JWIL Digital Twin – AI/ML Feature

Project Understanding

Objective:

- JWIL would like to setup a Centralized Total Water Management System (Digital twin) in their Delhi HQ for Monitoring, Analysis and Process Optimization of their existing and upcoming Water Infra Projects across India.
- In this Central Water Management application analytics solution required to present various KPI's and analytics to monitor performance of the system.

Here our focus will be to develop AI/ML features for:

1. **Provide pump efficient alert & recommendation based on ideal head to flow curve** (Expected timeline – 15 days)
2. **Future water demand, pump energy consumption** (Expected Timeline – 1.5 months)
3. **Gen AI based chatbot integration for water automation insights** (Expected Timeline – 1 month)

Integrate forecasts into a existing dashboard for actionable decision support and real time provide recommendation to JWIL team

1). Real Time Head to Flow Curve

Requirement: Plots the relationship between head (meter) and flow rate for the pump.

Actions:

1.Model the Head-Flow Curve:

- Create a real time scatter chart of the pump's head-flow curve based on its operational data and its manufacturer specifications. (sample chart on next page reference)
- Overlay the manufacturer's head-flow curve for comparison.
- Mark the Best Efficiency Point on the curve for visual clarity.
- *Flow rate (x axis) = 1_Flow_m3h + 2_Flow_m3h*
- Calculate Real-Time Head (y axis) :-

“ *Head (H)=P (outlet) − P (inlet) / γ* “

where P = pressure (Pa) from Pressure Transmitters , γ= specific weight of fluid (N/m^3).

And *γ=ρ * g* where:

- ρ = density of water (kg/m^3), approximately 1000 kg/m^3 at 4°C (temperature may slightly affect this value)
- g = acceleration due to gravity (≈9.81 m/s2)

- **Real-Time Head Calculation for Submersible Pumps (Without Inlet PT)**

Since the inlet is submerged and open to atmospheric pressure, we approximate inlet pressure using the water level (height h) in the sump tank:

Updated Formula:

Head (H) = [P(outlet) - $\gamma \times h$] / γ

- P(outlet) = (PT1 + PT2) / 2

Keys :

1. PT1 = 1_Pressure
2. PT2 = 2_Pressure

Where:

- P(outlet) = Pressure from outlet PT (in bar)
- γ = Specific weight of water ($\approx 9810\ N/m^3$)
- h = water level in sump tank (in meters, from a level transmitter or manually fixed value)

So you're essentially treating:

P(inlet) $\approx \gamma \times h$

Pump Performance Curve Plotting Logic :

Common Parameters (for Both Pumps) :

- **Flow (x-axis)**

Flow1 + Flow2 → From flow meters on both outlet pipe (in m^3/h)
Where : Flow1 = 1_Flow_m3h, Flow2 = 2_Flow_m3h

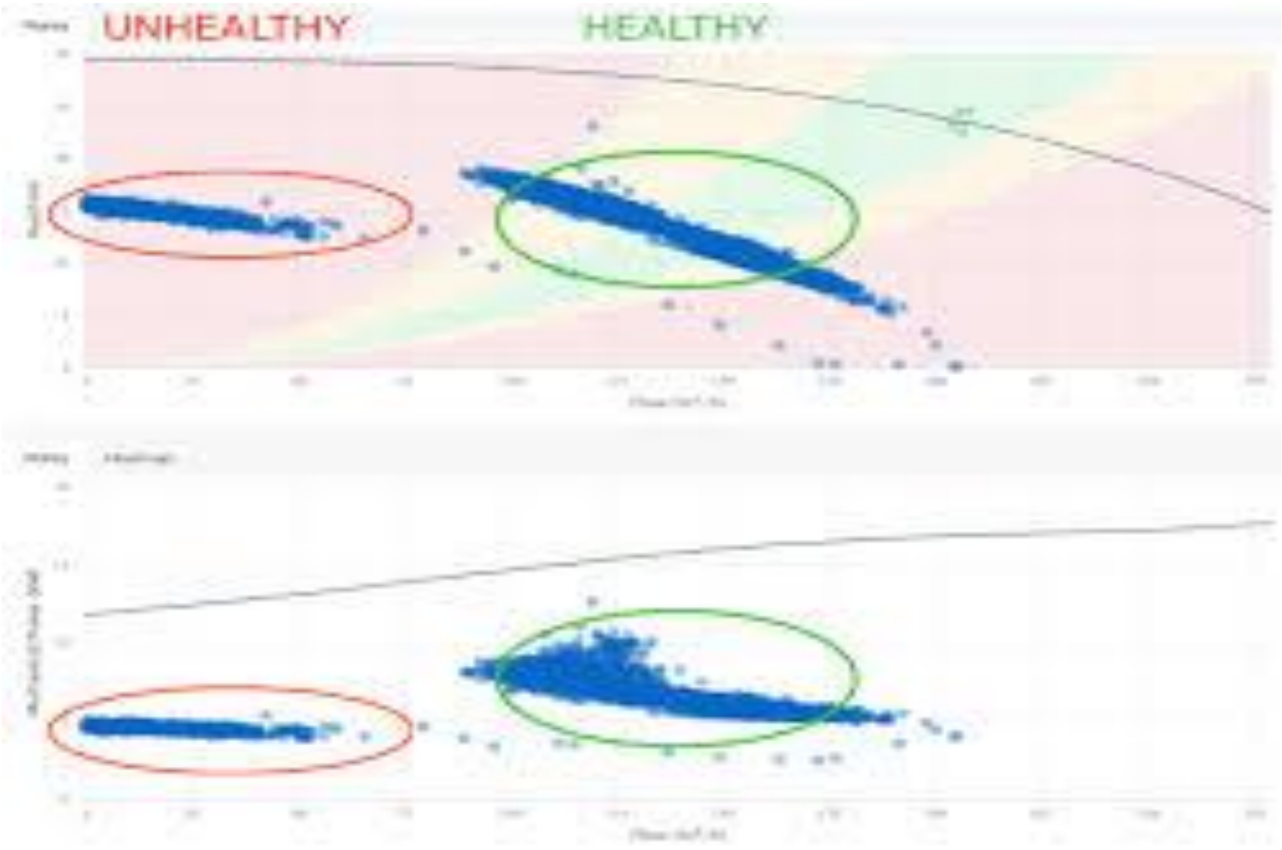
- **Head (y-axis)**

$H = [((PT1 + PT2) / 2) - (\gamma \times h)] / \gamma$
→ where:
  - PT1 = 1_Pressure, PT2 = 2_Pressure
  - h = Sump_level (ft)
    Water level in sump tank, (have to convert in meters)
  - γ = Specific weight of water ≈ 9810 N/m^3

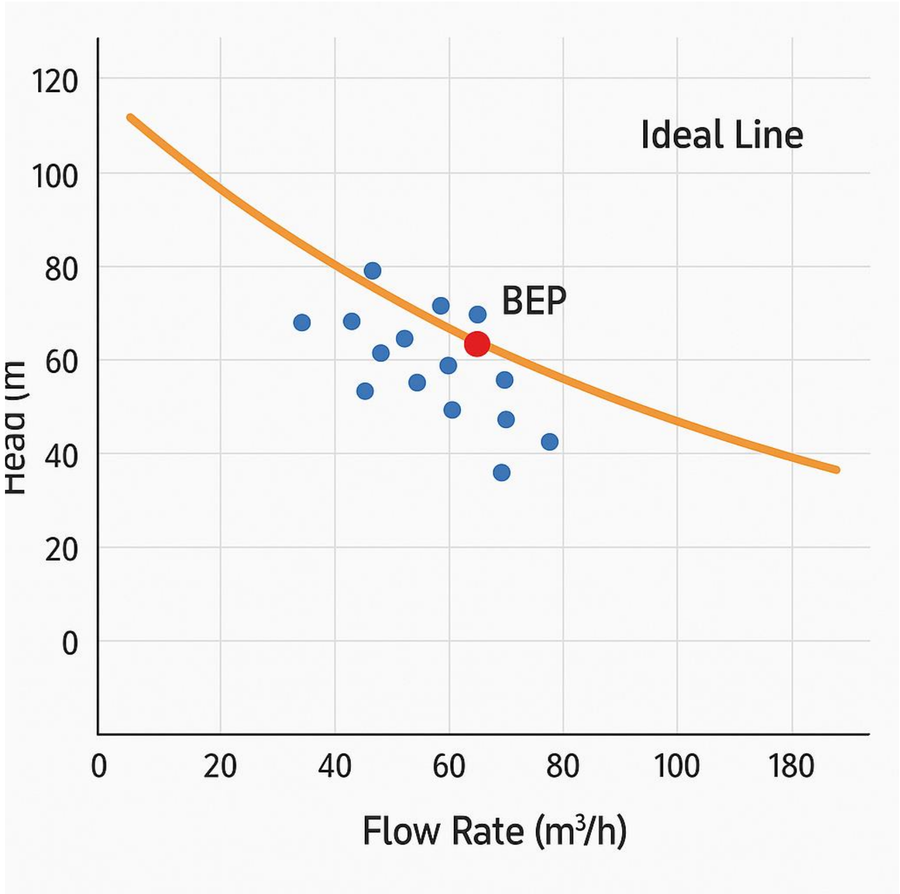
Pump-Specific Logic :

```
if Pump_1_On == 1:
flow_p1 = Flow1 + Flow2
avg_p1 = (PT1 + PT2) / 2
head_p1 = (avg_p1 - (γ * h)) / γ
# Plot these values on Pump 1's Head-Flow graph

If Pump_2_On == 1
flow_p2 = Flow1 + Flow2
avg_p2 = (PT1 + PT2) / 2
head_p2 = (avg_p2 - (γ * h)) / γ
# Plot these values on Pump 2's Head-Flow graph
```



Pump head-to-flow curve



Alerts : -

1. Efficiency Alert :-
"Pump is operating at optimal efficiency near the Best Efficiency Point"

2. Flow Rate Alert :-
"High/low flow rate detected from threshold"

Recommendations :-

1. Pump is operating inefficiently, far from the Best Efficiency Point. Check for mismatched flow or pressure demands.
2. Found deviations from the standard Head-Flow curve, needs to schedule maintenance activities.

2). Pump Energy Forecast / Water Demand

- **Requirement :**

1. Predict pump energy consumption based on historical and real-time data.
2. Forecast water demand to optimize pump scheduling and energy usage

- **Alerts :**

  High Energy Consumption Alert – Energy usage exceeds predicted optimal values.
  Water Demand Spike Alert – Unusual increase in water demand detected.

- **Recommendations :**

  Recommend best pump selection and operation schedules based on water forecasted demand.
  Reduce energy consumption by best pump selection & reducing throttling.

Technical Architecture

1). Collect Historical Data

Water usage, pump status, energy consumption

2). Preprocess Data

Clean missing data, format timestamps

3). Feature Engineering

Create time-based features, lag values

4). Train Model

ARIMA / LSTM / Prophet

5). Evaluate Model

MAE, RMSE, accuracy

6). Forecast Output

Water, energy predictions, Best efficiency point recommendation

7). Visualization & Recommendation

Add new outcome key in existing dashboards & and show recommendation

3). Gen AI based Chatbot Integration for Insights

Requirement:

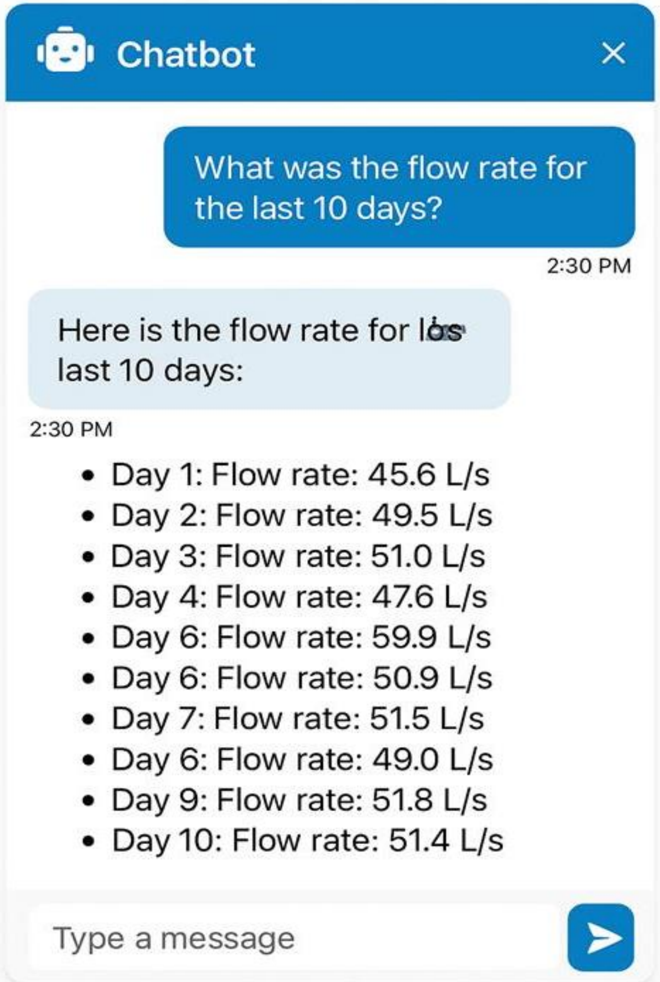
- Enable a conversational interface for users to interact with water system data.
- Allow querying historical and real-time data through natural language.

Action:

- Develop AI chatbot integrated into the existing dashboard.
- Use secure APIs to fetch real-time/historical data.
- Leverage AI to interpret user queries and return precise metrics or status updates.

Benefits:

- Improved Accessibility: Users can easily access critical insights.
- Faster Decision-Making: Instant answers to operational queries without dashboard navigation.
- Scalability: Chatbot can evolve to support recommendations and alerts over time.



Expected Business Impact, Next Roadmap

Expected Benefits:

- Optimized energy usage across all pump operations.
- Better Resource Planning: Data-backed forecasting enables timely decision-making.
- Reduced Operational Costs: Forecast-driven scheduling reduces energy wastage.
- Consistent water pressure and distribution, especially during peak times.

Next Steps & Roadmap

- Finalize data collection pipelines and historical data cleaning.
- Develop and evaluate forecasting models
- Pilot deployment in select zones → Full-scale rollout.
- Integrate models with real-time systems and dashboard.
- Feedback loop with JWIL team for continuous improvement and retraining.

Thank You