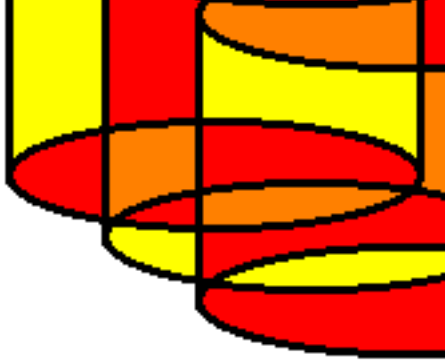
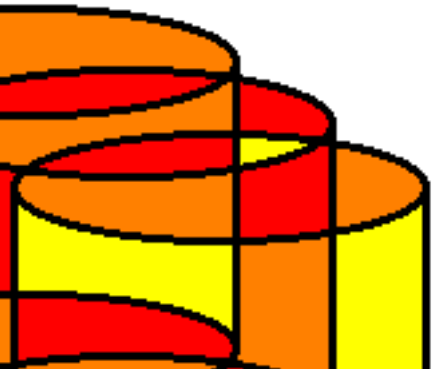
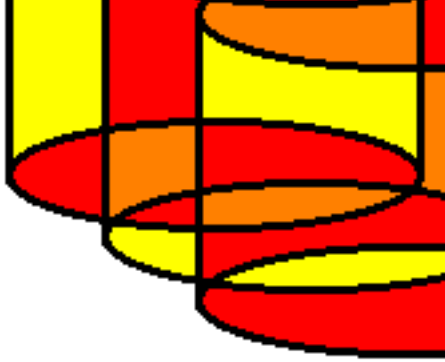
Prostorne baze podataka



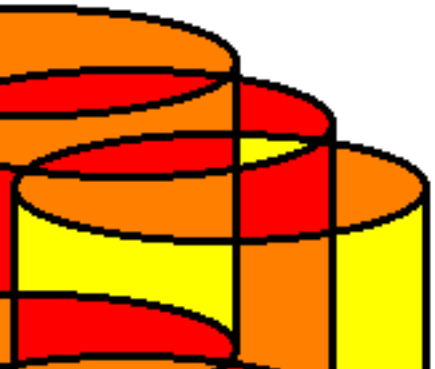
- Relacijske baze podataka koje uz standardne tipove definiraju različite vrste prostornih objekata kao i operacije nad njima.



OpenGIS Consortium

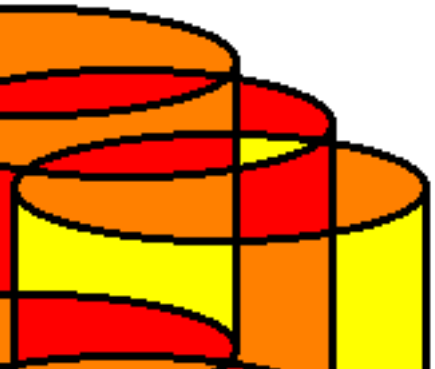


- OGC definira vrste (prostornih) objekata koje porstorni SQL treba podržavati.
- OGC specifikacije definiraju WKT (Well Known Text) i WKB (Well Known Binary) oblike zapisa prostornih objekata.

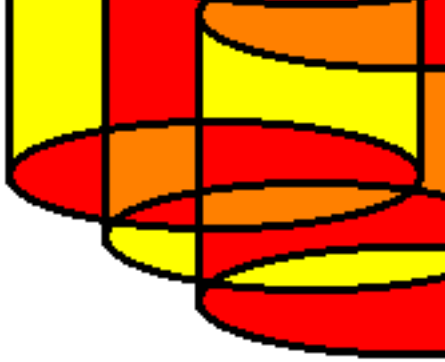


WKT

- WKT je opisni jezik za reprezentaciju vektorskih geometrijskih objekata na kartama, kartografske projekcije prostornih objekata te transformacije između kartografskih projekcija.
- WKB je binarni ekvivalent WKT posebno prilagođen pohranjivanju u bazama podataka.

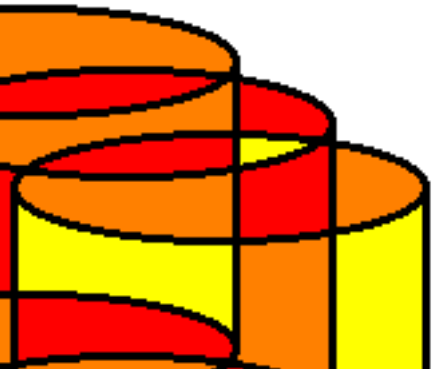


Geometrijski objekti

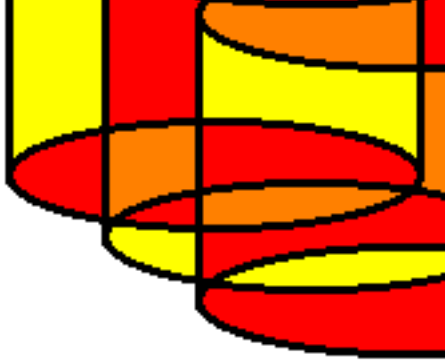


Objekti koje je moguće opisati putem WKB su:

- točke
- dužine
- n-terokuti
- TIN (Triangular Irregular Network - trigonometrijske nepravilne mreže)
- poliedri

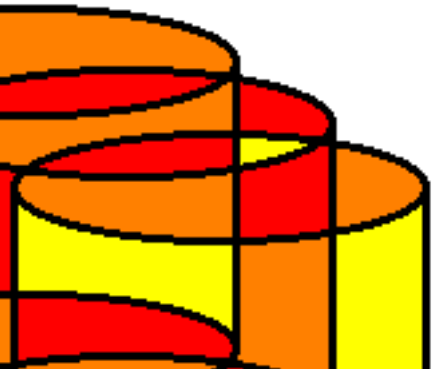


Geometrijski objekti

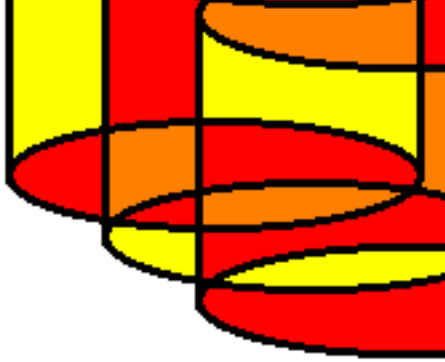


Multigeometrije (multigeometry) se koriste za reprezentaciju više objekata u istoj dimenziji od jednom (kao jedan objekt).

Kolekcije geometrija se koriste za reprezentaciju skupine objekata u različitim dimenzijama.

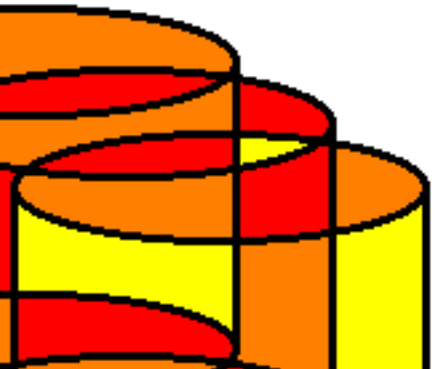


Koordinate



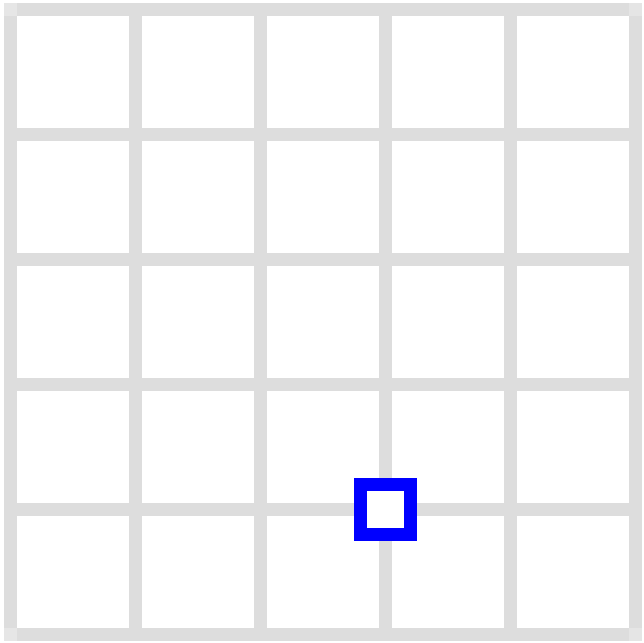
Koordinate objekata mogu biti:

- 2D (X Y)
- 3D (X Y Z)
- 4D (X Y Z M) gdje je M vrijednost linearnog referentnog sustava
- 2D s M vrijednošću (X Y M)



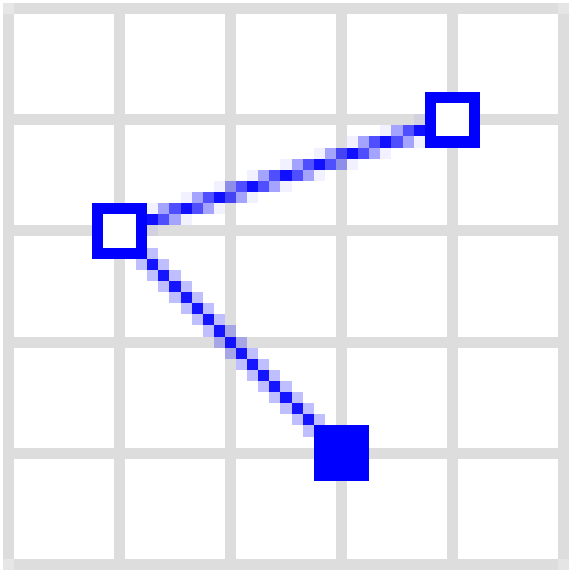
Točka

POINT (30 10)



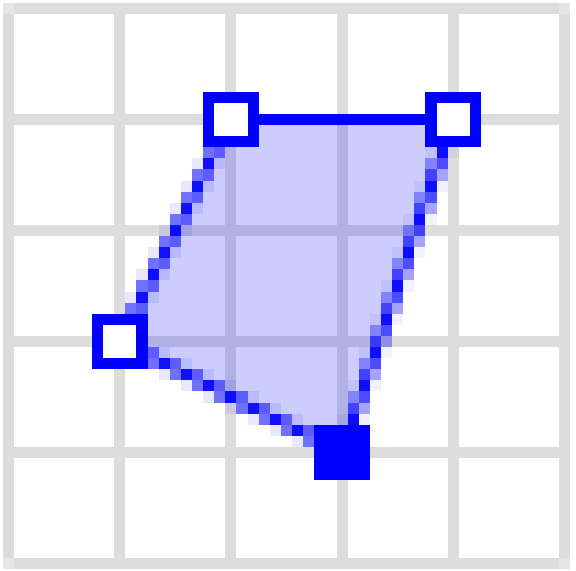
Niz dužina

LINESTRING (30 10, 10 30, 40 40)



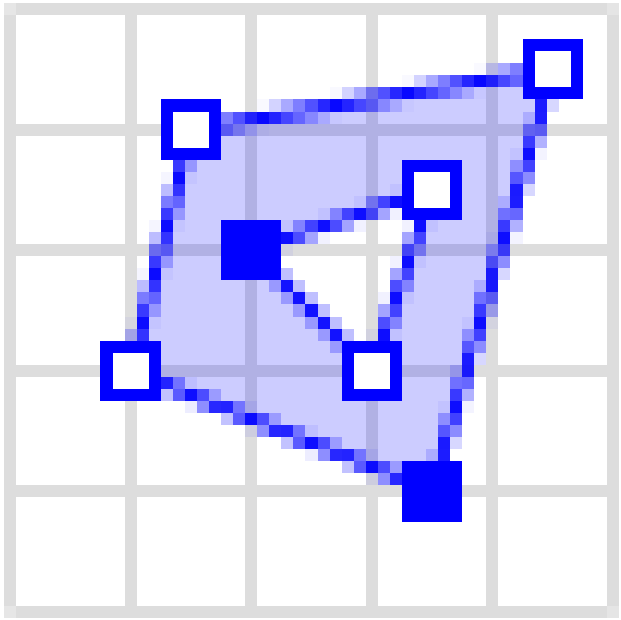
Poligon (n-terokut)

```
POLYGON ((30 10, 10 20, 20 40, 40
40, 30 10))
```



Poligon (n-terokut) #2

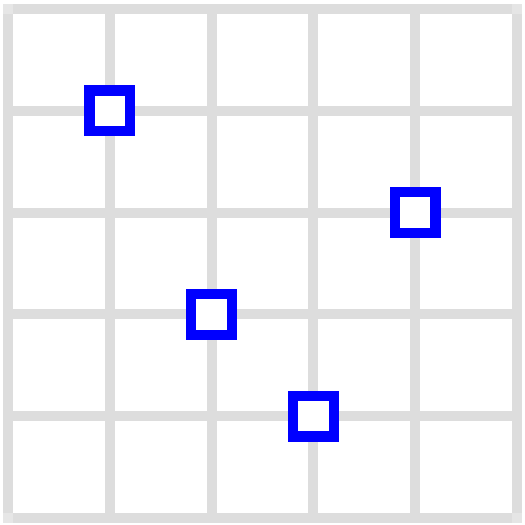
```
POLYGON ((35 10, 10 20, 15 40, 45
45, 35 10), (20 30, 35 35, 30 20, 20
30))
```



Skup točaka

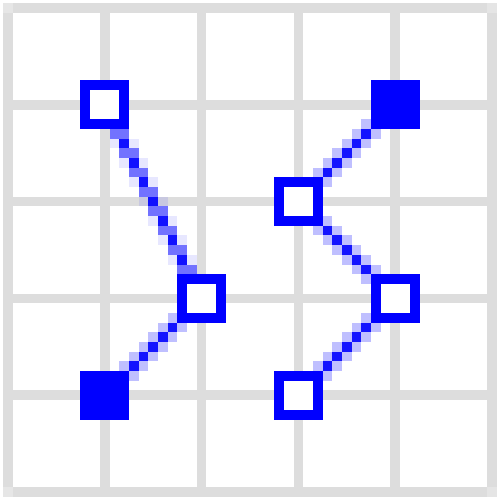
MULTIPOINT ((10 40), (40 30), (20 20), (30 10))

MULTIPOINT (10 40, 40 30, 20 20, 30 10)



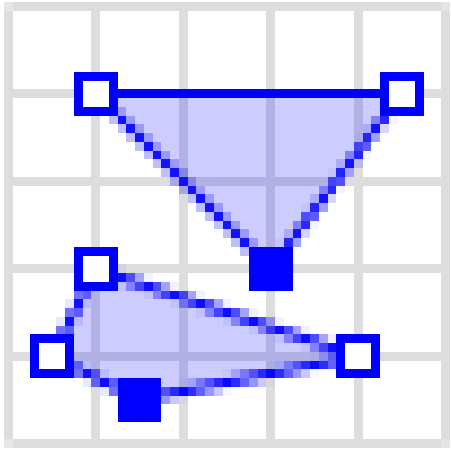
Skup nizova dužina

```
MULTILINESTRING ((10 10, 20 20, 10
40), (40 40, 30 30, 40 20, 30 10))
```



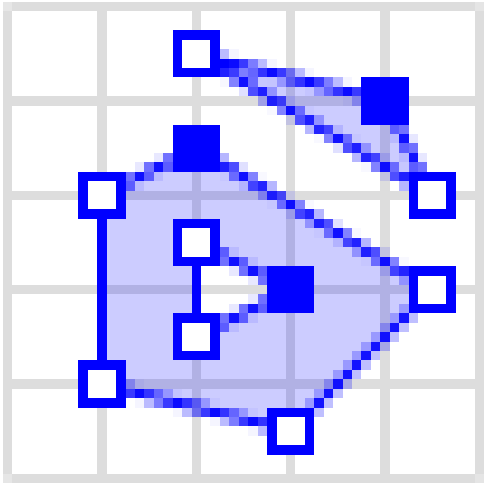
Skup n-terokuta

MULTIPOLYGON (((30 20, 10 40, 45 40, 30 20)),
((15 5, 40 10, 10 20, 5 10, 15 5)))

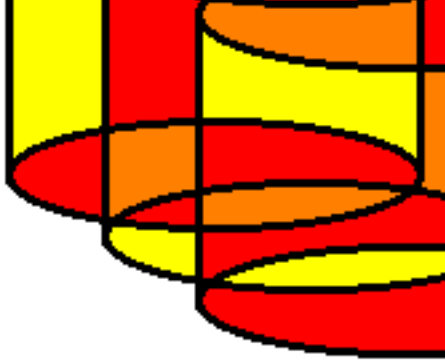


Skup n-terokuta

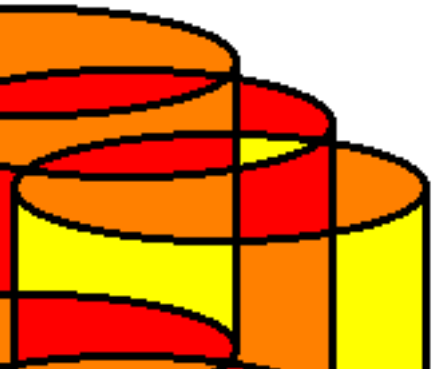
```
MULTIPOLYGON (((40 40, 20 45, 45 30,
40 40)), ((20 35, 45 20, 30 5, 10
10, 10 30, 20 35), (30 20, 20 25, 20
15, 30 20)))
```



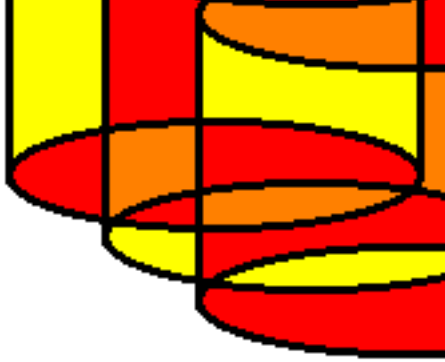
Kolekcija geometrija



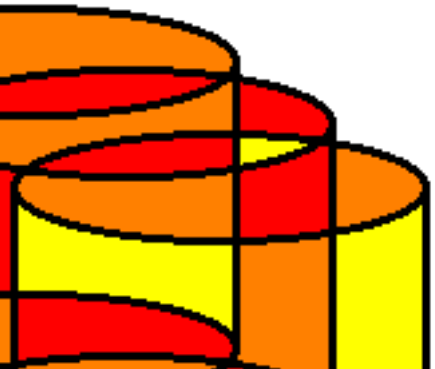
GEOMETRYCOLLECTION(POINT(4 6),
LINESTRING(4 6, 7 10))



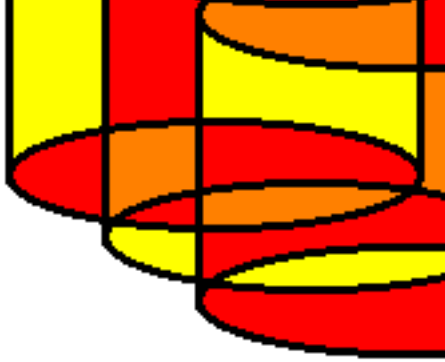
SRID



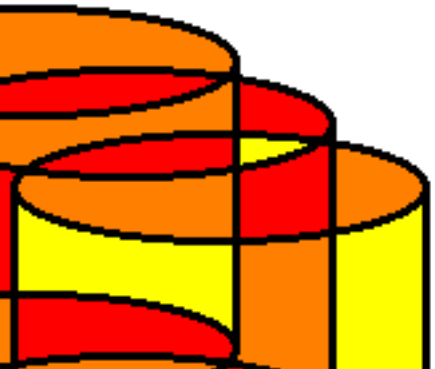
- OGC standard također zahtjeva korištenje SRID (spacial referencing system identifier) pri pohrani prostornih podataka.



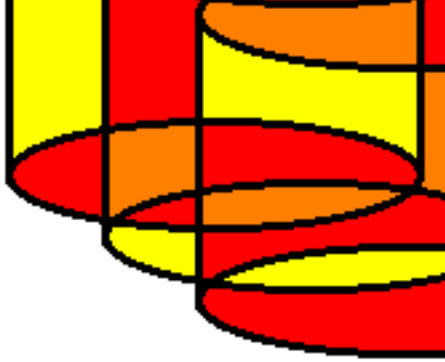
PostGIS



- Za rad s prostornim bazama podataka koristit ćemo PostGIS dodatak za PostgreSQL.
- PostGIS je kompatibilan s OGC standardom te ga proširuje drugim (nestandardnim) tipovima i operacijama.

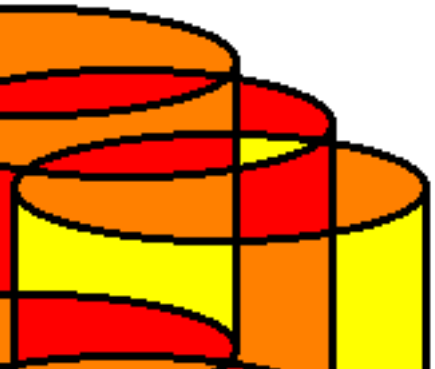


GEOMETRY i GEOGRAPHY



Geometry – prostorni objekt u linearnom prostoru

Geography – prostoni objekt u sfernom prostoru



PostGIS + QGIS - instalacija

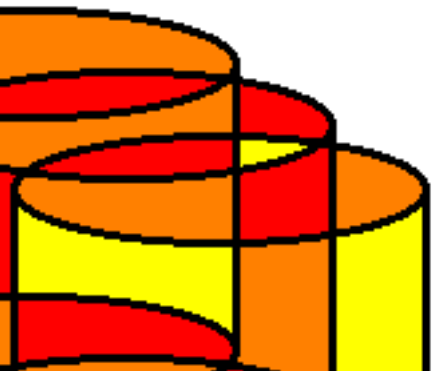
Ako Postgis i QGIS nisu instalirani potrebno ih je instalirati na sljedeći način (PostgreSQL 12):

```
sudo apt install postgresql-12-postgis-3 qgis postgresql-12-postgis-3-scripts
```

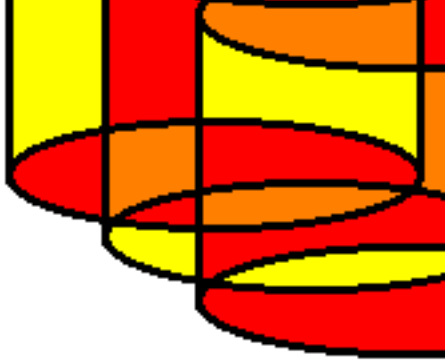
Zatim kreirati ekstenziju u psql-u.

```
sudo -u postgres psql

CREATE EXTENSION adminpack;

\q
```

NAPOMENA: Ako imate drugu verziju postgresql-a pronađite odgovarajuće pakete naredbom: **sudo apt search postgis**
Paketi imaju oblik p**ostgresql-[verzija]-postgis-[verzija] i postgresql-[verzija]-postgis-[verzija]-scripts**

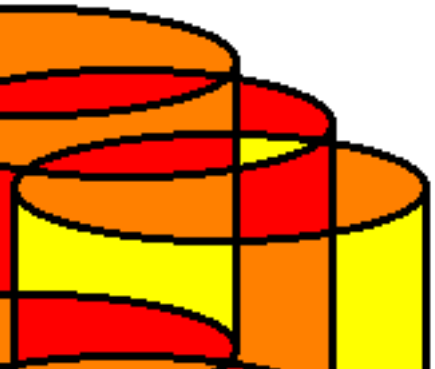


Kreiranje prostorne baze podataka

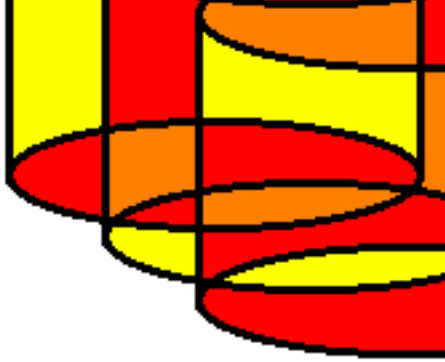


- Na konzoli kreirati novu bazu podataka:

```
createdb gis

psql gis

CREATE SCHEMA postgis;

ALTER DATABASE gis SET search_path=public, postgis, contrib;

\connect gis;

CREATE EXTENSION postgis SCHEMA postgis;

\q
```

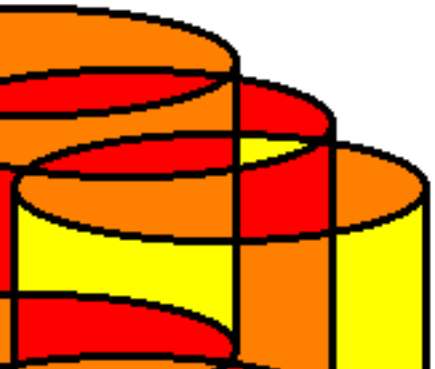


Unos testnih podataka



- Skinuti podatke za vježbu

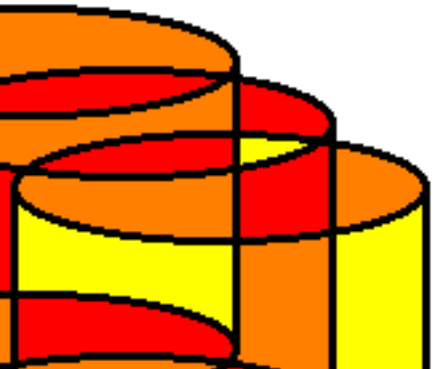
```
wget https://qgis.org/downloads/data/training_manual_exercise_data.zip
unzip training_manual_exercise_data.zip
cd exercise_data/postgis
```



Prijevod podataka 1/3

- Prevest ćemo podatke na hrvatski i unesti u bazu podataka koju smo kreirali (jedna naredba)

```
shp2pgsql -s 4326 -c -D -I polygons.shp postgis.regija |
sed -e 's/region/regija/g' | sed -e 's/name/naziv/g' |
sed -e 's/Queensland/Zagorje/g' | sed -e
's/Missouri/Međimurje/g' | sed -e 's/Hokkaido/Slavonija/
g' | sed -e 's/Saskatchewan/Dalmacija/g' | sed -e
's/Wales/Primorje/g' | sed -e 's/Germania/Podravina/g' |
sed -e 's/KwaZulu/Istra/g' | psql gis
```



Prijevod podataka 2/3

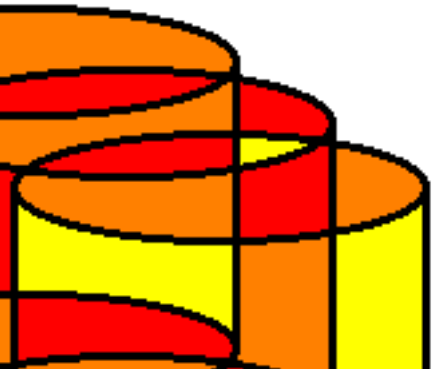
- Prevest ćemo podatke na hrvatski i unesti u bazu podataka koju smo kreirali (jedna naredba)

```
shp2pgsql -s 4326 -c -D -I points.shp postgis.zgrada  |
sed -e 's/Atlanta/Varaždin/g' | sed -e
's/Berlin/Čakovec/g' | sed -e 's/Santiago/Split/g' | sed
-e 's/York/Osijek/g' | sed -e 's/Beijing/Rijeka/g' | sed
-e 's/name/naziv/g' | sed -e 's/building/zgrada/g' |
psql gis
```

Prijevod podataka 3/3

- Prevest ćemo podatke na hrvatski i unesti u bazu podataka koju smo kreirali (jedna naredba)

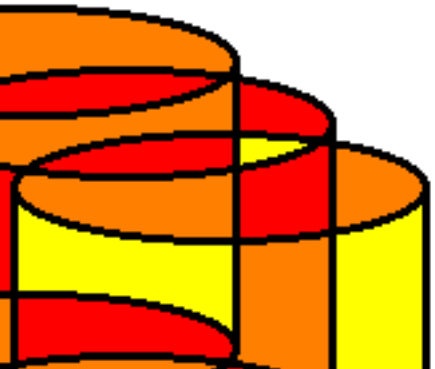
```
shp2pgsql -s 4326 -c -D -I lines.shp postgis.cesta  |
sed -e 's/roadtype/vrsta/g' | sed -e 's/road/cesta/g' |
sed -e 's/minor/županijska/g' | sed -e 's/major/državna/
g'  | sed -e 's/varchar(5)/varchar(20)/g' | psql gis
```



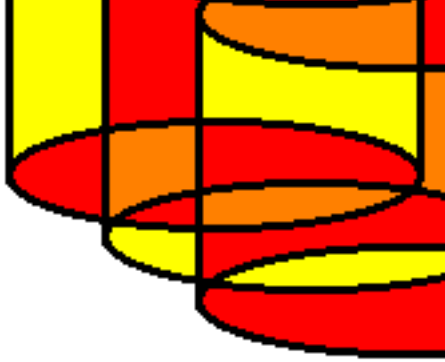
Isprobavanje

- Ako je unos bio uspješan, ako pokrenemo konzolu trebali bismo imati tri tablice:

```
psql gis
\dt
                List of relations
 Schema  |      Name        | Type  | Owner
---------+------------------+-------+--------
 postgis | cesta            | table | markus
 postgis | regija           | table | markus
 postgis | spatial_ref_sys  | table | markus
 postgis | zgrada           | table | markus
(4 rows)
```

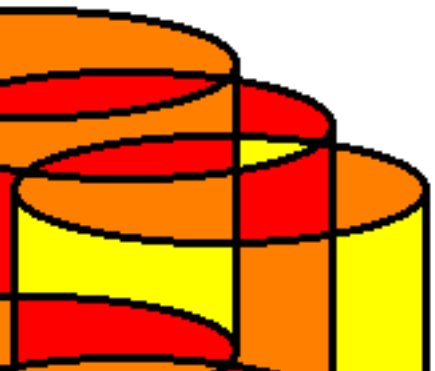


QGIS



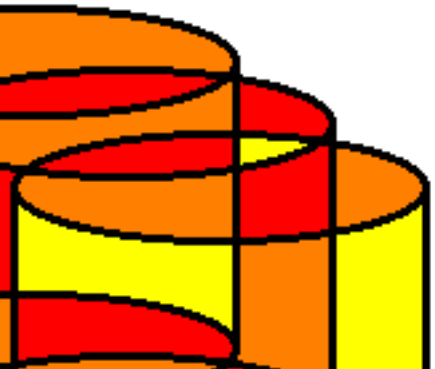
- Sustav za upravljanje zemljopisnim informacijskim sustavima koji omogućuje rad s PostGIS bazom podataka
- Pokrećemo ga s:

```
qgis &
```

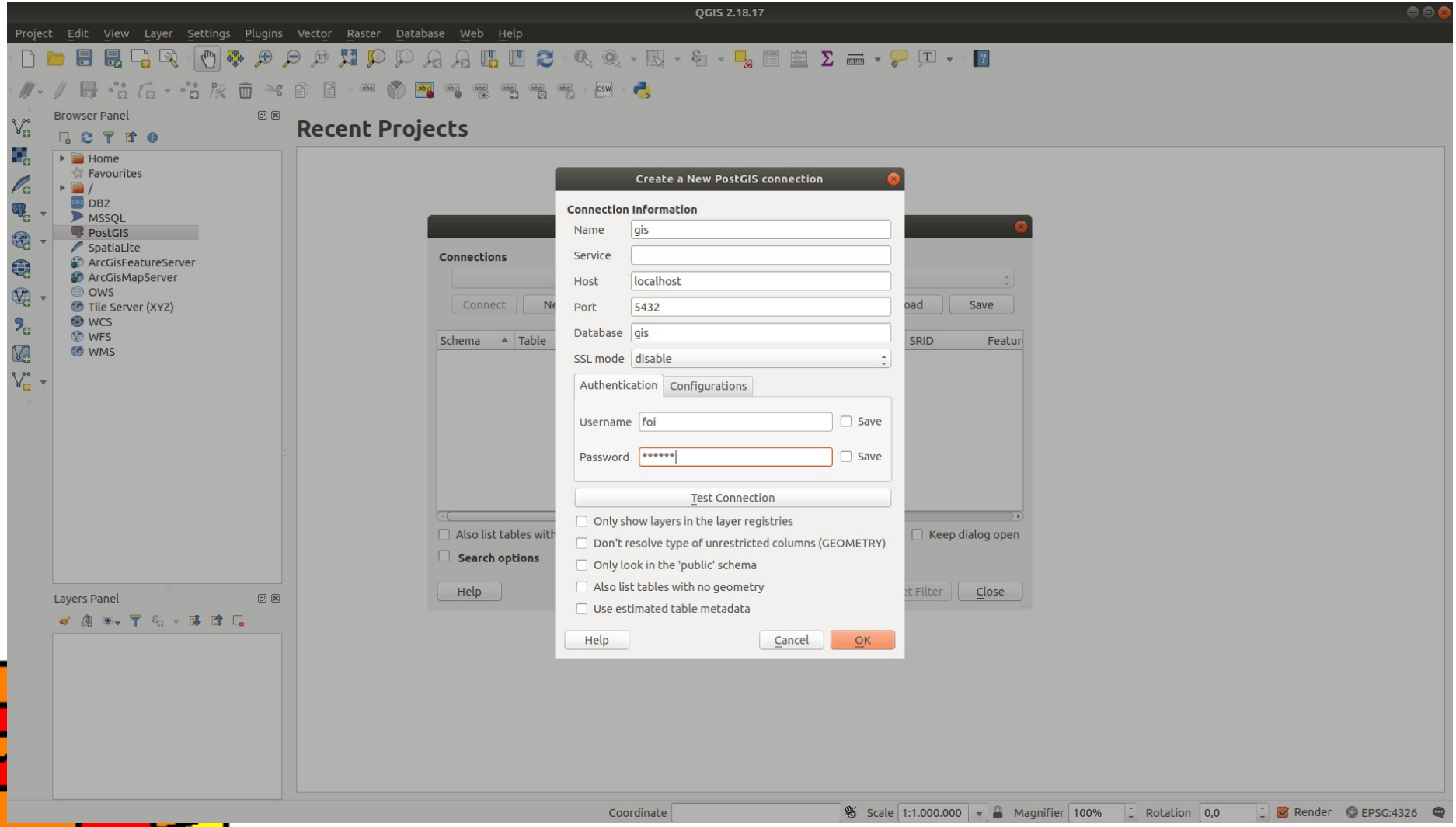


Spajanje na BP

- Browser Panel > PostGIS > dupli klik ili gumbić Add PostGIS table > New
- Unesti podatke za pristup bazi podataka:
  - name: proizvoljno (npr. gis)
  - host: localhost
  - port: 5432
- Pod authentication:
  - username: foi (ili username koji se koristi)
  - password: vjezbe (ili lozinka koja se koristi)
- Test Connection za isprobavanje, ako sve radi, ok i pod Browser Panel bi se trebalo pojaviti stablo koje sadrži tablice zgrada, cesta i regija.

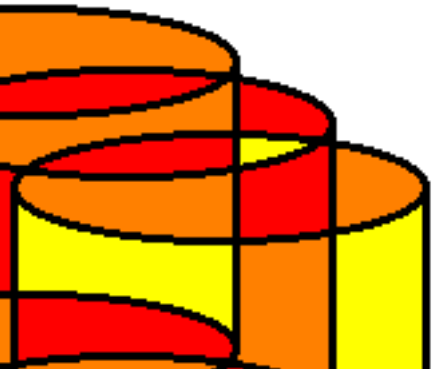


Spajanje na BP

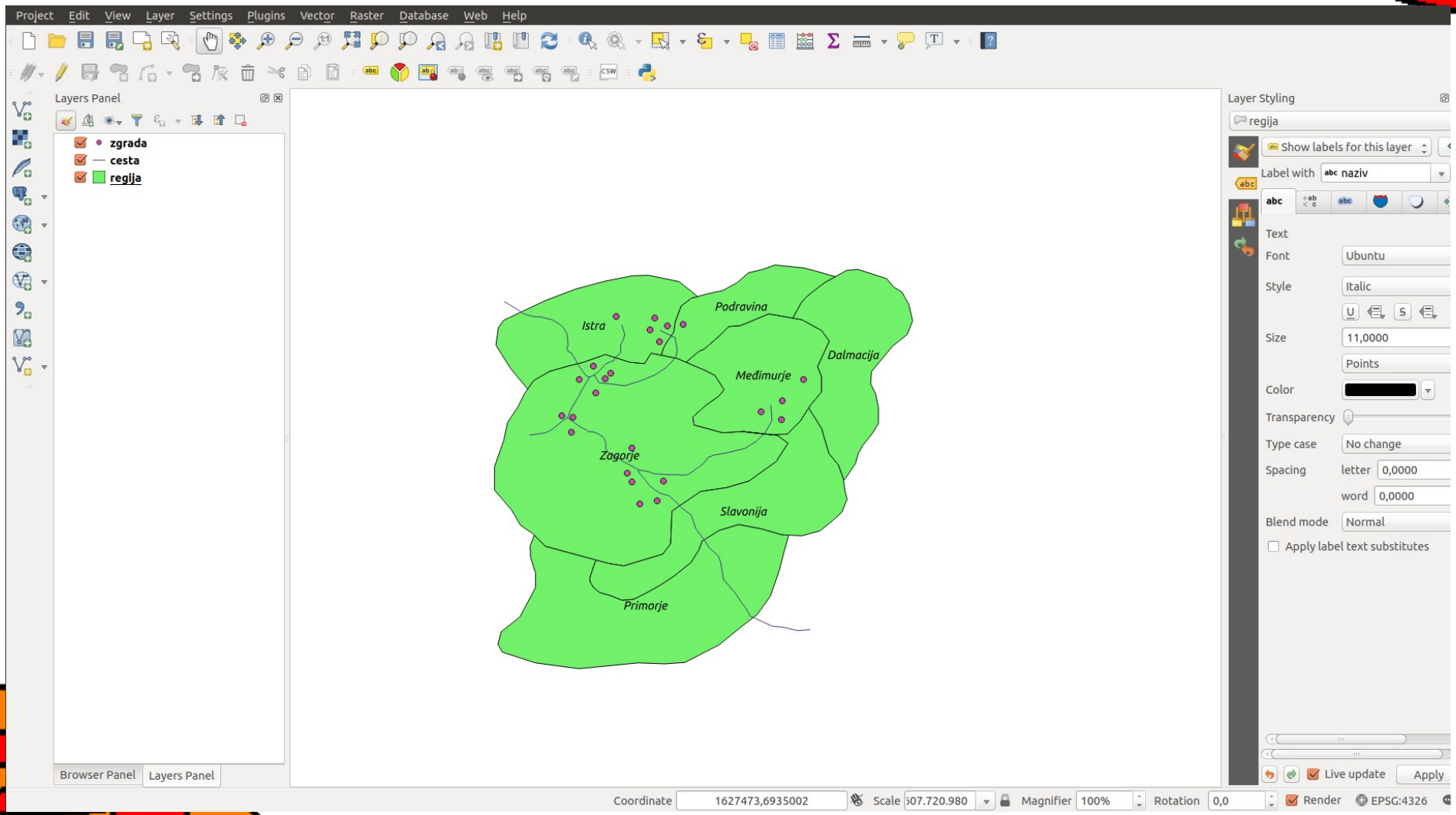


Prikaz prostornih podataka

- Duplim klikom na regija trebale bi se pojaviti regije (površine).
- Duplim klikom na cesta trebale bi se pojaviti ceste (dužine).
- Duplim klikom na zgrada trebale bi se pojaviti zgrade (točke).
- Da bismo uključili oznake idemo na Layer > Labeling te u meniju Layer Styling za sloj regija odabrati Show labels for this layer i odabrati naziv.
- Zatim na meni Database > DB Manager > DB Manager i zatim u novom prozoru koji se otvorio pod Database > SQL Window (ili F2).

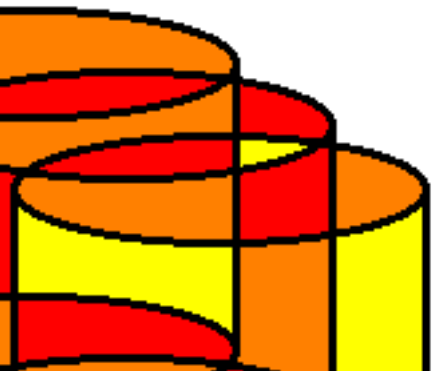


Prikaz

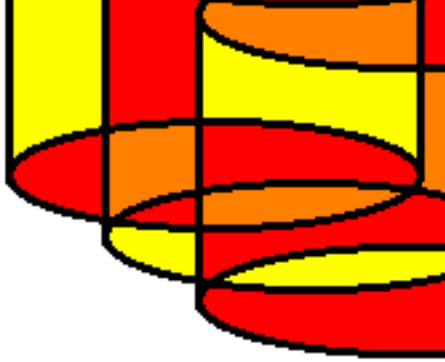

Project Edit View Layer Settings Plugins Vector Raster Database Web Help
Layers Panel
zgrada
cesta
regija
Istra
Podravina
Dalmacija
Međimurje
Zagorje
Slavonija
Primorje
Layer Styling
regija
Show labels for this layer
Label with naziv
Text
Font Ubuntu
Style Italic
Size 11,0000
Points
Color
Transparency
Type case No change
Spacing letter 0,0000
word 0,0000
Blend mode Normal
Apply label text substitutes
Live update
Apply
Browser Panel
Layers Panel
Coordinate 1627473,6935002
Scale
Magnifier 100%
Rotation 0,0
Render
EPSG:4326

Upute

- U nastavku je niz upita koje treba upisati u odgovarajuće polje te postaviti upit s Execute (F5) te uključiti Load as new layer te uključiti Load now!
- Nakon pregleda rezultata, pod Layers Panel maknuti kvačicu pod aktualnim QueryLayer slojem, da se ne prikazuju svi rezultati svih upita.

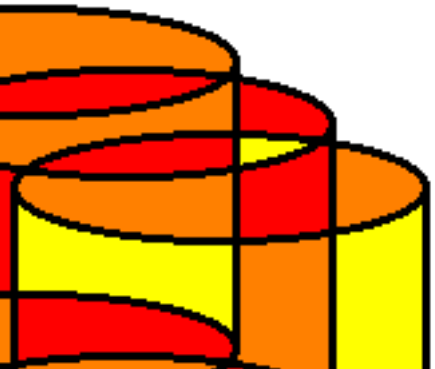


Primjeri upita

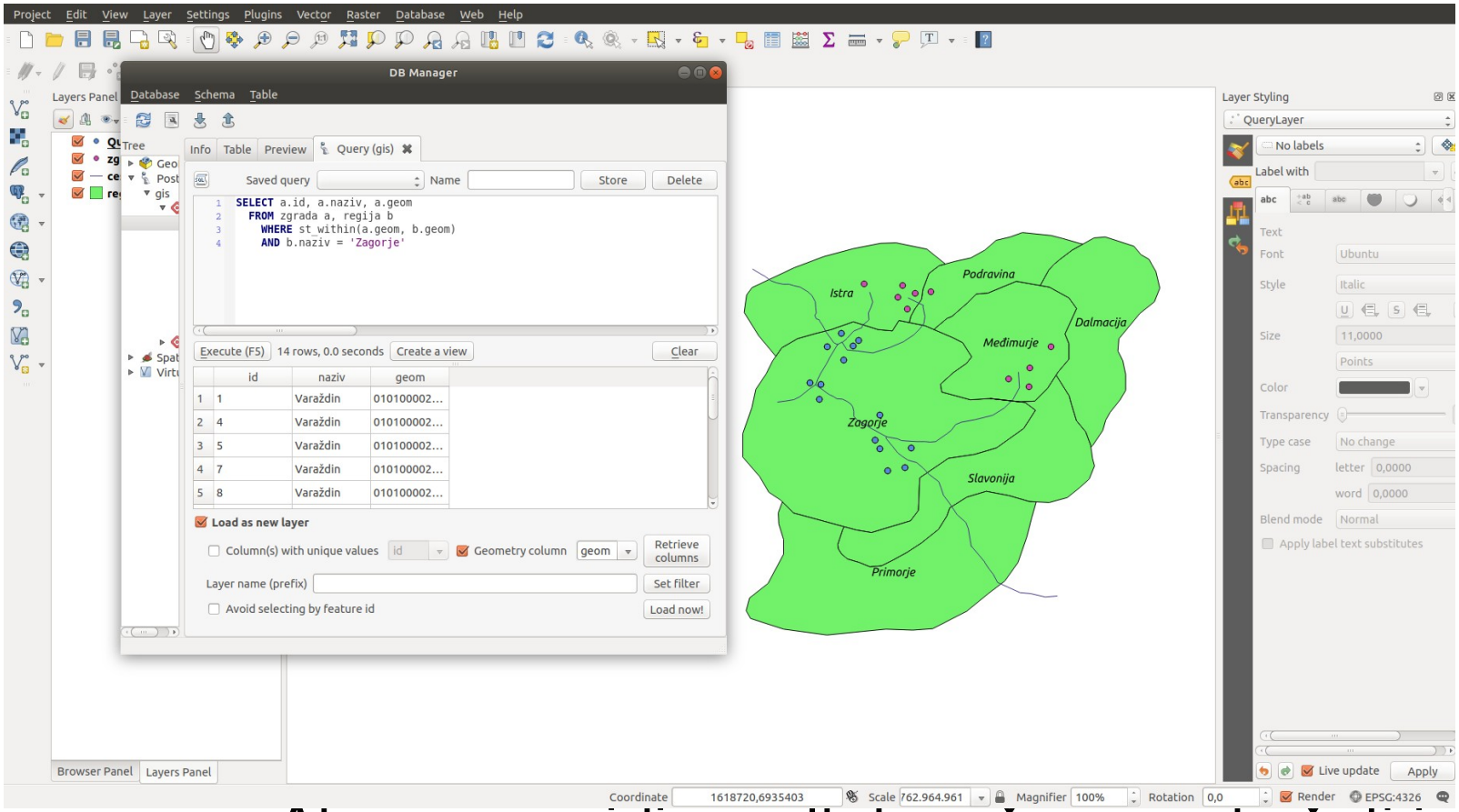


- Sve zgrade u regiji Zagorje:

```
SELECT a.id, a.naziv, a.geom
   FROM zgrada a, regija b
      WHERE st_within(a.geom, b.geom)
      AND b.naziv = 'Zagorje'
```



Očekivani rezultat

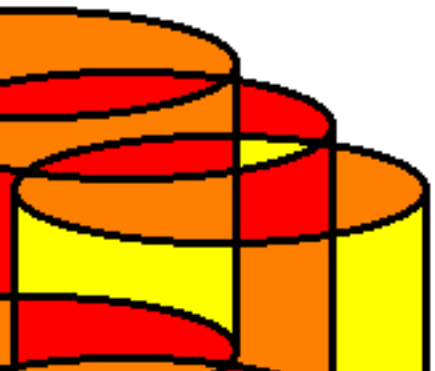


Ako se ne vidi rezultat može se pokušati isključiti sloj zgrade ili sloj QueryLayer staviti iznad sloja zgrada.

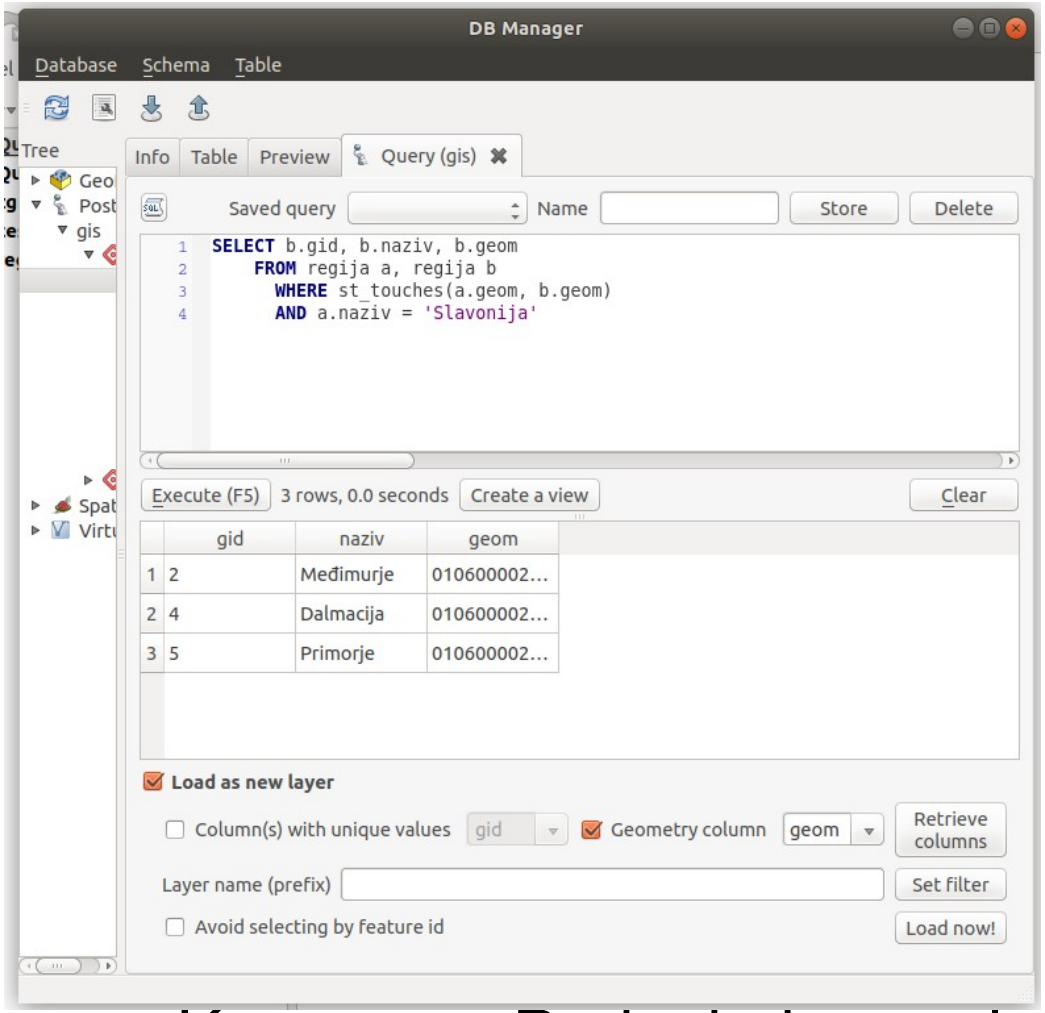
Primjeri upita

- Koja zgrada je u kojoj regiji (nema geom - ne treba Load now!):

```
SELECT DISTINCT a.naziv, b.naziv
 FROM zgrada a, regija b
 WHERE st_contains( b.geom, a.geom )
```

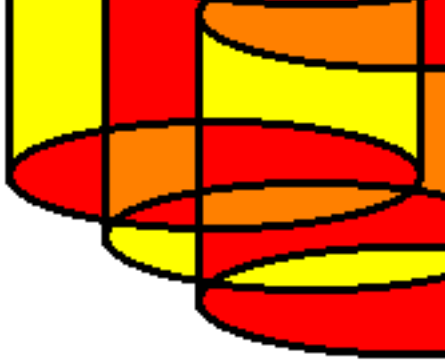


Očekivani rezultat



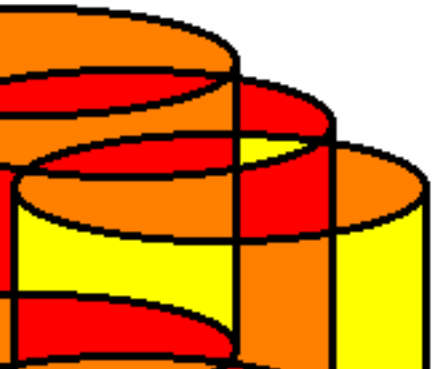
Komentar: Podaci nisu realni ;-)

Primjeri upita

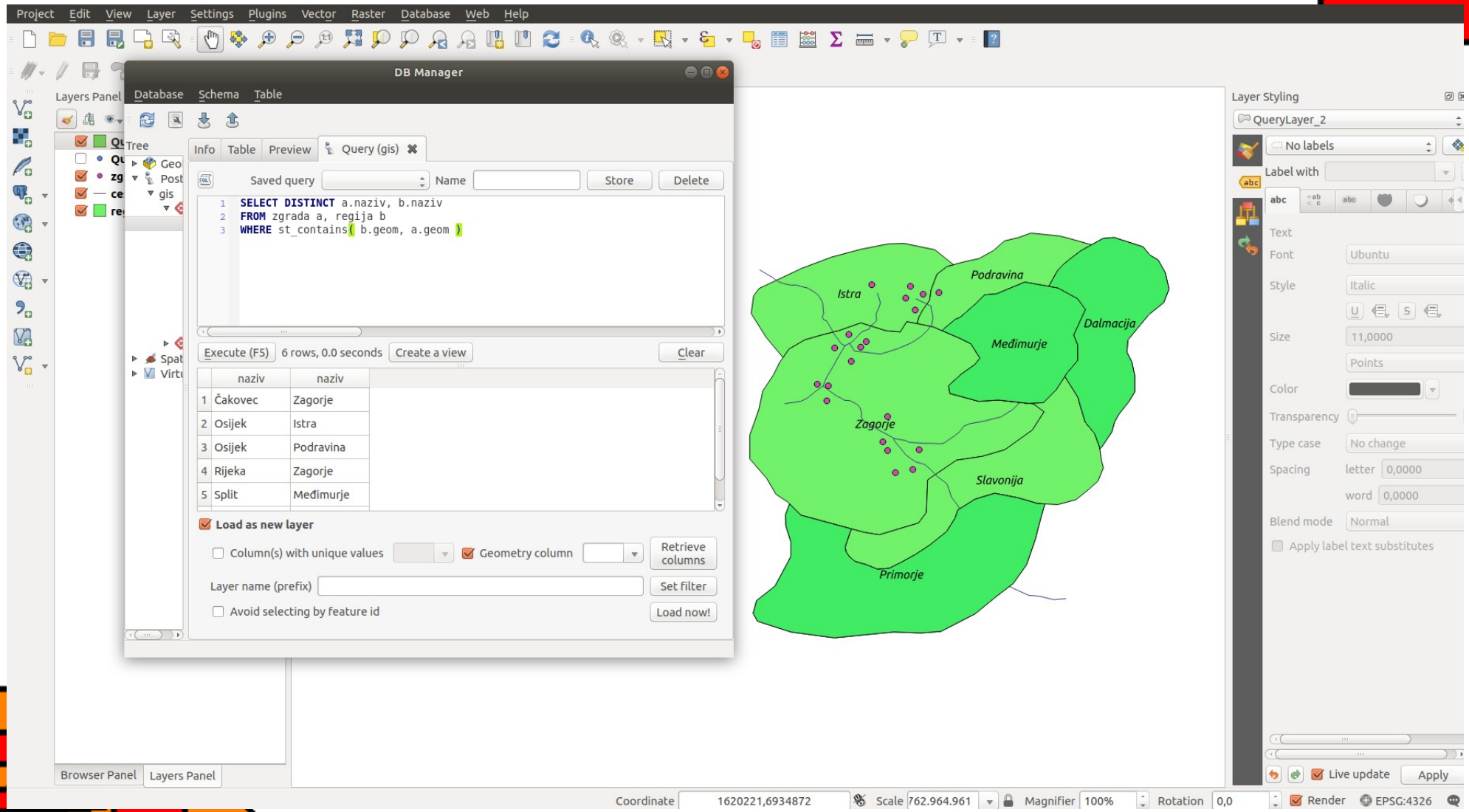


- Sve regije koje dodiruju regiju Slavonija:

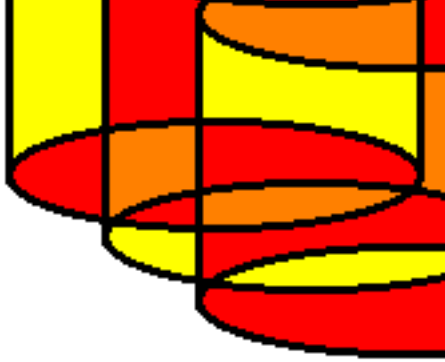
```
SELECT b.gid, b.naziv, b.geom
    FROM regija a, regija b
    WHERE st_touches(a.geom, b.geom)
      AND a.naziv = 'Slavonija'
```



Očekivani rezultat

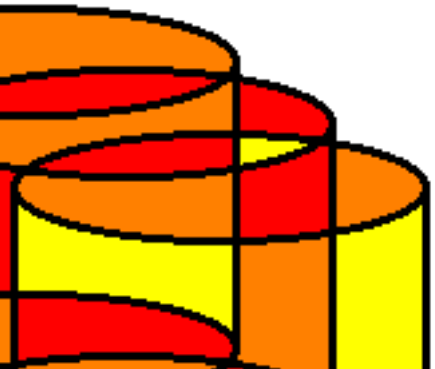


Primjeri upita

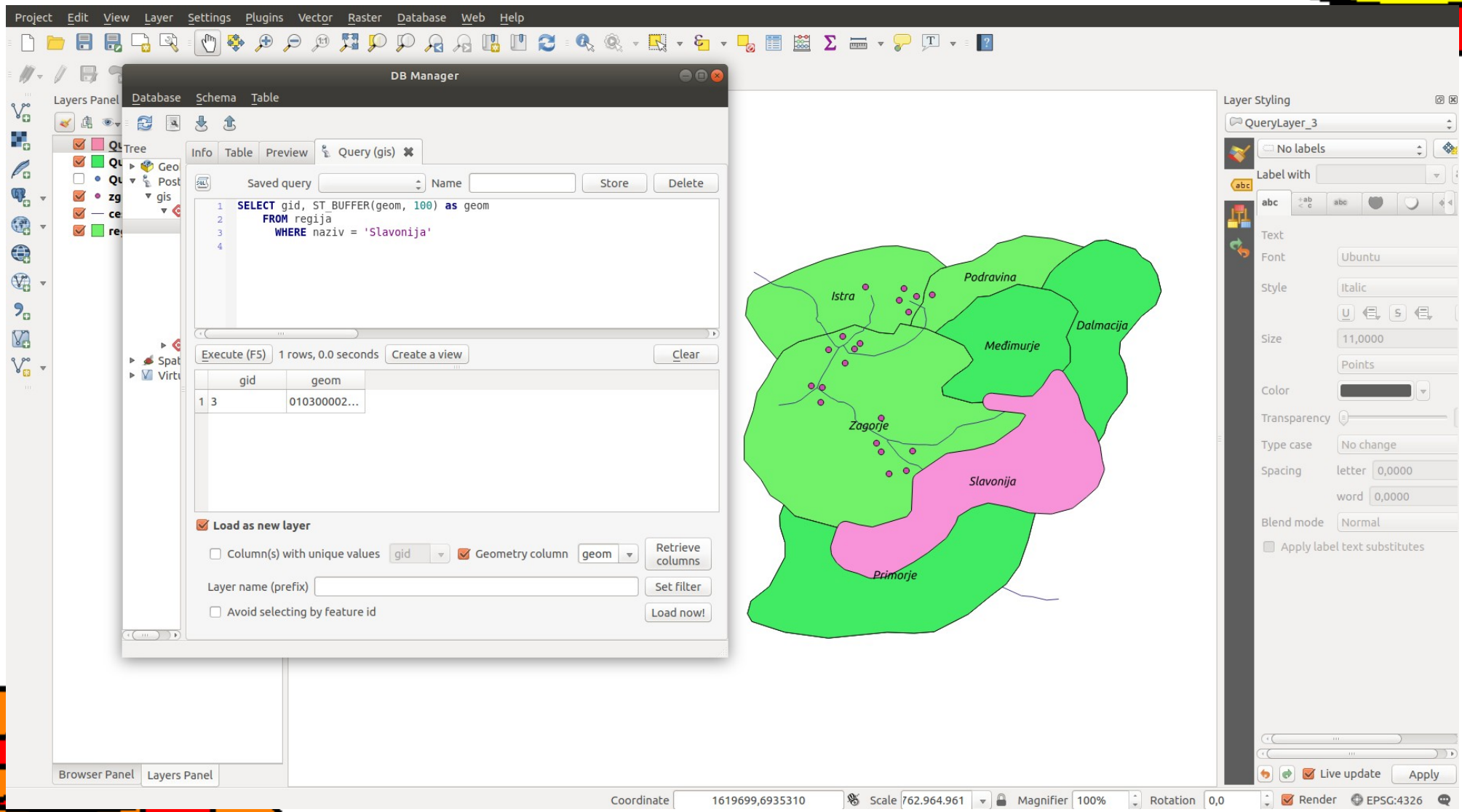


- Regija Slavonija proširena za 100 mjernih jedinica (engl. buffer):

```
SELECT gid, ST_BUFFER( geom, 100 ) as geom
   FROM regija
   WHERE naziv = 'Slavonija'
```



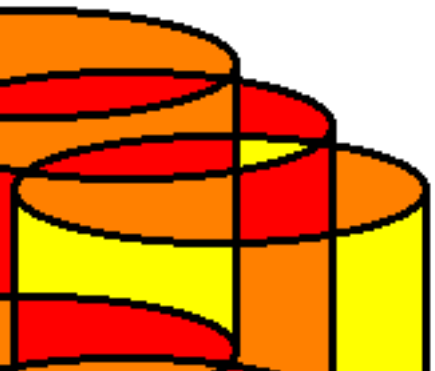
Očekivani rezultat



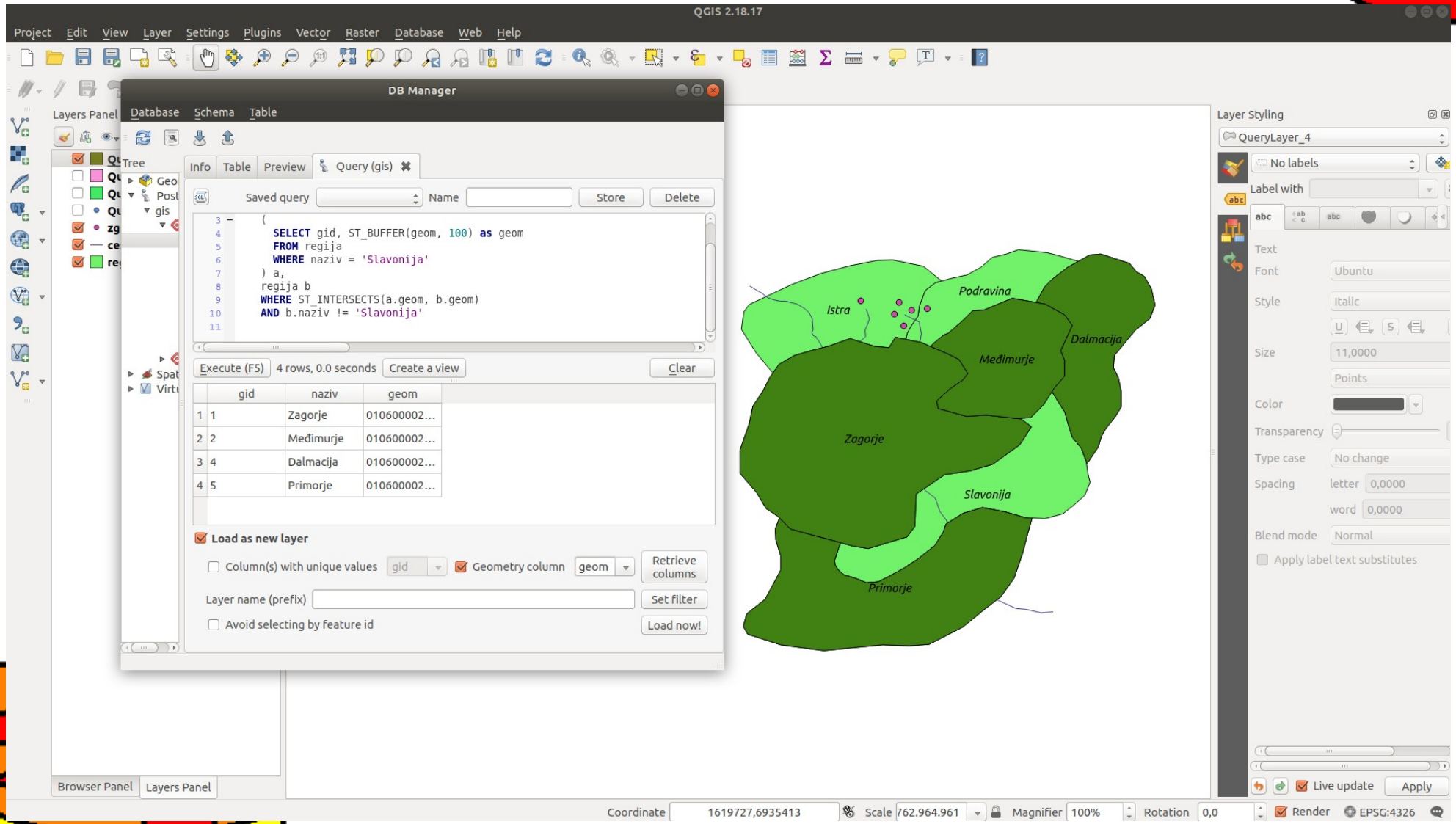
Primjeri upita

- Sve regije koje dotiču regiju Slavonija proširenu za 100 mjernih jedinica:

```
SELECT b.gid, b.naziv, b.geom
    FROM
    (
      SELECT gid, ST_BUFFER(geom, 100) as geom
      FROM regija
      WHERE naziv = 'Slavonija'
    ) a,
    regija b
    WHERE ST_INTERSECTS(a.geom, b.geom)
    AND b.naziv != 'Slavonija'
```



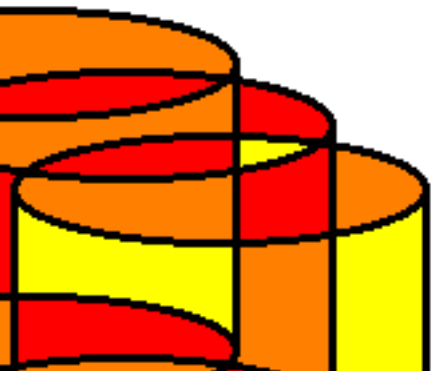
Očekivani rezultat



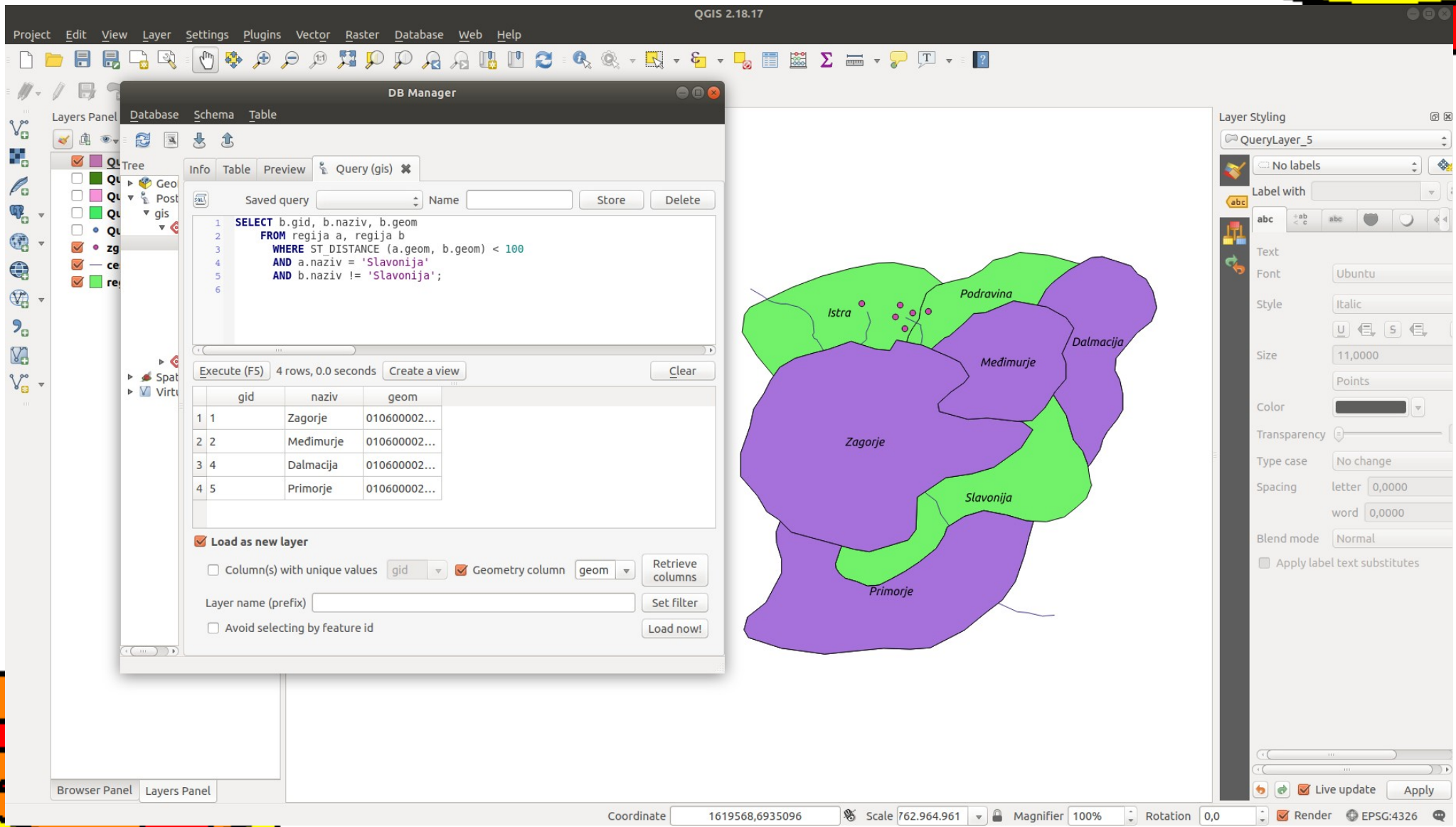
Primjeri upita

- Isti rezultat, drugi način: sve regije koje su udaljene za manje od 100 mjernih jedinica od pokrajine Slavonija:

```
SELECT b.gid, b.naziv, b.geom
    FROM regija a, regija b
      WHERE ST_DISTANCE (a.geom, b.geom) < 100
      AND a.naziv = 'Slavonija'
      AND b.naziv != 'Slavonija';
```



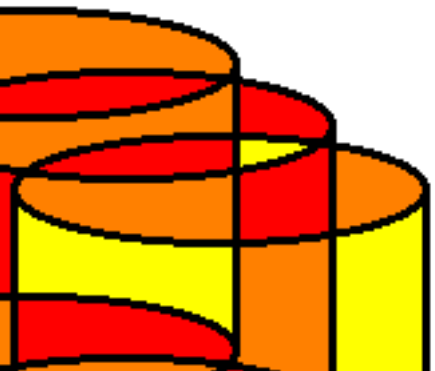
Očekivani rezultat



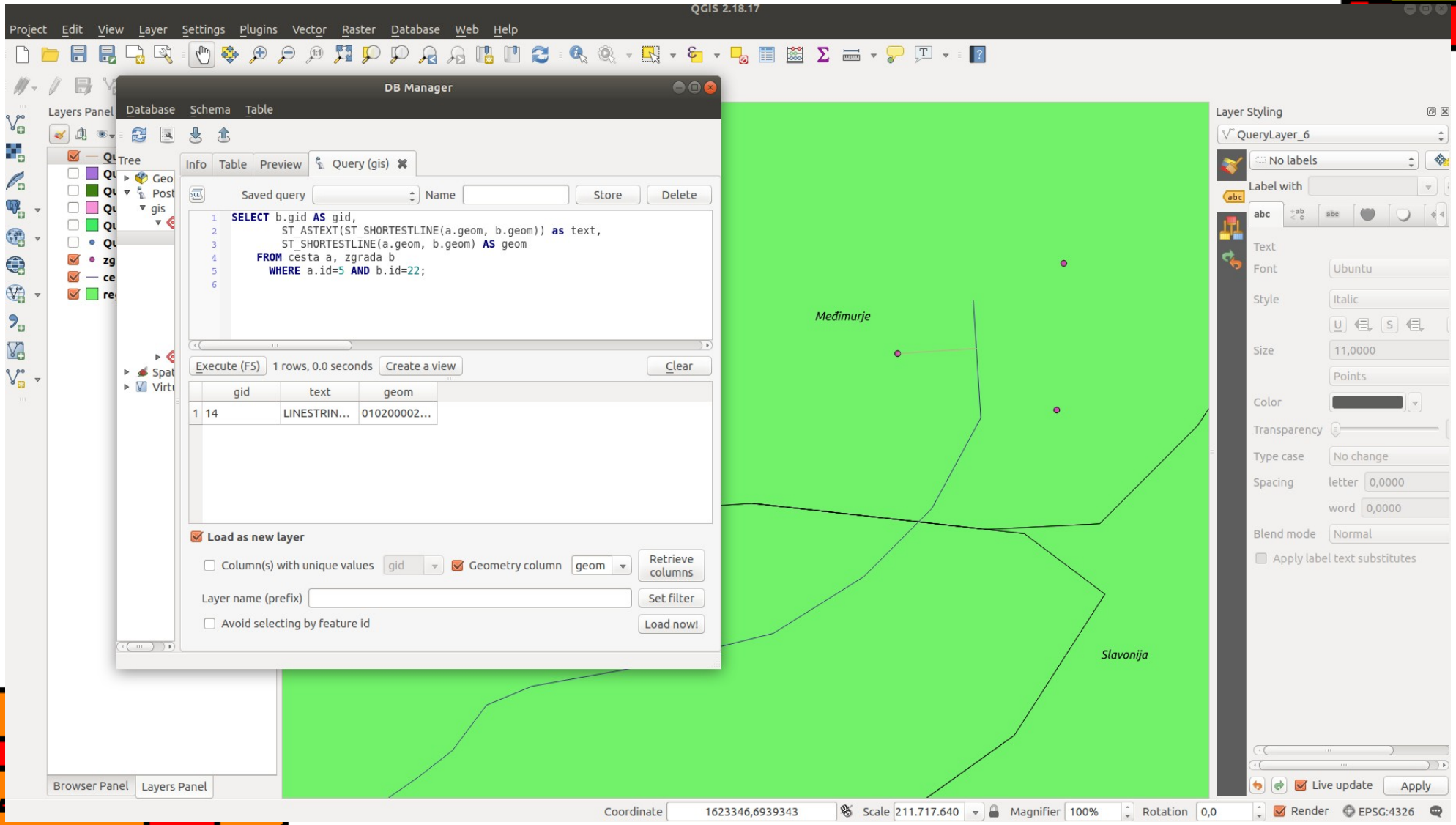
Primjeri upita

- Najkraći put (dužina) od ceste sa šifrom 5 do zgrade sa šifrom 22:

```
SELECT b.gid AS gid,
        ST_ASTEXT(ST_SHORTESTLINE(a.geom, b.geom)) as text,
        ST_SHORTESTLINE(a.geom, b.geom) AS geom
    FROM cesta a, zgrada b
    WHERE a.id = 5 AND b.id = 22;
```



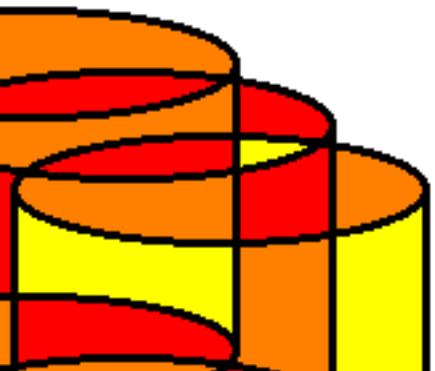
Očekivani rezultat



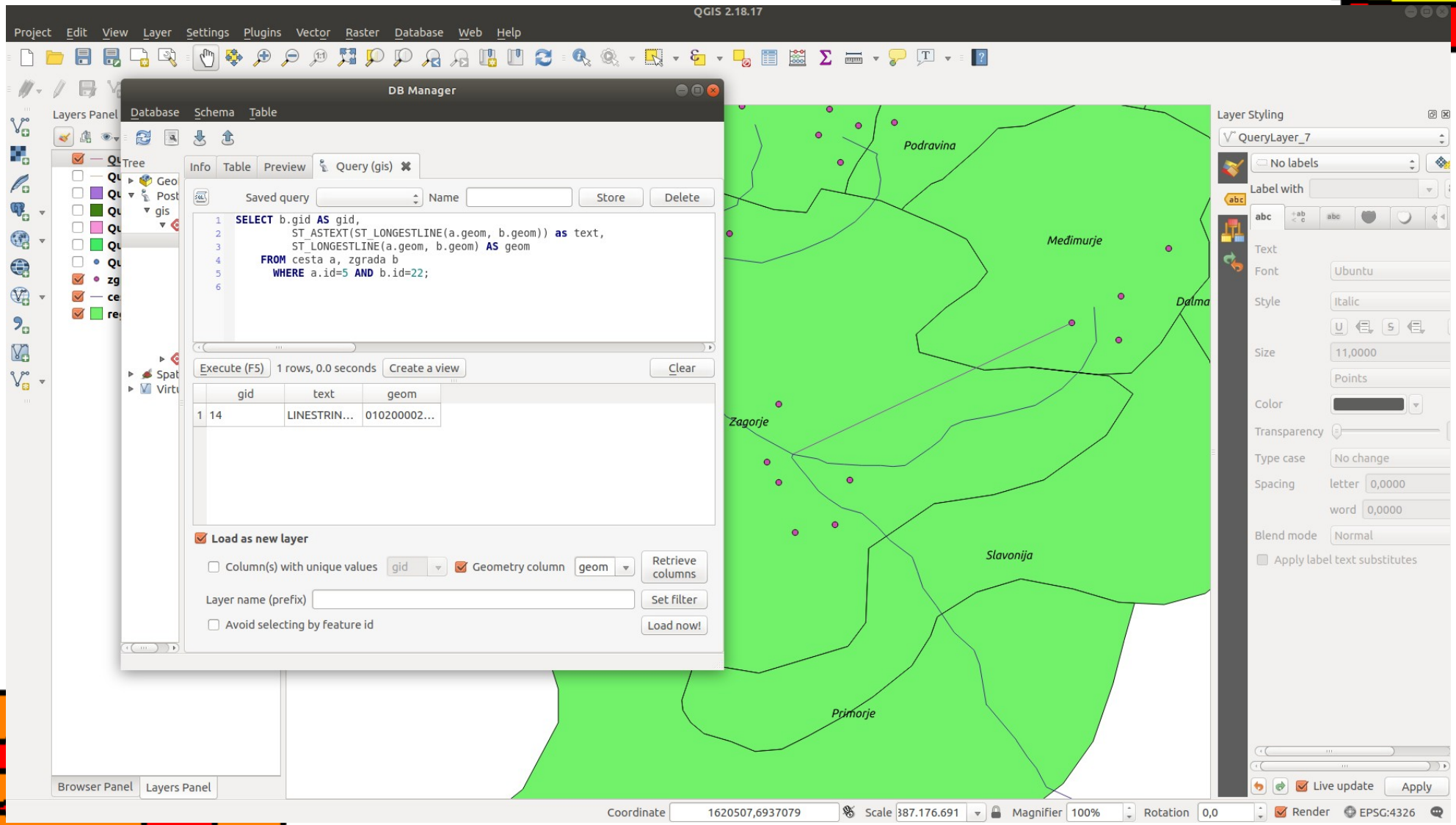
Primjeri upita

- Najveća udaljenost ceste sa šifrom 5 do zgrade sa šifrom 22:

```
SELECT b.gid AS gid,
        ST_ASTEXT(ST_LONGESTLINE(a.geom, b.geom)) as text,
        ST_LONGESTLINE(a.geom, b.geom) AS geom
    FROM cesta a, zgrada b
    WHERE a.id = 5 AND b.id = 22;
```



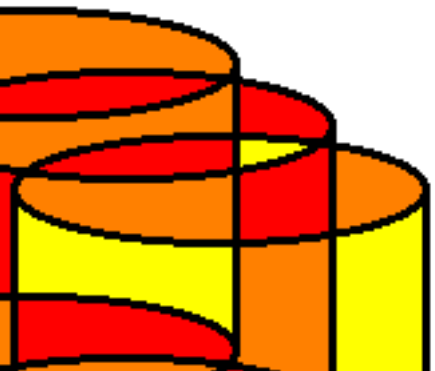
Očekivani rezultat



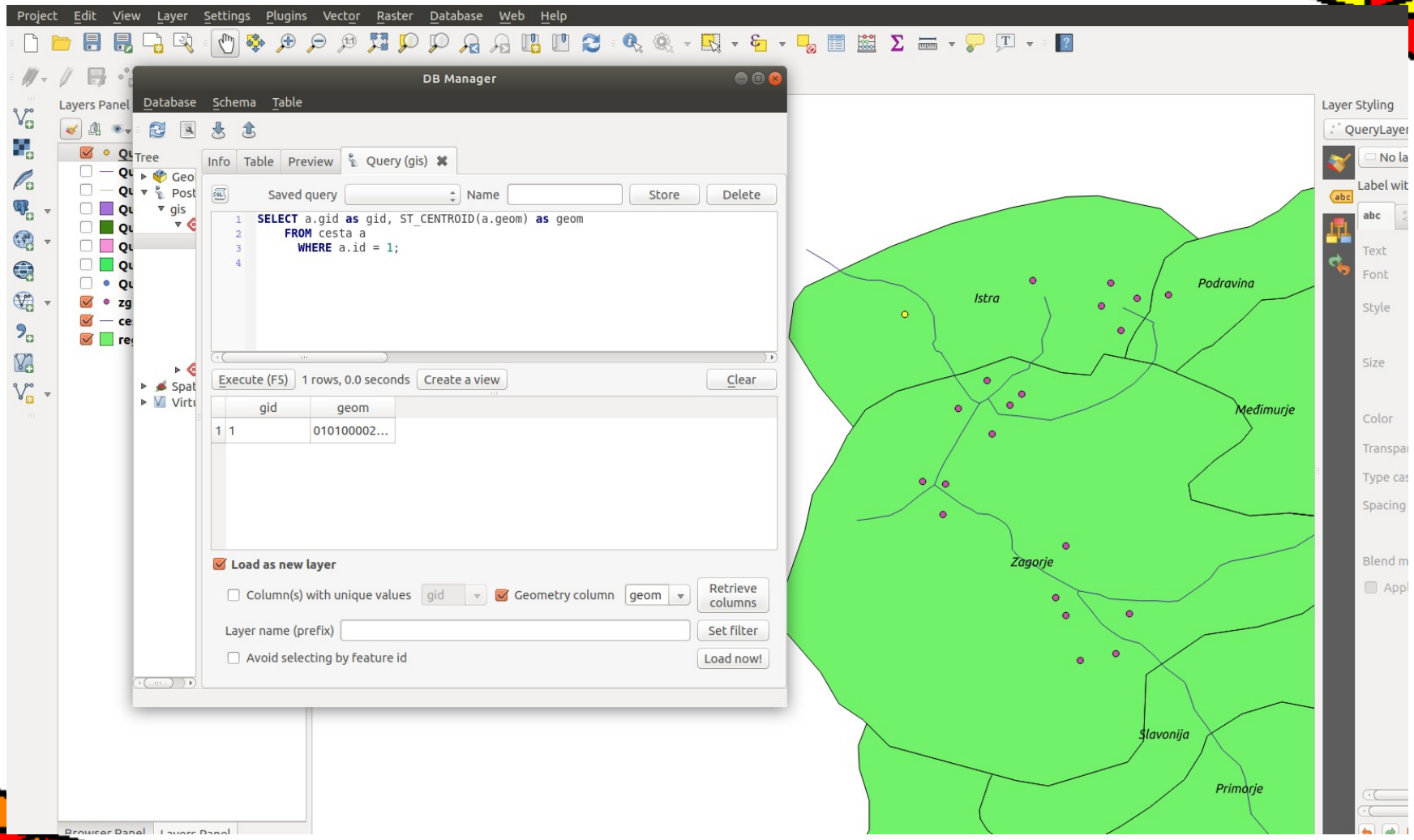
Primjeri upita

- Centroid (centralna točka slike) za cestu sa šifrom 1:

```
SELECT a.gid as gid, ST_CENTROID( a.geom ) as geom
    FROM cesta a
      WHERE a.id = 1;
```



Očekivani rezultat

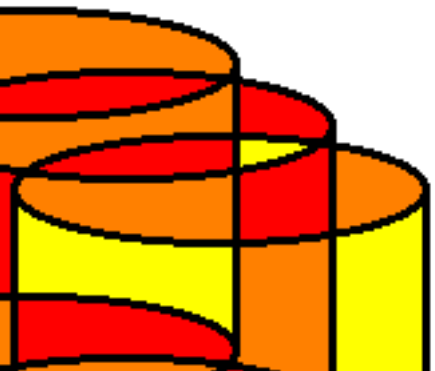


Komentar: Žuta točka u Istri

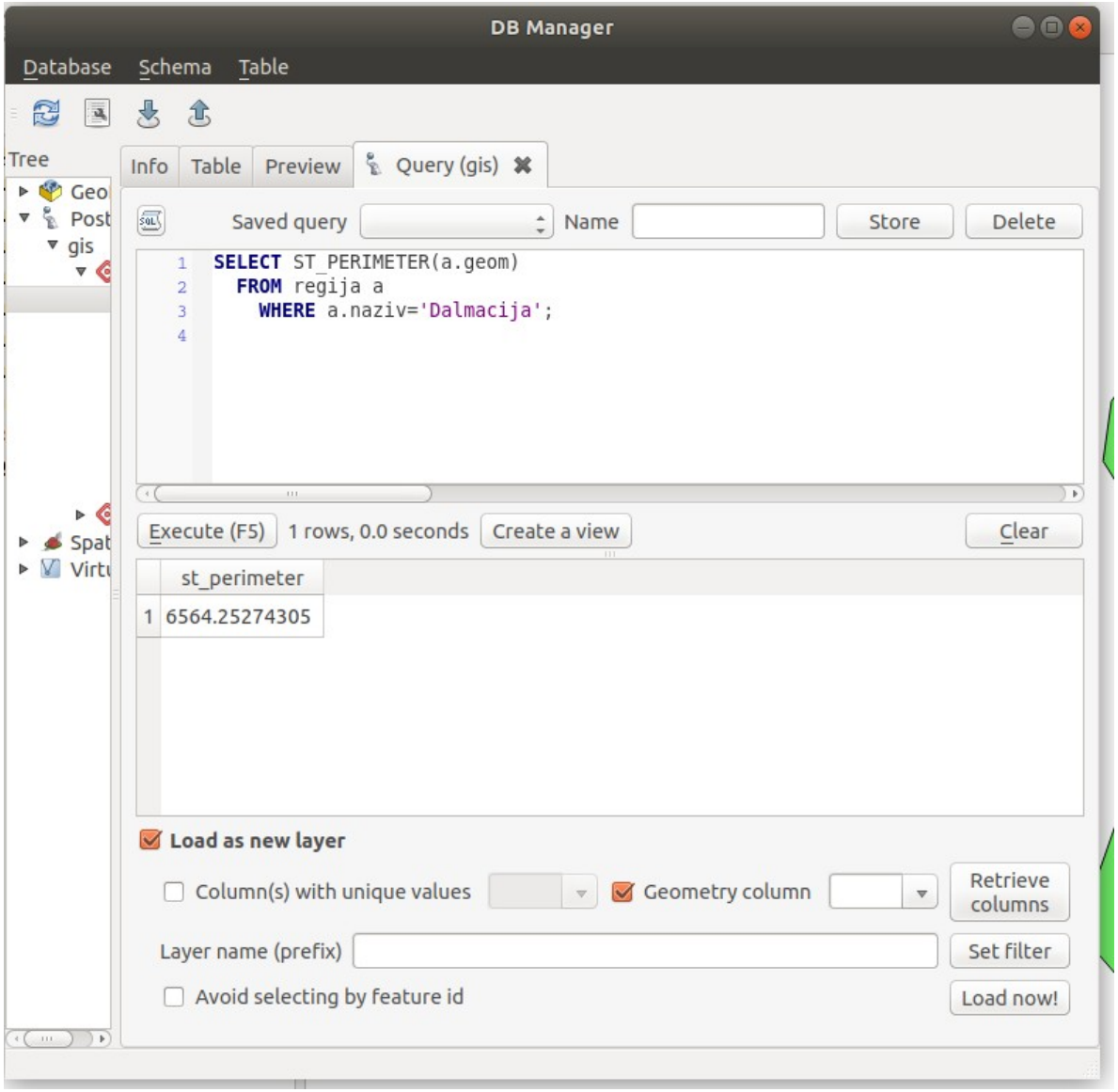
Primjeri upita

- Promjer regije Dalmacija (nema geom - ne treba Load now!):

```
SELECT ST_PERIMETER( a.geom )
  FROM regija a
    WHERE a.naziv='Dalmacija';
```



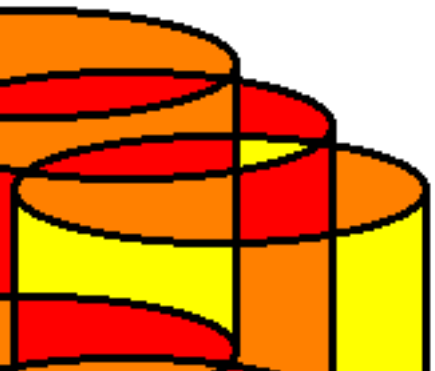
Očekivani rezultat



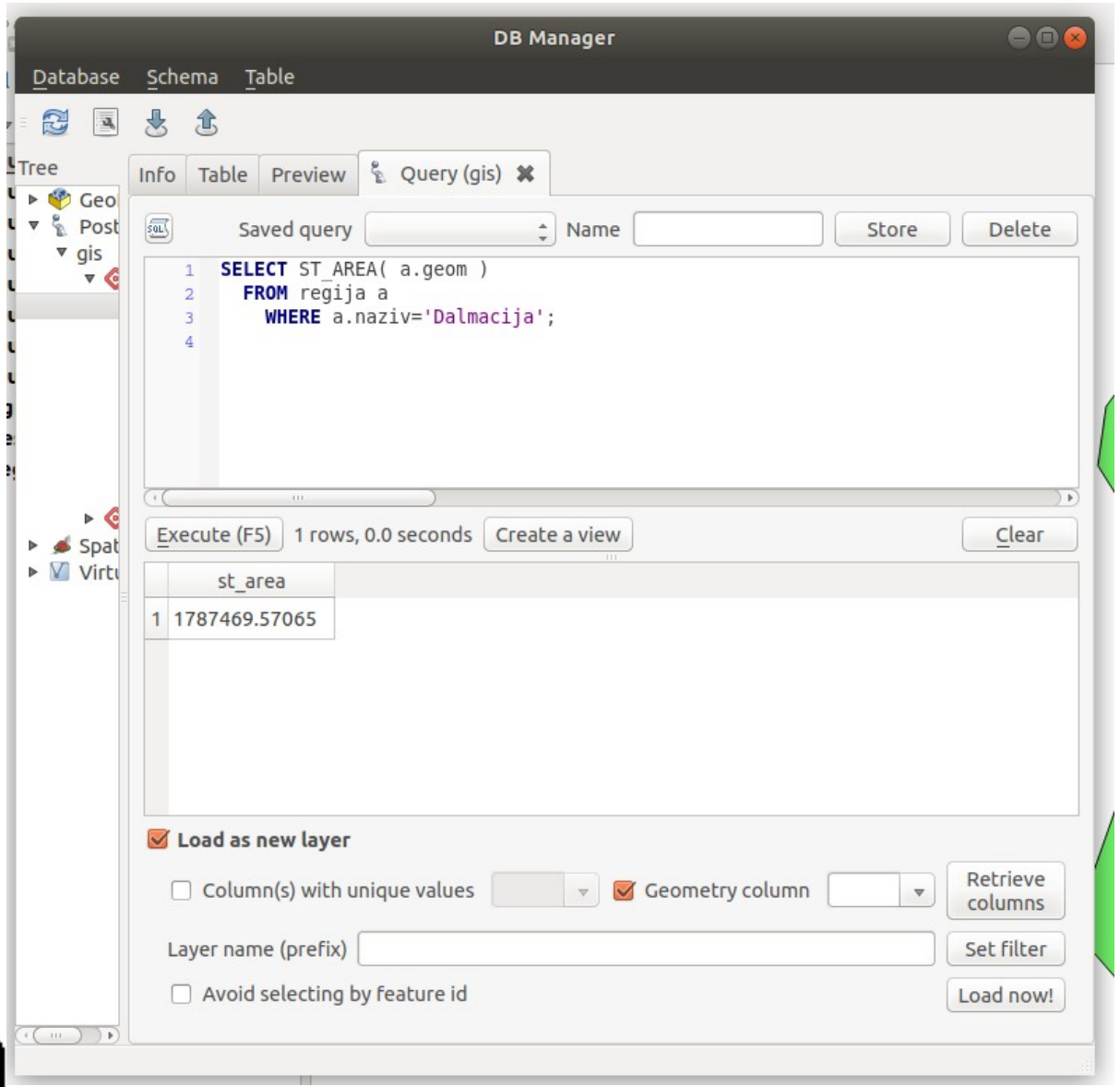
Primjeri upita

- Površina regije Dalmacija (nema geom - ne treba Load now!):

```
SELECT ST_AREA( a.geom )
  FROM regija a
    WHERE a.naziv='Dalmacija';
```



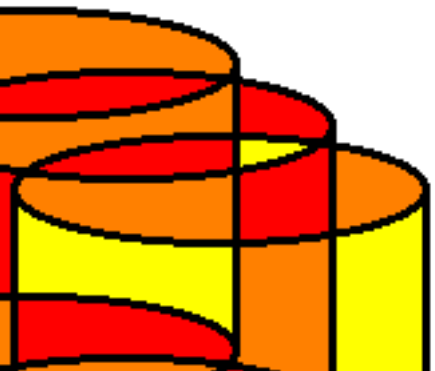
Očekivani rezultat



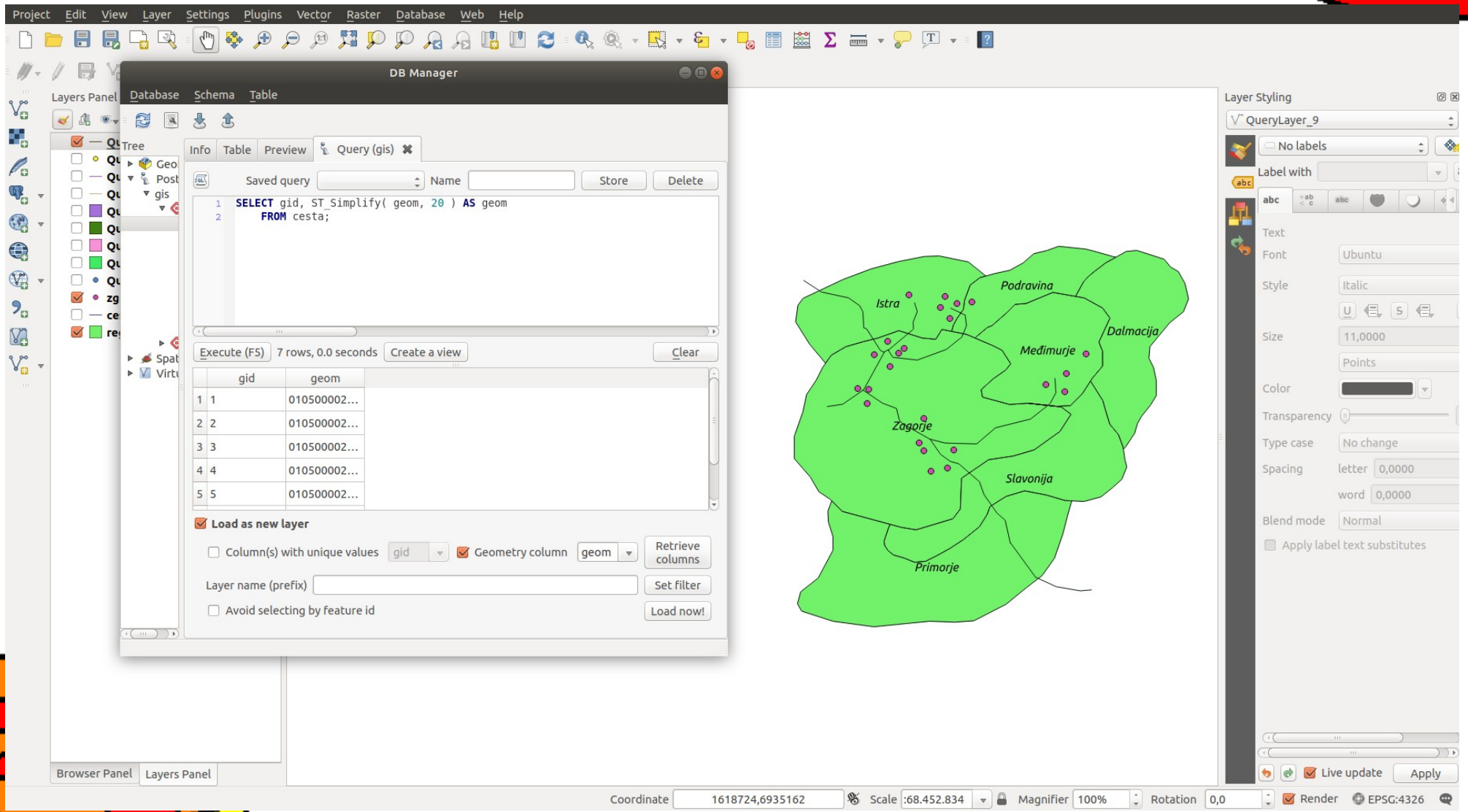
Primjeri upita

- Pojednostavljenje cesta na zrnatost 20 mjernih jedinica (ugasiti sloj cesta):

```
SELECT gid, ST_Simplify( geom, 20 ) AS geom
    FROM cesta;
```



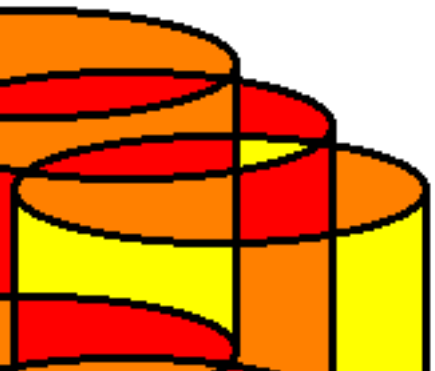
Očekivani rezultat



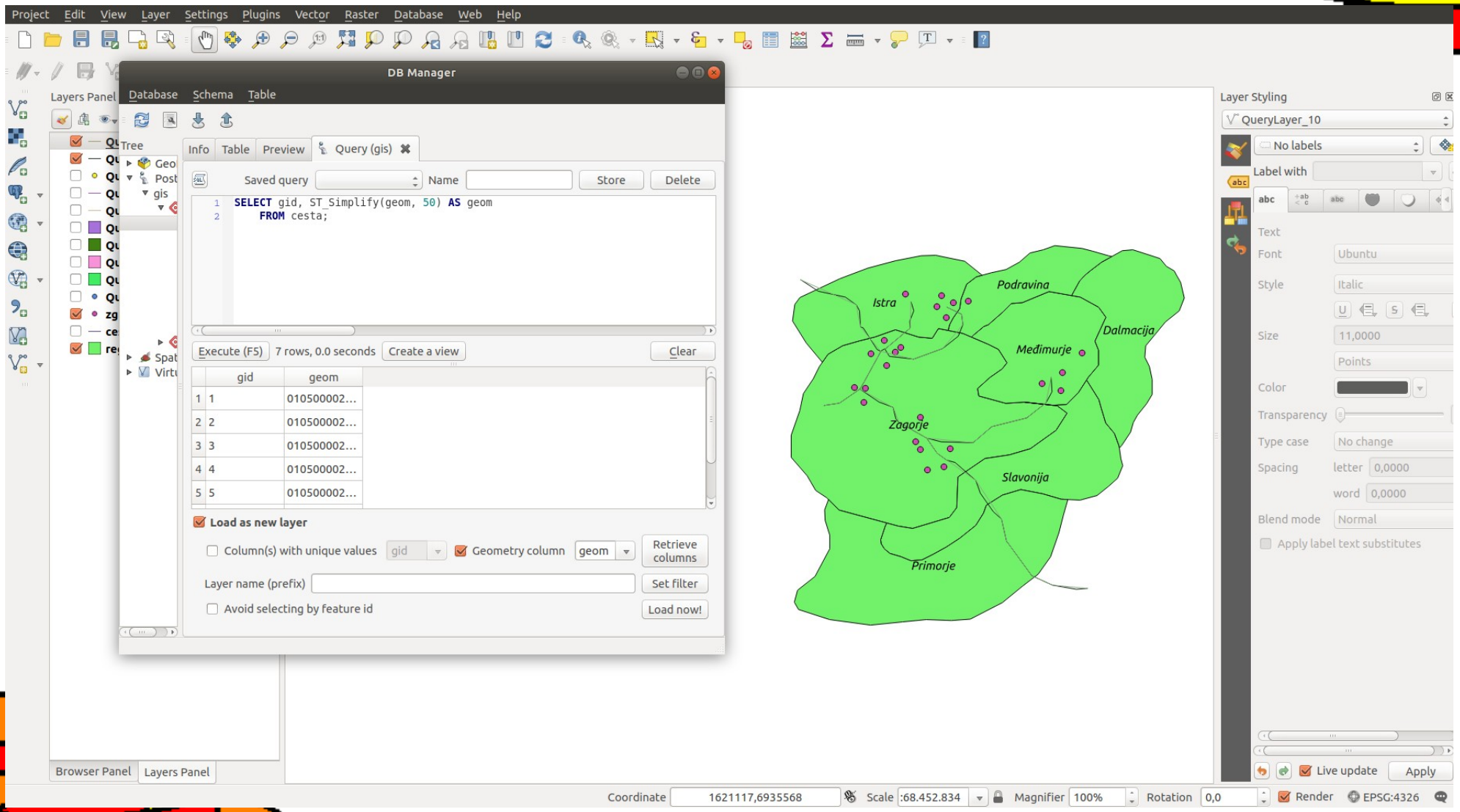
Primjeri upita

- Pojednostavljenje cesta na zrnatost 50 mjernih jedinica (ugasiti sloj cesta):

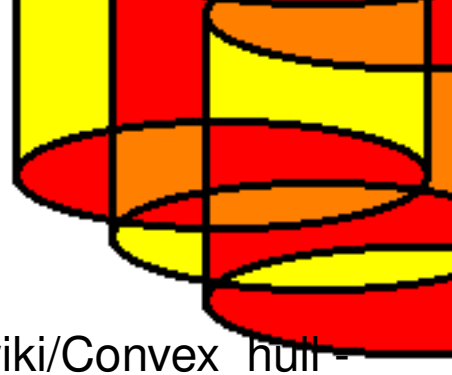
```
SELECT gid, ST_Simplify( geom, 50 ) AS geom
    FROM cesta;
```



Očekivani rezultat

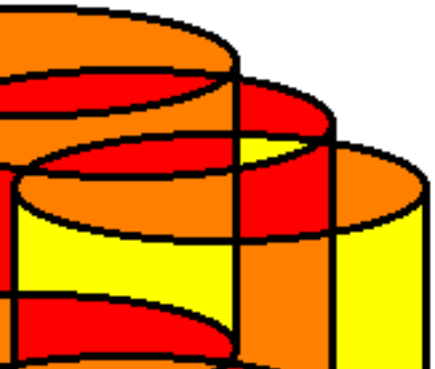


Primjeri upita

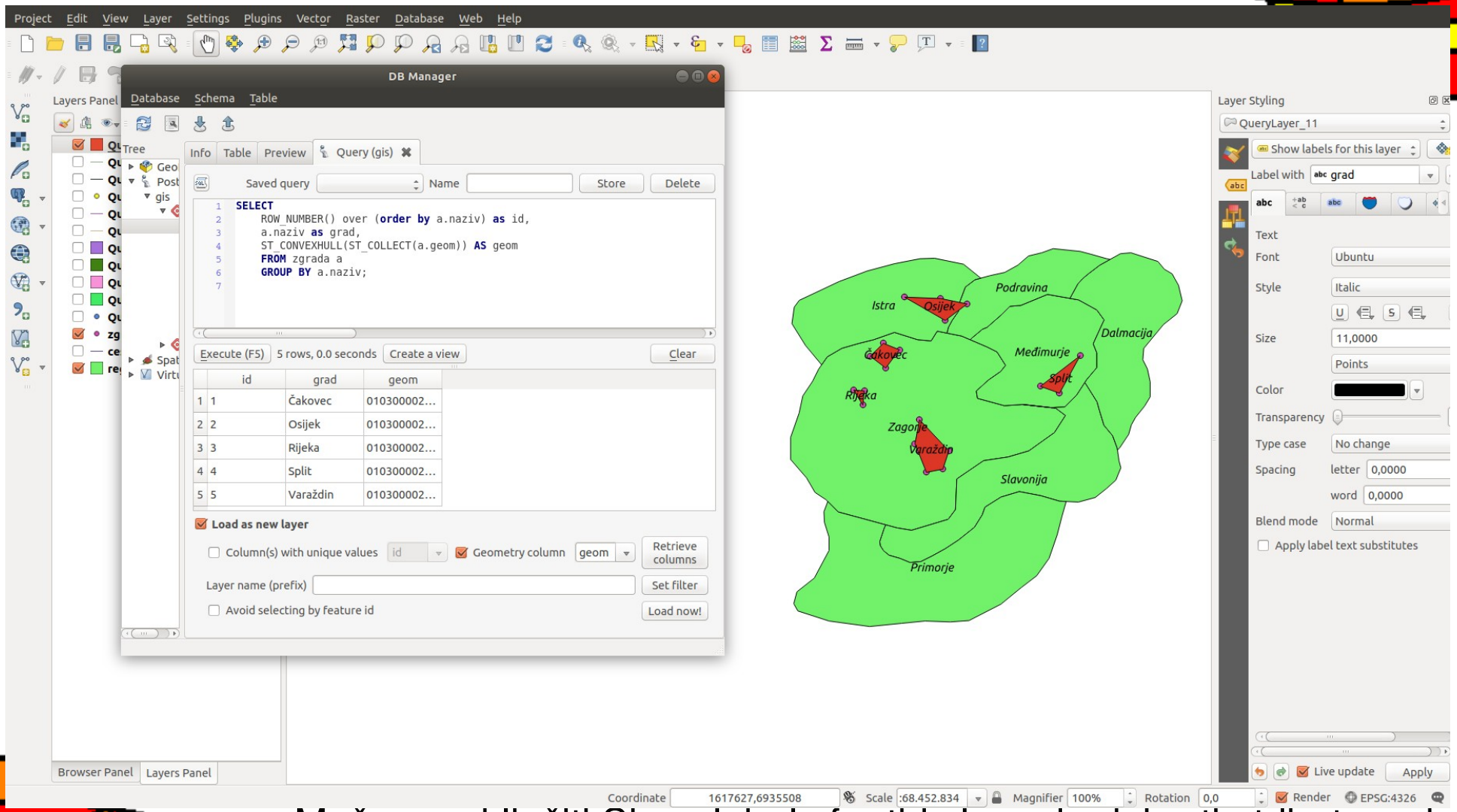


- Konveksno zatvaranje (engl. convex hull - https://en.wikipedia.org/wiki/Convex_hull - najmanji konveksni n-terokut takav da sadrži sve točke) - kompleksna prostorna agregacija skupova zgrada koje se nalaze u istom gradu - rezultat je najmanja moguća površina grada koja uključuje sve zgrade u tom gradu:

```
SELECT
    ROW_NUMBER() over (order by a.naziv) as id,
    a.naziv as grad,
    ST_CONVEXHULL(ST_COLLECT(a.geom)) AS geom
    FROM zgrada a
    GROUP BY a.naziv;
```

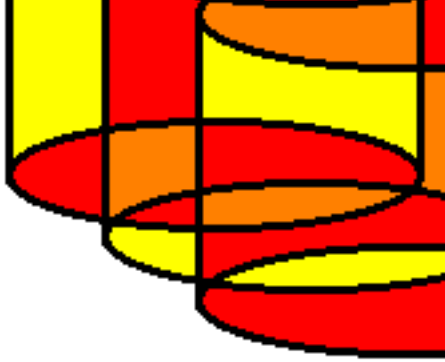


Očekivani rezultat



Možemo uključiti Show labels for this layer i odabrati atribut grad (pod Layer Styling za sloj zadnjeg upita QueryLayer_11)

Zadatak



- Implementirajte sljedeće upite:
  - Upit koji vraća sve regije koje **ne** graniče s Istrom
  - Upit koji vraća sve ceste proširene za 5 mjernih jedinica
  - Upit koji vraća sve zgrade koje nisu u Zagorju ili Međimurju
- Za sve upite napravite sliku zaslona rezultata
- Napravite kopiju vaše baze podataka uz alat pg_dump