



GEM4D DOCUMENTATION

Reconstructing a Surface from a Point Cloud

User Manual

PRODUCT	GEM4D
DOCUMENT	Reconstructing a Surface from a Point Cloud — User Manual
VERSION	1.9.1.4
DATE	6 October 2026

Contents

1. What this covers	2
2. Quick start	3
Route A — straight from a file to a surface	3
Route B — keep the cloud and build the surface later	3
3. Key ideas	4
3.1 The voxel cell sets the detail	4
3.2 Open surface or watertight solid	4
3.3 Settings measured in "× point spacing"	4
3.4 What goes into the surface	4
3.5 Mesh or Image	5
4. Loading a LAS/LAZ file	5
4.1 The dialog, top to bottom	5
4.2 Which option to choose	6
4.3 The recommended point count	7
4.4 After loading	7
5. Removing stray points: Denoise point cloud	7
6. The Reconstruct surface from points dialog	7
6.1 Preset	9
6.2 Voxel downsample cell (m; 0 = use all)	10
6.3 Texture from points colours - save image as Save OBJ	10
6.4 Texture quality	10
6.5 Remove outliers before reconstruction (statistical)	11
6.6 Remove small disconnected fragments (confetti)	11
6.7 Show advanced settings	11
6.8 Watertight solid (closed surface — wraps a volume)	11
6.9 Cell size (× point spacing; lower = finer)	11
6.10 Normal estimation neighbours (kNN)	12
6.11 Influence radius (× spacing) — open only	12
6.12 Cap openings (open only; close tunnel ends / scan edges)	12
6.13 Repair surface (fill holes; genuine openings stay open)	12
6.14 The Measured and Predicted lines	12
7. Running the reconstruction and keeping the result	13
7.1 Before the run	13
7.2 While it runs	13
7.3 A plain (untextured) surface is saved as DXF	13
7.4 A textured surface becomes an Image	14
7.5 Keeping everything together	14
8. Recipes	14
9. Troubleshooting	14
9.1 The result looks wrong	14
9.2 Messages	15
10. Reference	16
10.1 Reduce point cloud dialog	16
10.2 Reconstruct surface from points dialog	16
10.3 What happens in a run, in order	17

This manual shows you how to turn a scanned point cloud into a triangulated surface in GEM4D. The scan can be LiDAR or photogrammetry of a drive, a slope, a face or a stockpile. You can paint the scan's own colours onto the surface, or leave it plain.

Accuracy. A reconstructed surface is an interpolation of the points, not a survey. It follows the points to within about one grid cell (about 0.2 m at the default settings). It smooths out detail smaller than the voxel cell (§3.1). It also adds new geometry wherever **Repair surface** or **Cap openings** fills a gap. Compare the surface with the cloud before you use it for volumes, profiles or stability analysis.

How to use this manual

If you want to...	Read
Get a surface from a scan quickly	§2 Quick start
Understand the few ideas that matter	§3 Key ideas
Load a LAS/LAZ file and choose how many points to keep	§4
Clean stray points out of a cloud	§5
Look up a setting in the reconstruction dialog	§6
Know what happens when you press OK, and keep the result	§7
Find settings for a particular job	§8 Recipes
Fix a poor result or understand a message	§9 Troubleshooting
Check a default or a range	§10 Reference

1. What this covers

Three tools work together:

Tool	Where	What it does
Reduce point cloud dialog	Opens every time you load a LAS/LAZ file	Thins the cloud as it loads. Also asks whether you want to keep the points or go straight to a surface.
Denoise point cloud (remove outliers)	Toolbox 1	Removes stray points from a loaded cloud.
Reconstruct surface from points	Toolbox 1	Builds the surface.

Toolbox 1 is a drop-down button on the scene toolbar. It shows an icon only; hover over it to see its name.

The result is either a **mesh** (one plain colour) or an **Image**. An Image is a surface with the scan's colours painted on as a picture (a *texture*). Images are managed in the Image panel, which is described in Image_Objects_Manual.md.

This manual is the only one that covers loading LAS/LAZ files. It does not cover mapping joints from a cloud (**Auto mapping from points** and best-fit discs on points — see Wedge_Facet_Mapping_Manual.md) or saving a cloud in a project file (see Project_File_Manual.md).

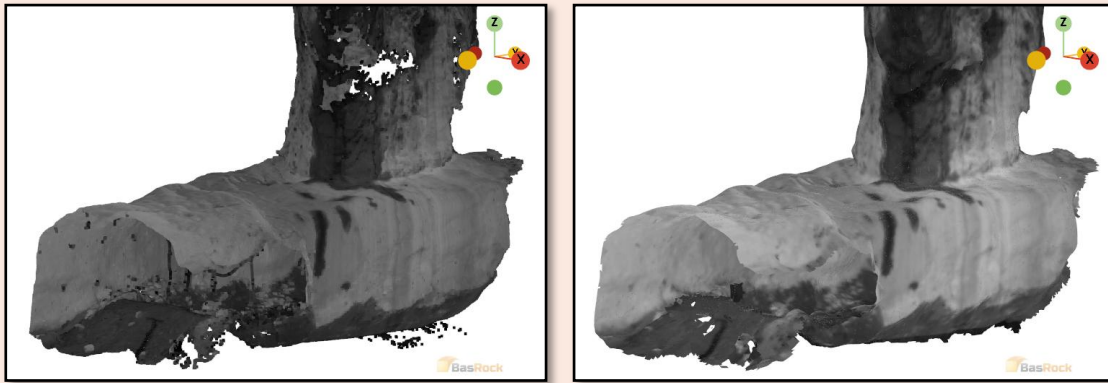


Figure 1: A shaft scan shown as a coloured point cloud (left) and the textured surface reconstruction (right).

2. Quick start

Route A — straight from a file to a surface

Use this route when you only want the surface, not the points.

1. Click **Mesh ▸ Load other formats ▸ Other formats ▸ Point cloud (LAS/LAZ)** and choose the file. You can also drag the file onto the scene.
2. In the **Reduce point cloud** dialog, select **Create a mesh surface from the points, after which the points are removed**. Leave the reduction option as it is. Click **OK**.
3. The **Reconstruct surface from points** dialog opens on the **Auto (recommended)** preset. Click **OK**.
4. A progress window shows each stage. **Cancel** stops the run.
5. Save the result:
 - **Without colour**, a Save dialog asks for a DXF file name. **Save the file. If you cancel this dialog, the new surface is deleted.**
 - **With colour**, GEM4D asks whether to save the surface as a textured OBJ. **Yes** writes an .obj, an .mtl and one or more .png files. **No** keeps the surface in the scene, unsaved.
6. Only the surface is shown; the points are released. If you cancel a later step, or the run fails, the points are added to the scene instead, and the Info panel says so.

Route B — keep the cloud and build the surface later

1. Load the file as in Route A, but keep the default choice, **Load the points cloud into the scene using the reduction options below**.
2. If the scan has stray points, run **Toolbox 1 ▸ Denoise point cloud (remove outliers)** (§5).
3. Hide every object you do not want in the surface. Reconstruction uses **all** visible meshes and clouds (§3.4).
4. Click **Toolbox 1 ▸ Reconstruct surface from points**, then **OK**.
5. Save the result as in Route A, step 5.

3. Key ideas

3.1 The voxel cell sets the detail

A **voxel** is a small cube of space. *Voxel downsampling* keeps one point for each cube that contains points. That point sits at the average position of the points in the cube and carries their average colour. The result has an even density, which is the best input for building a surface.

In the reconstruction dialog, **Voxel downsample cell (m; 0 = use all)** is the main control. The finished surface shows detail of about this size. The Auto preset uses **0.25 m**. Underground excavation scans are rough and noisy, and below about 0.25 m most of what you see is scanner noise. A larger cell gives a smoother surface and a faster run. A smaller cell gives finer detail, but the run is slower and the surface is noisier.

The load dialog also has a voxel option (§4). It controls how many points come into GEM4D. **The surface detail follows whichever of the two voxel cells is coarser.** For example, if you load at 0.5 m, the reconstruction's 0.25 m cell removes almost nothing and the surface has about 0.5 m detail.

3.2 Open surface or watertight solid

	Open surface (default)	Watertight solid
Use it for	Anything open-ended or scanned from one side: drives, tunnel networks, walls, faces, benches	A cloud that completely surrounds an object: a stockpile or muck pile scanned all the way round, an ore block
What you get	A skin that stops at the edge of the data	A closed solid
How to choose it	Leave Watertight solid unticked	Tick Watertight solid (under Show advanced settings)

If you tick **Watertight solid** for an open scan, the run stops with the message *"Watertight not suitable"*. To get a closed solid of a development, build an open surface first. Then run **Toolbox 1 ▶ Remesh for BEM analysis** on it.

3.3 Settings measured in "× point spacing"

The **point spacing** is the typical gap between neighbouring points. GEM4D measures it during the run, after the voxel step.

Two advanced settings, **Cell size** and **Influence radius**, are multiples of the point spacing, not metres. A Cell size of 0.8 means $0.8 \times$ the point spacing. This lets the same values work on fine and coarse clouds. The two voxel cells are the only settings in metres.

3.4 What goes into the surface

- **Every visible mesh and point cloud contributes its points**, including the corner points of ordinary meshes. Hide everything you do not want included. Images are never used.
- **In clipping mode, only the clipped part is used.** You can use this to rebuild one section of a large scan.
- **One surface or one per object.** The **TOGGLE: Single Delaunay Object** item in Toolbox 1 controls this. Ticked (the default), GEM4D builds one surface from all visible objects together. Unticked, it builds a separate surface for each visible object. The item's name mentions Delaunay, but it applies to reconstruction too. Route A always builds one surface from the file.
- An object with fewer than 10 points produces no surface.

3.5 Mesh or Image

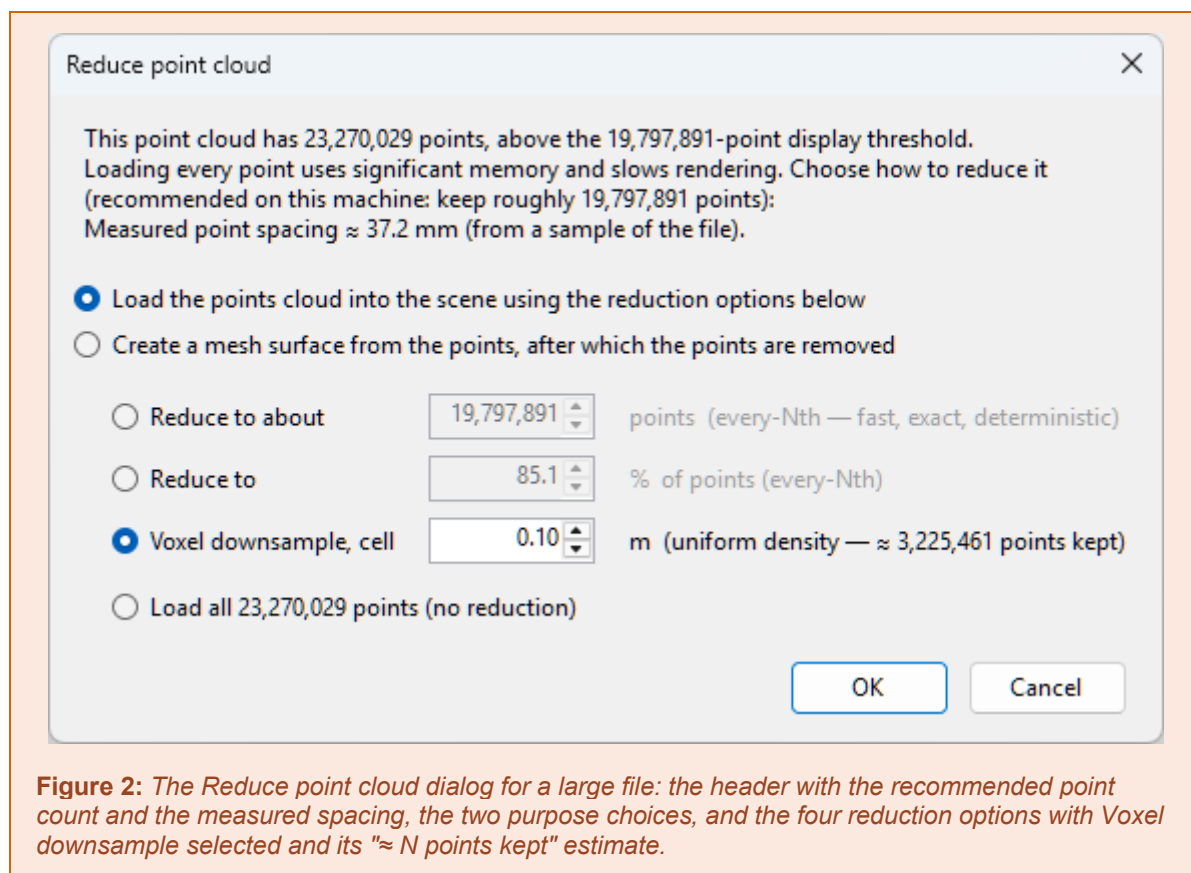
You asked for	You get	Where it goes
No texture (or the texture failed)	A mesh . It takes the colour and name of its source: the first visible object in single mode, or each source object in per-object mode. Route A uses the file name.	Saved to a DXF file that you name, and listed under it in the Mesh lists. The visible source objects are hidden.
A texture, and the cloud has colour	An Image : the surface with the scan colours painted on	Listed in the Image panel. GEM4D offers to save it as a textured OBJ. The source cloud stays visible.

An Image is for viewing. It is not in the Mesh lists, so tools that work on meshes (Remesh for BEM analysis and the BEM model, for example) do not see it. If you need both, reconstruct twice: once with texture and once without.

4. Loading a LAS/LAZ file

Click **Mesh ▸ Load other formats ▸ Other formats ▸ Point cloud (LAS/LAZ)**. You can select several files. You can also drag .las or .laz files onto the scene. Compressed LAZ files, including Deswik Suite exports, load the same way as LAS.

Before the dialog opens, GEM4D reads the file's header (to get the point count) and decodes the first million points (to measure the density). The dialog then opens for every file, whatever its size.



4.1 The dialog, top to bottom

The header states the number of points in the file. Above the *display threshold* (§4.3), it recommends reducing the cloud and gives the recommended number of points for your computer. Below the

threshold, it says the file is small enough to load in full. If the density sample worked, a last line gives *"Measured point spacing $\approx$..."*.

Two choices: keep the points, or make a surface.

Choice	What happens
Load the points cloud into the scene using the reduction options below (default)	The cloud is loaded and kept. Build a surface from it later with Toolbox 1.
Create a mesh surface from the points, after which the points are removed	The points are loaded only as input, and the reconstruction dialog opens straight away (§6). On success, only the surface is shown and the Info panel reads <i>"Surface created from \<file\> — the temporary point cloud was released."</i> If you cancel any later step (the reconstruction dialog, the progress window or the save dialog), or the run fails, the points are added to the scene after all: <i>"Surface not created — the loaded point cloud was kept: \<file\>".</i>

GEM4D remembers your choice for the rest of the session.

Four ways to reduce the points. Choose one:

Option	Value box	What it keeps
Reduce to about N points	1 up to the file's total. Starts at the recommended count.	Every N th point in file order, ending close to the count you set. Dense areas stay dense and sparse areas stay sparse.
Reduce to N % of points	1–100 %. Starts at the percentage that gives the recommended count.	The same every- N th thinning, set as a percentage. The row shows <i>"$\approx N$ points kept"</i> .
Voxel downsample, cell N m	0.10–10 m	One point for each cube of that size (§3.1). Gives an even density everywhere. If the density sample worked, the row shows <i>"$\approx N$ points kept"</i> . Selected at the start for files above the display threshold.
Load all N points (no reduction)	—	Every point. Selected at the start for files below the display threshold.

All four options keep the points' colours.

The suggested voxel cell. For a file above the recommended count, GEM4D suggests the cell that brings the kept count down to about that number. For a smaller file, it suggests the measured spacing, which evens out the density with almost no loss. The suggestion is never below 0.10 m, the smallest value the box accepts. If the density sample could not be read, the suggestion comes from the file's bounding box instead. That estimate tends to remove too many points from a long tunnel network, so check the *" $\approx N$ points kept"* figure.

4.2 Which option to choose

- **To build a surface, choose Voxel downsample.** The every- N th options keep the scanner's uneven density and thin the sparse patches even further, and those patches become holes in the surface. Voxel downsampling evens the density out.
- **To keep the cloud for viewing or joint mapping,** any option that brings the count near the recommendation is fine. Voxel downsampling still gives the most even result.
- **For a small file, Load all** is fine. The reconstruction's own 0.25 m voxel cell thins the points before the surface is built.

4.3 The recommended point count

The recommendation depends on your computer's memory (RAM):

RAM	4 GB	8 GB	16 GB	32 GB	64 GB	128 GB or more
Recommended points	2 million	4 million	8 million	20 million	45 million	90 million

Between these values, GEM4D interpolates. The **display threshold**, above which the dialog recommends reducing, is the recommended count or 10 million points, whichever is larger.

4.4 After loading

- The Info panel reports the result, for example *"Point cloud loaded: kept 4,812,330 of 61,507,442 points (voxel 0.1 m)"*.
- A cloud with colours shows them. A cloud without colours, or with colours that are all zero, shows in white. You can change its colour in the Objects list.
- The cloud is listed in the Mesh Files and Objects lists, like a mesh.
- If you selected several files, the dialog opens for each file in turn, starting on your previous choice.

5. Removing stray points: Denoise point cloud

Toolbox 1 ▶ Denoise point cloud (remove outliers) removes isolated stray points, also called *fliers*: dust, water drops and stray laser returns. Fliers are what grow spikes and bumps on a reconstructed surface.

- **What it works on:** every visible object made only of points. That includes a LAS/LAZ cloud and a point set from DXF, Deswik or Surpac. An object that also has lines or triangles is skipped.
- **No settings.** GEM4D measures each cloud's density and sets its own sensitivity. A patchy cloud is treated more gently, so sparse but real patches survive.
- **The cloud is replaced in place.** It keeps its name, colour and place in the lists, with fewer points. The file on disk is not changed; load it again to get the removed points back.
- **Safety limit.** It never removes more than 20 % of a cloud's points. Points with almost no neighbours (fewer than 3 nearby) are always removed and do not count towards that limit.
- **Report.** The Info panel shows *"Denoised N cloud(s): removed X of Y outlier points"*, where Y is the total number of points checked. If nothing needed removing: *"Denoise: no outliers found in N visible cloud(s)"*.

Denoising does not remove a dense clump that looks like a real surface, such as a parked vehicle, vegetation or standing water. Those need manual editing.

The reconstruction dialog can do the same cleaning with the **Remove outliers before reconstruction (statistical)** tick box (§6.5). The difference: this toolbox action changes the cloud you keep, while the tick box cleans only the working copy used to build the surface.

6. The Reconstruct surface from points dialog

When you click **Reconstruct surface from points**, GEM4D first measures the visible points. This takes a second or two on a large cloud. The dialog then opens in its **compact** view. Tick **Show advanced settings** to see six more settings.

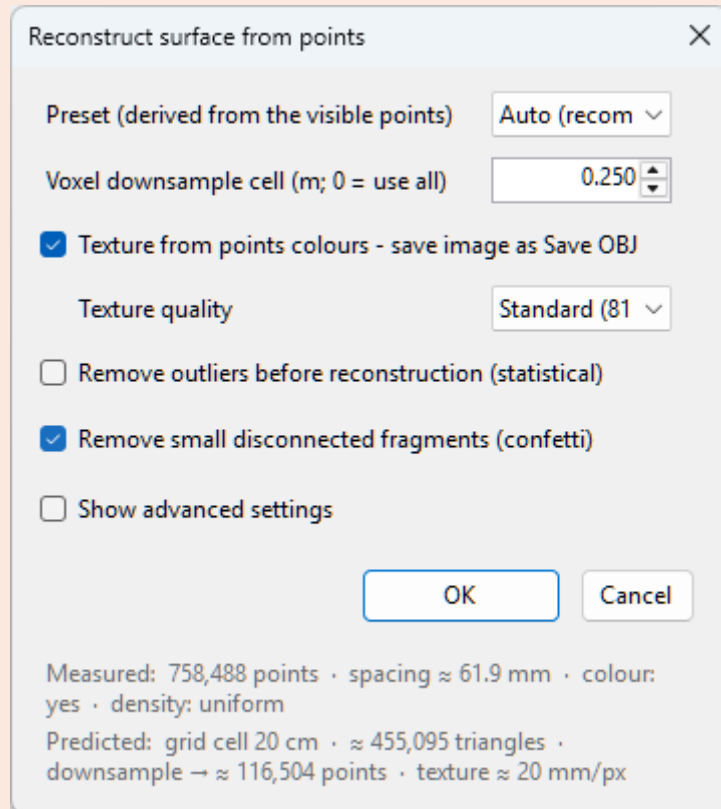


Figure 3: The *Reconstruct surface from points* dialog in its compact view, *Auto* preset, a coloured cloud: *Texture* ticked, with the *Measured* and *Predicted* lines filled in.

The settings, in order on screen:

1. **Preset (derived from the visible points)** — §6.1
2. **Voxel downsample cell (m; 0 = use all)** — §6.2
3. **Texture from points colours - save image as Save OBJ** — §6.3
4. **Texture quality** — §6.4
5. **Remove outliers before reconstruction (statistical)** — §6.5
6. **Remove small disconnected fragments (confetti)** — §6.6
7. **Show advanced settings** — §6.7

Advanced settings:

8. **Watertight solid (closed surface — wraps a volume)** — §6.8
9. **Cell size (× point spacing; lower = finer)** — §6.9
10. **Normal estimation neighbours (kNN)** — §6.10
11. **Influence radius (× spacing) — open only** — §6.11
12. **Cap openings (open only; close tunnel ends / scan edges)** — §6.12
13. **Repair surface (fill holes; genuine openings stay open)** — §6.13

The **Measured** and **Predicted** lines at the bottom are described in §6.14. Defaults and ranges for every setting are listed together in §10.2.

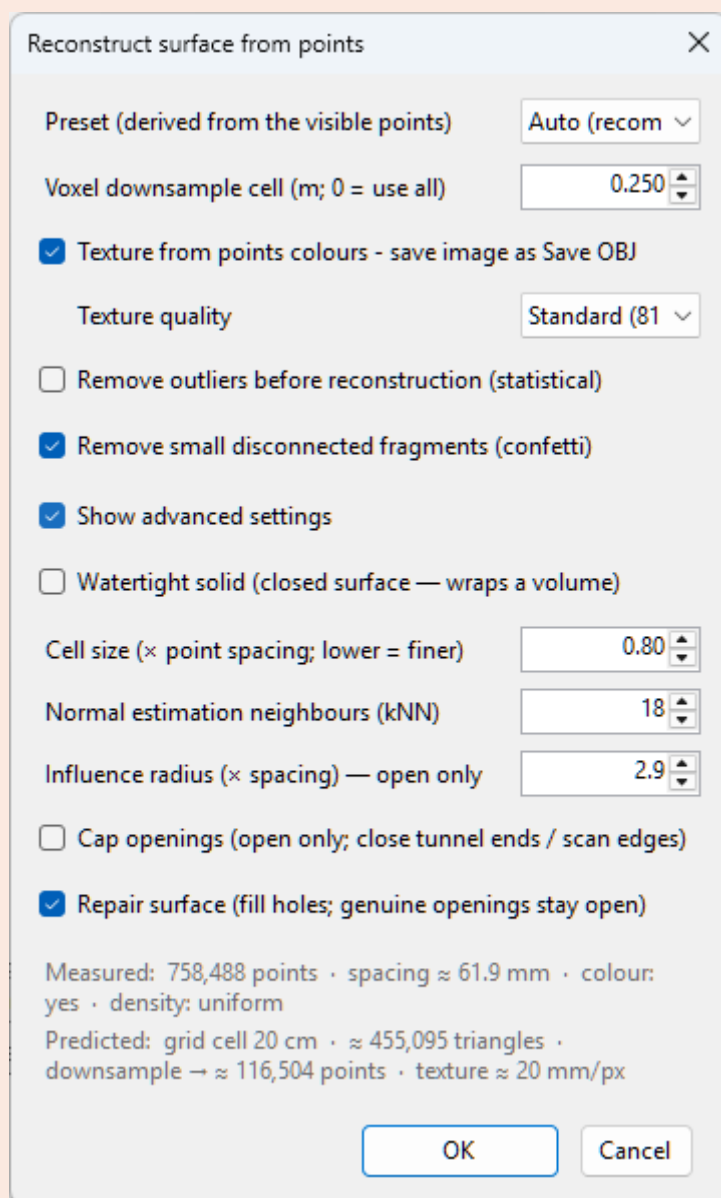


Figure 4: The same dialog with Show advanced settings ticked, showing the six advanced rows.

6.1 Preset

The preset fills in every setting for you, based on what GEM4D measured.

Preset	What it sets
Auto (recommended)	Voxel cell 0.25 m. Influence radius set from how even the density is: 2.0 for an even cloud, up to 4.0 for a patchy one. Texture ticked if the cloud has colour. High texture quality only when it will visibly sharpen the colours and the computer has at least 12 GB of RAM. Every other setting at its default.
Textured photo mesh	As Auto, but with Texture always ticked.
Clean analysis mesh	As Auto, but with no texture and Cell size 1.0 (slightly coarser and cleaner). This is a starting point for a surface you will analyse. It is still an open surface: run Remesh for BEM analysis on it before using it in BEM.
Quick draft	Voxel cell 0.5 m, Cell size 1.5, no Repair, no texture. Fast and rough, for a first look.

Preset	What it sets
Custom	Your own settings. Changing any setting switches the preset to Custom and keeps the values you set.

Every preset except Custom builds an open surface. GEM4D remembers the preset for the session. When you start from **Toolbox 1**, Custom also holds the settings of your last run. When the dialog opens during a load (Route A), it starts on Auto if you last used Custom.

6.2 Voxel downsample cell (m; 0 = use all)

This is the main control (§3.1). Just before building, GEM4D thins the points to one per cube of this size.

- **0.3–0.5 m:** a smoother surface and a faster run.
- **0.1 m:** finer detail on a clean scan. The run is slower and the surface noisier.
- **0:** uses every point. Use it only for a small, clean cloud, or for a cloud you already voxel-reduced to the detail you want when you loaded it.
- A cell smaller than the cloud's own spacing changes little or nothing.

The Predicted line shows "*downsample* → $\approx N$ points".

6.3 Texture from points colours - save image as Save OBJ

Tick this to paint the points' colours onto the surface. The result is an Image (§3.5), which you save through the Save OBJ prompt (§7.4). Auto ticks it when a visible point object has its own colours.

- **How the colour is made.** Each pixel of the texture blends the colours of the nearby points. Where no points are close, the colour is filled in from the surrounding pixels, so the surface has no grey patches. If more than 5 % of the surface had to be filled in this way (for example, holes closed by Repair), a "*Texture coverage*" message gives the percentage.
- **Colour detail comes from the loaded points.** GEM4D takes the colours from all visible coloured point objects, at the density they were loaded with, not from the thinned copy used to build the surface. A cloud loaded with more points gives sharper colour.
- **Large surfaces** are spread over several texture images, up to 12. They behave as one object, and Save OBJ writes them all together. At Standard quality, above about 50 million triangles, the texture is refused.
- **If the texture cannot be made** (no visible point object, no colours, or too many triangles), a "*Texture not applied*" message gives the reason. The surface is then created as a plain mesh.

Texturing adds time to the run.

6.4 Texture quality

This setting is greyed out unless **Texture** is ticked.

Choice	Effect
Standard (8192 px)	Each texture image is up to 8192 × 8192 pixels. Sharp enough for most work.
High (16384 px, ~1 GB RAM)	Each image is up to 16384 × 16384 pixels, with up to twice as many pixels along each triangle edge. Each image takes about 1 GB of memory, and the run and the saved .png files are slower and larger.

Choose **High** when you will inspect the surface close-up and Standard looks soft. Auto chooses High itself when it will help and the computer has enough memory.

6.5 Remove outliers before reconstruction (statistical)

Off by default. This runs the same cleaning as **Denoise point cloud** (§5) on the working copy of the points, before the voxel step. The cloud in the scene does not change.

Tick it when a scan has fliers or haze and the surface comes out spiky or bumpy. It adds a pass over every point, so leave it off for clean scans.

6.6 Remove small disconnected fragments (confetti)

On by default. After the surface is built, GEM4D finds the pieces that are not joined to each other. It removes **every piece smaller than 100 triangles or 0.5 % of the largest piece, whichever is larger**. The largest piece is always kept.

For example, if the main surface has 1,000,000 triangles, every separate piece under 5,000 triangles is removed. That clears the floating specks that dust and stray points create. It can also remove a genuine small object built in the same run, such as a short, separate drive. If that matters, untick this setting, or untick **TOGGLE: Single Delaunay Object** so that each object gets its own surface and is judged on its own.

Only detached pieces are removed. A spike still joined to the surface stays; use **Remove outliers** (§6.5) for that.

6.7 Show advanced settings

Shows or hides settings 8–13. It does not change any value. GEM4D remembers, for the session, whether you left it open.

6.8 Watertight solid (closed surface — wraps a volume)

Off by default. See §3.2 for when to use it.

When it is ticked, **Influence radius**, **Cap openings** and **Repair surface** are greyed out, because the watertight method always closes and repairs its own result.

The watertight method samples one grid over the whole cloud, with at most 600 cells along each axis. For a long or large cloud, the cells are therefore coarser than **Cell size** asks for; the Predicted line shows the cell actually used. The run time grows with the size of this grid, not with the number of points.

6.9 Cell size (× point spacing; lower = finer)

GEM4D builds the surface on an invisible 3D grid. This setting is the size of a grid cell, as a multiple of the point spacing (§3.3).

- **Lower:** finer detail, but slower and more memory. Going far below 1 gains little, because the surface cannot show detail finer than the points.
- **Higher:** smoother and faster, but small features are lost.

For an open surface, GEM4D samples the grid only around the points, so a long drive does not coarsen the cells. If the total surface is very large, GEM4D coarsens the cells to stay within its processing budget. The Predicted line then says *"auto-coarsened to fit the processing budget — Cell size has little effect"*. In that case, raise the voxel cell instead.

6.10 Normal estimation neighbours (kNN)

Before building, GEM4D works out which way the surface faces at each point (the point's *normal*). It does this by fitting a plane through the nearest points. This setting is how many points it uses.

- **More (for example 30):** steadier on noisy scans, but sharp edges get rounded.
- **Fewer (for example 8):** keeps sharp detail, but noise affects it more.

6.11 Influence radius (× spacing) — open only

How far each point reaches to join up with its neighbours into a continuous skin, as a multiple of the point spacing.

- **Too small:** the skin cannot bridge the gaps between points, which leaves holes and slits.
- **Too large:** the skin bridges gaps it should not. A narrow drive can fill in solid.

Raise it if the surface has holes. Lower it if a drive has filled in.

6.12 Cap openings (open only; close tunnel ends / scan edges)

Off by default. When it is on, GEM4D also closes the genuine openings, such as drive ends and the edges of the scan, sealing the surface.

Tiny slits between points are always closed, whatever this setting.

6.13 Repair surface (fill holes; genuine openings stay open)

On by default. After an open surface is built, Repair fills the holes left where the scanner saw nothing, such as shadows behind equipment or gaps between scan passes.

Repair only fills holes up to a size limit, measured across the hole's bounding box. The limit is about $20 \times$ the point spacing: **roughly 5 m at the default 0.25 m voxel cell**, and more if you raise **Influence radius**. Larger openings stay open.

An opening smaller than the limit is closed even if it is real, for example the end of a narrow raise. Untick Repair if such an opening must stay open. Unticking it also makes the run faster.

6.14 The Measured and Predicted lines

These two grey lines update as you change settings.

Measured describes the visible points: "*Measured: N points · spacing ≈ ... · colour: yes/no · density: uniform*" (or "*uneven (spread × N)*").

- The point count includes every visible object.
- *Spacing* is the median gap between neighbouring points, before any voxel step. It can be much smaller than the load dialog's "*Measured point spacing*", because scanners place points close together along each scan line but further apart between lines, and the two dialogs measure differently. Neither figure changes the result directly; the run measures the spacing again after the voxel step.
- *Uneven* means the larger gaps (the 90th percentile) are more than 1.6 times the median gap.

Predicted shows what the current settings will produce: the grid cell size, an estimated triangle count (accurate to within about $\pm 50\%$), the point count after the voxel step and, with Texture ticked, the texture detail per pixel.

If the surface would need more than 12 texture images, a second line warns "*Too many triangles to texture — increase Cell size or Voxel downsample.*" That happens above about 50 million predicted triangles at Standard quality, the same limit at which the texture is refused (§6.3). Because the estimate is only accurate to about $\pm 50\%$, treat a surface close to the limit with care.

If nothing is visible, the Measured line reads *"(no visible point data)"* and the presets fall back to plain defaults.

7. Running the reconstruction and keeping the result

7.1 Before the run

If more than 250,000 points are visible and the voxel cell is 0, a *"Large input"* message warns that the run can take minutes and a lot of memory. **Yes** runs anyway. **No** cancels the run (on Route A the points are kept in the scene); start again with a voxel cell set.

7.2 While it runs

A *"Reconstructing surface"* window shows a progress bar and the current stage:

- **Open surface:** *Reading points...* · *Measuring point spacing...* · *Removing outliers...* · *Voxel-downsampling the cloud...* · *Estimating point normals...* · *Building surface — block N of M...* · *Merging blocks...* · *Closing small slits...* · *Building the mesh...* · *Filling coverage holes...*
- **Watertight solid:** ... · *Estimating point normals...* · *Sampling the winding field...* · *Extracting the isosurface...* · *Polishing the solid...*
- **With Texture:** *Baking the texture...*

Stages for settings you switched off are skipped. In per-object mode, each stage adds *"[surface i of N]"*.

The scene cannot be used during the run. **Cancel** discards the run and the Info panel reads *"Surface reconstruction cancelled"*.

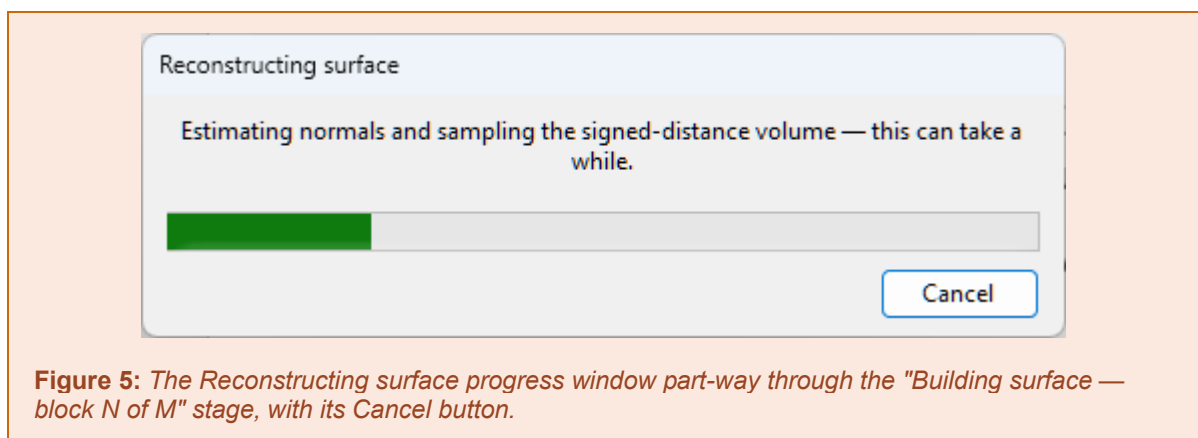


Figure 5: The *Reconstructing surface* progress window part-way through the *"Building surface — block N of M"* stage, with its *Cancel* button.

7.3 A plain (untextured) surface is saved as DXF

1. A Save dialog asks for a DXF file name. **Cancelling it deletes the new surface** (*"Saving was cancelled and the created objects deleted"*). If the name is already in the Files list, GEM4D asks again.
2. The surface is listed under that DXF in the Mesh Files and Objects lists, with its source's name and colour (§3.5).
3. The visible source objects are hidden, so you see the new surface on its own.

7.4 A textured surface becomes an Image

1. The Image is listed in the Image panel under its source's name (or "Textured surface").
2. GEM4D asks "Save it now as a textured OBJ (.obj + .mtl + .png)?"
 - **Yes** opens a Save dialog and writes the .obj, the .mtl and one .png per texture image.
 - **No** leaves the Image in the scene, unsaved. You can save it later with **Image ► Save and export files ► Textured OBJ**. An unsaved Image is lost when you close GEM4D, unless you save a project.
3. The source cloud stays visible and may cover the Image. Hide the cloud to see the Image.

7.5 Keeping everything together

A GEM4D project file (.gem4d) saves point clouds, meshes and Images together in one file. See `Project_File_Manual.md`.

8. Recipes

You have, or want...	Do this
A drive or stope scan; you need only the surface	Route A (§2) with the Auto preset.
The cloud and a surface	Route B (§2).
A coloured photogrammetry scan with a realistic look	Preset Textured photo mesh , then Yes to the Save OBJ prompt. For close-up mapping, choose High texture quality and load the cloud with more points (a smaller load voxel cell), because the colour detail comes from the loaded points.
A surface for BEM or other analysis	Preset Clean analysis mesh , then Toolbox 1 ► Remesh for BEM analysis to close it.
A stockpile or muck pile scanned all the way round	Tick Watertight solid (advanced).
A very large scan and a slow run	Raise the voxel cell to 0.4–0.5 m. Untick Repair surface and Texture while you try settings. Reduce harder when loading.
A spiky or bumpy surface	Tick Remove outliers before reconstruction , or run Denoise point cloud first. Raising Normal estimation neighbours also helps.
Only part of a large scan	Switch on clipping, then reconstruct. Only the clipped part is used.
Several objects as separate surfaces	Untick TOGGLE: Single Delaunay Object in Toolbox 1, and show only those objects.
A dense cloud to inspect, but a light surface	Load at a fine voxel cell, then reconstruct with the 0.25 m default. The cloud in the scene keeps its detail.

9. Troubleshooting

9.1 The result looks wrong

What you see	Likely cause	What to do
Holes or missing patches	Sparse patches in the cloud, often from an every- <i>N</i> th reduction on load. Or the influence radius is too small.	Load with Voxel downsample . Raise Influence radius . Keep Repair surface on.

What you see	Likely cause	What to do
A drive has filled in solid, or the surface is a blob	Influence radius is too large and bridged the drive.	Lower Influence radius , and/or Cell size .
No surface, " <i>Watertight not suitable</i> "	Watertight solid was ticked for an open scan.	Untick it (§3.2).
Spikes and bumps	Fliers in the cloud.	Tick Remove outliers , or run Denoise point cloud . Raise Normal estimation neighbours .
Small floating specks remain	Specks larger than the confetti limit (100 triangles when the main surface is small), or confetti removal is off.	Tick Remove small disconnected fragments . Try Remove outliers .
A small separate surface is missing	Confetti removal judged it a speck (§6.6).	Untick confetti removal, or build one surface per object.
A real opening, such as a raise end, was closed	Repair surface fills openings up to about 20 × the point spacing (§6.13).	Untick Repair surface .
Sharp edges are rounded	Too many neighbours, or the cells or voxels are too large.	Lower Normal estimation neighbours , the voxel cell or Cell size .
An unexpected shape is part of the surface	Another visible mesh or cloud was included (§3.4).	Hide everything except the cloud, and run again.
The run is very slow or runs out of memory	Too many points or too fine a grid.	Raise the voxel cell. Untick Repair and Texture . Use Standard texture quality.
The surface is plain when you wanted colour	The texture could not be made. The " <i>Texture not applied</i> " message gives the reason.	See §9.2.
The texture looks soft close-up	Not enough texture pixels or colour points.	Choose High texture quality. Load the cloud with more points.
The textured surface is not visible	The source cloud is still shown on top of it.	Hide the cloud.
The surface disappeared after the run	The DXF Save dialog was cancelled, which deletes the surface.	Run again and save the file.

9.2 Messages

Title	Message (start)	What to do
Large input	<i>"The visible data has N points..."</i> (Route B) or <i>"This cloud has N points and no voxel downsample is set..."</i> (Route A)	Yes to continue, or No to cancel and run again with a voxel cell (§7.1).
No surface produced	<i>"Could not reconstruct a surface from the visible points..."</i>	Check that a point cloud is visible. Try a smaller Cell size or a larger Influence radius .
Watertight not suitable	<i>"Could not build a watertight solid from the visible points..."</i>	Untick Watertight solid . For a closed development, use Remesh for BEM analysis on the open result.
Texture not applied	<i>"No point object is visible to take colour from..."</i>	Show the coloured cloud as well as anything else you are reconstructing.
Texture not applied	<i>"The visible point object has no per-point RGB colour..."</i>	The scan holds no colour (intensity or classification only). Untick Texture .

Title	Message (start)	What to do
Texture not applied	<i>"The surface has too many triangles to texture..."</i>	Raise the voxel cell or Cell size , or reduce the triangle count with Toolbox 1 ► Reduce polygon count , then try again.
Texture too large	<i>"One or more surfaces had too many triangles to texture at full resolution and were skipped..."</i>	As above, for the surfaces that were skipped.
Texture coverage	<i>"About N% of the textured surface had no cloud colour within the search band..."</i>	For information. Those areas were coloured from their surroundings.
Save textured OBJ	<i>"Textured surface created (a GEM4D "Image")..."</i>	§7.4.
Warning	<i>"Saving was cancelled and the created objects deleted"</i>	Run again and save the DXF (§7.3).
Denoise points	<i>"Show at least one visible object made of points only..."</i>	Show a point cloud. Objects that include lines or triangles cannot be denoised.
Empty point cloud	<i>"No points found in ..."</i>	The file contains no points.
Error reading LAS/LAZ file	The reader's own error text	The file could not be read. Check that it is a complete, valid LAS or LAZ file.
Error reconstructing surface	The error text	Route A only. The points are kept in the scene; try again from Toolbox 1 .

For support, the file %LOCALAPPDATA%\GEM4D\GEM4D_diag.log records what each run did. Look for lines starting confetti cull:, recon outlier removal: and cloud denoise:.

10. Reference

10.1 Reduce point cloud dialog

Setting	Default	Range
Load the points / Create a mesh surface	Load the points (remembered for the session)	one or the other
Reduce to about <i>N</i> points	The recommended count (§4.3), or the file's total if smaller	1 to the file's total
Reduce to <i>N</i> % of points	The percentage that gives the recommended count (100 % for a smaller file)	1–100 %
Voxel downsample, cell	Measured suggestion (§4.1)	0.10–10 m
Load all points	—	—
Option selected at the start	Voxel downsample above the display threshold; Load all below it	—

10.2 Reconstruct surface from points dialog

Setting	Default (Auto)	Range	Applies to
Preset	Auto (recommended)	Auto / Textured photo mesh / Clean analysis mesh / Quick draft / Custom	both

Setting	Default (Auto)	Range	Applies to
Voxel downsample cell (m)	0.25 m (Quick draft 0.5 m)	0–100 m (0 = use every point)	both
Texture from points colours	Ticked if the cloud has colour	on / off	both
Texture quality	Standard (8192 px); High when Auto judges it worthwhile	Standard / High	both, with Texture
Remove outliers before reconstruction	Off	on / off	both
Remove small disconnected fragments	On	on / off	both
Show advanced settings	Off (remembered for the session)	on / off	—
Watertight solid (<i>advanced</i>)	Off	on / off	—
Cell size (<i>advanced</i>)	0.8 (Clean analysis 1.0, Quick draft 1.5)	0.25–4.0 × spacing	both
Normal estimation neighbours (<i>advanced</i>)	18	4–100	both
Influence radius (<i>advanced</i>)	2.0 for an even cloud, up to 4.0 for a patchy one	0.5–20 × spacing	open only
Cap openings (<i>advanced</i>)	Off	on / off	open only
Repair surface (<i>advanced</i>)	On (Quick draft off)	on / off	open only

10.3 What happens in a run, in order

1. Read the points of every visible object (or the clipped part), and measure their spacing.
2. **Remove outliers**, if ticked.
3. **Voxel downsample** to the voxel cell, then measure the spacing again.
4. Estimate the normal at each point, using **Normal estimation neighbours**.
5. Build the surface:
 - **Open**: sample the grid in blocks around the points, using **Cell size** and **Influence radius**. Join the blocks. Close tiny slits, or every opening if **Cap openings** is on. Then **Repair surface**, if ticked.
 - **Watertight**: sample one grid over the whole cloud, extract the closed solid and repair it.
6. **Remove small disconnected fragments**, if ticked.
7. With **Texture**: paint the colours on and create an Image (§7.4). Otherwise: save the mesh as DXF (§7.3).