

The Architect of the Capitol

Chilled Water Efficiency Improvements Through Revitalization

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IDEA2017
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108TH ANNUAL CONFERENCE & TRADE SHOW
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The Architect of the Capitol



The Architect of the Capitol



Care for: 17.4 million+ square feet of facilities; 580+ acres of grounds and thousands of works of art

Serve



Oversee annual budget of approximately \$600 million per year and manage \$1 billion+ in active construction projects

Preserve



Host 3 million+ visitors annually while serving 30,000 daily occupants around the clock to maintain the Capitol campus

Inspire

The Capitol Power Plant



The Capitol Power Plant



West Refrigeration Plant

Data as of 2008

Originally constructed in 1978

*Expansion completed in 2007
for the Capitol Visitor Center*

Served approximately 15 million sq. ft.

Distribution system length of 4 miles

7 electric-driven chillers (40,200 tons)

4 free-cooling heat exchangers

*Primary-secondary pumping
(125 - 150 psig)*

Supply temperature 40°F - 42°F

Operator training program

*Improved efficiency
from 1.2 KW/ton (2005)
to 0.97 KW/ton (2008)*

The Capitol Power Plant



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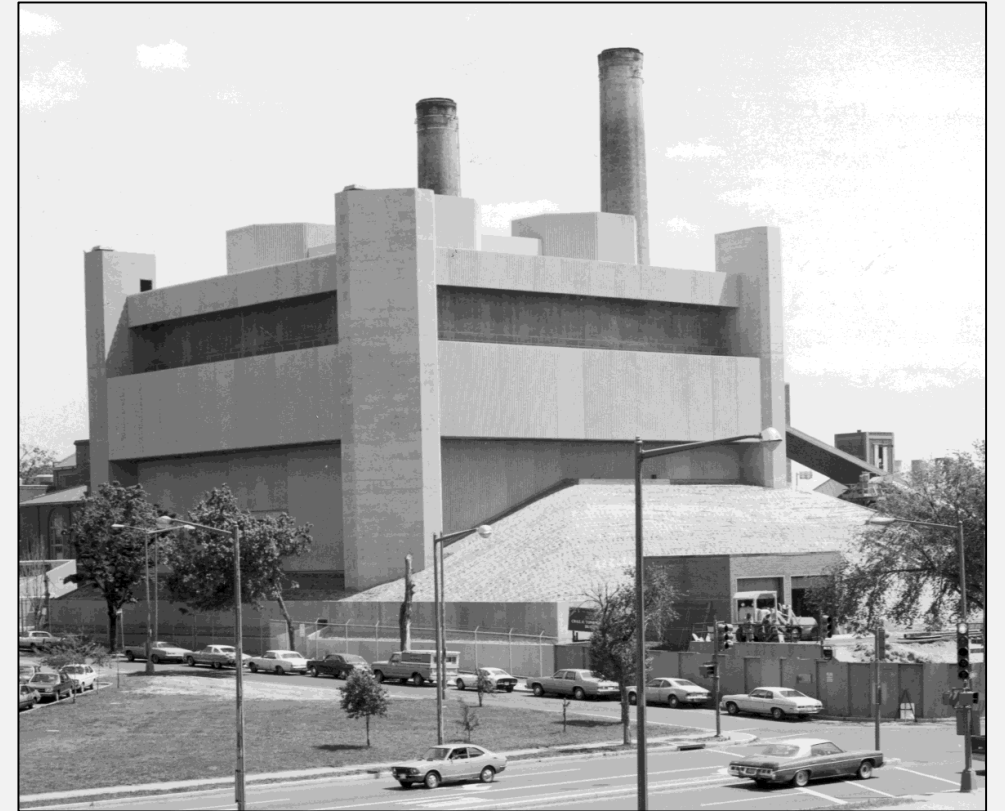
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Refrigeration Plant Revitalization

Program Requirements

- Replace WRP chillers, pumps & piping
- Refurbish WRP cooling towers
- Maintain N+1 capacity
- Keep free cooling system operational
- Integrate into existing DCS control system
- Replace secondary pump control system



Refrigeration Plant Revitalization

Program Goals

- Do not impact operations of the US Congress
- Keep the refrigeration plant fully operational
- Cost and schedule control
- Design for construction in multiple phases
- Best value equipment
- Reduce energy consumption
- Safety



Refrigeration Plant Revitalization

Design Challenges

- Original Design Criteria
- Chiller Capacity Options
- Chilled Water Pumps
- Cooling Tower Capacity Options
- Condenser Pump & Pipe Comparison



Design Challenges

Original Design Criteria

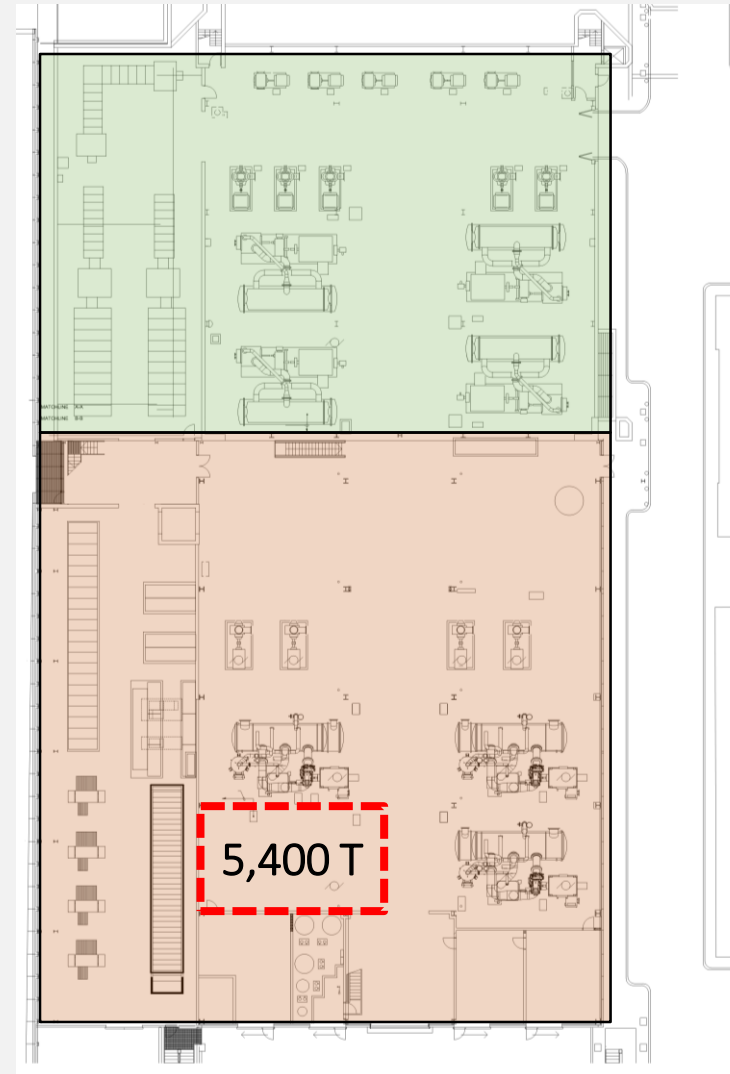
AOC Load = 25,000 Tons

N+1 = 30,000 Tons Available

WRP: 24,000 Tons

WRPE: 16,200 Tons (21,600 Tons)

Total: 40,200 Tons (45,600 Tons)



West Refrigeration Plant
(WRP) 1970's

West Refrigeration Plant
Expansion (WRPE) 2008

Design Challenges

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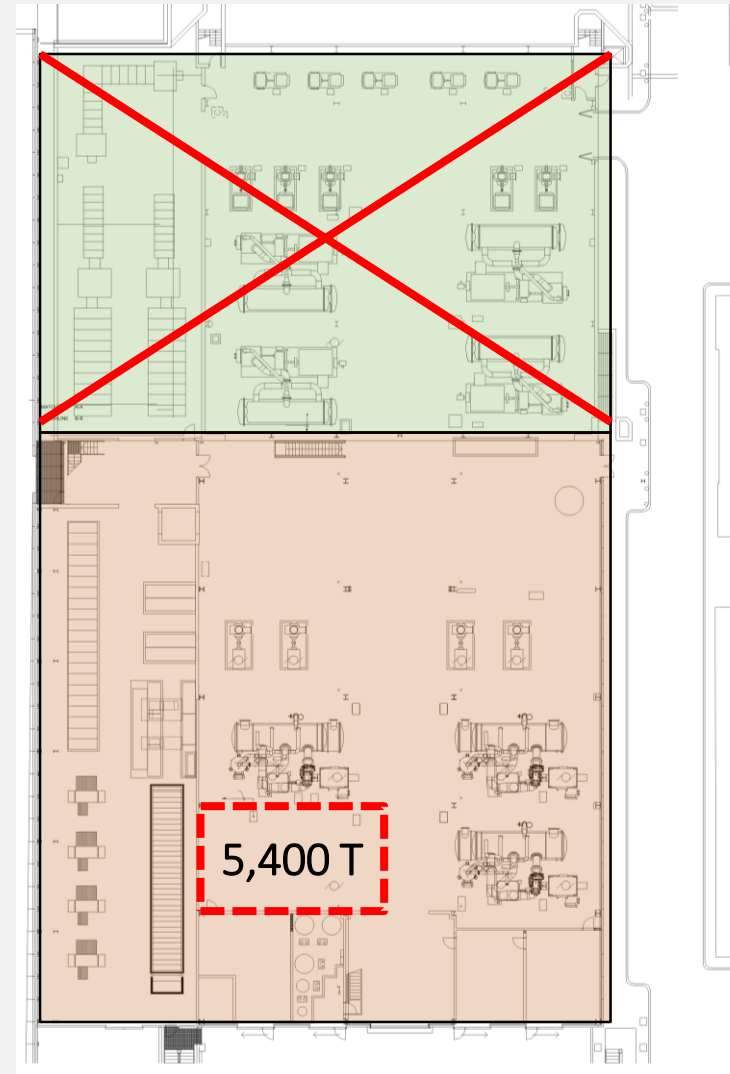
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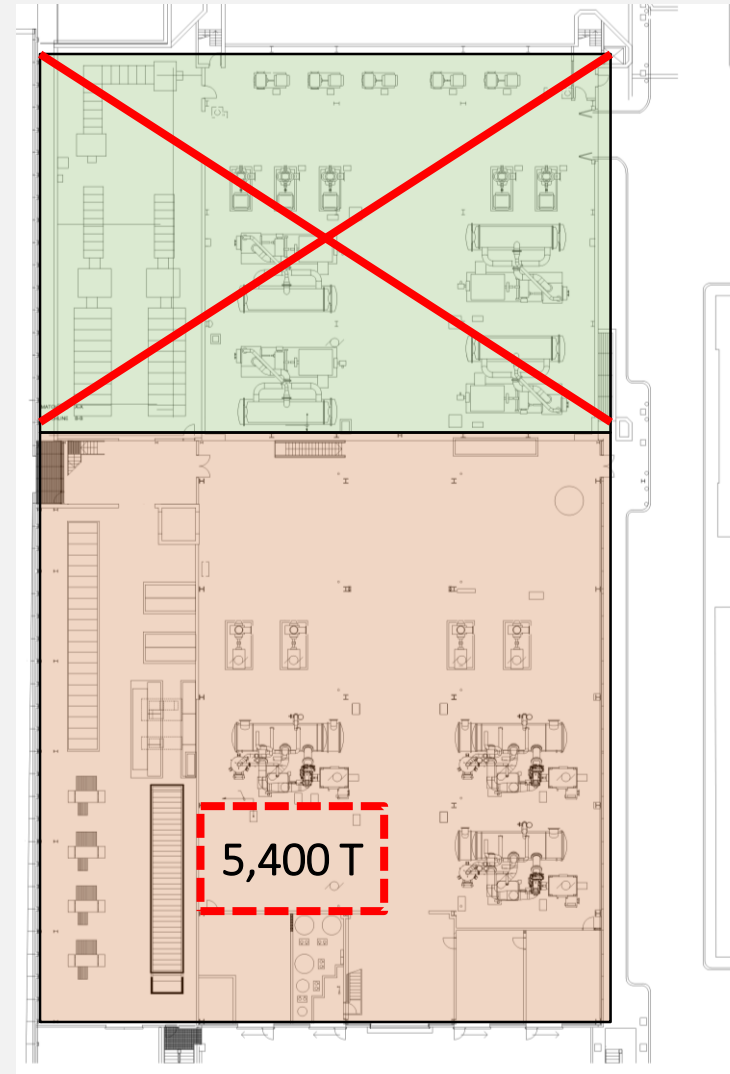
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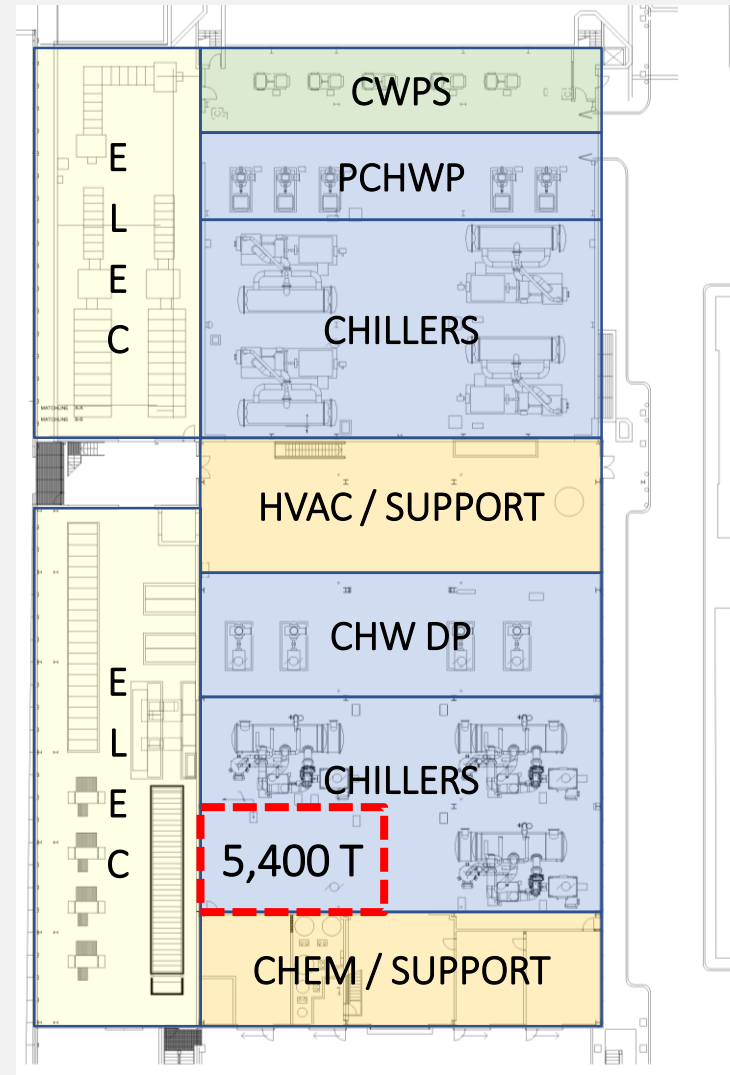
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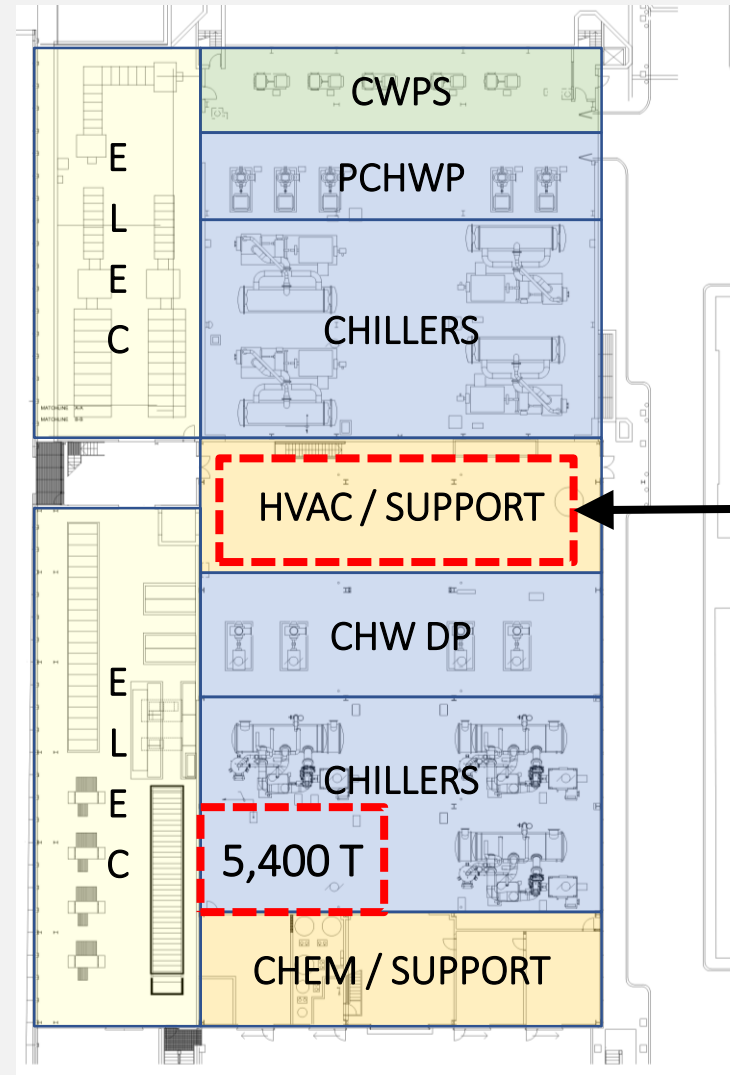
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WRP: ~~24,000 Tons~~

WRPE: 27,000 Tons

Total: ~~40,200 Tons (45,600 Tons)~~

Total: 27,000 Tons < 30,000 Tons



West Refrigeration Plant
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(2) 2,700 T

West Refrigeration Plant
Expansion (WRPE) 2008

Design Challenges

Chiller Capacity Options

AOC Load = 25,000 Tons

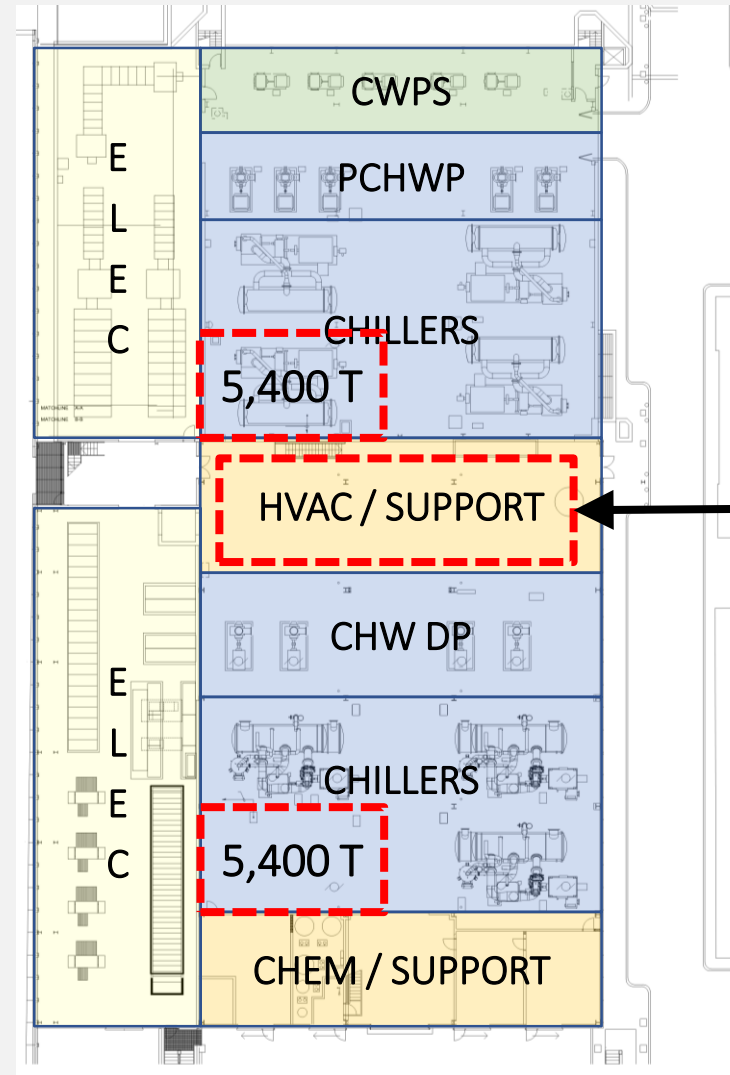
N+1 = 30,000 Tons Available

WRP: ~~24,000 Tons~~

WRPE: 32,400 Tons

Total: ~~40,200 Tons (45,600 Tons)~~

Total: 32,400 Tons > 30,000 Tons



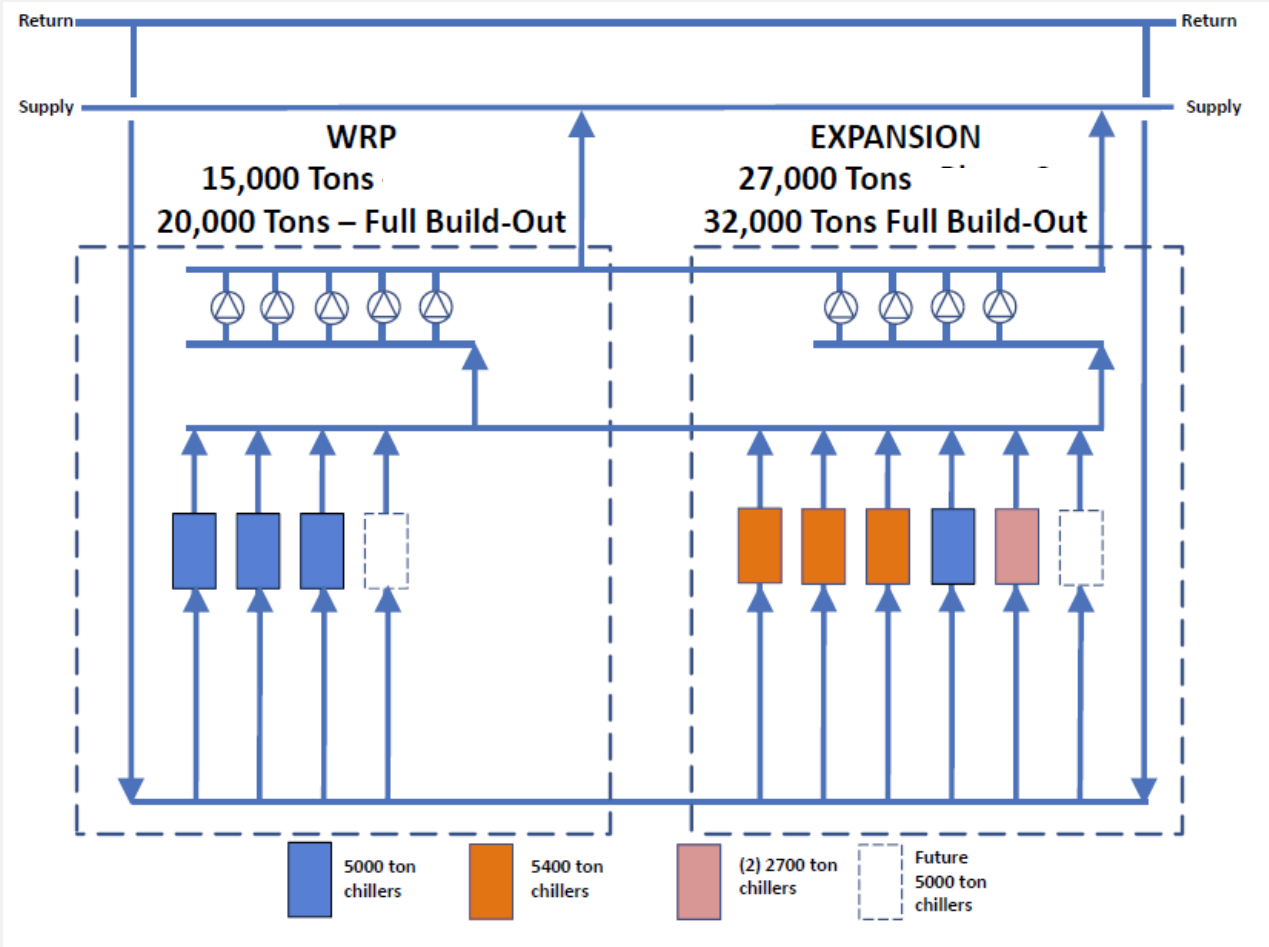
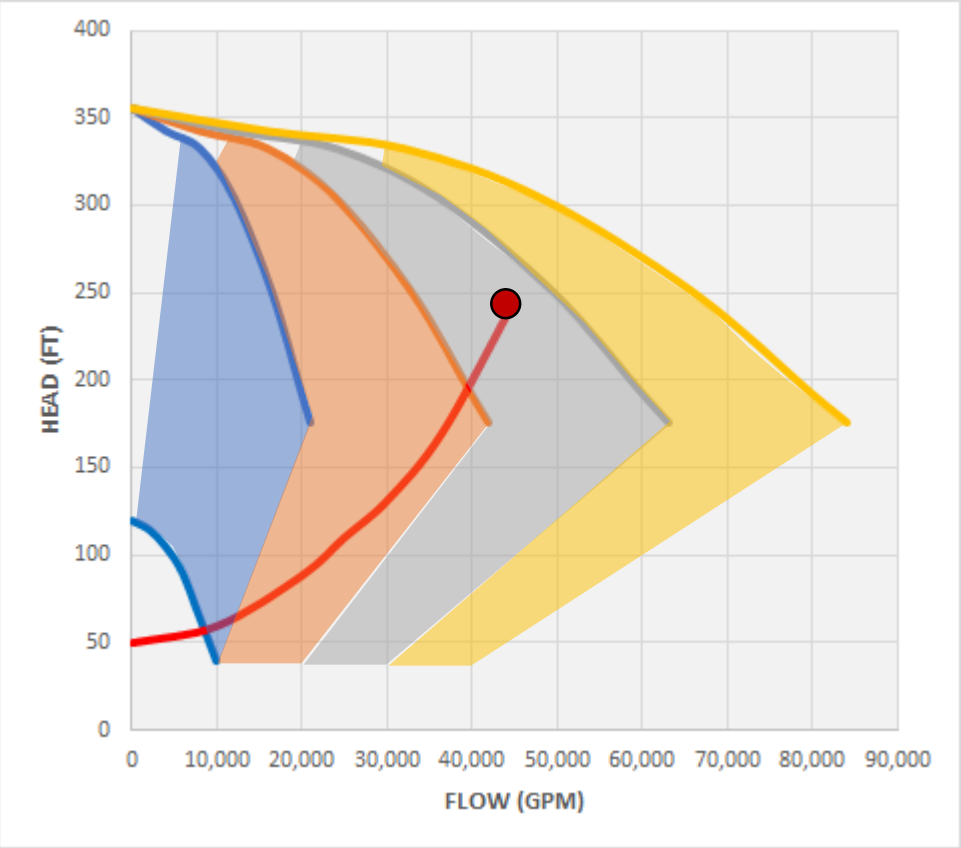
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Design Challenges

Chilled Water Pumps



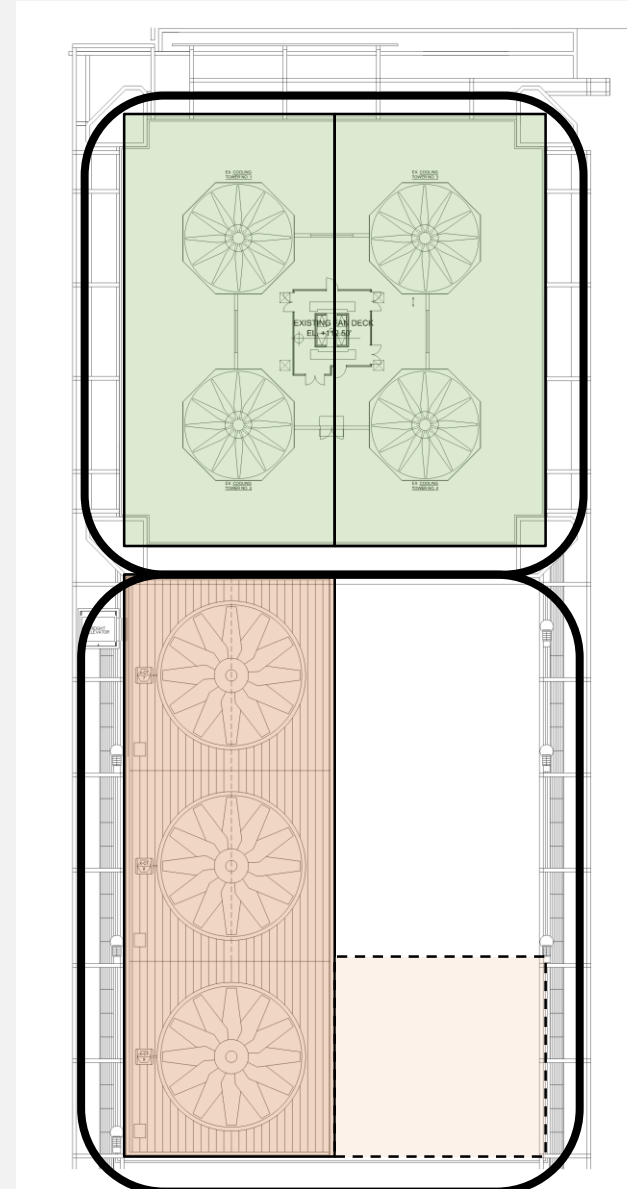
Design Challenges

Cooling Tower Capacity Options

WRP: 24,000 Tons

WRPE: 16,200 Tons (21,600 Tons)

Total: 40,200 Tons (45,600 Tons)



WRP Capacity:
(4) 6,000 TON CELLS

WRPE Capacity:
(4) 5,400 TON CELLS

Design Challenges

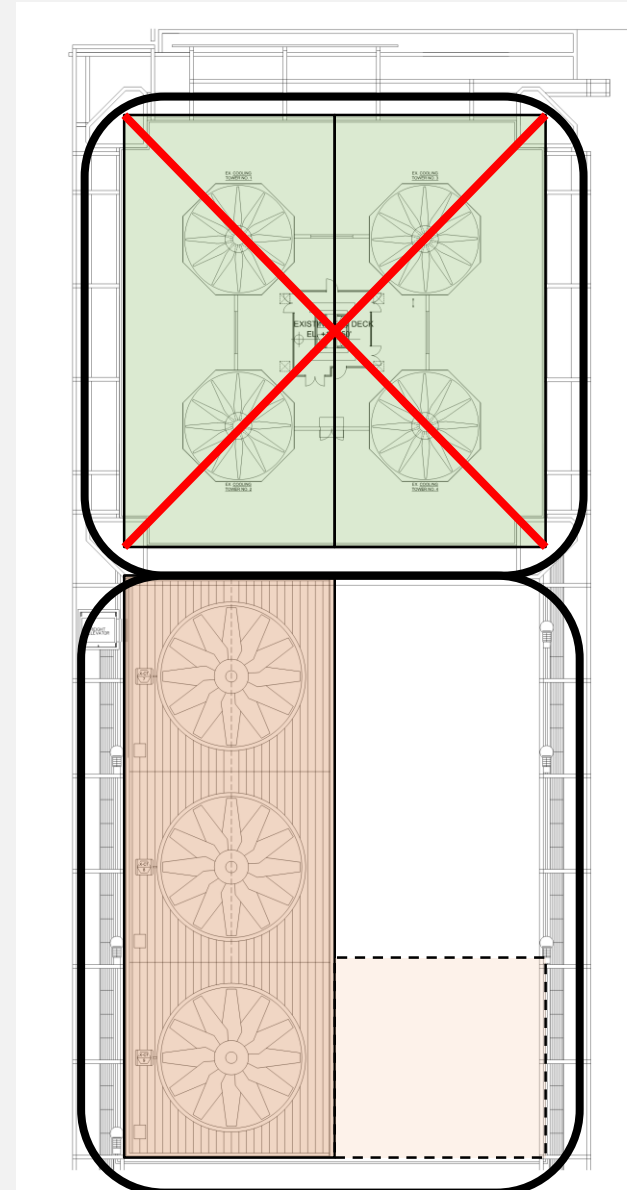
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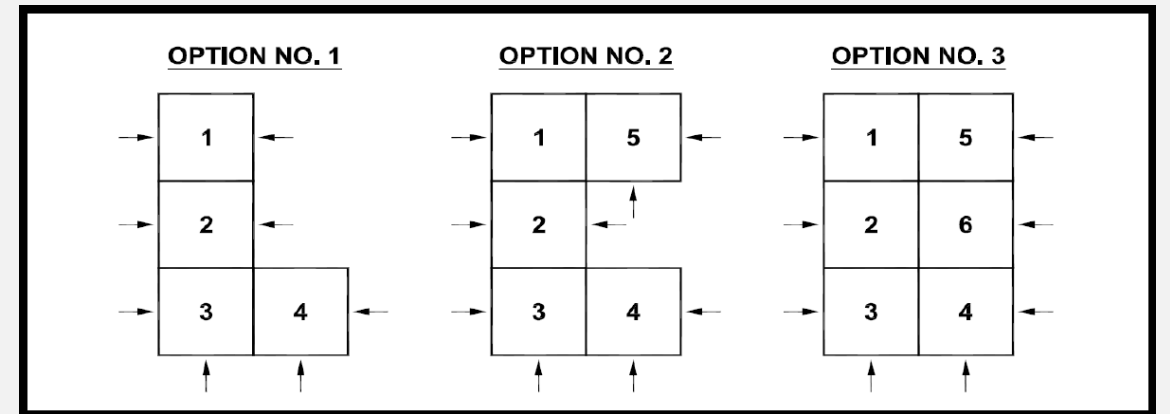
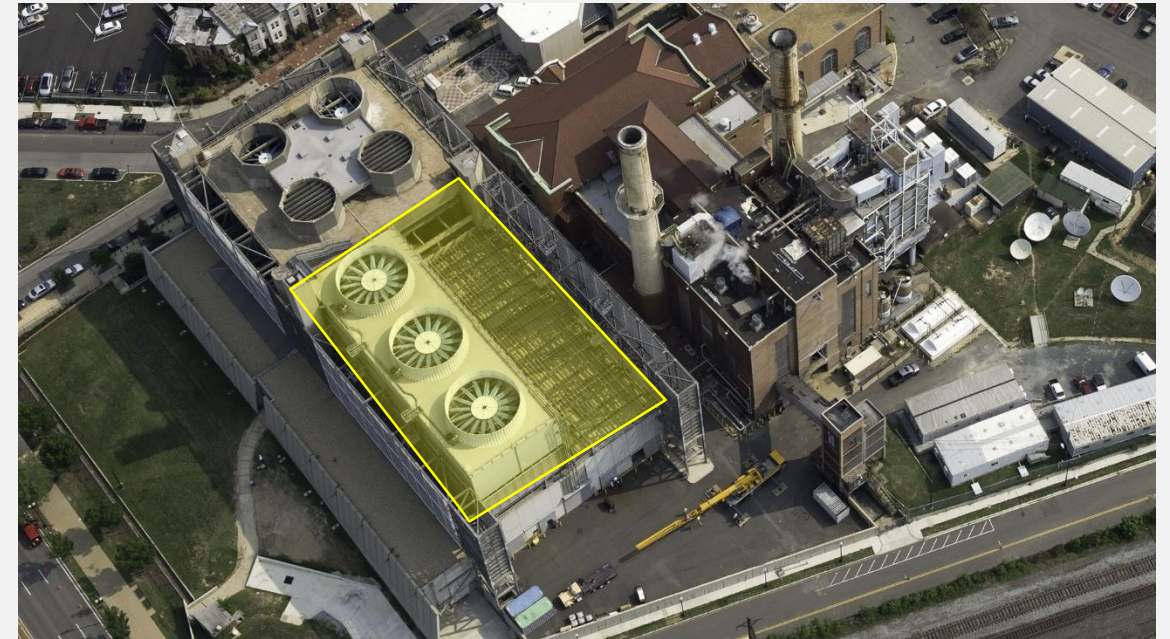
WRPE Capacity:
(4) 5,400 TON CELLS

Design Challenges

Cooling Tower Capacity Options

- 30,000 Tons @ 80°F WB

OPTION NO.	SYSTEM DESCRIPTION		COOLING TOWER CELL CAPACITY						
	WB (°F)	RANGE (°F)	CELL NO. 1 (TONS)	CELL NO. 2 (TONS)	CELL NO. 3 (TONS)	CELL NO. 4 (TONS)	CELL NO. 5 (TONS)	CELL NO. 6 (TONS)	TOTAL (TONS)
	80	10	5,400	5,400	5,400	5,400	---	---	21,600
1	80	12	6,080	6,080	6,080	6,080	---	---	24,320
	79	12	6,560	6,560	6,560	6,560	---	---	26,240
	80	10	4,200	5,400	5,400	5,400	5,400	---	25,800
2	80	12	4,730	6,080	6,080	6,080	6,080	---	29,050
	79	12	5,080	6,560	6,560	6,560	6,560	---	31,320
	80	10	4,200	4,200	5,400	5,400	4,200	4,200	27,600
3	80	12	4,730	4,730	6,080	6,080	4,730	4,730	31,080
	79	12	5,080	5,080	6,560	6,560	5,080	5,080	33,440



Design Challenges

Condenser Pump & Pipe Comparison

- Ultimate Chiller Capacity – 31,200 Tons
- Existing Pumps – 17,100 GPM at 130' Head, 25.55" Impeller
- Replace Impeller – 19,200 GPM at 130' Head, 26.5" Impeller

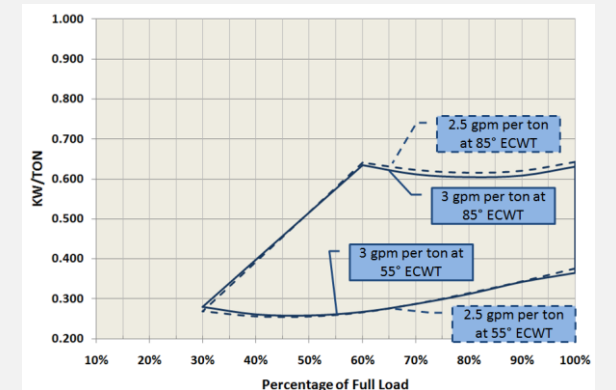
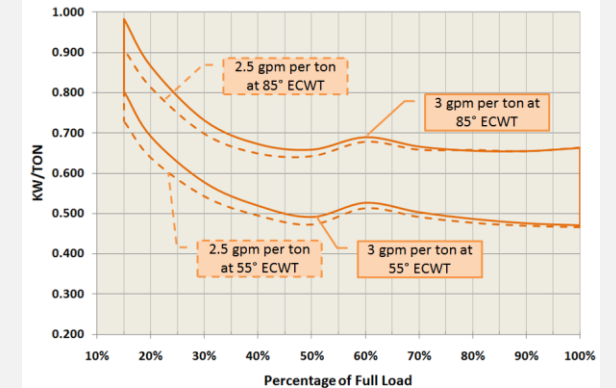
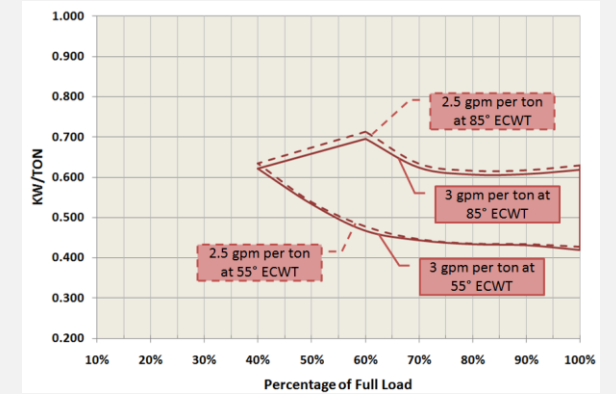
	2.8 GPM/Ton – Single Riser	2.8 GPM/Ton – Double Riser	2.4 GPM/Ton – Single Riser	2.4 GPM/Ton – Double Riser
Flow Rate	90,000 GPM	90,000 GPM	75,000 GPM	75,000 GPM
Pump Head Required	145'	133'	125'	115'
Pump Conditions– 5 Pumps, 1 spare	22,500 GPM at 145'	22,500 GPM at 133'	18,750 GPM at 125'	18,750 GPM at 115'
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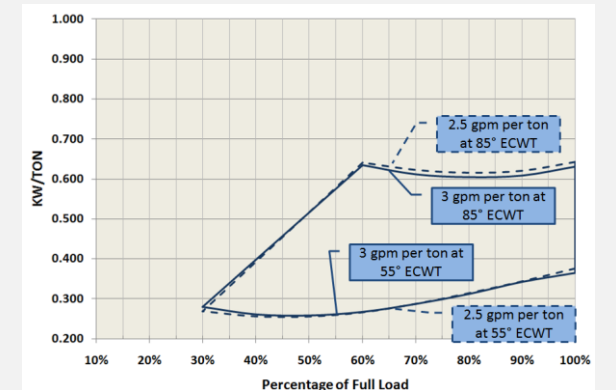
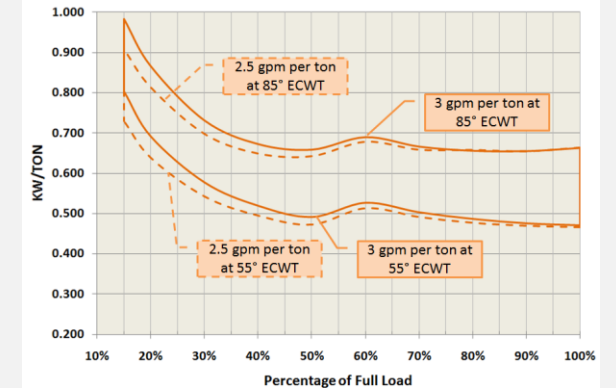
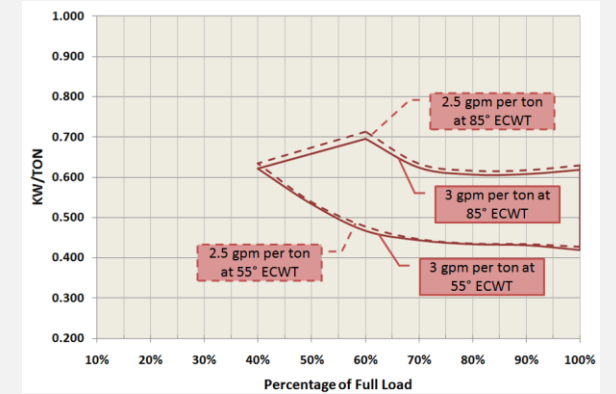
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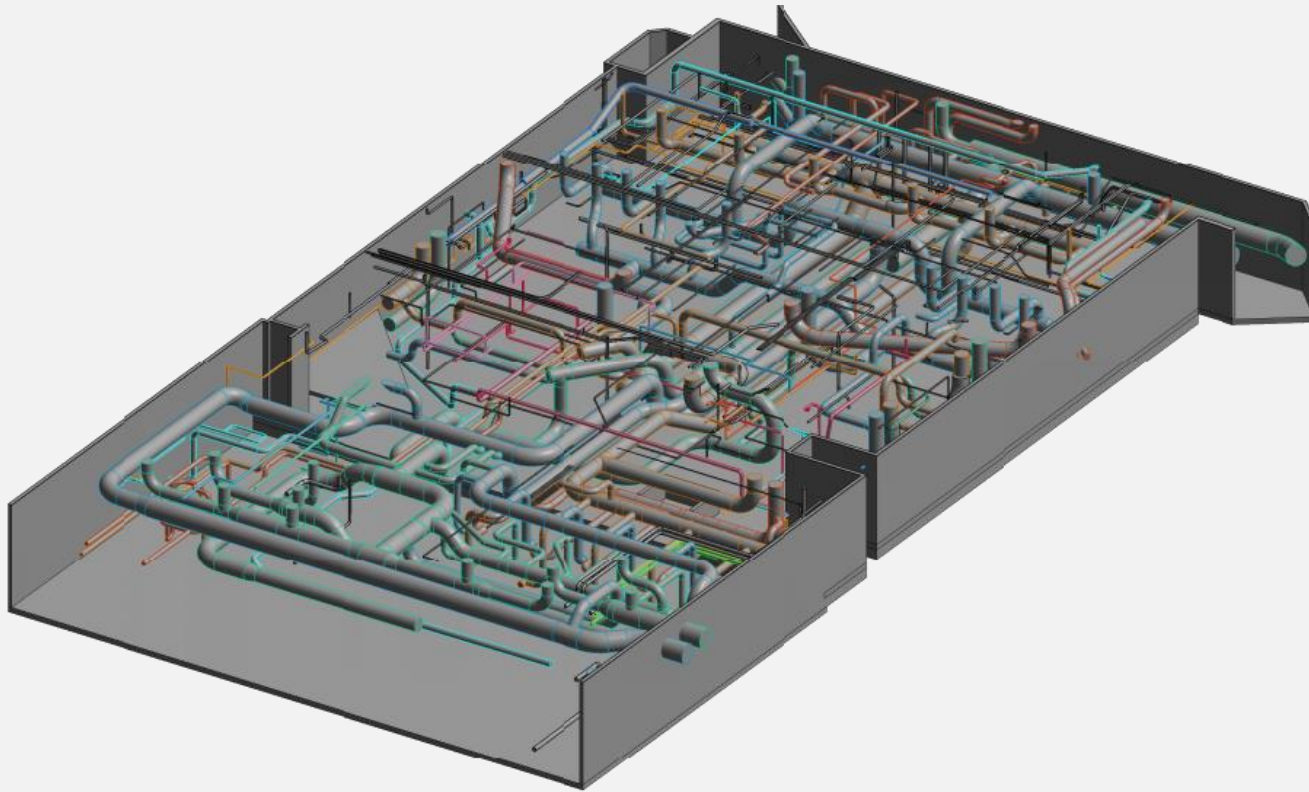
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Recommended Solution



Design Challenges



Construction



Coordination between trades during construction

Tight spaces for staging equipment before installation

1,300 days & 680 crane lifts without a lost-time injury



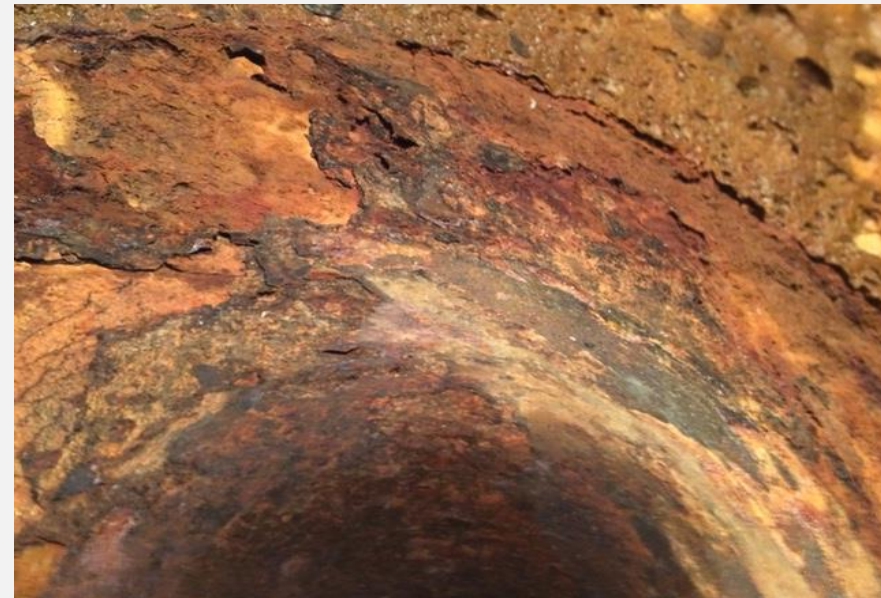
Large Bore Piping



Field Erection of large bore piping

Deterioration of 40 year old piping.

Ventilation of basement during weld operations



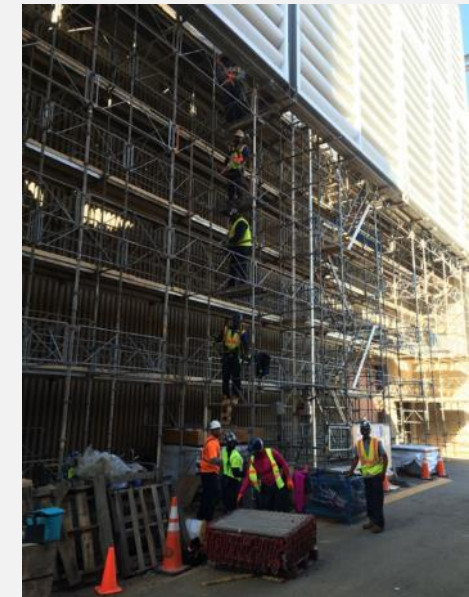
Continuing Operations



Installing new piping while leaving room to remove the old.

Protecting existing roof structures and water proofing

Providing egress during construction



Existing Tower Renovation



Silica Hazard to workers

Silica Dust in existing equipment (Boiler & Chiller Plants)

Short outage period – March 1 to May 15th

Reinforcing of existing structure during construction.



Logistics and Deliveries



Special coordination between vendors and United States Capitol Police for delivery

Tight spaces for the Cranes to get equipment into the facility



5000 Ton Chillers



5,000 ton field-erected chillers were chosen for their high operational efficiency, and large cooling output for the required footprint

Chillers have variable speed compressors and operate through greater temperature ranges.



2700 Ton Chillers



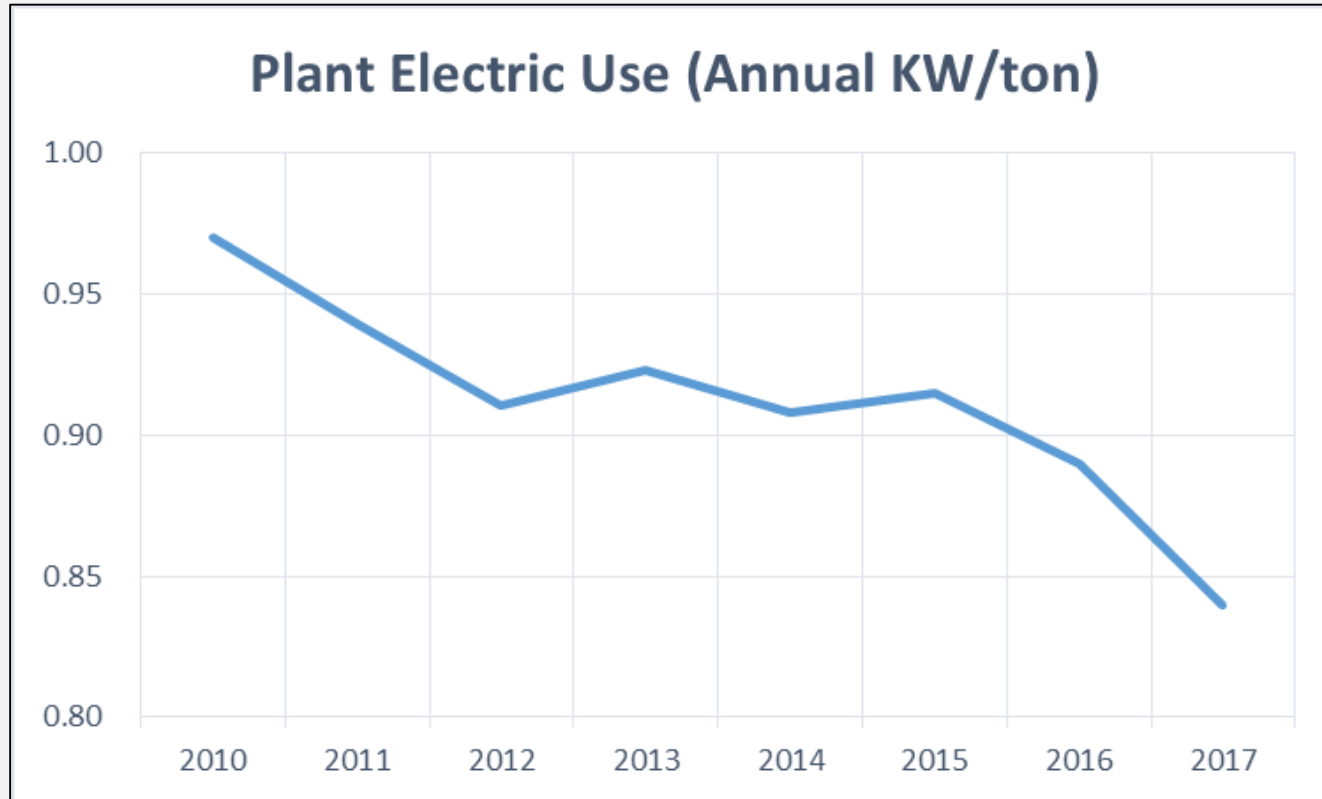
Installed two “half-size” chillers with pumps and piping.

Value engineering during construction resulted in cost avoidance of \$897,000.

Chillers have variable speed compressors and operate through greater temperature ranges. This allows the Capitol Power Plant to operate Free-Cooling while also running chillers in a new “Co-Cooling” mode, increasing CPP energy efficiency in Spring and Fall seasons



Performance Results (..... so far)



- Reduced KW/ton from 0.97 to 0.84
- Installation of two “half-size” chillers improved winter and shoulder season efficiencies
- Extensive training and aggressive use of free cooling and co-cooling
- Installation of two “full-size” chillers improved base-load and peak cooling efficiencies
- Conversion to variable primary resulted in year-round overall system improvements

Lessons Learned

- Goal identification
- Early involvement
- Communication
- Flexibility of design
- FAT
- Shutdown planning & coordination
- VP conversion – all or nothing
- Commissioning



Thank You

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