXF / DWG	**DESIGN → Drawing DXF / DWG**: contours, feature lines on layers per code, axes, zones, labels, **polygon earthworks** (outline with design elevations, zero line, daylight) and **excavation daylight / bottom** — ready for AutoCAD / Civil 3D.
LandXML	TIN surface with breaklines and EPSG (Civil 3D and other software).
CSV / XYZ	TIN vertices with 0.1 mm precision.
Spot grid	**EXPORT → Points → Spot grid**: the points of a spot grid as CSV (PT,X,Y,Z,CODE), TXT (PNEZD), DXF / DWG (SG_… layers), Excel or PDF with a plan at scale (section 5.4).
LAS	Points as LAS 1.2 with EPSG.
OBJ / STL	Mesh for 3D software and printing. Writing relative to an origin is recommended (STL is always relative) to keep precision.
GeoTIFF	Gridded DEM with selectable cell size, georeference, NoData and .tfw / .prj files.
ESRI ASCII Grid	DEM as text (`.asc`) with selectable cell size and a `.prj` file — for GIS and hydraulic / hydrological software.
PDF plan	Plan with contours, labels and triangles.
Image (PNG/JPG)	The current 3D view.

A `.prj` file with the project coordinate system is written next to DXF/CSV/XYZ/OBJ/STL/LAS exports.

21. Coordinate systems

EPSG	System
2100	GGRS87 / Greek Grid (default)
4326	WGS 84 (geographic degrees)
4258	ETRS89 (geographic degrees)
32634 / 32635	WGS 84 / UTM 34N, 35N
25834 / 25835	ETRS89 / UTM 34N, 35N
3857	Web Mercator
—	Local system (no transformation)

Transformations are applied on import (field "Source CRS" or "File coordinate system"; for DEMs the system is also read from the `.prj`). The Transverse Mercator projection is computed with sub-millimetre accuracy; the GGRS87 ↔ WGS84 conversion uses the official 3-parameter shift (about 1 m absolute accuracy). Elevations are not changed.

22. Shortcuts and controls

Key / mouse	Action
`Ctrl` + `N` / `O` / `S`	New / Open / Save project
`Ctrl` + `Z` / `Ctrl` + `Y`	Undo / Redo
`F5`	Rebuild the TIN of the active surface
`Enter` / double-click / right-click	Finish drawing a line or polygon
`Backspace`	Remove the last vertex while drawing
`Esc`	Cancel tool / clear selection
Left drag	Orbit
Right / middle drag, `Shift` +left	Pan
Wheel	Zoom to cursor
Double-click in the tree	Zoom to the item
Right-click (without dragging) on a feature line, in the 3D view	The menu of the line: Zoom to, Weighted slope…, Edit elevations…, Grade labels, Delete (section 15.7)

23. Sample data

In the `Samples` folder of the installation (shortcut in the Start menu):

File	Content
00_etoimo_ergo.ct3d	Complete project with surfaces, volumes, excavation and axis
01_topografiko_EGSA87.csv	3,000 points with codes (`;` , decimal comma); the BL points form a ditch
02_simeia.xyz	XYZ points without header
03_meleti_platia.xml	Design surface (LandXML) for volume comparison
04_topografiko.dxf	Points and a 3D breakline
05_lidar.las	Point cloud with 200,000 points
07_orthofoto.jpg (+ .jgw)	Sample orthophoto with world file for project 00 / CSV 01
08_kodikopoiisi.csv	Survey with Greek field codes (curbs ΚΡ1/ΚΡ2, axis ΑΞ, buildings ΚΤ, fence ΠΕ, trees ΔΕ) for automatic linework
09_epipedo_3dpoly.dxf	Cut-and-fill level as 3D polylines (outline + ridge) for the demo project
10_zones_kyvismou.dxf	Outlines of volume areas with names (texts) for the zone import and polygon earthworks
11_diadromi.csv	Route points every ~20 m for the weighted slope
12_dromos_lidar.las	LiDAR cloud of a road on a hillside (cut with a ditch, fill, curve, vehicles, trees, shrubs) for following a road (section 8.4); unclassified (class 1), as it comes
13_diadromes.dxf	10 routes (3D polylines) in GGRS87, 17 km in all, on the layers ROADS and TRACKS, and a 2D frame on the layer FRAME, which starts unticked in **Import routes**; try **SECTIONS → Route → Import routes...** (section 15.7)
06_dem.tif	DEM on a 2 m grid

Exercise: import 01 (with "Codes as breaklines"), then 03, create a volume comparison and a PDF report; then draw an axis and produce a profile and sections.

24. Troubleshooting

Problem	Solution
Windows shows a warning during setup	Click "More info → Run anyway". Always download from civilshop.gr.
The 3D view is empty or shows "OpenGL unavailable"	Update the graphics driver. Over Remote Desktop OpenGL may not be available.
LAZ does not open	Put `laszip64.exe` in the installation `tools` folder or convert to LAS.
Points in the wrong place after import	Check the X/Y columns (or "Swap X/Y") and the "Source CRS".
Long "bridge" triangles at the edges	Set **Max edge length** or an **Outer boundary**.
Message about breaklines not inserted	Breaklines crossing boundaries or other lines inconsistently; check the data.
"Could not contact the license server"	Check Internet/firewall. The program keeps working for 7 days offline.
"This TIFF is a picture, not elevations"	The file is a coloured image (e.g. an elevation map). Ask for the DEM with elevation values (e.g. Float32 or Int16) or load the image as an orthophoto.
The DEM appears far from the project	Check the "File coordinate system" in the DEM import dialog (e.g. WGS 84 for SRTM and Copernicus, GGRS87 for Hellenic Cadastre DEMs).
Slow with very large files	Use grid thinning when importing LAS, or DEM thinning.
Trucks and machines in a drone survey count in the volumes	**TERRAIN → Remove objects** (section 10.4): automatic detection, check the list, **Apply**. For debris or a pile inside an excavation: **Replace terrain** (section 10.5). The ground filter does not run on a triangle mesh (DEM / DSM, LandXML, OBJ / PLY).
The spot grid is not created ("Too many points (more than 250,000)…") or its DWG is not written	A spot grid takes up to 250,000 points: increase the spacing or make the perimeter smaller. A DWG is written for up to 50,000 points; save it as DXF (the same layers) or CSV.
How do I get the weighted slope of many routes without	**SECTIONS → Route → Import routes…**: the 3D polylines of the DXF / DWG become 3D lines without a surface. Click a line: its weighted

a ground surface?	slope is in the Properties; all of them together are in the **Weighted slope of all lines** table, with Excel / CSV (section 15.7).

The error log is in `%APPDATA%\CivilTerrain3D\error.log`; send it with a description of the problem to **Info@civilshop.gr**.

25. Technical notes and accuracy

- **Triangulation:** Delaunay (sweep-hull, O(n log n)) with constrained edges for breaklines and boundaries; crossing breaklines are split automatically.
- **Coordinate precision:** all calculations are in double precision in a local reference frame; GGRS87 coordinates are kept without rounding.
- **Volumes:** exact overlay of the two TINs (triangle intersection) and integration of the linear elevation difference on every polygon, with an exact split at the zero-difference line. No grid approximation is used.
- **Contours:** computed from the TIN edges as topologically continuous lines.
- **Excavation:** slopes are defined as the union of per-side wedges; the daylight line is found numerically (marching and bisection) on the real TIN.
- **Verification:** the software is tested automatically against examples with known results (pyramid, inclined planes, frustum, Steiner formula for pits, etc.).
- **Performance:** TIN of 300,000 points in about 1 second; volume comparison of 300,000 × 100,000 triangles in about 2 seconds (typical laptop).
- **Remove objects / replace terrain:** the new ground is computed on a grid inside the outlines, with the elevations held on a strip about 1 m wide around them. Smooth surface: the Laplace equation (a membrane) solved by conjugate gradients; plane: least squares; lowest level: about the 5th percentile of the strip; both for each outline (together for outlines that touch or overlap). Up to 500,000 nodes per computation; on larger outlines the spacing grows by itself. The removed / added volumes are the cut and fill between the TIN before and after, measured on the triangles that changed (the same as a volume comparison of the two surfaces).
- **Automatic object detection:** the surface is turned into a 0.25 – 0.5 m grid; a morphological opening with a window as large as the largest machine gives the ground, and every group of cells more than 0.80 m above it is checked for size, plan, steep sides, a flat top and lower, even ground around. The shape measures are taken from areas within contours, not from single cells, so noise does not make a pile look like a machine.
- **Spot grid:** the elevation of every point is interpolated linearly on the TIN triangle that holds it; up to 250,000 points per grid. A point of the perimeter within 2% of the spacing of a grid node (at most 5 cm, at least 2.5 mm) is that node.

> **Engineer's responsibility:** results depend on the quality of the input data and must be checked by the engineer using them.