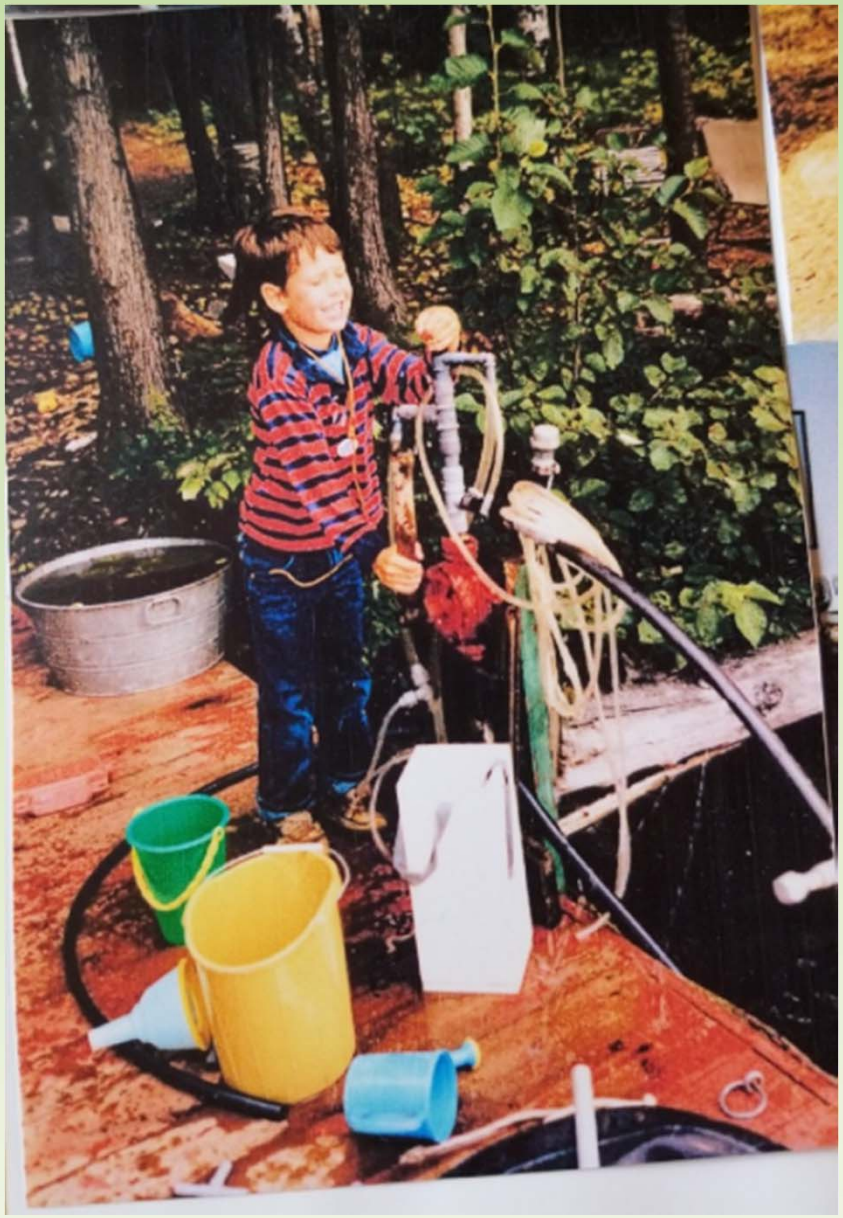
Operational Dashboards for monitoring Water Main Flow Patterns, Tower Levels, and Realtime Pumping Energy Costs per m3

Speaker: Graham Nasby, Water SCADA & Security Specialist, Guelph Water Services

OWWA Automation Seminar - Nov 6, 2019 – Mississauga, Ontario, Canada

Making Complicated Computer Screens of Squiggly Lines that no one Understands



I wanna be a Water Guy when I grow up!

So I got to live the dream!

About the Speaker

Graham Nasby, P.Eng., PMP, CAP
Water SCADA & Security Specialist
City of Guelph Water Services

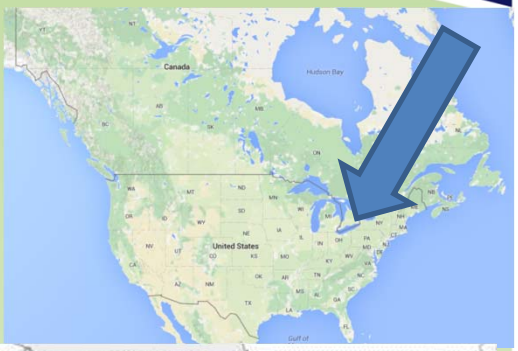
- 10 years in the consulting sector;
- Joined Guelph Water Services in 2015

- OWWA and WEAO Member, Member of OWWA Automation Committee
- Co-chair of ISA112 SCADA Systems standards committee
- Voting member of ISA101 HMI Design standards committee
- Voting member of ISA18 Alarm Management standards committee
- Named Canadian Expert on IEC/SCC-TC65 with Standards Council of Canada

- Guest instructor at McMaster University, Conestoga College and Mohawk College
- Has published over 40 papers and articles on automation topics
- Received University of Guelph "Mid Career Achievement Award" in 2014
- Named ISA's technical division leader of the year award in 2013.

- Contact: graham.nasby@guelph.ca

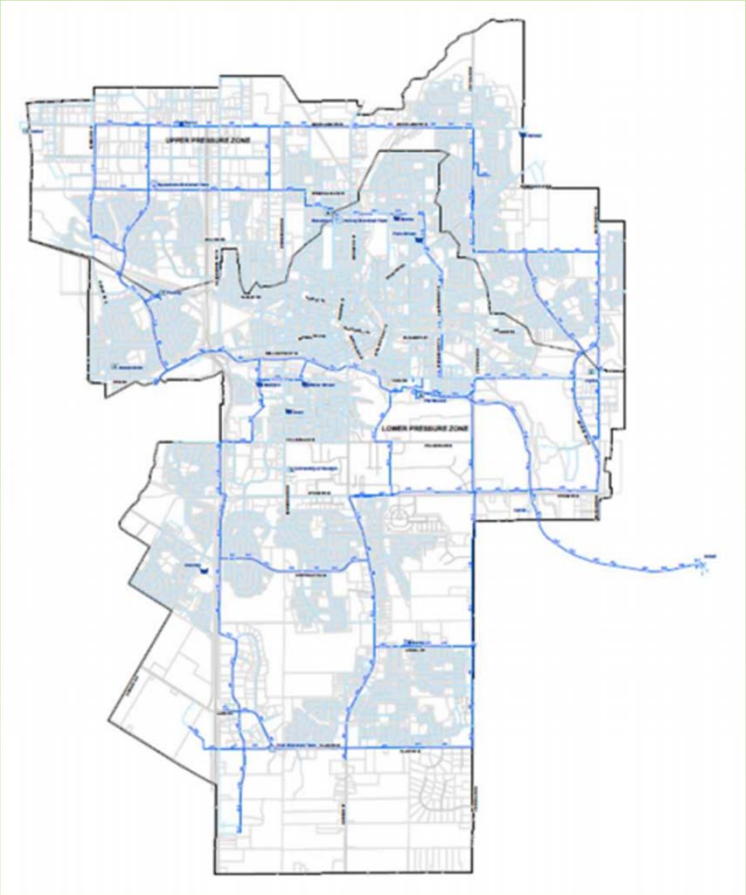
City of Guelph Water Services



- Guelph, Ontario, Canada
- 130,000 residents
- 21 groundwater wells
- 3 water towers
- 549 km of water mains
- 49,000 service connections
- 2,750 fire hydrants
- 46,000 m^3/day [12 MGD]

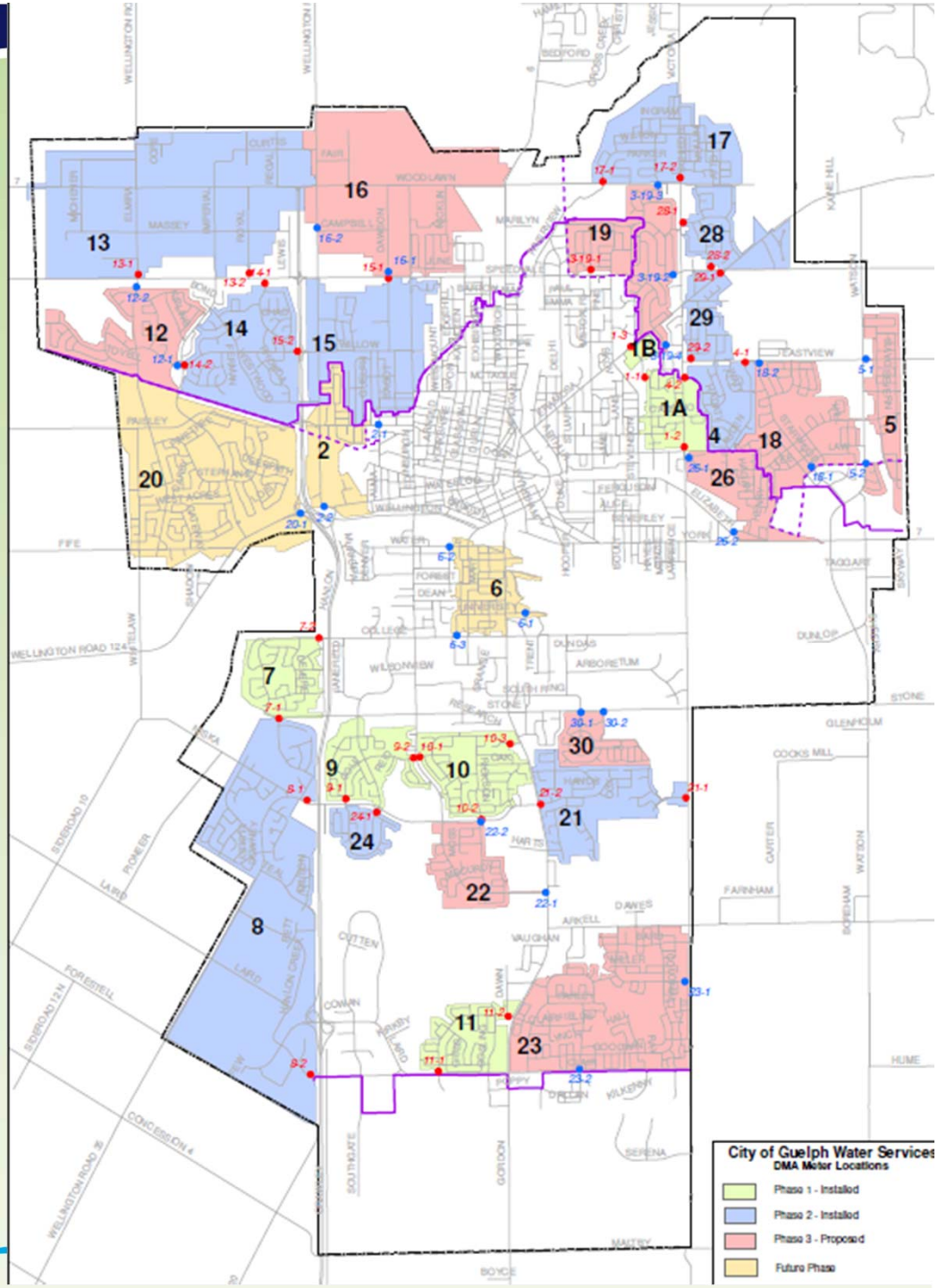
Guelph Water Facilities

- Approx. 15km x 15km area
- 35 Facilities
  - 4 booster stations
  - 21 wells
  - 2 valve chambers
  - 3 water towers
  - 5 monitoring sites
- 40 PLCs plus 2 data centers
- Redundant Datalogging
  - Realtime datalogging
  - QuickPanels with store/forward
  - DNP3 Dataloggers with store/forward
  - Raspberry PI Dataloggers with store/forward
- High availability SCADA network
  - Primary: private fibre optic
  - Secondary: private wireless, with 45 second auto-failover



District Metered Areas

- Segments Water Distribution into DMA Areas with 1-3 connections on borders
- Put flowmeters on the DMA's border connections
- What this give us:
  - Water in/out of DMAs
  - Compare to Customer Meters
  - Compare to Wells & Pumping Station meters
  - Calibrate Water Models



The Challenge

We are a water utility = a lot of what we do involves pumping water

- **How much electricity do we use to pump water?**
- **How much is this electricity costing us?**
- **How can we get good/timely data about how we use electricity?**

- Waiting until we get power bills at the end of each month is not that helpful

- The gold standard is to create an automated reporting tool to give us:
  - kWh per m3 produced
  - $ of electricity per m3 produced

  - Ability to compare one facility to another
  - Ability to compare one operating strategy vs. another

  - Timely information for the operations team
  - Long term reporting to measure performance over time
  - Something that looks nice!

Prior Work

Smart Water Initiative (2013)

- Grant money was used to install building digital power meters at all water facilities
- Custom daily power reports created by an system integrator
- Reports stopped working in mid-2015 due to software/data-feed issues

Hydro Bill Analysis Company, online services (available since 2015)

- Service the city uses to analyze power bills
- Web-based tool for downloading and analyzing power bills
- Data is available at the end of each month, **monthly power totals only**

Online Power Reports 2.0 (2016-2017)

- SCADA Group was asked to work with system integrator to fix online power reports
- Conventional SCADA software was used
- After a year of work with the integrator, the power reports were working again
- Reports provided daily totals (cost, kWh, m3 pumped), **data available "next day"**

But could we do better?

Better granularity, more timely data, better reports, ability to self-edit….

Skunkworks

A **Skunkworks project** is
a project developed by a small and loosely structured group of people who research and develop a project primarily for the sake of radical innovation.

The term originated with Lockheed's World War II *Skunk Works* project.

Let's see if we can use Open Source software to build something using IIoT…

IIoT = Industrial Internet of Things

Skunkworks SCADA Team

Goal: Make a better power reporting tool

Kick-off: Met at May 2017 OWWA conference

Graham Nasby
- Water SCADA & Security Specialist

Jason Little
- Open Source Software Developer
- Day job is a SCADA specialist at a nearby utility

Noah Clark
- SCADA co-op student (Jan-Apr 2018)
- Had a previous co-op at an energy management firm

Travis Murray
- SCADA Specialist (Nov`18-Jun`19)

This is what we built

Operational Dashboards - Watermain Flows/Pressures, Towers, Pumping Costs

How it works

Digital Power Monitors

Plant PLC's
(Flow Data)

NEPTUNE CLUSTER

Polls Data Every Second

Pump Motor Starters

Single Board Computer < $35
(Neptune Cluster software)

Logs data every 5min
Logs changes on 1 sec intervals

TITAN
BROKER

Pushes to Historizer Server

TRIDENT
HISTORIZER

Pushes to Time Series Database

CASSANDRA
STORAGE DB

Distributed Open Source Database (no licensing fees)

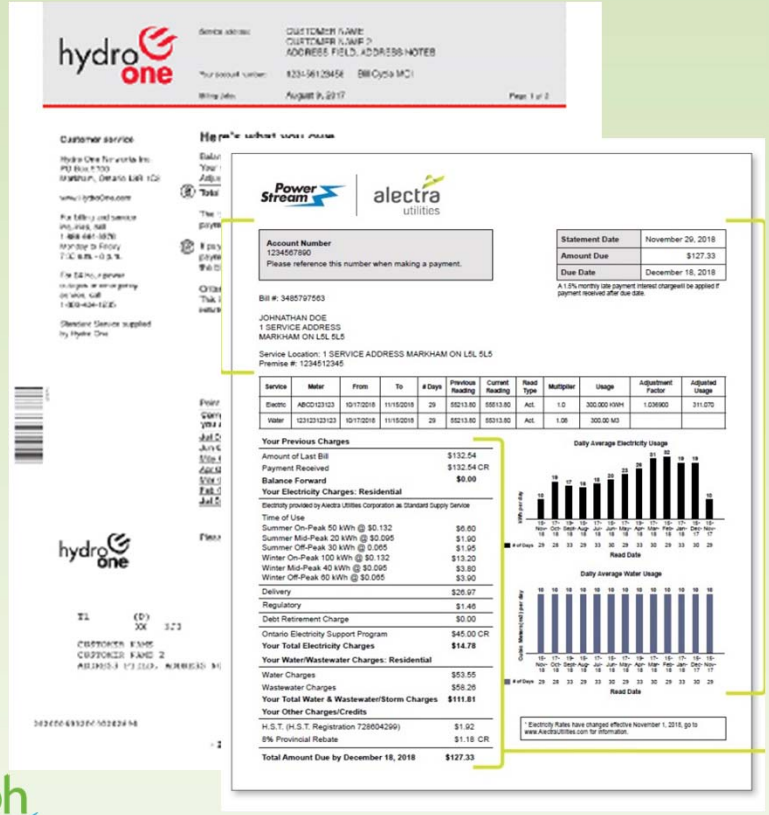
Web-based Dashboard & Reporting Tool

Grafana

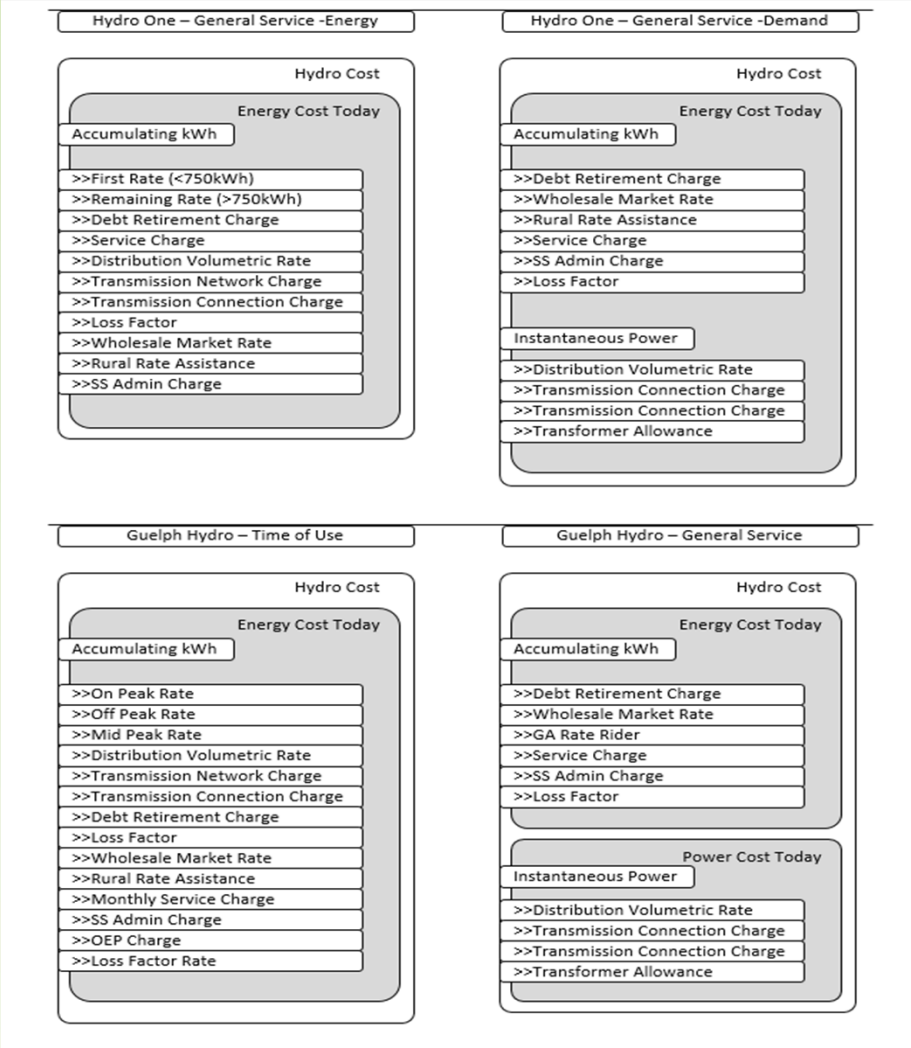
Power Calculations

- **Measuring Electricity Usage is EASY…**
- **Calculating Power Costs is HARD!**
- **Ontario has one of the most complicated electricity pricing schemes in the world**

- **Connection Charges**
- **Transmission Charges**
- **Distribution Charges**
- **Transformer Factors**
- **Energy Usage**
- **Peak Charges**
- **Ontario Hourly Energy Prices**
- **Time of Day Adjustments**
- **Global Adjustment**
- **Global Adjustment Estimates**
- **End of the Month Balancing**
- **Debt Retirement Charges**
- **Rebates**
- **Etc.**



Power Calculations



Hydro One	
<50kW	>50kW
General Service – Energy (aka Two Tiered)	General Service – Demand
Arkell 08	Arkell 06
Arkell 14	Arkell 07
Arkell 15	
Guelph Hydro	
<50kW	>50kW
Time of Use	General Service
Calico	Burke Well
Carter	Clythe Creek
Clair Booster	Downey
Dean	Emma
Helmar	Membro
Queensdale	Paisley
Robertson	Park
	Univeristy
	Water Street
	Woods

Power Calcs

Digital Power Monitors

Plant PLC's
(Flow Data)

Polls Data Every
Second

Pump Motor Starters

ieso
Connecting Today.
Powering Tomorrow.

IESO Website

Live Feed of
Hourly
Global Adjustment
Hourly Energy Prices

NEPTUNE
CLUSTER

Calculates Live
Energy Costs
every 5 mins

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CASSANDRA
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Distributed
Open
Source
Database

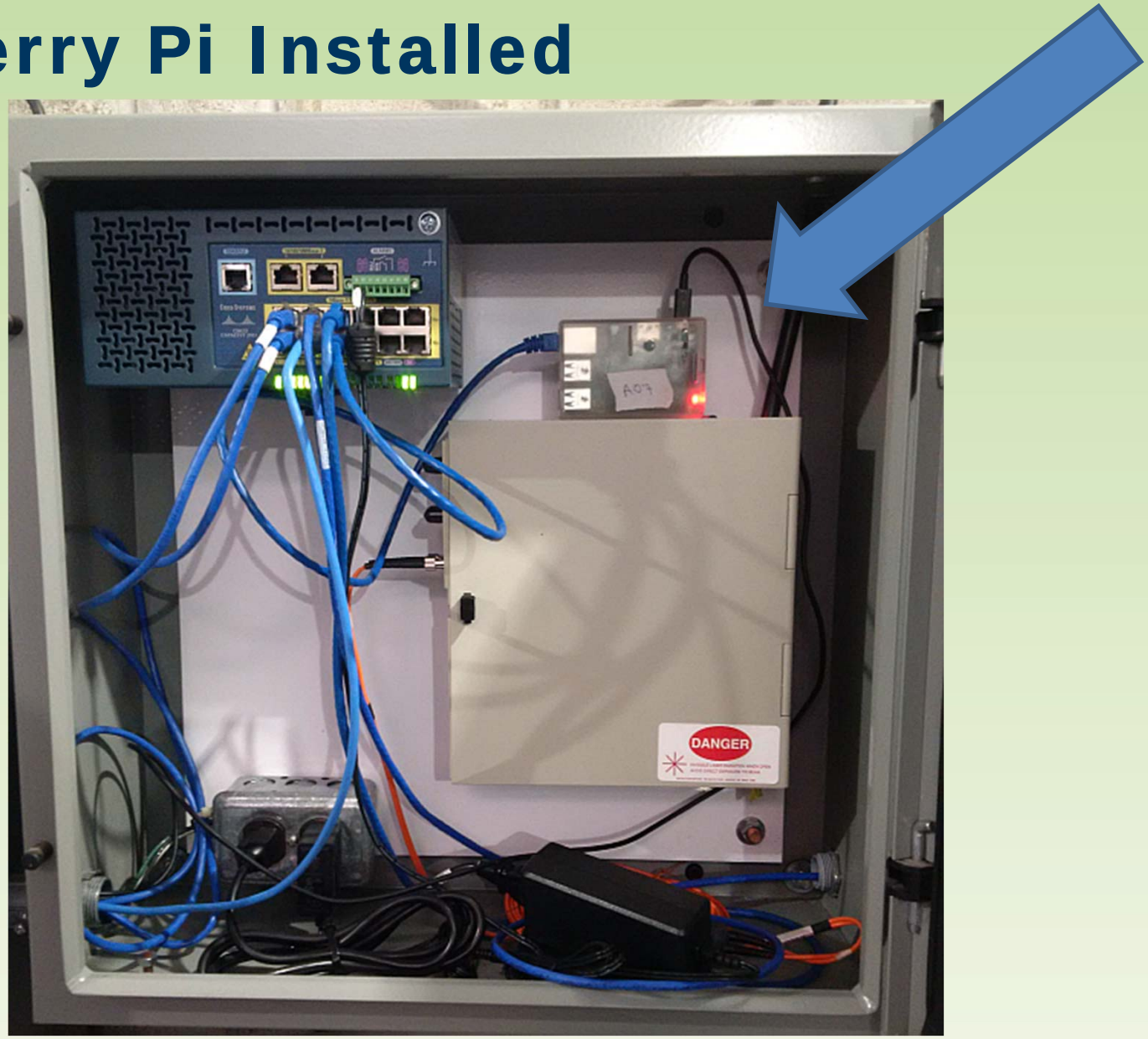
Web-based
Dashboard
& Reporting
Tool

Grafana

Operational Dashboards - Watermain Flows/Pressures, Towers, Pumping Costs

Guelph
Making a Difference

Raspberry Pi Installed



Collecting the Data

Grafana - DMA Overview | Grafana - Report - Monthly Powe | 172.16.1.122:8080 | Node-RED Dashboard | Trident Historizer : 172.16.1.120

Not secure | 172.16.1.122:1880/ui/#/0

Neptune Cluster Dashboard

Triton Edge Messengers

Site	State	Buffer	Poll	RBE	CPU	IP	Uptime
A06	ONLINE	0	52	3	0.63	172.16.65.29	507.89
A07	ONLINE	0	56	8	0.79	172.16.65.39	503.22
A08	ONLINE	0	55	13	0.89	172.16.65.49	385.23
A14	ONLINE	0	53	10	0.66	172.16.65.19	41.38
A15	ONLINE	0	55	2	0.62	172.16.65.9	507.87
ADV	ONLINE	0	7	1	0.20	172.16.65.59	507.88
BKS	ONLINE	0	40	3	0.88	172.16.72.49	148.31
CAB	ONLINE	0	49	12	0.63	172.16.28.49	510.82
CBS	ONLINE	0	58	7	0.74	172.16.73.49	349.00
CCB	ONLINE		51	6	0.72	172.16.51.49	116.16
CLT	ONLINE	0	5	0	0.22	172.16.73.46	30.63
CWS	ONLINE	0	52	6	0.57	172.16.53.49	99.34
DEB	ONLINE	0	50	2	0.61	172.16.22.49	70.16
DOB	ONLINE	0	56	13	0.72	172.16.71.49	210.07
EWS	ONLINE	0	52	1	0.64	172.16.43.49	56.23
HEB	ONLINE		60	5	0.87	172.16.45.49	350.18
MEB	ONLINE	0	53	13	0.69	172.16.23.49	507.74
PAB	ONLINE		54	7	0.61	172.16.44.49	127.15
PRB	ONLINE	0	51	2	0.53	172.16.26.49	15.17
QUB	ONLINE	0	49	4	0.53	172.16.25.49	510.79
ROB	ONLINE	0	52	11	0.65	172.16.41.49	36.30
SCS	ONLINE		2	0	0.09	172.16.52.49	507.91
SPT	ONLINE	0	5	0	0.24	172.16.27.49	41.27
UNB	ONLINE	0	57	3	0.72	172.16.24.49	13.18
VET	ONLINE	0	4	0	0.14	172.16.42.49	52.86
WDB	ONLINE		13	1	0.33	172.16.1.79	166.96
WWS	ONLINE		52	2	0.63	172.16.21.49	237.14

Titan Brokers

Broker 1: **ONLINE**

response **0.382 ms**

Trident Historizers

Historizer 1: **ONLINE**

Tag Count: **6617**

Tag Rate

Tag Rate History

Insert Rate

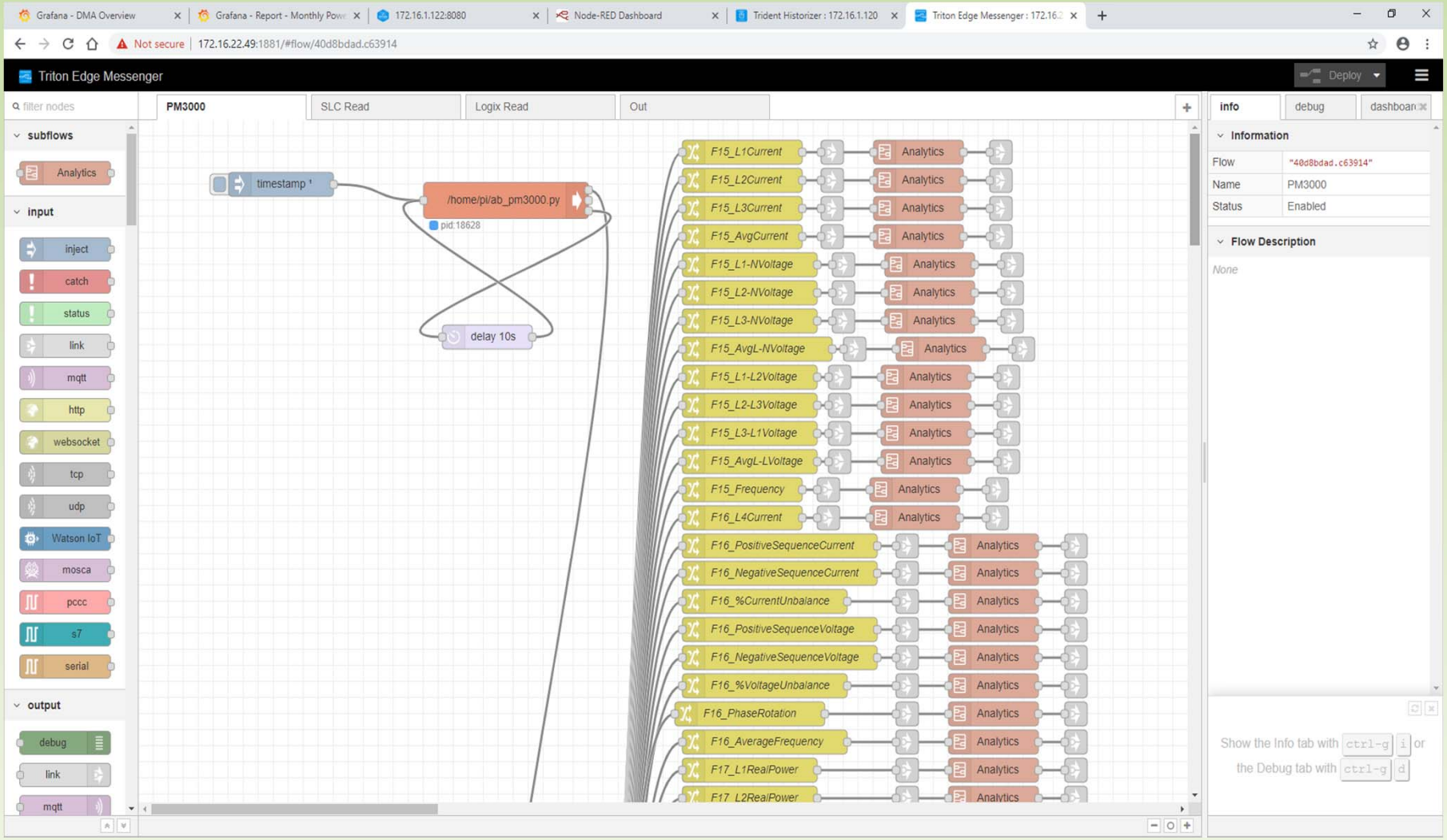
Insert Rate History

Clustered Storage Nodes

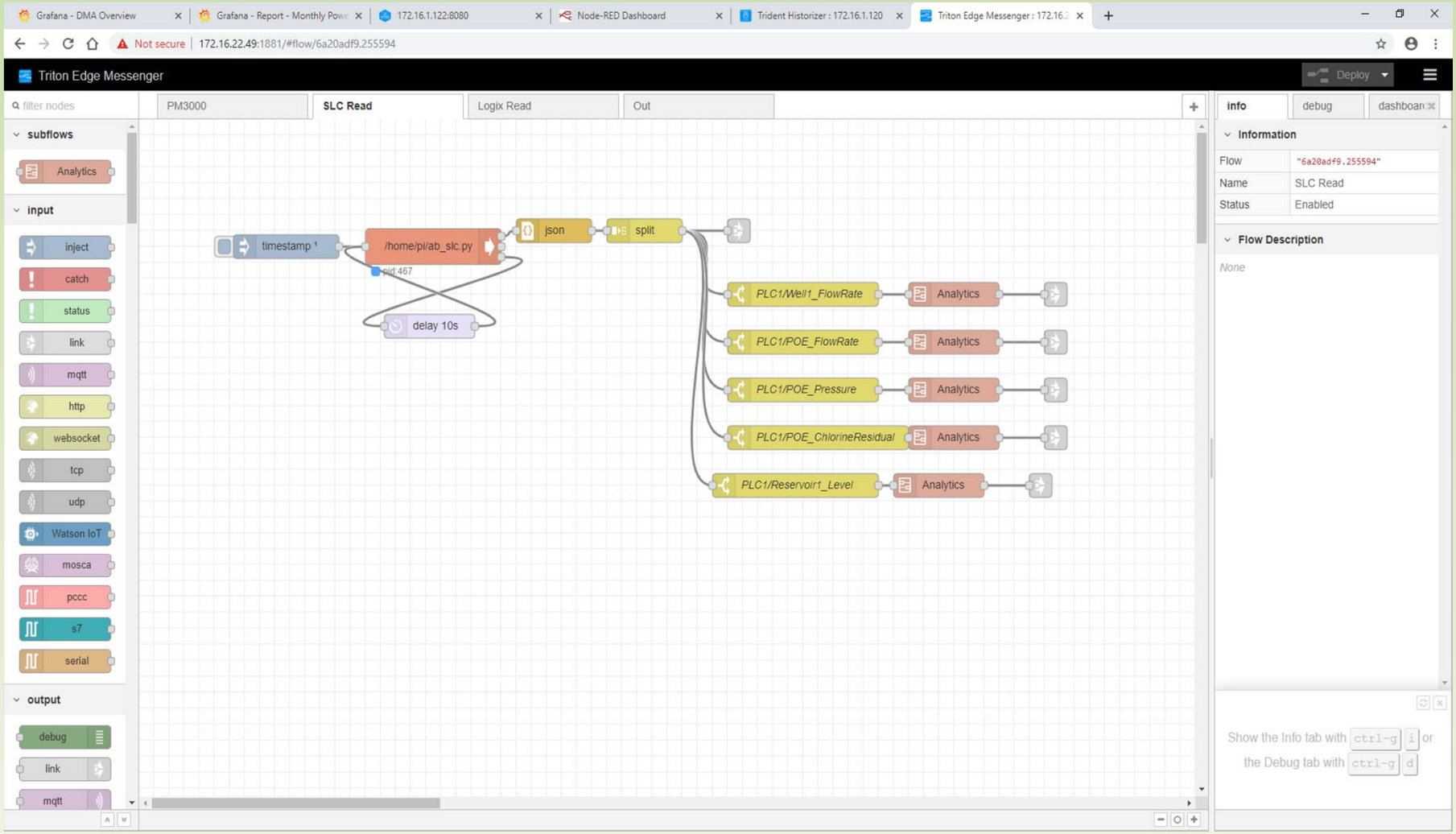
Node 1: **ONLINE**

response **1.03 ms**

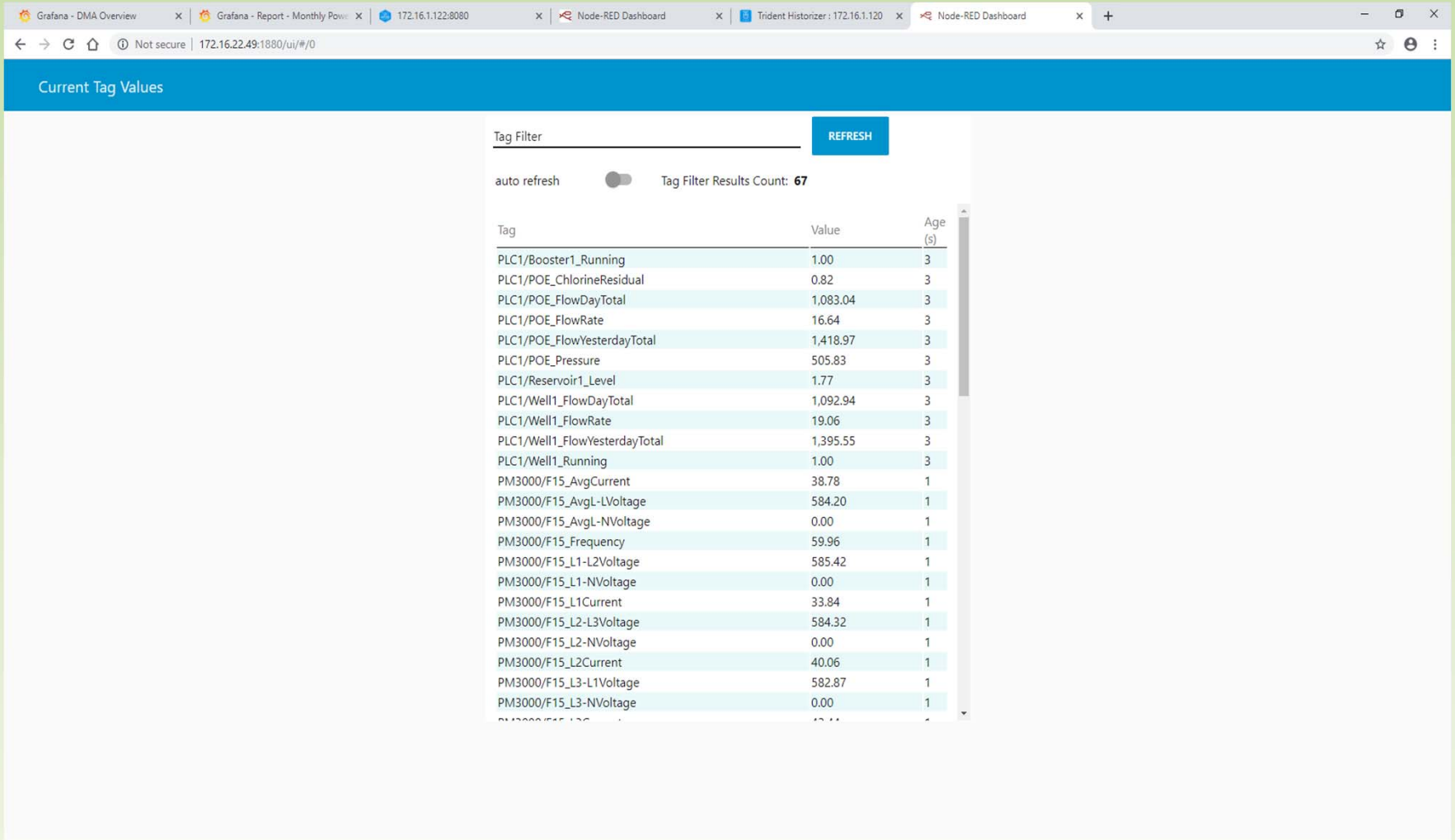
Pulling Data from Digital Power Monitors



Pulling Data from Water Supply Site PLCs

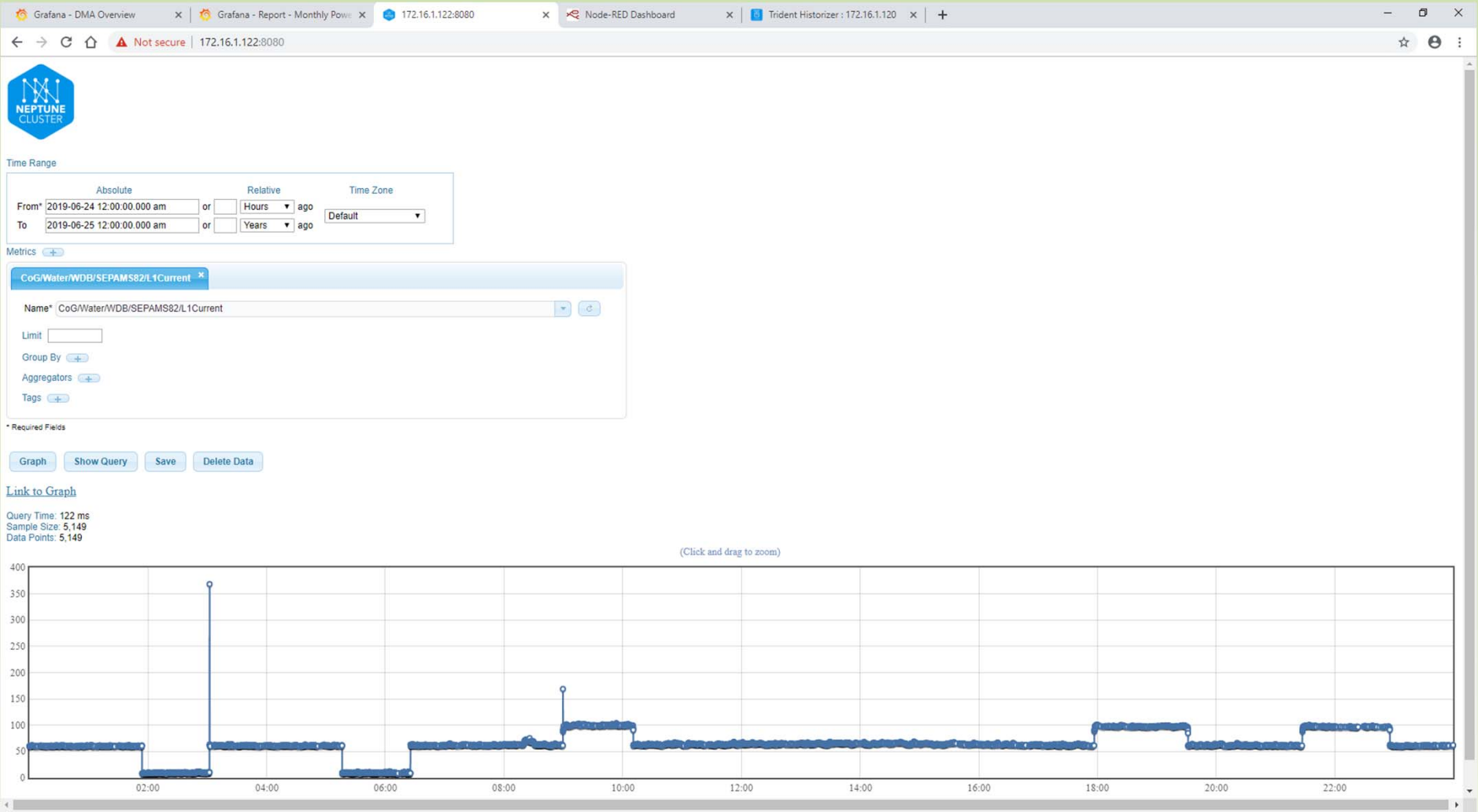


Buffering Data in the Raspberry Pi's



Tag	Value	Age (s)
PLC1/Booster1_Running	1.00	3
PLC1/POE_ChlorineResidual	0.82	3
PLC1/POE_FlowDayTotal	1,083.04	3
PLC1/POE_FlowRate	16.64	3
PLC1/POE_FlowYesterdayTotal	1,418.97	3
PLC1/POE_Pressure	505.83	3
PLC1/Reservoir1_Level	1.77	3
PLC1/Well1_FlowDayTotal	1,092.94	3
PLC1/Well1_FlowRate	19.06	3
PLC1/Well1_FlowYesterdayTotal	1,395.55	3
PLC1/Well1_Running	1.00	3
PM3000/F15_AvgCurrent	38.78	1
PM3000/F15_AvgL-LVoltage	584.20	1
PM3000/F15_AvgL-NVoltage	0.00	1
PM3000/F15_Frequency	59.96	1
PM3000/F15_L1-L2Voltage	585.42	1
PM3000/F15_L1-NVoltage	0.00	1
PM3000/F15_L1Current	33.84	1
PM3000/F15_L2-L3Voltage	584.32	1
PM3000/F15_L2-NVoltage	0.00	1
PM3000/F15_L2Current	40.06	1
PM3000/F15_L3-L1Voltage	582.87	1
PM3000/F15_L3-NVoltage	0.00	1

Direct Query Tool for Cassandra Database



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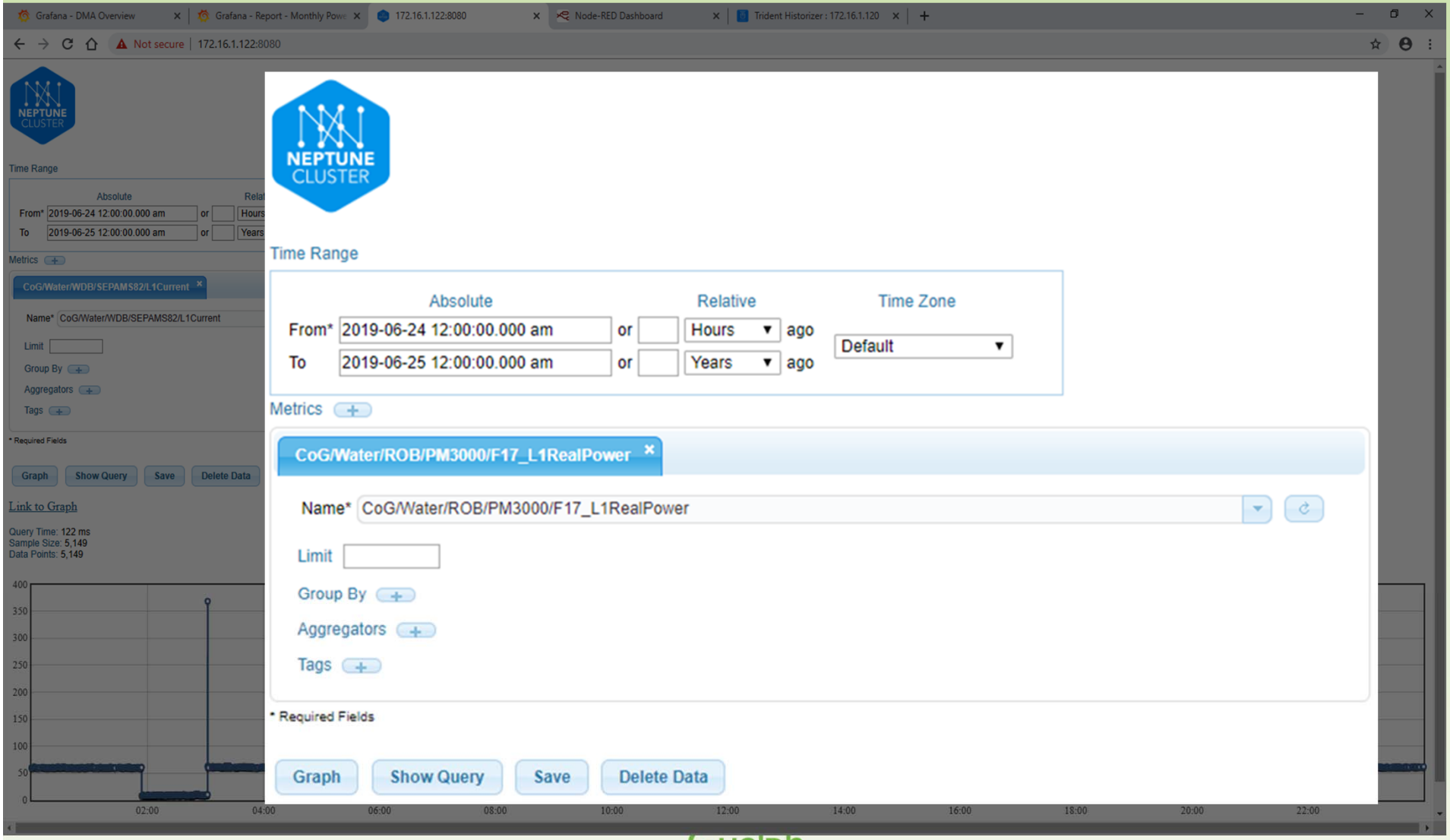
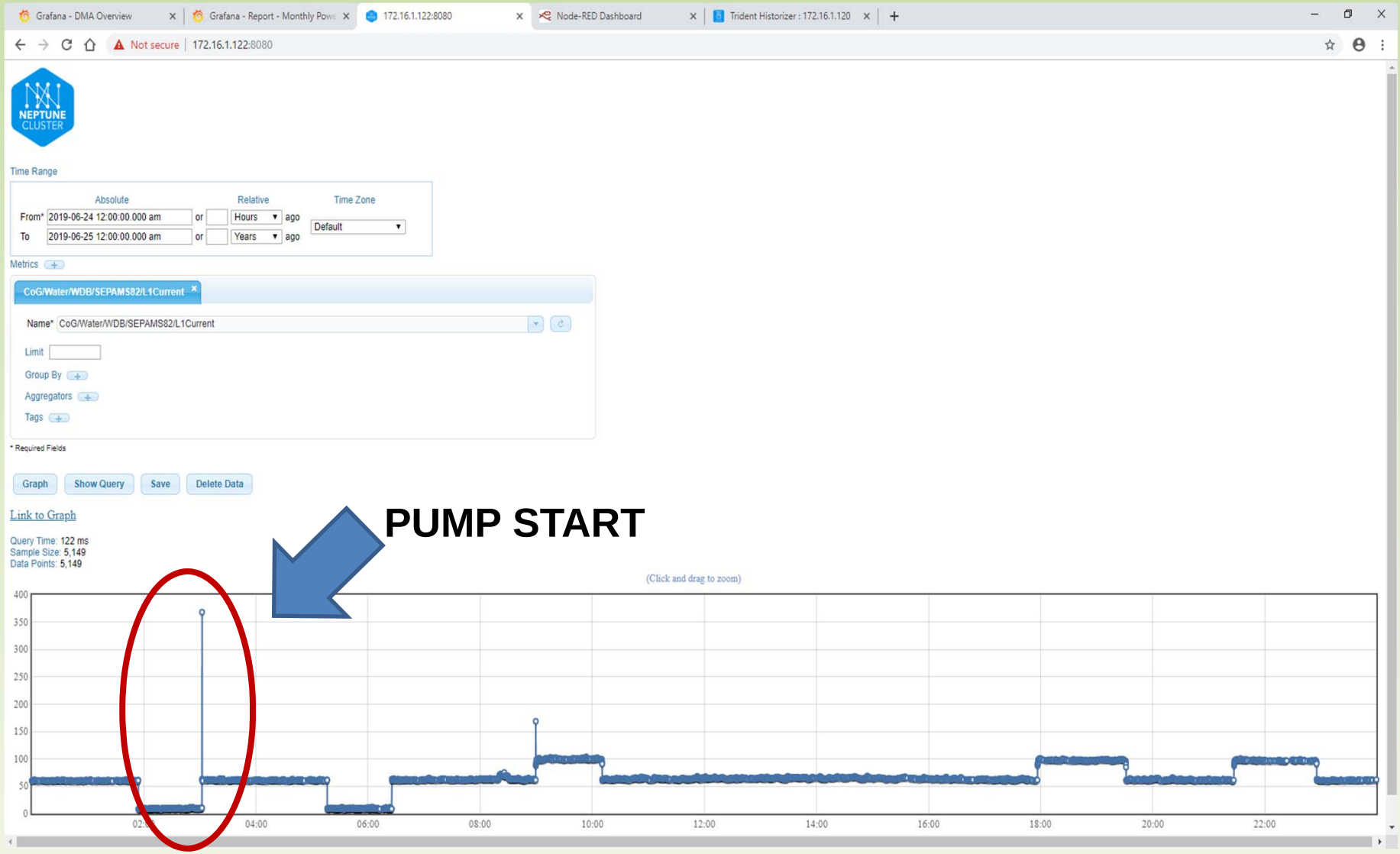


Direct Query Tool: Woods Pump Starts



PUMP START

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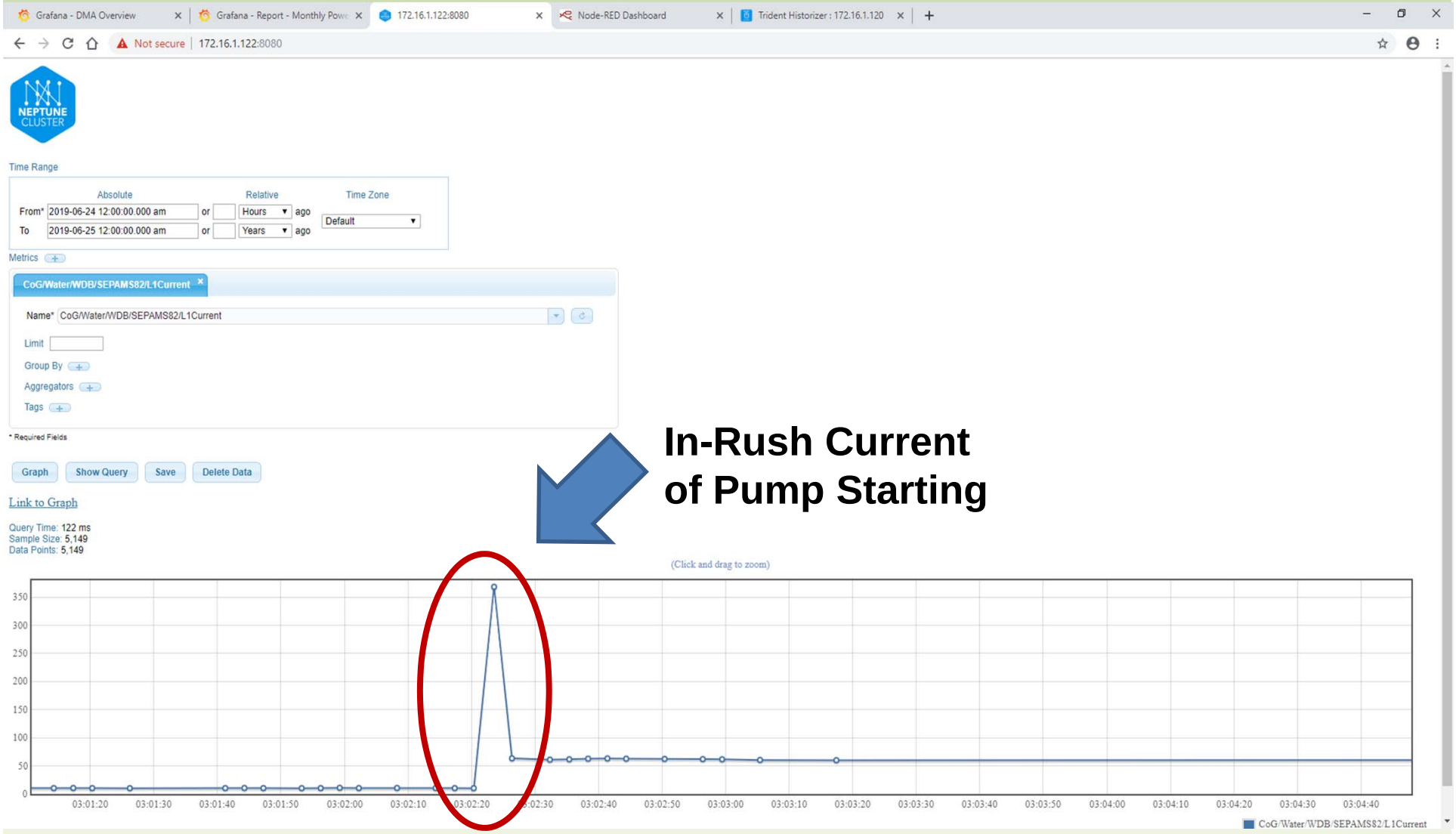
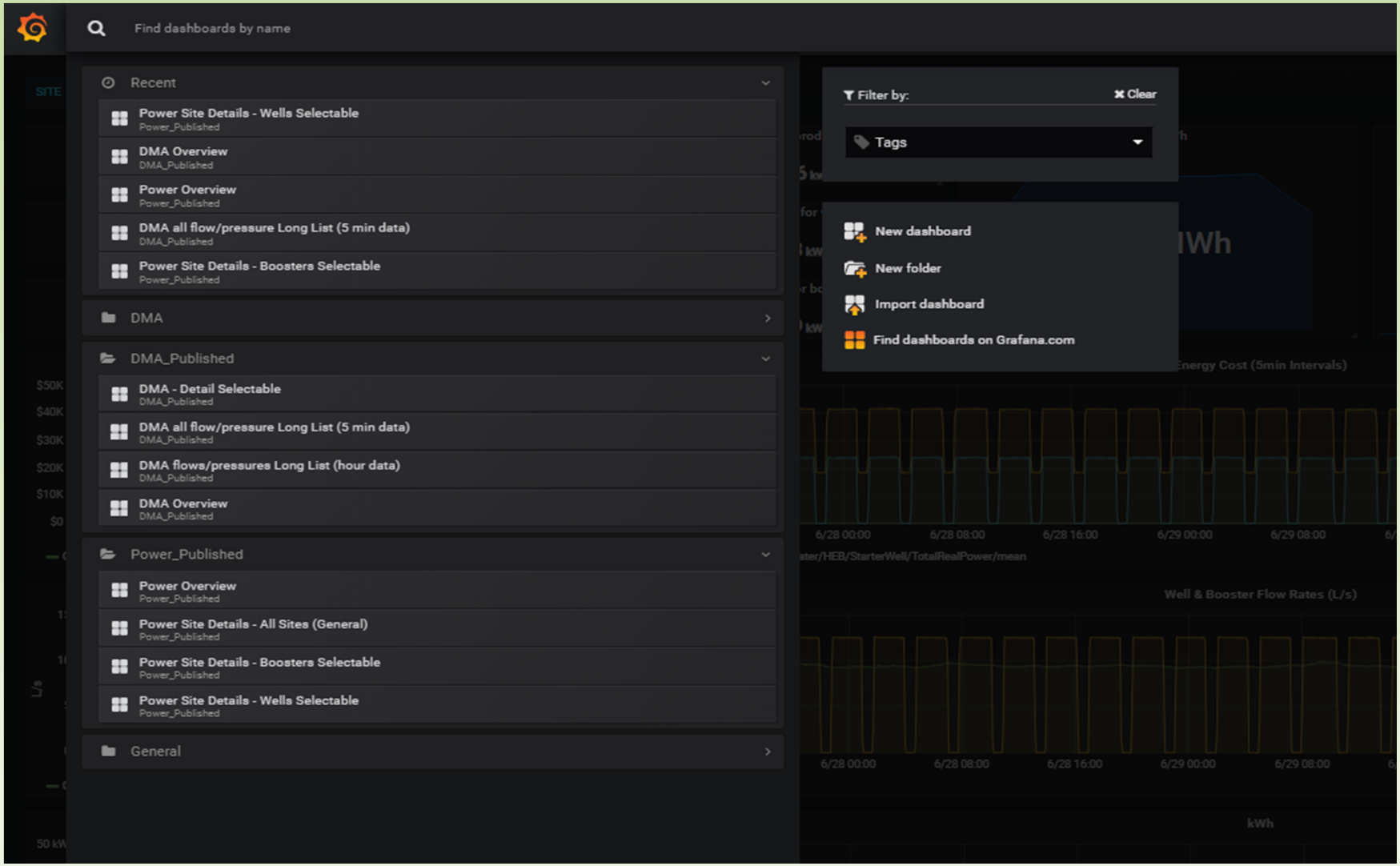


In-Rush Current of Pump Starting

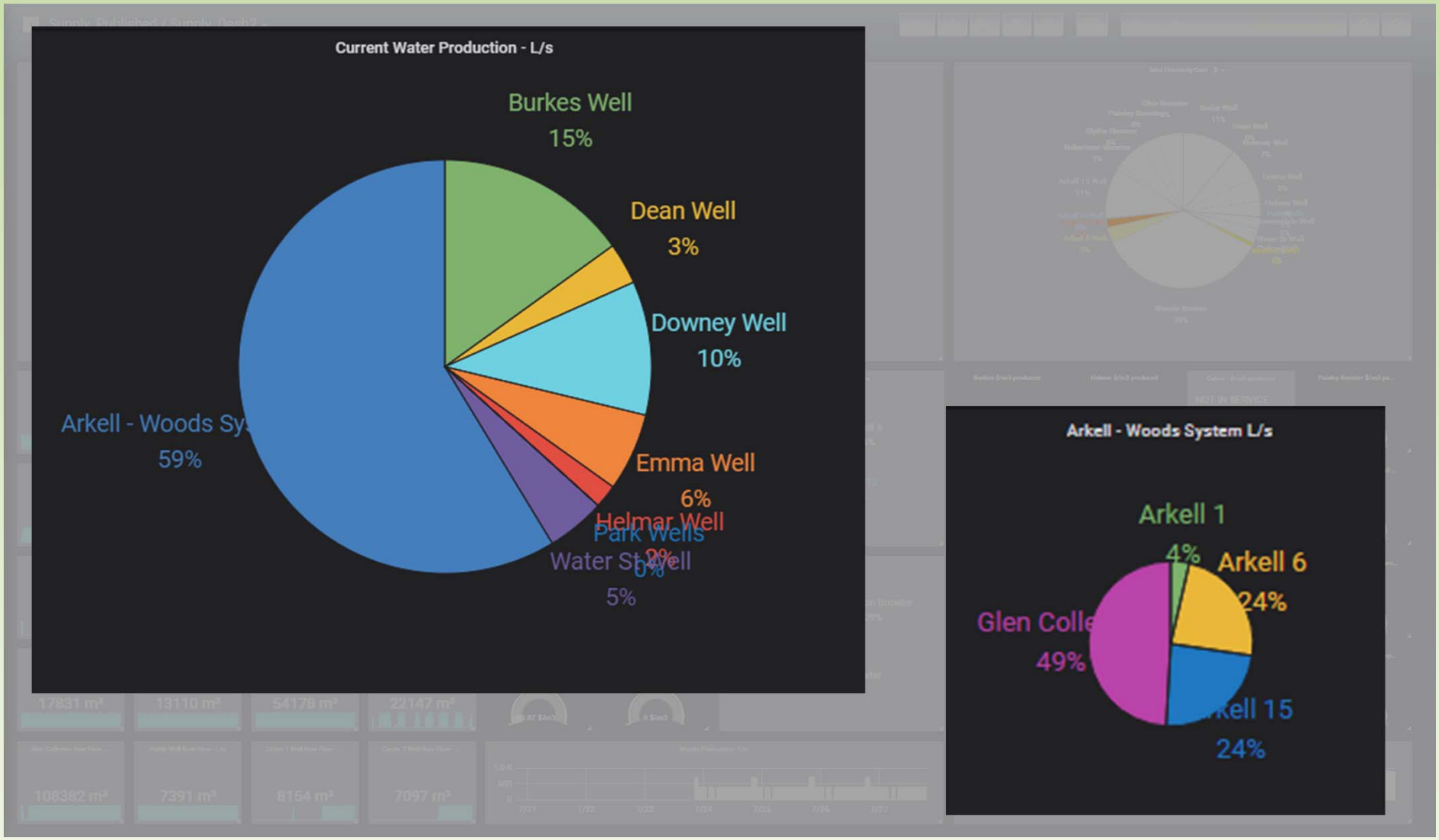
Grafana web-based Dashboarding Tool



Power Dashboard (in our Treatment Ops Area)

Operational Dashboards - Watermain Flows/Pressures, Towers, Pumping Costs

Where the water comes from



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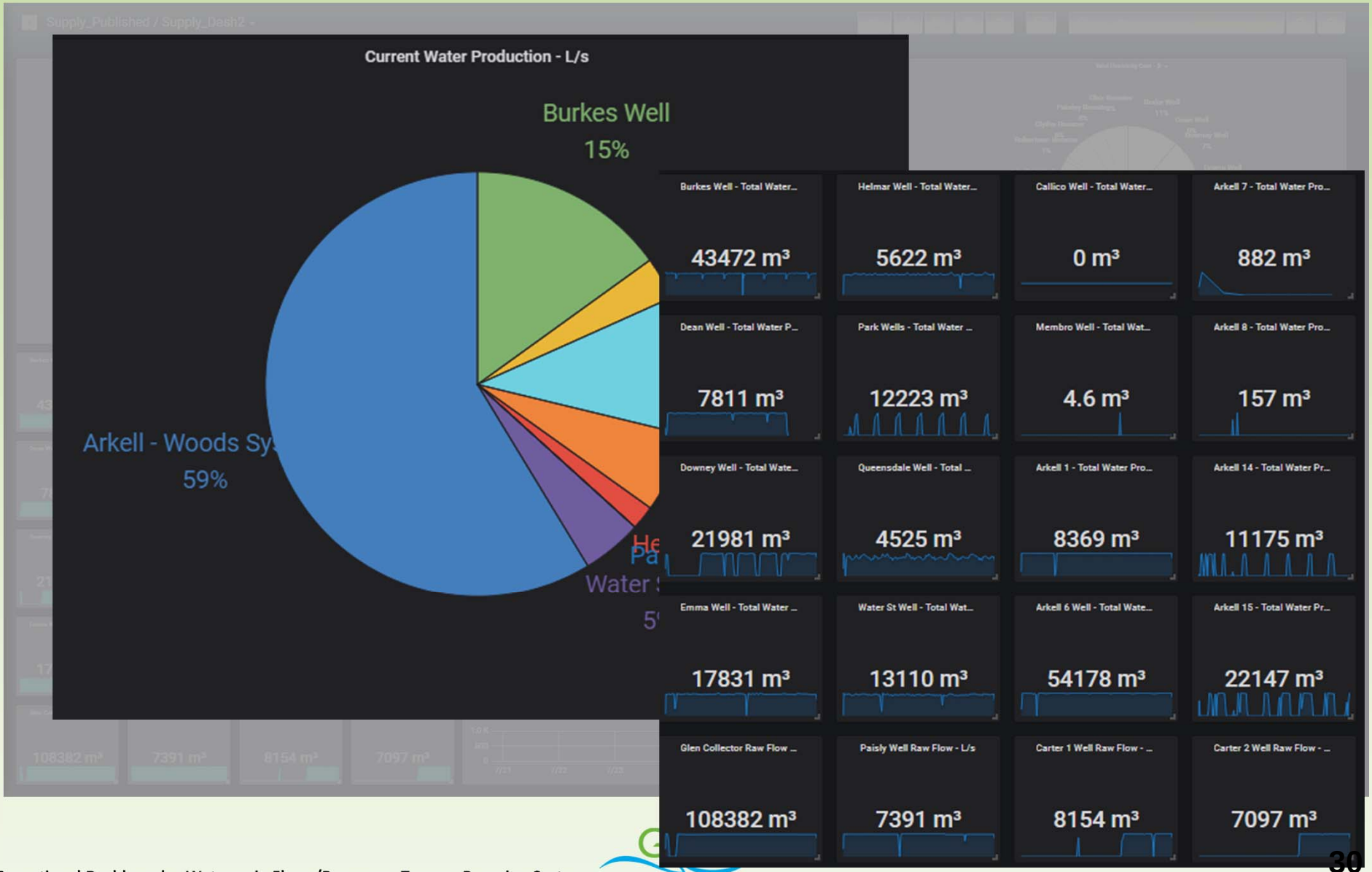
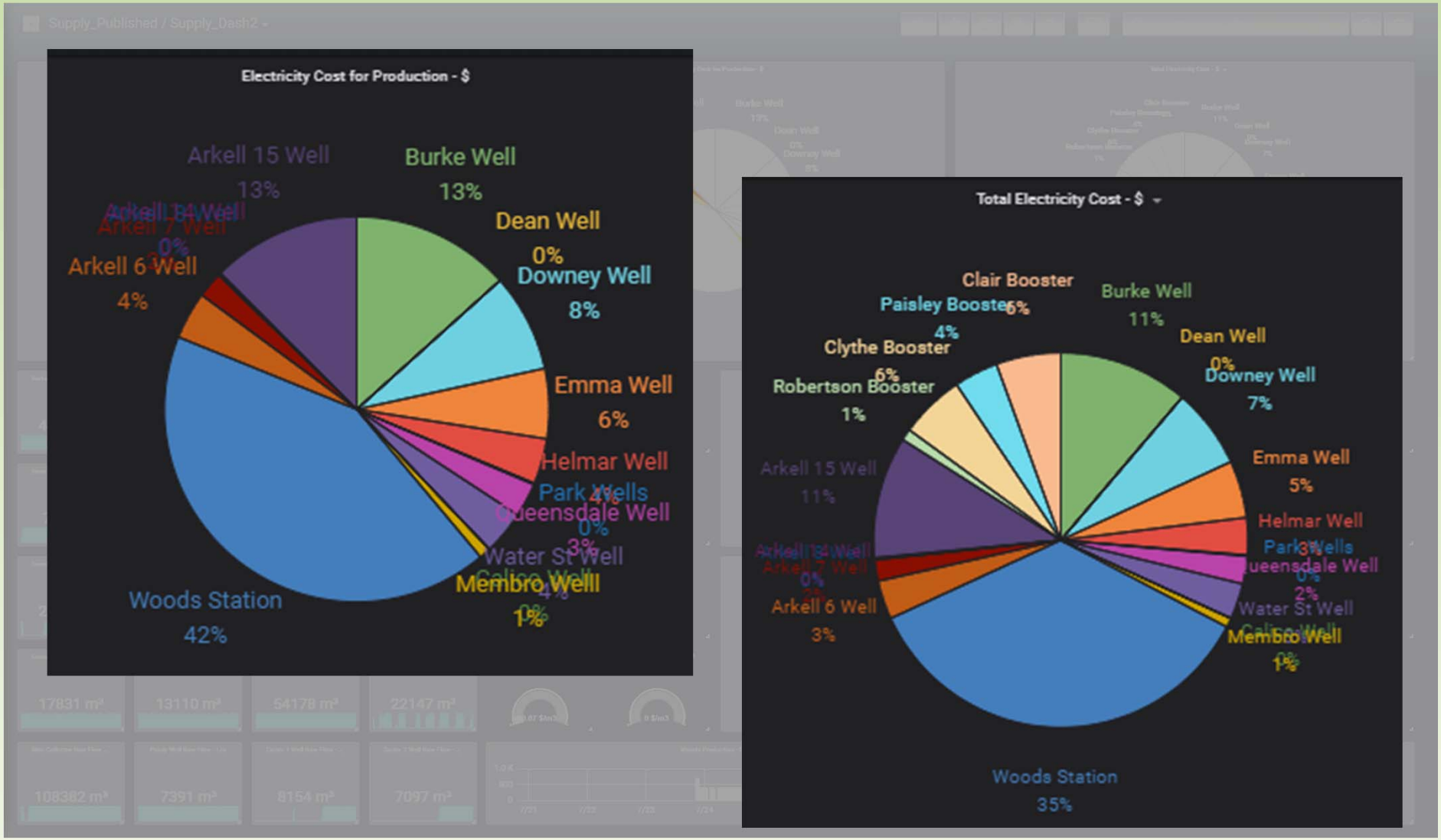


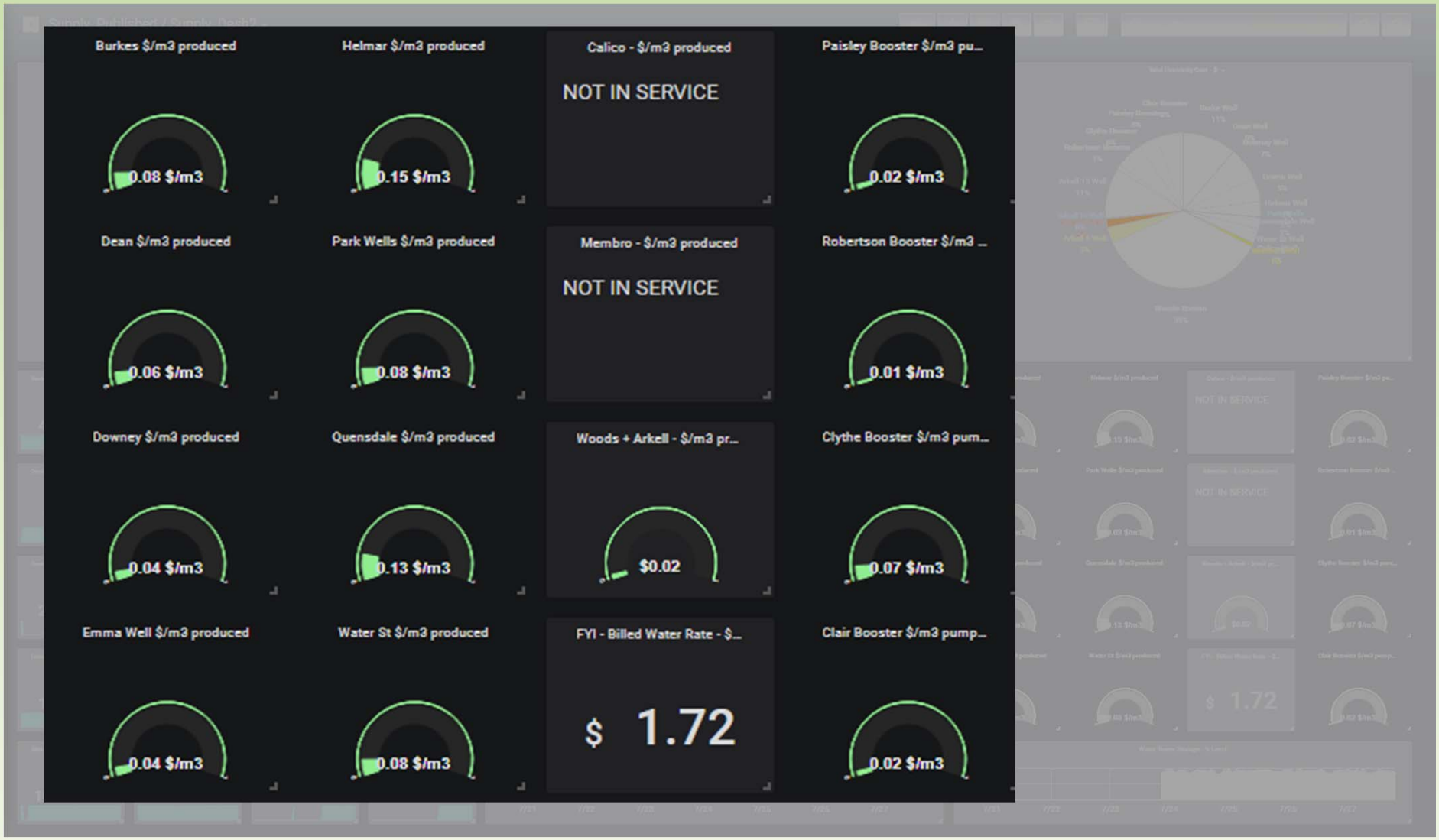
Operational Dashboards - Watermain Flows/Pressures, Towers, Pumping Costs

Live Breakdown of Electricity Costs for Water Utility



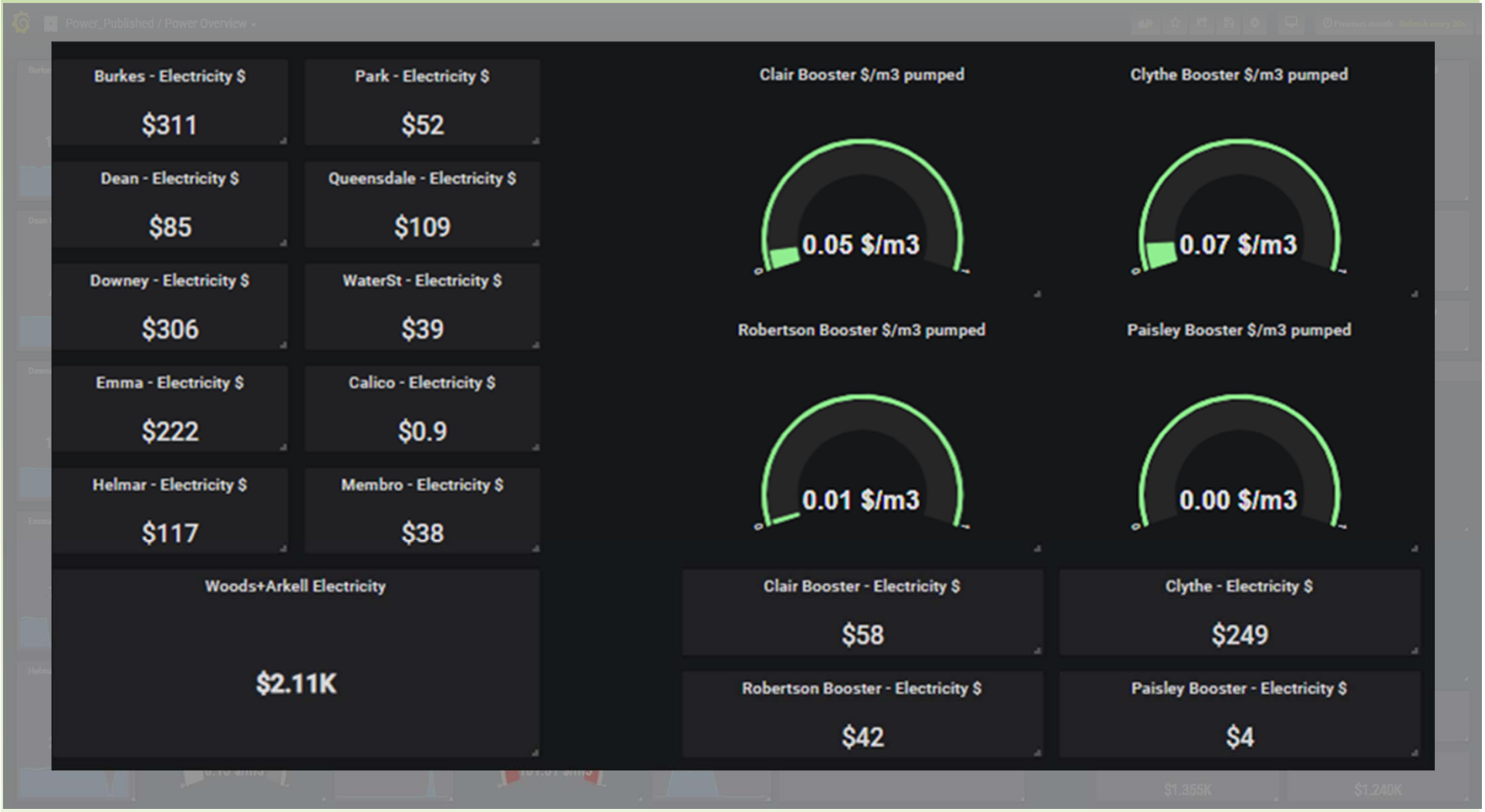
Electricity cost to Produce Water: $/m3

Putting Electricity Costs in Perspective:
Water Production & Booster Pumping

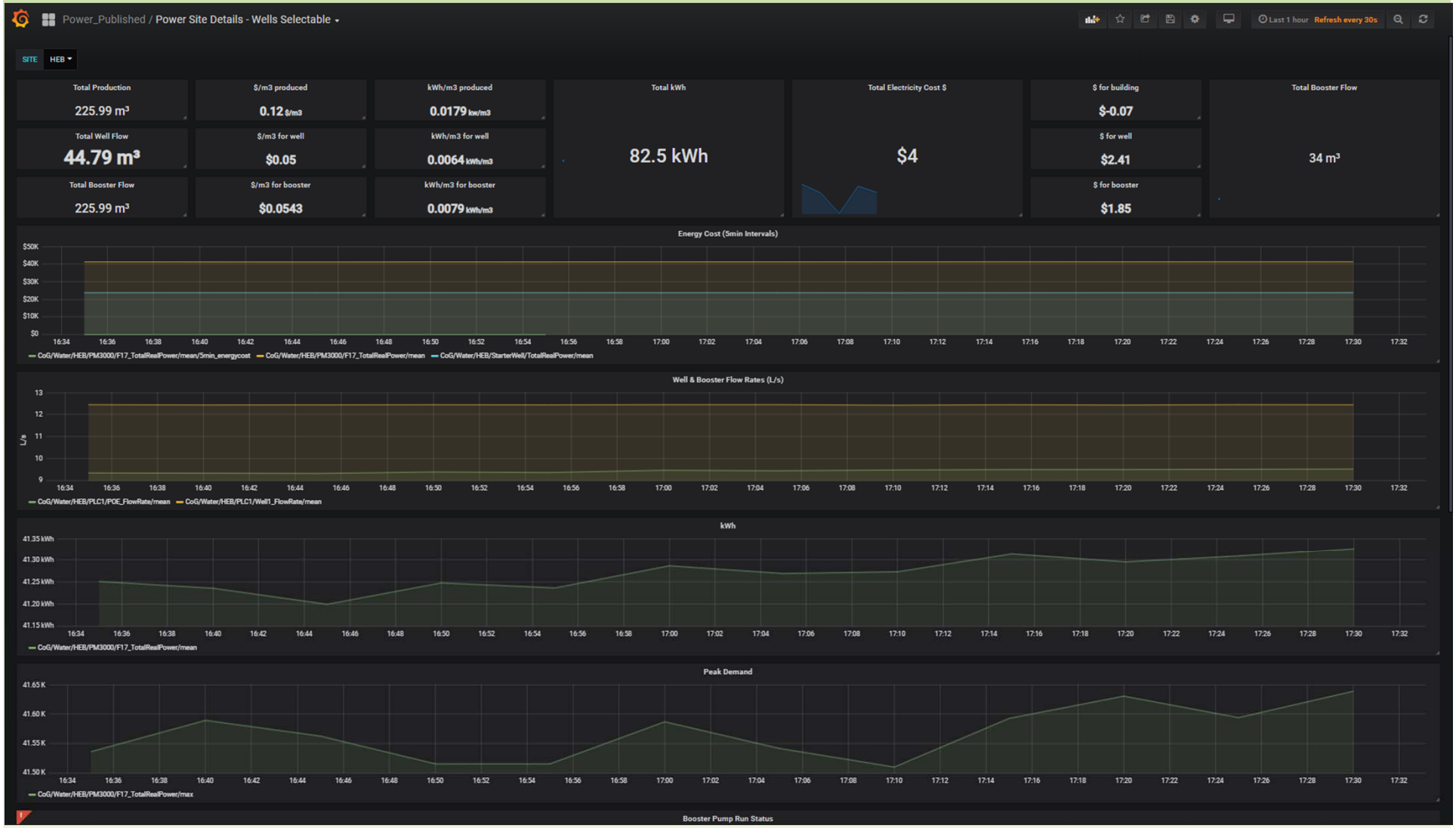


Power Operational Dashboard

Power Operational Dashboard: Daily Electricity Costs



Site Detail - Helmar Well (1hour)



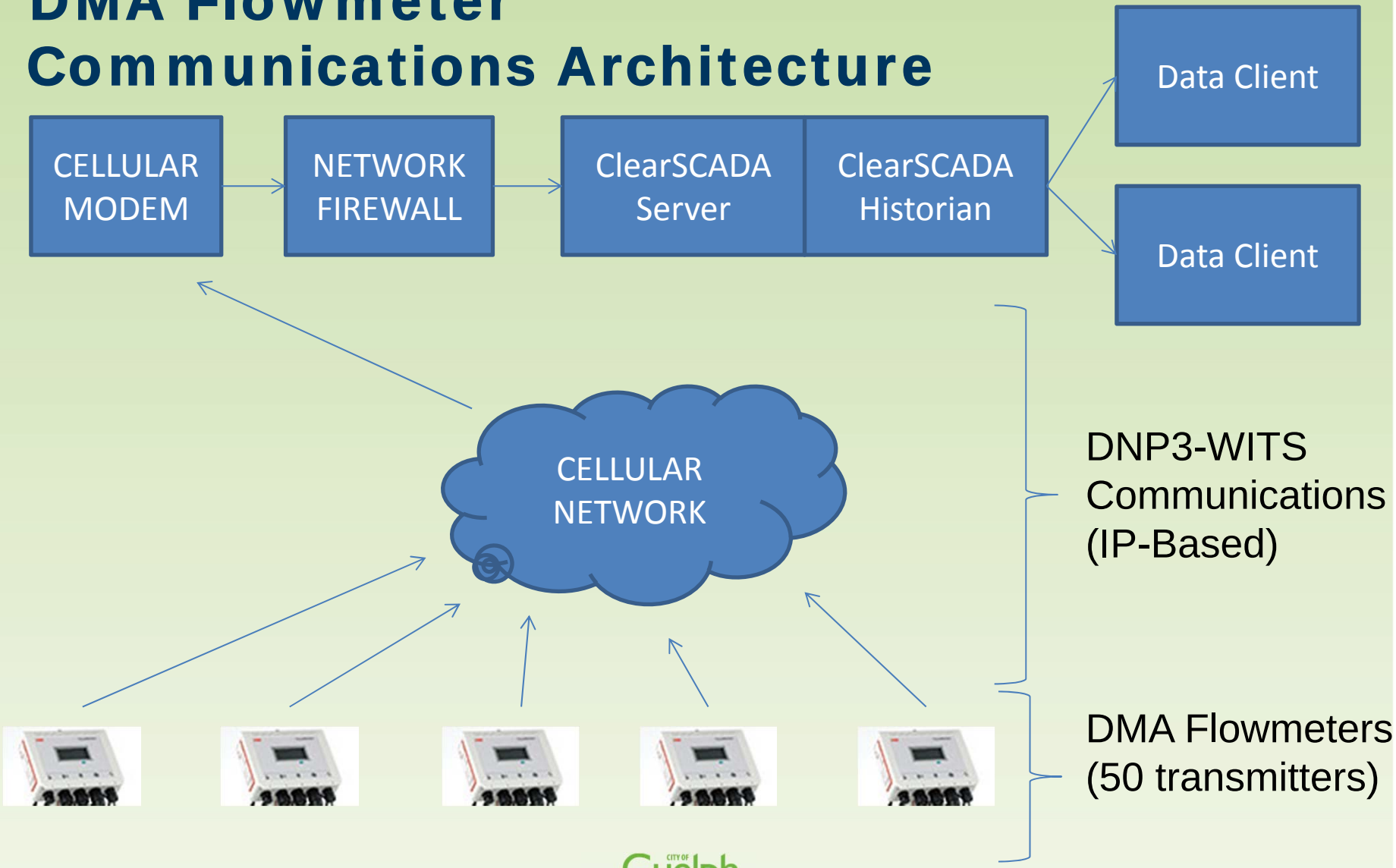
Site Detail– Robertson Booster (2 days)

Site Detail– Robertson Booster (30 days)

Let's use Neptune to manage our DMA Flowmeter Data…

DMA = District Metered Area Flow / Pressure Monitoring in Water Distribution System

DMA Flowmeter Communications Architecture



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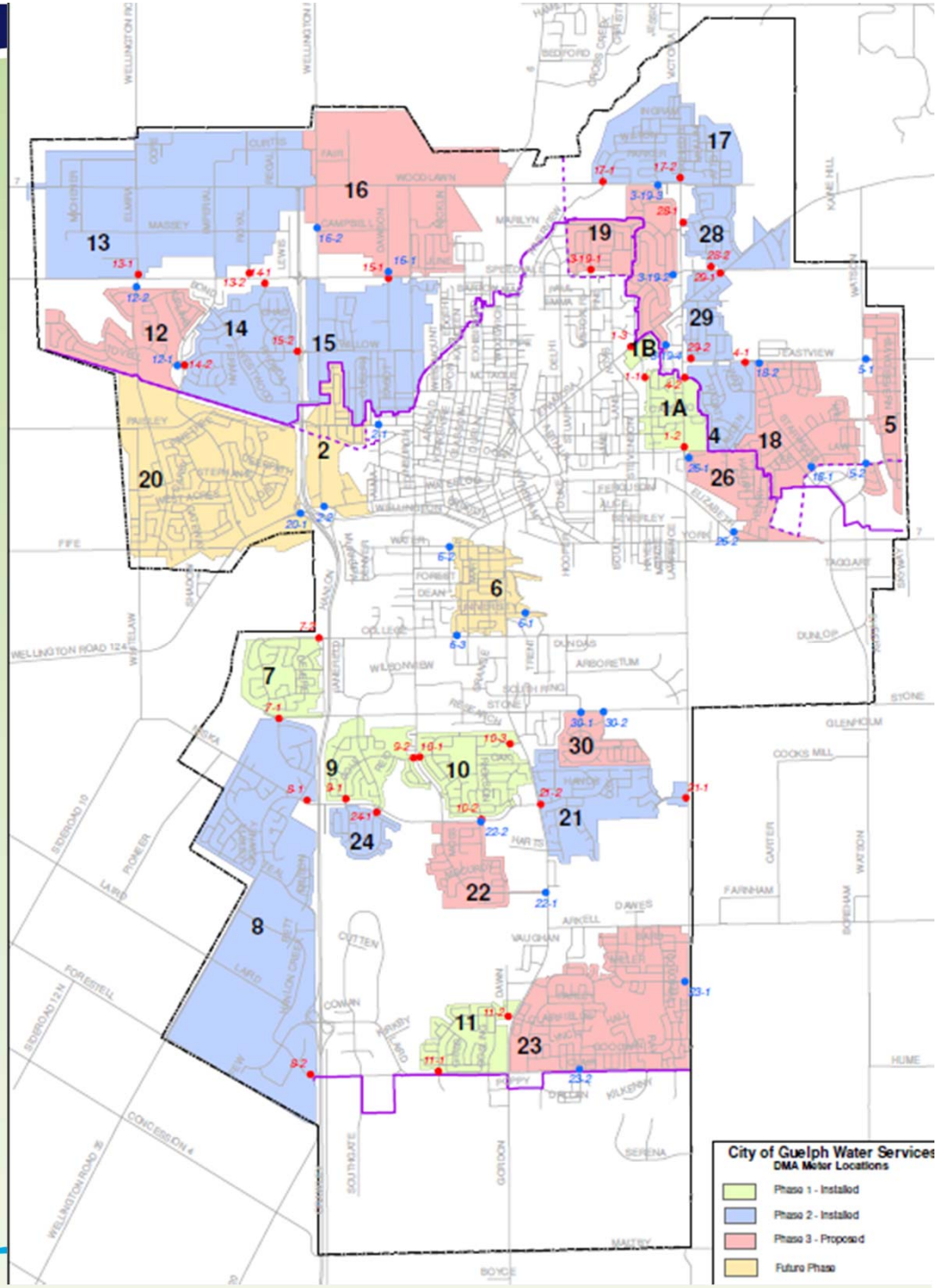
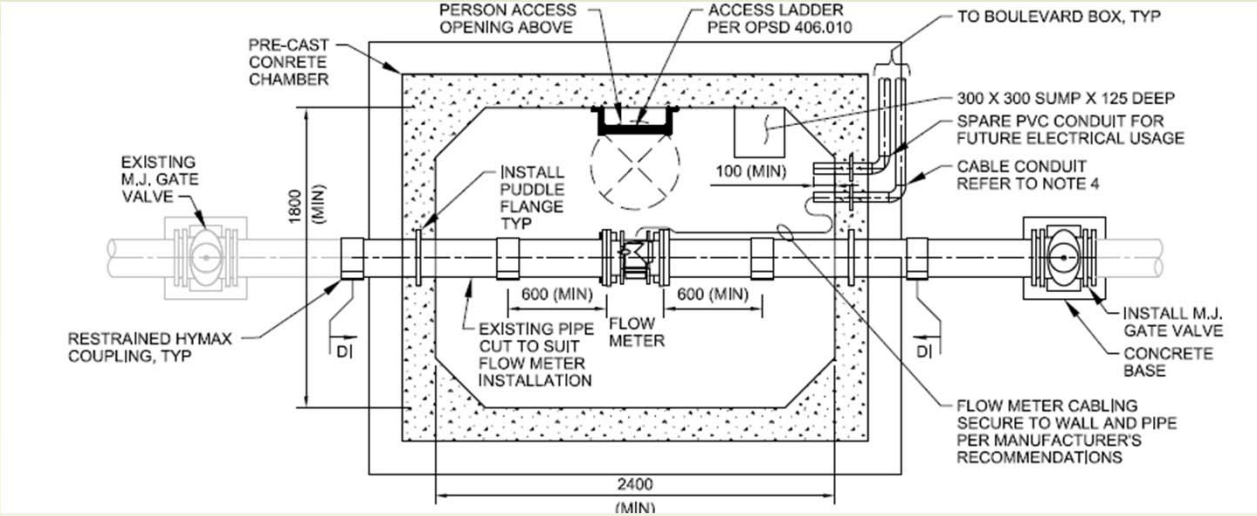


District Flow Meters

- Magnetic Flowmeter
- Integrated Remote Transmitter
  - Transmitter
  - Data Logger
  - Cellular Modem & Antenna
  - Built-in DNP3-WITS Protocol
  - IP 68 Submersion Rated
  - Long Life Battery
- Flow Tube
  - IP68 Submersion Rated

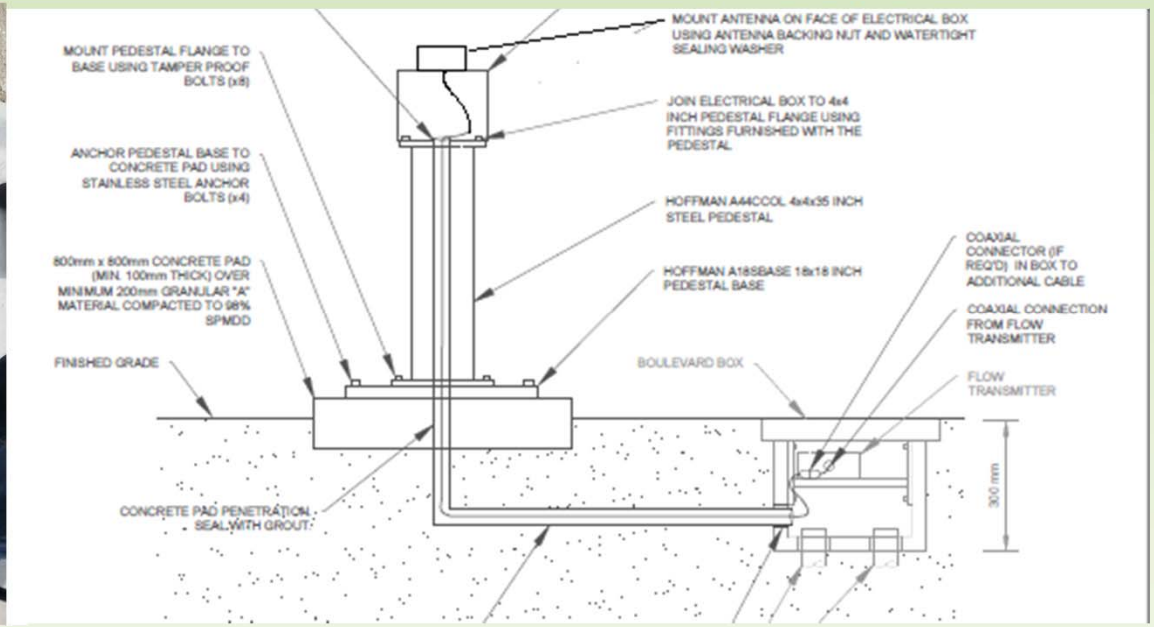
Flowmeter Chambers

- Each DMA is enabled by closing valves, so only 2-3 entry points
- Put Flowmeter chamber on each of DMA's entry points
  - Chamber contains the Flowmeter "flow tube"
  - Pressure sensor (also monitored by flowmeter electronics)
  - Upstream and downstream isolation valves

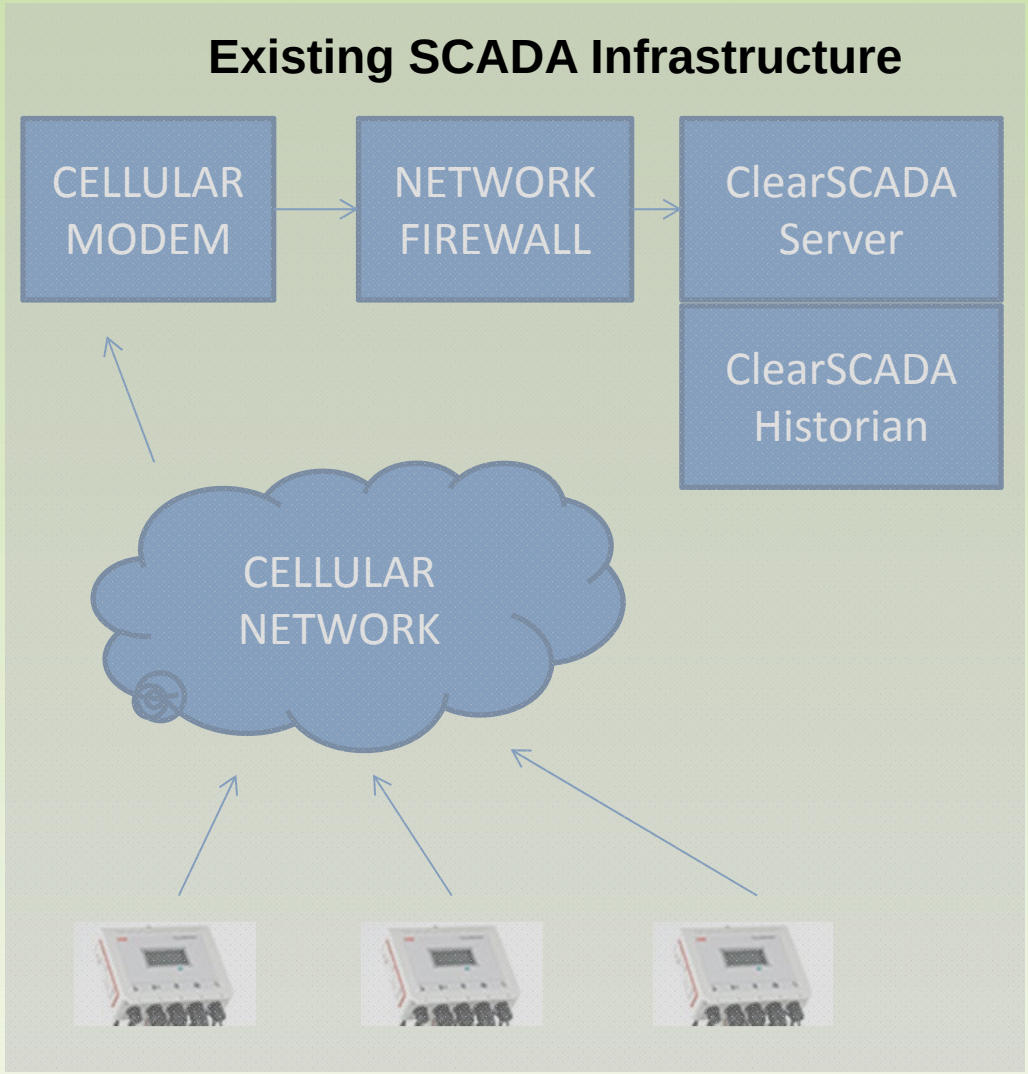


Flowmeter Transmitters

- Flowmeters installed into boulevard boxes
- Antenna pedestals to mount cellular antennas on

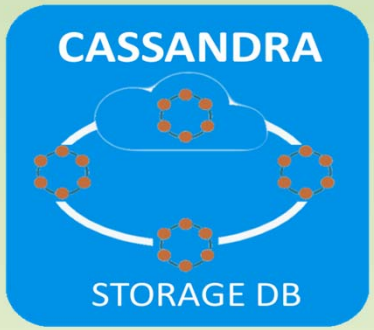


Applying Neptune to DMAs

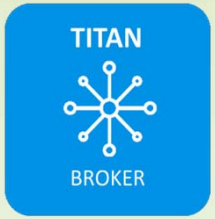


Web-based Dashboard & Reporting Tool

Distributed Open Source Database (no licensing fees)



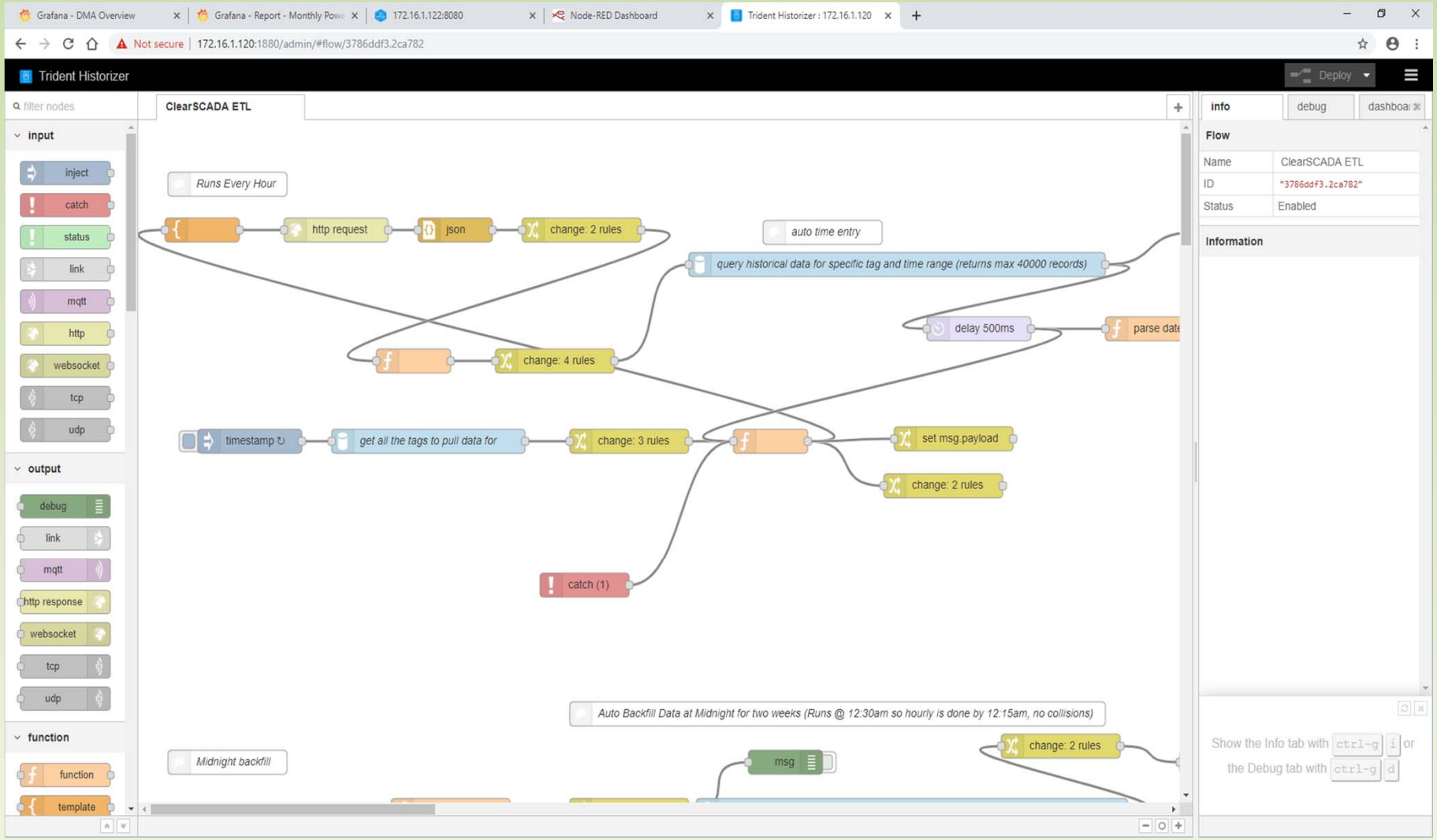
Hourly Data Sync Script



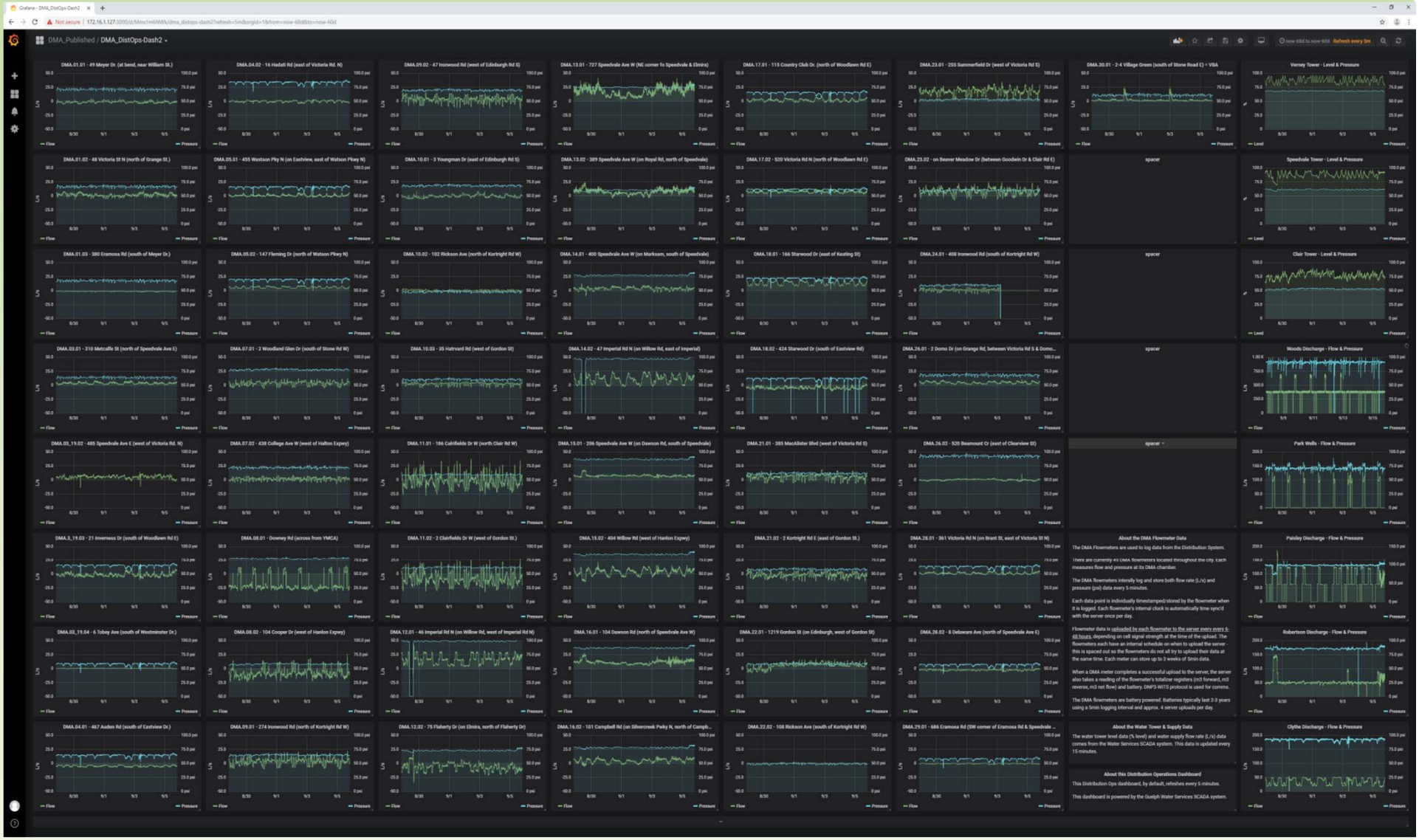
Pushes to Historizer Server

Pushes to Time Series Database

Neptune Hourly Data Sync Scripting

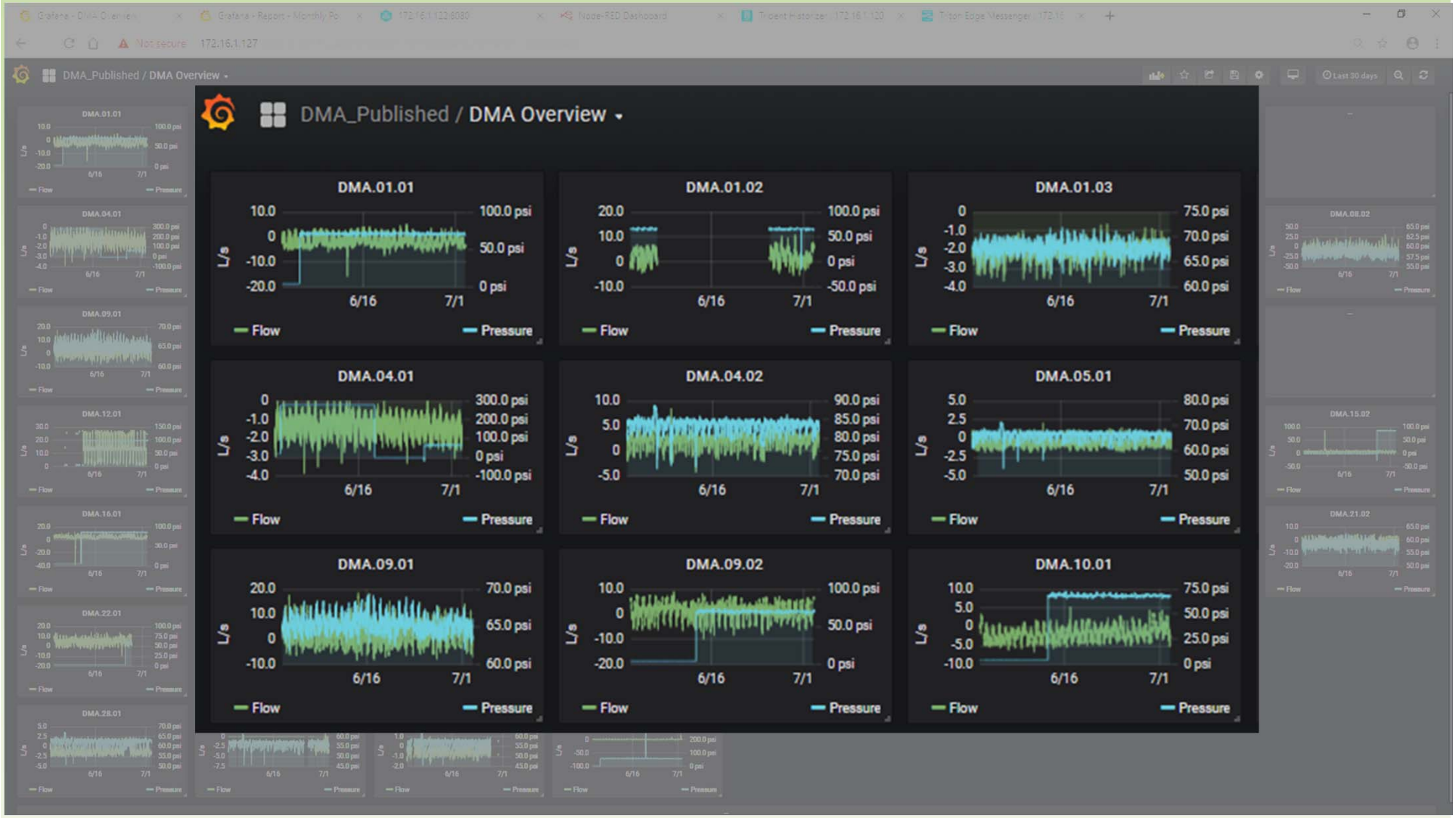


DMA Dashboard Display (in our Distribution Ops Area)

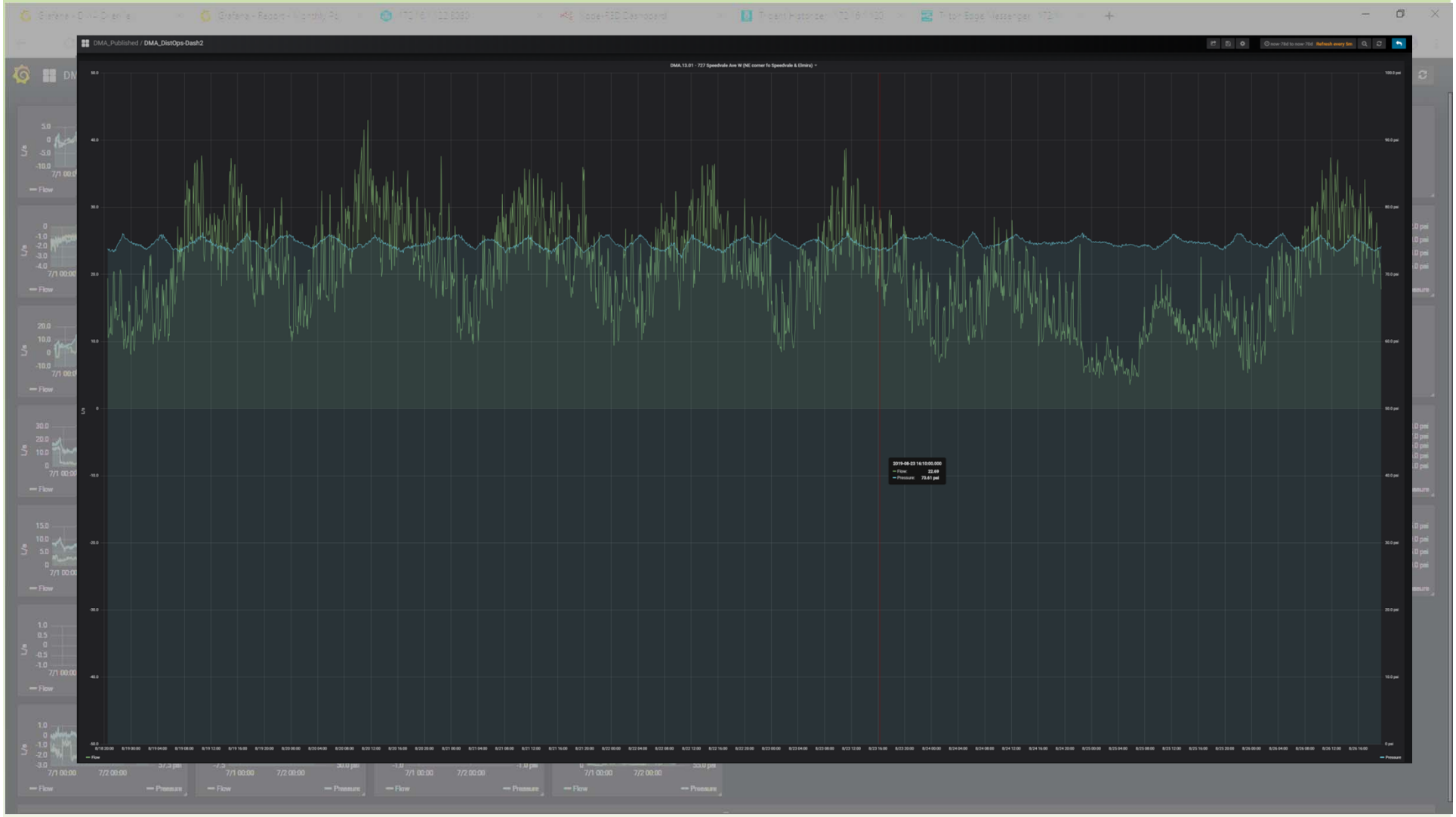


DMA Dashboard – showing last 7 days

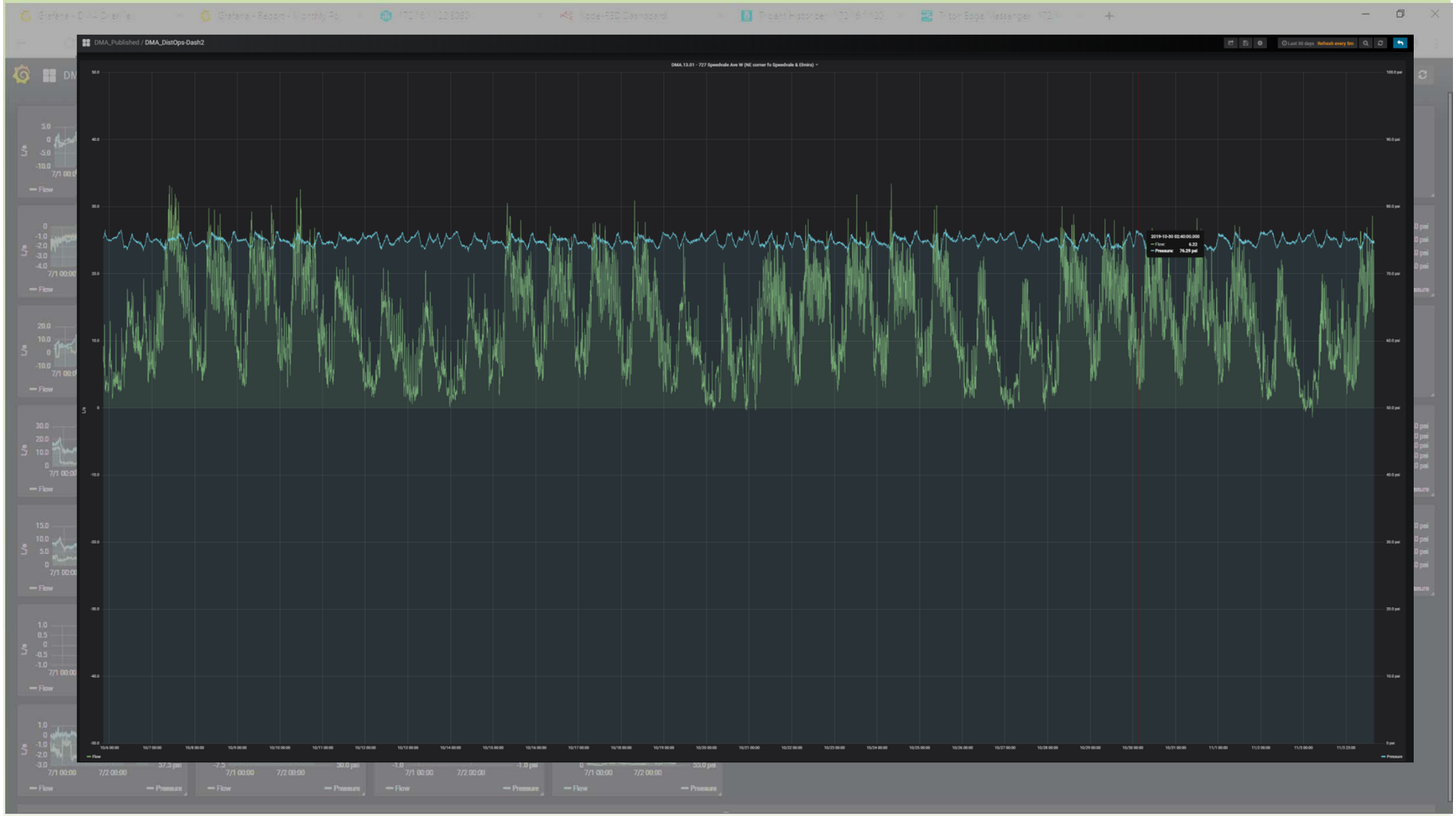
DMA Dashboard – showing last 30 days (auto-scaled to show variations)



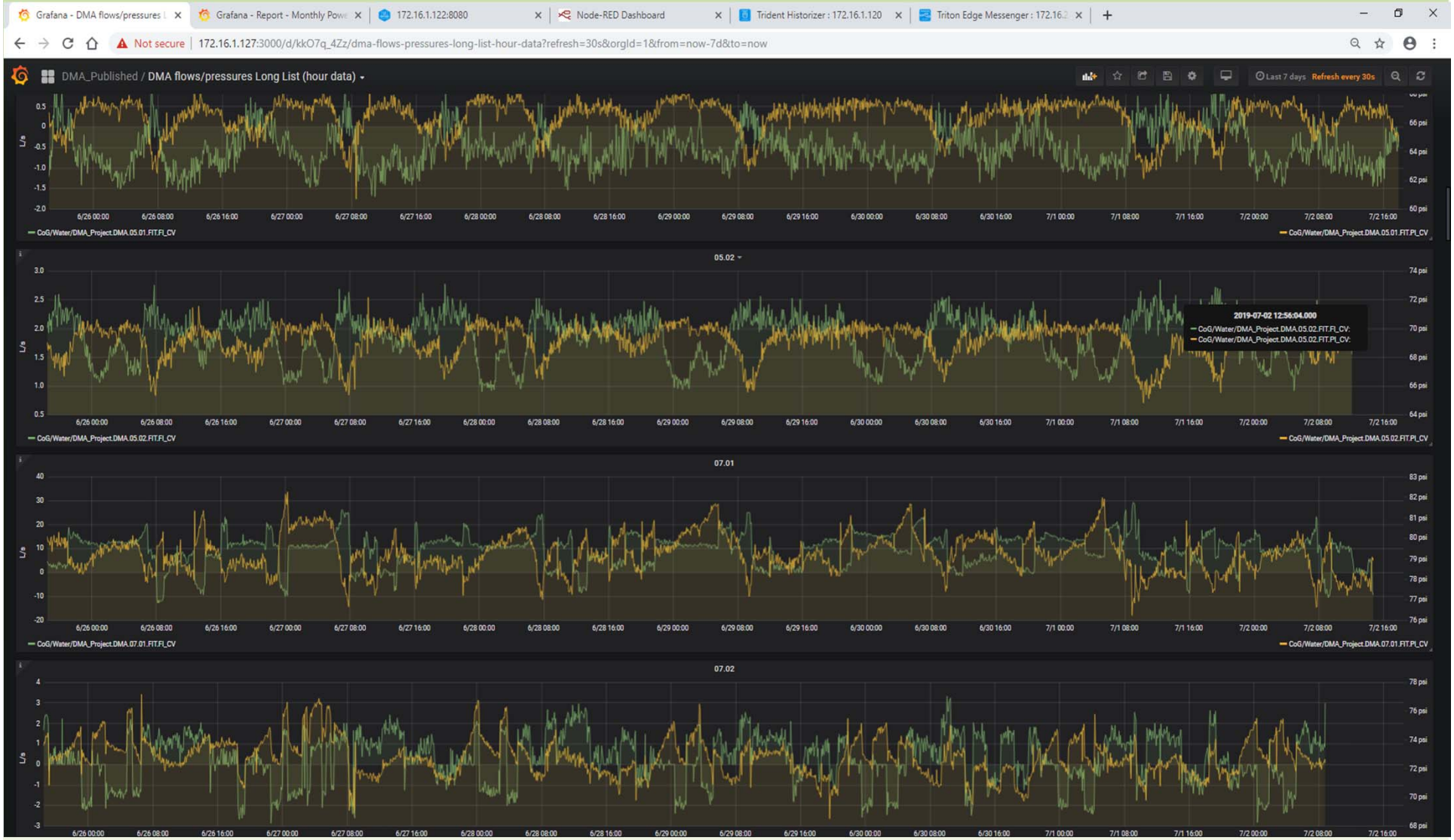
DMA Dashboard – detail view (7 days)



DMA Dashboard – detail view (30 days)

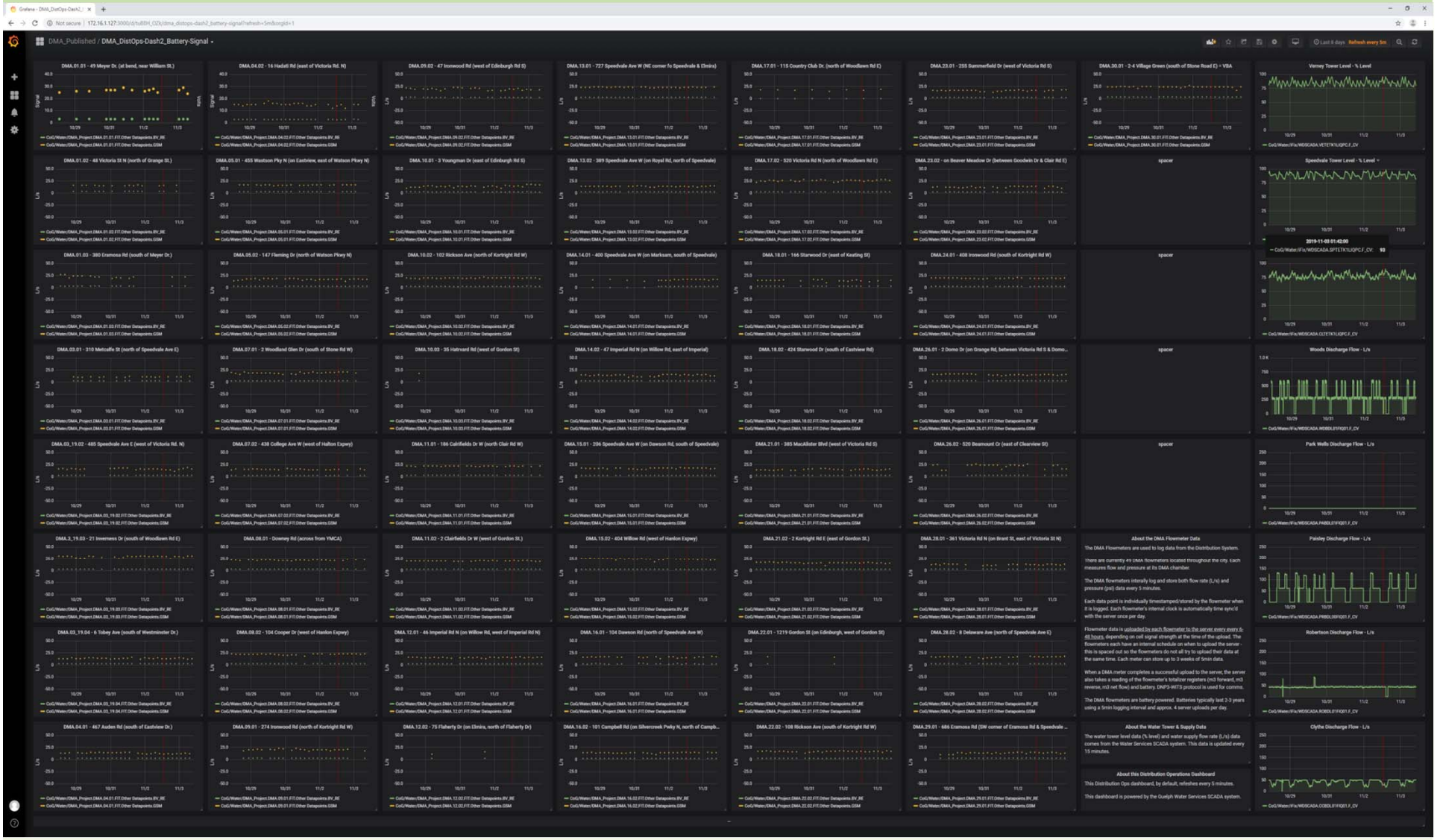


DMA Dashboard – Another Detail View



DMA Dashboard – DMA Flowmeter Health & Performance

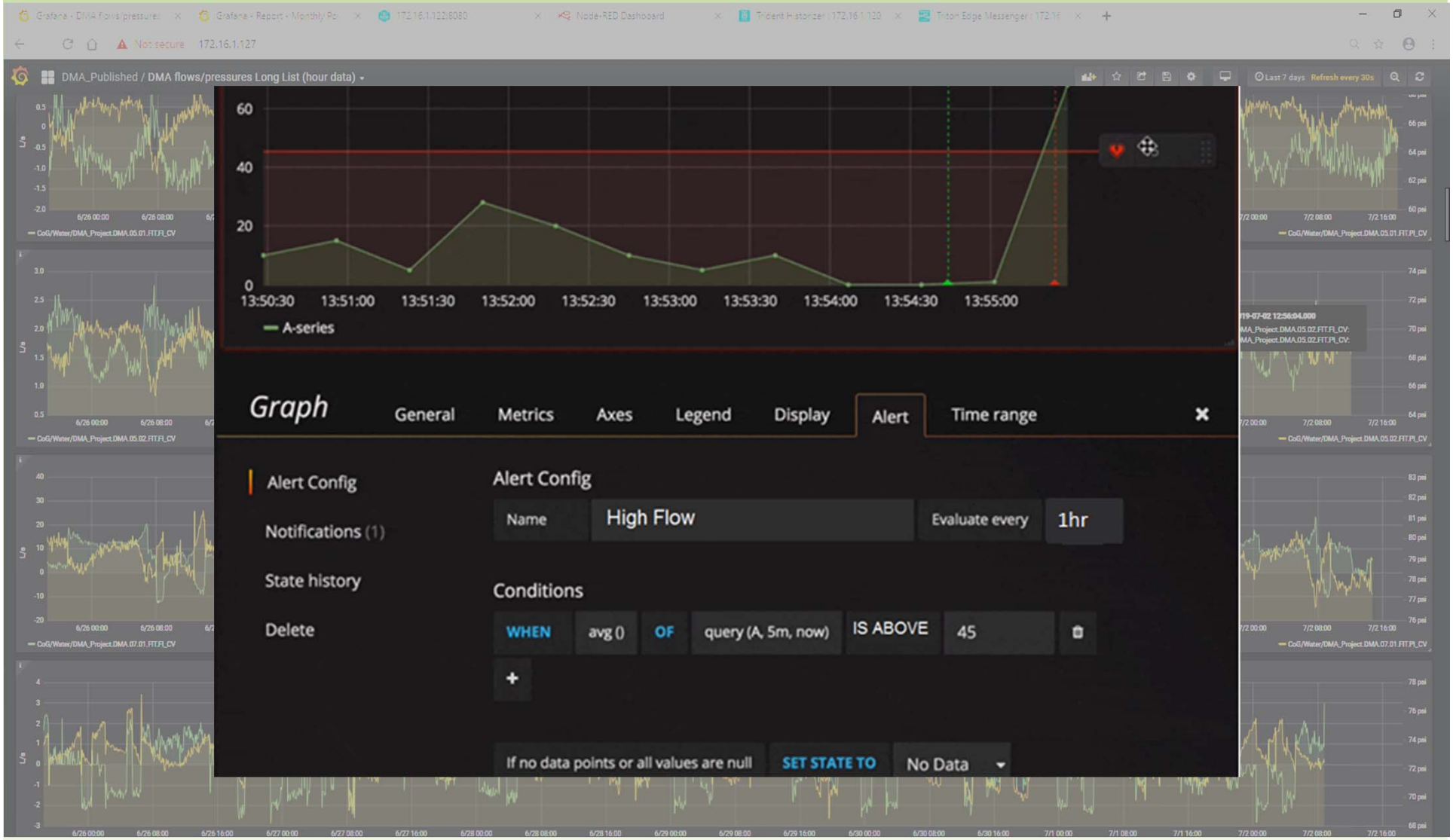
DMA Dashboard – Tracking Battery Life & Cell Signal Strength



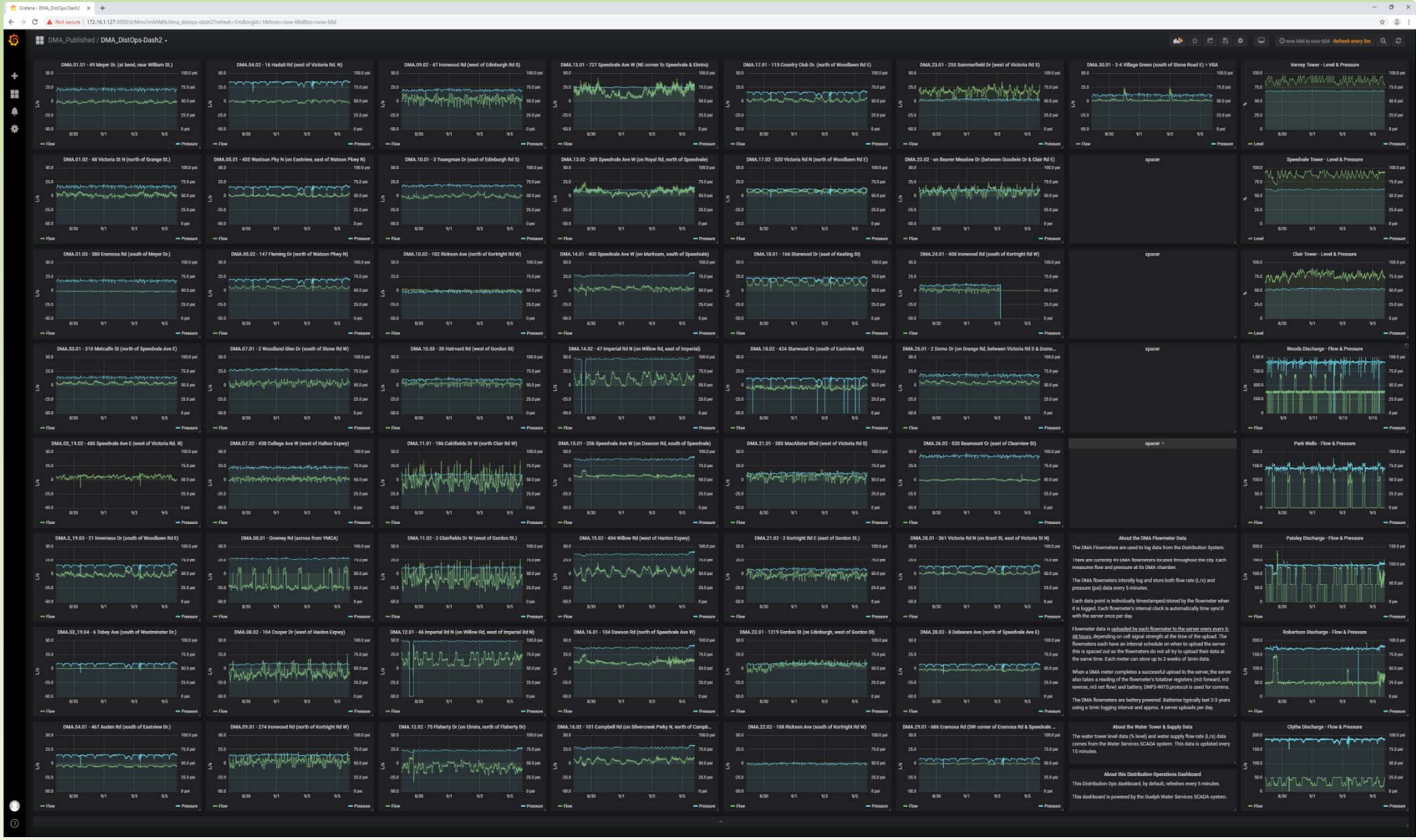
DMA Dashboard – Tracking Battery Life & Cell Signals

Live displays of Water Towers & Key Station Flows

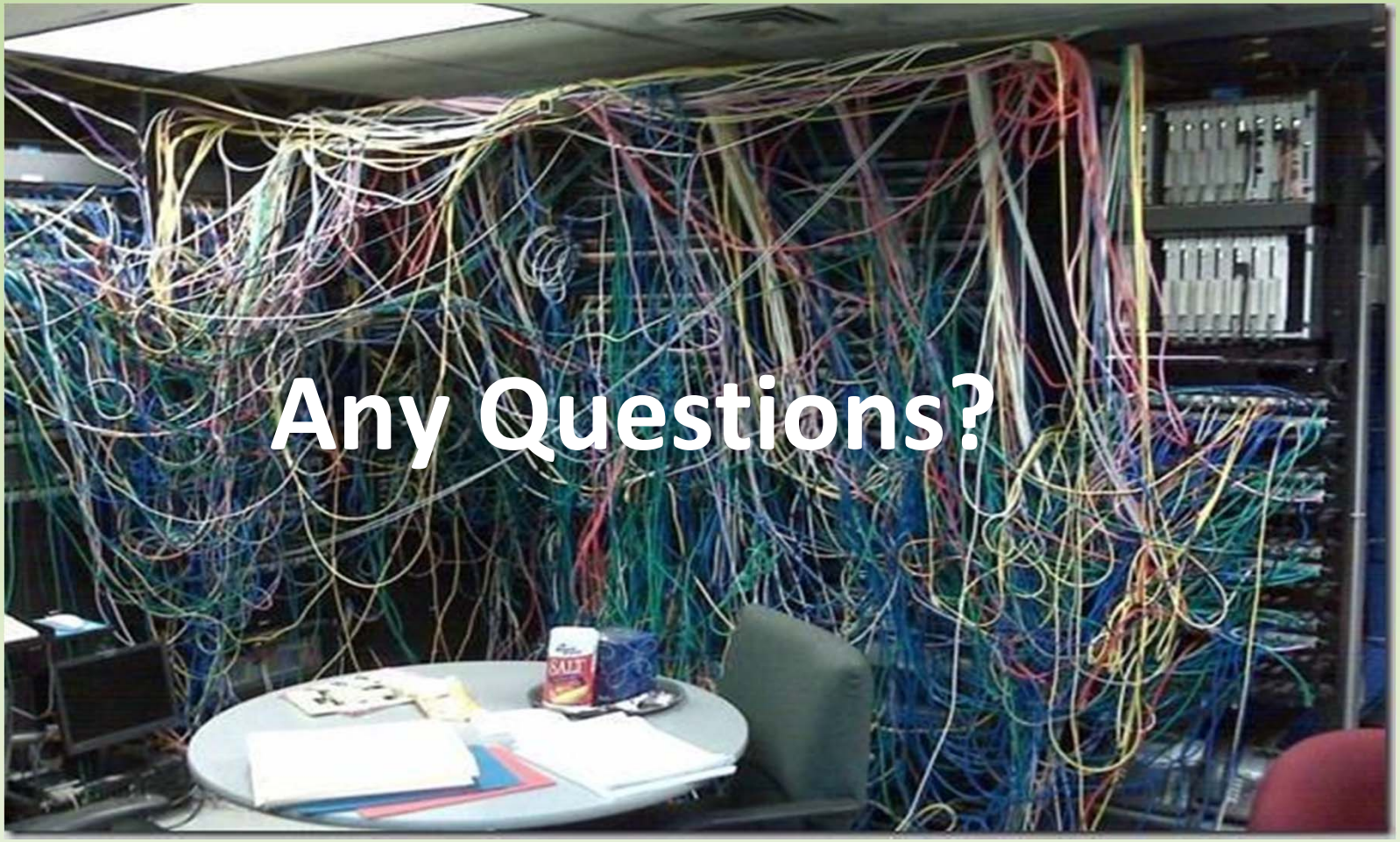
DMA Dashboard – Setting up Email Alerts



DMA Dashboard



Power Overview Dashboard



* Not a High Performance SCADA System

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Special thanks to Jason Little and Triple Point Solutions for helping us develop our Power and DMA Dashboards with their Neptune Cluster system.