

CityGML 3DCityDB-Loader plugin for QGIS

Quick user guide

Last update: 2 November 2022

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Motivation

Motivation

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IDEA:

- **CityGML 3D City Database:** Why not letting users benefit from *directly* working with the 3DCityDB?
 - No need to work with files
 - Editing of features attributes could become way easier
 - SQL/relational model are rather well-known in the user community
 - Last but not least.... "3D city models belong best in a database" ☺



Motivation

BUT:

- 3DCityDB structure is rather complex
 - Lots of nested tables, intricate structure
 - Data management is difficult, although some functions are provided (e.g. delete functions)
 - There can be multiple citydb schemas in the same database instance (aka "scenarios")
- CityGML does not follow the Simple Feature for SQL model (SFS)
 - Nested features
 - One feature can have multiple representations (multiple LoDs, multiple geometry types)
- The existing **Importer/Exporter** offers some functionalities, but its *raison d'être* is basically different (...as the name says!)

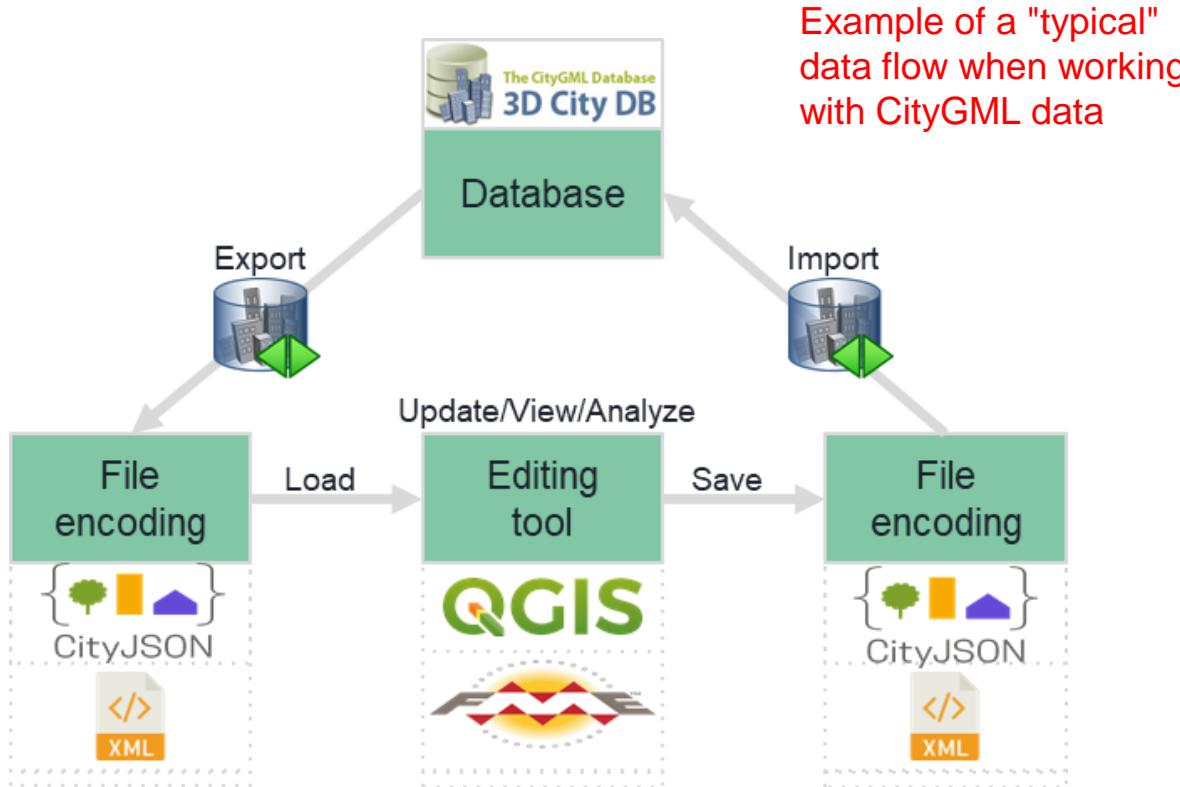
Motivation

SO:

- Why not using **QGIS**?
 - Well-known and established open-source software
 - Rather mature, version 3.22 LTR released in autumn 2021, well documented
 - Native support for PostgreSQL/PostGIS, support also for Oracle Spatial
 - Has strong 2D and some (definitely less mature) 3D visualisation functionalities
 - Can be extended with Python-based plugins

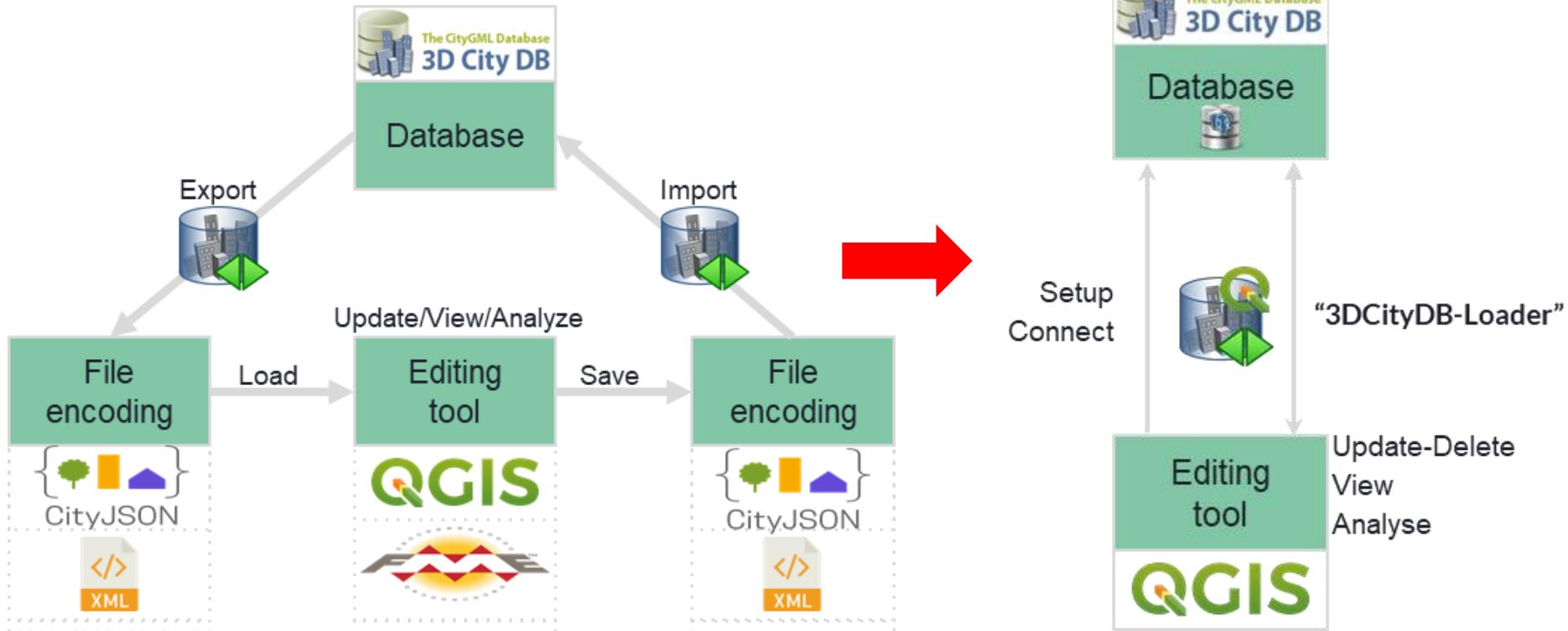


Motivation



Motivation

Vision / goal of the plugin



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Main functionalities

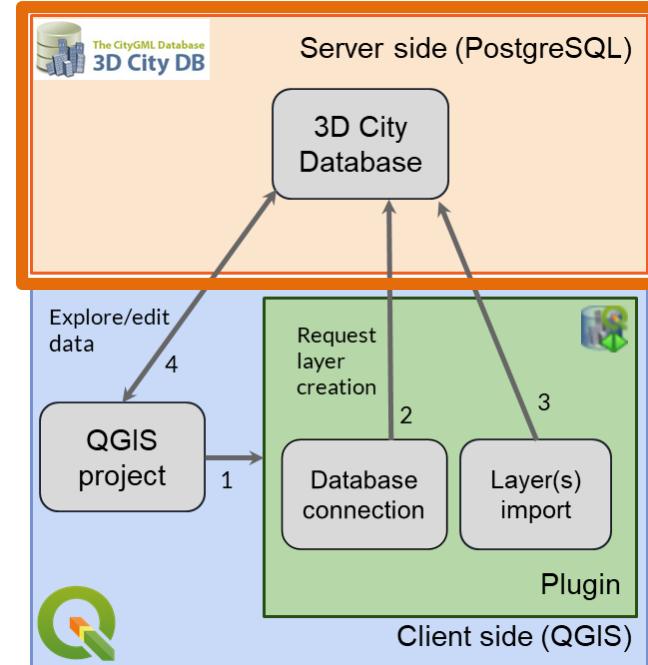
- Create "**SFS-like layers**" to hide 3DCityDB complexity when interacting with data
 - Deal efficiently with multi-LoD / different geometries / implicit representations
 - Up to 530+ possible combinations in CityGML
 - Merge all standard attributes of a CityObject into a single "table"
- **Deal with the possibly huge size of city models** stored in a database
- Support for **multiple citydb schemas** in the same 3DCityDB instance
- Support for **multiple users with different privileges** (read-only, read-write)
- **Editing of attributes:** possible (depending on user privileges)
- **Deletion of features:** possible (depending on user privileges)
- Editing of geometries: NOT possible

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Server-side PostgreSQL "QGIS Package"

- Creates and manages layers as views (for attributes) linked to materialized views (for geometry) following the SFS model
- Manages
 - users and privileges
 - multiple citydb schemas
- Adds default users with ro & rw privileges



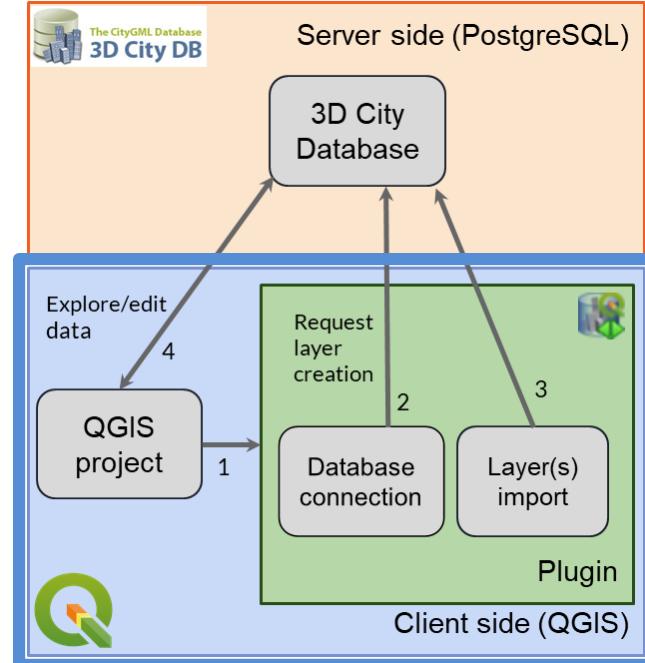
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Client-side

QGIS plugin “3DCityDB-Loader”

- Manages db connections + installation of the **QGIS Package**
- Allows for GUI-based
 - layer creation and management
 - management of multiple citydb schemas
 - editing of feature attributes
- GUI includes
 - support for children tables (e.g. generic attributes)
 - CityGML enumerations
 - (optionally) codelists
- Creates a hierarchical Table of Contents



BEWARE

The following slides assume that you are already familiar with the 3DCityDB Suite

In particular you must:

- Have an already installed 3DCityDB database instance
- Be able to use the 3DCityDB Importer/Exporter
- Be able to import CityGML data into the 3DCityDB
- (Optionally) be able to create additional citydb schemas

Otherwise, here a tutorial: <https://github.com/3dcitydb/tutorials>

Last but not least...

- You need at least a basic knowledge of the main CityGML concepts ☺
- Otherwise, here a crash course for free: <http://www.urbangeobigdata.it/?p=195>

Installation

Software requirements

- CityGML 3D City Database **v. 4.x or higher** for PostgreSQL
 - Requires PostgreSQL **v. 10 and higher**
 - <https://github.com/3dcitydb/3dcitydb-suite/releases>
 - <https://3dcitydb-docs.readthedocs.io/en/latest/>
 - **BEWARE:** 3DCityDB v. 3.x and older are NOT supported!
- QGIS 3.22
 - Works from **v. 3.20 and higher**
 - NOT compatible with older versions
 - <https://qgis.org/en/site/forusers/download.html>
- PgAdmin (suggested, not required)
 - <https://www.pgadmin.org/download/>

Installation

3DCityDB-Loader compatibility matrix as of **October 2022**

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QGIS version	3DCityDB-Loader works?	Comments
QGIS 3.28 RC	✓	Works, but minor glitches in the ToC generation
QGIS 3.26	✓	Works
QGIS 3.24	✓	Works
QGIS 3.22 LTR	✓	Works. Reference version used for development
QGIS 3.20	✗	Works
QGIS 3.18	✗	"Import selected layers" button always disabled
QGIS 3.16 LTR	✗	User's GUI won't load. Issues with (outdated?) method QgsExtentGroupBox.setMapCanvas()

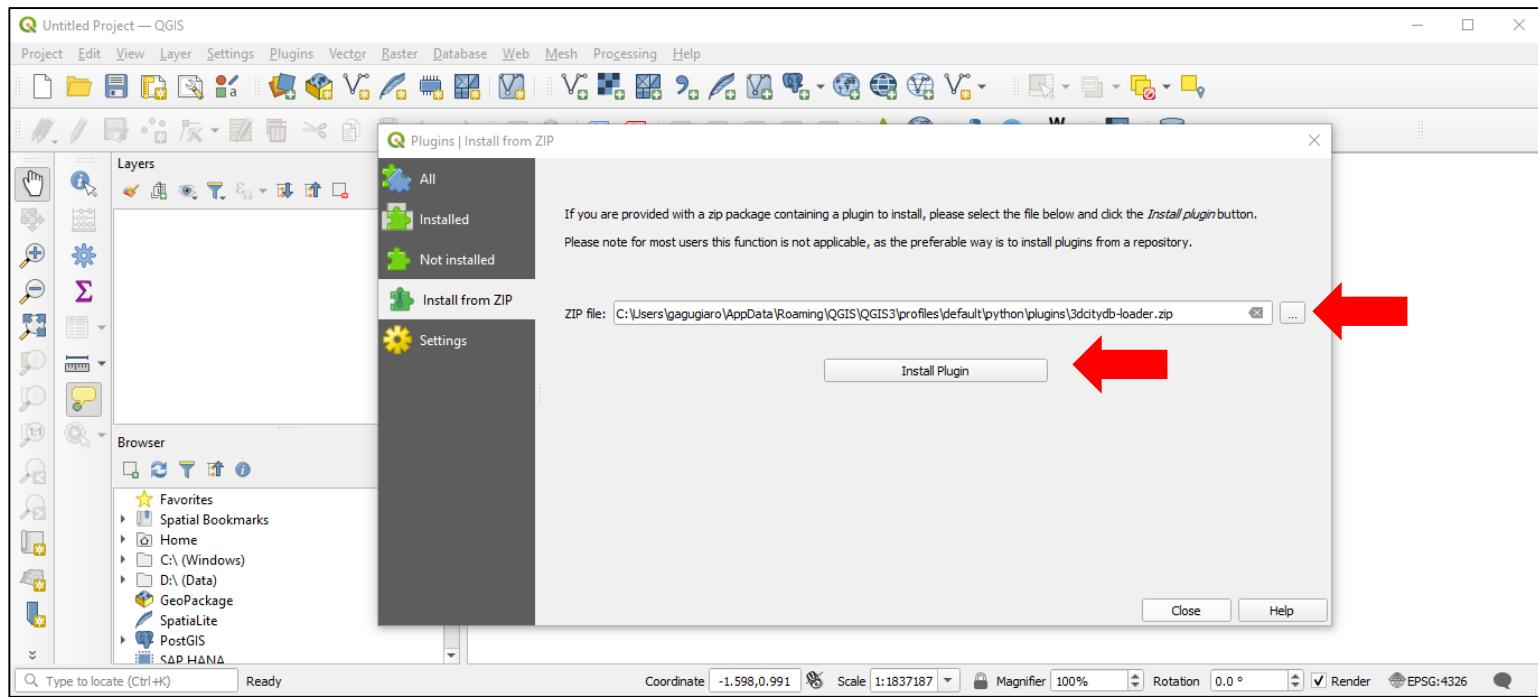
Testing machines as of September 2022

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OS	Processor(s)	HD	RAM	PostgreSQL	PostGIS
Windows 10 2009 64bit	Core i7-8650U 1.7 GHz	SSD 2 TB	32 GB	14, 64bit	3.2
Linux (Ubuntu 20.04.3 LTS x86_64)	Intel i7-7500U (4) 3.500GHz	SSD 250 GB	8 GB	12, 64bit	3.1
Mac OS (11.6.2 64bit)	Core i9-??	1TB SSD	32 GB	13, 64bit	3.1
Linux server (Ubuntu 18.4)	TUD Virtual Machine			10, 64bit	3.0

Installation

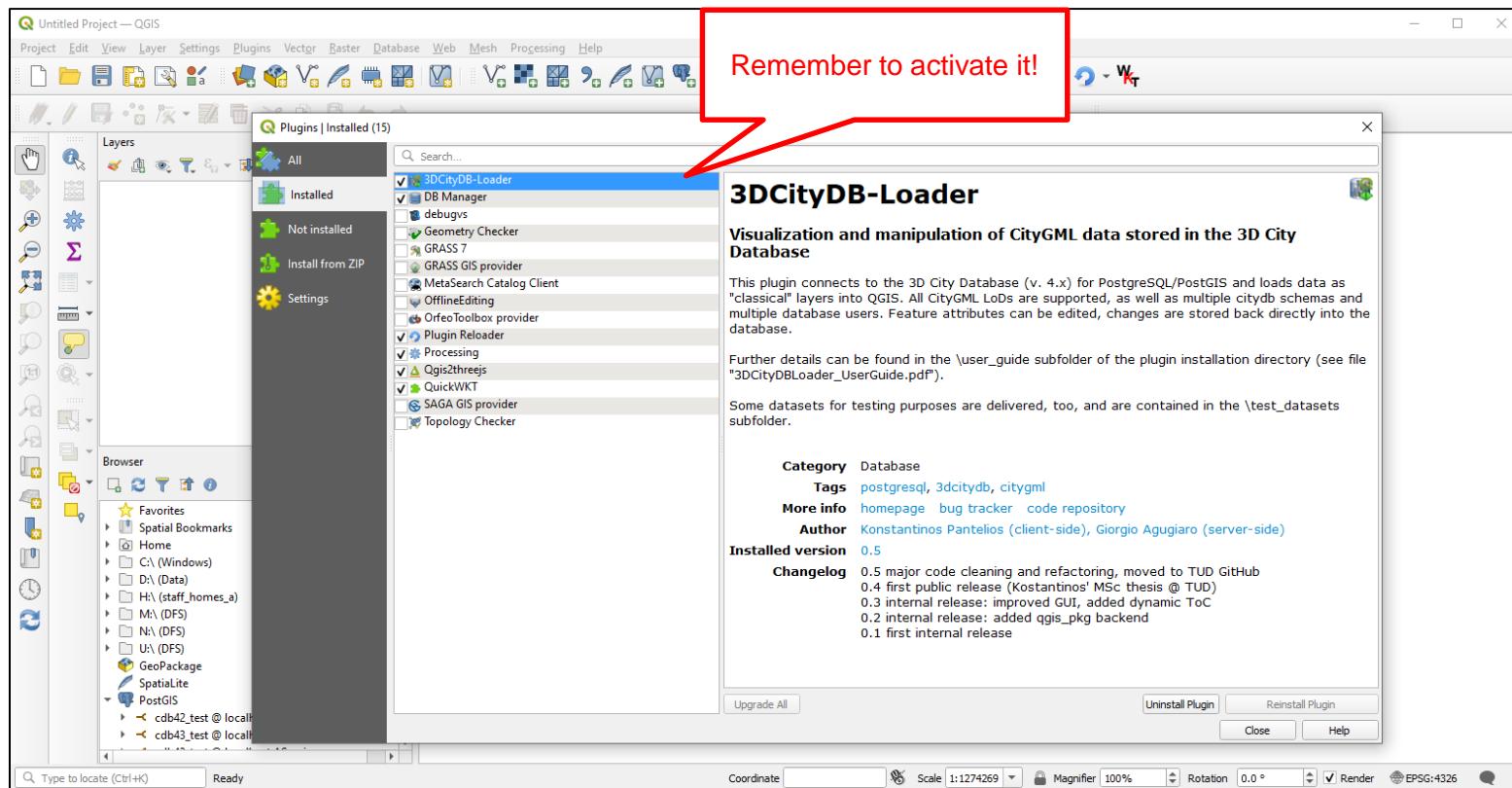
- The "3DCityDB-Loader" for QGIS is currently available as zip file
- In QGIS, open the Plugins\Manage and install plugins window, and choose "Install from ZIP". Select the provided zip file and click the "Install Plugin" button



Installation

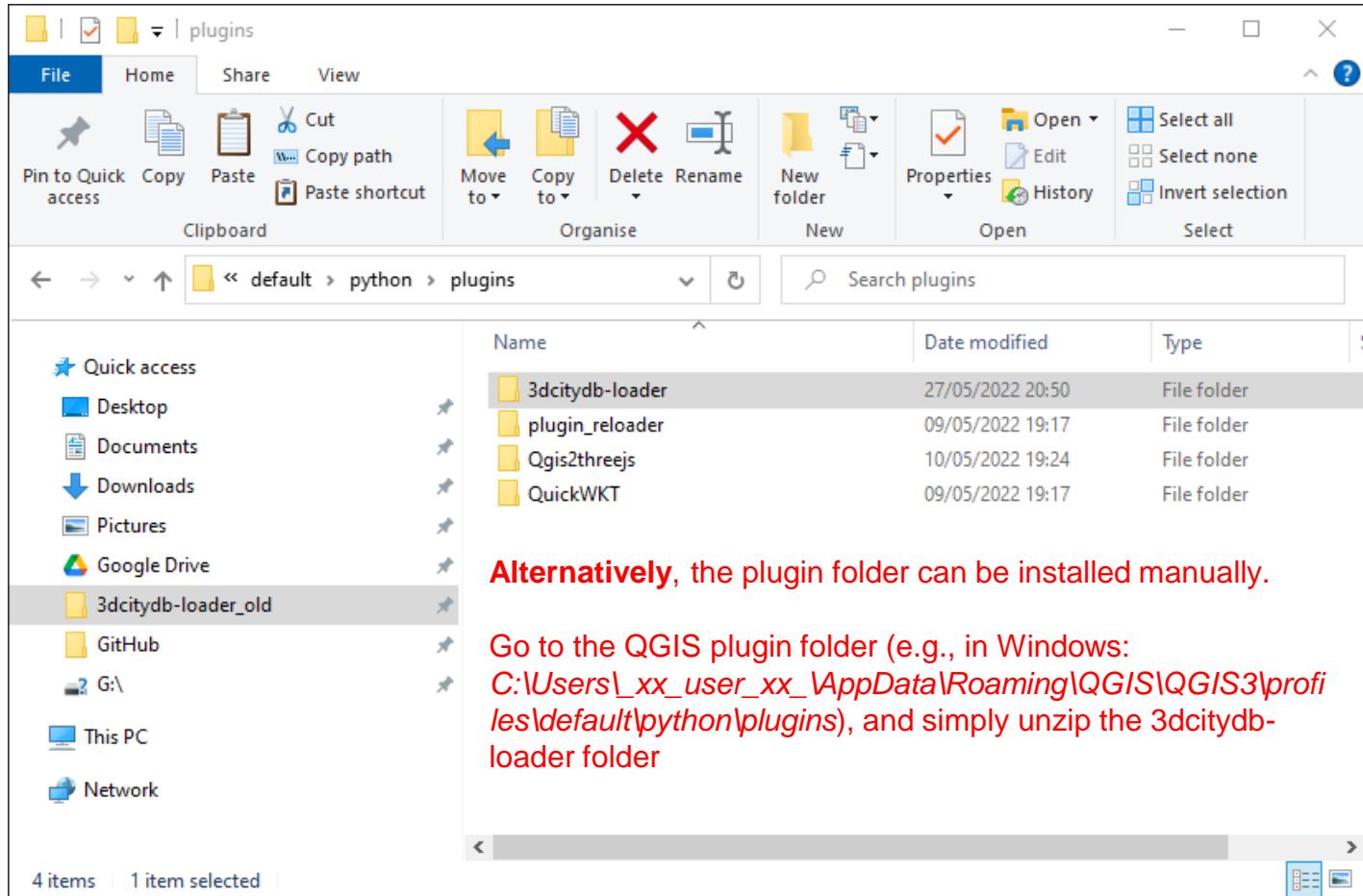
- Upon installation, you must activate the plugin

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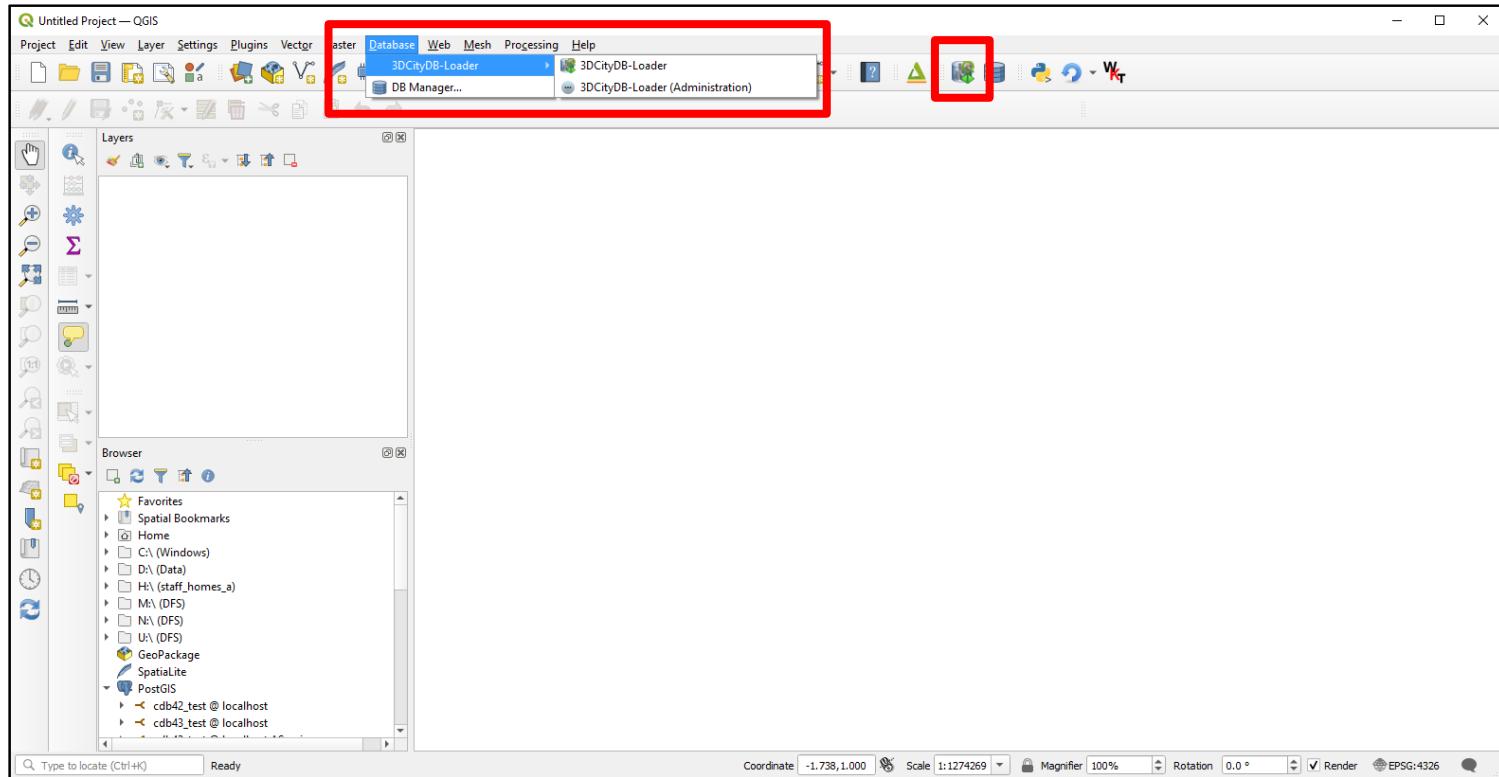
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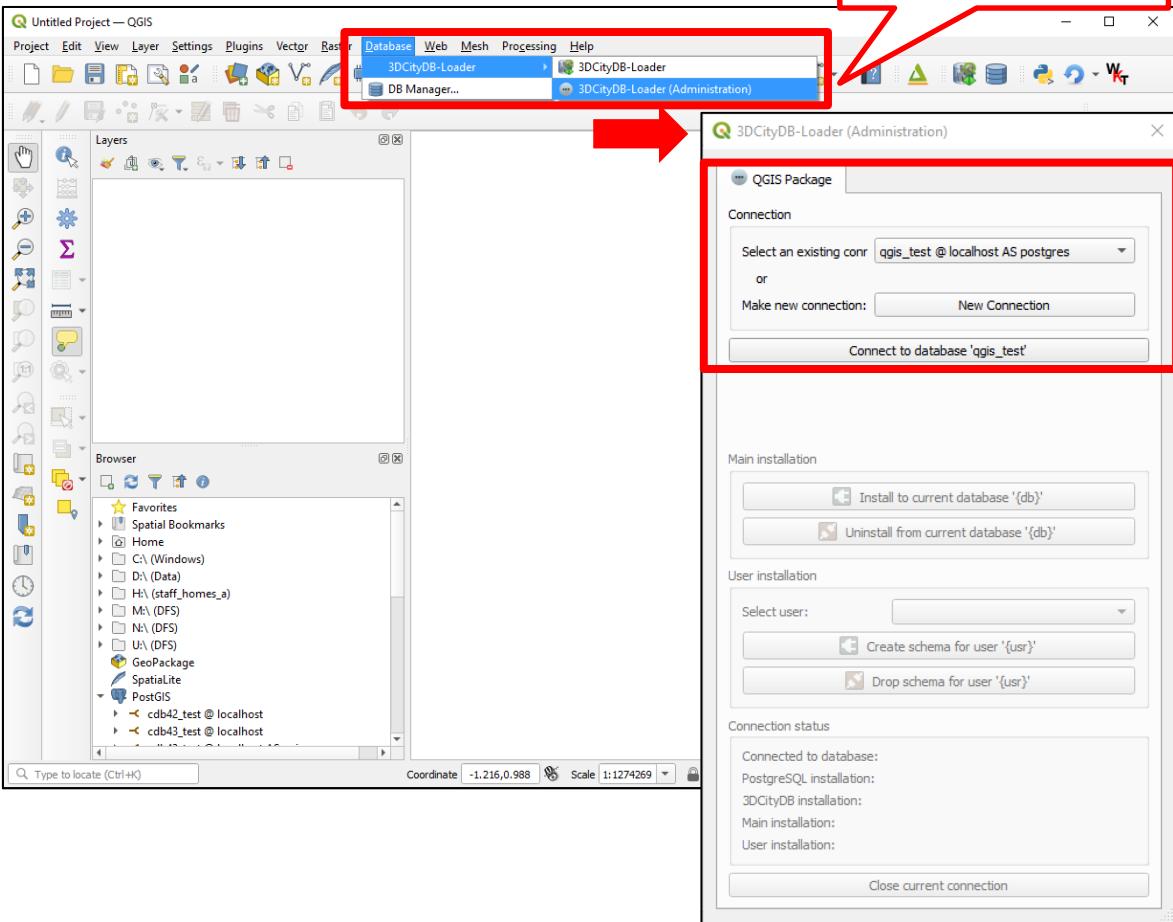
Use: As database administrator

Watch out! Pick the Administration one!

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The database administrator (superuser) is responsible for setting up in advance the server-side part of the plugin for *any* user

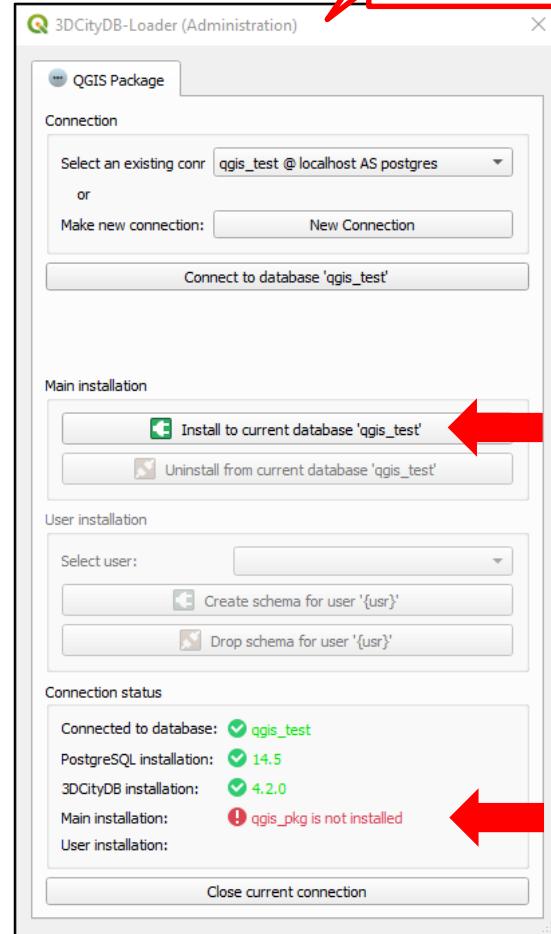
1) Create a new connection or use an existing one to the desired 3DCityDB instance (here: "qgis_test")



Use: As database administrator

Watch out! Pick the Administration one!

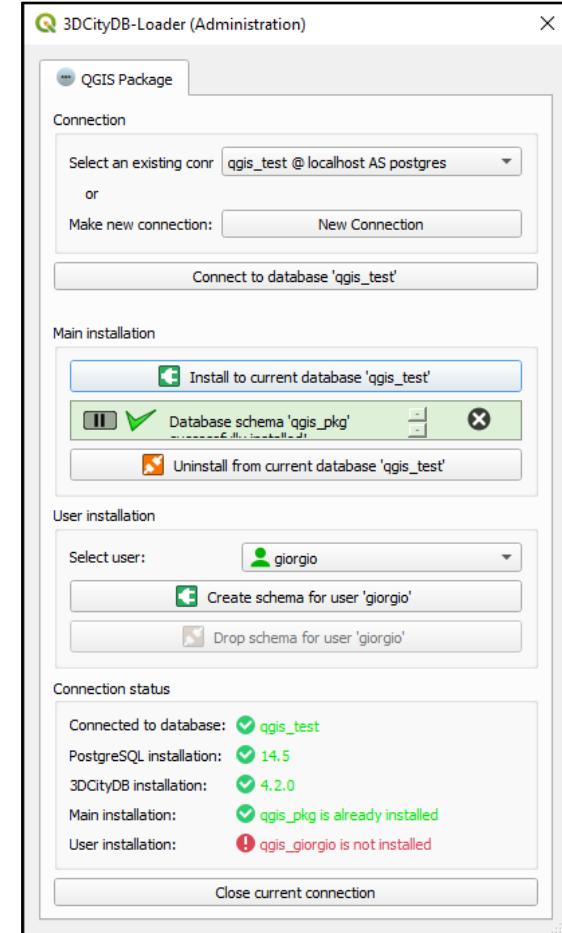
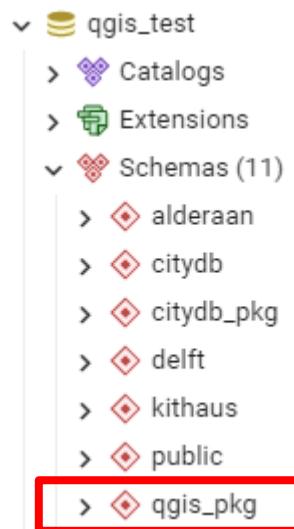
2) Install the QGIS Package ("Main installation")



Use: As database administrator

2) Install the QGIS Package ("Main installation")

Upon successful installation, in the 3DCityDB, a "qgis_pkg" database schema is created in the selected 3DCityDB instance

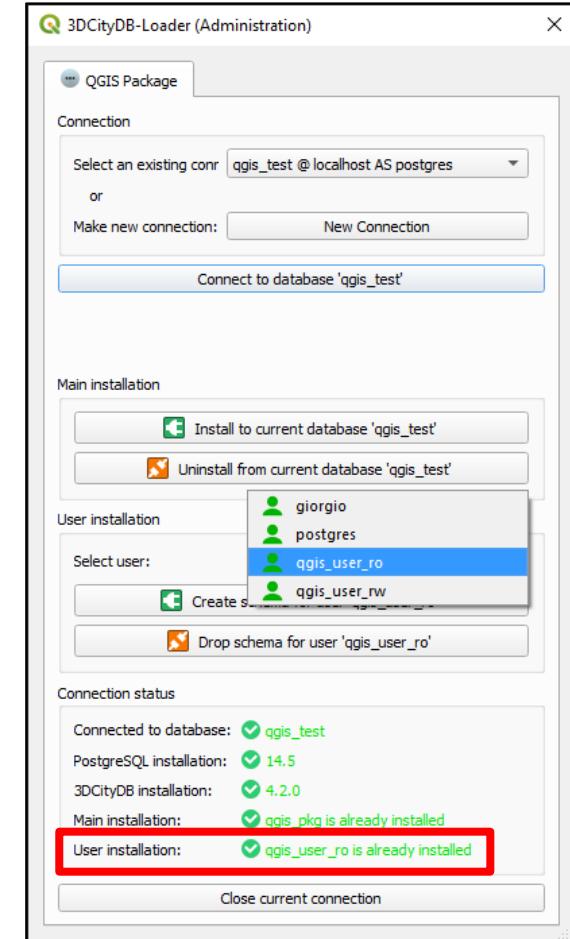


Use: As database administrator

3) (Optionally) create user schemas

In order to use the plugin, a user needs a schema, named "qgis_" + username

- 2 users are **automatically** added, and their schemas created by default ("qgis_user_ro", "qgis_user_rw")
- You can also create the user schema for database user "postgres" (NOT recommended!)
- For other database users, see the **Advanced options** slides (later on)



Use: As database administrator

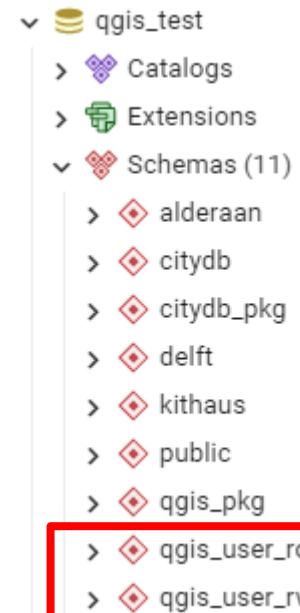
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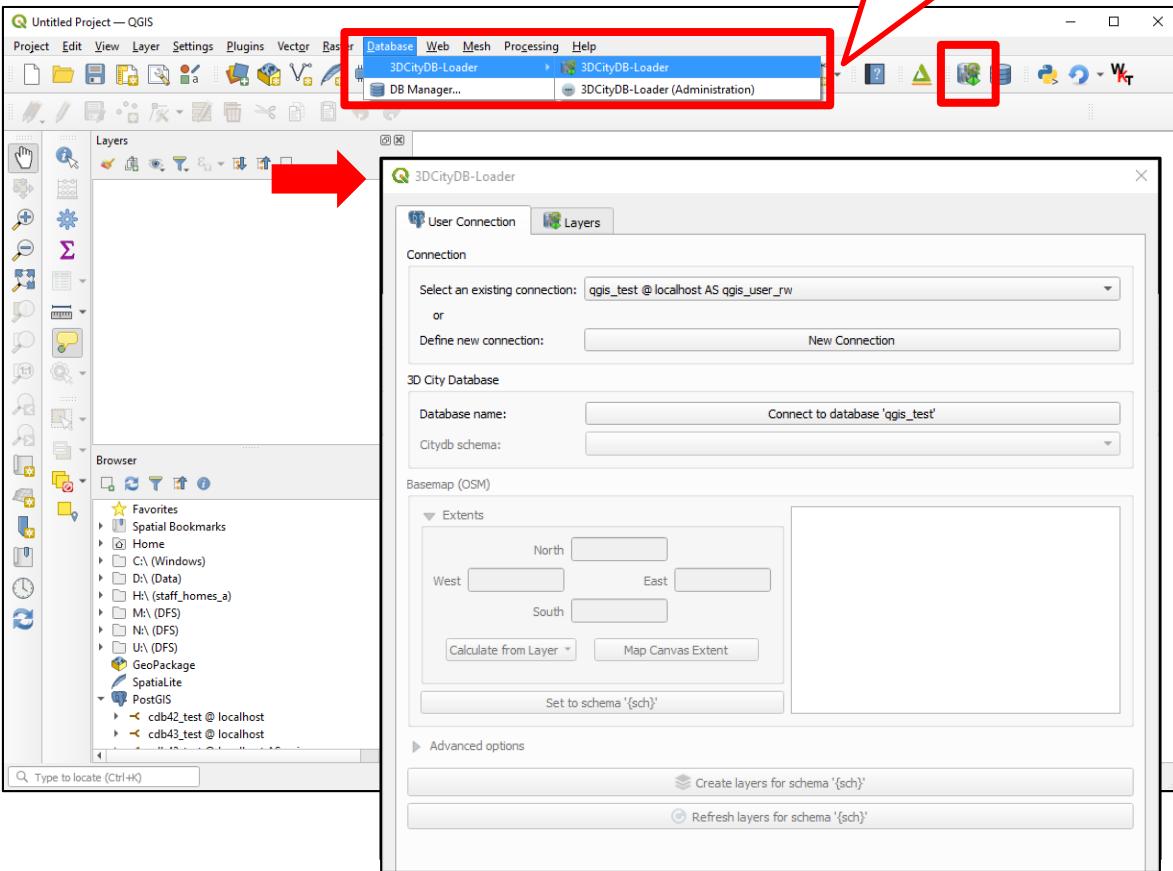
Connection parameter:

- Login/password: "qgis_user_ro"
- Login/password: "qgis_user_rw"



Use: As user

As "normal" user
open the plugin
from the menu or
by clicking on the
icon



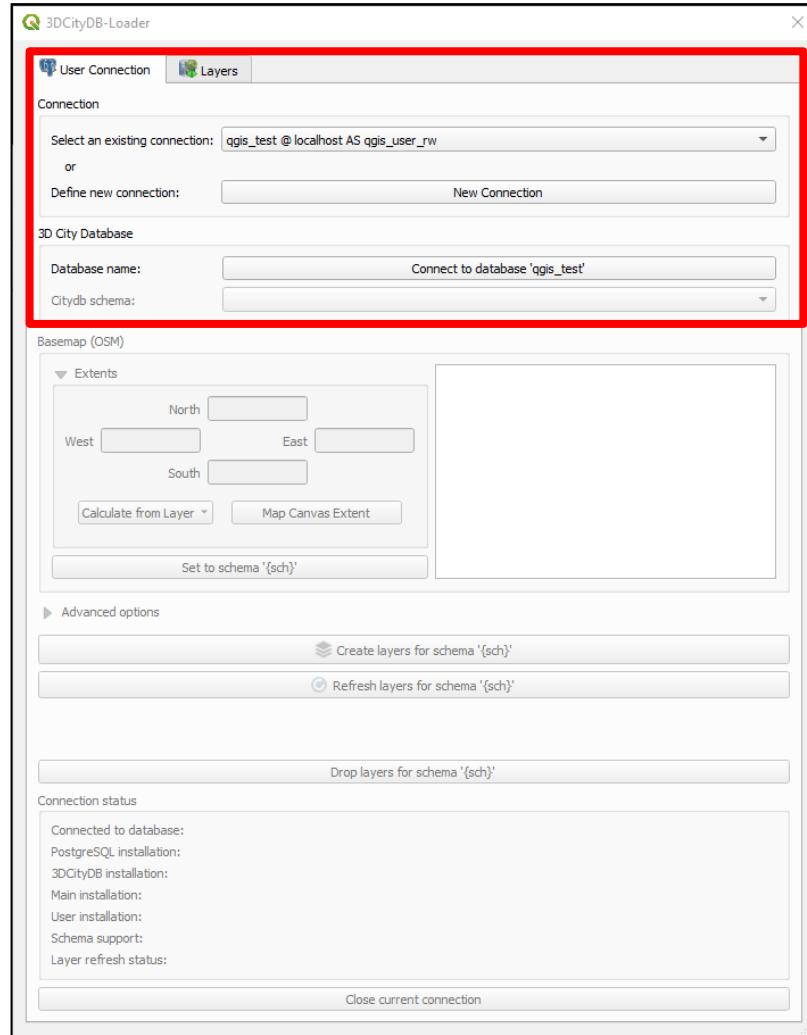
Use: As user

In the "User connection" tab

- 1) Create a new connection or use an existing one to the desired 3DCityDB instance (here: "qgis_test")

- 2) Use the credentials of the default users:
 - "`qgis_user_ro`" has read-only privileges
 - "`qgis_user_rw`" has read-write privileges

(You may also connect with your own credentials if the database administrator has set up your user schema before)



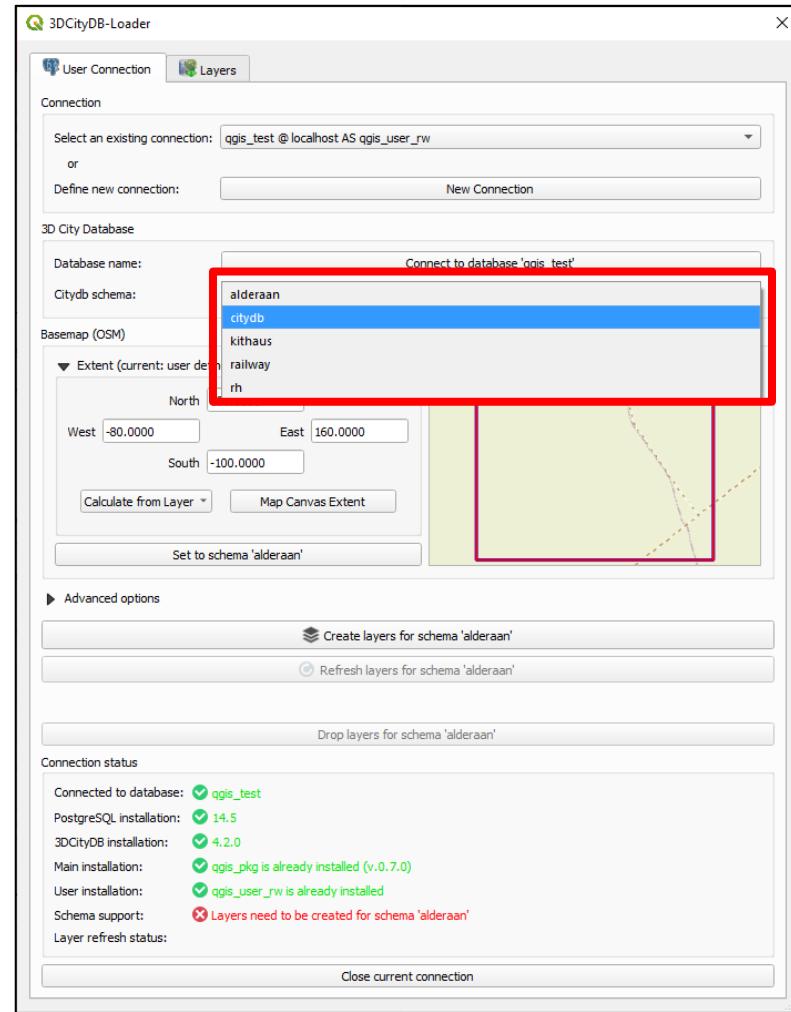
Use: As user

In the "User connection" tab

3) Choose one of the existing scenarios (i.e. citydb schemas). If they contain CityGML data, they will be listed.
"citydb" is the most common one – and, very often, the only one!!

Nota bene: the next slides refer to the "rh" schema

How to create additional citydb schemas
<https://3dcitydb-docs.readthedocs.io/en/latest/3dcitydb/multi-schema.html>

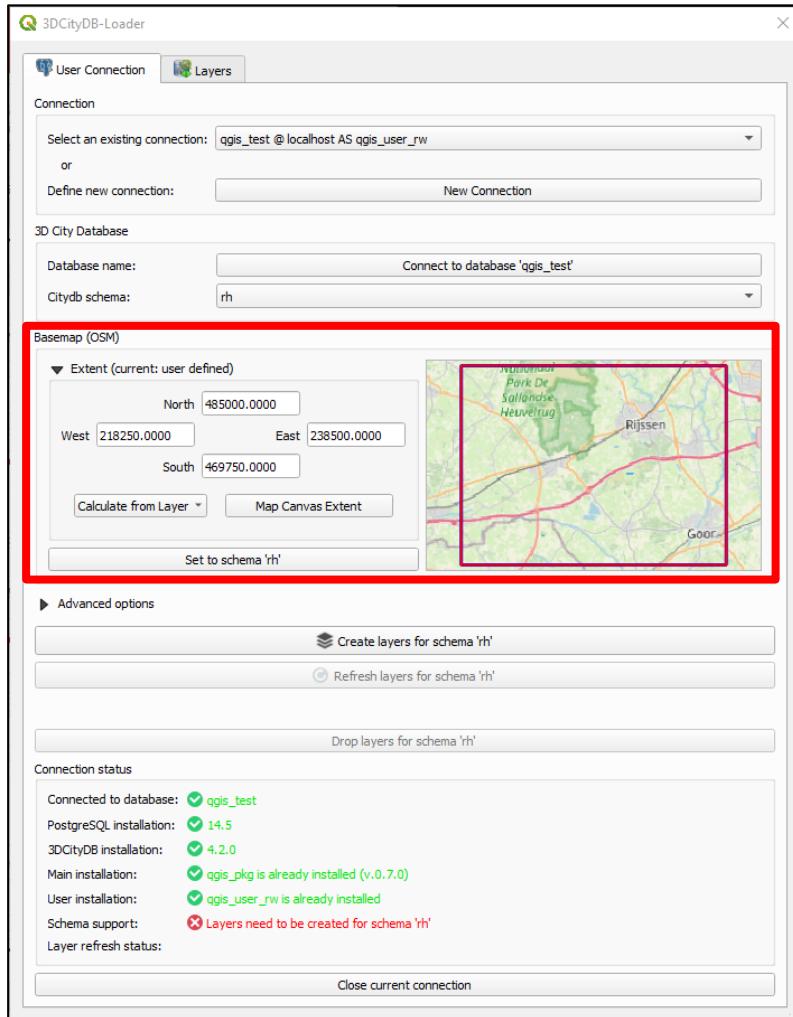


Use: As user

In the "User connection" tab

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4) Upon selection of the database schema, you will see the extents of the dataset



Use: As user

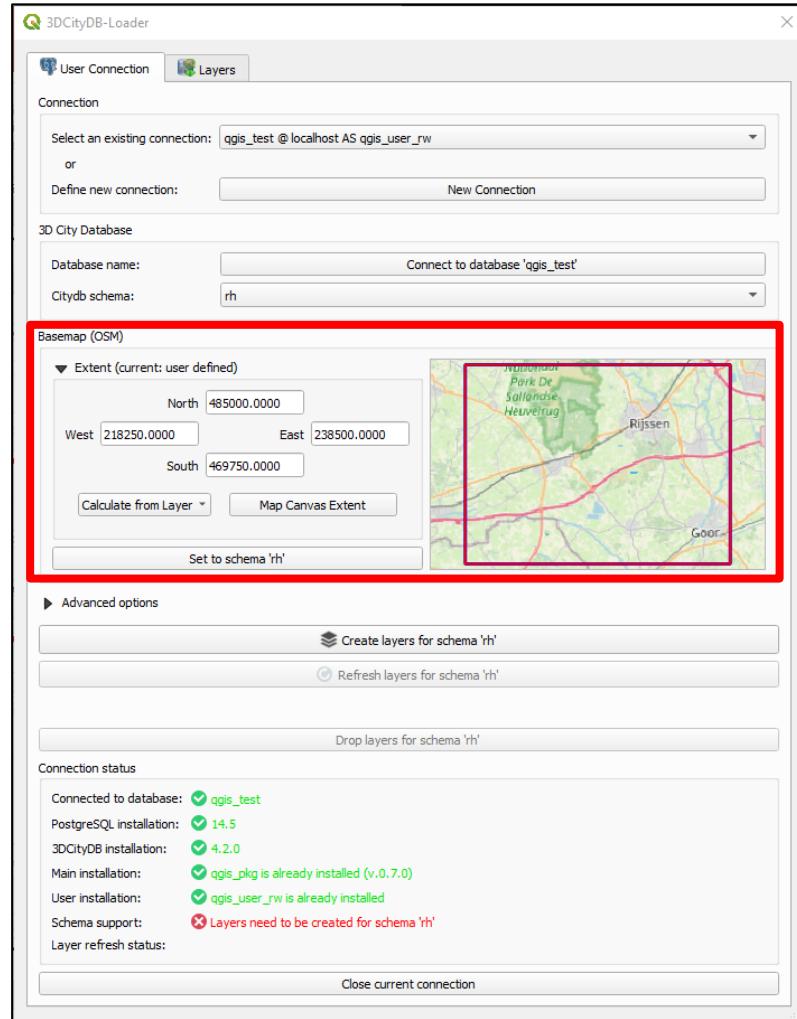
In the "User connection" tab

5) Depending on your needs, you can set the spatial extents of the study area for which the layers will be created

- Default: same size of the whole dataset
- Otherwise: zoom in the map and choose your own area

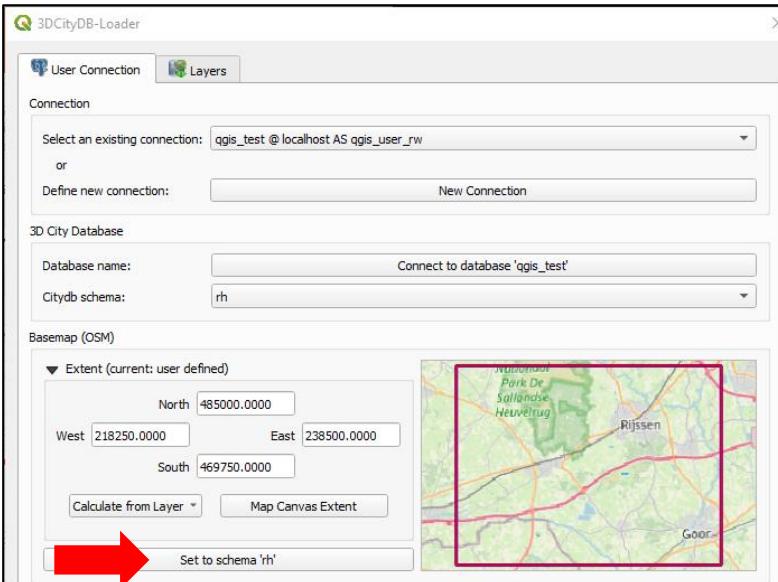
Beware: the bigger the size, the more time it will take to populate the layers!

Behind the scenes: In the database, materialised views of the geometries will be generated according to the selected extents. In case of very large cities, it might take a long time (and a lot of space on the server)!

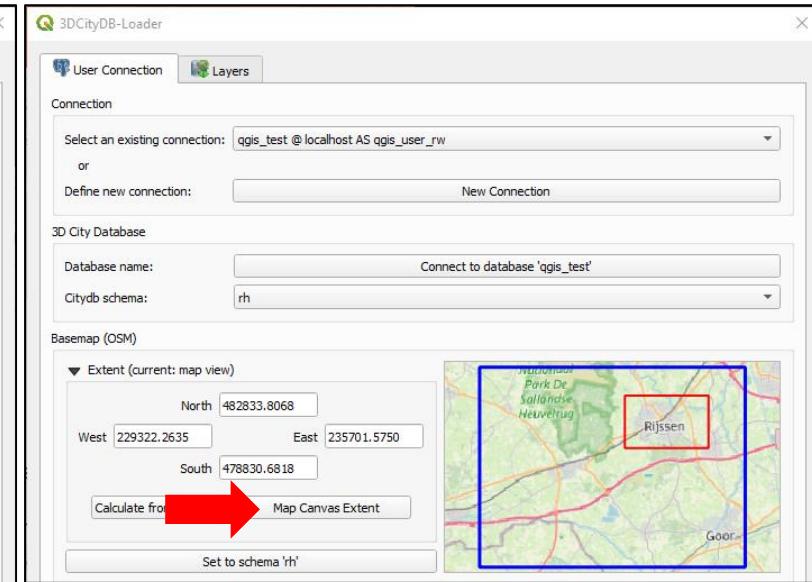


Use: As user

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Both areas coincide (default)



User-selected layers extents

Use: As user

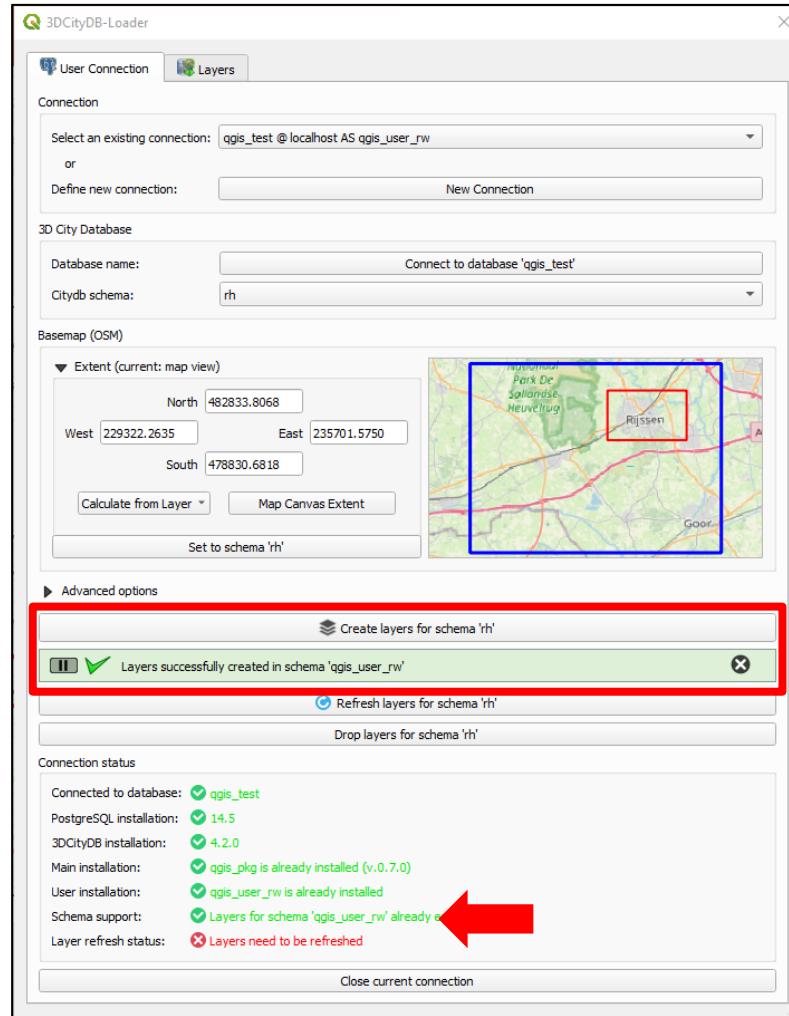
In the "User connection" tab

6) Create the layers

Otherwise, if available, layers created in a previous session can be used

Behind the scenes: In the database, (empty) materialised views of the geometries and views will be created as layers.

Only layers for *existing* data will be created.



Use: As user

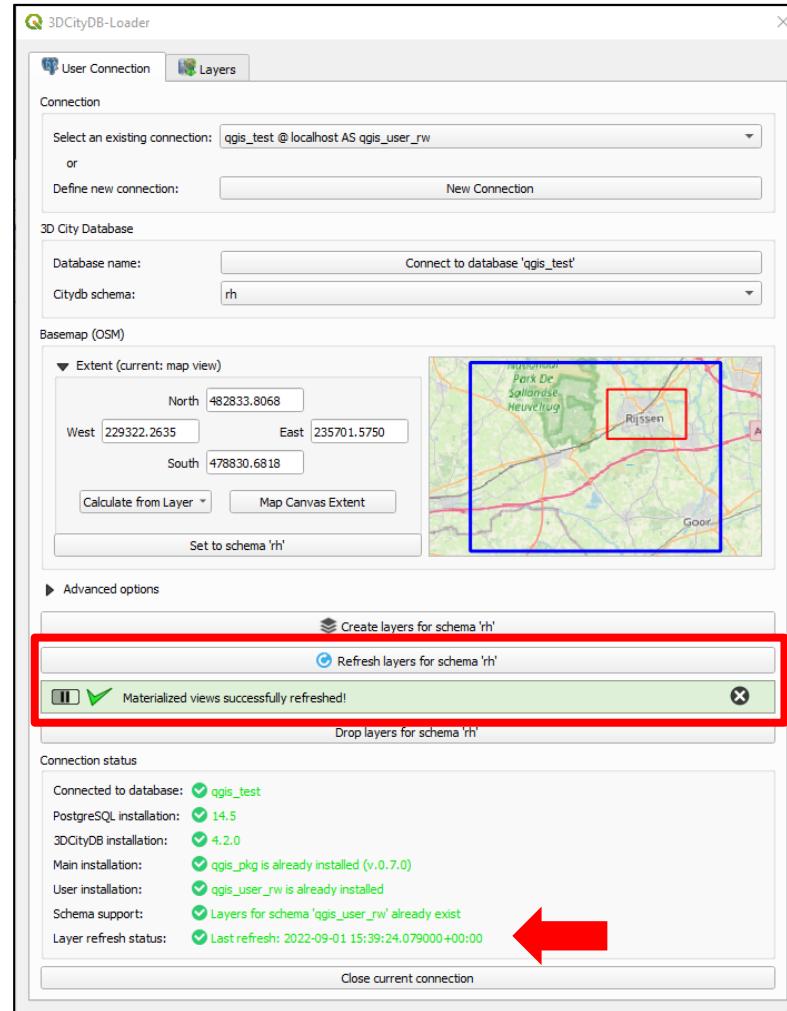
In the "User connection" tab

7) Populate/refresh the layers

Otherwise, if available, layers created in a previous session can be used (or refreshed again)

Beware: depending on the size of the selected area, and the amount of data in the city model, this operation might take long.

Behind the scenes: In the database, the materialised views of the geometries are refreshed.



Use: As user

Behind the scenes:

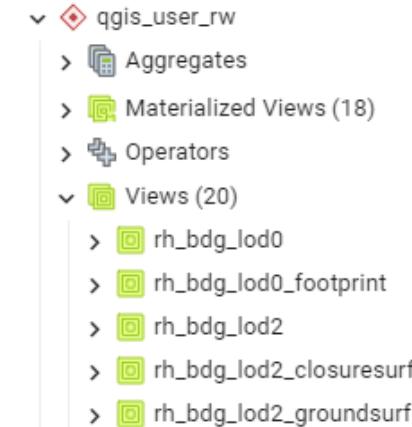
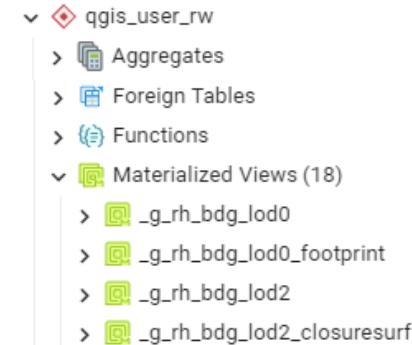
In the database user schema, both materialised views (containing the feature geometries) and the layers (as updatable views, containing the feature attributes linked to the corresponding geometries in the materialised views) can be accessed.

Materialised views name coding:

- "_g_" prefixed + citydb schema name + feature name + lodx + (optional) semantic details

Views name coding:

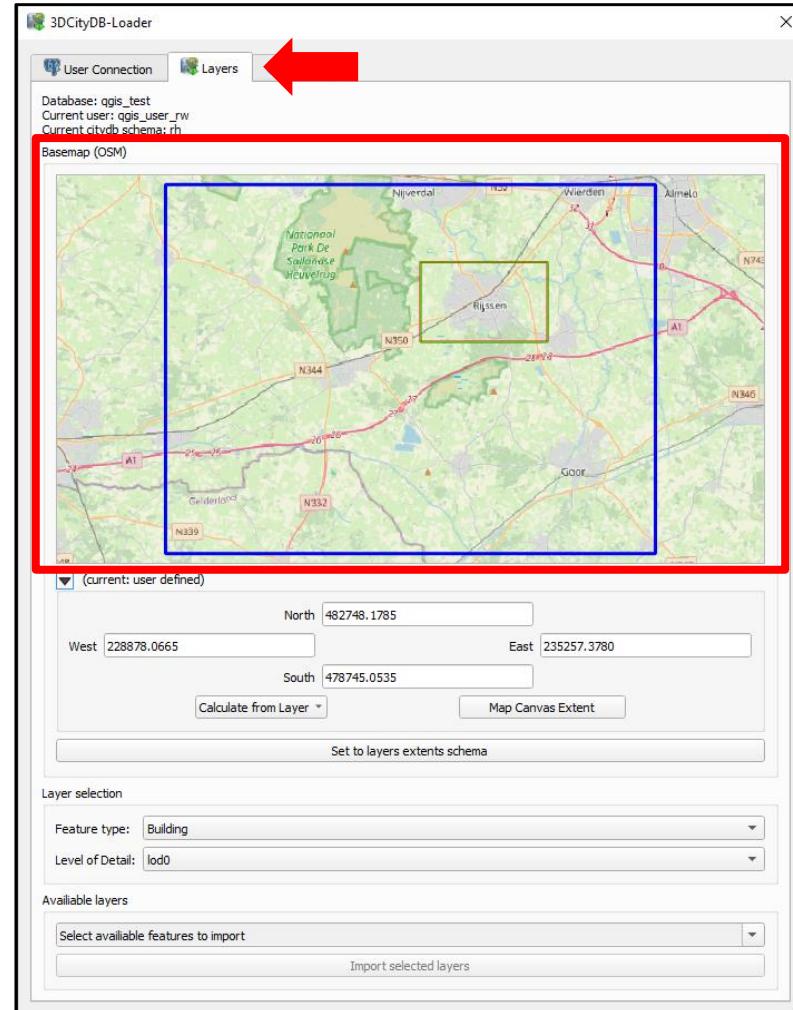
- citydb schema name + feature name + lodx + (optional) semantic details
- Linked via column co_id (PK and FK to the materialised views)



Use: As user

In the "Layers" tab

- 8) The dataset and the (database-side) layer extents are shown again in the map



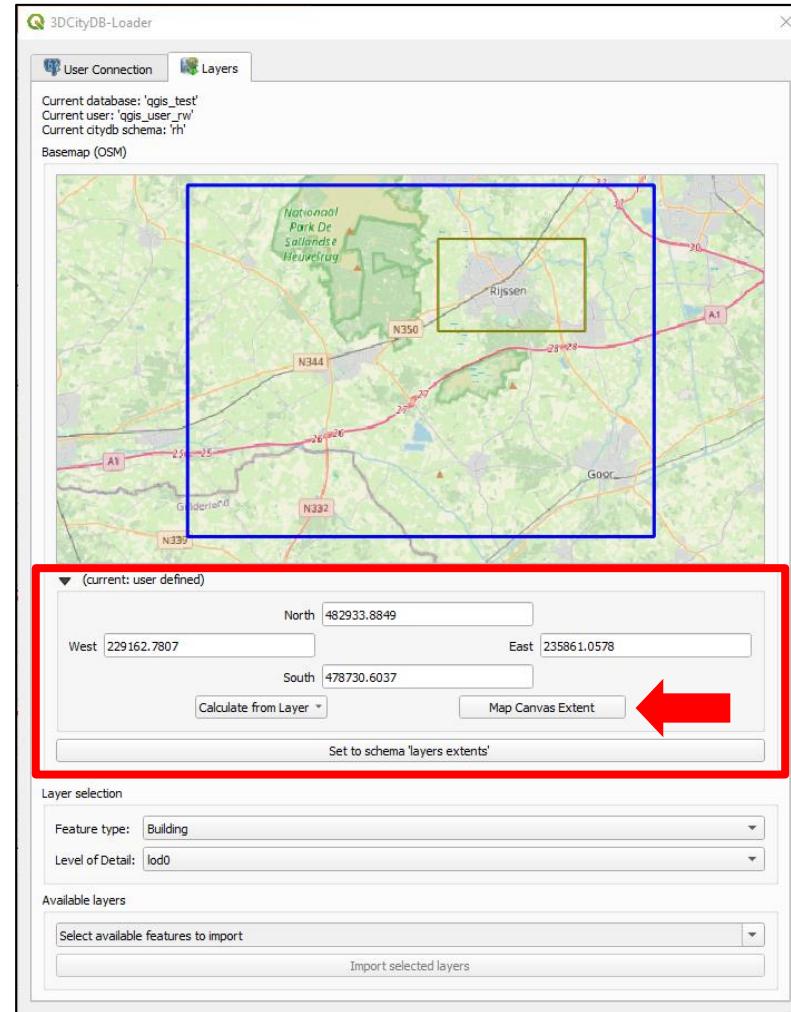
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Use: As user

In the "Layers" tab

9) Depending on your needs, you can further reduce the extents of the layers to be loaded into QGIS

- Default: same size of the materialised view extents
- Otherwise: zoom in the map and choose your own area



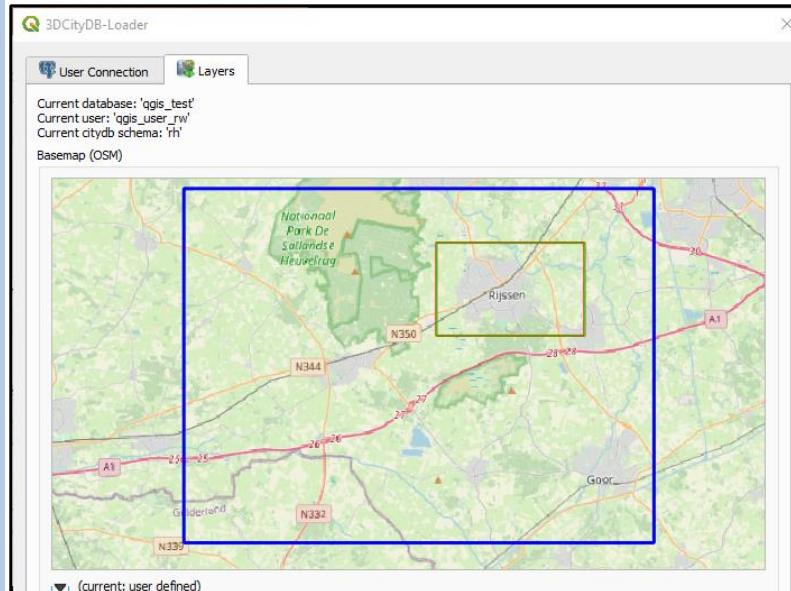
Use: As user

Blue: database schema extents (i.e. extents of the whole city model/dataset)

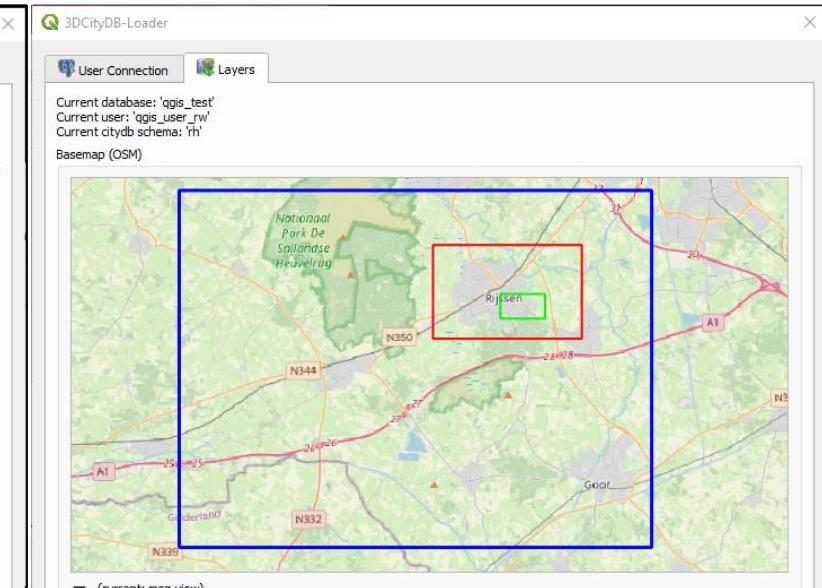
Red: database-side layers extents (i.e. extents of the materialised views)

Green: QGIS-side layers extents (i.e. extents of the data loaded into QGIS)

Remember: **QGIS-extents \subseteq Mat. views extents \subseteq City model extents**



Database- and QGIS-side extents coincide (default)



User-selected QGIS-layers extents

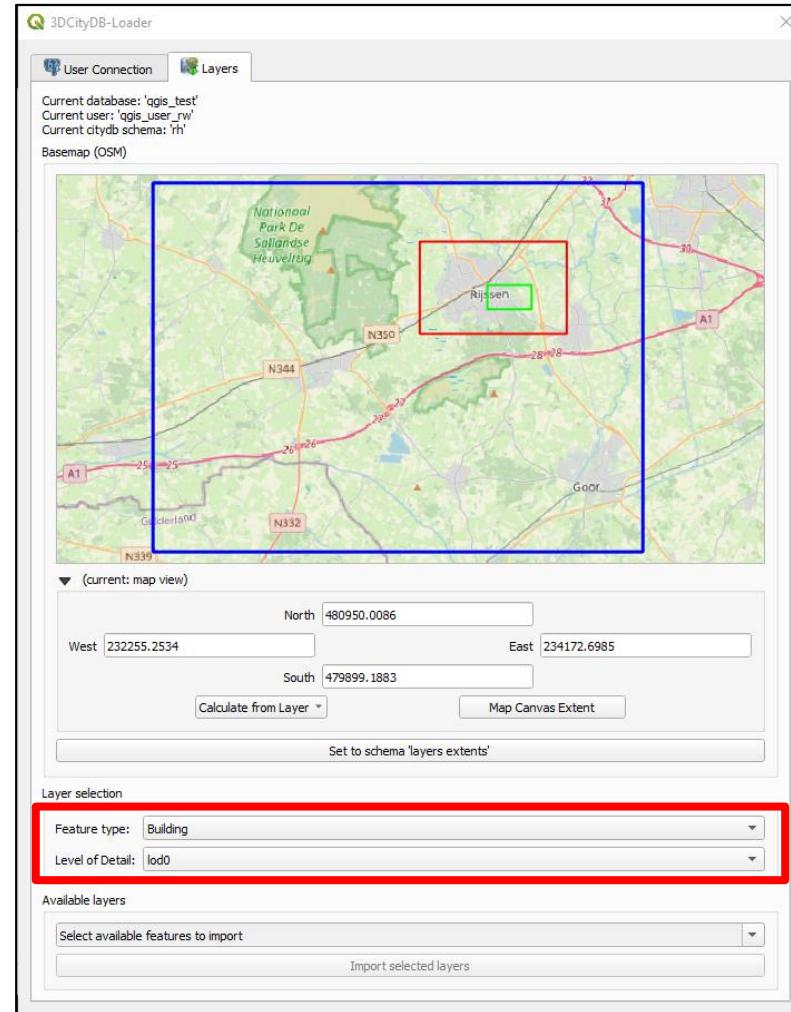
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In the "Layers" tab

10) Select feature type and LoD

- Layers are grouped according to the CityGML modules (or "Feature Types", such as "Bridge", "Building", "Tunnel", "Relief", etc.)
- Depending on the data stored in the database, only certain Feature Types and LoDs will be selectable



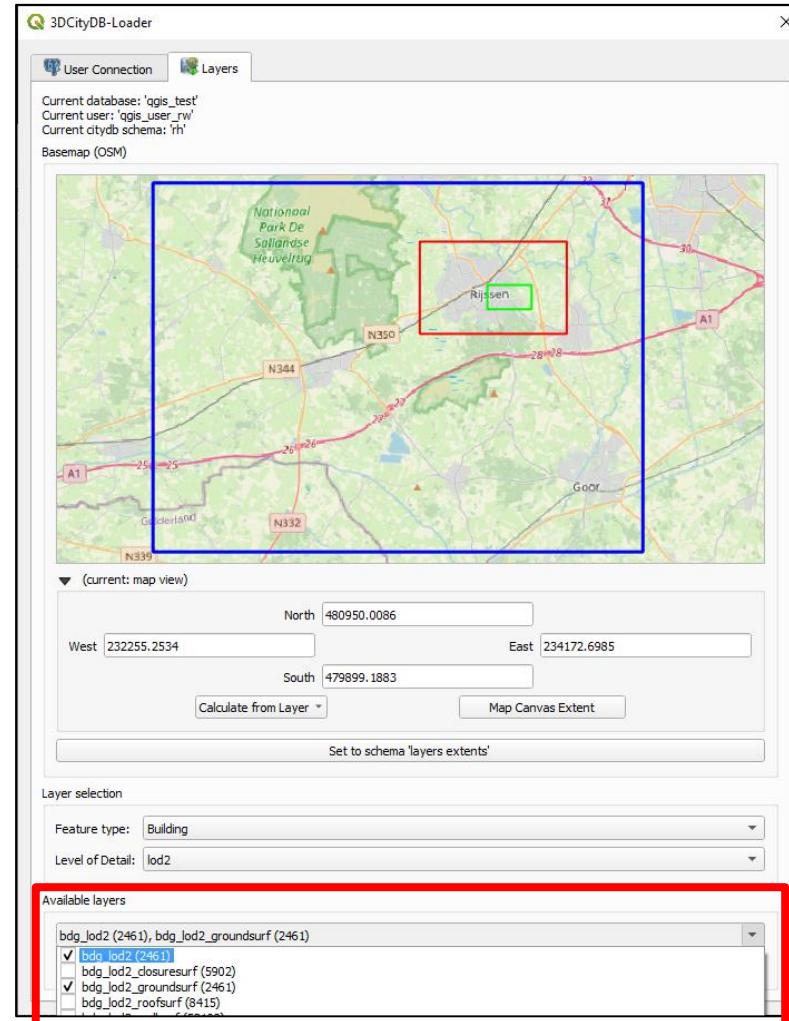
Use: As user

In the "Layers" tab

11) Select the layer(s) to import in QGIS

- The number of available features is shown next to the layer name

Behind the scenes: Depending on the QGIS layers extents, the plugin shows only the available layers with data *within* the given extents.

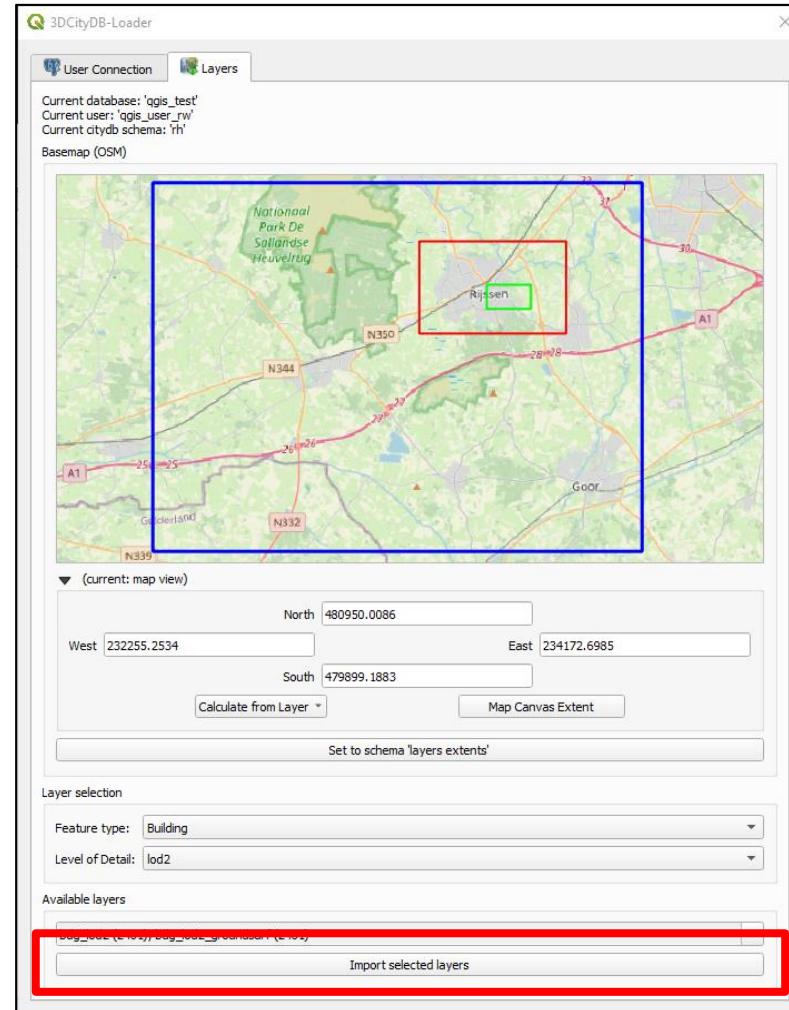


Use: As user

In the "Layers" tab

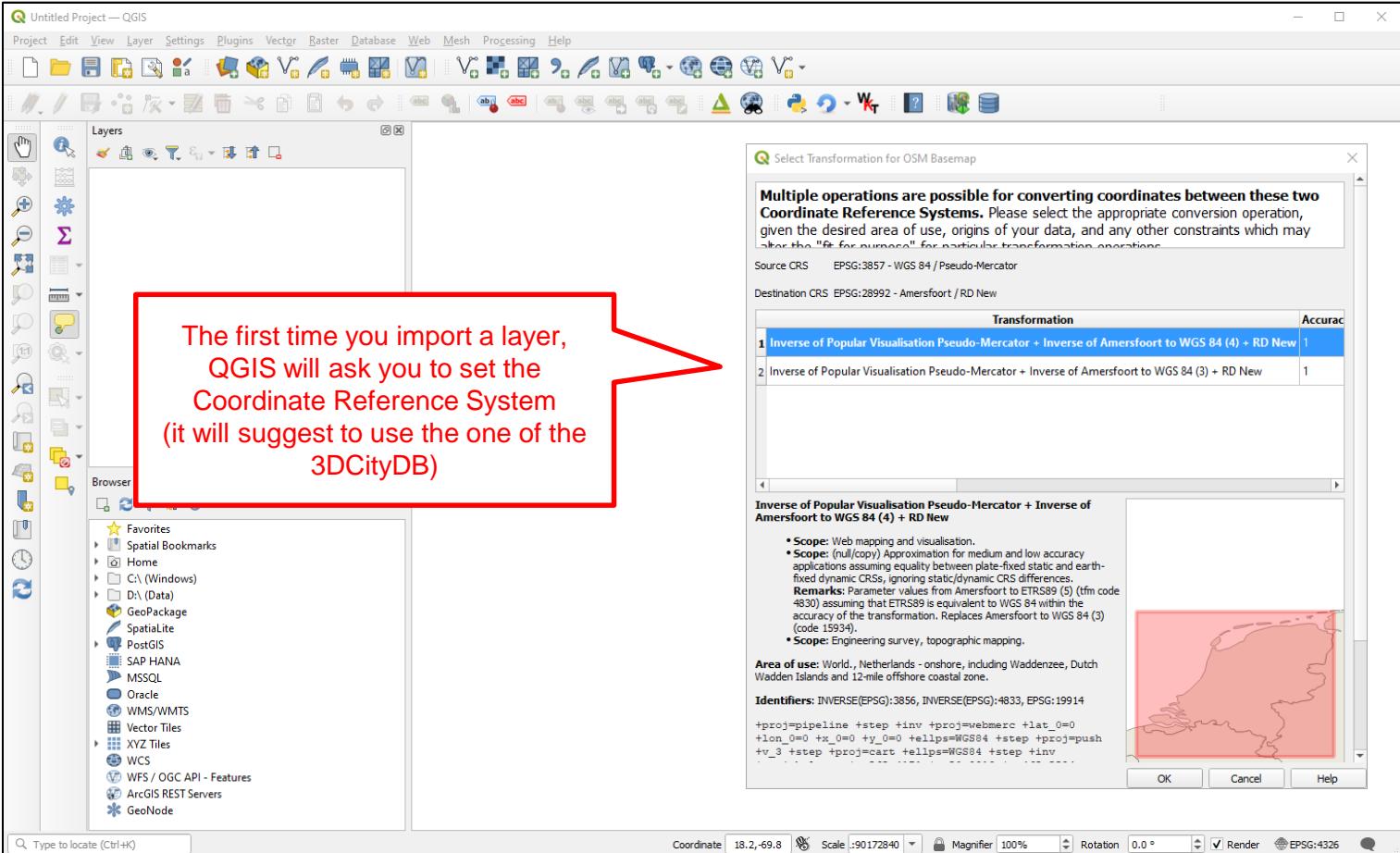
12) Import the selected layers into QGIS

- The import operation can be repeated with different layers
- The layers will be automatically added to the QGIS Table of Contents
- The Plugin window can be closed, the connection parameters and settings will be kept until the connection is intentionally closed by the user (in the "User connection" tab)



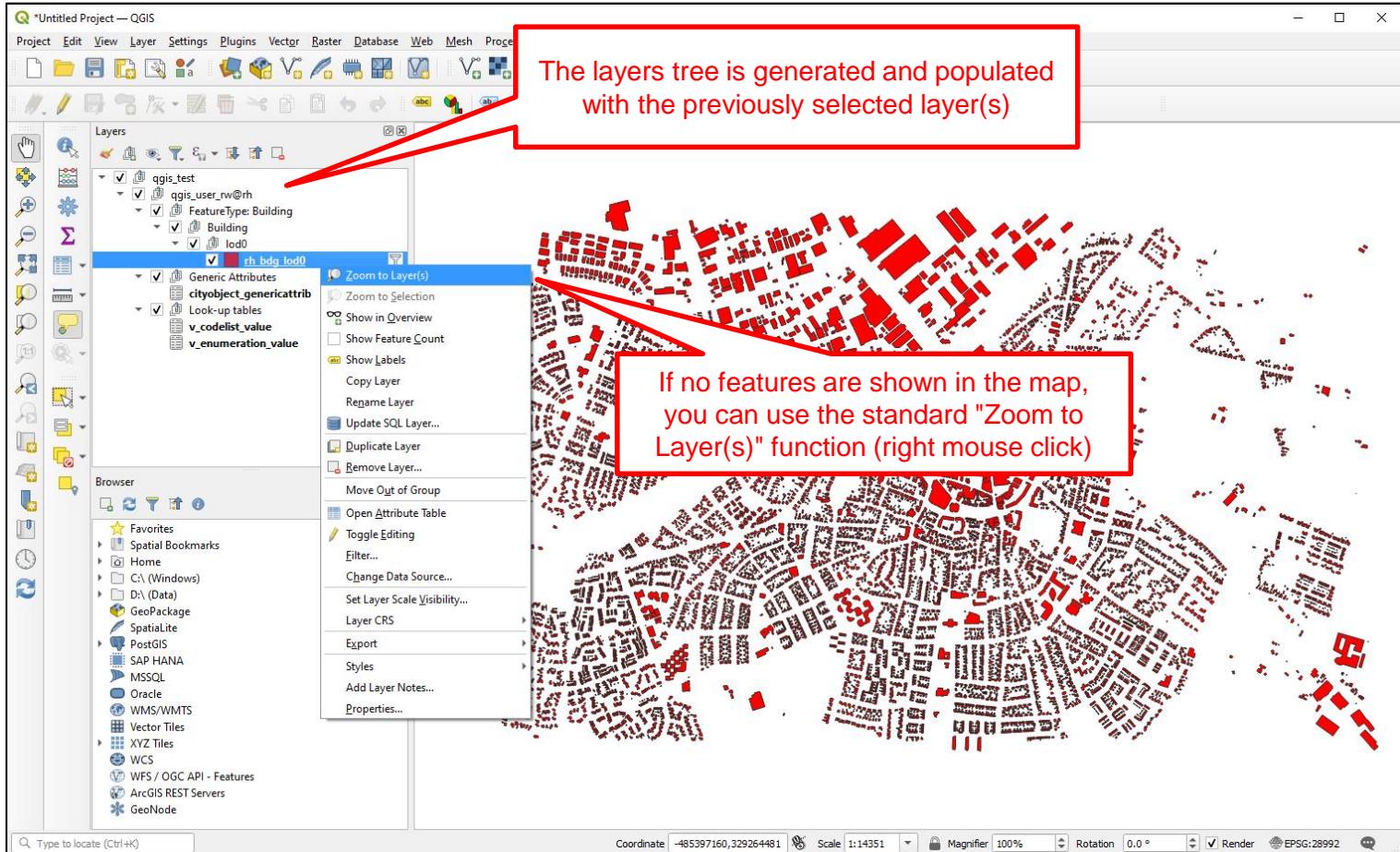
Use in QGIS: Layers

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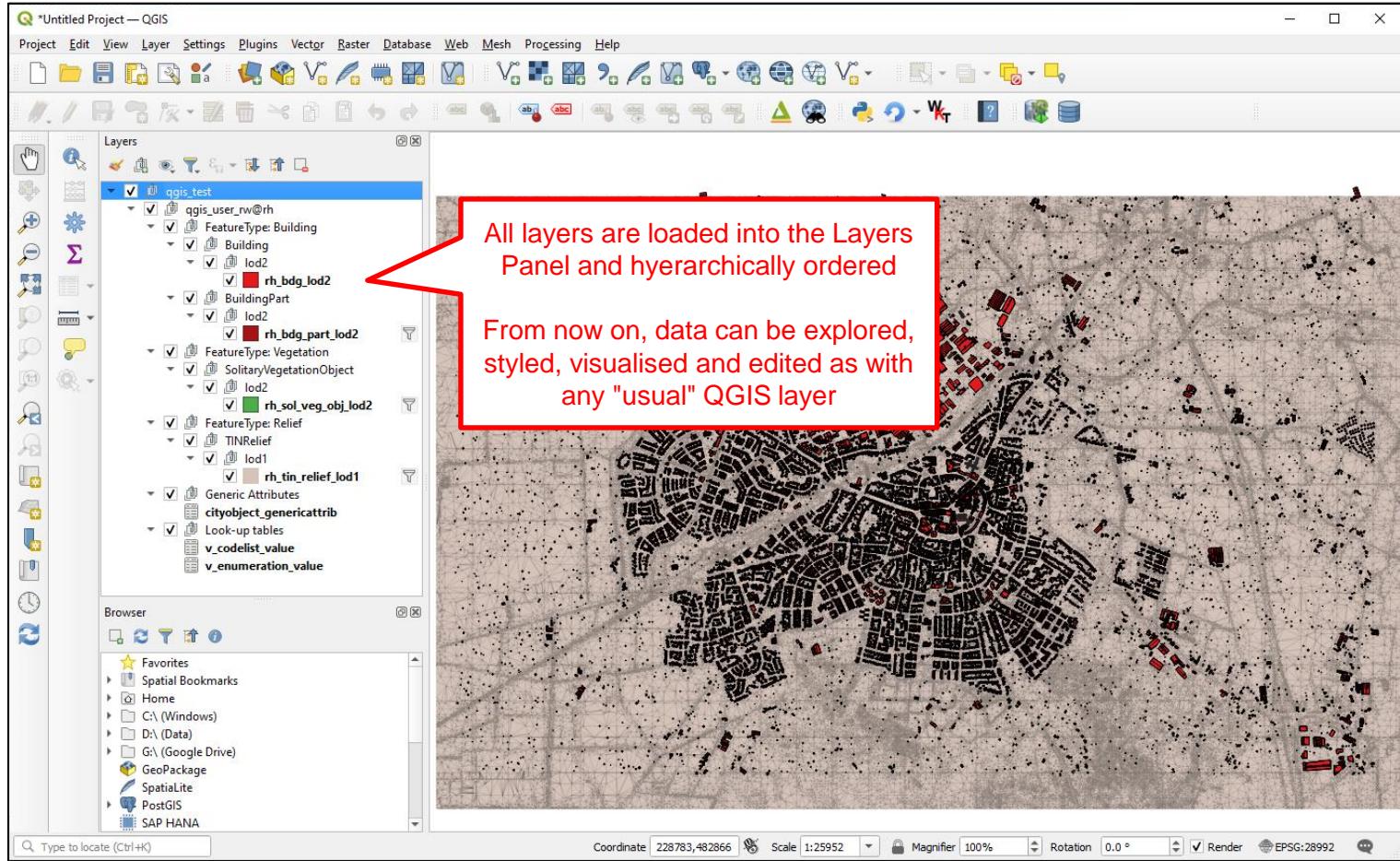
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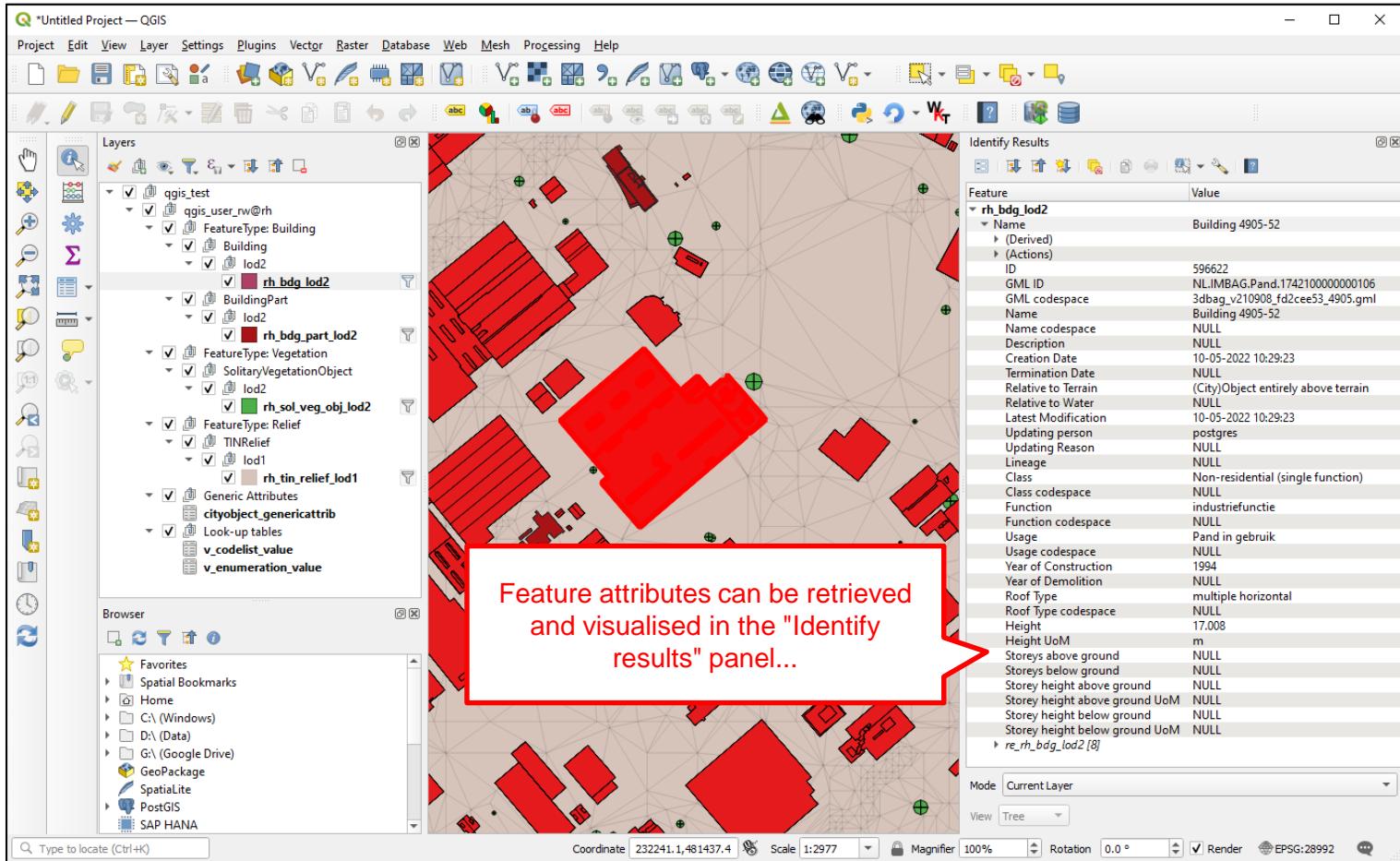
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Use in QGIS: Attributes

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The screenshot shows the QGIS interface with a map of buildings highlighted in red. The 'Identify Results' panel on the right displays detailed attributes for a selected feature, specifically a building labeled 'rh_bdg_lod2'. A callout bubble points to this panel with the text: 'Feature attributes can be retrieved and visualised in the "Identify results" panel...'. The 'Identify Results' panel includes columns for 'Feature' and 'Value', listing numerous attributes such as Name, ID, GML ID, and various height and classification parameters.

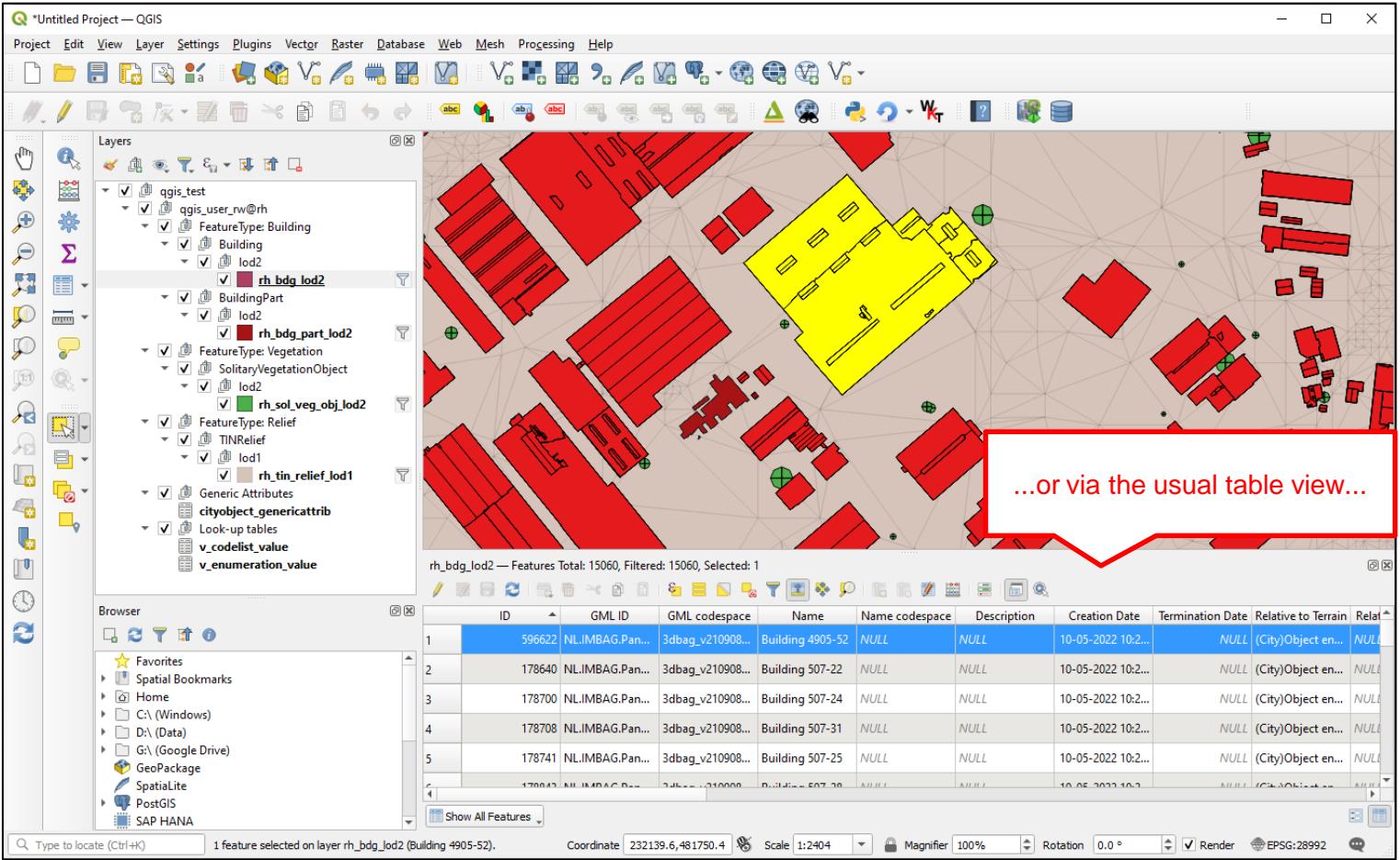
Feature	Value
rh_bdg_lod2	Building 4905-52
Name	(Derived)
ID	596622
GML ID	NLIMBAG.Pand.174210000000106
GML codespace	3dbag_v210908_fd2ceef53_4905.gml
Name codespace	Building 4905-52
Description	NULL
Creation Date	NULL
Termination Date	NULL
Relative to Terrain	(City)Object entirely above terrain
Relative to Water	NULL
Latest Modification	10-05-2022 10:29:23
Updating person	postgres
Updating Reason	NULL
Lineage	NULL
Class	Non-residential (single function)
Class codespace	NULL
Function	industriefunctie
Function codespace	NULL
Usage	Pand in gebruik
Usage codespace	NULL
Year of Construction	1994
Year of Demolition	NULL
Roof Type	multiple horizontal
Roof Type codespace	NULL
Height	17.008
Height UoM	m
Storeys above ground	NULL
Storeys below ground	NULL
Storey height above ground	NULL
Storey height above ground UoM	NULL
Storey height below ground	NULL
Storey height below ground UoM	NULL
re_rh_bdg_lod2 [8]	

Mode: Current Layer
 View: Tree

Coordinate: 232241.1, 481437.4 Scale: 1:2977 Magnifier: 100% Rotation: 0.0° Render: EPSG:28992

Use in QGIS: Attributes

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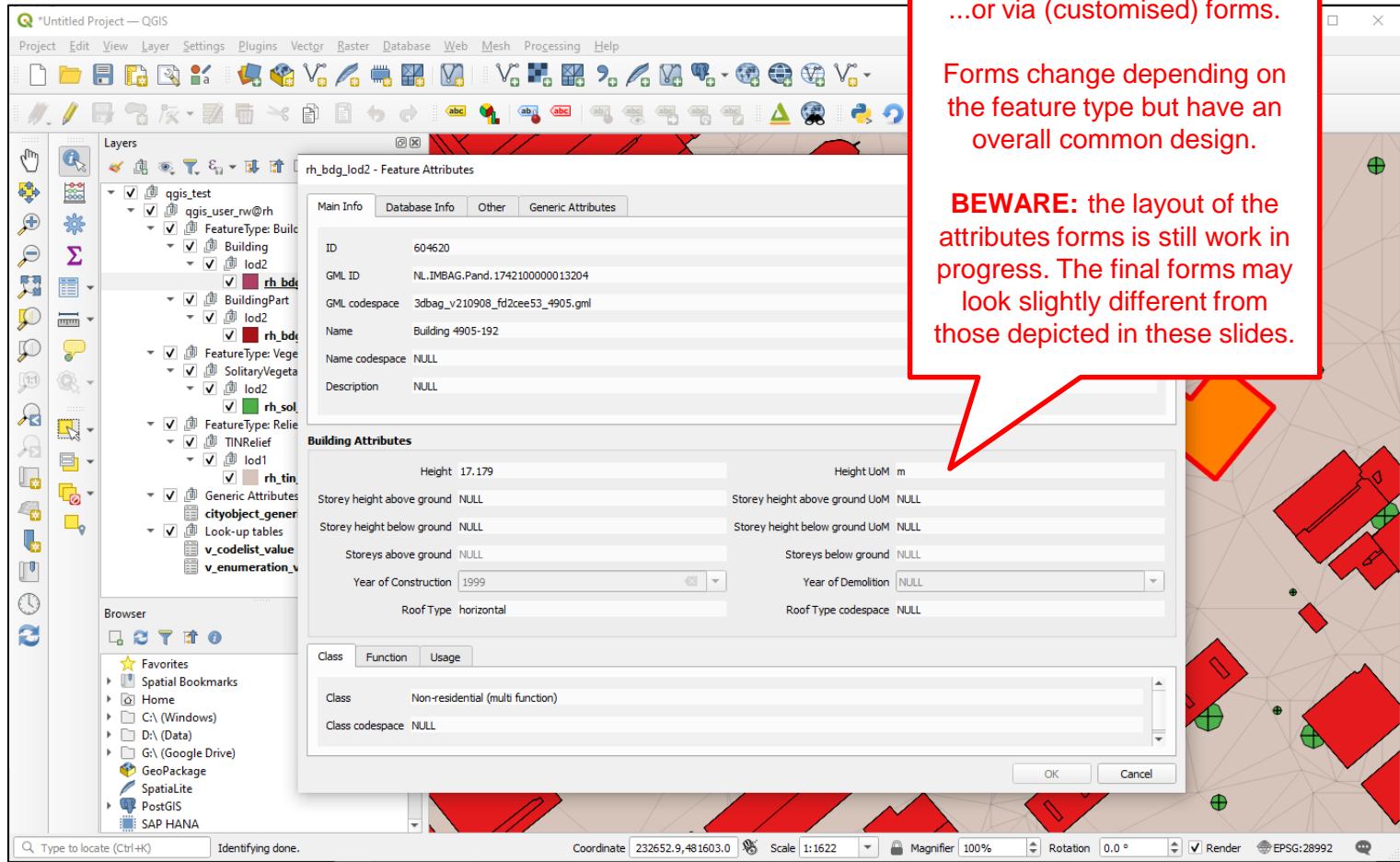
The screenshot shows the QGIS interface with a map of buildings and vegetation. A red callout box points to the attribute table at the bottom right of the interface.

...or via the usual table view...

ID	GML ID	GML codespace	Name	Name codespace	Description	Creation Date	Termination Date	Relative to Terrain	Relat...
1	596622	NL.3DGeoInfo.3dbag_v210908...	Building 4905-52	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL
2	178640	NL.3DGeoInfo.3dbag_v210908...	Building 507-22	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL
3	178700	NL.3DGeoInfo.3dbag_v210908...	Building 507-24	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL
4	178708	NL.3DGeoInfo.3dbag_v210908...	Building 507-31	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL
5	178741	NL.3DGeoInfo.3dbag_v210908...	Building 507-25	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL
	178602	NL.3DGeoInfo.3dbag_v210908...	Building 507-20	NULL	NULL	10-05-2022 10:2...	NULL	(City)Object en...	NULL

Use in QGIS: Attributes

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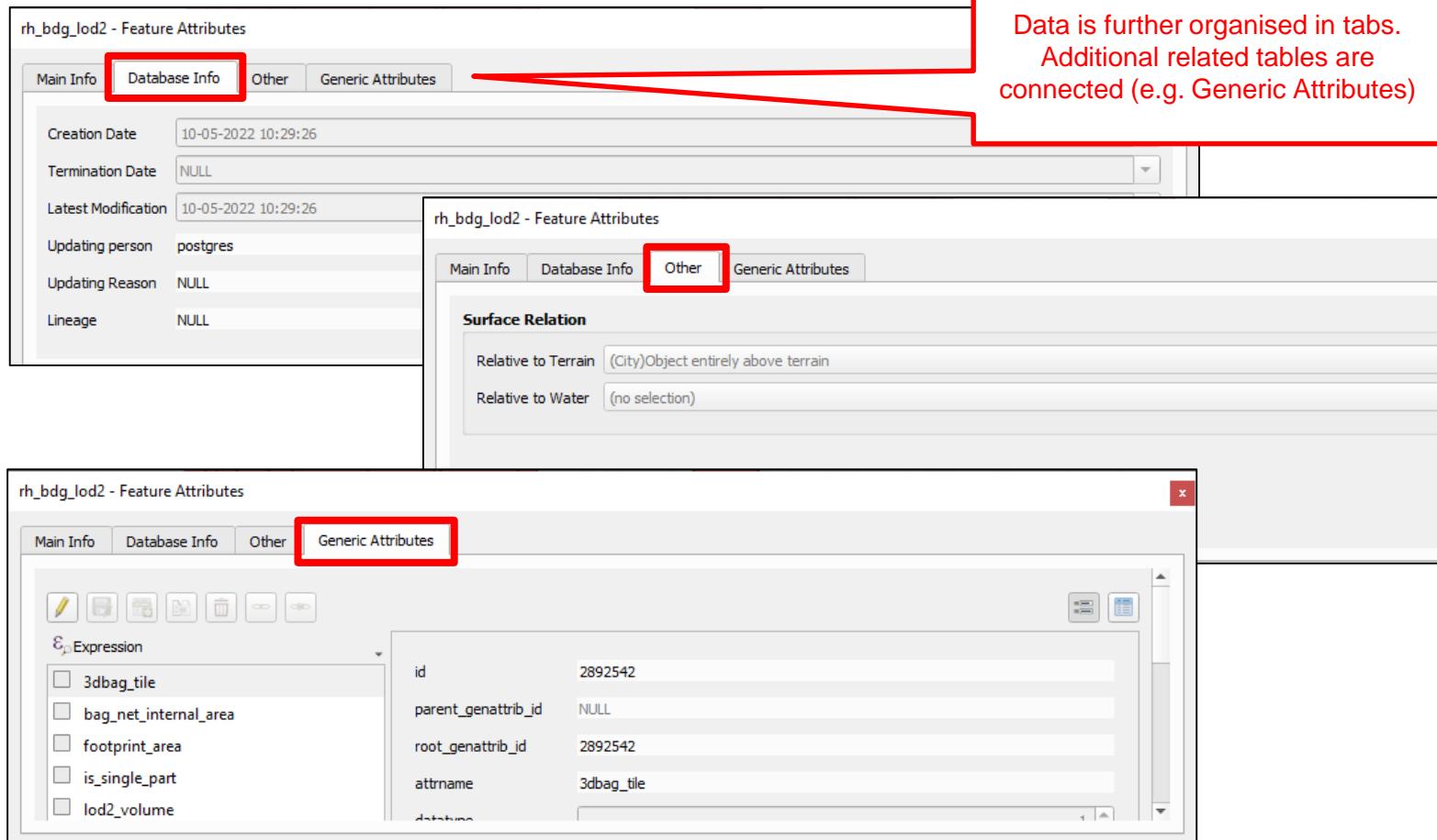
...or via (customised) forms.

Forms change depending on the feature type but have an overall common design.

BEWARE: the layout of the attributes forms is still work in progress. The final forms may look slightly different from those depicted in these slides.

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Data is further organised in tabs.
 Additional related tables are connected (e.g. Generic Attributes)

rh_bdg_lod2 - Feature Attributes

Main Info Database Info Other Generic Attributes

Creation Date 10-05-2022 10:29:26

Termination Date NULL

Latest Modification 10-05-2022 10:29:26

Updating person postgres

Updating Reason NULL

Lineage NULL

rh_bdg_lod2 - Feature Attributes

Main Info Database Info Other Generic Attributes

Surface Relation

Relative to Terrain (City)Object entirely above terrain

Relative to Water (no selection)

rh_bdg_lod2 - Feature Attributes

Main Info Database Info Other **Generic Attributes**

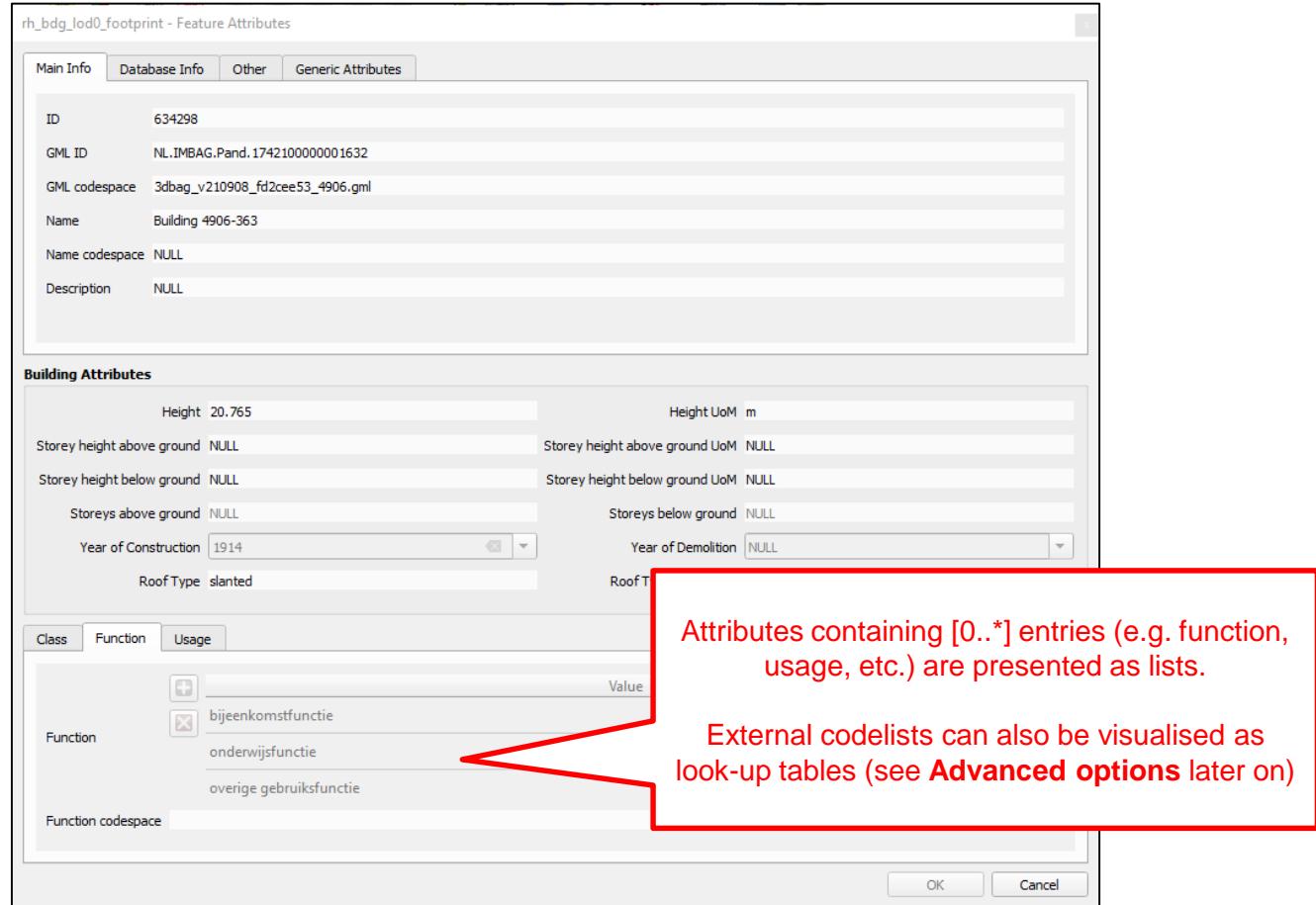
Expression

- 3dbag_tile
- bag_net_internal_area
- footprint_area
- is_single_part
- lod2_volume

id	2892542
parent_genattrib_id	NULL
root_genattrib_id	2892542
attrname	3dbag_tile
datatype	

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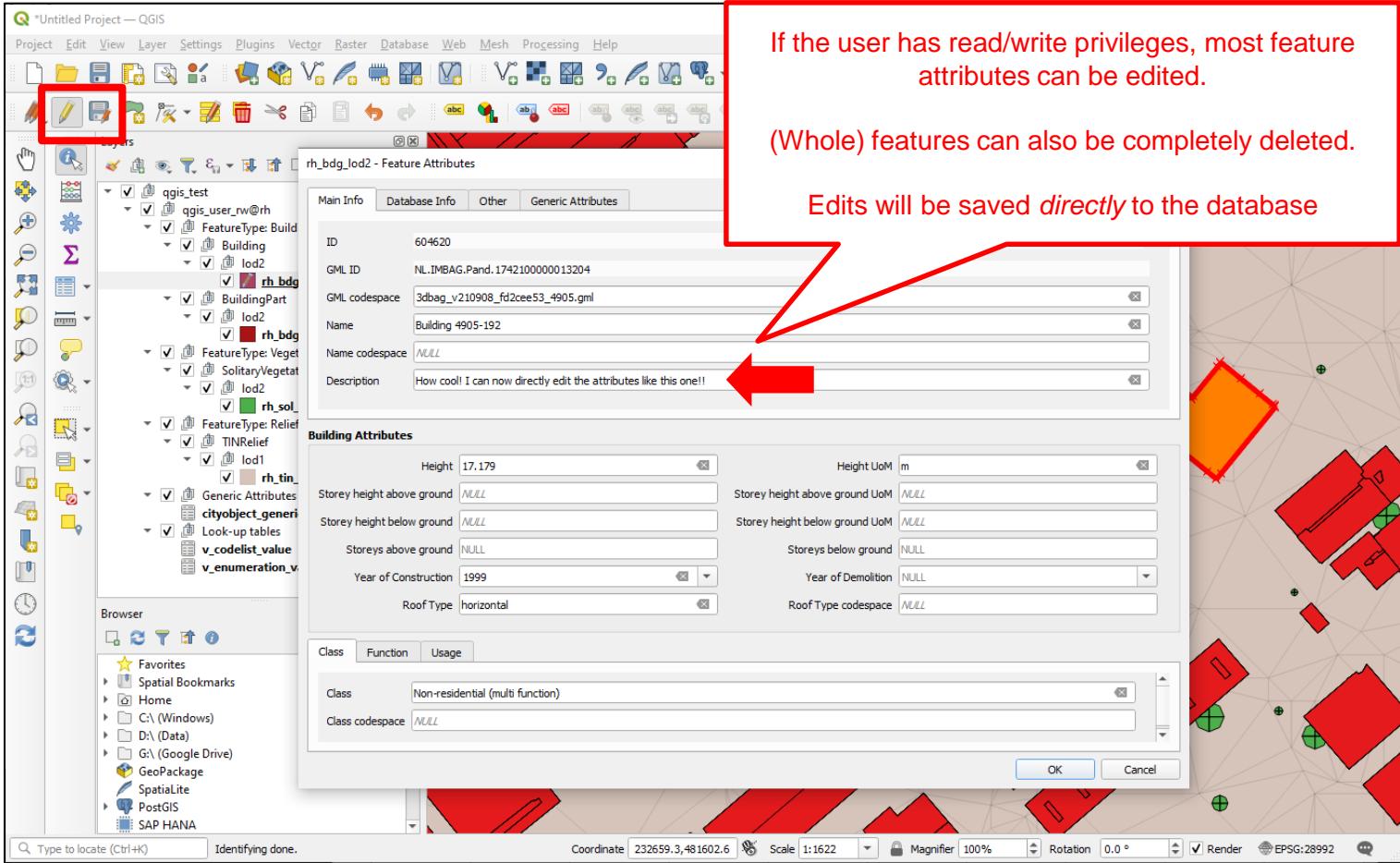
The screenshot shows the 'Feature Attributes' dialog for a building feature in QGIS. The dialog has tabs for 'Main Info', 'Database Info', 'Other', and 'Generic Attributes'. Under 'Main Info', fields include ID (634298), GML ID (NL.IMGAG.Pand.1742100000001632), GML codespace (3dbag_v210908_fd2cee53_4906.gml), Name (Building 4906-363), Name codespace (NULL), and Description (NULL). The 'Building Attributes' section contains fields for Height (20.765), Height UoM (m), Storey height above ground (NULL), Storey height below ground (NULL), Storeys above ground (NULL), Storeys below ground (NULL), Year of Construction (1914), Year of Demolition (NULL), and Roof Type (slanted). At the bottom, there are tabs for 'Class', 'Function', and 'Usage'. The 'Function' tab is selected, showing a list of values: bijeenkomstfunctie, onderwijsfunctie, and overige gebruiksfunctie. A red box highlights this 'Function' section, and a red arrow points from it to a callout text.

Attributes containing [0..*] entries (e.g. function, usage, etc.) are presented as lists.

External codelists can also be visualised as look-up tables (see **Advanced options** later on)

Use in QGIS: Attribute editing

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The screenshot shows the QGIS interface with a red box highlighting the edit tool icon in the toolbar. The left panel displays a tree view of layers and features, with a specific building feature selected. The main window shows the 'Feature Attributes' dialog for this feature. The 'Building' tab is active, displaying attributes like ID, GML ID, Name, and Description. The 'Building Attributes' section contains fields for Height, Storey height above ground, Storey height below ground, etc. A large red callout box on the right side of the dialog contains the following text:

If the user has read/write privileges, most feature attributes can be edited.
 (Whole) features can also be completely deleted.
 Edits will be saved *directly* to the database

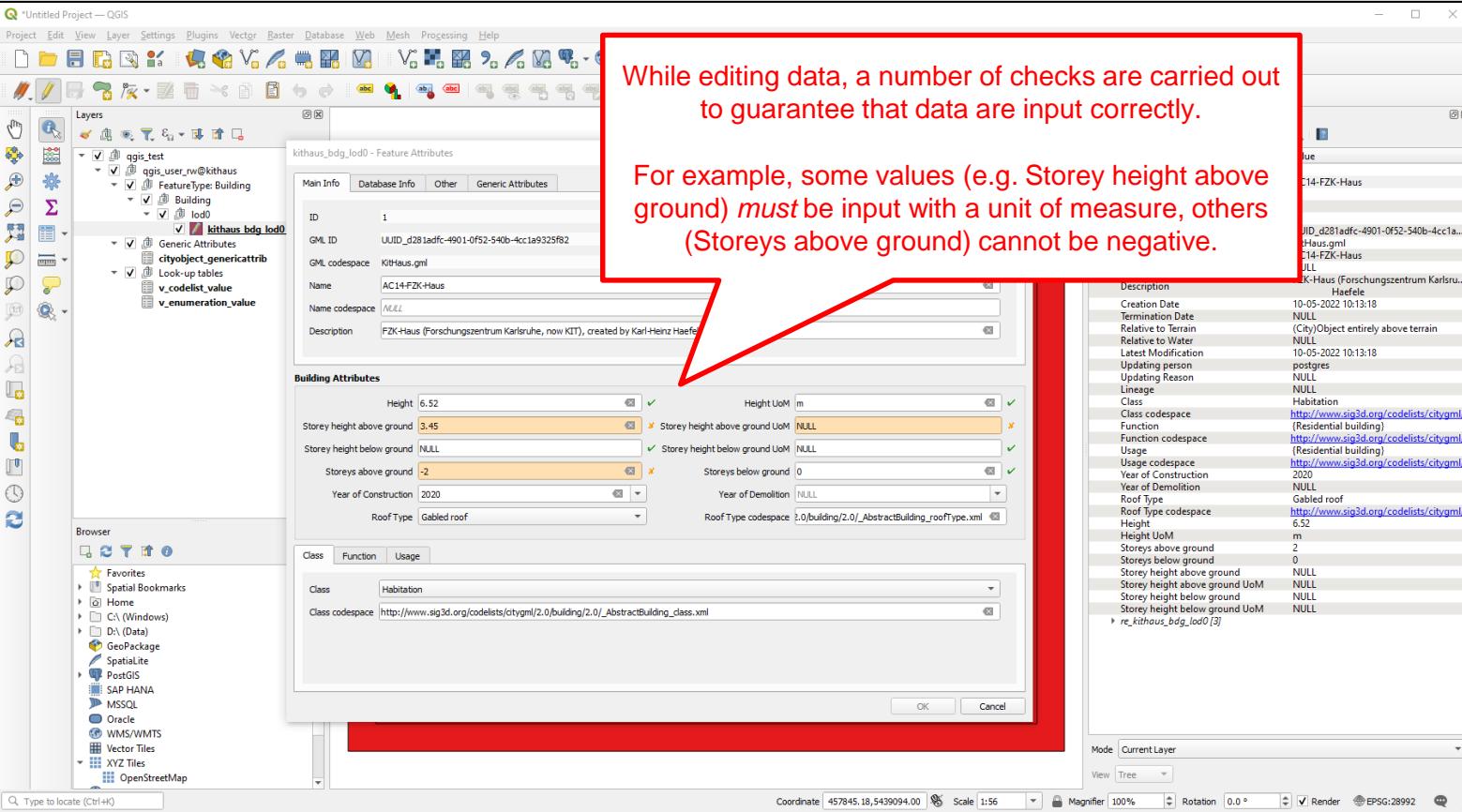
A red arrow points from the bottom of the callout box back towards the 'Description' field in the dialog.

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While editing data, a number of checks are carried out to guarantee that data are input correctly.

For example, some values (e.g. Storey height above ground) *must* be input with a unit of measure, others (Storeys above ground) cannot be negative.



The screenshot shows the QGIS attribute editor for a building feature. A red callout box highlights the 'Building Attributes' section where several fields have validation errors:

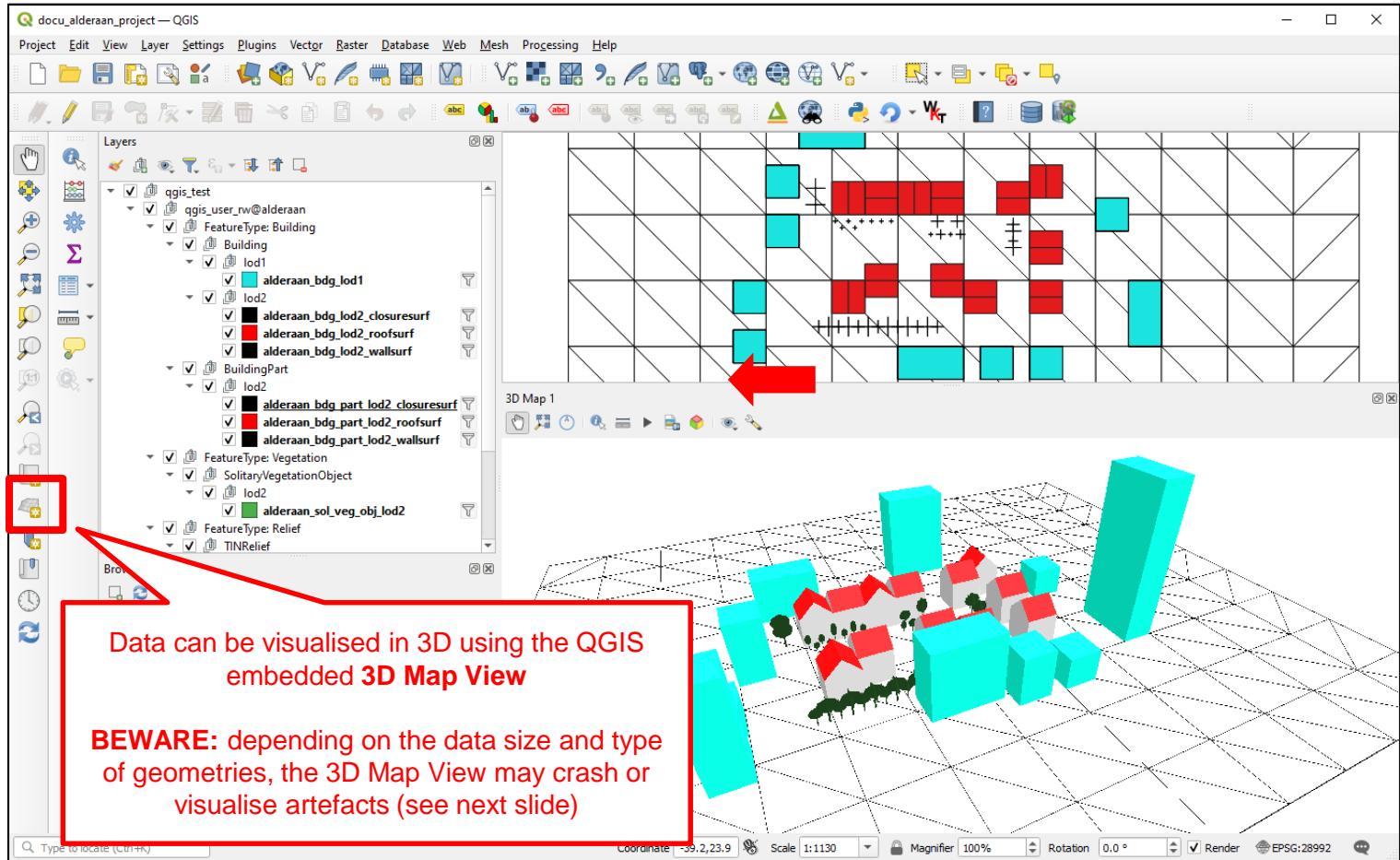
- 'Height' has a green checkmark and a unit of 'm'.
- 'Storey height above ground' has an orange error icon and a value of '3.45'.
- 'Storey height below ground' has a green checkmark and a value of 'NULL'.
- 'Storeys above ground' has an orange error icon and a value of '-2'.
- 'Storeys below ground' has a green checkmark and a value of '0'.

To the right, the 'Attribute Table' shows the raw data with units and null values. A red arrow points from the error message in the callout box to the 'Storeys above ground' field in the attribute table.

Field	Description	Value	Unit	Notes
ID	ID	1		
GML ID	GML ID	UUID_d281adfc-4901-0f52-540b-4cc1a9325f82		
GML codespace	GML codespace	Kithaus.gml		
Name	Name	AC14-FZK-Haus		
Name codespace	Name codespace	NULL		
Description	Description	FZK-Haus (Forschungszentrum Karlsruhe, now KIT), created by Karl-Heinz Haefe		
Building Attributes				
Height	Height	6.52	m	✓
Storey height above ground	Storey height above ground	3.45	m	✗
Storey height below ground	Storey height below ground	NULL	m	✓
Storeys above ground	Storeys above ground	-2	m	✗
Year of Construction	Year of Construction	2020		
Roof Type	Roof Type	Gabled roof		
Height UoM	Height UoM	m		✓
Storey height above ground UoM	Storey height above ground UoM	NULL		✗
Storey height below ground UoM	Storey height below ground UoM	NULL		✓
Storeys above ground	Storeys above ground	2		✓
Storeys below ground	Storeys below ground	0		✓
Year of Demolition	Year of Demolition	NULL		
Roof Type codespace	Roof Type codespace	http://www.sig3d.org/codelists/building/2.0/_AbstractBuilding_rooftype.xml		
Class				
Class	Class	Habitation		
Class codespace	Class codespace	http://www.sig3d.org/codelists/citygml/2.0/building/2.0/_AbstractBuilding_class.xml		

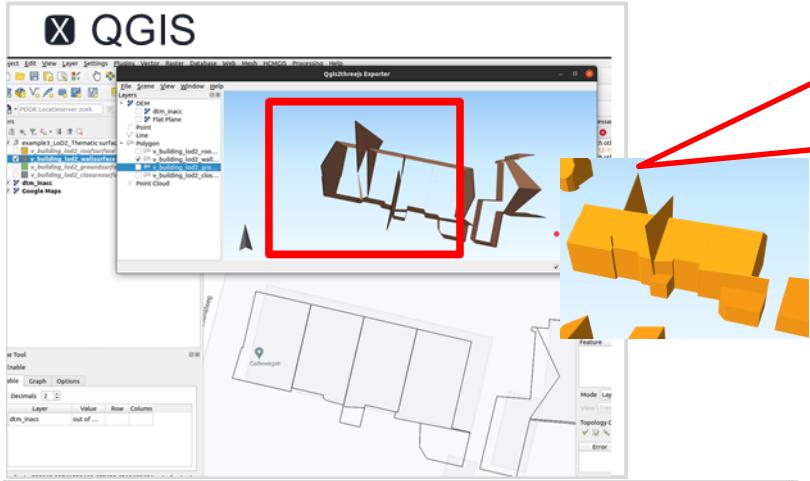
Use in QGIS: 3D visualisation

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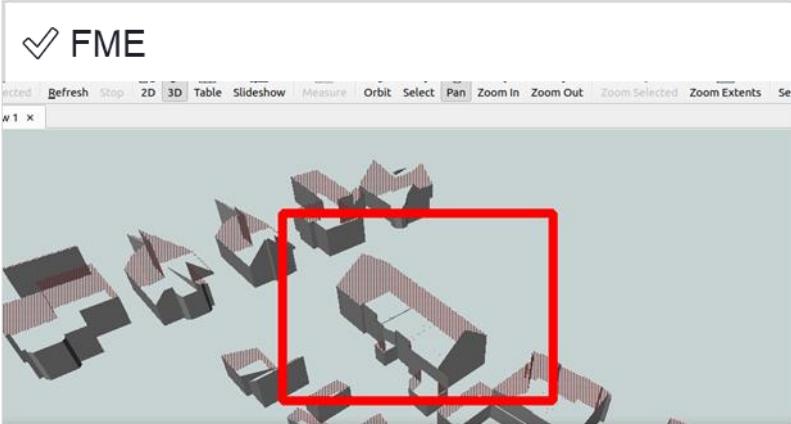
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In our tests, such artefacts are however a 3D visualisation issue (QGIS 3D renderer?) and *not* related to the actual data. 3D visualisation in FME and in Google Earth show indeed correct results.

In order to minimise this problem, please refer to **Advanced options** (see later)



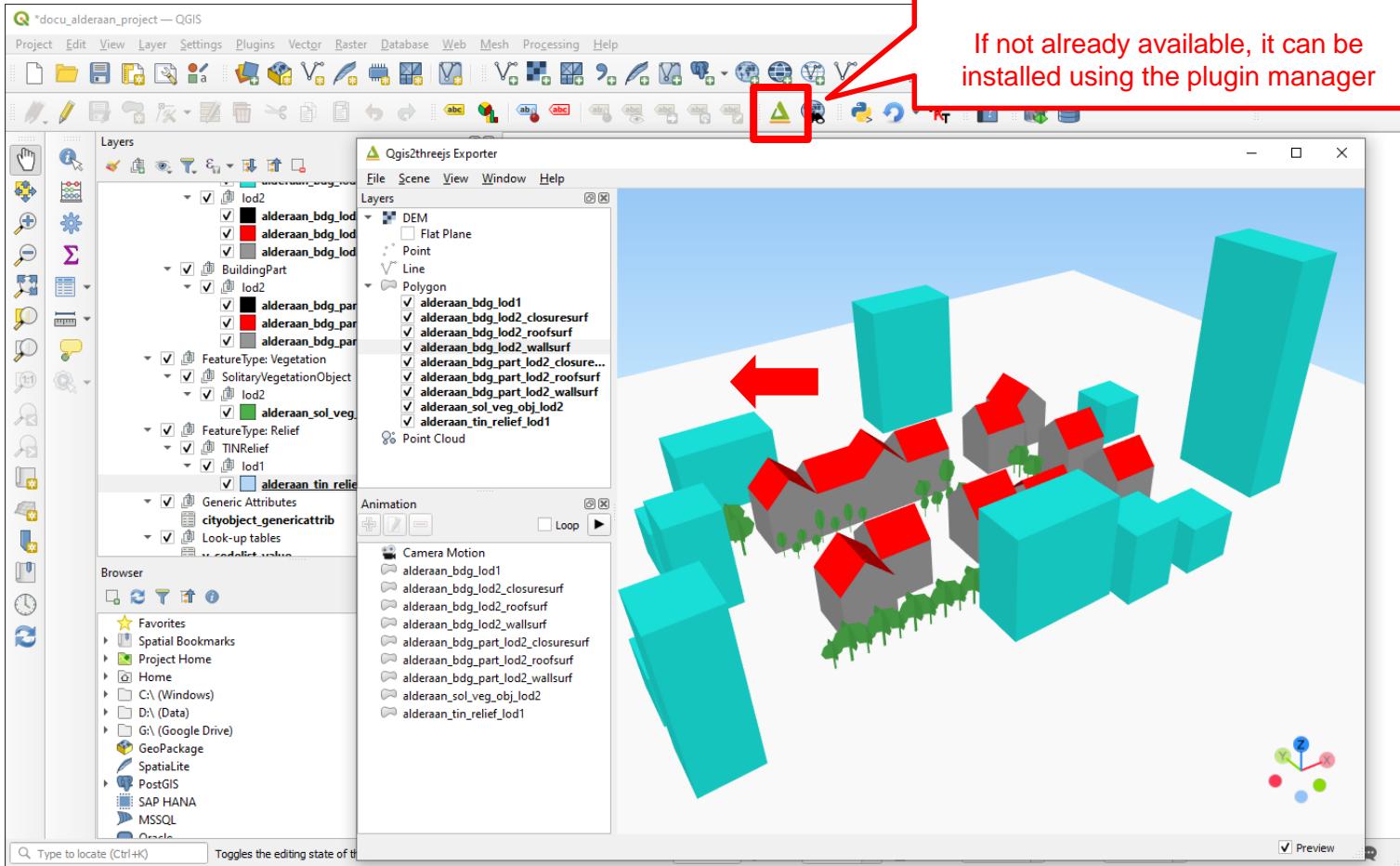
✓
**Google earth
 (as KML)**

Use in QGIS: 3D visualisation

Alternatively, the **Qgis2threejs** plugin can be used for 3D visualisation.

If not already available, it can be installed using the plugin manager

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Advanced options

- As administrator
 - Add and manage non-default database users
 - Fine-tune privileges
- As user
 - Simplify geometries in materialised views
 - Set up look-up tables in the attribute forms
 - Add personalised codelists

Database user management (as Administrator)

IMPORTANT: The following operations are currently NOT supported by the QGIS 3DCityDB-Loader GUI and must be carried out by the database administrator via a SQL console, e.g. from PgAdmin.

In general, the database administrator (or a superuser) can:

- Allow or disallow database users to use the QGIS plugin
- Choose specifically which citydb schema(s) a user can access
- Grant/revoke read-only or read-write privileges per user and per citydb schema
- Uninstall the default users "qgis_user_ro" and/or "qgis_user_rw"

The required SQL functions are all available in schema **qgis_pkg** and will be explained in the next slides.

Database user management (as Administrator)

In order to be visible from the Plugin, a user must be added to the group "qgis_pkg_usrgroup". Predefined PL/pgSQL functions take care of it.

Function **qgis_pkg.grant_qgis_usr_privileges(usr_name, priv_type [, cdb_schema])** can be used and offers multiple possibilities.

SQL examples

-- Database user "giorgio" is added to group "qgis_pkg_usrgroup", can access data in citydb schema "citydb" of the current database with read-only privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('giorgio', 'ro','citydb');
```

-- Database user "kostantinos" is added to group "qgis_pkg_usrgroup", can access data in citydb schema "citydb_2" of the current database with read-write privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('kostantinos ', 'rw','citydb_2');
```

-- Database user "camilo" is added to group "qgis_pkg_usrgroup", can access data in ALL citydb schemas of the current database with read-write privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('camilo ', 'rw');
```

Database user management (as Administrator)

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To revoke the privileges, the corresponding function is **qgis_pkg.revoke_qgis_usr_privileges(usr_name [, cdb_schema])** and offers multiple possibilities.

SQL examples

-- Database user "giorgio" cannot access anymore data in citydb schema "citydb" of the current database
SELECT qgis_pkg.revoke_qgis_usr_privileges('giorgio', 'citydb');

-- Database user "camilo" cannot access anymore ANY citydb schemas of the current database
SELECT qgis_pkg.revoke_qgis_usr_privileges('camilo');

IMPORTANT: The database users are NOT automatically removed from the group "qgis_pkg_usrgroup", as they could still be using other database instances of the 3D City Database. If required, the administrator has to remove them manually.

-- Database user "giorgio" is removed from group "qgis_pkg_usrgroup" and won't be able to use the QGIS plugin anymore
REVOKE qgis_pkg_usrgroup **FROM** giorgio;

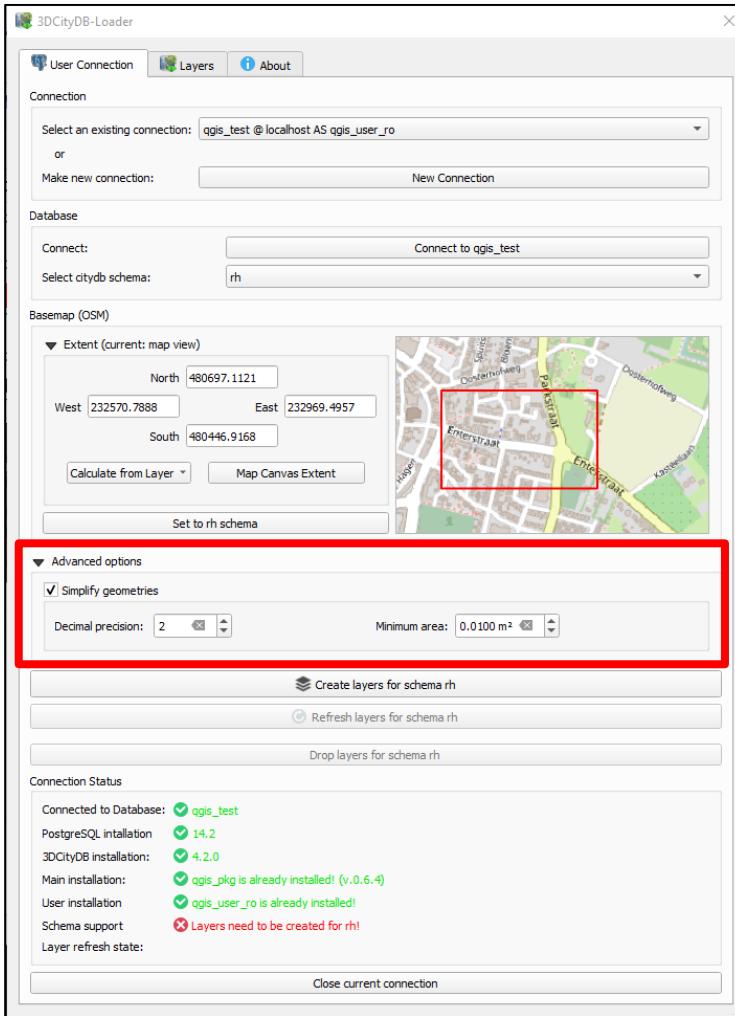
Geometry simplification

In order to simplify geometries and (partially) cope with the 3D visualisation issues of the 3D View Map in QGIS, the user can set some simplification parameters *before* generating the views.

All polygons composing the geometries will be checked. The user can set the number of decimal positions in the coordinates. Resulting degenerate geometries are filtered out. The second parameter filters out all polygons smaller than the chosen threshold.

BEWARE! This operation:

- can significantly increase the time needed to refresh the layers
- does NOT change the original data in the database! ☺



Codelists and look-up tables

For certain CityGML properties (e.g. class, function, usage, roof type, etc.) the QGIS attribute forms can be linked to look-up tables containing

- values from the non-normative CityGML specifications
- values optionally defined by the user

This applies to properties containing single (e.g. class, roof type) or, possibly, multiple values (e.g. function, usage)

If required, in this way the user does not have to "remember" specific codes, thus reducing the chances of wrong data input.

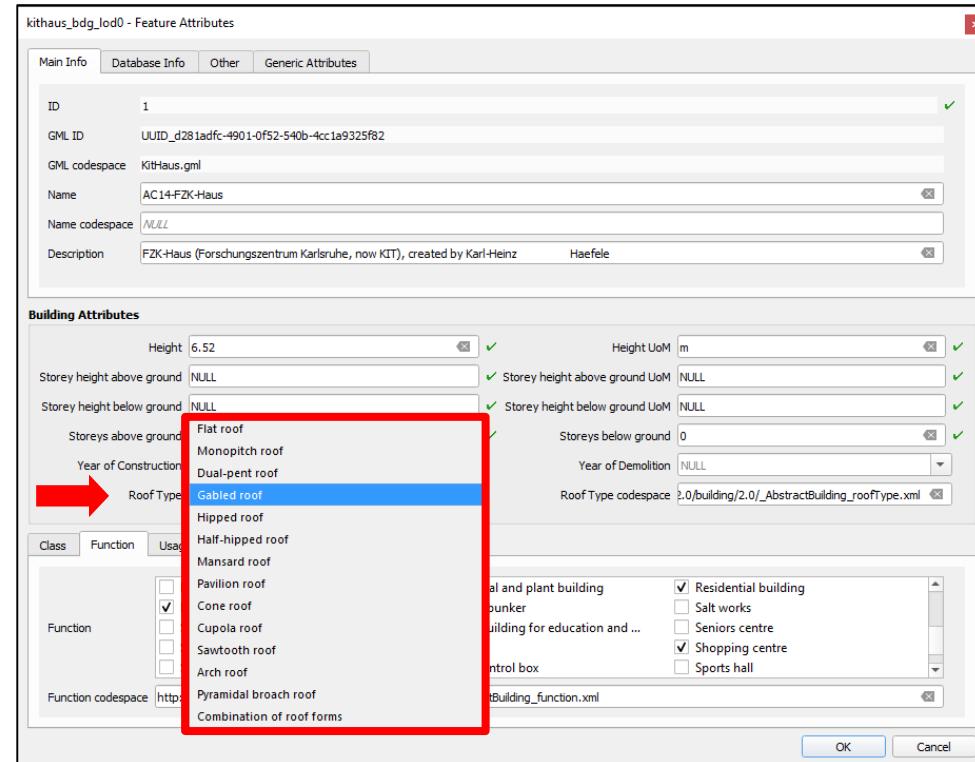
See next slides for examples

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In the case of a CityGML property with cardinality **[0..1]**, the associated codelist values are presented as a drop-down list.

Example: property **Roof type**



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In the case of a CityGML property with cardinality **[0..*]**, the associated codelist values are presented as a multiple-selection list.

Example: property (Building) function

kithaus_bdg_Iod0 - Feature Attributes

Main Info Database Info Other Generic Attributes

ID: 1
 GML ID: UUID_d281adfc-4901-0f52-540b-4cc1a9325f82
 GML codespace: KitHaus.gml
 Name: AC14-FZK-Haus
 Name codespace: NULL
 Description: FZK-Haus (Forschungszentrum Karlsruhe, now KIT), created by Karl-Heinz Haefele

Building Attributes

Height: 6.52	Height UoM: m
Storey height above ground: NULL	Storey height above ground UoM: NULL
Storey height below ground: NULL	Storey height below ground UoM: NULL
Storeys above ground: 2	Storeys below ground: 0
Year of Construction: 2020	Year of Demolition: NULL
Roof Type: Gabled roof	Roof Type codespace: 2.0/building/2.0/_AbstractBuilding_roofType.xml

Function

<input type="checkbox"/> Residential and office building	<input type="checkbox"/> Residential and plant building	<input checked="" type="checkbox"/> Residential building
<input checked="" type="checkbox"/> Restaurant	<input type="checkbox"/> Rubbish bunker	<input type="checkbox"/> Salt works
<input type="checkbox"/> Sanatorium	<input type="checkbox"/> School Building for education and ...	<input type="checkbox"/> Seniors centre
<input type="checkbox"/> Shipping terminal	<input type="checkbox"/> Shipyard	<input checked="" type="checkbox"/> Shopping centre
<input type="checkbox"/> Signal box or stop signal	<input type="checkbox"/> Signal control box	<input type="checkbox"/> Sports hall

Function codespace: http://www.sig3d.org/codelists/citygml/2.0/building/2.0/_AbstractBuilding_function.xml

OK Cancel



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Behind the scenes:

In the 3DCityDB, string-based columns of attributes containing multiple values (separated by the --\-- field separator) are transformed into arrays in the QGIS Package layers.

Trigger functions take care of data conversion from/to arrays when needed.

3DCityDB table BUILDING (excerpt)

id [PK] bigint	class character varying (256)	function character varying (1000)
1531	Mixed-use	overige gebruiksfunctie--/\-woonfunctie
4431	Mixed-use	winkelfunctie--/\-woonfunctie
7839	Non-residential (multi function)	gezondheidszorgfunctie--/\-kantoorfunctie--/\-winkel functie
15423	Non-residential (multi function)	gezondheidszorgfunctie--/\-kantoorfunctie
15499	Mixed-use	gezondheidszorgfunctie--/\-kantoorfunctie--/\-winkelfunctie--/\-woonf.
16545	Mixed-use	overige gebruiksfunctie--/\-woonfunctie
14490	Mixed-use	bijeenkomstfunctie--/\-gezondheidszorgfunctie--/\-kantoorfunctie--/\-...
15956	Mixed-use	overige gebruiksfunctie--/\-woonfunctie

QGIS Package layer BUILDING (excerpt)

```
function
character varying[])
("overige gebruiksfunctie",woonfunctie)
{winkelfunctie,woonfunctie}
{gezondheidszorgfunctie,kantoorfunctie,winkelfunctie}
{gezondheidszorgfunctie,kantoorfunctie}
{gezondheidszorgfunctie,kantoorfunctie,winkelfunctie,woonfunctie}
("overige gebruiksfunctie",woonfunctie)
{bijeenkomstfunctie,gezondheidszorgfunctie,kantoorfunctie,"overige gebruiksfunctie",woonfunctie}
```



Codelists and look-up tables



- All codelists values are retrieved from the view **v_codelist_value** in the qgis schema of every user (e.g. "qgis_user_rw")
- By default, all CityGML codelists are already available
- To set up the QGIS attributes form, please refer to the next slides

View V_CODELISTS_VALUE (excerpt)

id bigint	data_model character varying	name character varying	value character varying	description text	name_space character varying
1	CityGML 2.0	MimeType	model/vrml	VRML97	https://www.sig3d.org/codelists/stan...
2	CityGML 2.0	MimeType	application/x-3ds	3ds max	https://www.sig3d.org/codelists/stan...
3	CityGML 2.0	MimeType	application/dxf	AutoCad DXF	https://www.sig3d.org/codelists/stan...
4	CityGML 2.0	MimeType	application/x-autocad	AutoCad DXF	https://www.sig3d.org/codelists/stan...
39	CityGML 2.0	_AbstractBuildingClass	1110	Maintainence and waste mana...	https://www.sig3d.org/codelists/stan...
40	CityGML 2.0	_AbstractBuildingClass	1120	Healthcare	https://www.sig3d.org/codelists/stan...
41	CityGML 2.0	_AbstractBuildingClass	1130	Communicating	https://www.sig3d.org/codelists/stan...
42	CityGML 2.0	_AbstractBuildingClass	1140	Security	https://www.sig3d.org/codelists/stan...
43	CityGML 2.0	_AbstractBuildingClass	1150	Storage	https://www.sig3d.org/codelists/stan...
44	CityGML 2.0	_AbstractBuildingClass	1160	Industry	https://www.sig3d.org/codelists/stan...
45	CityGML 2.0	_AbstractBuildingClass	1170	Traffic	https://www.sig3d.org/codelists/stan...
46	CityGML 2.0	_AbstractBuildingClass	1180	Other function	https://www.sig3d.org/codelists/stan...
47	CityGML 2.0	_AbstractBuildingClass	9999	Unknown	https://www.sig3d.org/codelists/stan...
48	CityGML 2.0	_AbstractBuildingFunct...	1000	Residential building	https://www.sig3d.org/codelists/stan...
49	CityGML 2.0	_AbstractBuildingFunct...	1010	Tenement	https://www.sig3d.org/codelists/stan...

Codelists and look-up tables

Example: property **Roof type**
(cardinality [0..1])

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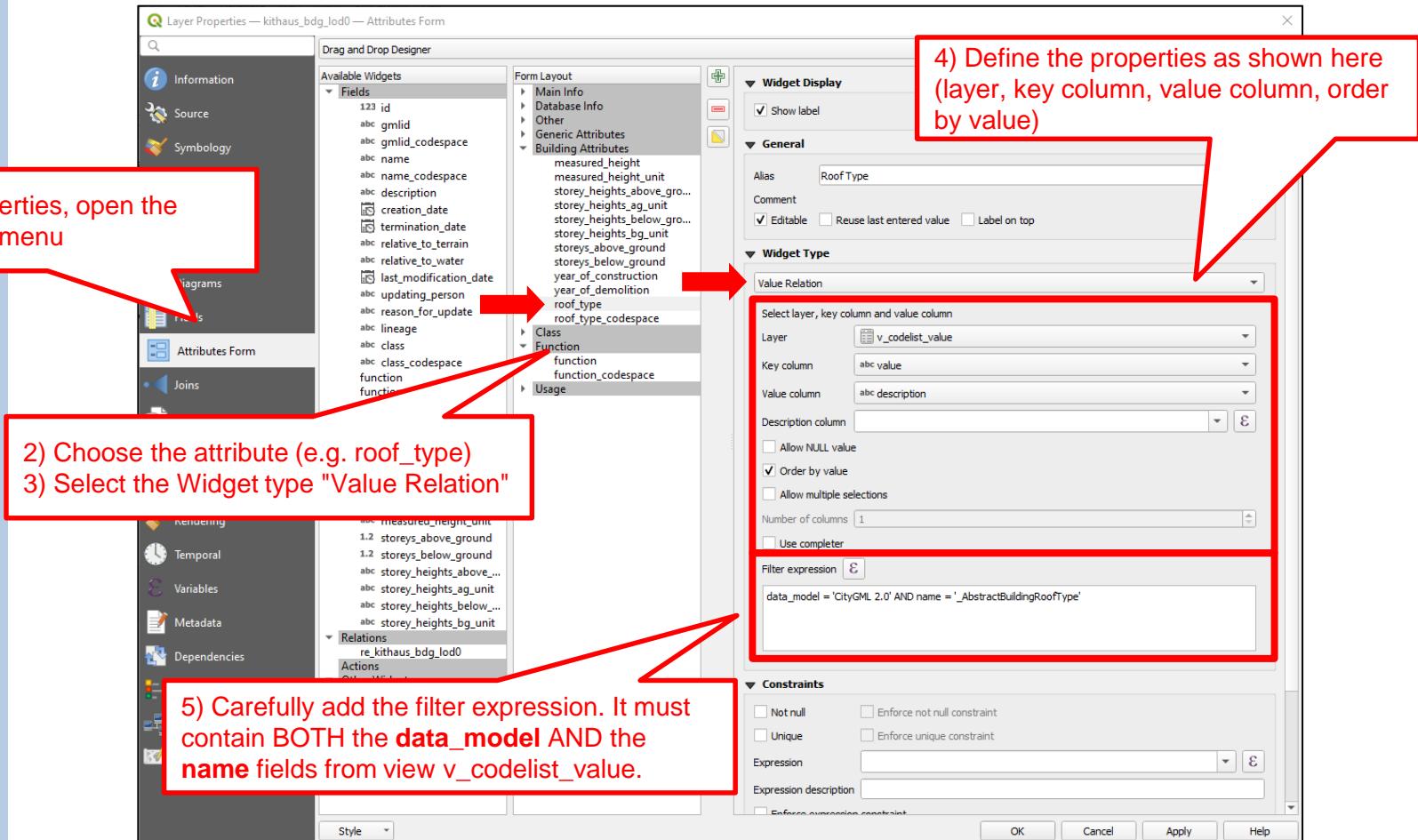
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- 1) In the Layer properties, open the Attributes Form submenu



The screenshot shows the 'Layer Properties — kithaus_bgd_lod0 — Attributes Form' dialog. On the left, the 'Drag and Drop Designer' panel lists 'Available Widgets' under 'Fields'. A red box highlights the 'Fields' section, with an arrow pointing from the 'Motivation' section above. The 'Fields' list includes attributes like 'id', 'gmlid', 'name', etc., and a 'Building Attributes' group containing 'measured_height', 'rooftype', and 'rooftype_codespace'. A red box highlights the 'Building Attributes' group, with an arrow pointing from the 'Software use' section above. To the right, the 'Widget Display' and 'General' sections are shown, with a red box highlighting the 'Alias' field set to 'Roof Type'. The 'Widget Type' section is expanded, showing 'Value Relation' selected. A large red box highlights the 'Value Relation' configuration area, with an arrow pointing from the 'Advanced options' section above. This area includes fields for 'Layer' (set to 'v_codelist_value'), 'Key column' ('abc value'), 'Value column' ('abc description'), and a 'Filter expression' box containing the SQL-like expression 'data_model = 'CityGML 2.0'' AND name = '_AbstractBuildingRoofType''. Below this, the 'Constraints' section is visible.

4) Define the properties as shown here (layer, key column, value column, order by value)

2) Choose the attribute (e.g. roof_type)
 3) Select the Widget type "Value Relation"

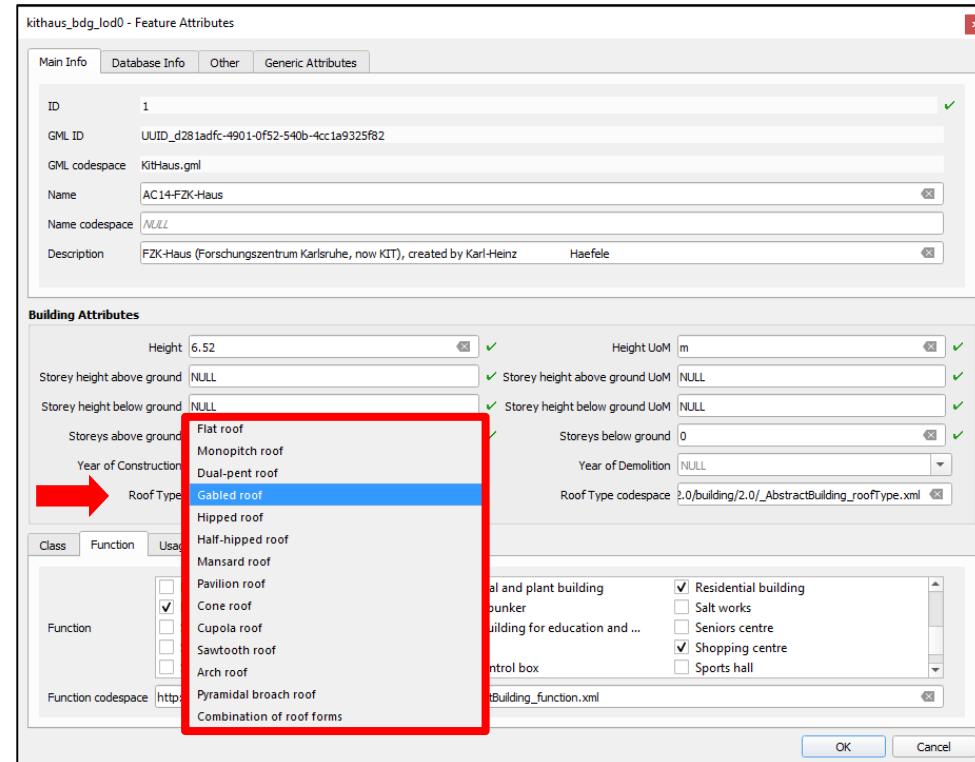
5) Carefully add the filter expression. It must contain BOTH the **data_model** AND the **name** fields from view **v_codelist_value**.

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Apply the Layer Properties,
 reload the attributes form
 from QGIS as usual.

Et voilà! 😊



Codelists and look-up tables

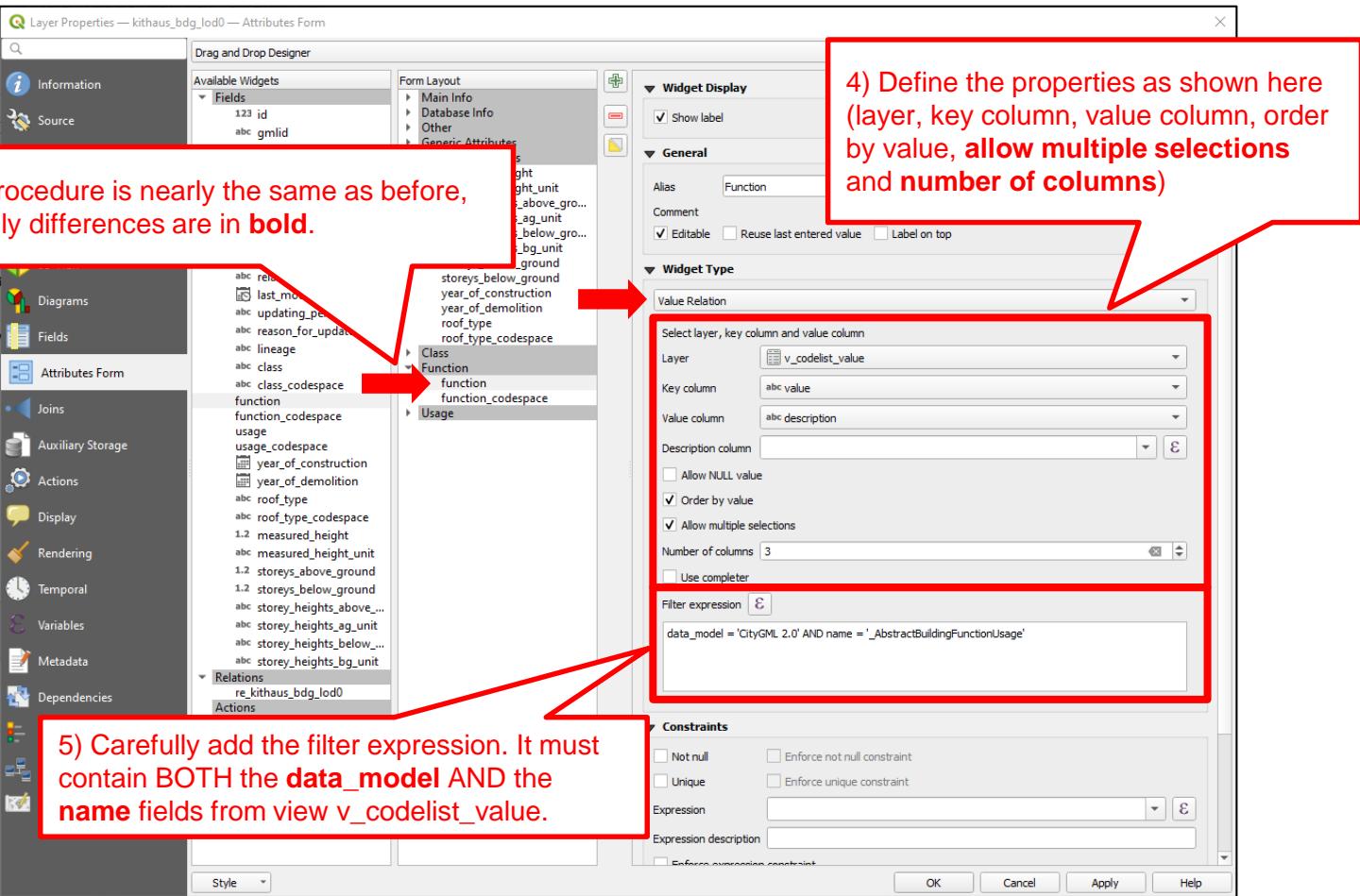
Example: property **(Building)**
function (cardinality [0..*])

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The procedure is nearly the same as before,
 the only differences are in **bold**.

4) Define the properties as shown here
 (layer, key column, value column, order by value, **allow multiple selections** and **number of columns**)

5) Carefully add the filter expression. It must contain **BOTH** the **data_model** AND the **name** fields from view **v_codelist_value**.

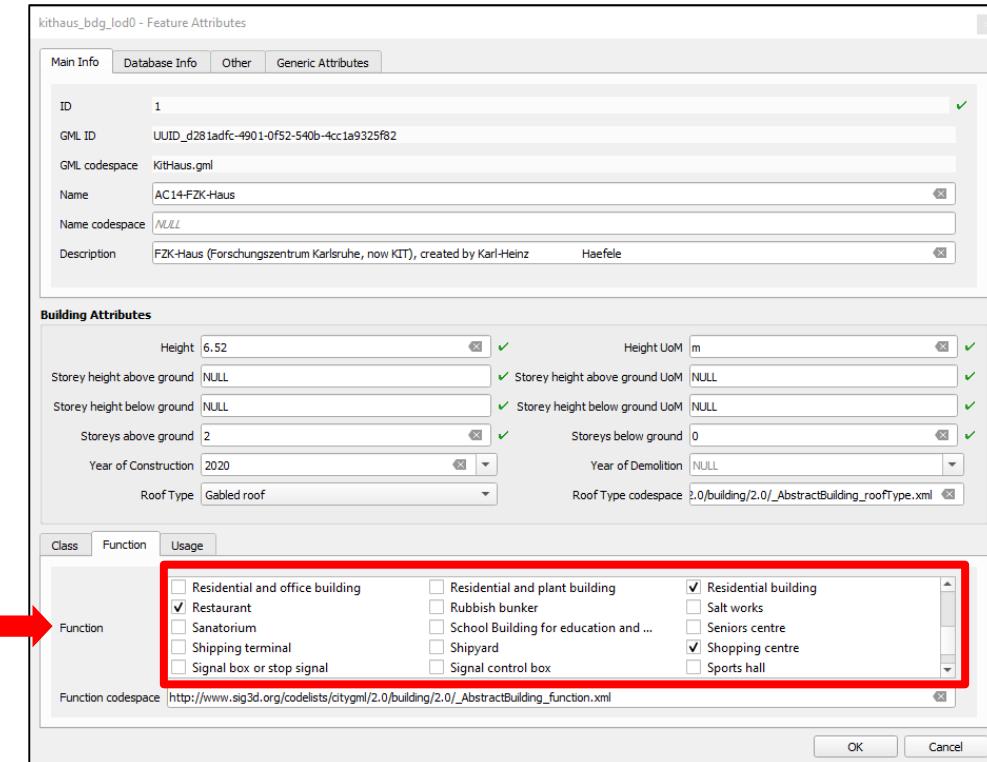


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Apply the Layer Properties,
 reload the attributes form
 from QGIS as usual.

Et voilà! 😊



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To add or customise codelist values, **two tables** in the qgis user schema must be edited: **codelist** and **codelist_value**

Table **codelist** contains some metadata values such as the codelist name, its name_space and data_model.

It is referenced by table **codelist_value** which contains the actual values.

Table CODELIST (excerpt)

id [PK] bigint	data_model character varying	name character varying	name_space character varying	description text
1	CityGML 2.0	MimeType	https://www.sig3d.org/codelists/standard/core/2.0/ImplicitGeometry_mimeType.xml	[null]
2	CityGML 2.0	_AbstractBridgeClass	https://www.sig3d.org/codelists/standard/bridge/2.0/_AbstractBridge_class.xml	
3	CityGML 2.0	_AbstractBridgeFunctionUsage	https://www.sig3d.org/codelists/standard/bridge/2.0/_AbstractBridge_function.xml	
4	CityGML 2.0	_AbstractBuildingClass	https://www.sig3d.org/codelists/standard/building/2.0/_AbstractBuilding_class.xml	
5	CityGML 2.0	_AbstractBuildingFunctionUsage	https://www.sig3d.org/codelists/standard/building/2.0/_AbstractBuilding_function.xml	
6	CityGML 2.0	_AbstractBuildingRoofType	https://www.sig3d.org/codelists/standard/building/2.0/_AbstractBuildingRoof_type.xml	
7	CityGML 2.0	RoomClass	https://www.sig3d.org/codelists/standard/building/2.0/Room_class.xml	
8	CityGML 2.0	RoomFunctionUsage	https://www.sig3d.org/codelists/standard/building/2.0/RoomFunction_usage.xml	
9	CityGML 2.0	BuildingFurnitureClass	https://www.sig3d.org/codelists/standard/building/2.0/BuildingFurniture_class.xml	
10	CityGML 2.0	BuildingFurnitureFunctionUsage	https://www.sig3d.org/codelists/standard/building/2.0/BuildingFurnitureFunction_usage.xml	

Table CODELIST_VALUE (excerpt)

id [PK] bigint	code_id integer	value character varying	description text
1	1	model/vrml	VRML97
2	1	application/x-3ds	3ds max
3	1	application/dxf	AutoCad DXF
4	1	application/x-autocad	AutoCad DXF
5	1	application/x-dxf	AutoCad DXF
6	1	application/acad	AutoCad DWG
13	1	image/tiff	*.tiff, *.tif images
14	1	image/bmp	*.bmp images
15	2	1000	Arced bridge
16	2	1010	Cable-stayed bridge
17	2	1020	Deck bridge
18	2	1030	Cable-stayed overpass

Codelists and look-up tables

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To add (or remove) values from the **codelist** and **codelist_value** tables, the user can for example issue a SQL statement such as:

```
-- Optionally, delete previously loaded values belonging to the same codelist in user schema "qgis_giorgio"  
DELETE FROM qgis_giorgio.codelist WHERE data_model = 'NL-BAG';  
-- Insert first the codelist metadata and then the values in one single SQL statement  
WITH cl AS (  
    INSERT INTO qgis_giorgio.codelist (data_model, name, name_space, description)  
    VALUES  
        ('NL-BAG', 'BAG', 'https://..some_url_here....', 'Codelist containing the values of the Dutch Basisregistratie  
        Adressen en Gebouwen')  
    RETURNING id)  
INSERT INTO qgis_giorgio.codelist_value (code_id, value, description)  
SELECT cl.id, v.value, v.description FROM cl, (VALUES  
    ('apple' , 'Codelist value for "apple"'),  
    ('orange' , 'Codelist value for "orange"'),  
    ('pear' , 'Codelist value for "pear"'),  
    ('banana' , 'Codelist value for "banana"')  
) AS v(value, description);
```

This SQL statement can be adapted by changing only the parts in red

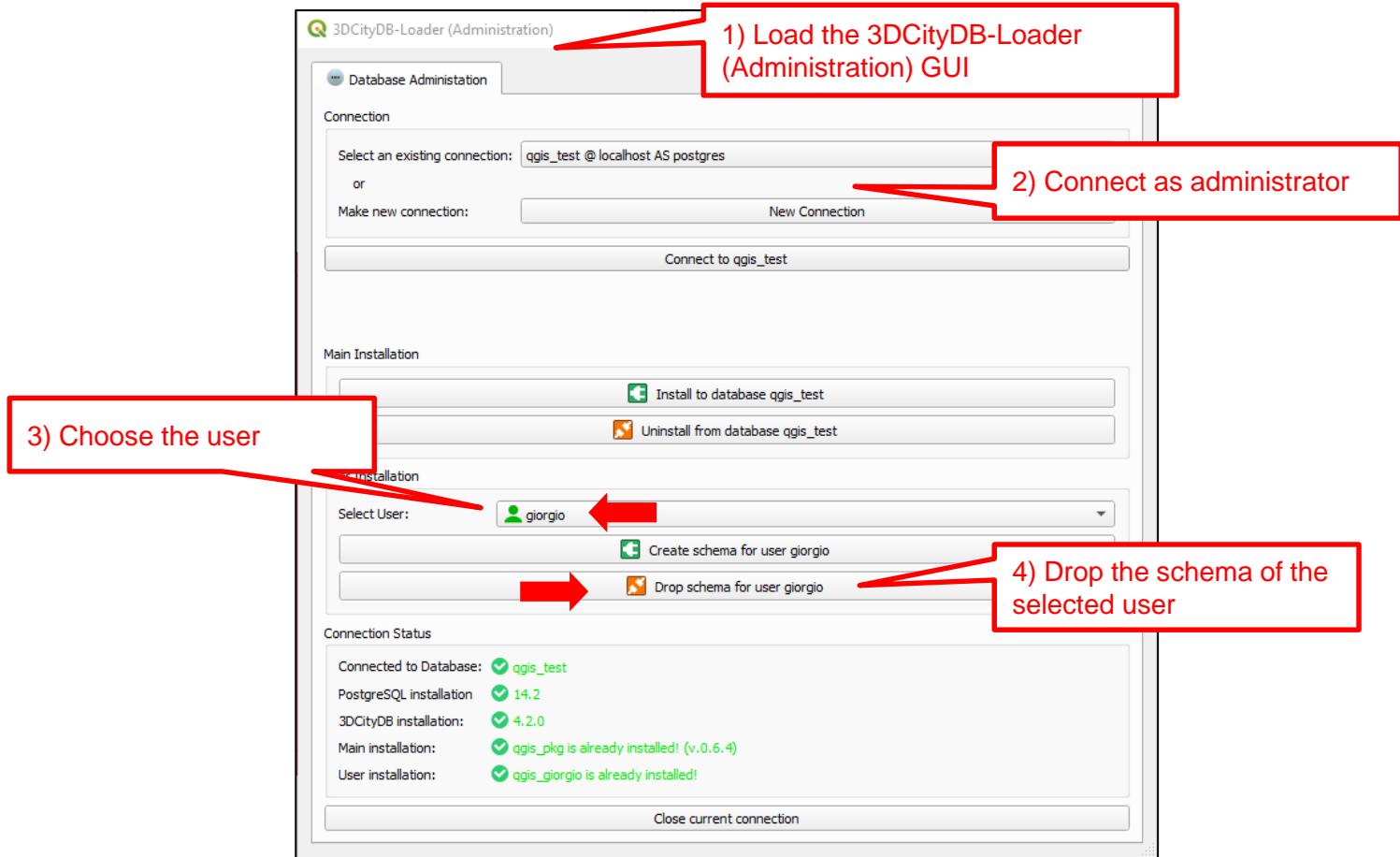
Software uninstall

Uninstallation consists of two parts:

- 1) Partial/complete removal of the QGIS Package from PostgreSQL
 - This operation can be carried out only by the database administrator
 - The administrator can choose to drop only the schema of a selected user (e.g. "qgis_giorgio")
 - The administrator can remove all user schemas AND the qgis_pkg schema
- 2) Removal of the 3DCityDB-Loader plugin from QGIS
 - This operation can be carried out by any user
 - The plugin can be uninstalled from the \Plugins\Manage and Install Plugins... Menu in QGIS
 - Alternatively, it can be uninstalled manually by simply removing the plugin folder

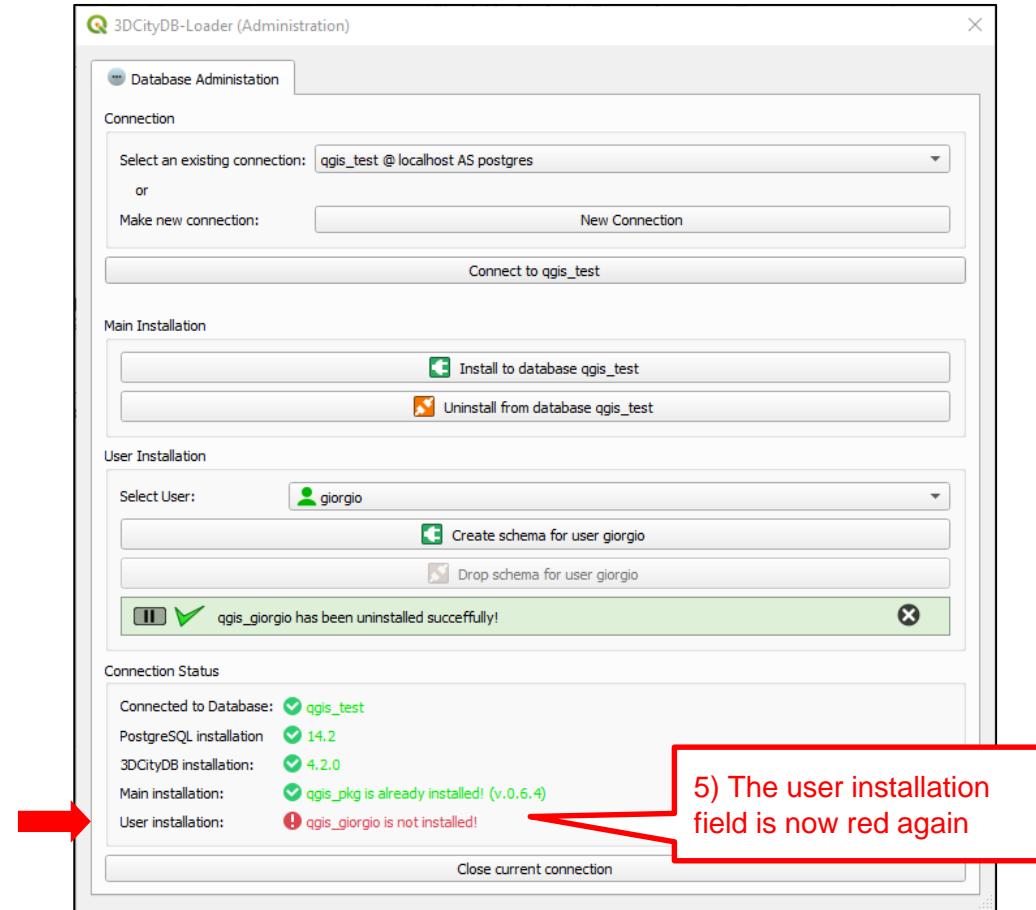
Software uninstall: Drop user schema

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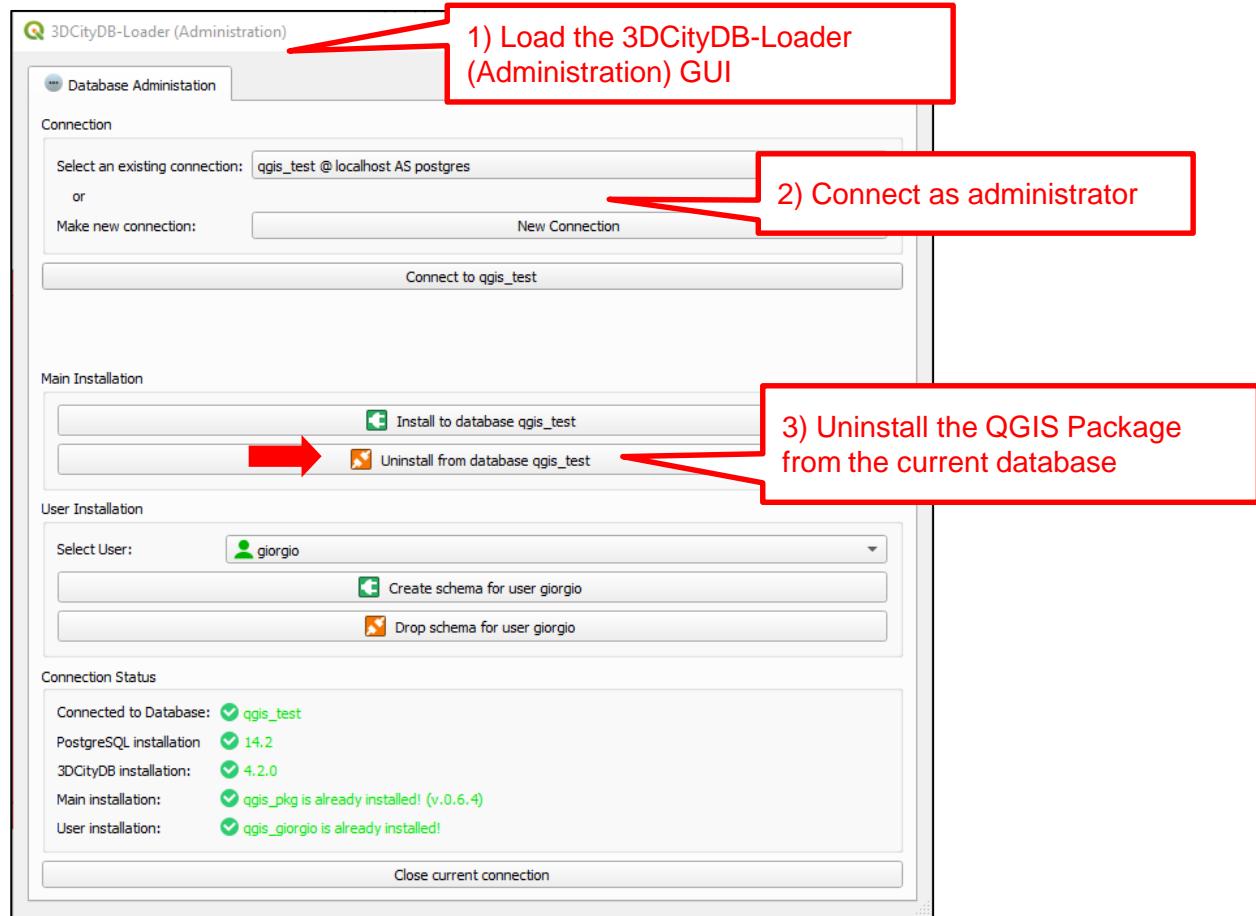
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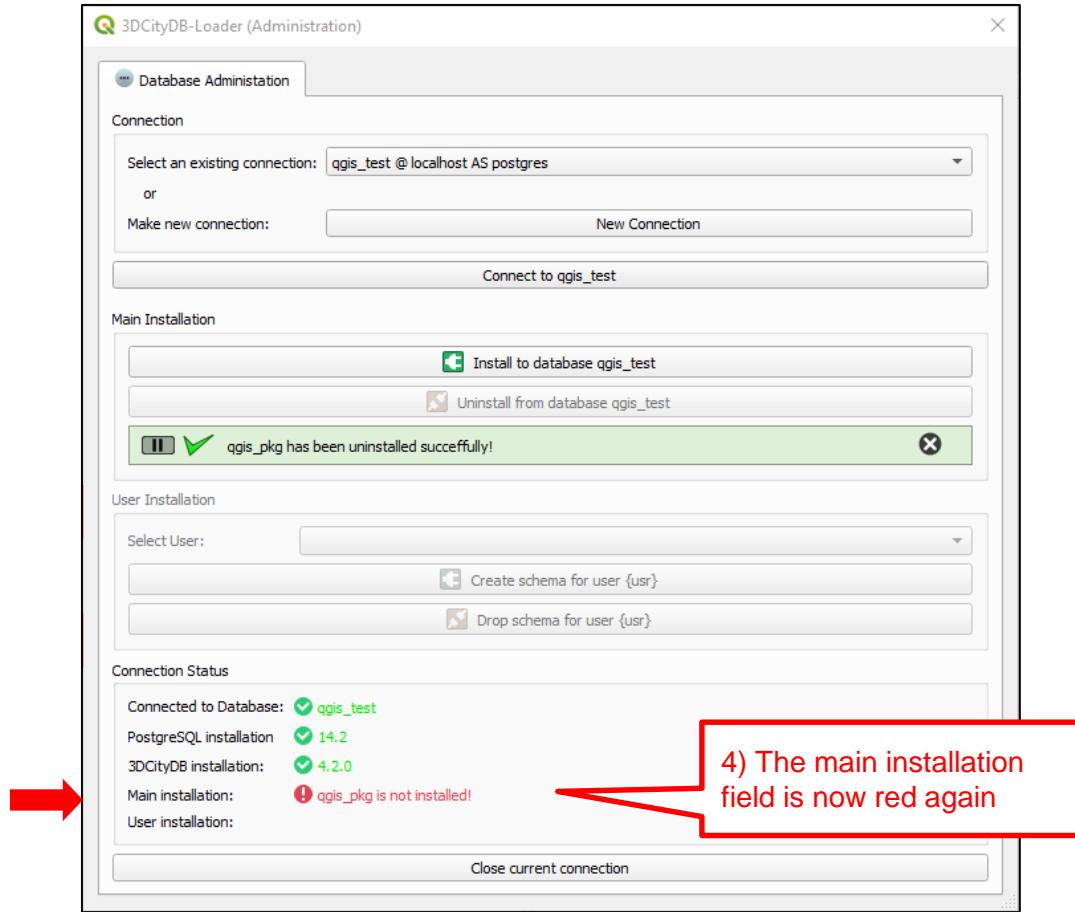
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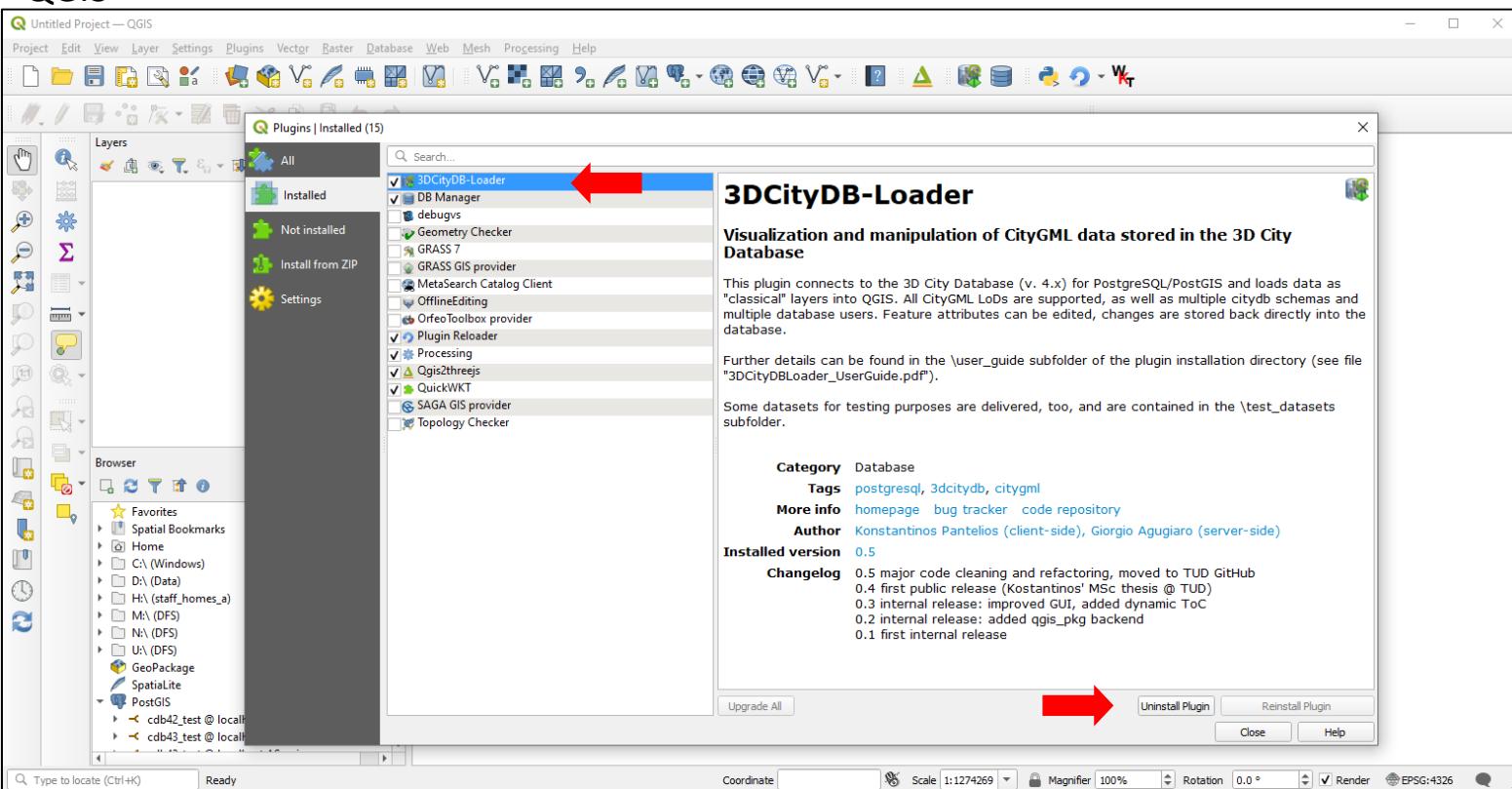
Software uninstall: Uninstall QGIS Package

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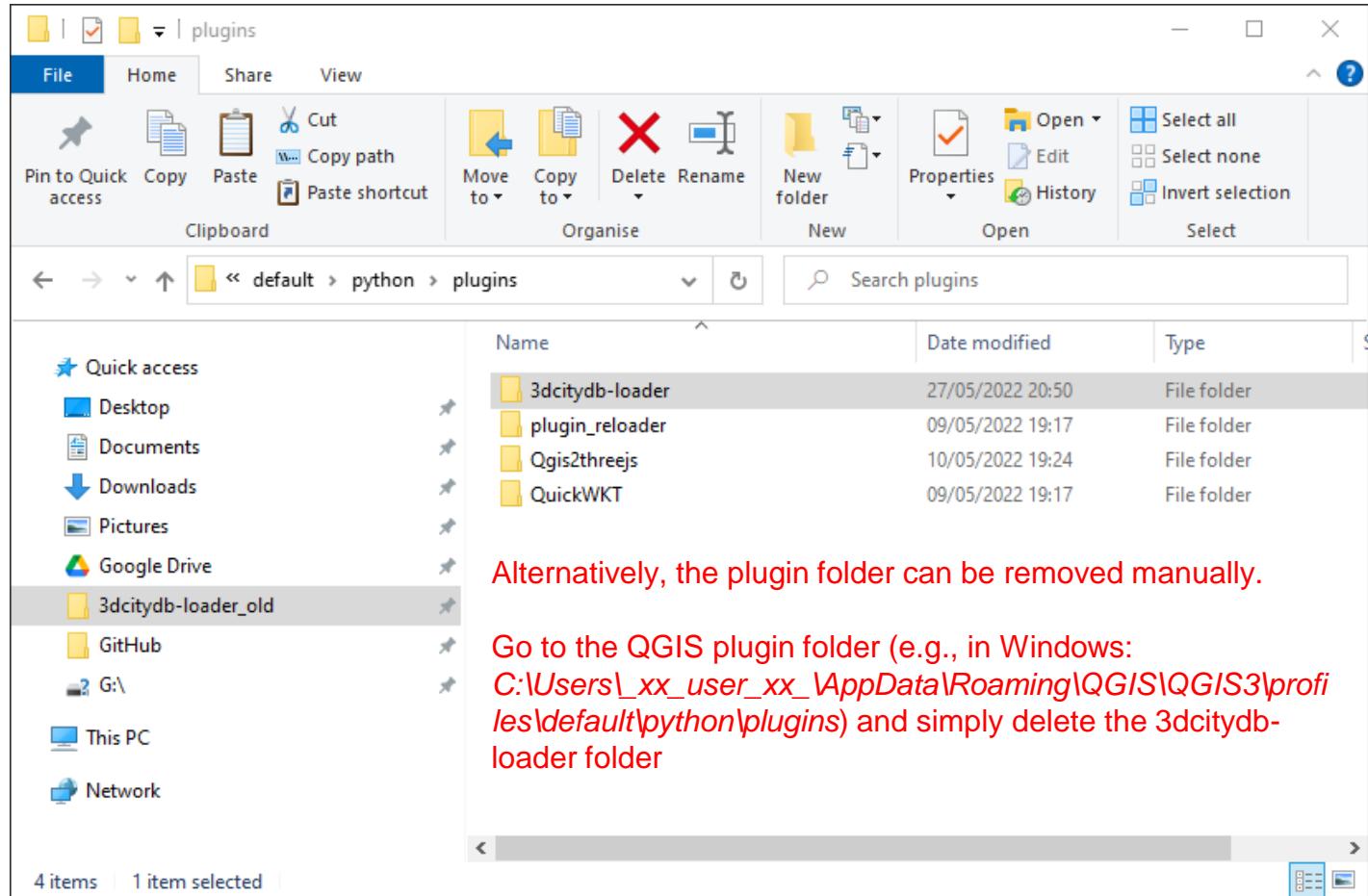
Software uninstall: Uninstall 3DCityDB-Loader

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Software uninstall: Uninstall 3DCityDB-Loader

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Current limitations

As of October 2022 (Plugin version 0.5.1)

In general:

- CityGML appearances are not supported
- CityGML ADEs (Application Domain Extensions) are not supported

The QGIS Package does not support the following CityObjects

- Raster-based Relief features
- CityObjectGroups

Current limitations

As of October 2022 (Plugin version 0.5.1)

In the 3DCityDB-Loader plugin GUI, following functionalities are still missing

- GUI for advanced user management
- GUI for codelist/look-up table management and settings

In particular, when it comes to attributes editing

- The design of the attribute forms is still being improved
- Forms of children tables need most likely some redesign

QGIS Package in a nutshell

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- It represents the server-side part of the QGIS plugin
- It can be installed and used independently from the QGIS client-side part
 - E.g. with FME, or programmatically via Python, SQLAlchemy, etc.
- It requires
 - PostgreSQL
 - An existing installation of the 3DCityDB (v. 4.x)
- All relevant entities are installed in the "qgis_pkg" database schema
 - Database types
 - Triggers and trigger functions
 - Functions
 - Tables, mostly used as templates for the user schemas

QGIS Package: As database administrator

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Usage overview

- 1) Create user schemas, i.e. for each user a specific database schema is created. E.g.:
 - User "giorgio" -> schema "qgis_giorgio"
 - User "kostantinos" -> schema "qgis_kostantinos"
 - User "postgres" -> schema "qgis_postgres"
 - Each user schema will be used only by the corresponding user
 - Each user schema is accessible only by the corresponding user (and the database superusers)
 - In a user schema all necessary tables, updatable views, materialized views etc. will be created

SQL examples

```
-- Create the schema for user "giorgio". It will create schema "qgis_giorgio" in the current database
SELECT qgis_pkg.create_qgis_usr_schema('giorgio');
```

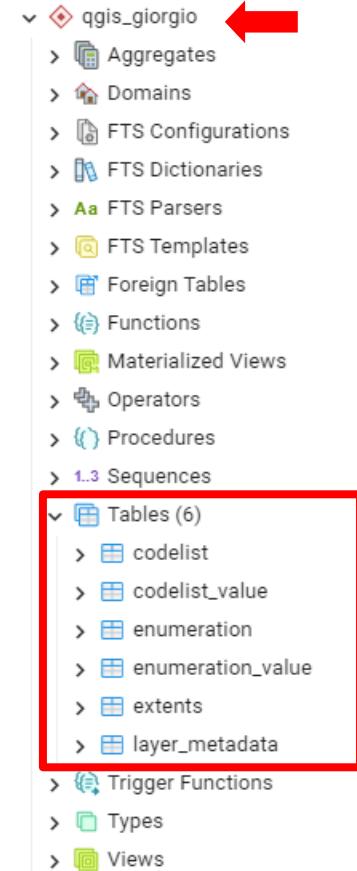
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User schema overview

In each user schema (e.g. "qgis_giorgio") some tables are generated upon schema creation:

- Table **LAYER_METADATA** contains information about all generated and refreshed layers
- Table **EXTENTS** contains the bounding boxes of the citydb schemas, those of the materialized views, and those of the last QGIS session
- Tables **ENUMERATION** and **ENUMERATION_VALUE** are used to store enumeration values
- Tables **CODELIST** and **CODELIST_VALUE** are used to store codelist values. To add customized codelists, please refer to the previous slides on **advanced options** for more details.



QGIS Package: As database administrator

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Usage overview

- 2) Set the user privileges (see previous slides on **advanced options** for more details)

SQL examples

-- Database user "giorgio" is added to group "qgis_pkg_usrgroup", can access data in citydb schema "citydb" of the current database with read-only privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('giorgio', 'ro','citydb');
```

-- Database user "kostantinos" is added to group "qgis_pkg_usrgroup", can access data in citydb schema "citydb_2" of the current database with read-write privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('kostantinos ', 'rw','citydb_2');
```

-- Database user "camilo" is added to group "qgis_pkg_usrgroup", can access data in ALL citydb schemas of the current database with read-write privileges

```
SELECT qgis_pkg.grant_qgis_usr_privileges('camilo ', 'rw');
```

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Usage overview

3) Drop a user schema

FIRST, revoke privileges of the user for all citydb schemas, THEN drop the user schema. Please refer to the previous slides on the **advanced options** for more details about user privileges.

SQL example

```
-- First revoke all ro/rw privileges of user "giorgio" for all citydb schemas
SELECT qgis_pkg.revoke_qgis_usr_privileges('giorgio');

-- Then drop the user schema
DROP SCHEMA qgis_giorgio CASCADE;
-- Optionally (if possible/necessary) remove user "giorgio" from the "qgis_pkg_usrgroup"
REVOKE qgis_pkg_usrgroup FROM giorgio;
```

QGIS Package: As database administrator

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Usage overview

- 4) Drop the qgis_pkg schema and remove the QGIS Package completely

FIRST, revoke privileges of all users for all citydb schemas, THEN drop the qgis_pkg schema. Please refer to the previous slides on the **advanced options** for more details about user privileges.

SQL example

-- First revoke all ro/rw privileges of users "qgis_user_ro", "qgis_user_rw", "giorgio", etc. for all citydb schemas

SELECT qgis_pkg.revoke_qgis_usr_privileges('qgis_user_ro');

SELECT qgis_pkg.revoke_qgis_usr_privileges('qgis_user_rw');

SELECT qgis_pkg.revoke_qgis_usr_privileges('giorgio');

-- Then drop the qgis_pkg schema

DROP SCHEMA qgis_pkg **CASCADE**;

-- Optionally (if possible/necessary) remove users from the "qgis_pkg_usrgroup"

REVOKE qgis_pkg_usrgroup **FROM** qgis_user_ro, qgis_user_rw, giorgio;

-- Finally, remove the user group

DROP GROUP qgis_pkg_usrgroup;

QGIS Package: As user

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Usage overview

- 1) Create layers with function **qgis_pkg.create_layers(...)**.
 - All materialized views and updatable views are created, but only if corresponding data exist in the database
 - The user can create layers only for selected CityGML modules using the similar functions:
 - **qgis_pkg.create_layers_bridge(...)**
 - **qgis_pkg.create_layers_building(...)**
 - ...
 - **qgis_pkg.create_layers_waterbody(...)**
 - All functions are in schema qgis_pkg and have the same signature (see next slide)

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Usage overview

Function

```
qgis_pkg.create_layers(usr_schema, cdb_schema [, perform_snapping] [, digits]
[, area_poly_min] [, bbox_corners_array] [, force_layer_creation])
```

Parameter	Type	Description
usr_schema	varchar	The database user schema, e.g. "qgis_giorgio".
cdb_schema	varchar	the citydb schema where data are stored, e.g. "citycb", or "citydb2".
perform_snapping	integer	DEFAULT 0 (i.e. disabled). If 1, geometry simplification is performed. Unused if perform_snapping is set to 0.
digits	integer	DEFAULT 3. Number of decimal positions to keep during geometry simplification. Unused if perform_snapping is set to 0.
area_poly_min	numeric	DEFAULT 0.001 [m ²]. Minimum polygon area during geometry simplification. Unused if perform_snapping is set to 0.
bbox_corners_array	numeric[]	DEFAULT Null, i.e. the extents of the whole <i>cdb_schema</i> . Otherwise, extents of the materialized views to be created, e.g. {x_min, y_min, x_max, y_max}. Coordinates must be in the same SRS as the <i>cdb_schema</i> !
force_layer_creation	boolean	DEFAULT False. Otherwise: force creation of all layers, also the empty ones.

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Usage overview

SQL examples

-- For user "giorgio", create all layers for existing data in citydb schema "citydb"

```
SELECT qgis_pkg.create_layers('giorgio', 'citydb');
```

-- For user "giorgio", create all layers for existing data in citydb schema "citydb2" and perform geometry simplification with 2 decimal places and 0.01 m² minimum area for polygons

```
SELECT qgis_pkg.create_layers('giorgio', 'citydb', 1, 2, 0.01);
```

-- For user "camilo", create all building module layers for existing data in citydb schema "vienna"

```
SELECT qgis_pkg.create_layers_building('camilo', 'vienna');
```

-- For user "kostantinos", create all waterbody module layers for existing data in citydb schema "alderaan" within a certain bounding box

```
SELECT qgis_pkg.create_layers_waterbody('kostantinos', 'alderaan', bbox_corners_array := '{10, 20, 110, 220}');
```

QGIS Package: As user

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Usage overview

SQL examples

-- The following query works, but actually it is not written in a user-friendly way.

```
SELECT qgis_pkg.create_layers('giorgio', 'citydb', 1, 2, 0.01);
```

-- In general, therefore, it is always a good habit to use **named parameters** when calling functions!

```
SELECT qgis_pkg.create_layers(  
    usr_name := 'giorgio',  
    cdb_schema := 'citydb',  
    perform_snapping := 1,  
    digits := 2,  
    area_poly_min := 0.01)
```

QGIS Package: As user

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Usage overview

- 2) Refresh the materialized views with function **qgis_pkg.refresh_mvviews(...)**.
 - All materialized views created before will be refreshed. This is necessary every time the layers are generated (or re-generated using a different bounding box).
 - The user can refresh the materialized views only for selected CityGML modules using the similar functions:
 - **qgis_pkg.refresh_mvviews_bridge(...)**
 - **qgis_pkg.refresh_mvviews_building(...)**
 - ...
 - **qgis_pkg.refresh_mvviews_waterbody(...)**
 - All functions are in schema qgis_pkg and have the same signature (see next slide)

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Usage overview

Function

qgis_pkg.refresh_mviews(usr_schema, cdb_schema)

Parameter	Type	Description
usr_schema	varchar	The database user schema, e.g. "qgis_giorgio".
cdb_schema	varchar	the citydb schema where data are stored, e.g. "citycb", or "citydb2".

SQL examples

-- In user schema "qgis_giorgio", refresh all materialized views in citydb schema "citydb"

SELECT qgis_pkg.refresh_mviews('qgis_giorgio', 'citydb');

-- In user schema "qgis_kostantinos", refresh all waterbody module materialized views in citydb schema "alderaan"

SELECT qgis_pkg.refresh_mviews_waterbody('qgis_kostantinos', 'alderaan');

QGIS Package: As user

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Usage overview

- 3) Drop layers with function **qgis_pkg.drop_layers(...)**.
 - All existing layers in the selected user schema and related to the selected citydb schema will be dropped
 - The user can drop layers only for selected CityGML modules using the similar functions:
 - **qgis_pkg.drop_layers_bridge(...)**
 - **qgis_pkg.drop_layers_building(...)**
 - ...
 - **qgis_pkg.drop_layers_waterbody(...)**
 - All functions are in schema qgis_pkg and have the same signature (see next slide)

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Usage overview

Function

qgis_pkg.drop_layers(usr_schema, cdb_schema)

Parameter	Type	Description
usr_schema	varchar	The database user schema, e.g. "qgis_giorgio".
cdb_schema	varchar	the citydb schema where data are stored, e.g. "citycb", or "citydb2".

SQL examples

-- In user schema "qgis_giorgio", drop all layers related to citydb schema "citydb"

SELECT qgis_pkg.drop_layers('qgis_giorgio', 'citydb');

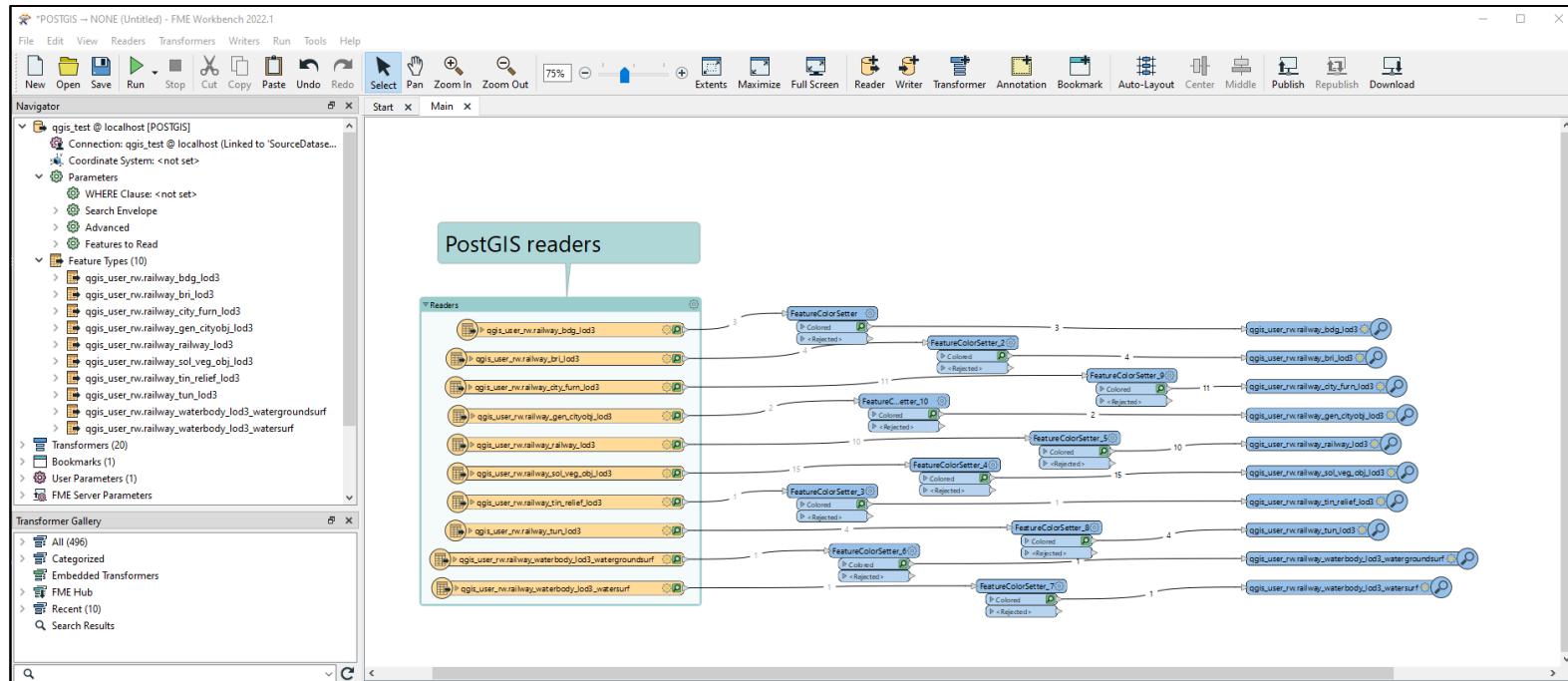
-- In user schema "qgis_kostantinos", drop all waterbody module layers related to citydb schema "alderaan"

SELECT qgis_pkg.drop_layers_waterbody('qgis_kostantinos', 'alderaan');

QGIS Package via FME

- This is a simple example of how the QGIS package can be used via FME
 - Simply connect to the 3D City Database and import the views with PostGIS readers

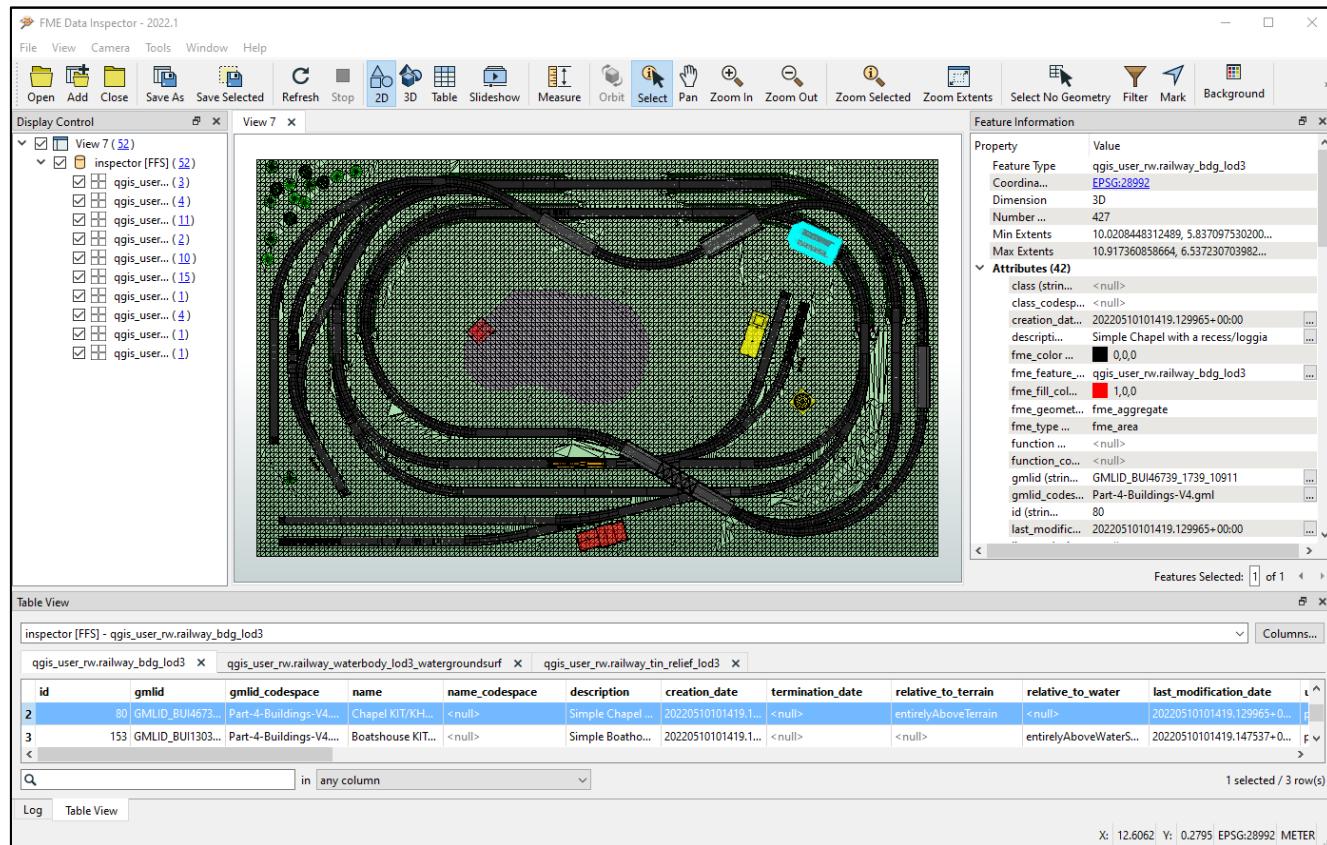
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QGIS Package via FME

- 2D visualisation via FME Data Inspector

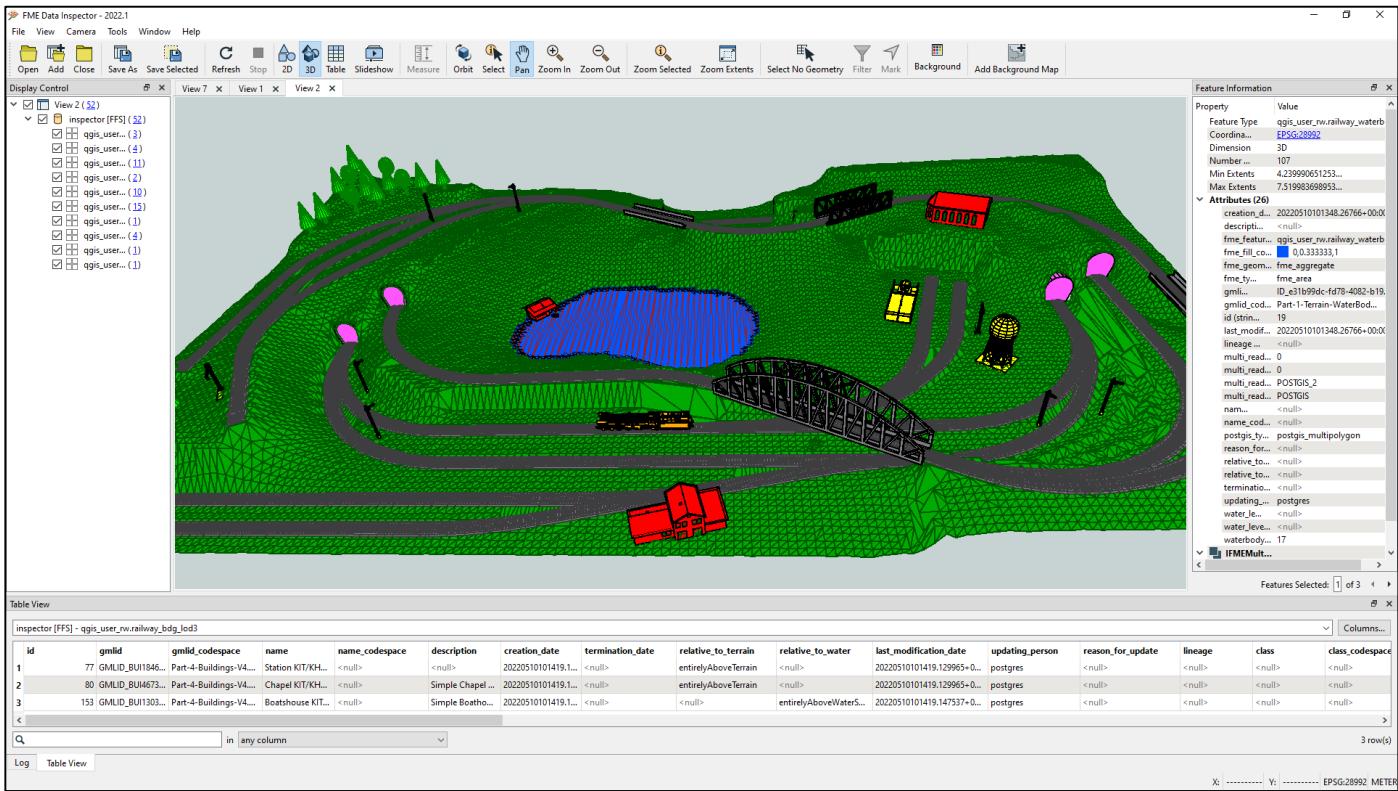
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QGIS Package via FME

- 3D visualisation via FME Data Inspector

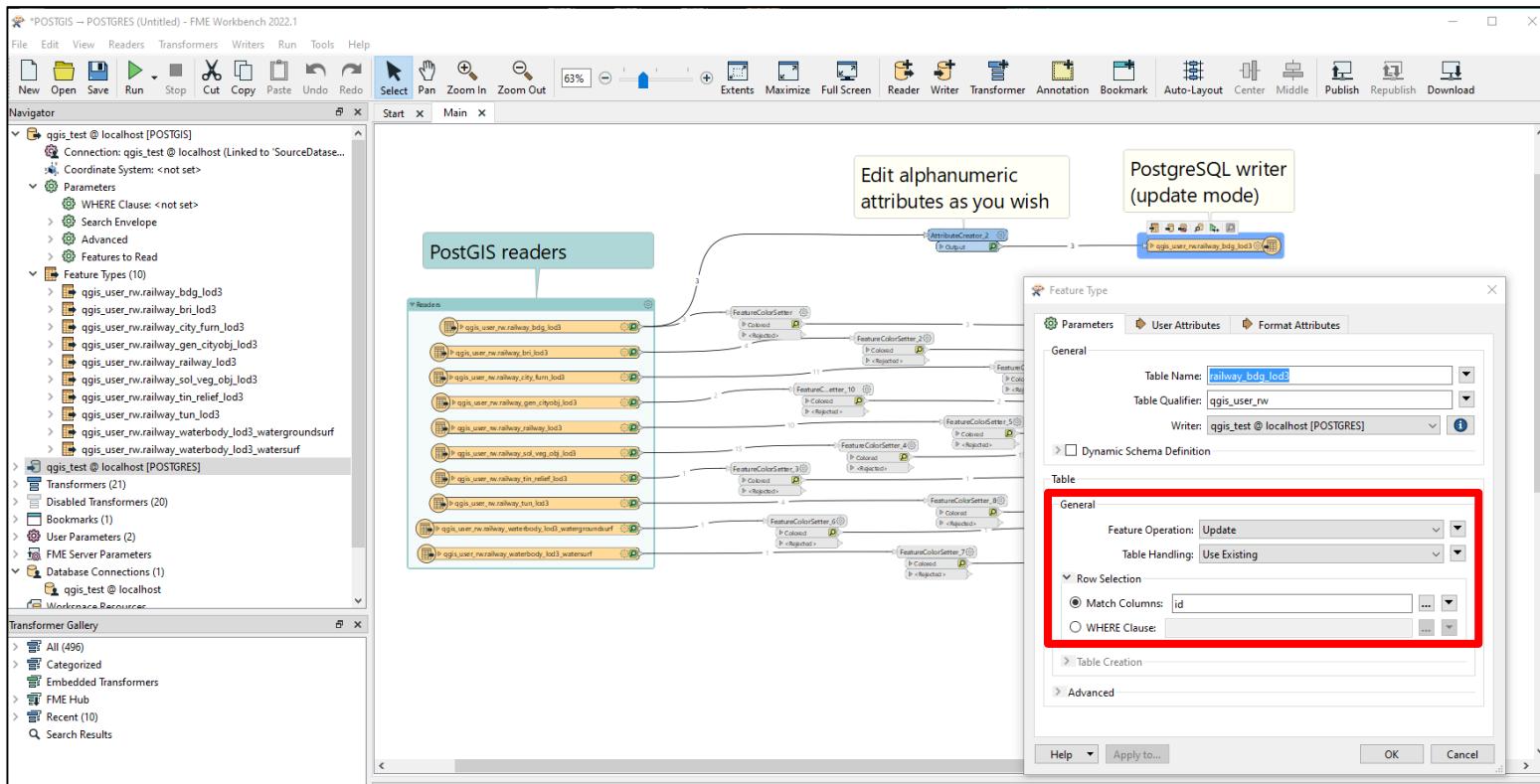
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QGIS Package via FME

- Remember: alphanumeric attributes in the views are updatable! 😊
- You will need a PostgreSQL writer in *update mode*

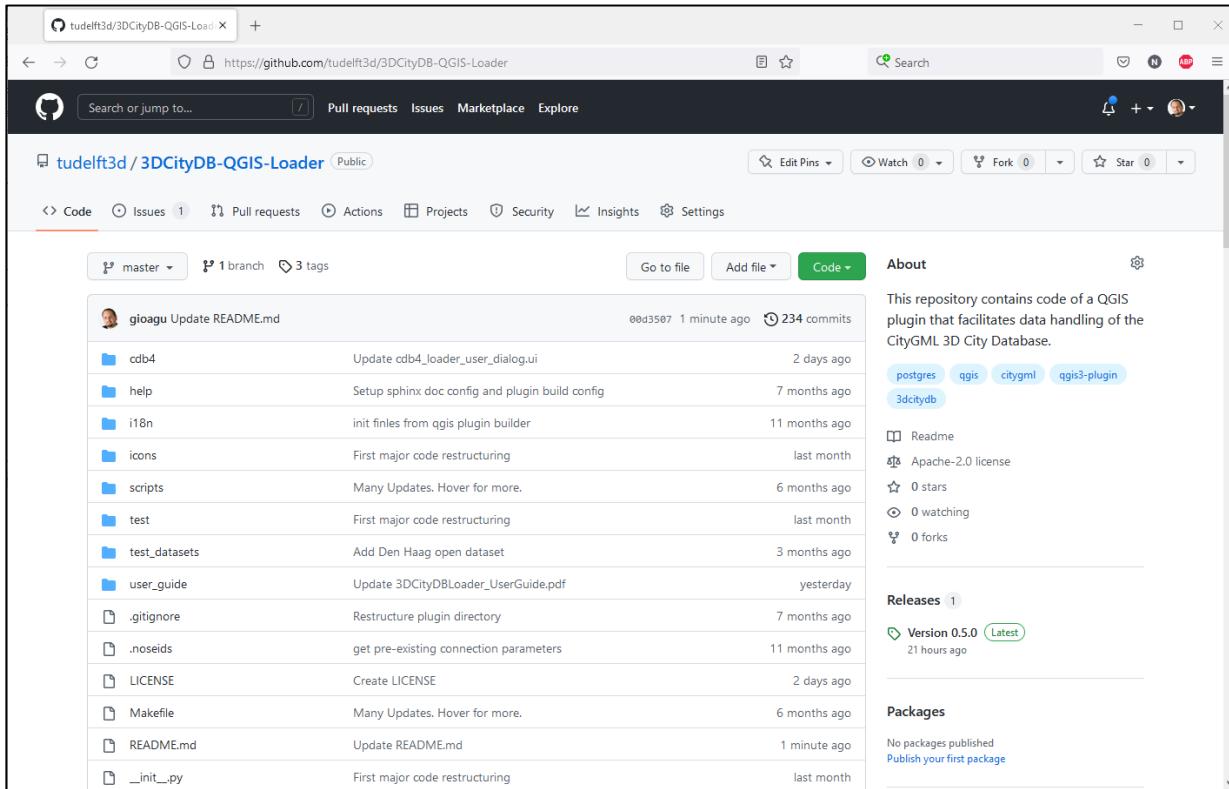
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Resources

Source code and GitHub repository

- GitHub: <https://github.com/tudelft3d/3DCityDB-QGIS-Loader>



The screenshot shows the GitHub repository page for `tudelft3d / 3DCityDB-QGIS-Loader`. The repository is public and contains 234 commits. The master branch has 1 branch and 3 tags. The repository description states: "This repository contains code of a QGIS plugin that facilitates data handling of the CityGML 3D City Database." It includes tags for `postgres`, `qgis`, `citygml`, `qgis3-plugin`, and `3dcitydb`. The repository has 0 stars, 0 watching, and 0 forks. A single release, "Version 0.5.0 (Latest)", was published 21 hours ago. There are no packages published.

File	Description	Updated
<code>cdb4</code>	Update cdb4_loader_user_dialog.ui	2 days ago
<code>help</code>	Setup sphinx doc config and plugin build config	7 months ago
<code>i18n</code>	init files from qgis plugin builder	11 months ago
<code>icons</code>	First major code restructuring	last month
<code>scripts</code>	Many Updates. Hover for more.	6 months ago
<code>test</code>	First major code restructuring	last month
<code>test_datasets</code>	Add Den Haag open dataset	3 months ago
<code>user_guide</code>	Update 3DCityDBLoader_UserGuide.pdf	yesterday
<code>.gitignore</code>	Restructure plugin directory	7 months ago
<code>.noseids</code>	get pre-existing connection parameters	11 months ago
<code>LICENSE</code>	Create LICENSE	2 days ago
<code>Makefile</code>	Many Updates. Hover for more.	6 months ago
<code>README.md</code>	Update README.md	1 minute ago
<code>__init__.py</code>	First major code restructuring	last month

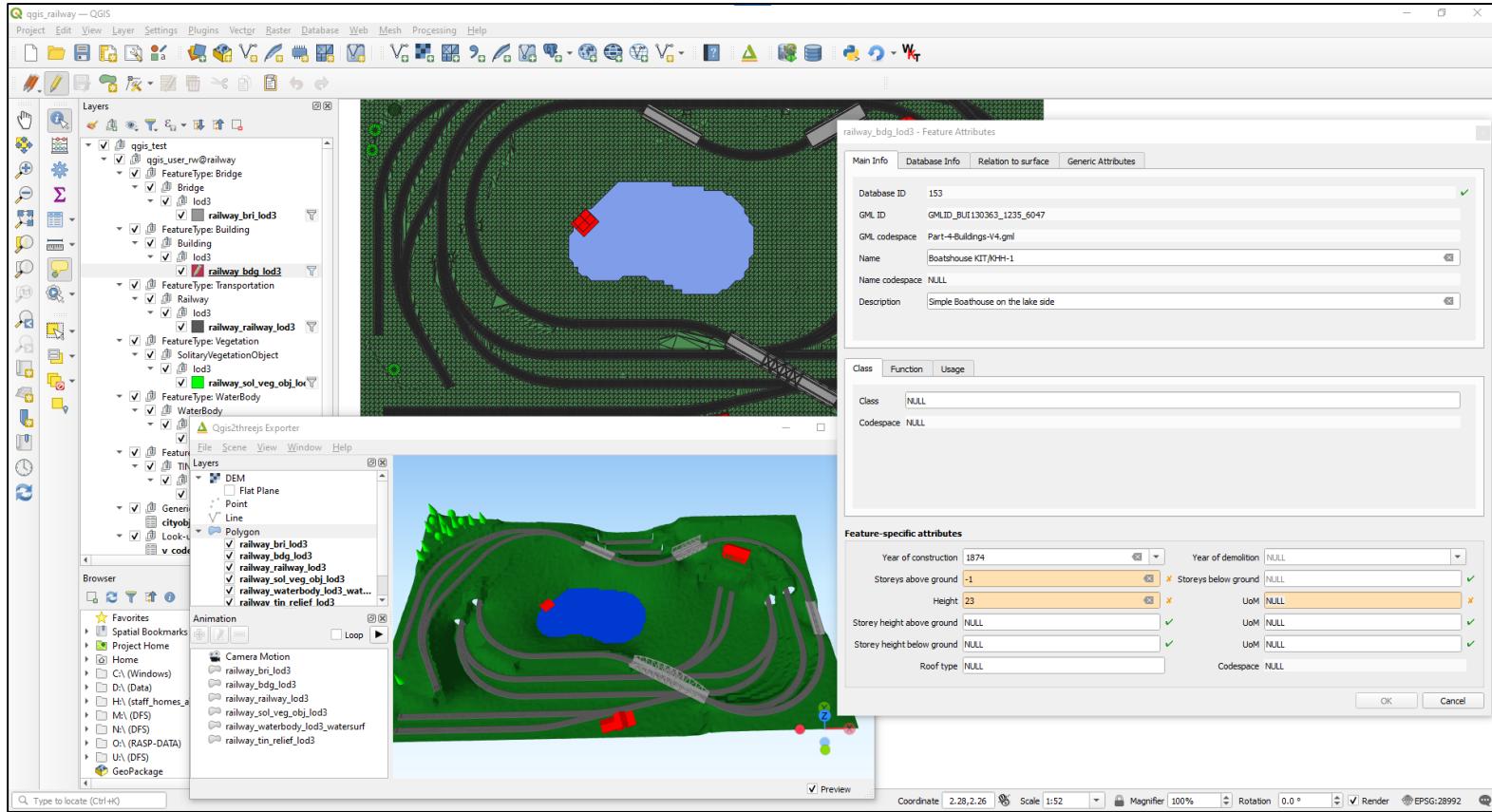
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Test datasets

- In the QGIS plugin folder, you will find 3 test datasets that you can import into the 3DCityDB (using the Importer/Exporter) to test the 3DCityDB-Loader plugin. They are located in subfolder \test_datasets
- The test datasets are:
 - CityGML_2.0_Test_Dataset_2022-03-11.zip (aka "Railway")
 - FZK-Haus-LoD-all-KIT-IAI-KHH-B36-V1.zip (aka "Kit House")
 - DenHaag_bdg_lod2.zip
- You can find links to many additional free and open CityGML/CityJSON datasets at:
 - Awesome CityGML: <https://github.com/OloOcki/awesome-citygml>
 - 3D Geoinformation group @ TU Delft: <https://3d.bk.tudelft.nl/opendata/opencities/>

Enjoy! ☺



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