Primary Beamline
Low Conductivity Water (LCW)
Preliminary Design Review

BOE Adjustments and Review Summary

131.01.03.03.02.04.02 Primary Water LCW System
131.01.03.03.02.04.03 Electrical Bus

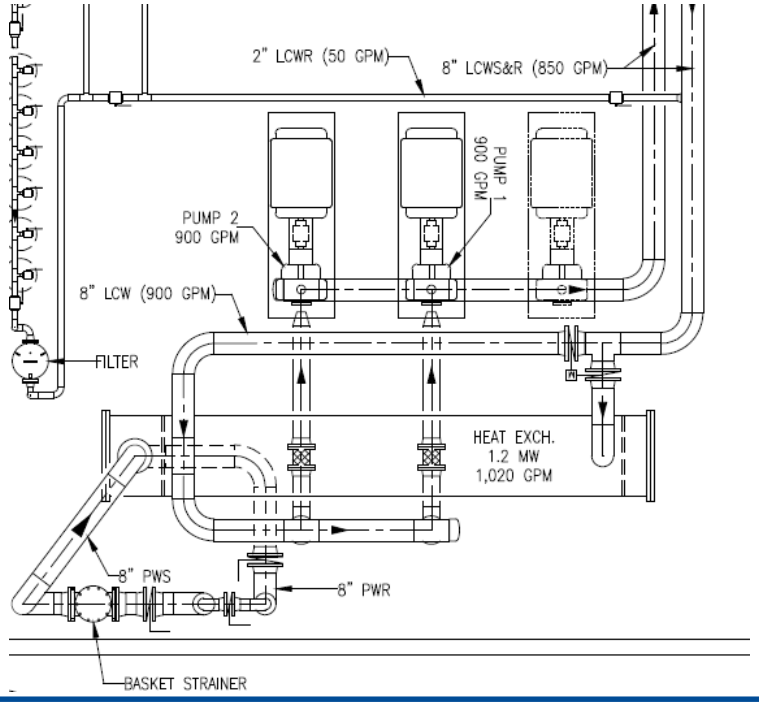
Noah Curfman

October 31, 2019

Fermilab CERN Sanford Underground Research Facility U.S. DEPARTMENT OF ENERGY Office of Science

Primary LCW Pumps

- Reduction from 3 pumps to 2 pumps
  - One running pump, one spare
  - Reduces number of VFDs from 3 to 2
  - Reduces labor associated with pump/VFD installation by 1/3



DUNE DocDB Doc. #8912 BOE Report Revisions

- $41,960 reduction in M&S
- 10 hr. reduction in mechanical/electrical technician labor

Activity Name	Resource Type	Resource Name	Planned	Revised	Contingency
Deliver Primary LCW System Pumps	Material	M&S Standard with Base Year FY19	$76,886	**$51,257**	30%
Deliver Variable Frequency Drives for LCW Pumps	Material	M&S Standard with Base Year FY19	$28,764	**$19,176**	30%
Install Primary LCW System Pumps - Subcontractor	Material	M&S Standard with Base Year FY19	$13,088	**$8,725**	30%
Install Primary LCW System Pumps - Labor	Labor	Mechanical Design Engineer	4	**4**	30%
		Mechanical Assembly Technician	16	**11**	30%
Install Variable Frequency Drives - Subcontractor	Material	M&S Standard with Base Year FY19	$7,141	**$4,761**	40%
Install Variable Frequency Drives - Labor	Labor	Electrical Technician	15	**10**	30%
		Mechanical Design Engineer	4	**4**	30%
		Electrical Design Engineer	4	**4**	30%

DUNE DocDB Doc. #8912 BOE Report Revisions

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Install Variable Frequency Drives - Labor	Labor	Electrical Technician	15	**10**	30%
		Mechanical Design Engineer	4	**4**	30%
		Electrical Design Engineer	4	**4**	30%

DUNE DocDB Doc. #8912 BOE Report & Schedule

- LCW final design: Apr. 2020 – May 2021
  - 280 days
- 200 hours of engineering
  - Includes preparing final prints, prepping PRs, and prototyping
- 400 hours of drafting

Activity Name	Resource Type	Resource Name	Planned	Contingency
Final Design Primary LCW System	Labor	Mechanical Drafter	**400**	30%
		Mechanical Design Engineer	**200**	30%
		Electrical Design Engineer	**80**	30%
		Radiation Protection	**10**	30%
		Control System Engineer	**140**	30%
Final Design Review Primary LCW System	Labor	Radiation Protection	**10**	30%
		Control System Engineer	**10**	30%
		Mechanical Drafter	**40**	30%
		Particle Physicist Experimental	**10**	30%
		Mechanical Design Engineer	**40**	30%
		Electrical Design Engineer	**20**	30%

DUNE DocDB Doc. #8912 BOE Report & Schedule

- Bus & piping removal/replacement: Aug. 2024 – Feb. 2025
- Not Included in this review

Activity Name	Resource Type	Resource Name	Planned	Contingency
Engr. Removal of LCW Lines & Buswork Through Extraction Region	Labor	Mechanical Drafter	40	40%
		Mechanical Design Engineer	30	40%
Engr. Replacement of LCW Lines, Inside Wall Through Extraction Region	Labor	Mechanical Drafter	40	40%
		Mechanical Design Engineer	30	40%
Engr. Replacement of Buswork, Through Extraction Region	Labor	Mechanical Drafter	40	40%
		Mechanical Design Engineer	40	40%
Engr. Replacement of LCW Lines, Crossover to Outside Wall Through Extraction Region	Labor	Mechanical Drafter	40	40%
		Mechanical Design Engineer	50	40%
Engr. Replacement of Buswork, Special Fittings, Through Extraction Region	Labor	Mechanical Drafter	40	40%
		Mechanical Design Engineer	50	40%
Design Review Primary LCW System Q100 Extraction Region - Re-routing	Labor	Mechanical Drafter	20	30%
		Mechanical Design Engineer	20	30%
		Electrical Design Engineer	20	30%
		Particle Physicist Experimental	10	30%
		Radiation Protection	10	30%

DUNE DocDB Doc. #8915 BOE Report & Schedule

- Bus final design: Jul. 2020 – May 2021
  - 150 days including design review
- Aluminum shielding final design: Jan. 2021 – Aug. 2021
  - 150 days including design review

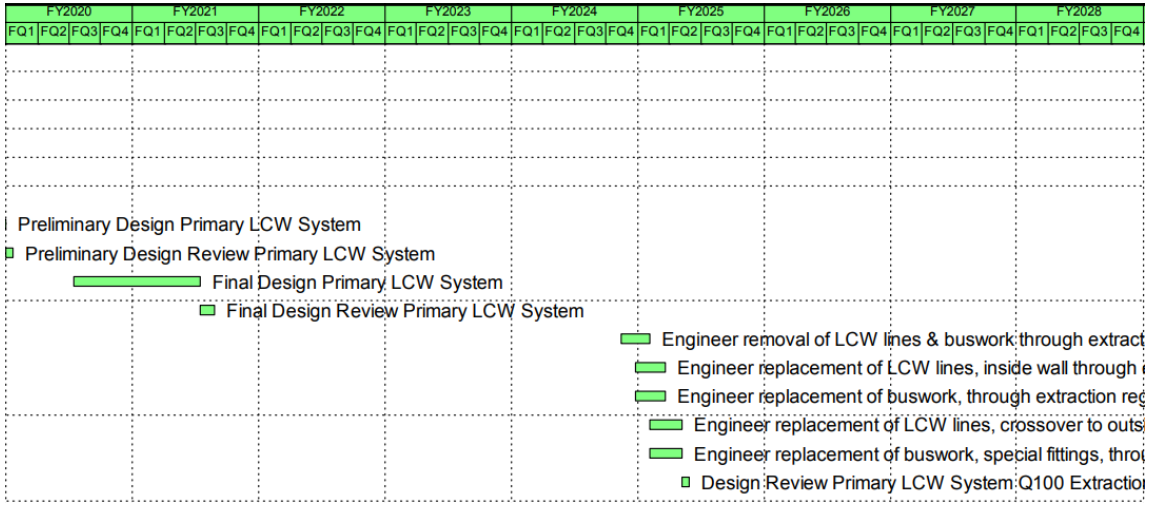
Activity Name	Resource Type	Resource Name	Planned	Contingency
Primary LCW System Electrical Bus Final Des.	Labor	Mechanical Drafter	**600**	60%
		Mechanical Design Engineer	**32**	60%
		Electrical Design Engineer	**400**	60%
Primary LCW System Electrical Bus Final Des. Review	Labor	Mechanical Drafter	**40**	30%
		Particle Physicist Experimental	**10**	30%
		Mechanical Design Engineer	**60**	30%
		Electrical Design Engineer	**15**	30%
Primary LCW System Bus Aluminum Shielding Final Design	Labor	Mechanical Drafter	**600**	60%
		Electrical Design Engineer	**32**	60%
		Mechanical Design Engineer	**400**	60%
Primary LCW System Bus Aluminum Shielding Final Design Review	Labor	Electronics Design Engineer	**15**	40%
		Mechanical Drafter	**40**	40%
		Particle Physicist Experimental	**10**	40%
		Mechanical Design Engineer	**60**	40%

DUNE DocDB Doc. #8915 BOE Report & Schedule

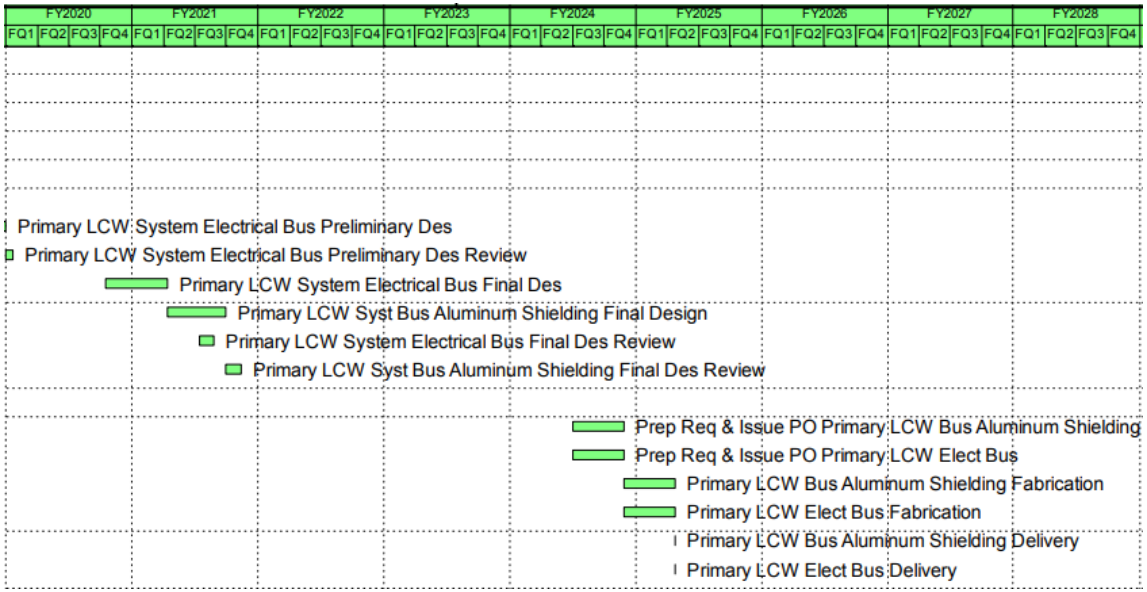
- Bus final design
  - Electrical engineering focused, 400 EE hours allotted
- Aluminum shielding final design
  - Mechanical design includes prototyping, 400 ME hours allotted

Activity Name	Resource Type	Resource Name	Planned	Contingency
Primary LCW System Electrical Bus Final Des.	Labor	Mechanical Drafter	**600**	60%
		Mechanical Design Engineer	**32**	60%
		Electrical Design Engineer	**400**	60%
Primary LCW System Electrical Bus Final Des. Review	Labor	Mechanical Drafter	**40**	30%
		Particle Physicist Experimental	**10**	30%
		Mechanical Design Engineer	**60**	30%
		Electrical Design Engineer	**15**	30%
Primary LCW System Bus Aluminum Shielding Final Design	Labor	Mechanical Drafter	**600**	60%
		Electrical Design Engineer	**32**	60%
		Mechanical Design Engineer	**400**	60%
Primary LCW System Bus Aluminum Shielding Final Design Review	Labor	Electronics Design Engineer	**15**	40%
		Mechanical Drafter	**40**	40%
		Particle Physicist Experimental	**10**	40%
		Mechanical Design Engineer	**60**	40%

DUNE DocDB Doc. #8912 BOE Schedule (LCW Piping)



DUNE DocDB Doc. #8915 BOE Schedule (Buswork & Shielding)



Other BOE Considerations

- Instrumentation estimates update
  - Previously estimated M&S 5% higher than updated estimate
    - Includes increased instrumentation due to service building changes
    - Includes additional electrically operated valves
    - Detailed estimates and info found in DUNE DocDB Doc. #9955
- LCW piping, fittings, and valves
  - Previous estimates remain accurate
- Dipole Bus runs
  - Previous estimates remain accurate

System Summary

- Two 150 HP primary pumps
  - One running, one hot spare
- 1,200 kW heat exchanger
  - 900 GPM LCW, 1020 GPM pond water
- Max estimated system pressure: 178 psig
- MAWP: 200 psig
- Nominal fluid temp: 95°F
- Max fluid temp: 118°F
- 4,342 gal. system volume
  - 1,000 gal. expansion tank

System Operational Scope

- Provide LCW cooling
  - LBNF magnets downstream of Q203
  - LBNF magnet power supplies in LBNF – 5
  - Horn power supplies in LBNF – 20
  - Water cooled bus
- Manage dipole bus routing and hydraulics
  - System does not include cable-connected magnets
  - System does not include bus-to-magnet connections (flags)
  - Includes pump room bus shielding
- Provide LCW makeup for RAW room

System Summary

- Designed based on previously established flow, capacity, and safety guidelines for other Fermilab LCW systems
  - All established technical specifications met or exceeded
- System conforms to ASME B31.3 and FESHM 5031.1
- Detailed print package to ensure successful integration with other beamline systems
- Prototype items to be addressed in final design:
  - Bus safety enclosures in service building
  - Bus-to-magnet connections/connectors

System Design Requirements

- Meet previously described operational goals
- Require minimal unscheduled interventions
- Meet established lab standards for flow and capacity
- Operate over a range of elevations determined by CF
- Use pond water for cooling and MI LCW for fill
- Conform to ASME B31.3 and FESHM 5031.1

Fluid	Low Conductivity Water
Resistivity	9MΩ·cm or better
Nominal Temperature	95°F
Radioactivity	< 1900 pCi/ml
MAWP	200 psig