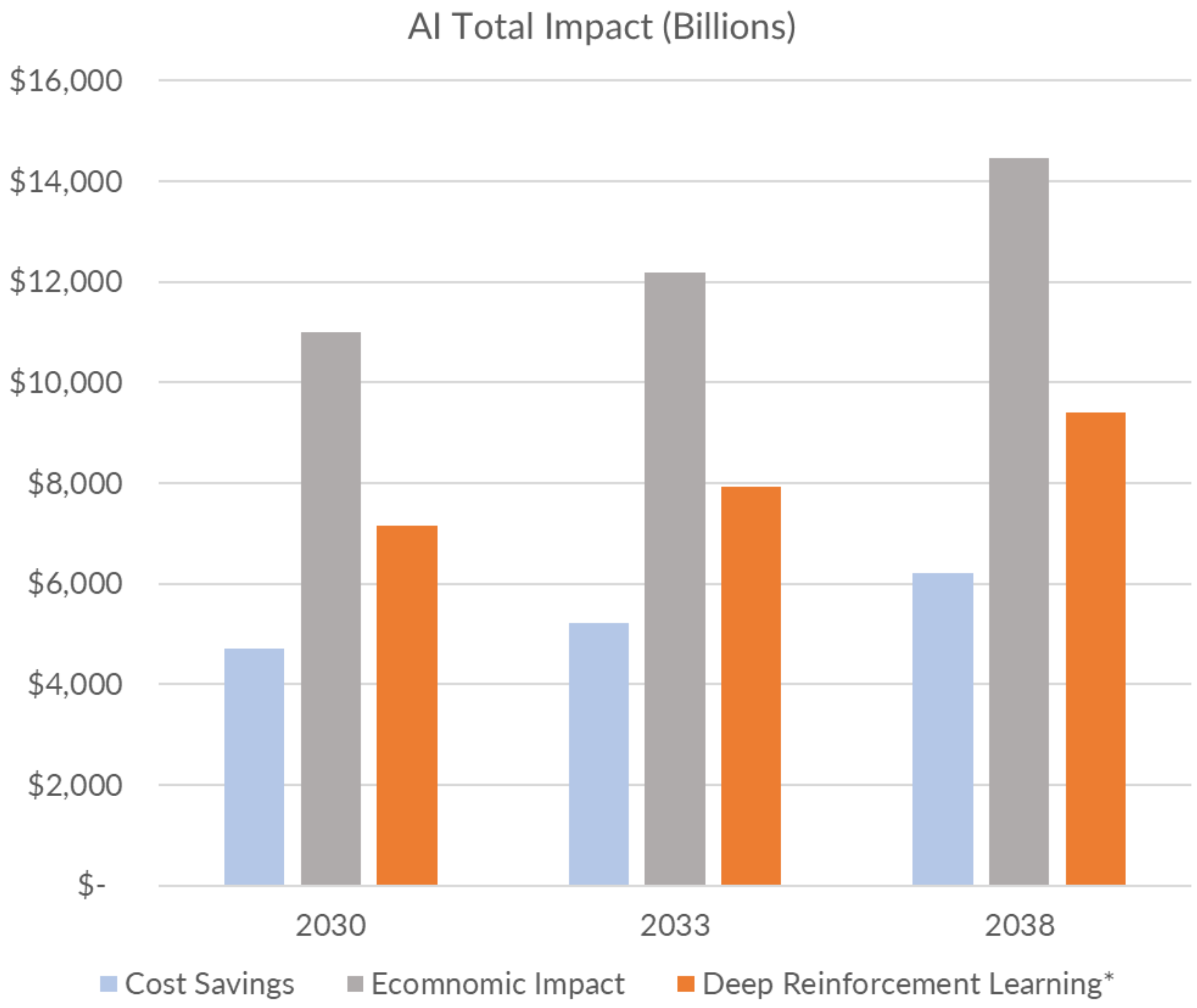
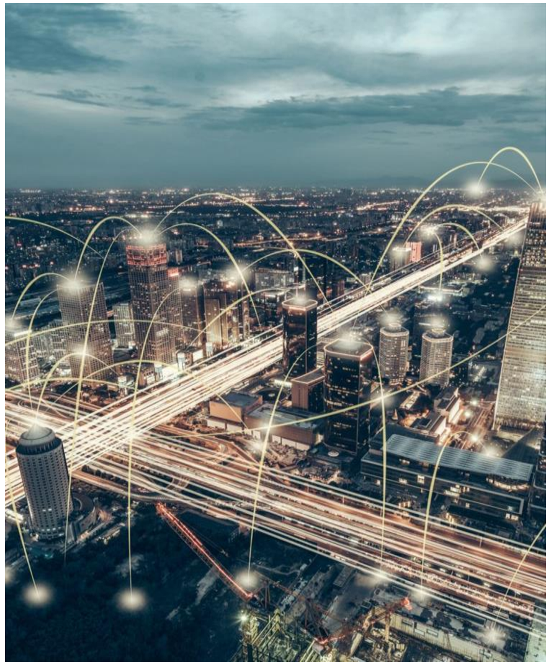
Advancing Energy Efficiency in Wastewater Treatment

Through AI-Powered Solutions

The Economic Impact of Industrial Ai – PBC's Opportunity



- **By 2030**: Up to **$15.7 trillion** added to the global economy through productivity gains and innovation. (Source: PWC, 2017)
- **By 2040**: Annual economic impact of **$15.5–$22.9 trillion**, driven by AI software and services. (Source: McKinsey, 2023)
- **By 2030**: AI to contribute **3.5% of global GDP**, transforming industries worldwide. (Source: IDC, 2024)



* Ai-OPs estimate: 65% of industrial value will be delivered by Neural Networked – Deep Reinforcement Learning

What’s the Cost of Palm Beach Water Not Optimizing

Optimization Area	Total Annual Cost (Without Optimization)	Potential Annual Savings (With Optimization)	Notes
Lift Station Optimization	$5,070,000	$760,000	Based on 20% of total energy cost ($25.4M), with 15% savings from optimization.
Aeration Optimization	$15,220,000	$1,900,000	Assumes 60% of total energy cost ($25.4M), with 20% savings focused on energy efficiency.
Polymer Addition Optimization	$6,350,000	$792,000	50% of chemical costs ($12.7M), with 20% savings from optimized dosing.
Chemical Feed Optimization	$6,350,000	$1,200,000	50% of chemical costs (excluding polymer/chlorine), with 15% savings from automation.
Total Chlorine Effluent Treatment	$2,540,000	$317,000	20% of chemical costs ($12.7M), with 20% savings from optimized chlorine use.
Total	**$35,530,000**	**$4,686,000**	Sum of all areas, reflecting combined energy and chemical cost savings potential.

Key Assumptions

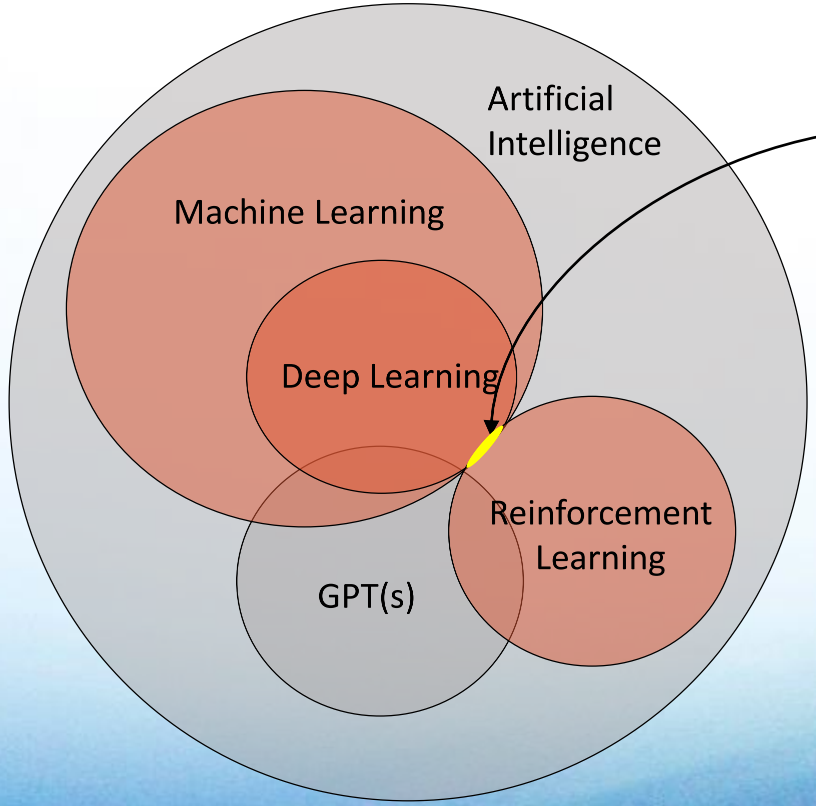
- Total energy consumption: 207 million kWh/year (150 MGD × 3,785.41 m^3/day × 1 kWh/m^3 × 365 days).
- Energy cost: $0.1225/kWh (Florida average, April 2025).
- Operating costs: $84.7M (energy cost ÷ 0.3, as energy is ~30% of total).
- Chemical costs: 15% of operating costs ($12.7M).
- Savings percentages are industry averages adjusted for Palm Beach’s scale and conservative estimates.

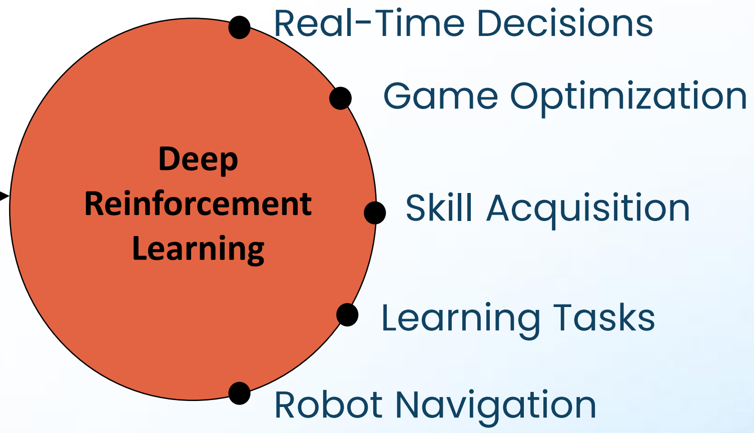
WWTP Process Optimization

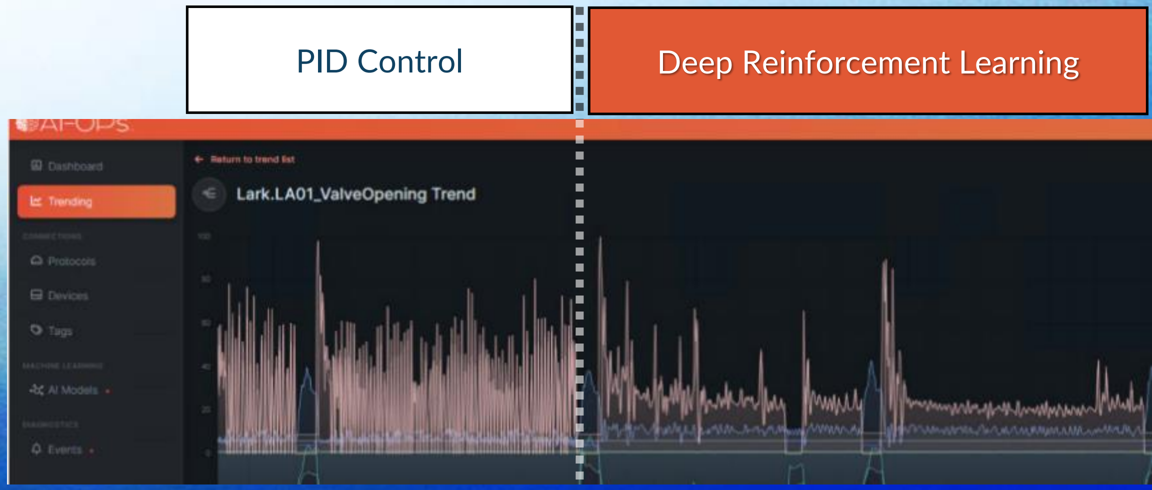
~$4.6 Million/Yr

Our Niche (DRL) – A Process Optimization Game Changer

PID &
Linear
Optimizations





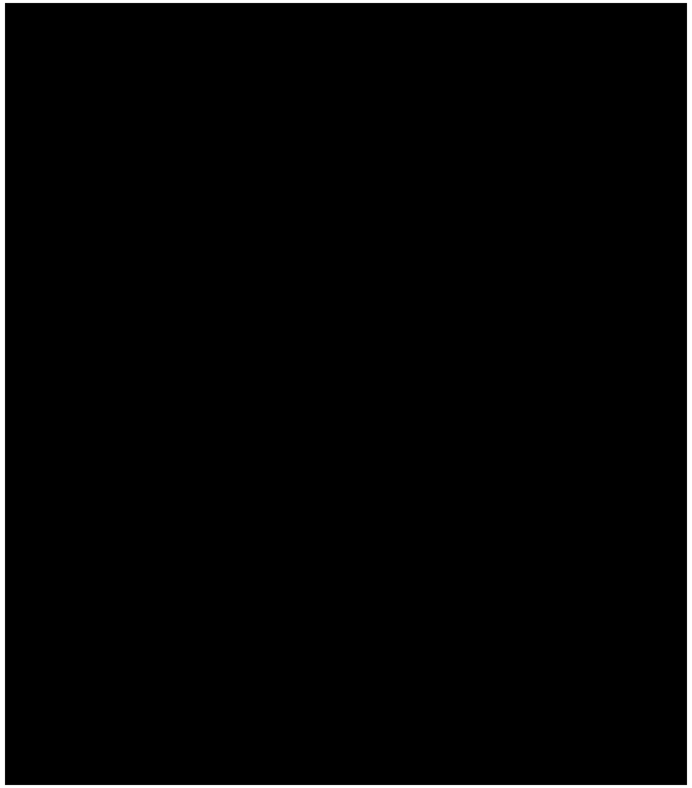
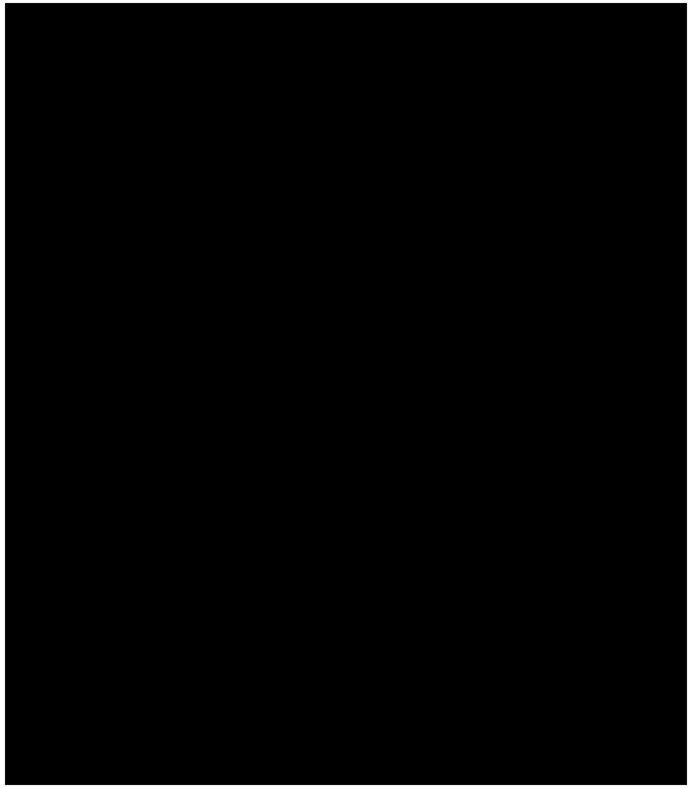
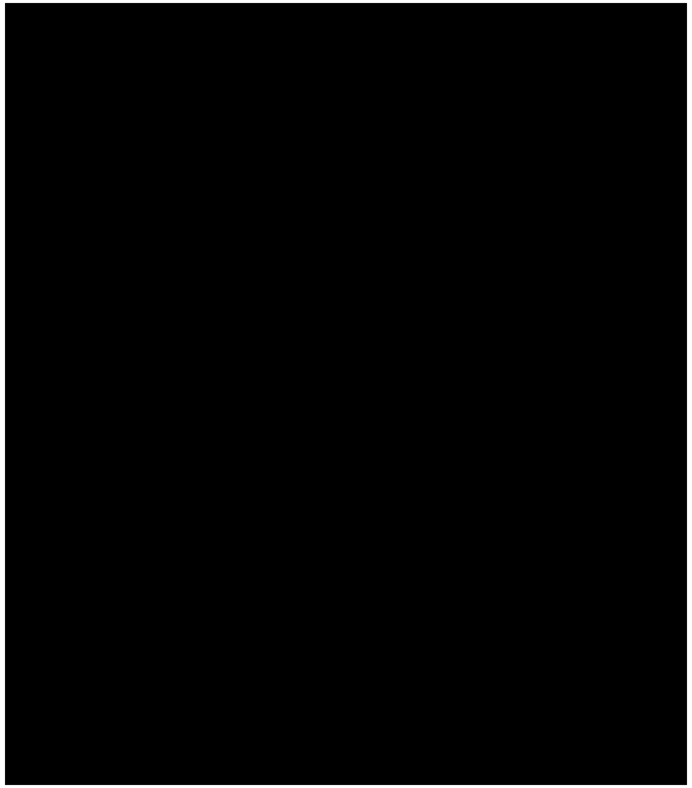


* Ai-OPs estimate: 65% of industrial value will be delivered by Neural Networked – Deep Reinforcement Learning

DRL – Learning, Mastering and Strategizing

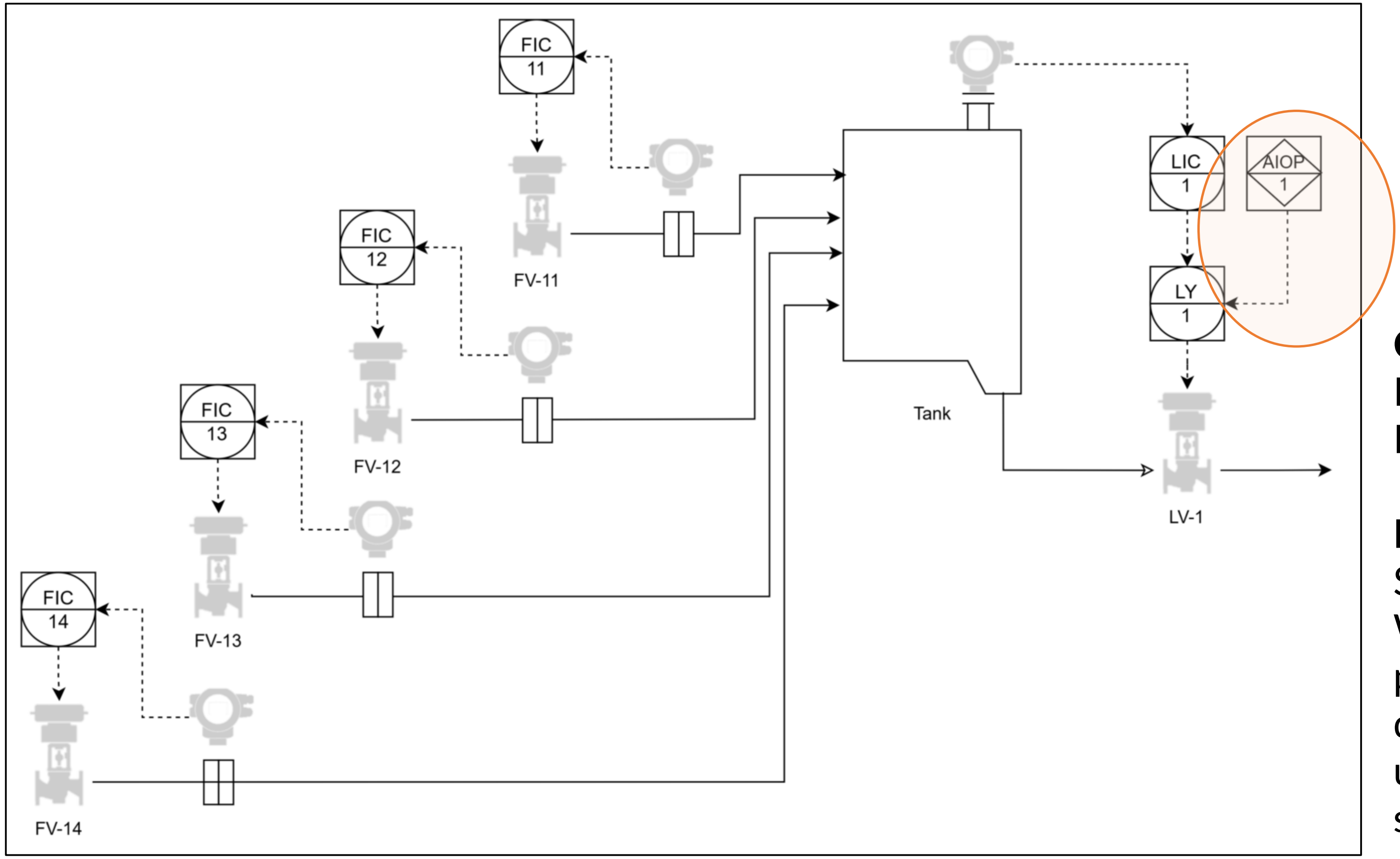
- 2014 Google demonstrated DRL
- Challenged ATARI's Break Out game

Google DeepMind VS ATARI

10 min of DRL training → 120 min of DRL training → 240 min of DRL training

Bringing the game to life at PBC



Incorporate a DRL controller to control the level drain valve. Bumpless transfer for PID shed mode.

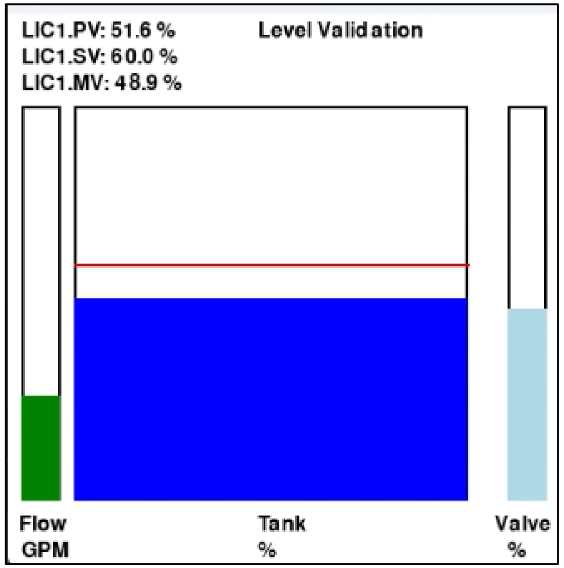
Challenge:
Maintain stable setpoint regardless of Set Point Value and in coming flow conditions.

Payback:
Savings in downstream chemical dosing. When the level isn't controlled right at set point the skimmer cannot effectively skim, and dirty water makes its way downstream, ultimately requiring heavier treatment for stable and compliant water outfall.

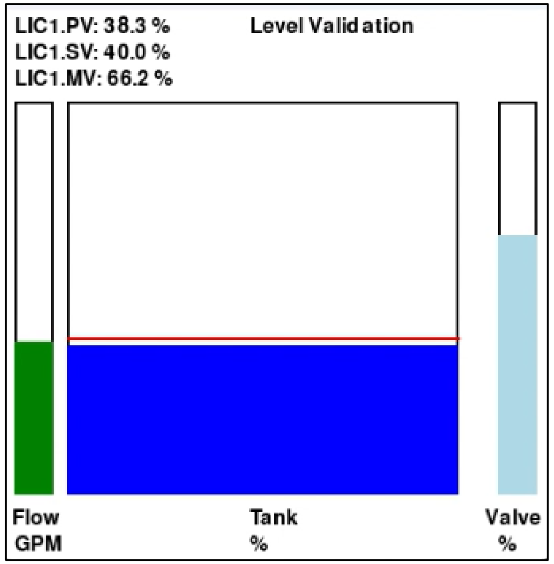
DRL – Learning, Mastering Level Control

- Challenge is to maintain Level Control regardless influent flow

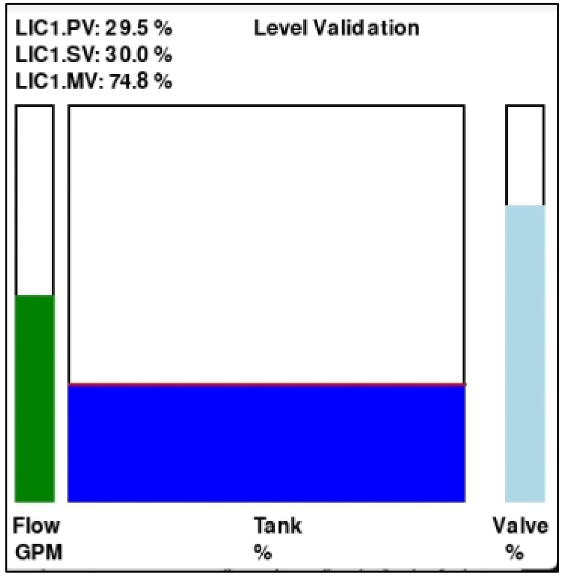
15 Seconds of Training



1 Minute of Training (PID-Like Capabilities)



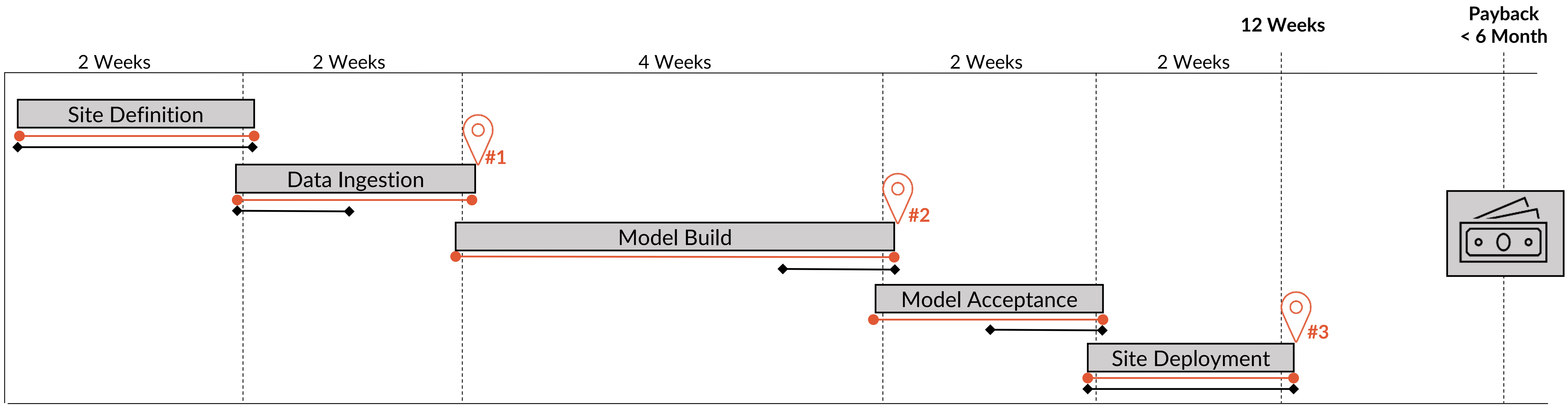
10 Minutes of Training



Ready to Deploy On Ai-OPs' Koios!!!

10k Timesteps → **50k Timesteps** → **500k Timesteps**

Pilot Project Milestones



Timeline Legend

- Ai-OPs Project Hours
- Client Project Hours

Pilot Project	Ai-OPs	Client	Sub Total
Milestone #1	$12k	$8k	$20k
Milestone #2	$24k	$6k	$30k
Milestone #3	$20k	$12k	$32k
6 Month Support	$24k	---	$24k
Total	$80k	$26k	**$106k**

Recurring	Ai-OPs	Client	Sub Total
Koios Recurring	$7.5k	---	$7.5k
Annual Support*	$48k	---	$48k
Total	**$55.5k**	---	**$55.5k**

*16 hours monthly support

330 %

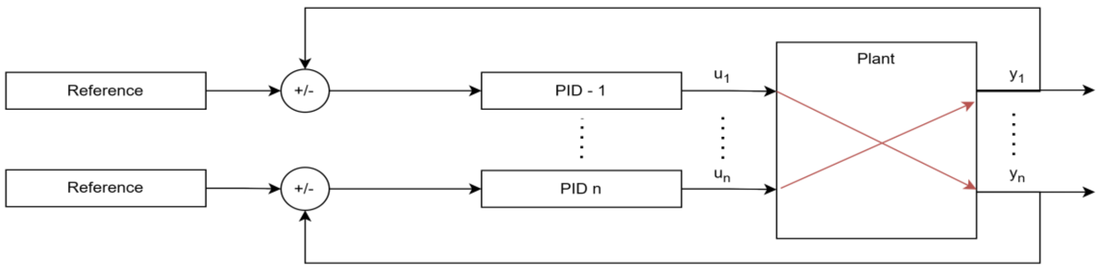
in 5 Years

Payback@ 6 Months
Based on Total Project Cost

The Evolution of Direct Process Control Loops

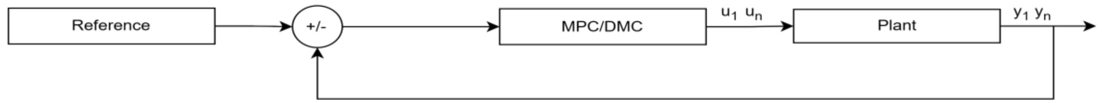
PID Loops - *circa 1920*

Pros:
Quick to reaction times
Cons:
Decoupled systems often work against each other
– increased mechanical wear, energy wasteful



MPC/DMC Loops - *circa 1980*

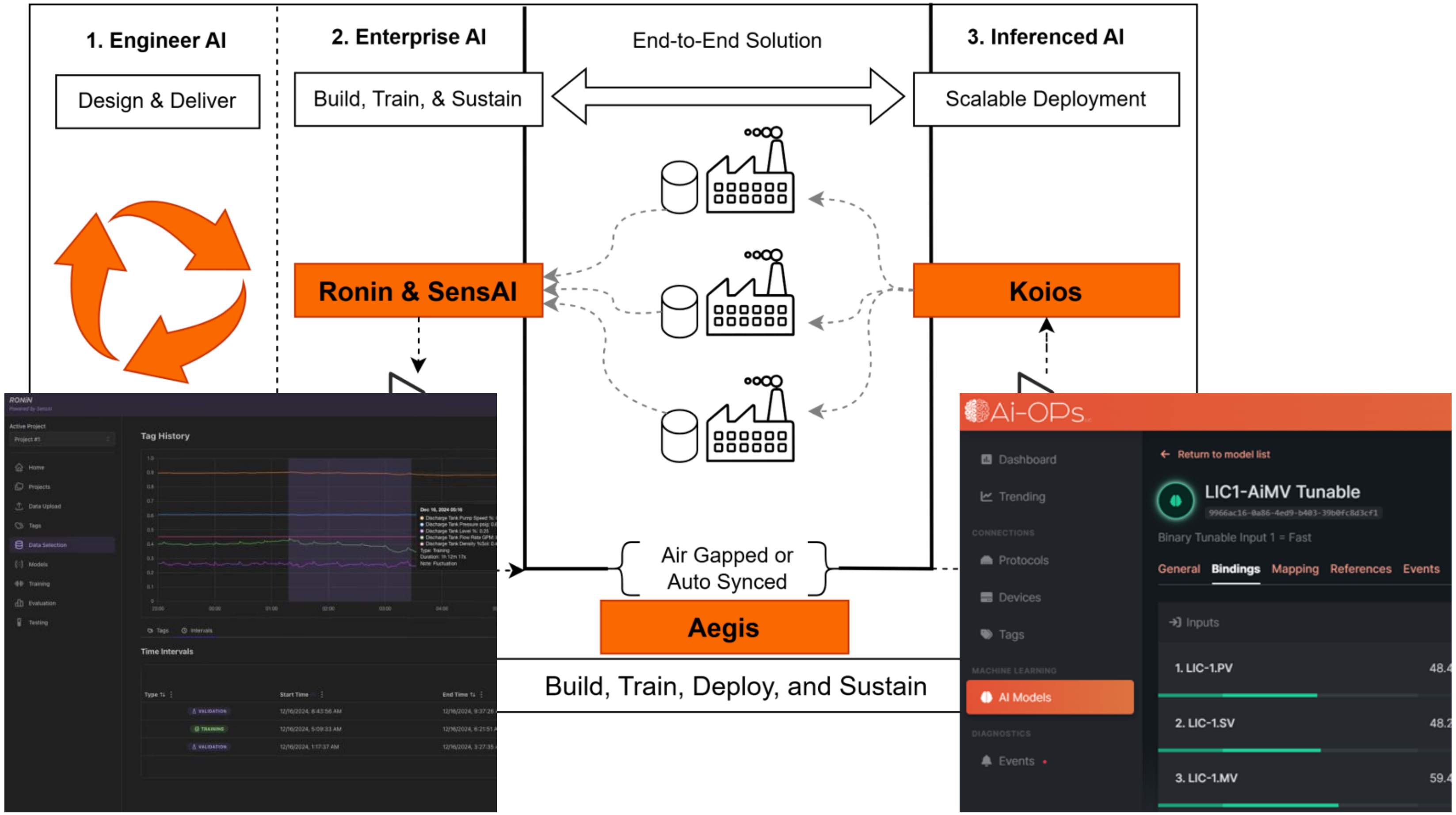
Pros:
Can control complex systems with less waste.
Bundles many Loops into one central control. Predictive
Cons:
Requires specialist maintenance/programming (optimizer)
Reaction times lag often resulting in off-spec or less optimal production periods
Maintenance (OPEX) Costs $$$
Hardware dependent



DRL-AI - circa 2020 (Koios)

Advantages:
Optimal control of complex systems
Quick reaction times
Predictive enhancements
Very robust with high tolerance for system variability
Low (OPEX) costs – basic license
Hardware agnostic
Enhanced security – Runs off-line

Ai-OPs – Product and Software Delivery



Ronin and SensAI

- Build and maintain your own AI solutions for process control and optimization.
- Ronin is Ai-OPs' user interface for engineering workflows for building AI for process control
- SensAI is Ai-OPs' API for access to the Ai-OPs' training libraries and methods.

Aegis

- Optionally connect your Koios to your Ronin and SensAI organization for remote management.

Koios:

- On-premises (No Internet Required!) or connect through Aegis to your organizations Ronin and SensAI.
  - Standard protocols
    - EtherIP, OPC-UA, XML, SQL
  - Long-term historian
  - Scales well, run 1000's of models
  - Requires little management time

Pilot Project Proposed – Lift Station Optimization

The Challenges:

Energy Inefficiency:
- ~1000 lift stations that transport over 35 million gallons per day (MGD) of raw sewage to its treatment facilities. These lift stations consume nearly 20% of the utility's total energy budget (~$5.07 million annually).

Overuse of Equipment:
- Frequent cycling of pumps lead to premature wear and higher maintenance costs.

Compliance Risk:
- Maintaining consistent flow rates to the treatment plant improves process stability, prevents hydraulic overflows and bypasses.

The Solution:

Dynamic Optimization:
- DRL models predict oxygen demand fluctuations and adjusted blower speed and output in real-time.

Energy Efficiency:
- The AI model prioritizes flow rates to the treatment plant during peak events with minimal energy.

Closed-Loop Control:
- Seamless integration with existing control systems ensures smooth operation without disruptions.

Anomaly Detection:
- Additional models can be deployed to monitor the health of the pumps and stations.

Key Benefits

Energy Reduction

As much as 20%

Maint. Reduction

As much as 43%

Savings

~$760k per year

How do we do better

Sewer main break causes delays on Okeechobee Boulevard

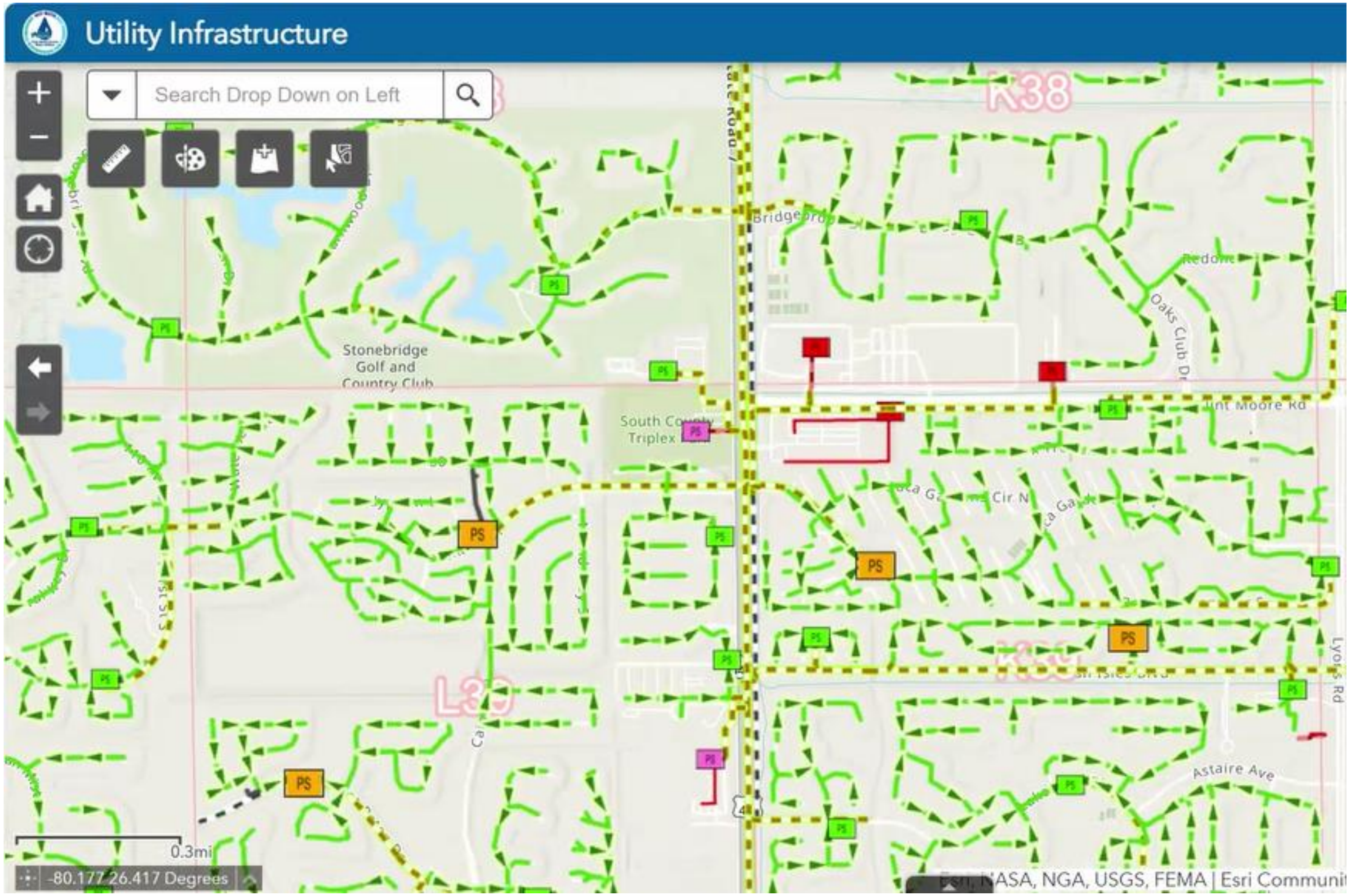
- Use multiple lift-stations to create a “surge tank” via control of sewage
- Monitor for what would otherwise be undetected events
- Early notification of Forced main breaks

Available Data for Creation of a Digital Twin

- Approx half are RTU connected
- RTU's are Scanned every 5 minutes
- Lift station data measurement available:
  - Pump run status
  - Level
  - Pressure

* Ai-OPs estimate: 65% of industrial value will be delivered by Neural Networked – Deep Reinforcement Learning

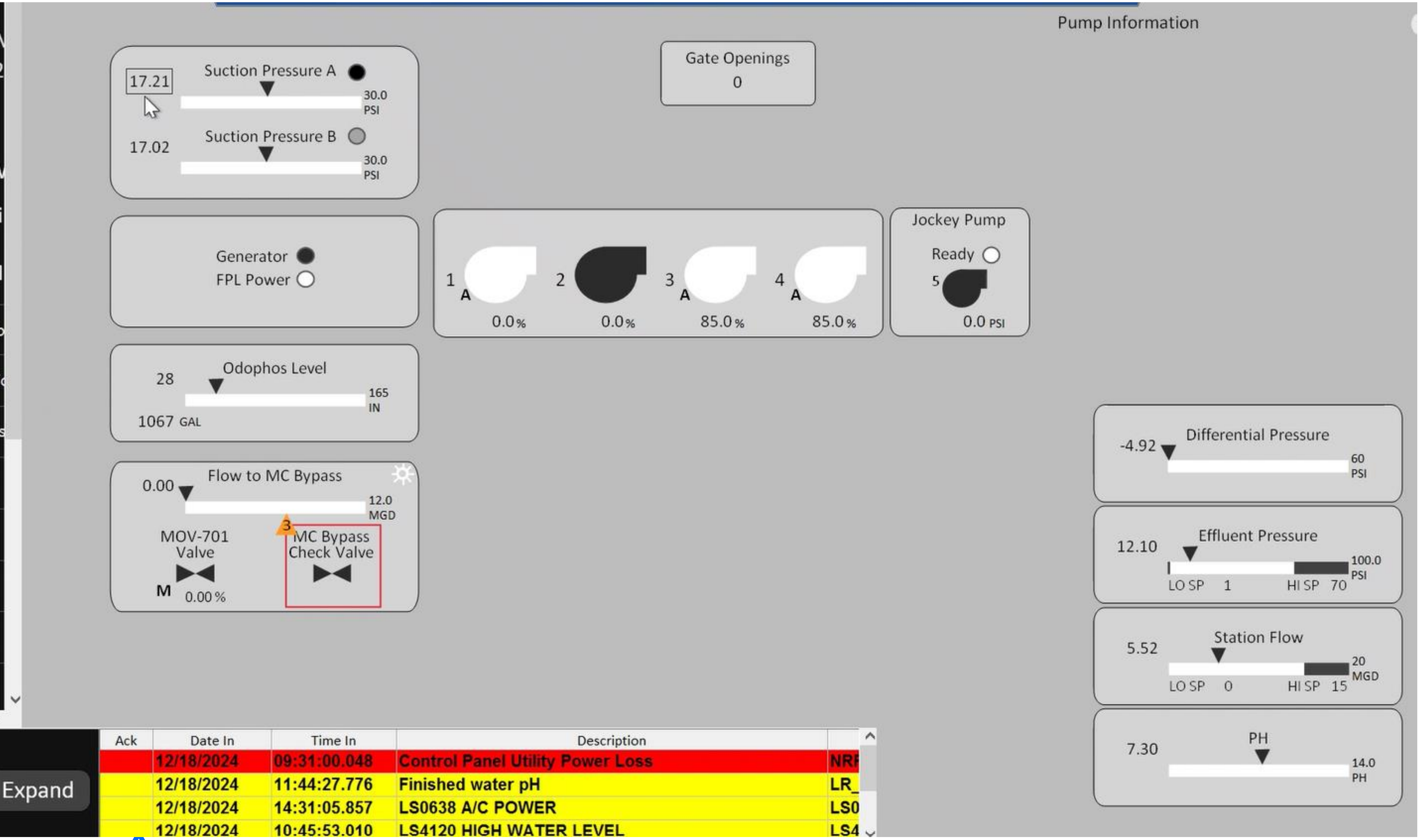
PBC Collections SCADA



- **By**

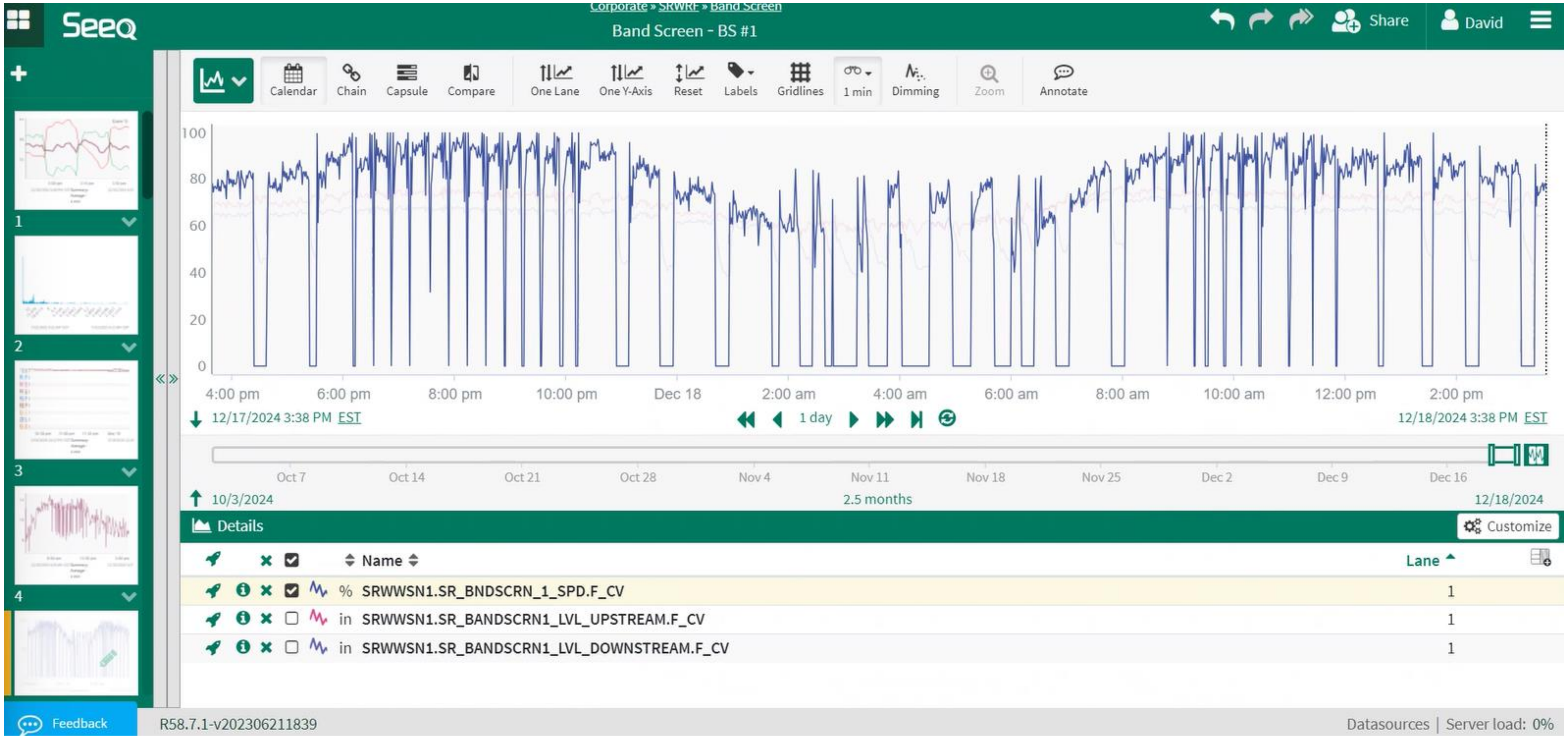
* Ai-OPs estimate: 65% of industrial value will be delivered by Neural Networked – Deep Reinforcement Learning

Booster Repump Station



- Dual pump lift-stations
- 480VAC 100 HP pumps
- VFD runs <60 sec
- black off
- white on

The cost of inefficiency



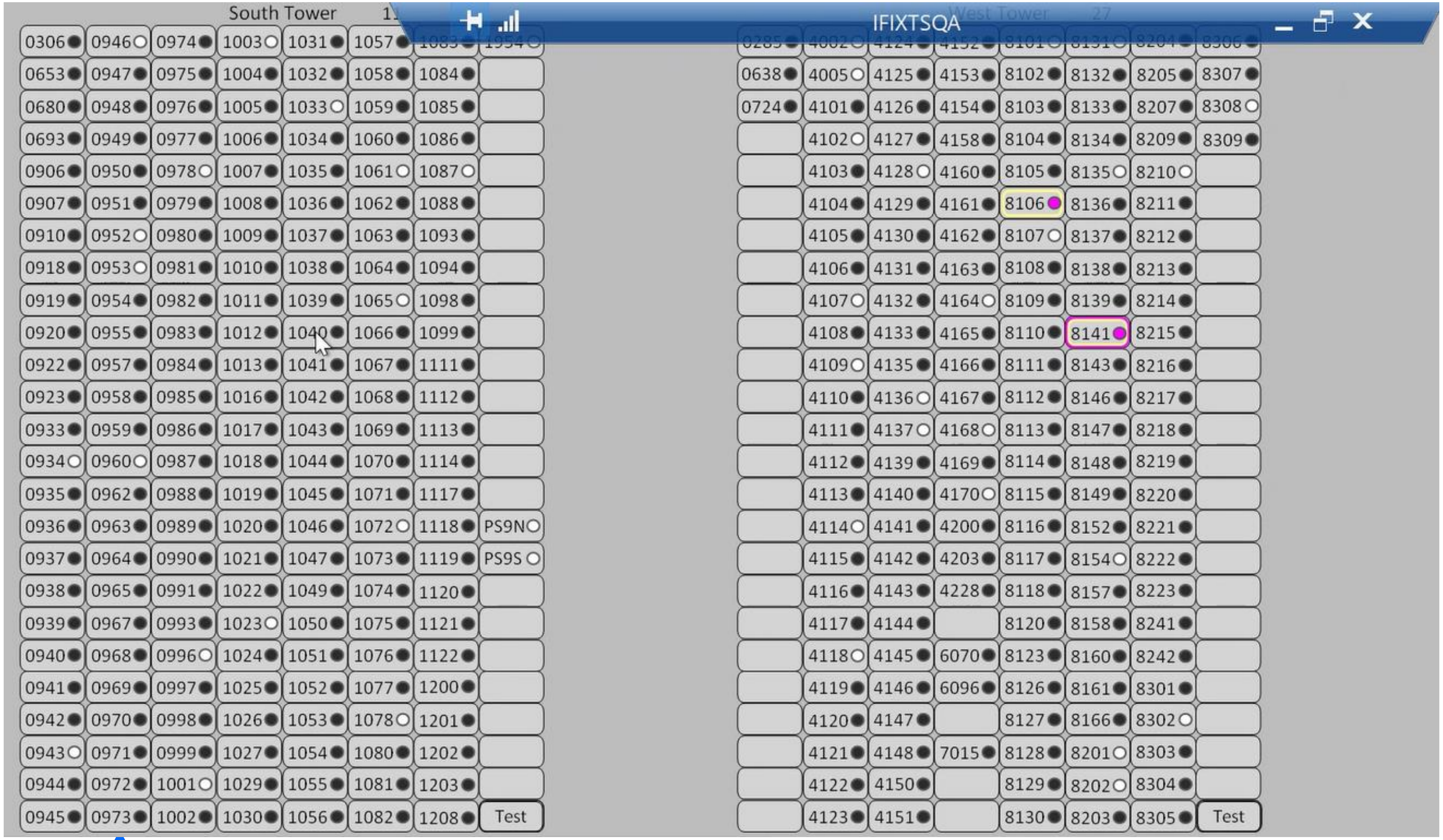
- **Frequent pump motor starts & stops:**
  - **Inefficient control**
  - **Excessive equipment wear & tear**
  - **Reduces life expectancy of assets**

A traffic cop for PBC Collections

Digitally reproduced by the USC Digital Archive (c)2004, California Historical Society, CHS-36733

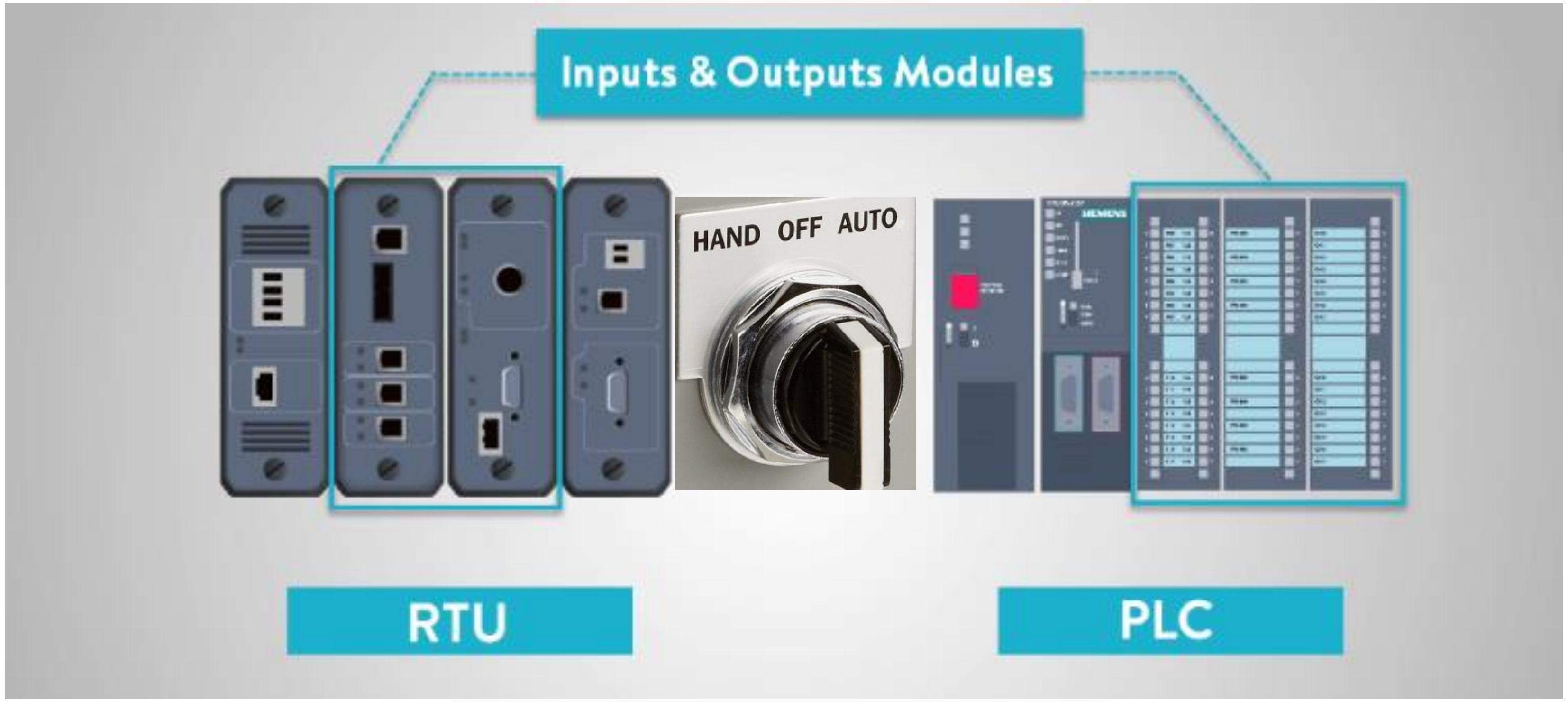
* Ai-OPs estimate: 65% of industrial value will be delivered by Neural Networked – Deep Reinforcement Learning

Ai Directed Traffic



- **Requirements:**
- **External permissive implementation between SCADA and radio**
- **Self-hosted or hosted by AI-Ops**
- **After 15 minute time-out limit:**

RTU control would default back to run condition


Inputs & Outputs Modules
HAND OFF AUTO
RTU
PLC

PLC Upgrades Already Slated for Collections

Application 2 – Aeration Control Optimization

The Challenges:

Energy Inefficiency:

- Existing PID-based control systems for the blowers are reactive and incapable of dynamically adapting to fluctuating oxygen demands.

Overuse of Equipment:

- Frequent cycling of blowers lead to premature wear and higher maintenance costs.

Compliance Risk:

- Maintaining consistent biological oxygen demand (BOD) and dissolved oxygen (DO) levels are critical to meeting discharge regulations.

The Solution:

Dynamic Optimization:

- DRL models predict oxygen demand fluctuations and adjusted blower speed and output in real-time.

Energy Efficiency:

- The AI model prioritizes achieving the required DO levels with minimal energy usage.

Closed-Loop Control:

- Seamless integration with existing control systems ensures smooth operation without disruptions.

Anomaly Detection:

- Additional models can be deployed to monitor the health of the blowers and basin.

Key Benefits

Energy Reduction

As much as 20%

Compliance

DO Consistency

Savings

~$2M per year

Application 3 – Chemical Dosing (& Other Chems)

The Challenges:

Reactive Nature:

- This reactive behavior often leads to overshooting or undershooting the target, resulting in inefficiencies and wasted chemicals.

Nonlinear Dynamics:

- The relationship between chemical dosing and process outcomes (e.g., pH or residual chlorine levels) is nonlinear.

Lag and Dead Time:

- Chemical reactions, mixing times, and sensor delays introduce dead time between dosing and the measurable response.

The Solution:

Dynamic Optimization:

- The DRL model adapts in real time to changing process conditions, such as shifts in flow rate, buffering capacity, or chlorine demand.

Multi-Variable Control:

- Optimizes multiple variables, ensuring that chemicals are balanced for maximum efficiency and effectiveness.

Closed-Loop Control:

- Seamless integration with existing control systems ensures smooth operation without disruptions.

Anomaly Detection:

- Additional models can be deployed to monitor the health of the dosing system.

Key Benefits

Chemical Usage

As much as 20% usage reduction

Compliance

Increased adherence to constraints

Savings

~$2.3M per year

Application 4 – Energy Balancing

The Challenges:

High Energy Consumption:

- Aeration systems, pumps, and sludge processing accounted for over 50% of the plant's total energy use, peak demands leading to increased operational costs.

Limited Control Over Demand Management:

- Traditional PID and Model Predictive Control (MPC) struggled to adjust aeration and pumping schedules dynamically.

Regulatory Constraints & Operational Complexity:

- The plant needed to maintain strict effluent quality while minimizing energy usage

The Solution:

Dynamic Optimization:

- The DRL model adapts in real time to shift energy loads away from peak hours where possible.

Multi-Variable Control:

- Optimizes multiple variables, ensuring that big energy users are balanced for maximum efficiency.

Closed-Loop Control:

- Seamless integration with existing control systems ensures smooth operation without disruptions.

Peak Demand Reduction:

- AI with DRL can automatically adjust blower and pump usage to operate at off-peak rates when possible.

Key Benefits

Peak Demand Charges

Compliance

Savings

~$320k per year

Expanding AI Applications

Opportunities and More

Water & Utilities
Level and Flow Control
Pump Controls
Dosing Optimizations

Boilers and Heaters
Fuel Control
Steam Demand and Header
Feedwater Control

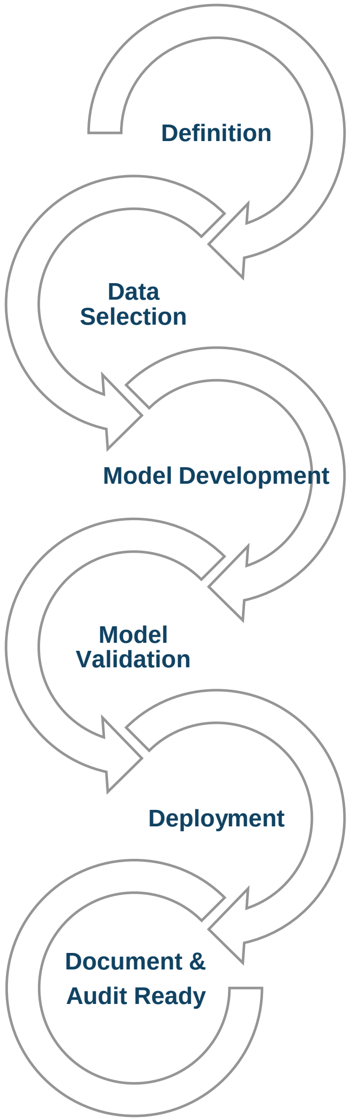
Emissions
Leak Detection
Flue Gas Control
Flare Smoke Prevention

Plant Operations
Compressor and Pump Control
Valve Control
Advanced Alarming

Gen & Transmission
Power Factor Control
Load Shed and Balancing
Supply and Demand Predictions

Commercial
Refrigeration Control
Chiller and HVAC

TRINOVA



Ai-OPs Capabilities	Purpose	Regulatory Reference
AI Model Validation Report	Summarizes AI training, testing, and performance results.	ICH Q8 (Pharmaceutical Development)
Risk Assessment Report	Identifies potential risks associated with AI-based decisions.	ICH Q9 (Quality Risk Management)
Change Control Documentation	Records modifications, retraining, and updates to AI models.	ICH Q10 (Pharmaceutical Quality System)
Audit Log & AI Decision Traceability	Maintains a record of AI-generated predictions and outcomes.	21 CFR Part 11 (Electronic Records & Signatures)