

Development of a Spatial Database for Geodetic Control Points at PNG University of Technology

Presenter: **Bobby Ula**

Supervisor: **Mr. Lewi Kari & Dr. Richard Stanaway**



Table of Contents

Title Slide

1. Introduction

2. Conceptual Framework

3. Literature Review

4. Methodology

5. Analysis

6. Results

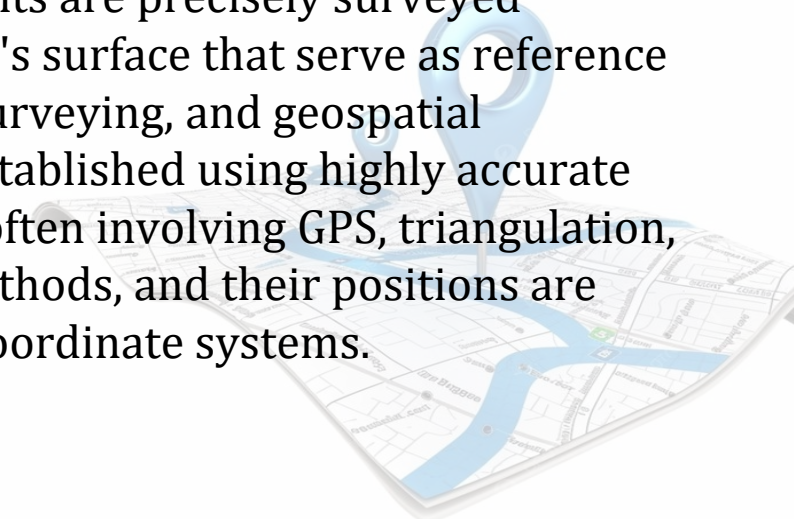
7. Discussion & Conclusion

Q&A Session



1. INTRODUCTION

- GIS is essential for managing and analyzing spatial data in science and engineering.
- It revolutionizes how we understand and interact with our environment.
- A well-organized spatial database is central to a functional GIS.
- Spatial databases are crucial for managing geodetic control points.
- Geodetic control points enable accurate spatial referencing in surveying and mapping.
- Effective data management is vital in tectonically active regions to address potential network distortions.
- Geodetic control points are key reference locations used for accurate surveying and mapping.
- In the 1990s, Bob Curly established a network of over 90 control points at PNGUOT.
- Since its establishment, the network has not undergone systematic upgrades or management.
- Geodetic control points are precisely surveyed locations on the Earth's surface that serve as reference points for mapping, surveying, and geospatial measurements and established using highly accurate geodetic techniques, often involving GPS, triangulation, or other advanced methods, and their positions are recorded in specific coordinate systems.



The Problem Statement

Current Challenges at PNGUoT

Fragmented Data Management

- Control point data scattered across different systems
- Inconsistent formats and accessibility issues

Outdated Information

- Historical data not properly maintained
- No systematic updating procedures

Geological Reality

- PNG's active crustal movements affect control point reliability
- Coordinates shift over time due to tectonic activity

Geodetic control points are fundamental to ensuring accuracy in spatial referencing and surveying.

Some of the challenges data often poses by (Connolly, T. M., & Begg, C. E. (2015))

- **Data Inaccessibility**
- **Data Inconsistency**
- **Inefficient Data Management**
- **Limited Spatial Analysis**

Time for a change?



AIM AND OBJECTIVES

Aim

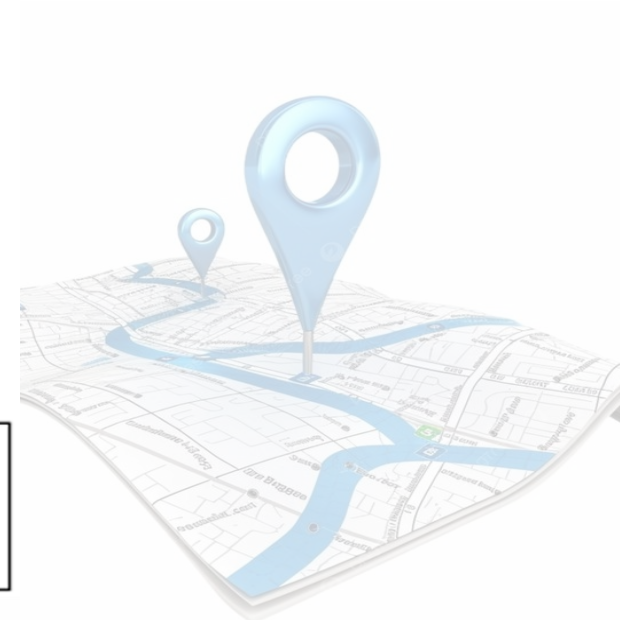
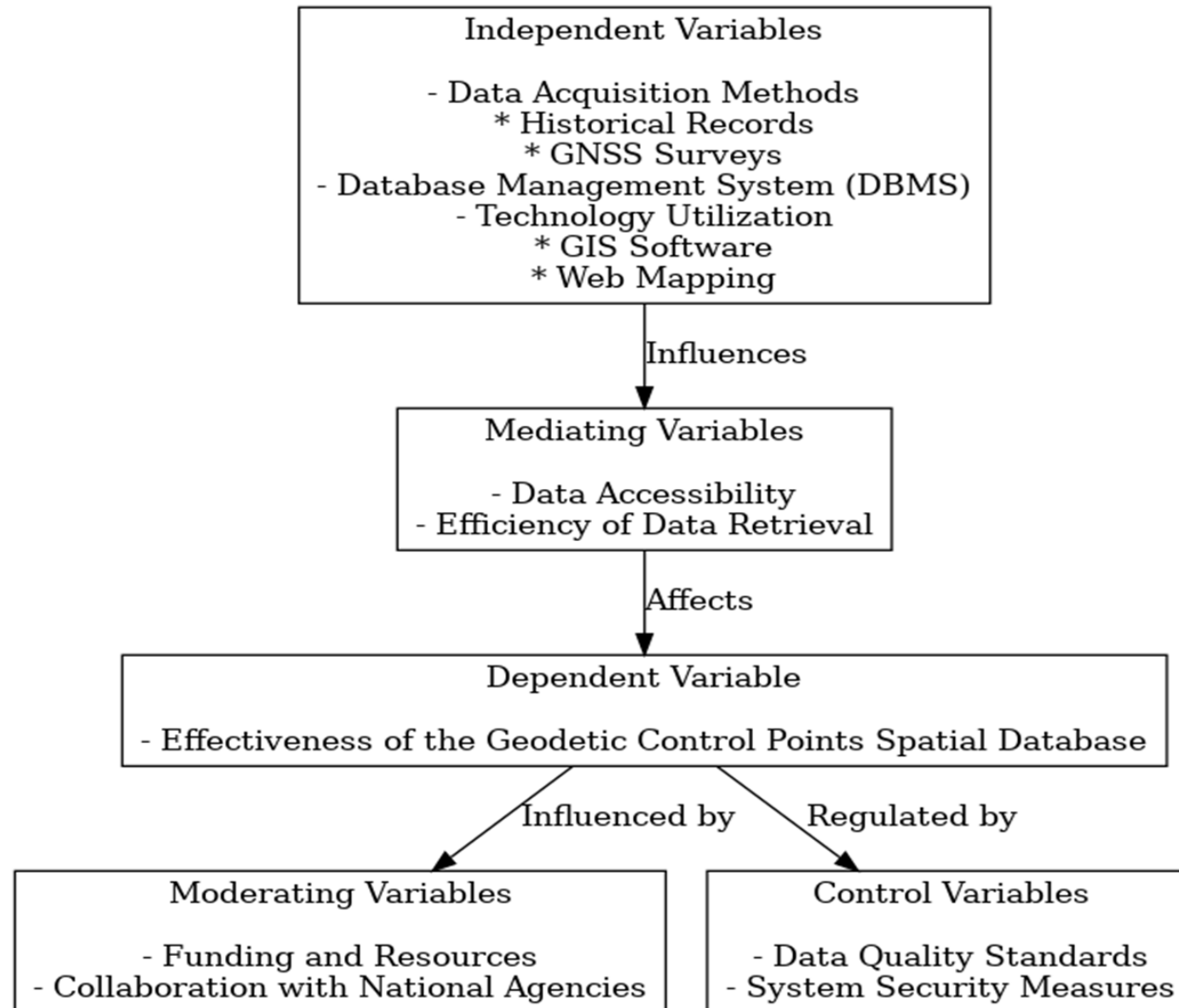
To create a spatial database of geodetic control points at PNG University of Technology to enhance data availability, accuracy and efficiency in geospatial applications.

Objectives

1. Identify and compile a comprehensive list of geodetic control points at PNGUOT.
2. Design and implement a GIS-based spatial database for storing control point data.
3. Develop a web mapping interface for easy visualization and querying of reference points.



2. CONCEPTUAL FRAMEWORK



Locality Map



<p>New_Stations</p> <p>●</p> <p>Exist_Stations</p> <p>●</p>	PNG UNITECH Locality Map		
		2025	
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere			



3. LITERATURE REVIEW

Longley et al. (2015) Geographic Information Science and Systems:

- **(GIS) and Spatial Databases** It emphasizes key concepts such as spatial data infrastructure, spatial relationships, and the importance of data quality, which are all highly relevant to the development of a geodetic control point database.

Chang, K-T., 2019. Introduction to geographic information systems:

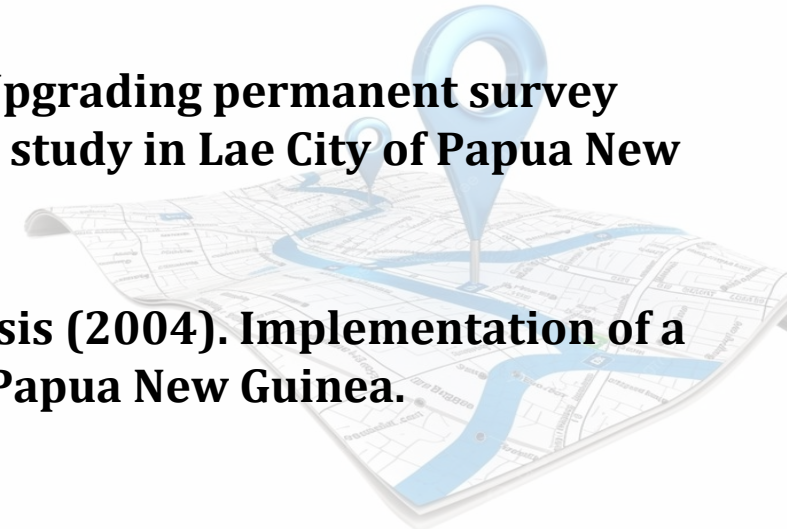
- GIS Data Acquisition
- Coordinate Systems and Spatial Referencing
- Spatial Data Models
- Spatial Data Accuracy and Quality

Connolly & Begg (2015) Database systems: A practical approach to design, implementation, and management:
This includes conceptual, logical, and physical database design.
Data modeling
Data integrity and normalization
Implementation and management

Connolly & Begg (2015) Database systems: A practical approach to design, implementation, and management:

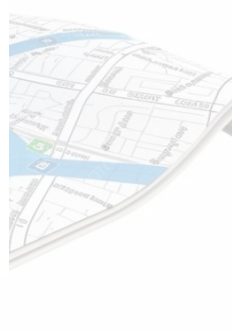
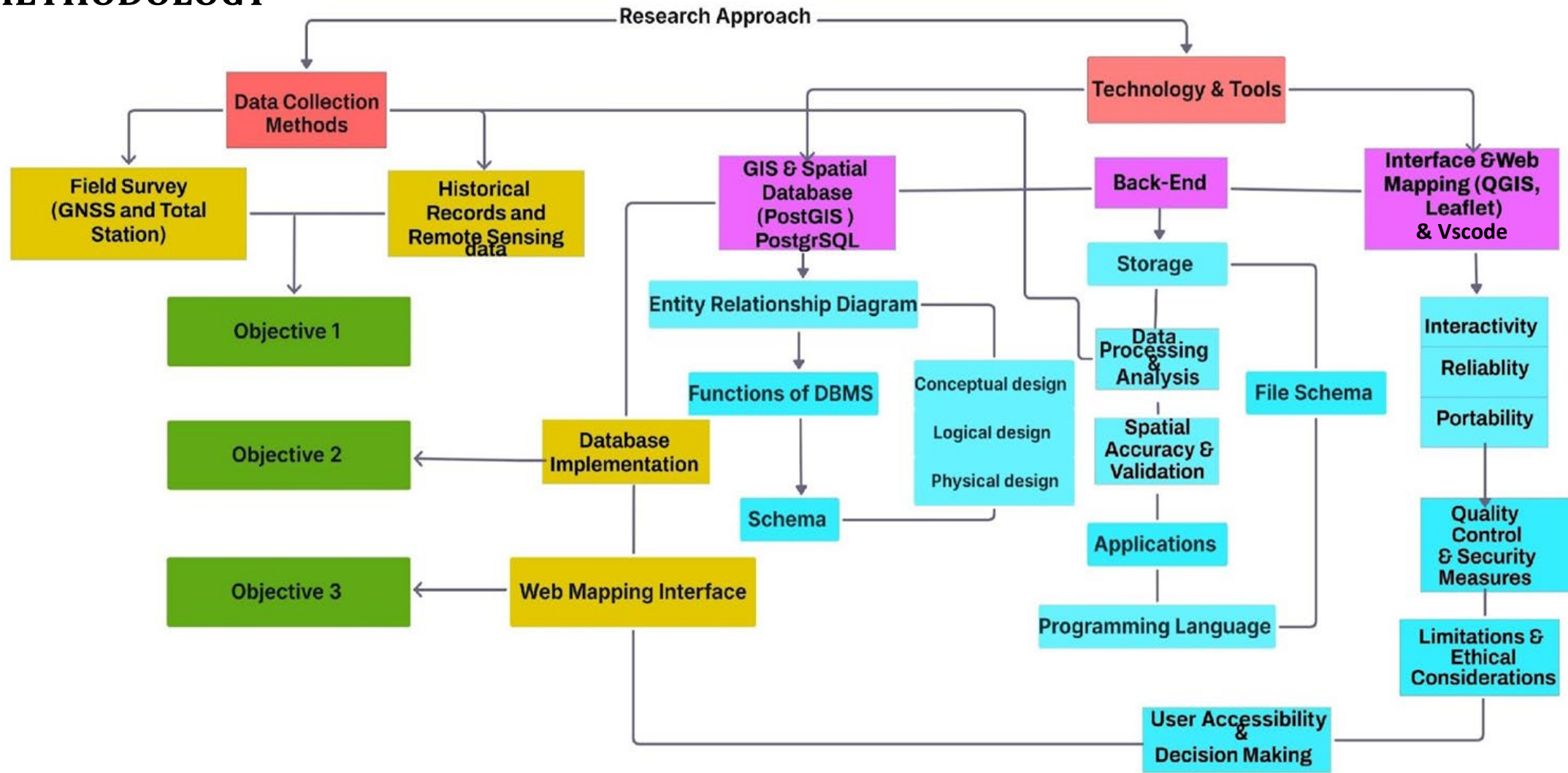
Sekac, T., Paraka, J.(2023) 'Upgrading permanent survey marks infrastructure: a case study in Lae City of Papua New Guinea:

R.F. Stanaway's Master's thesis (2004). Implementation of a dynamic geodetic datum in Papua New Guinea.

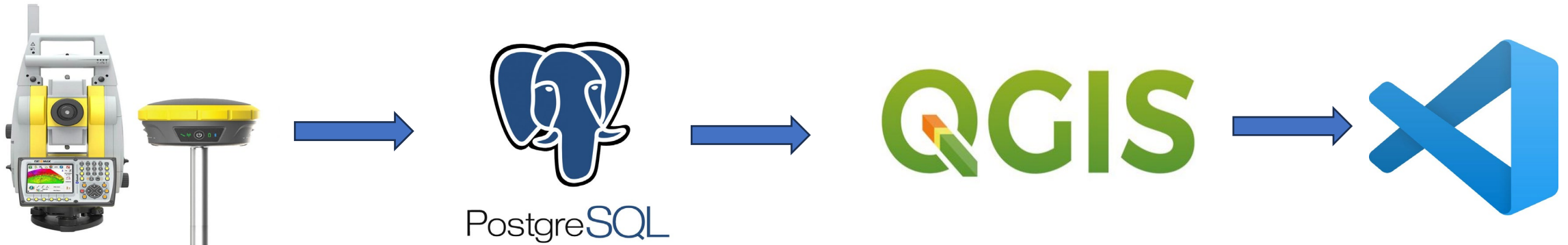




4. METHODOLOGY



EQUIPMENT AND SOFTWARE USED



Data collected from GNSS (Global Navigation Satellite Systems) and Total stations are: Latitude, Longitude, and Elevation (3D Position) – Geographic coordinates of a point

PostgreSQL uses extension as PostGIS and others to support data types:
Numeric
Character
Boolean
Geometric
JSON
XML

QGIS acts as a desktop client that directly connects to the database using the PostGIS extension for spatial data.

VS Code is a powerful editor that supports SQL and PostgreSQL, allowing me to write, test, and manage spatial data efficiently for my spatial database project.

5. ANALYSIS

Data Pre-processing and Analysis

The data pre-processing and analysis phase involves preparing the collected data for inclusion in the spatial database and performing the necessary analysis to meet the project objectives.

Data Pre-processing:

- Data Validation and Cleaning
- Coordinate Transformation
- Accuracy Assessment

Database Design and Implementation:

- Database Management System (DBMS)
- Database Schema Design
- Database Creation and Population

Spatial Analysis:

- Spatial Queries
- Data Visualization



PNGUoT Taraka Campus - Coordinate Schedule - PNG2020 (post-earthquake 2022) - Provisional 25th September 2025

Station	PNGMG2020 Zone 55				UOT2020 Grid			PNG2020 ellipsoidal coordinates			Uncertainty 95% CL			PNG08
	Easting	Northing	RL MSL PNG08	Combined Scale Factor	Easting	Northing	Combined Scale Factor	Latitude	Longitude	ellipsoid height	E	N	H	
EDM PILLAR 1	498962.658	9262331.125	55.230	0.999580	2362.390	7030.927	1.000000	-6.67361938	146.99061450	128.147	0.022	0.003	0.006	72.917
EDM PILLAR 2	498939.727	9262259.748	54.453	0.999580	2339.449	6959.520	1.000000	-6.67426505	146.99040701	127.371	0.004	0.004	0.008	72.918
EDM PILLAR 3	498919.871	9262197.955	53.663	0.999580	2319.585	6897.701	1.000001	-6.67482403	146.99022735	126.581	0.006	0.006	0.016	72.918
EDM PILLAR 5	498826.401	9261907.030	51.882	0.999580	2226.075	6606.654	1.000001	-6.67745575	146.98938161	124.801	0.012	0.012	0.034	72.919
EDM PILLAR 6	498782.834	9261771.423	51.108	0.999581	2182.490	6470.990	1.000001	-6.67868245	146.98898740	124.029	0.007	0.010	0.005	72.921
EDM PILLAR 7	498733.243	9261617.092	50.703	0.999581	2132.878	6316.594	1.000001	-6.68007853	146.98853868	123.624	0.002	0.002	0.008	72.921
GCP X1	499239.163	9262361.607	54.310	0.999580	2639.011	7061.422	1.000000	-6.67334367	146.99311622	127.226	0.004	0.007	0.022	72.916
GCP X2	499324.186	9262334.329	54.325	0.999580	2724.070	7034.132	1.000000	-6.67359044	146.99388548	127.241	0.011	0.009	0.021	72.916
LAE1 PSM 31107	499247.473	9262322.171	67.273	0.999578	2647.324	7021.969	0.999998	-6.67370041	146.99319140	140.189	0.000	0.000	0.000	72.916
LAE1 RMA	499233.954	9262311.064	54.567	0.999580	2633.800	7010.858	1.000000	-6.67380089	146.99306909	127.483	0.005	0.018	0.003	72.916
LAE1 RMB	499251.131	9262306.095	54.260	0.999580	2650.984	7005.887	1.000000	-6.67384584	146.99322450	127.175	0.004	0.002	0.010	72.915
LAE1 RMC	499264.026	9262309.472	54.241	0.999580	2663.884	7009.265	1.000000	-6.67381530	146.99334116	127.157	0.013	0.005	0.027	72.916
LAE2 RMC	499283.317	9262374.297	55.304	0.999580	2683.184	7074.117	1.000000	-6.67322889	146.99351571	128.220	0.009	0.006	0.018	72.916
LAE2 RMD	499252.818	9262377.446	54.840	0.999580	2652.672	7077.268	1.000000	-6.67320039	146.99323977	127.756	0.002	0.002	0.012	72.916
LAE2 RME	499222.440	9262377.187	54.721	0.999580	2622.281	7077.009	1.000000	-6.67320273	146.99296492	127.637	0.006	0.006	0.011	72.916
LAE200PNG	499247.311	9262340.788	67.243	0.999578	2647.162	7040.594	0.999998	-6.67353200	146.99318994	140.159	0.002	0.002	0.002	72.916
NIC01	499225.564	9262350.377	54.501	0.999580	2625.406	7050.187	1.000000	-6.67344526	146.99299318	127.417	0.006	0.008	0.047	72.916
PM 08	499625.382	9262793.870	58.786	0.999579	3025.392	7493.867	1.000000	-6.66943342	146.99661061	131.700	0.003	0.002	0.007	72.914
PM 09	499486.877	9262688.499	57.808	0.999579	2886.829	7388.451	1.000000	-6.67038661	146.99535747	130.722	0.006	0.005	0.012	72.914
PM 29	499900.131	9262525.587	57.382	0.999580	3300.257	7225.471	1.000000	-6.67186035	146.99909642	130.295	0.010	0.008	0.013	72.913
PM 30	499992.349	9262667.137	58.693	0.999579	3392.514	7367.081	1.000000	-6.67057987	146.99993078	131.605	0.002	0.004	0.008	72.912
PM 32	499862.675	9262865.287	60.121	0.999579	3262.785	7565.314	1.000000	-6.66878739	146.99875754	133.034	0.005	0.006	0.006	72.913
PM 38	499766.596	9262580.014	57.278	0.999580	3166.665	7279.921	1.000000	-6.67136799	146.99788825	130.192	0.009	0.007	0.031	72.914
PM 40	499329.822	9262080.833	52.274	0.999580	2729.708	6780.530	1.000001	-6.67588359	146.99393644	125.190	0.007	0.004	0.007	72.916
PM 42	499036.260	9262131.896	52.561	0.999580	2436.023	6831.614	1.000001	-6.67542163	146.99128039	125.478	0.006	0.006	0.010	72.917
PM 43	499010.292	9262367.723	53.888	0.999580	2410.043	7067.541	1.000001	-6.67328831	146.99104548	126.806	0.005	0.010	0.008	72.918
PM 44	499176.281	9262357.485	54.309	0.999580	2576.102	7057.298	1.000000	-6.67338096	146.99254728	127.225	0.006	0.015	0.028	72.916
PM 45	499217.701	9262518.521	55.538	0.999580	2617.540	7218.402	1.000000	-6.67192421	146.99292206	128.454	0.016	0.010	0.022	72.916
PM 46	499331.811	9262361.101	54.656	0.999580	2731.698	7060.916	1.000000	-6.67334826	146.99395447	127.571	0.010	0.005	0.019	72.915
PM 48	499422.253	9262264.792	54.158	0.999580	2822.178	6964.567	1.000000	-6.67421949	146.99477274	127.073	0.011	0.006	0.010	72.915
PM 86alt	499613.632	9262271.534	54.925	0.999580	3013.637	6971.311	1.000000	-6.67415852	146.99650427	127.838	0.011	0.004	0.003	72.913
PSM 35485	499265.168	9262360.473	54.529	0.999580	2665.027	7060.288	1.000000	-6.67335393	146.99335151	127.444	0.009	0.005	0.008	72.915
PSM 35485 RM1	499266.999	9262360.408	54.499	0.999580	2666.859	7060.222	1.000000	-6.67335453	146.99336807	127.415	0.007	0.003	0.017	72.916
PSM 35485 RM2	499264.470	9262356.866	54.488	0.999580	2664.329	7056.679	1.000000	-6.67338657	146.99334519	127.404	0.007	0.004	0.013	72.916
SM01	499204.078	9262331.975	54.554	0.999580	2603.912	7031.777	1.000000	-6.67361172	146.99279878	127.470	0.010	0.008	0.014	72.916
U02	499145.563	9262312.129	54.163	0.999580	2545.372	7011.923	1.000000	-6.67379124	146.99226935	127.079	0.008	0.010	0.020	72.916
U04	499272.810	9262269.948	53.688	0.999580	2672.672	6969.724	1.000001	-6.67417283	146.99342064	126.603	0.004	0.004	0.010	72.915



Newly Establish Control Stations						
Stations	Easting (m)	Northing (m)	Elevation (m)	Lat	Lon	Ellipsoid height $h = H+N$ (m)
SIP1	499072.029	9262529.956	55.594	-6.67182	146.9916	125.594
SIP2	499138.550	9262900.600	57.545	-6.66847	146.9922	127.545
SIP3	499333.558	9263504.832	62.744	-6.663	146.994	132.744
SIP4	499402.886	9263697.372	64.960	-6.66126	146.9946	134.96
SIP5	499467.487	9262959.966	59.867	-6.66793	146.9952	129.867
SIP6	499413.985	9262981.907	59.747	-6.66773	146.9947	129.747
SIP7	499622.265	9263390.241	62.976	-6.66404	146.9966	132.976
SIP8	499753.48	9263773.656	66.148	-6.66057	146.9978	136.148
SIP9	499816.022	9263917.58	67.661	-6.65927	146.9983	137.661
SIP10	499861.35	9264015.104	68.528	-6.65839	146.9987	138.528
SIP11	500038.122	9263972.781	69.330	-6.65877	147.0003	139.33
SIP12	499994.161	9263871.458	68.582	-6.65969	146.9999	138.582
SIP13	500116.262	9263564.836	67.381	-6.66246	147.0011	137.381
SIP14	500179.037	9263692.491	68.725	-6.6613	147.0016	138.725
SIP15	500381.27	9263878.409	71.143	-6.65962	147.0034	141.143
LAE200PNG	499247.312	9262340.787	67.242	-6.67353	146.9932	137.242
LAE1 PSM 31107	499247.473	9262322.171	67.273	-6.6737	146.9932	137.273
GIP1	499140.960	9262756.595	57.010	-6.66977	146.9922	127.01
GIP2	499249.937	9263241.633	60.484	-6.66538	146.9932	130.484



6. RESULTS

Database Schema

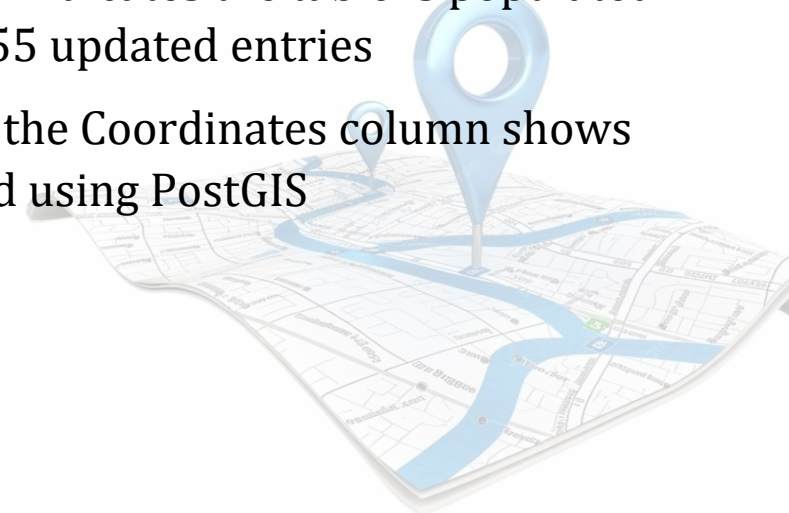
The schema is designed to accommodate both current and historical control point data from various sources. The core components of the schema include:

Spatial Reference System Table: Chang, K. (2019)

- Stores information about coordinate reference systems for geodetic control points
- Includes SRID, authority name, authority SRID, projection text, and WKT representation
- Ensures proper georeferencing and transformation within the database.

PostgreSQL Database and Table Structure

- Confirms successful creation of the central table based on the proposed schema.
- Table includes data for geodetic control points: station name, latitude, longitude, UTM zone, ellipsoidal height, source, and geometry
- "Showing rows 1-108" indicates the table is populated with 108 entries or 1-55 updated entries
- Geometry data type in the Coordinates column shows spatial data is managed using PostGIS





RESULTS cont..

public.Campuscontrol/Geodetic_Control_Points/postgres@Pos...

Query Query History Scratch Pad x

```
1 SELECT * FROM public."Campuscontrol"
```

Showing rows: 1 to 108 Page No: 1 of 1

Station character varying (350)	Latitude double precision	Longitude double precision	Zone integer	Ellipsoid double precision	Source character varying (350)	Coordinates geometry
1 BAS7	83.40449985	146.9011601	55	123.766	from 1999 list	0101000000ADA3AA09A25F6240B858518369B81AC0
2 GCN1	83.40396955	146.9097181	55	121.867	from 1999 list	01010000009DD7D825AASF6240B7B41A12F7B81AC0
3 GCN2	83.41078631	146.9899385	55	129.046	from 1999 list	01010000007008556AF65F624052B81E85EBB11AC0
4 GCN3	83.41801246	147.0347326	55	136.94	from 1999 list	0101000000F5108DEE2060624043AD69DE71AA1AC0
5 GCN4	83.42387199	147.0248759	55	142.795	from 1999 list	010100000003ACC9717606240A3CC069964A41AC0
6 IP71	83.41481751	147.0022152	55	133.924	by xfm from old trav listing	0101000000E76F42210260624020240B98C0AD1AC0
7 L1A	83.41072312	146.940152	55	127.835	Based on 1999 coords	0101000000E8DEC32C75F6240FCDEA63FFB11AC0
8 L1B	83.41067845	146.9414916	55	128.751	Based on 1999 coords	010100000076374F75C85F62408B54185B08B21AC0
9 L1C	83.41071539	146.942612	55	127.835	Based on 1999 coords	0101000000696FF085C95F62401990BDDDEFB11AC0
10 L2A	83.41132311	146.9380948	55	128.751	Based on 1999 coords	01010000009B8F6B43C55F6240535C55F650B11AC0
11 L2B	83.41131922	146.9409345	55	127.835	Based on 1999 coords	0101000000B84082E2C75F6240535C55F650B11AC0
12 L2C	83.41128967	146.9440001	55	128.751	Based on 1999 coords	0101000000F7C77BD5CA5F6240A86F99D365B11AC0
13 LAE1	83.41082238	146.9412058	55	140.472	from 1999 list	0101000000D8166536C85F6240
14 NIC01	83.41107489	146.9394929	55	127.835	Based on 1999 coords	010100000029E8F692C65F62401AA88C7F9F811AC0
15 PM01	83.41203313	147.0067861	55	0	by xfm from old trav listing	01010000003E0C07806606240548C

Successfully run. Total query runtime: 223 msec. 108 rows affected.

PostgreSQL 15/Geodetic_Control_Points - Database connected.

Figure 1: The main campus control table within a PostgreSQL database, managed using pgAdmin 4.

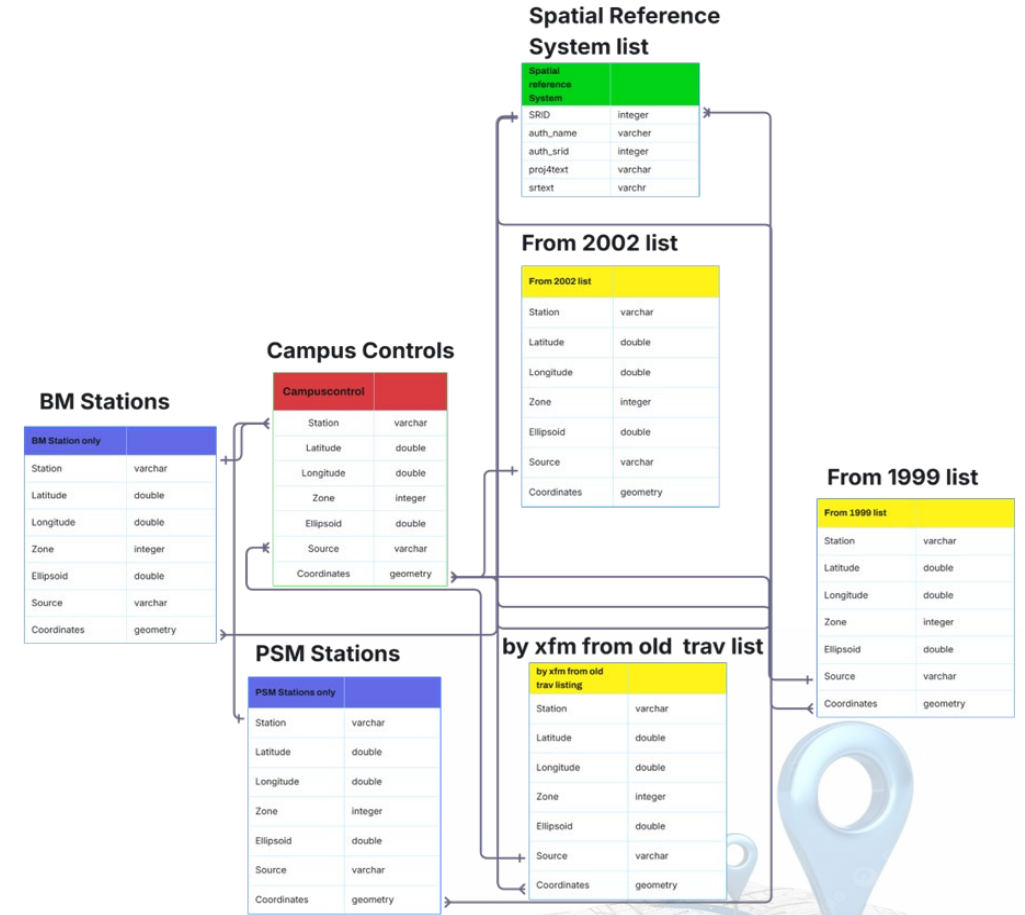


Figure 2: ERD schema with other successfully run queries.

public.Update/PNGUoT - Coordinate Schedule - PNG2020 (post-earthquake 2022) /postgres@PostgreSQL 15 X

public.Update/PNGUoT - Coordinate Schedule - PNG2020 (post-...

Query Query History

Scratch Pad X

Data Output Messages Notifications

Showing rows: 1 to 28 Page No: 1 of 1

station	latitude	longitude	zones	ellipsoid	sources	coordinates
character varying (20)	double precision	double precision	integer	double precision	character varying (50)	geometry
1 GCN1	83.40396955	146.9097181	55	121.867	From August 2025 list	0101000020E61000009D07D825AASF624087B41A12F7B81A...
2 GCN2	83.41078631	146.9899385	55	129.046	From August 2025 list	0101000020E6100000700855AF65F624052B81E85EBB11AC0
3 L1A	83.41072312	146.940152	55	127.835	From August 2025 list	0101000020E6100000E80EC325C75F6240FCDEA63FFBB11A...
4 L1B	83.41067845	146.9414916	55	128.751	From August 2025 list	0101000020E610000076374F75C85F62408B54185808B21AC0
5 L1C	83.41071539	146.942612	55	127.835	From August 2025 list	0101000020E6100000696FF085C95F62401990B0DEFDB11AC0
6 L2A	83.41132311	146.9380948	55	128.751	From August 2025 list	0101000020E610000098B643C55F6240533C55F65DB11AC0
7 L2B	83.41131922	146.9409345	55	127.835	From August 2025 list	0101000020E6100000B94082E2C75F6240533C55F65DB11AC0
8 L2C	83.41128967	146.9440001	55	128.751	From August 2025 list	0101000020E6100000F7C77BD5CASF6240A86F990365B11A...
9 LAE1	83.41082238	146.9412058	55	140.472	From August 2025 list	0101000020E6100000DB166536C85F6240E0F3C308E1B11AC0
10 NIC01	83.41107489	146.9394929	55	127.835	From August 2025 list	0101000020E610000029E8F692C65F62401AA88C7F9FB11AC0
11 PM08	83.41505025	146.970685	55	131.592	From August 2025 list	0101000020E610000032E6AE25E45F62407689EAAAD1AD1AC0
12 PM09	83.41410534	146.9598459	55	130.639	From August 2025 list	0101000020E61000005B423EE8D95F62401FF46C567DAE1AC0
13 PM29	83.41264763	146.9921481	55	130.532	From August 2025 list	0101000020E61000005778978BF85F624072A774B0FEAF1AC0
14 PM30	83.41391579	146.9993482	55	131.85	From August 2025 list	0101000020E6100000B9533A58FF5F62403B191C25AFAE1AC0
15 PM32	83.41569071	146.9892185	55	133.276	From August 2025 list	0101000020E6100000295C8FC2F55F62405B423E8D9AC1AC0
16 PM38	83.41313509	146.9817203	55	130.077	From August 2025 list	0101000020E6100000A4A09A2EE5F624001C11C3D7EAF1A...
17 PM39	83.41044758	146.9723319	55	127.996	From August 2025 list	0101000020E6100000585F2484E...
18 PM40	83.40862231	146.9472548	55	125.421	From August 2025 list	0101000020E6100000C004EDD0...
19 PM42	83.40911678	146.9247369	55	125.86	From August 2025 list	
20 PM43	83.41122751	146.9226873	55	127.019	From August 2025 list	

Successfully run. Total query runtime: 238 msec. 28 rows affected. X

PostgreSQL 15/PNGUoT - Coordinate Schedule - PNG2020 (post-earthquake 2022) - Database connected X

Total rows: 28 Query complete 00:00:00.241 CRLF Ln 1, Col 1

Figure 3: The updated control table within a PostgreSQL database, managed using pgAdmin 4.

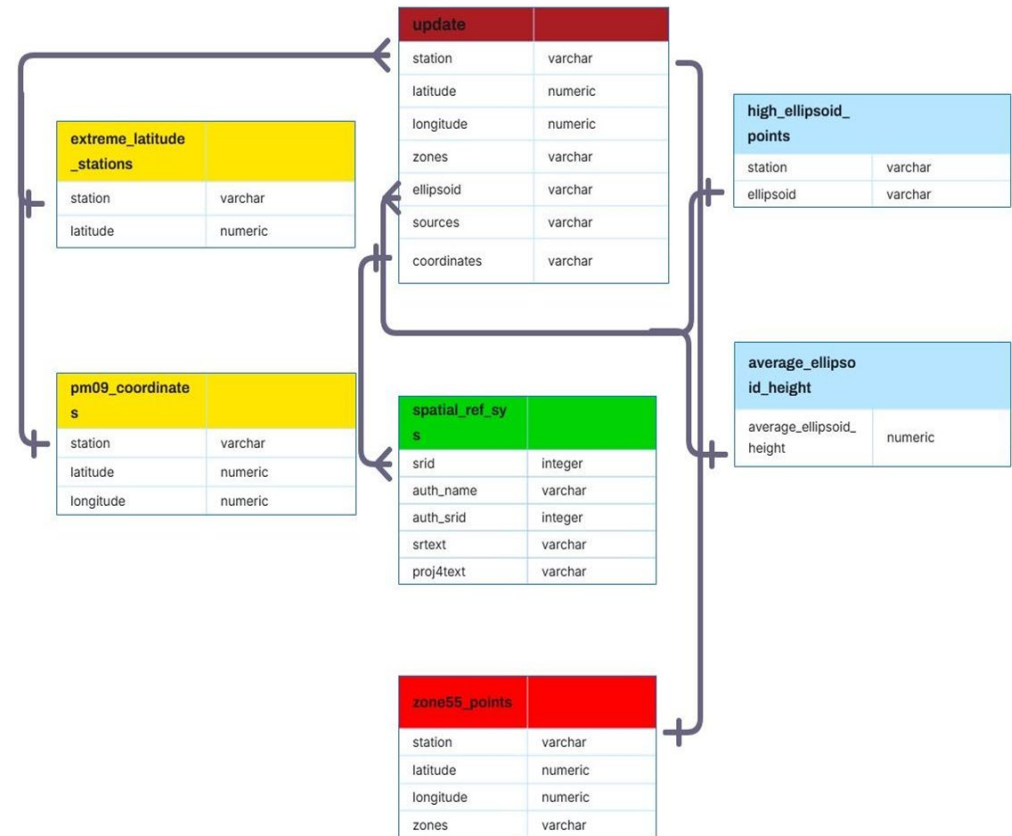
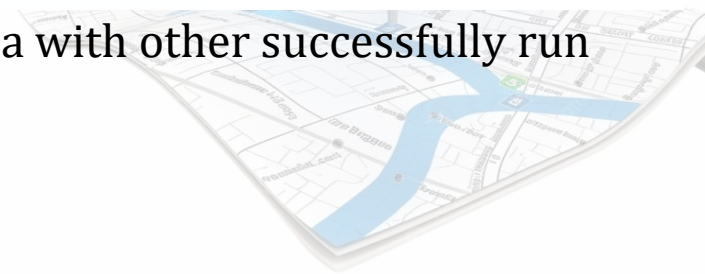


Figure 4: ERD schema with other successfully run queries.



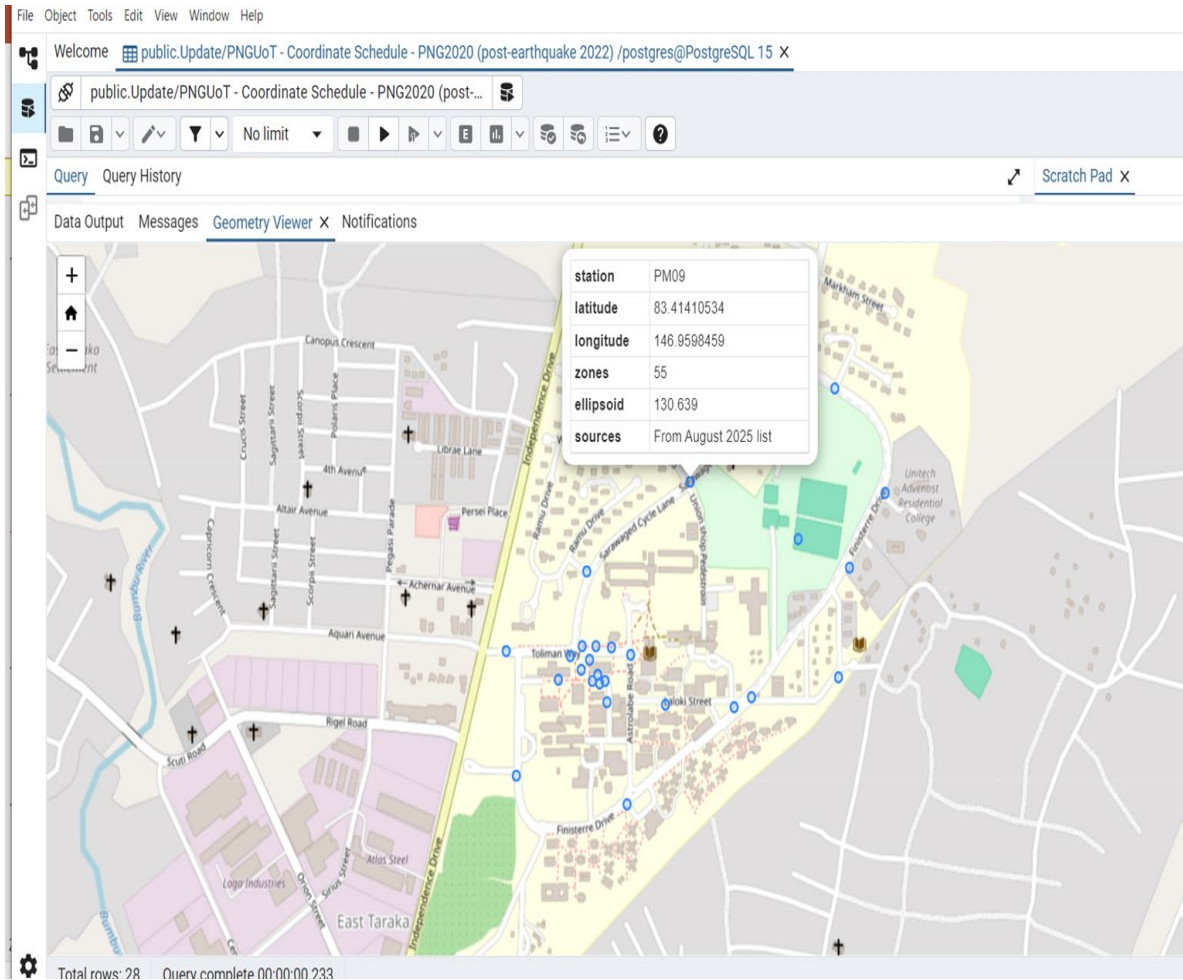


Figure 5: Visualizes data from the Update control table using the Geometry Viewer in pgAdmin

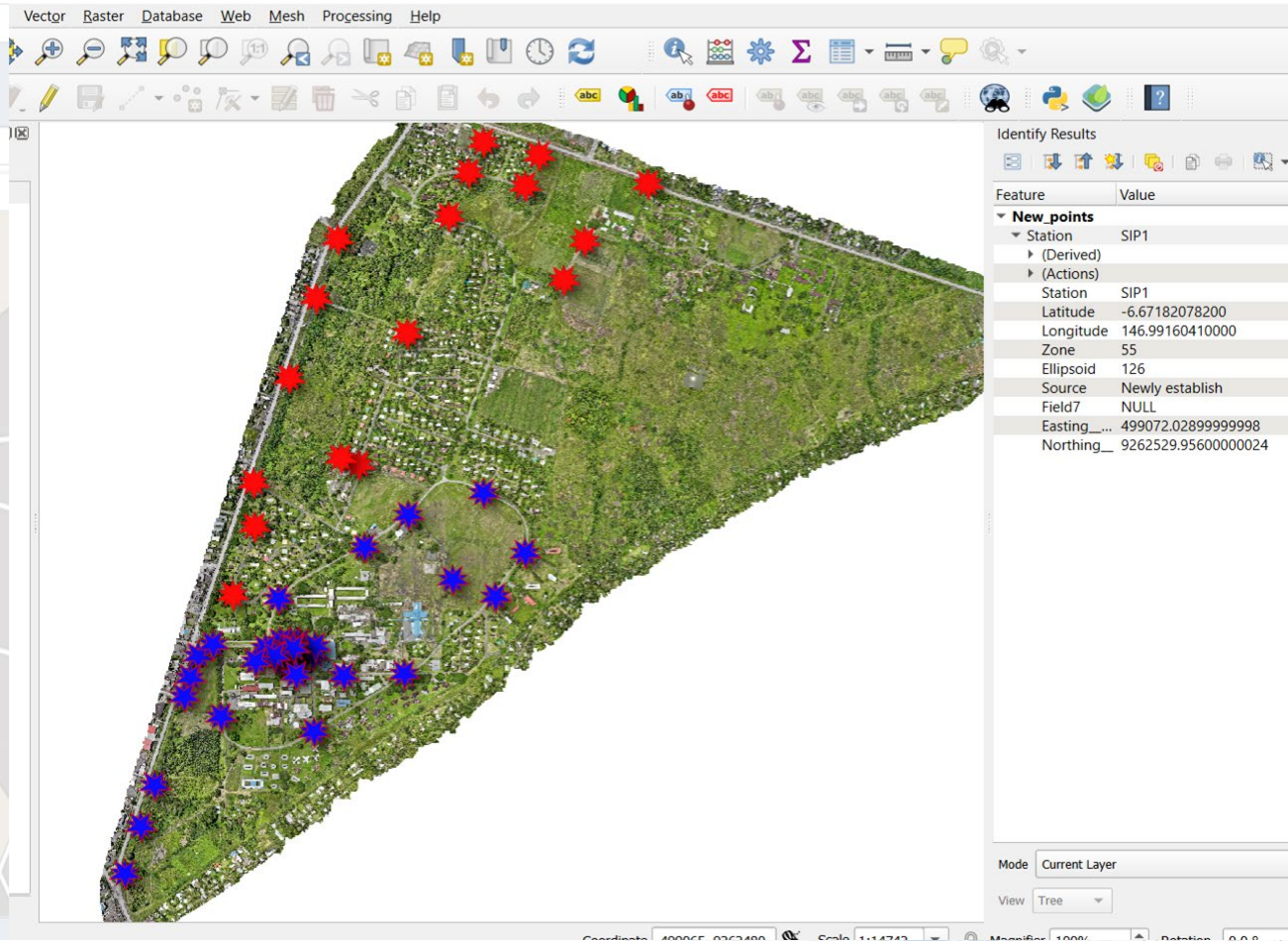


Figure 6: Demonstrates the integration of the PostgreSQL database with QGIS

WebGIS Interface

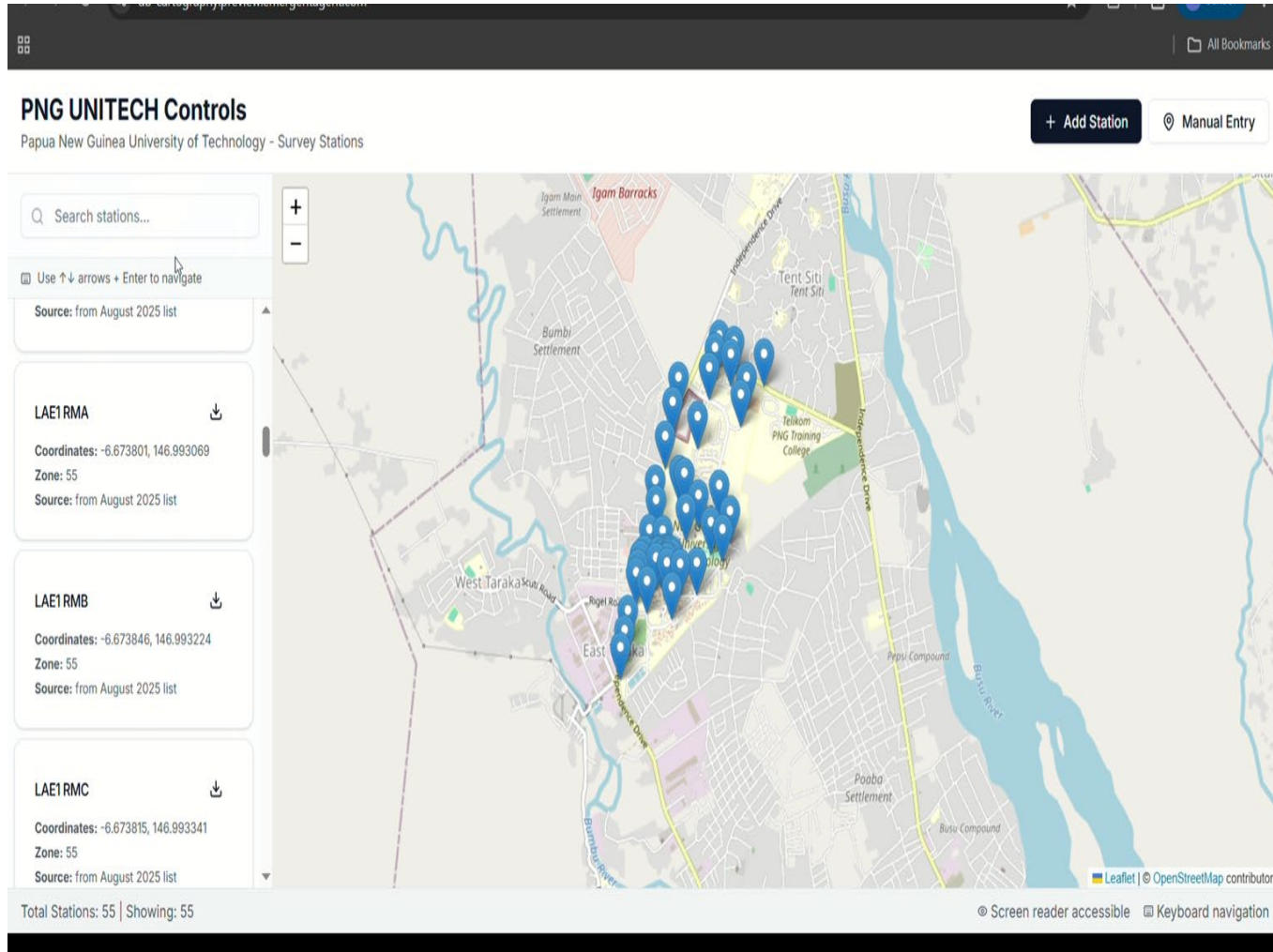


Figure 4: User Interface of Geodetic Control Points within East Taraka, Lae – Interactive Web Map



Figure 4: Automatic Download of Essential Station Information.

7. DISCUSSION

Key Achievements

Robust Database Foundation: Successfully established a spatial database using **PostgreSQL** and **PostGIS**, demonstrating a scalable and reliable foundation for future geospatial applications.

Improved Data Accessibility: The new system overcomes the issue of data inaccessibility by digitizing historical control points, making them easily retrievable for analysis and use.

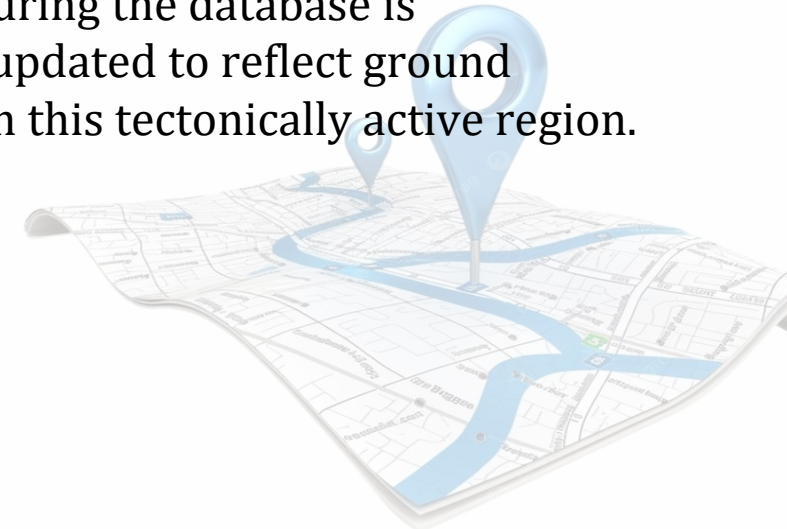
Enhanced Data Integrity: By centralizing the data, we've improved consistency and reduced the risk of errors associated with fragmented, outdated manual records.

User-Friendly Interface: The development of the interactive web interface provides a simple and intuitive way for users to visualize and query the data, empowering a wider range of users to access geodetic information.

Progress and Future Work

•**Completed:** The foundational database design, data compilation, and the basic web mapping interface have been successfully implemented.

•**Ongoing:** Future work will focus on integrating real-time data from GNSS surveys, developing more advanced spatial analysis tools, and ensuring the database is continuously updated to reflect ground deformation in this tectonically active region.



8. CONCLUSION & RECOMMENDATIONS

Our progress to date includes:

- **Database Foundation:** I've successfully designed and populated a robust PostgreSQL database with the PostGIS extension, which is now holding **108 historical control points and 55 updated or post earthquake data**. This fulfills the core objective of creating a scalable and reliable data repository.
- **Web Interface Development:** The development of the user interface demonstrates a commitment to making this data usable and accessible. As shown in the presentation, the web map allows for easy visualization and download of key station information.
- **Proof of Concept:** The successful integration of the PostgreSQL database with both **pgAdmin 4** and **QGIS** validates my methodology and proves that this system is fully functional and ready for further development.

The project has transitioned from a theoretical concept to a tangible, working platform, setting a strong foundation for future geodetic and geospatial applications at the university.

Move the data into National Spatial Database Infrastructure.



National Spatial Database Infrastructure

- What is this project? Centralize all spatial data in the country starting with Unitech.
- Running Infrastructure-Cluster of Servers, 4 currently (2 uni, 2 Sydney)
- Kubernetes, Postgresql/postgis, minio(object DB), Next Js Framework
- Data Governance, centralised repository, authentication, Authorization, Analysis in cloud





End of Presentation
Thank you for your time and attention

