Grabbing Live Wires: Plotting Our EV Future with APEX, GeoSpatial, and ML Analytics

NYOUG

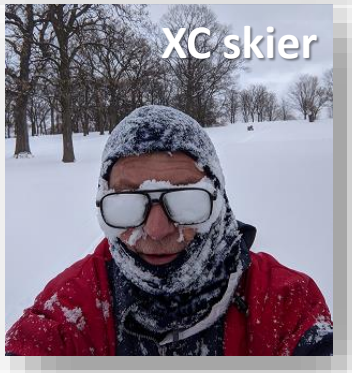
March 28, 2023

Jim Czuprynski
Zero Defect Computing, Inc.

Who Am I, and What Am I Doing Here?

ORACLE ACE Director

ORACLE Certified Professional



- E-mail me at jim@jimthewhyguy.com
- Follow me on Mastodon (@**JimTheWhyGuy@techfieldday.net**)
- Connect with me on LinkedIn (**Jim Czuprynski**)

Oracle ACE Program

500+ technical experts helping peers globally

The **Oracle ACE Program** recognizes and rewards community members for their technical and community contributions to the Oracle community

3 membership tiers

Oracle ACE Director | Oracle ACE Pro | Oracle ACE Associate

For more details on Oracle ACE Program:
ace.oracle.com

Oracle ACE

Nominate

yourself or someone you know:

ace.oracle.com/nominate

Connect: **aceprogram_ww@oracle.com** Facebook.com/OracleACEs @oracleace

BEYOND TECH SKILLS

Liron Amitzi

Jim Czuprynski

The podcast that talks about everything tech – except tech.™

https://www.beyondtechskills.com

ODTUG Kscope23

aurora, co june 25-29

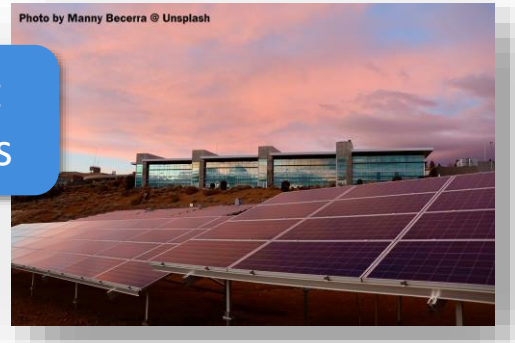
Kscope23.odtug.com

GAYLORD ROCKIES
RESORT & CONVENTION CENTER
Colorado

EVs and Electrical Infrastructure: What a Difference One Year Makes!

Overwhelming US Federal & state support for transitioning from **fossil fuels** to **alternative energy resources**

Generous **incentives** to adopt **solar energy** for private homes

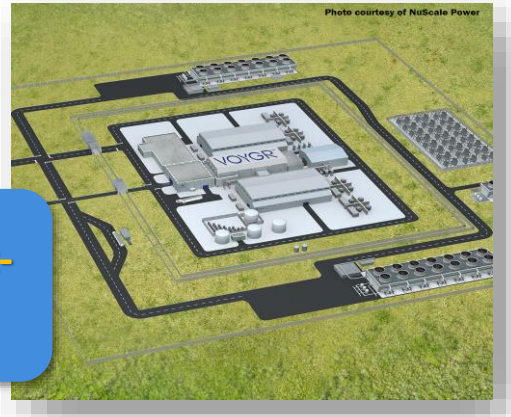


EV adoption rates soaring worldwide – USA sales **doubled to 600K** in 2021

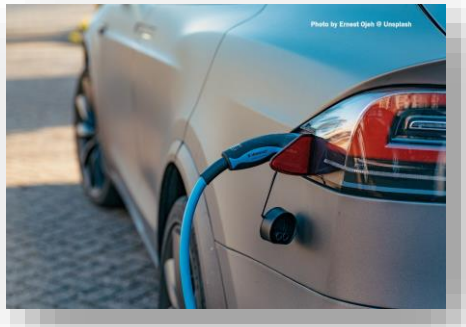
Power walls are replacing gas / LNG / propane-powered **home generators**

Automakers are releasing **largest-ever number of EV models** in 2023 & 2024

NuScale's Idaho facility is the **first-ever approved SMR** in the USA



2022 Inflation Reduction Act (IRA): Re-Electrifying the USA, *Equitably*



The **Justice40** (**J40**) initiative that's part of the 2022 IRA encourages each US state to place EV chargers **equitably** so that their **40% most underserved populations** will have access to these resources

- EV prices **continue to decrease** as US and foreign automakers shift production to **purely EVs** in coming decades
- Companies and organizations are also shifting their **last-mile delivery vehicles** to BEVs (e.g. **Amazon**, **US Postal Service**)
- Building this new energy infrastructure offers **excellent employment opportunities** for poorer communities

EV Chargers: Terminology and Capacity

Term / Acronym	Charging Voltage	Average Installation Cost Per Port	Description
Level 1 Charger	**120V**	**$400**	Delivers ***slow*** "trickle" charge (**3–5** miles of range per hour); OK for most **PHEVs**, but not **BEVs**
Level 2 Charger	**208V – 240V**	**$850**	Delivers ***moderate*** charging (**12–80** miles of range per hour); preferred by most BEV owners for **overnight home charging**
Level 3 Charger	**400V – 900V**	**$22,500**	Delivers ***extremely fast*** charging (**3 – 20** miles of range per **minute**); also known as **DC Fast Chargers (DCFCs)** or **SuperChargers**

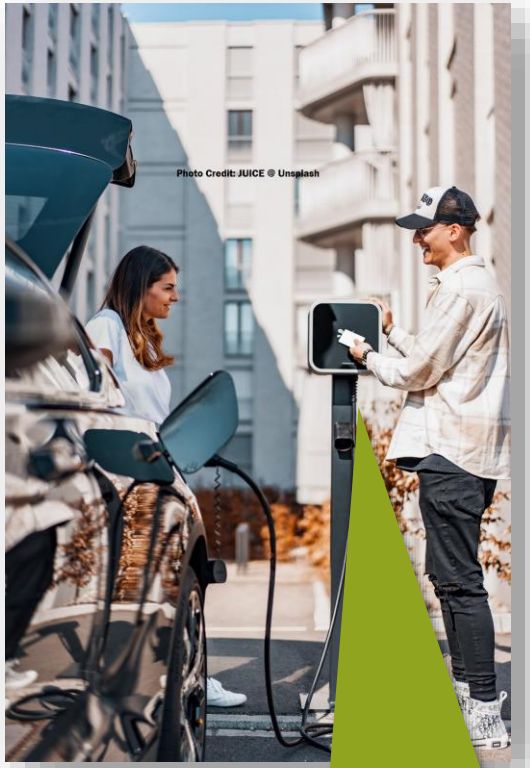
Sources: https://www.forbes.com/wheels/advice/ev-charging-levels/

Considerations for Installing EV Charging Stations

Site Survey

Future Maintenance

Physical Equipment

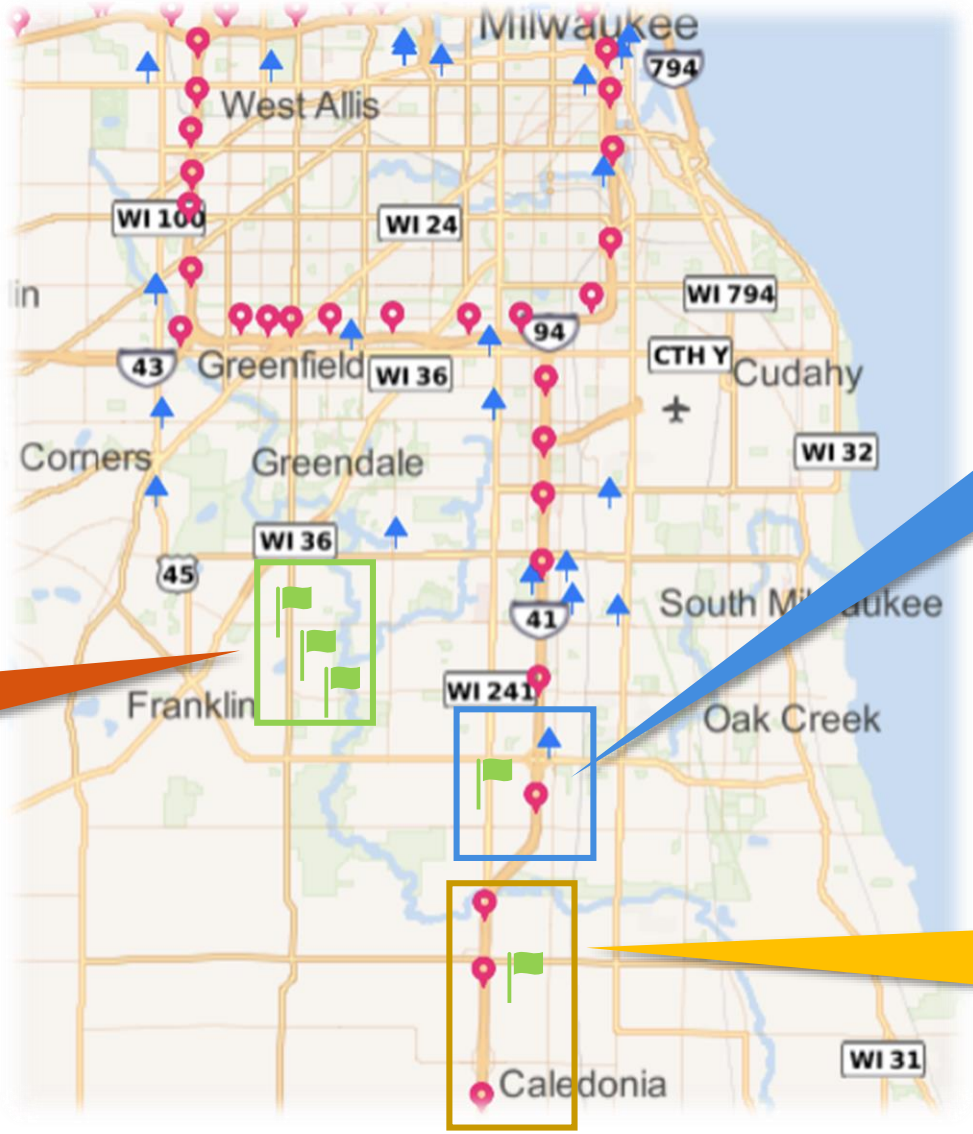


Networking & Payment Collection

Source: https://www.chargedfuture.com/cost-to-install-ev-charging-stations/

WTFC 1.0: Focus on Placing Charging Stations Near **Traffic Hotspots**

For each **location** that's part of a selected subset of **key traffic hotspots**:



… that are **within a specified distance** (**1 KM**) …

Locate all **potential** charging locations …

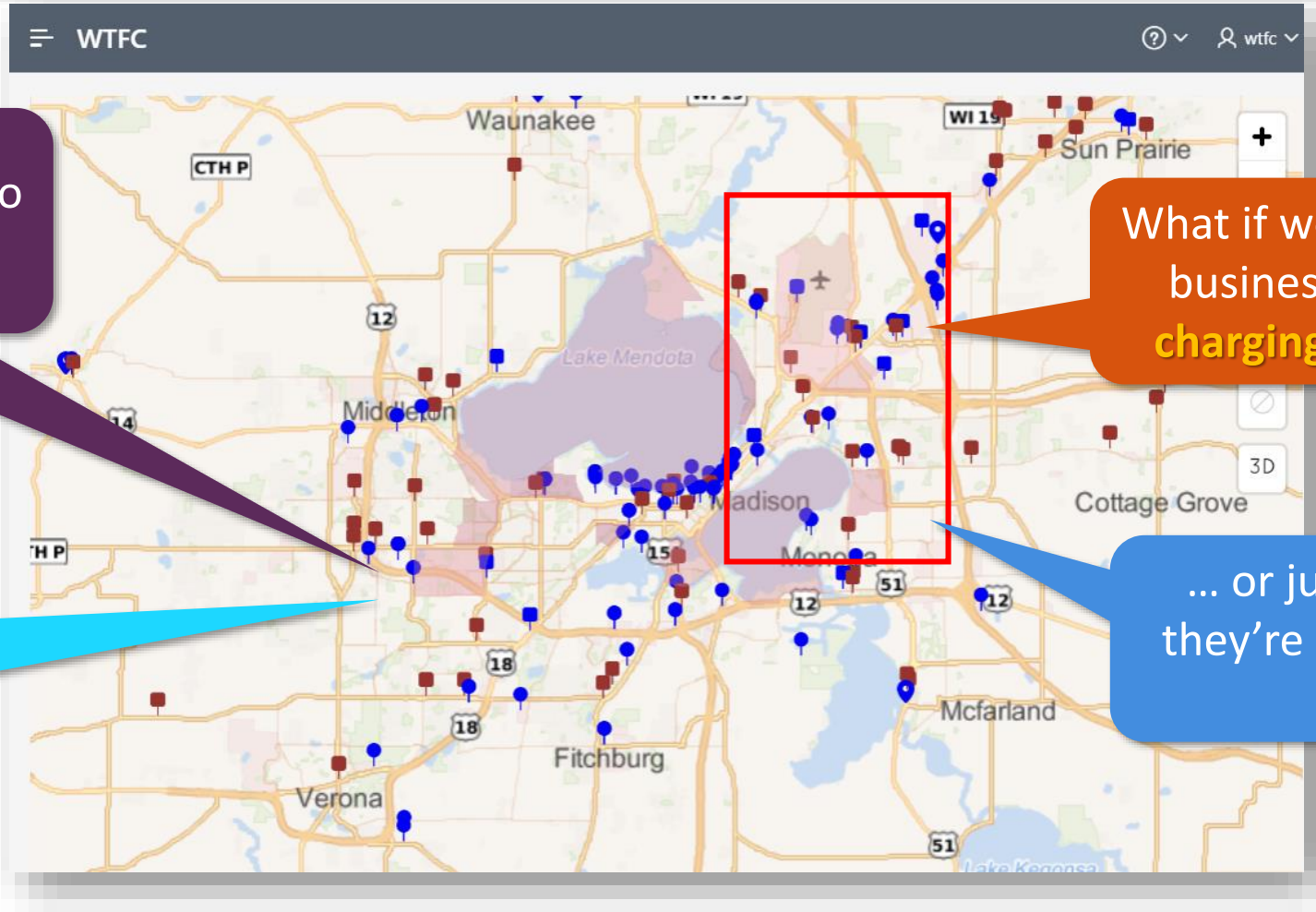
… but that currently have **no** charging station **within 1 KM**

WTFC 2.0: Shifting to the **J40 Definition** of **Underserved**

Per USA's 2022 **Inflation Reduction Act**, EV charging ports must be distributed **equitably** within at least **40% of disadvantaged communities (DACs)**

What **metrics** do we use to **locate & quantify** DACs?

How do we **prove** we've **fully covered** 40% of all DACs?



What if we **incentivized** local businesses to **build new charging infrastructure** …

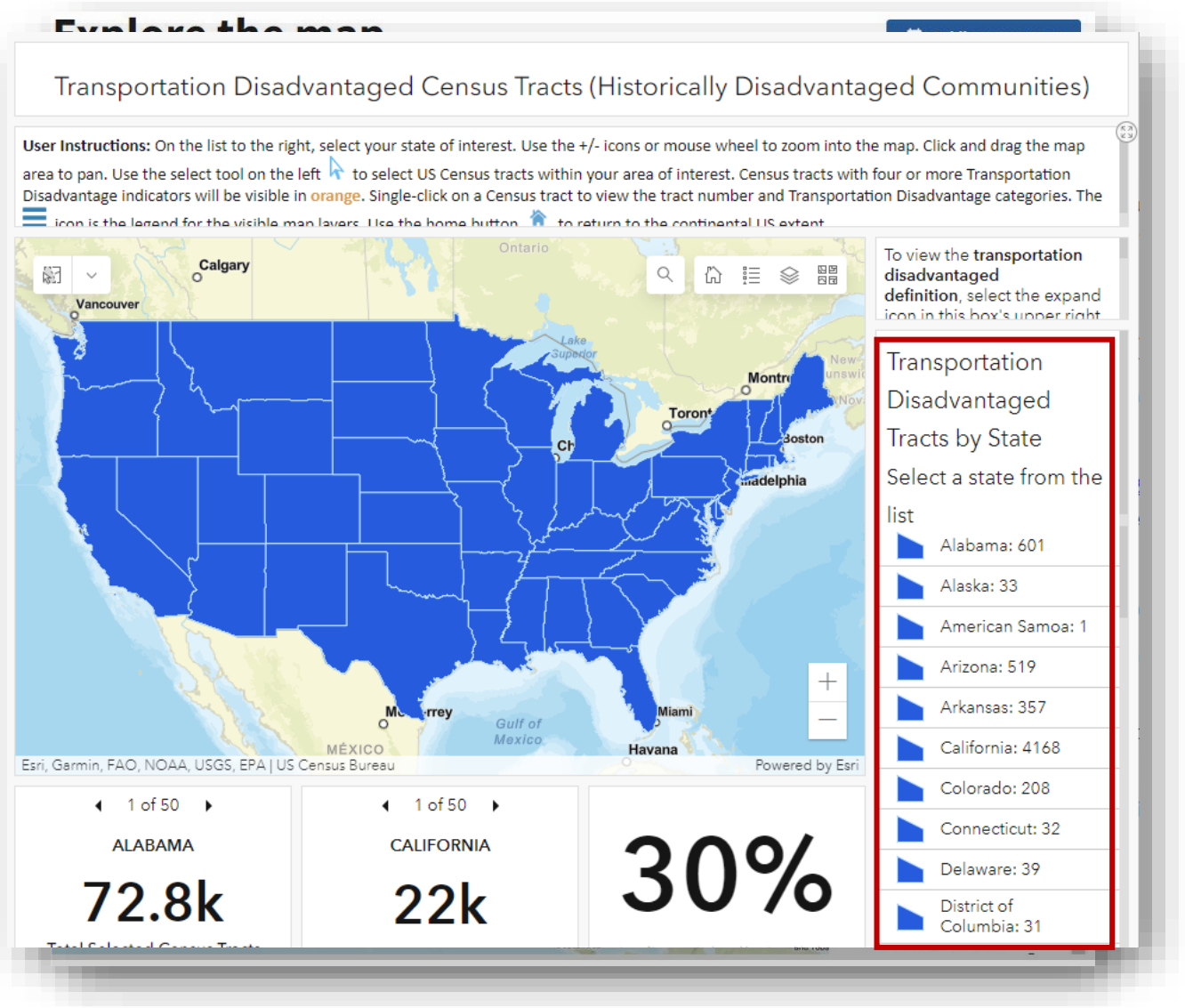
… or just **expand** what they're **already planning to build**?

Oracle Spatial Studio: Sophisticated GIS Data Manipulation and Visualization

Good News! Extensive Resources from US Department of Transportation (DOT)

Climate and Economic Justice Screening Tool

… including **extremely detailed breakdowns** of DAC factors across the entire US geography within **census tracts**



Translating ArcGIS Shapefiles To Oracle SDO_GEOMETRY Format

What Charging Points Are Already **Active** or **Planned**?

Private businesses in Wisconsin (and nationwide) are already planning to **build new** Level 3 charging stations or **expand their existing EV charging infrastructure**

Ideal locations would include places that people typically spend **at least 15 – 20 minutes** performing daily or weekly errands

CHARGING_POINTS captures locations of +1100 potential businesses gleaned from public sources, including **pharmacies, grocery stores, gas stations, convenience centers, hotels, recreation areas,** and **parking structures**

```
CREATE TABLE wtfc.charging_points (
    cp_id              NUMBER(8,0)      NOT NULL
   ,cp_name            VARCHAR2(60)     NOT NULL
   ,cp_address         VARCHAR2(40)     NOT NULL
   ,cp_city            VARCHAR2(40)     NOT NULL
   ,cp_state_abbr      VARCHAR2(02)     NOT NULL
   ,cp_zip_code        CHAR(05)         NOT NULL
   ,cp_status          CHAR(03)         NOT NULL
   ,cp_bus_type        VARCHAR2(03)     NOT NULL
   ,cp_chg_type        VARCHAR2(04)     NOT NULL
   ,cp_chg_avail       VARCHAR2(04)     NOT NULL
   ,cp_potentiality NUMBER(8,6) );
```

What Charging Points Are Already **Active** or **Planned**?

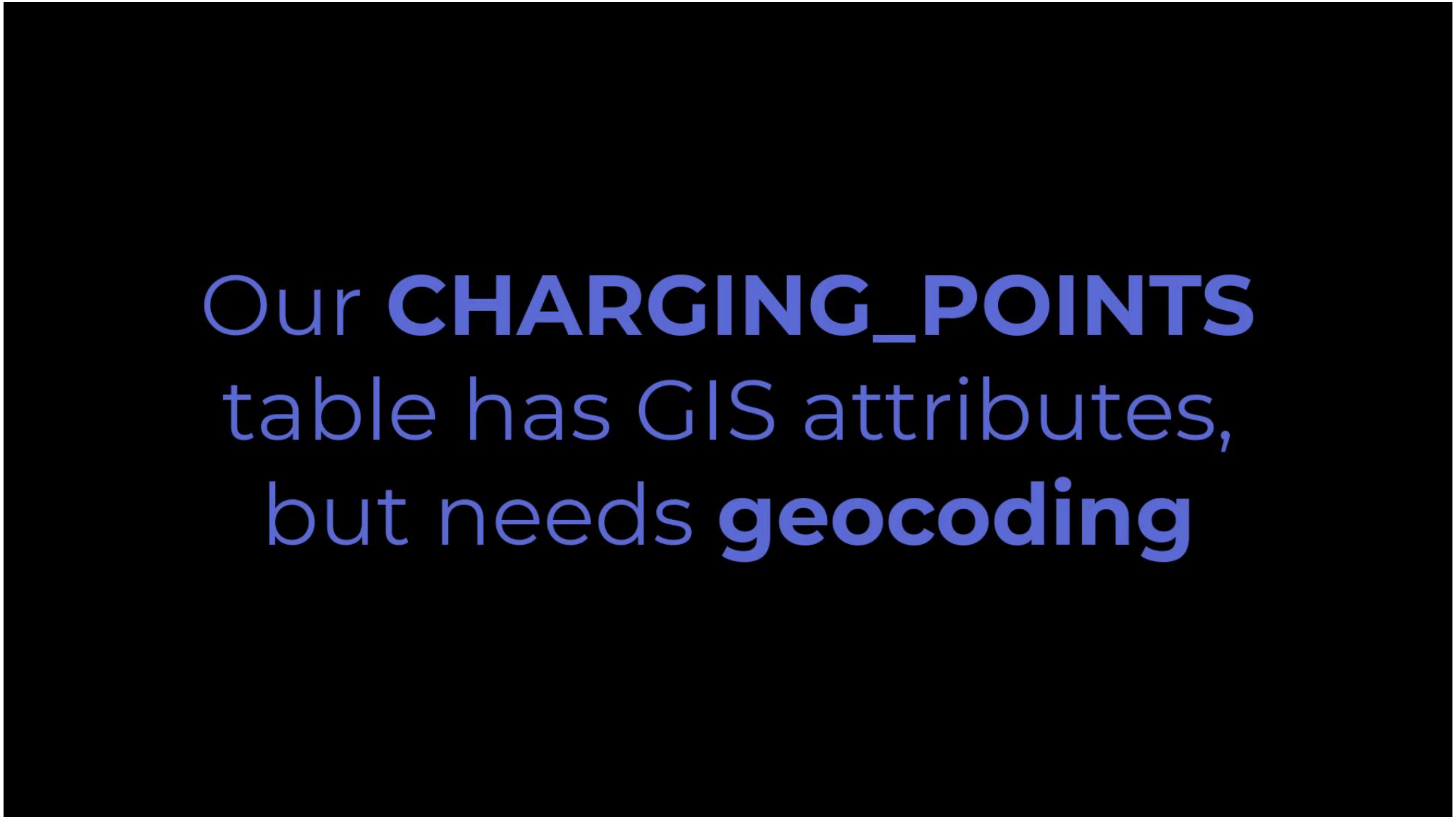
Private businesses in Wisconsin (and nationwide) are already planning to **build new** Level 3 charging stations or **expand their existing EV charging infrastructure**

Ideal locations would include places that people typically spend **at least 15 – 20 minutes** performing daily or weekly errands

CHARGING_POINTS captures locations of +1100 potential businesses gleaned from public sources, including **pharmacies, grocery stores, gas stations, convenience centers, hotels, recreation areas,** and **parking structures**

ID	Name	Status	Level	Bus Type
550001	CVS Pharmacy	PLN	L3	RTL
550002	PickNSave	PLN	L3	RTL
550003	PickNSave	PLN	L3	RTL
550004	Walgreens Drugstore	PLN	L3	RTL
550005	Walgreens Drugstore	PLN	L3	RTL
550006	PickNSave	PLN	L3	RTL
550007	CVS Pharmacy	PLN	L3	RTL
550008	PickNSave	PLN	L3	RTL
550009	Walgreens Drugstore	PLN	L3	RTL
550010	NCG BRKFLD HILTON	ACT	L2	HTL
550011	KWIK TRIP	PLN	L3	GS
550012	KWIK TRIP	PLN	L3	GS
550013	CVS Pharmacy	PLN	L3	RTL
550014	Washington House Inn - Tesla Destination	ACT	L2	HTL
550015	Walgreens Drugstore	PLN	L3	RTL
550016	Walgreens Drugstore	PLN	L3	RTL
550017	CVS Pharmacy	PLN	L3	RTL
550018	Walmart SuperCenter	PLN	L3	RTL
550019	Walgreens Drugstore	PLN	L3	RTL
550020	PickNSave	PLN	L3	RTL

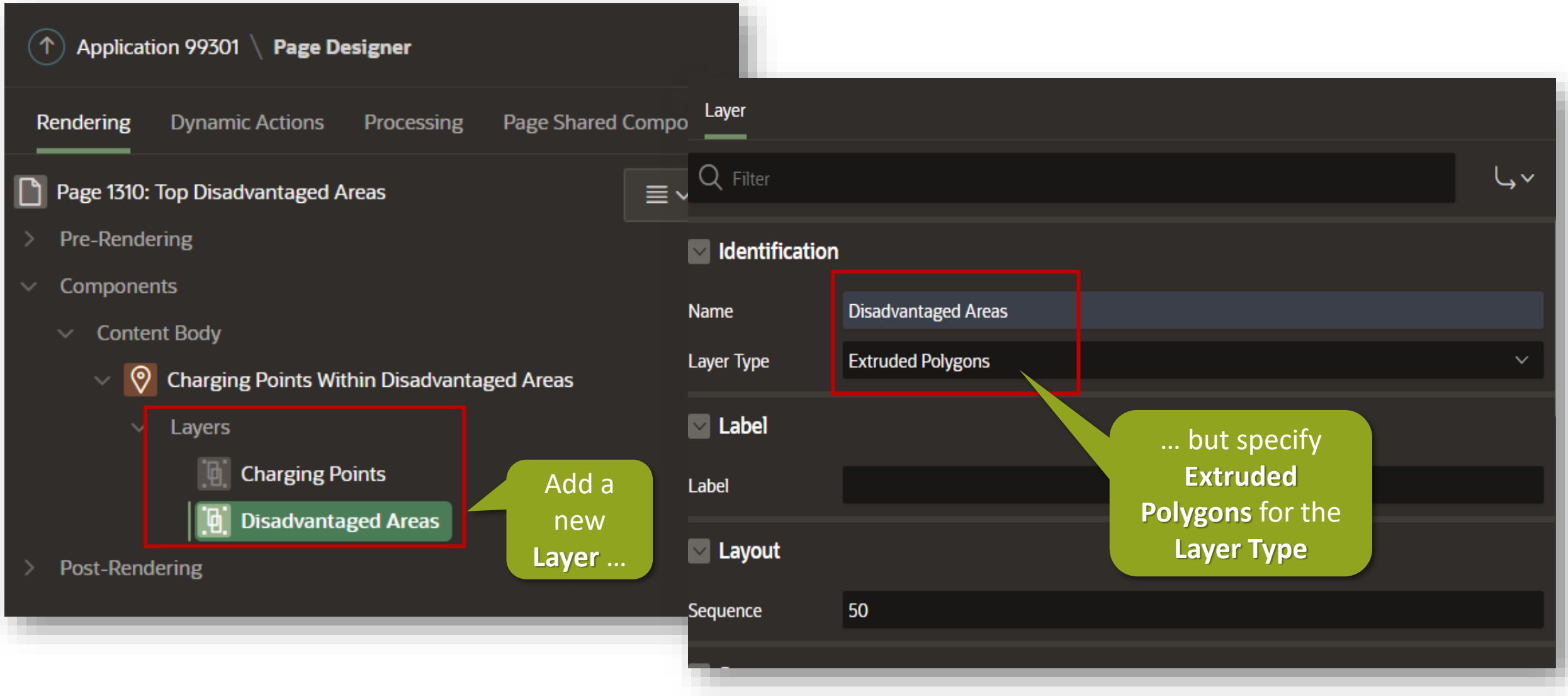
No Geolocation Attributes? No Problem.



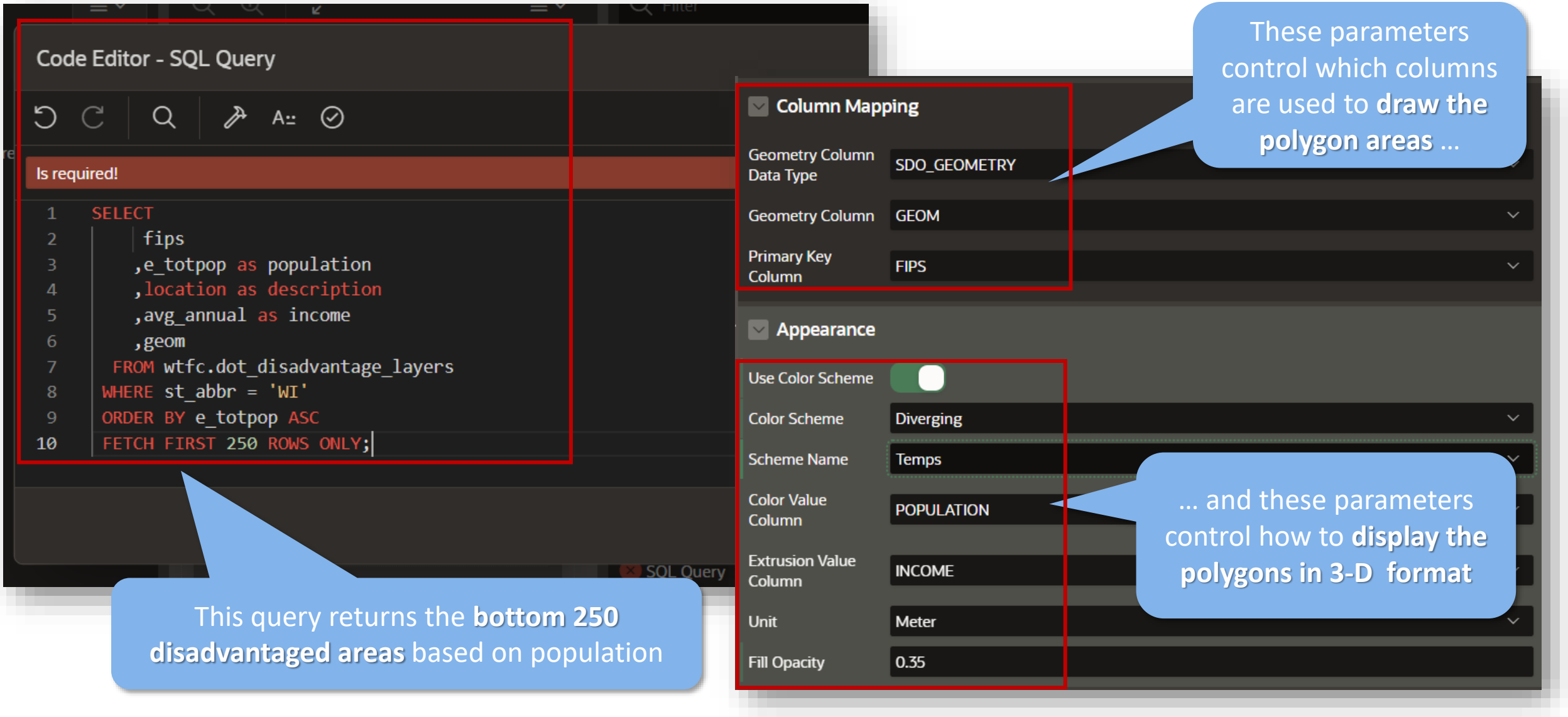
Plotting Simple Maps With Spatial Studio

APEX Native Map Regions:
Customized GIS Data Handling Within Applications

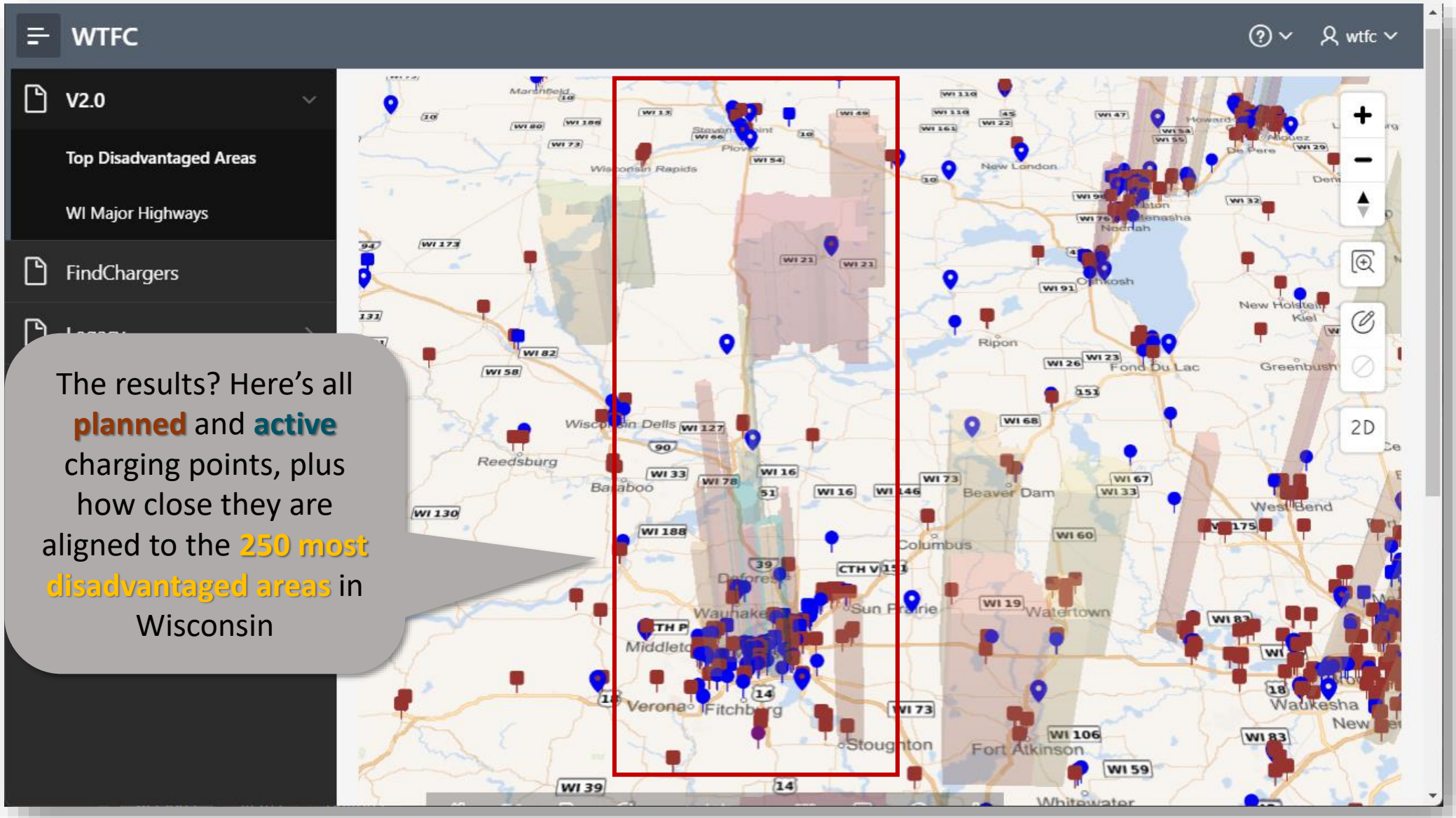
Getting Dimensional: Extruded Polygon Map Layers (1)



Getting Dimensional: Extruded Polygon Map Layers (2)

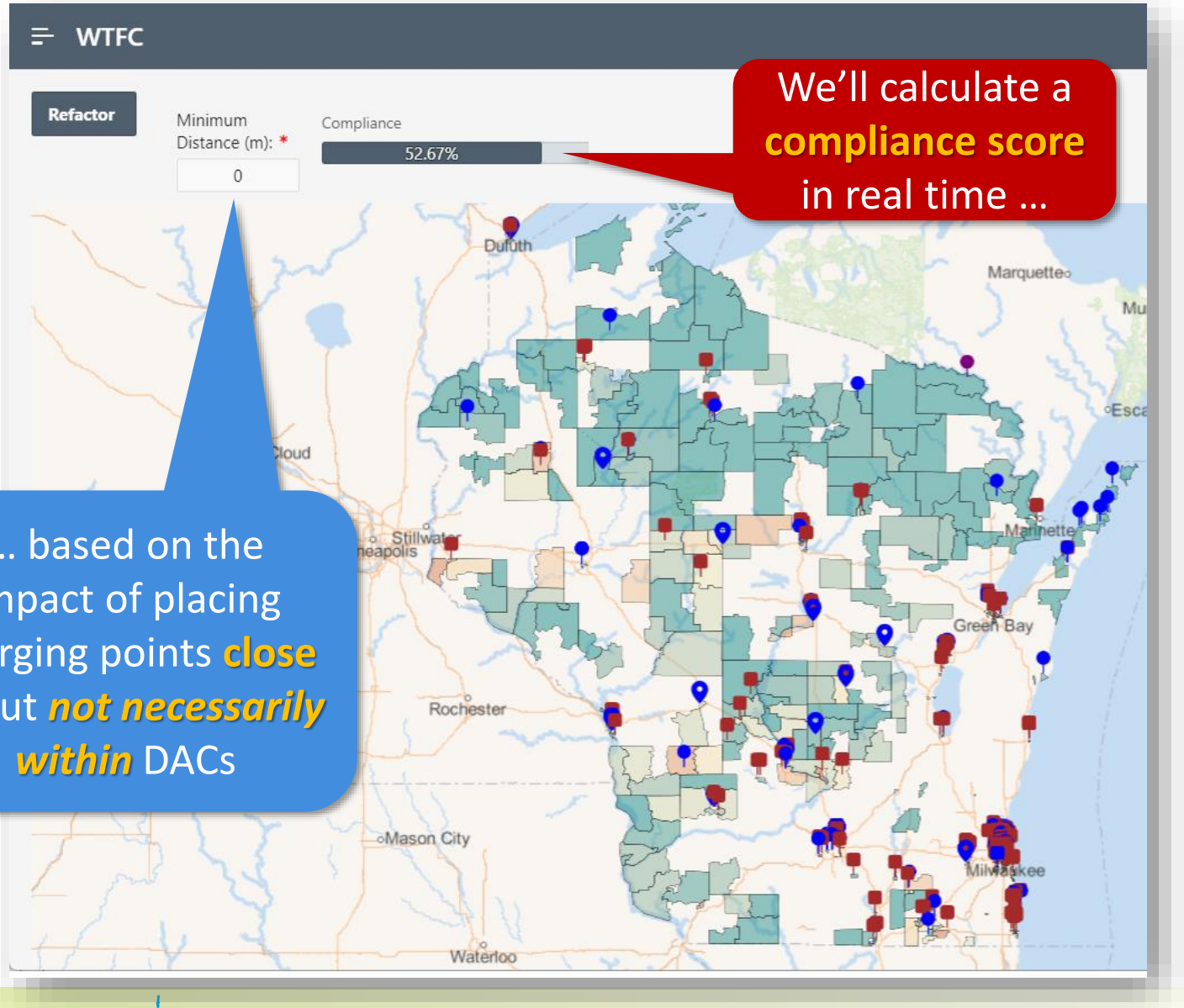


Getting Dimensional: Extruded Polygon Map Layers (3)



How Do We Best Satisfy the 40% Equity Provision for DACs?

Since there are **1,108** DACs in Wisconsin, **40% coverage** equates to placing charging points close to **450** of the **most disadvantaged DACs** in the state



Capturing Charging Points Based On Specific Distance From DACs

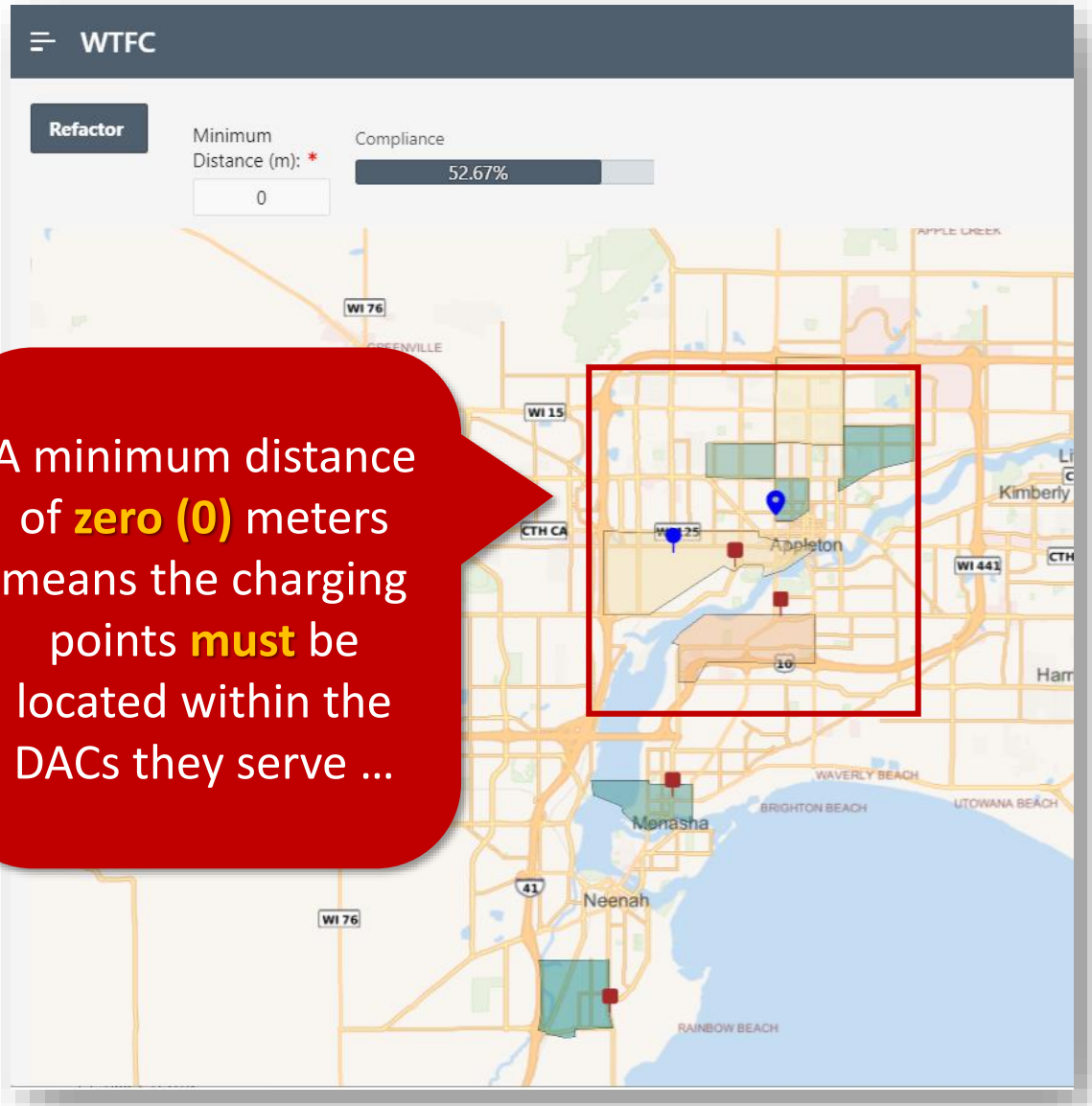
```
SELECT * FROM
 (SELECT
    CP.cp_id
   ,CP.cp_name AS info_title
   ,CP.cp_address || ', ' || CP.cp_city || ' ' || CP.cp_zip_code AS info_body
   ,DECODE(CP.cp_status,'PLN','brown','ACT','blue','purple') AS color
   ,DECODE(CP.cp_chg_type,'L2','Pin Circle','L3','Pin Square','point') AS icon
   ,CP.cp_bus_type
   ,CP.gc_geometry
   ,DA.fips
   ,DA.location
  FROM wtfc.charging_points CP, wtfc.dot_disadvantage_layers DA
 WHERE SDO_WITHIN_DISTANCE(DA.geom, CP.gc_geometry,
   'distance=&P1410_MINIMUM_DISTANCE. unit=meter') = 'TRUE'
 ORDER BY CP.cp_id) APC,
 (SELECT fips AS ltd_fips
    FROM wtfc.dot_disadvantage_layers
   WHERE st_abbr = 'WI'
   ORDER BY sumdis DESC, e_totpop ASC
   FETCH FIRST 450 ROWS ONLY) DF
 WHERE DF.ltd_fips = APC.fips;
```

Charging points **icon formatting**

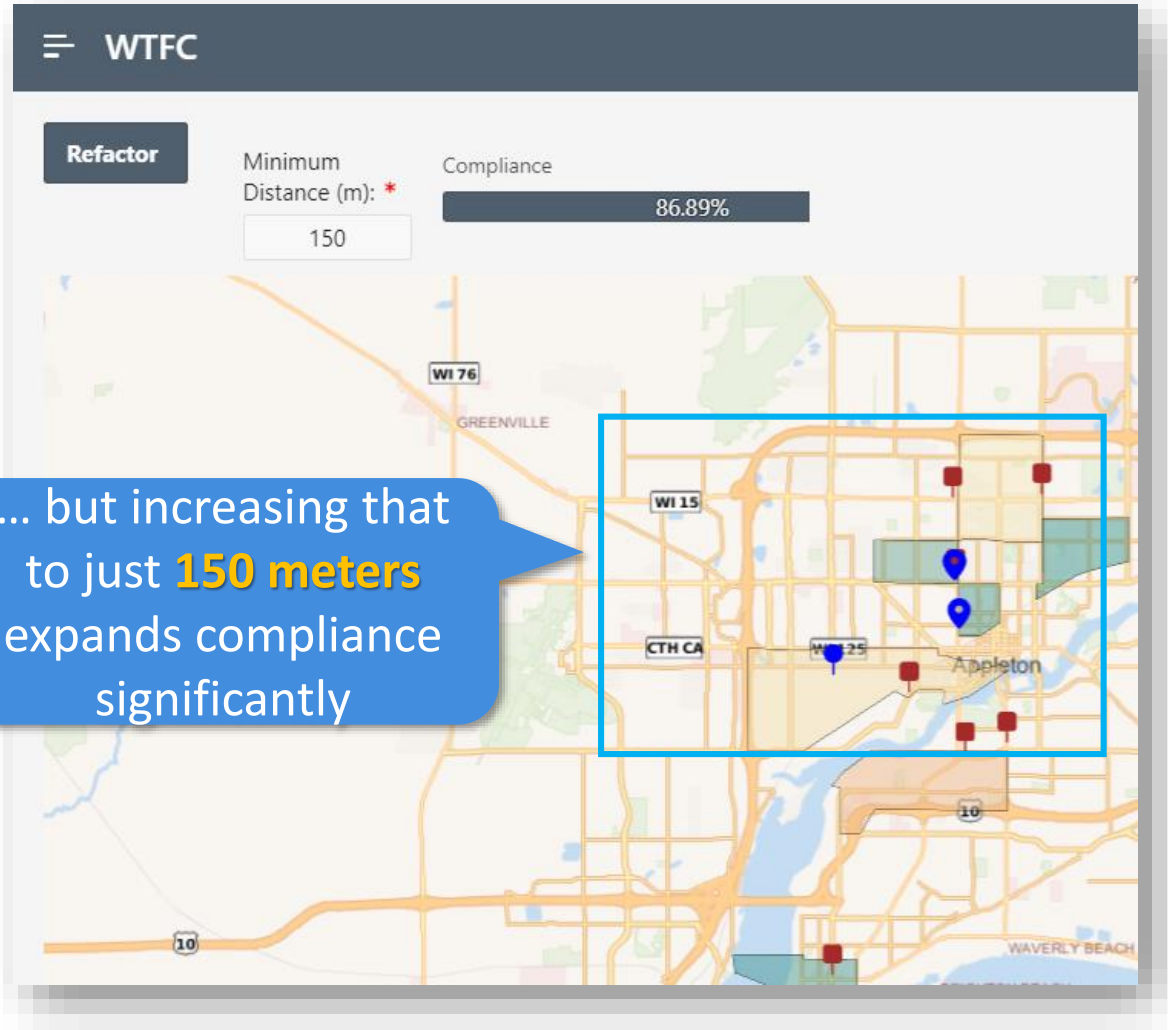
Chooses charging points **within specified distance of DACs**

Limits charging points to only **top 40% of DACs**

40% Equity Provision: How Close Is Close Enough?

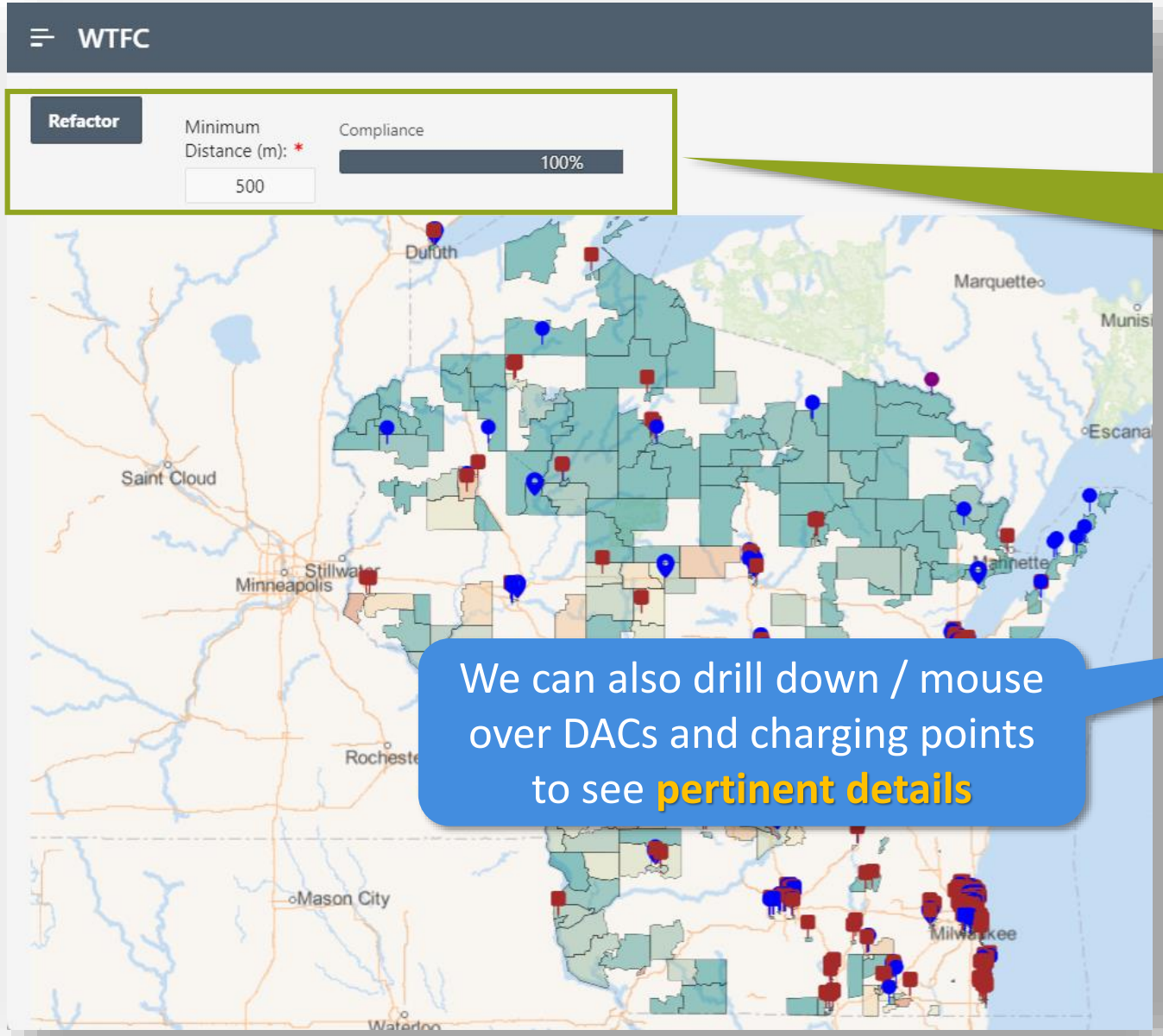


A minimum distance of **zero (0)** meters means the charging points **must** be located within the DACs they serve …



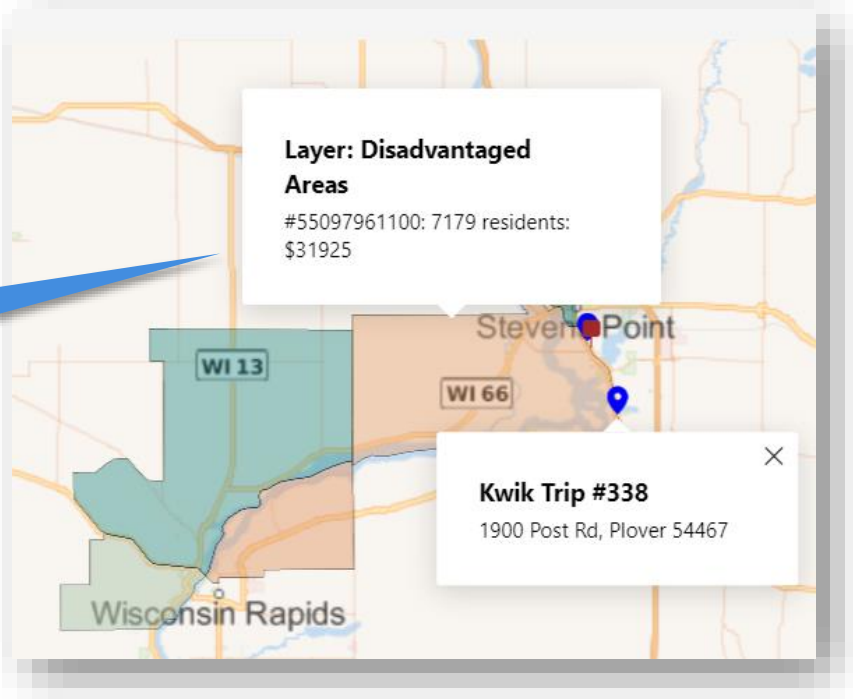
… but increasing that to just **150 meters** expands compliance significantly

Can We Get to 100% Compliance?

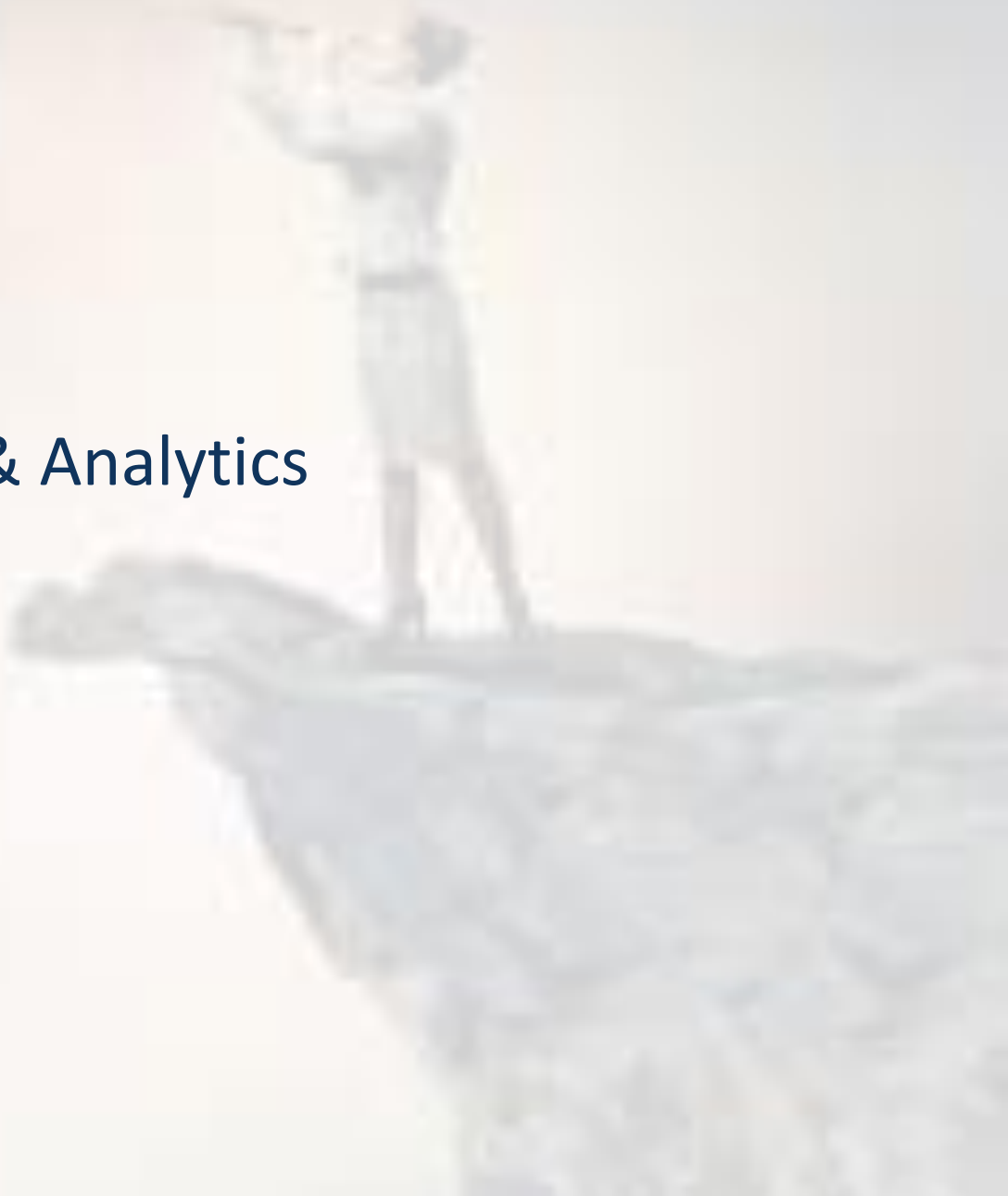


With a minimum distance of **500 meters** between charging points and DACs, we've achieved **100% compliance**

We can also drill down / mouse over DACs and charging points to see **pertinent details**



Looking Deeper for Insights:
Applying Machine Learning & Analytics



DAC Dataset: A Cornucopia of Details About Disadvantaged Communities

The DOT's **Disadvantaged Communities (DAC)** dataset contains **fine-grained analytics** at **census tract** levels:

- Well-documented **sources** for 30+ factors and ratings
- Includes expected data about location, area size, and population of the census tracts themselves
- Gathers transportation data (miles traveled to work, # of vehicles, fuel costs, even "walkability index") of each community
- Factors in **education, health, age, poverty,** and **environmental pollution**
- Calculates six different **disadvantage indicators based on all these features**

Analyzing DOT's DAC Dataset with ML Algorithms (1)

```
CREATE OR REPLACE VIEW wtfc.chargepoint_anomaly_research
AS
SELECT
  DA2.fips           AS fips_code
, DTL.tot_cps        AS total_charging_points
, DA2.sumdis         AS dac_summary_score
, DA2.e_totpop       AS total_population
, DA2.total_
, DA2.avg_ar
, DA2.mean_a
, DA2.epl_nw
, DA2.healtH
, DA2.equity
, DA2.enviro
FROM
. . .
```

Build a new view with more DAC **disadvantaged ratings** information …

```
. . .
 (SELECT
  DA.fips,
  COUNT(CP.cp_id) AS tot_cps
  FROM
   wtfc.charging_points CP
  ,wtfc.dot_disadvantage_layers DA
 WHERE SDO_NN(DA.geom, CP.gc_geometry, 'distance=1 unit=meter', 1) = 'TRUE'
   AND CP.cp_status = 'ACT'
 GROUP BY DA.fips) DTL
,wtfc.dot_disadvantage_layers DA2
 WHERE DTL.fips = DA2.fips;
```

… filtered by **active charging points** extremely close to or within FIPS **census tracts**

Analyzing DOT's DAC Dataset with ML Algorithms (2)

```
DECLARE
  v_setlist DBMS_DATA_MINING.SETTING_LIST;
BEGIN
  -- Add settings
  v_setlist('PREP_AUTO') := 'ON';
  v_setlist('ALGO_NAME') := 'ALGO_SUPPORT_VECTOR_MACHINES';

  DBMS_DATA_MINING.CREATE_MODEL2(
    model_name           => 'SVM_CHARGEPOINT_ANOMALIES'
   ,mining_function      => DBMS_DATA_MINING.CLASSIFICATION
   ,data_query           => 'SELECT * FROM wtfc.chargepoint_anomaly_research'
   ,set_list             => v_setlist
   ,case_id_column_name  => 'fips_code'
   ,target_column_name   => 'dac_summary_score'
   );
END;
/
```

First, let's create a **Support Vector Machines (SVM)** model against the new view

The FIPS code (which identifies each census tract) will be our **case identifier**, and we'll focus the model on the **DAC disadvantagedness summary score**

Analyzing DOT's DAC Dataset with ML Algorithms (3)

```
SELECT
  target_value
, attribute_name
, coefficient
, reversed_coefficient
 FROM DM$VLSVM_CHARGEPOINT_ANOMALIES
WHERE attribute_name IN
('DAC_SUMMARY_SCORE'
,'AVG_ANNUAL_SALARY')
 ORDER BY
  attribute_name,
  target_value;
```

The results from the **SVM Linear Coefficients** view that the ML model automatically generated …

TARGET_VALUE	ATTRIBUTE_NAME	COEFFICIENT	REVERSED_COEFFICIENT
1	AVG_ANNUAL_SALARY	-0.000000004397143499298697	-0.000000000000040706105758067
2	AVG_ANNUAL_SALARY	0.000000298927190701935740	0.000000000027672878632720907
3	AVG_ANNUAL_SALARY	-0.000000139049881490287930	-0.000000000012872400417437322
4	AVG_ANNUAL_SALARY	-0.000000523517720359445300	-0.000000000048464116976334460
5	AVG_ANNUAL_SALARY	0.000000327741269269608830	0.000000000030340312455801825
6	AVG_ANNUAL_SALARY	0.000000022178636400985800	0.000000000002053164557973253
7	AVG_ANNUAL_SALARY	0.000000010487376905440151	0.000000000000970858179874388
8	AVG_ANNUAL_SALARY	-0.9570826422616179	-0.000088600945730622310
9	AVG_ANNUAL_SALARY	-0.000189809701184338550	-0.000000017571438756886592
1	DAC_SUMMARY_SCORE	-0.000000017965939166483936	-0.000000016892942745651368
2	DAC_SUMMARY_SCORE	-0.000000328557195648746300	-0.000000308934470017593840
3	DAC_SUMMARY_SCORE	-0.000000257348203527186200	-0.000000241978358470185300
4	DAC_SUMMARY_SCORE	-0.000000096545186729110350	-0.000000090779129143754450
5	DAC_SUMMARY_SCORE	0.000000439642277464381500	0.000000413385114630055700
6	DAC_SUMMARY_SCORE	0.000000028928892268627010	0.000000027201145248265560
7	DAC_SUMMARY_SCORE	-0.000000147714997942234330	-0.000000138892878339881980
8	DAC_SUMMARY_SCORE	-0.4238955834280258	-0.39857887498266265
9	DAC_SUMMARY_SCORE	0.06694013440912581	0.06294220677698523

… reveal how accurately different attributes **predict the linearity of classifications** within the DAC dataset's collected statistics

Analyzing DOT's DAC Dataset with ML Algorithms (4)

```
DECLARE
  v_setlist DBMS_DATA_MINING.SETTING_LIST;
BEGIN
  -- Add settings
  v_setlist('PREP_AUTO') := 'ON';
  v_setlist('ALGO_NAME') := 'ALGO_EXPLICIT_SEMANTIC_ANALYS';

  DBMS_DATA_MINING.CREATE_MODEL2(
    model_name           => 'ESM_CHARGEPOINT_ANOMALIES'
   ,mining_function      => DBMS_DATA_MINING.CLASSIFICATION
   ,data_query           => 'SELECT * FROM wtfc.chargepoint_anomaly_research'
   ,set_list             => v_setlist
   ,case_id_column_name  => 'fips_code'
   ,target_column_name   => 'dac_summary_score'
   );
END;
/
```

Now let's create an **Explicit Semantic Analysis (ESM)** model against this same view

We'll use the same **case identifier** and still focus the model on the **DAC disadvantagedness summary score**

Analyzing DOT's DAC Dataset with ML Algorithms (5)

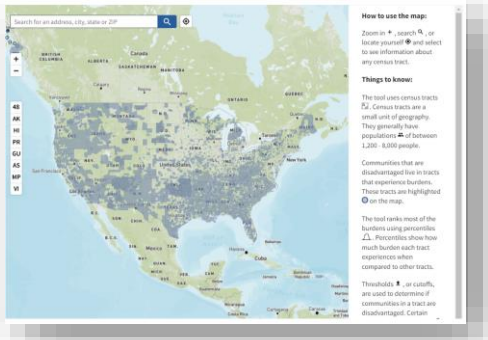
The results from the **Normalization and Missing Value Handling** view that the ML model automatically generated …

```
SELECT
  attribute_name
, numeric_missing_value
, normalization_shift
, normalization_scale
  FROM DM$VNESM_CHARGEPOINT_ANOMALIES;
```

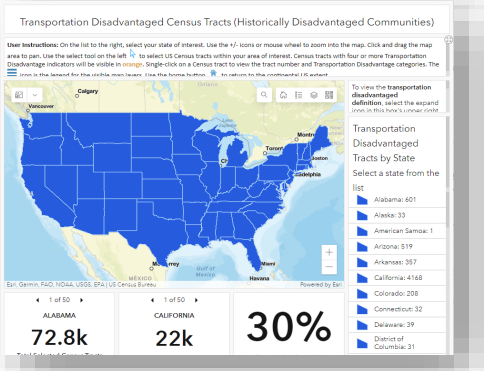
ATTRIBUTE_NAME	NUMERIC_MISSING_VALUE	NORMALIZATION_SHIFT	NORMALIZATION_SCALE
AVG_ANNUAL_SALARY	35829.02867383513	-4007.4444444444443	74224.44444444444
ENVIRONMENTAL_SCORE	29.662370382537993	6.267759781633336	48.54344818166666
EQUITY_SCORE	36.06913978494626	-10.201111111111111	102.01111111111112
HEALTH_SCORE	41.78236293548291	-6.308209174077778	88.83886707407778
MEAN_ANNUAL_TRAVEL_HOURS	85.58243727537632	26.527777777777782	105.5555555222222
NATL_WALKABILITY_INDEX	49.655566666666665	-10.508222222222223	107.16922222222223
TOTAL_CHARGING_POINTS	1.8100358422939067	0.11111111111111116	8.88888888888889
TOTAL_POPULATION	4717.612903225807	25.666666666666742	11063.333333333334
TOTAL_WORKERS	2490.9928315412194	-333.8888888888888	7318.888888888889

… offer insights into several rating components that the DOT used to compute the **summary disadvantagedness score**

Plans for Future R&D



Improve **mapping methods** to plot optimal charging points every 50 miles on major US Interstates and State highways



Analyze the **complete** DAC dataset vs. all **existing & active** charging points across the USA using **traditional** as well as **spatial** machine learning algorithms

Create ML model(s) projecting **optimal charging locations** within each Midwestern state based on **Wisconsin test cases**

Mapping + Geospatial Projects: Valuable Lessons Learned

Bountiful public data sources exist

- **US Department of Transportation** and **US Census Bureau** portals are excellent starting points
- For resources closer to home, check your **state's DOT** websites and portals
- Great for learning basics of **GIS interpretation and manipulation**
- Excellent bases for experimentation with **Oracle Machine Learning** algorithms & **Analytics** toolsets
- Most government agencies tend to use **ArcGIS shapefiles**, so you'll need to know how to convert them to **SDO_GEOMETRY** datatype

Use the right tool for the job!

- **Oracle Spatial Studio** is a great all-purpose, **no-code** solution for visualization and analyses
- If you need to build more complex mapping visualization applications with tighter control over what users can explore and visualize, consider **Oracle APEX** and its **Native Map Region**
- Both Spatial Studio and Oracle APEX **use the same Spatial functionality** …
- … so **there's no wasted learning, regardless of which toolset environment you start with!**

Public Data Sources and Additional Reference Material

Technology Deep Dive on Electric Vehicles:
https://www.iea.org/reports/electric-vehicles

US Department of Transportation Justice40 Portal:
https://www.transportation.gov/equity-Justice40

National Electric Vehicle Infrastructure (NEVI) Competitive Program:
https://driveelectric.gov/

Climate + Economic Justice Screening Tool:
https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5

Transportation Disadvantaged Census Tracts (Historically Disadvantaged Communities):
https://usdot.maps.arcgis.com/apps/dashboards/d6f90dfcc8b44525b04c7ce748a3674a

Argonne National Labs - Electric Vehicle Charging Equity Considerations:
https://www.anl.gov/esia/electric-vehicle-charging-equity-considerations

Spatial Studio and APEX Native Map Region: Useful Resources

Spatial Studio Guide:

https://docs.oracle.com/en/database/oracle/spatial-studio/index.html

Spatial Studio Application in Oracle Cloud Marketplace:
https://cloud.oracle.com/marketplace/application/71472162/overview

Oracle Spatial Developer's Guide:
https://docs.oracle.com/en/database/oracle/oracle-database/19/spatl/index.html

APEX 21.1 Native Map Regions:

https://docs.oracle.com/en/database/oracle/application-express/21.1/htmdb/creating-maps.html

Carsten Czarski Article on APEX Native Map Region:
http://www.oraworld.org/fileadmin/documents/26-ORAWORLD.pdf