Massachusetts Water Resources Authority

Wachusett Aqueduct Pumping Station
Energy Optimization

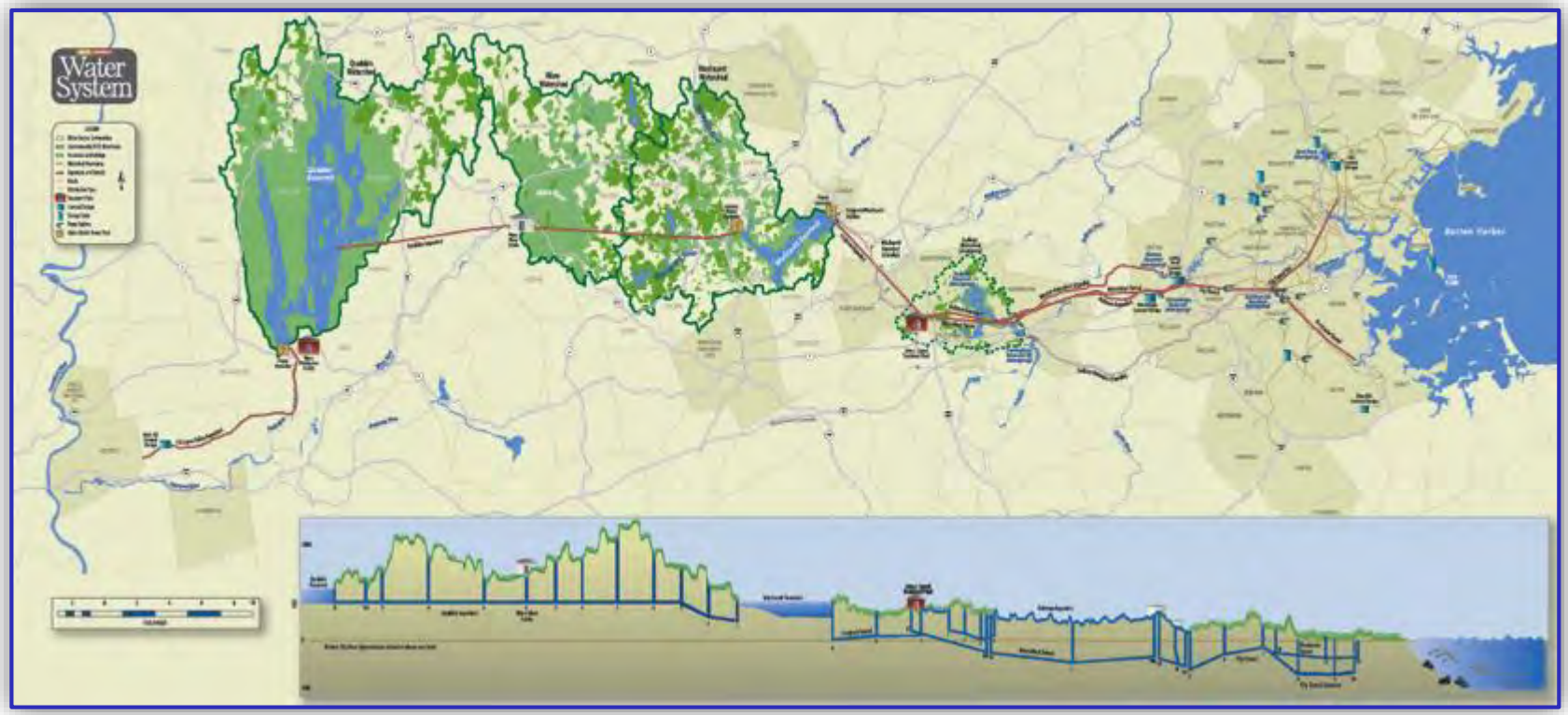
Thomas Renaud, PE, Massachusetts Water Resources Authority
Michael Bartley, PE, Stantec

Agenda

- Pumping Station Project Background
- Design and Construction
- Zero Net Energy Basics
- Zero Net Energy Project Improvements
- Onsite Energy Generation Measures
  - Photovoltaic System

MWRA Drinking Water System

- 102 miles of transmission mains (43 miles standby)
- Two water treatment plants; 430 mgd capacity
- 284 miles of distribution mains; over 4,700 valves
- 243 million gallons of covered storage
- 12 pumping stations



MWRA Water Redundancy Program

- Lack of tunnel redundancy from Wachusett Reservoir to John Carroll Water Treatment Plant (CWTP).

Project Background

- **1898 –** Wachusett Aqueduct was constructed.
  - 240 mgd capacity by gravity.

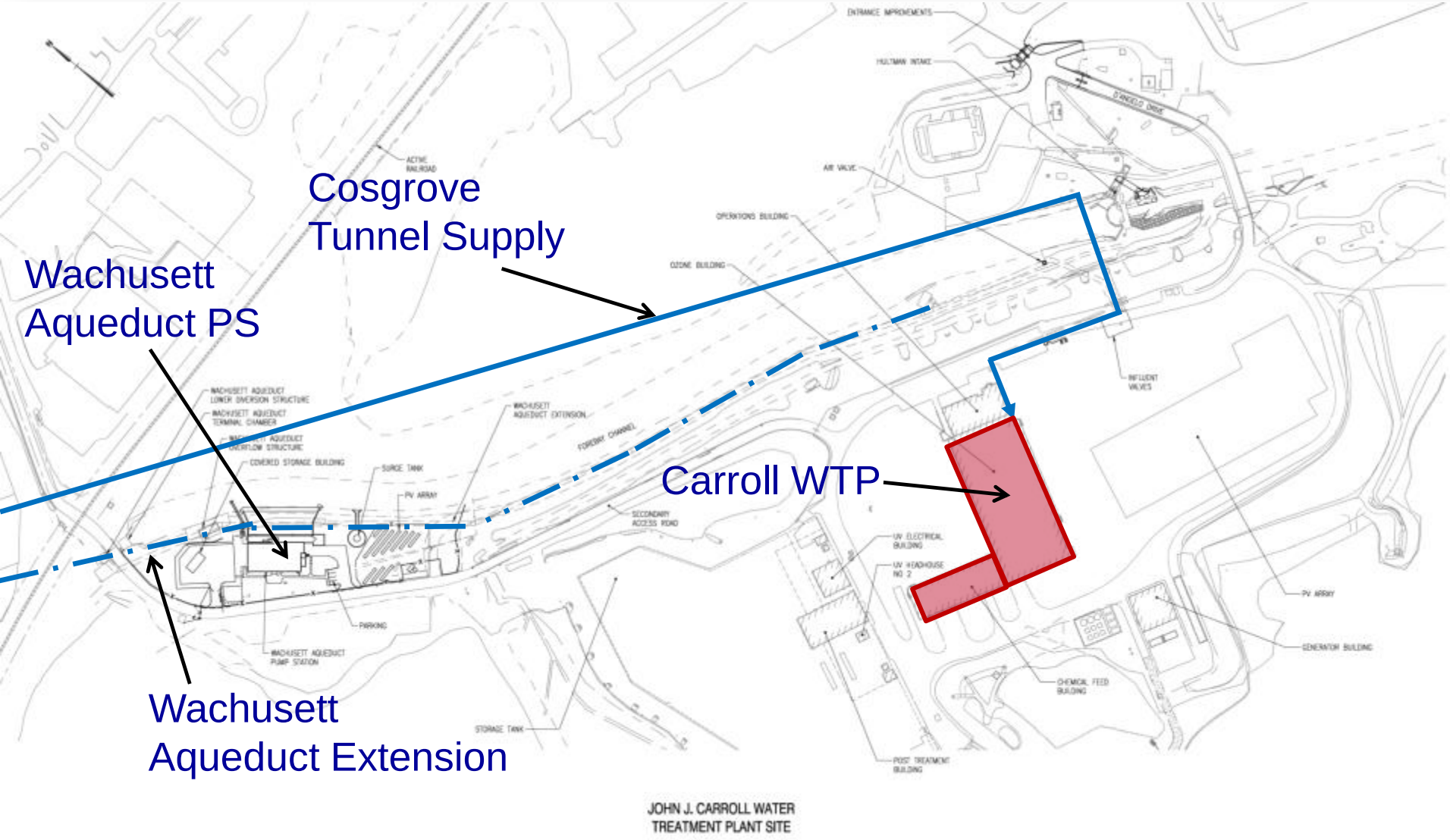
Project Background

- **1966 –** Cosgrove Tunnel replaced aqueduct as water supply source.
  - Wachusett Aqueduct maintained as emergency water supply source.

- **2003 –** Wachusett Aqueduct rehabilitated and placed temporarily in service during construction of Cosgrove Tunnel connection to CWTP.

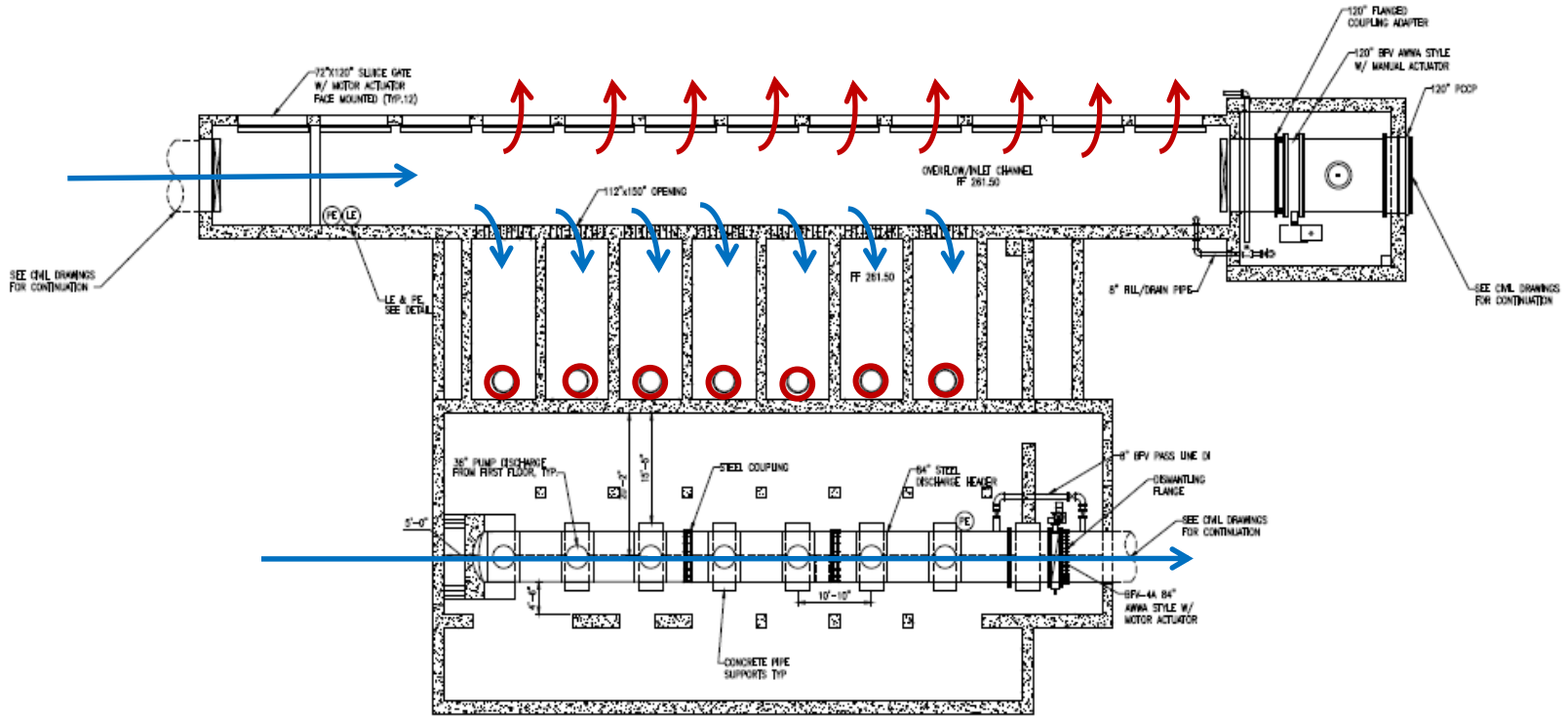
John J. Carroll Water Treatment Plant

Wachusett Aqueduct Redundant Supply



Pumping Station Design

- 122′ x 68′ and 51′ high masonry building
  - 240 mgd design pump rate
  - 7 identical pumps (6 operating, 1 stand-by)
- Surge tank and storage yard



BASEMENT PLAN

SCALE: 1/8" = 1'-0"

Construction Schedule

- Construction Contract Award: November 18, 2015
  - Awarded at MWRA Board of Directors' Meeting to Barletta Companies (BHD/BEC Joint Venture 2015) for $47,011,000.
- Construction Notice to Proceed: March 1, 2016
- Construction Substantial Completion: February 14, 2019

Building Use

- Typically unoccupied.
- Used as necessary for emergencies.
- Pumps will be operated for a short period each month to ensure reliability.
- Annual operation of the entire station for testing & training.

Why Look at Sustainable Design?

- Executive Order 484 – Leading by Example
  - Massachusetts LEED Plus
- Massachusetts Energy Code
- Zero Net Energy Goals

What is Zero Net Energy?

"A zero net energy building is one that is optimally efficient and, over the course of a year generates energy onsite, using clean renewable resources in a quantity equal to or greater than the total amount of energy consumed onsite."

-Governor's Task Force

Optimally Efficient

- Building systems and envelope are as efficient as possible. Minimize energy consumption.

- Operations within the building are as efficient as practical without jeopardizing the effectiveness and readiness of the facility.

Power Generation for Zero Net Energy

- Power that is generated onsite has to be from a renewable resource.
  - Solar, wind or hydroelectric systems
- Use of emergency generators is not considered a renewable resource.

Zero Net Energy Process

1. Optimize Building Efficiencies
   a) Kickoff Meeting: MWRA, Stantec and Architerra
   b) Facility design and operating requirements reviewed
   c) Workshop on preliminary ideas
   d) Develop preliminary and final recommendations
2. Develop Energy Budgets for the Optimized Facility
   a) Utilize Final Recommendations from Optimization
3. Develop Renewable Energy Source to account for Energy Budget

Pumping Conditions Analyzed

- Standby Mode
  - Only building support systems; No Pumps
- Monthly Pump Operation
  - 1 hour each pump monthly
  - Includes Standby Mode loads

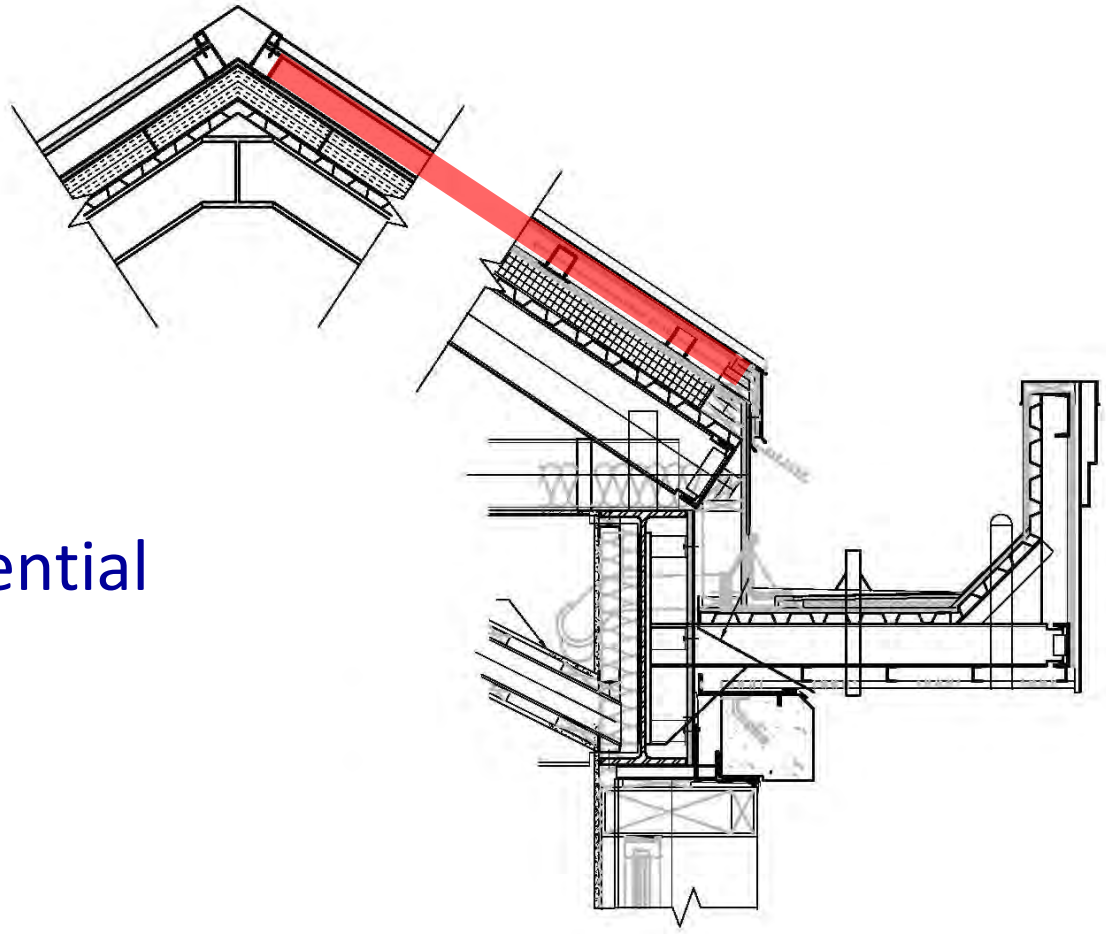
- Annual Operation Testing and Training
  - 3 days continuous pumping, maximum of 4 pumps
  - Includes Standby Mode + Monthly Pump Operation Loads

Building Optimization

- Insulation Upgrades
  - Walls increased from R11.4 to R25.
  - Roof increased from R25 to R38.
  - Subgrade 2” slab on grade 4” on basement walls.
  - Continuous air barrier foundation to roof line.
  - Hard Ceiling in pump room.
- Lighting Optimization
  - High Efficiency Fixtures; Smart Controls.

Cold Roof

- Continuous Air Gap
- Minimize heat gain in Summer
- Minimize heat loss in Winter
- Reduces ice dam potential



Geothermal Heat Pump

- Geothermal Heating
  - Water cooled more efficient
  - Single piece of equipment for heating and cooling

Geothermal Heat Pump

- Geothermal Heating
  - Uses source water for heating/cooling
  - Bypass allows free cooling

Estimate of Energy Consumption

Operating Mode	Est. Annual Energy Use
Standby Mode	67,100 kWh
Standby and Monthly Maintenance	108,000 kWh
Standby Monthly Maintenance & Annual Training	216,600 kWh

Solar System Design

- On-Site Energy Generation for Standby Mode Only
  - Power generation for monthly testing and annual training not feasible.
  - PV Cells on the roof and ground.
  - 84,000 kWh total; Some excess (+/- 16,900 kWh) provided.

Revisions During Construction

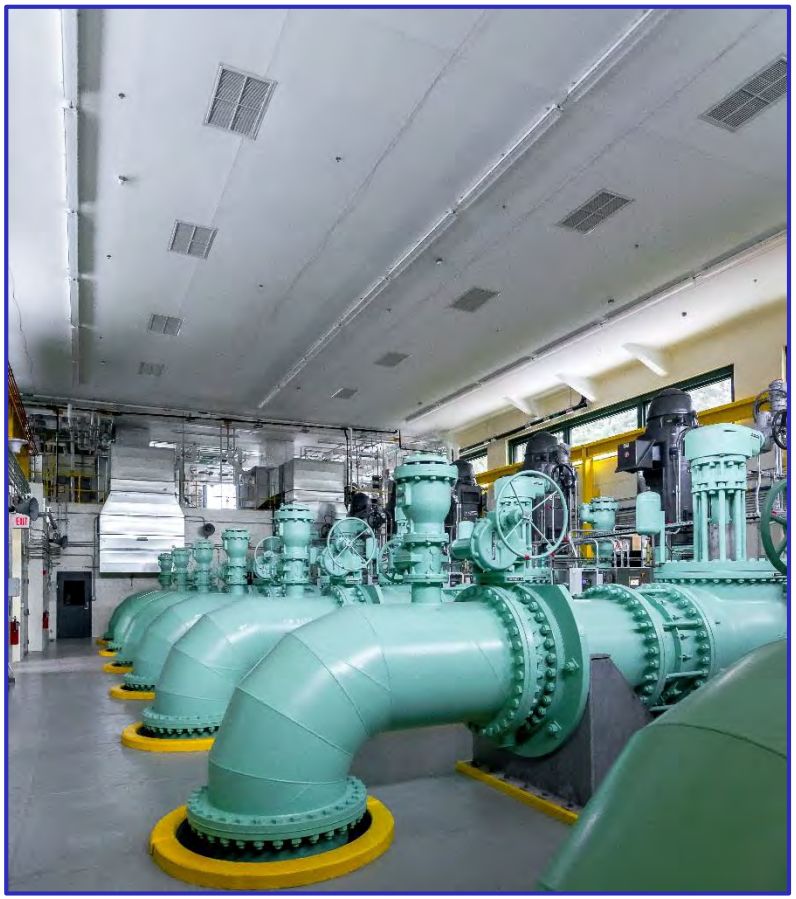
- Construction Changes; Improvement in Solar Technology.
- Increased Efficiencies.
- Same relative footprint w/ more output.

- 90kW nominal DC; 115,000 kWh production.
- Additional Pump Loads can be handled.

Building Exterior, Surge Tank, and Solar Panels (May 2019)

Final Conclusions

- Building Optimizations positive for any project.
- Large pumps used intermittently create unique energy totals.
- Design Conditions: Solar on site offsets building support Standby Mode.
- Construction Revisions: Additional Capacity could cover standby and monthly operation.



Wachusett Aqueduct Pumping Station
Energy Optimization