Full-scale FEED Study for Retrofitting the Prairie State Generating Station with an 816 MWe Capture Plant using Mitsubishi Heavy Industries Post-Combustion CO_2 Capture Technology

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FINAL REPORT

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PROJECT BACKGROUND

The overall goal of the project is to conduct a full front-end engineering design (FEED) study to for a carbon capture system for Unit #2 (816 MWe) at the Prairie State Generating Company's (PSGC) Energy Campus in Marissa, IL based on the KM CDR Process CO_2 capture technology from Mitsubishi Heavy Industries (MHI) using their proprietary solvent KS-21™. This capture technology is the current state-of-the art and in use in smaller commercial applications. The capture technology was scaled up to 816 MWe to be the largest post-combustion capture plant in the world. In addition, it incorporated advancements in the proprietary solvent that translate into reduced capital costs.

PSGC is a mine-mouth power plant, burning high-sulfur Illinois coal mined nearby and has a typical gross capacity of approximately 816MWn per unit. The plant normally operates at full load but can run at a minimum low load of 420MWn. The new CO_2 capture facility will pre-treat the flue gas from the Unit 2 coal-fired boiler to remove CO_2 from the flue gas and generate a high purity CO_2 stream that is conditioned and compressed to pipeline quality for transportation via a dedicated pipeline off-site for sequestration.

The CO_2 capture facility has the capacity to treat 100% of the flue gas generated by Unit 2, as well as the flue gas from the auxiliary boilers supplying steam for the CO_2 capture facility. The facility also has turndown capability to treat only a part of the PSGC's and auxiliary boilers' flue gas exhaust. The flue gas tie-in will be incorporated downstream to the Unit 2 wet electro-static precipitator (WESP), upstream of the existing stack. To promote balanced flow, the new ductwork ties-in to the Unit 2 duct and will transition to a fiberglass reinforced plastic (FRP) duct to the CO_2 capture facility.

The CO_2 capture team acknowledges the economic benefit of the 45Q tax credit of $50/ton for stored CO_2 and $35/ton for used CO_2 and targeted an overall cost of capture that would make the commercial project economical. The cost of capture calculated as part of this project and was found to be $43.42 per metric tonne of CO_2 based on levelized costs for 30 years of operation (85% capacity factor), and includes Interest on Debt and Return on Equity During Operation. This cost of capture was minimized as a result of the benefits of using the KS-21™ solvent and lessons learned from other capture projects.

PROJECT SCOPE

This project is for a full front-end engineering design (FEED) for a carbon capture system that will capture CO_2 from Unit #2 (816 MWe) at the Prairie State Generating Company's (PSGC) Energy Campus in Marissa, IL. The capture facility is based on the KM CDR Process CO_2 capture technology from Mitsubishi Heavy Industries (MHI) and will use the KS-21™ solvent.

Kiewit Corporation (Kiewit) and Sargent & Lundy (S&L) provided engineering services for the project. They provided: (1) detailed design for the OSBL; (2) ISBL and OSBL capital cost estimates; (3) operating and maintenance costs; and (4) aid in developing the overall procurement and construction timeline.

Mitsubishi Heavy Industries (MHI) provided the detailed design and engineering of the ISBL components for the carbon capture island, as well as providing the solvent used in the system. The carbon capture system being designed as part of this study is based MHI's KM CDR Process™ CO_2 capture technology using KS-21™. KS-21™ has several advantageous properties such as lower volatility and greater stability against degradation. Therefore, amine emissions have become lower because KS-21™ is more thermally stable, the Regenerator can be operated at a higher pressure which reduces the power required to drive the compressor.

PROJECT DESIGN BASIS

Site Characteristics

Location

See ***Figure 1***.

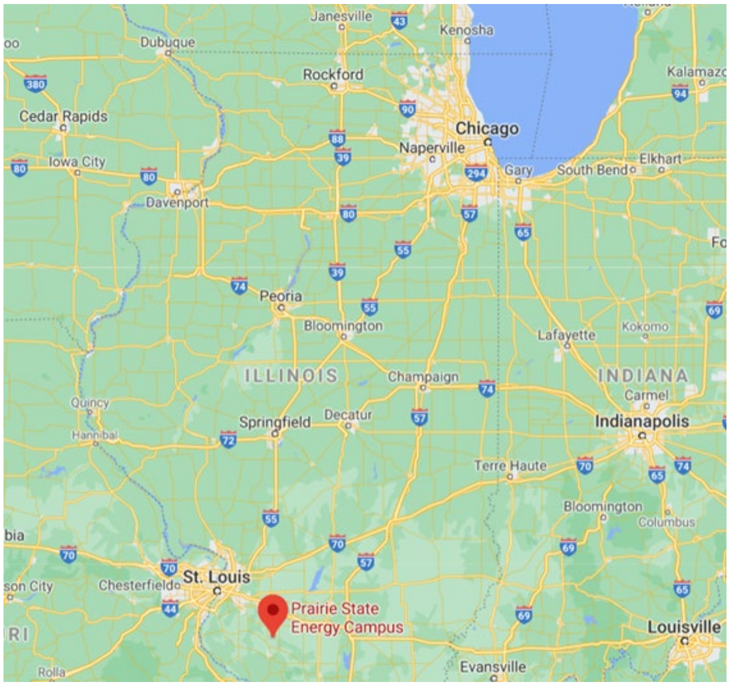

Figure 1. *PSGC is located outside of Marissa in southern Illinois.*

The following aerial view (***Figure 2***) shows the layout of PSGC outside of Marissa, IL at address 1739 New Marigold Rd., Marissa, IL 62257.

Figure 2. *Aerial view of the Prairie State Generating Company campus.*

Topography

The site topographic information for the build location of the CO_2 capture facility indicates the site is generally flat. The build location is shown in the map below in the red square (***Figure 3***). Currently the location of the CO_2 capture facility is being used to produce agricultural products such as corn and soybeans. Prospective laydown areas are marked with in the light blue boxes on the map.

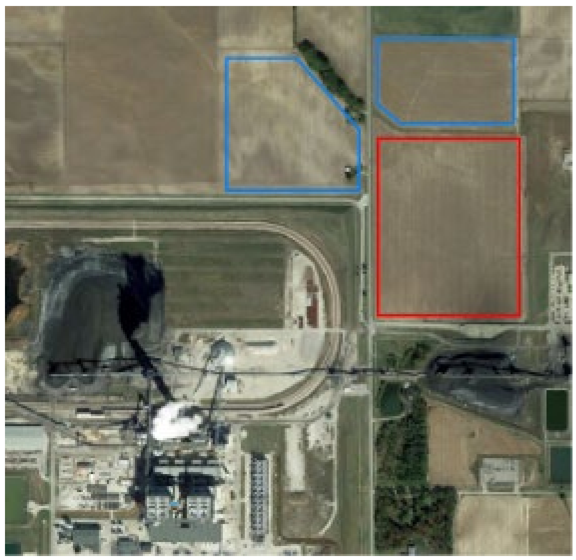

Figure 3*. The build location is outlined in red.*

Transportation Access

Three potential transportation routes were surveyed in May 2020. The roll-off locations that were analyzed were the Ingram Dock located on the Mississippi river in Dupo, IL; KPRD Dock located on the Kaskaskia River in Lenzburg, IL; and the Evansville Dock located on the Kaskaskia River in Evansville, IL.

Present conditions limit the following cargo dimensions (L x W x H) to be able to transport.

See ***Figure 4.*** Mississippi River (Ingram dock)

58.18m [191ft.] x 14.00m [46ft.] x 3.96m [13ft.]

See ***Figure 5.*** Kaskaskia River – KPRD Dock (Option 1)

58.18m [191ft.] x 14.00m [46ft.] x 4.88m [16ft.] **Height can increase by raising utility lines*

See ***Figure 6.*** Kaskaskia River – Evansville Dock (Option 2)

58.18m [191ft.] x 14.00m [46ft.] x 4.88m [16ft.]

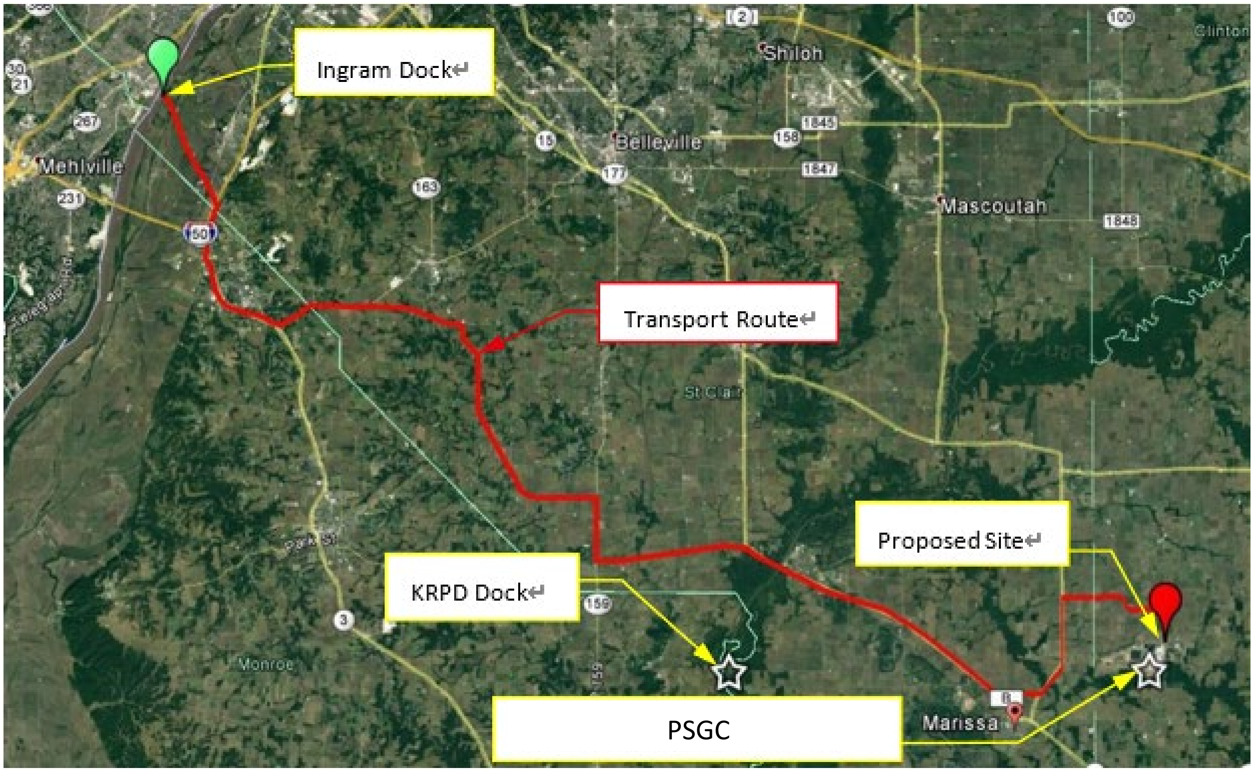

Figure 4. *Route from Mississippi River (Ingram dock) to Proposed Site*

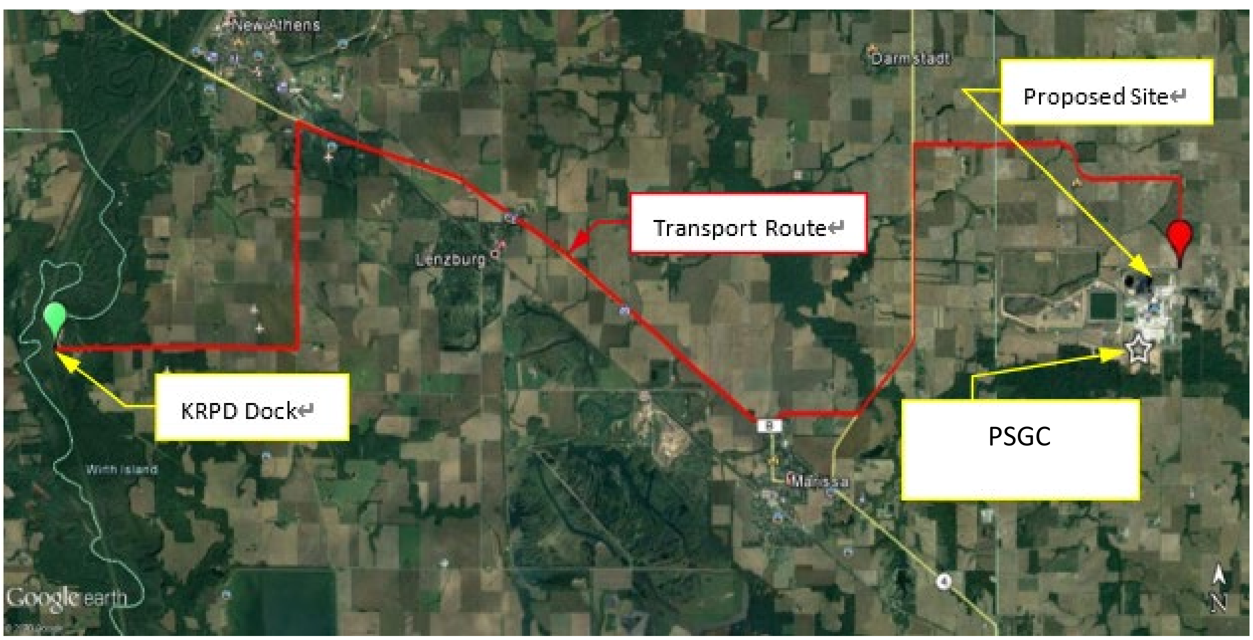

Figure 5. *Route from Kaskaskia River (KPRD Dock (Option 1)) to Proposed Site*

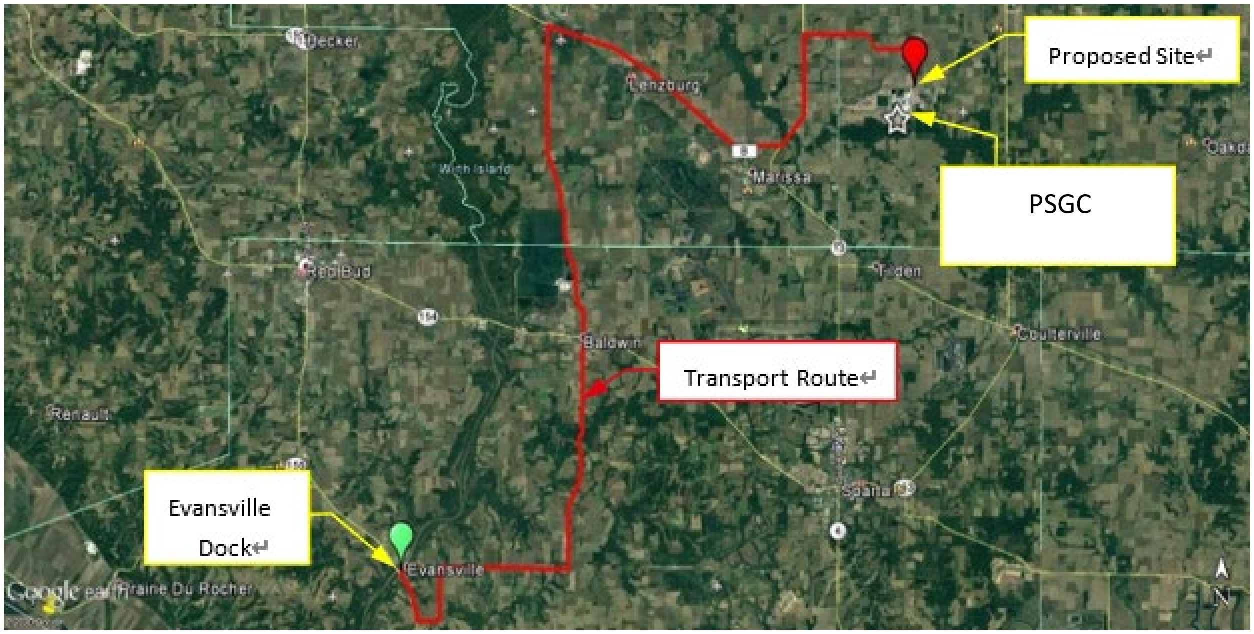

Figure 6. *Route from Kaskaskia River (Evansville Dock (Option 2)) to Proposed Site*

For transport throughout the United States of America, the maximum payload that can be transported along these routes is determined by the Department of Transportation and the local governing officials based on evaluation of loadings to be exerted on the roads and bridges. If any of the roads or bridges are deemed not suitable, minor adjustments will be made to the route. Prior to shipment of equipment a review of the routes will be performed to evaluate any changes that could have occurred to the route such as construction of roads or bridges or new, low-hanging lines being strung. If such changes are identified, minor adjustments will be made to the route.

Additionally, there are height limitations due to bridge crossings on the Kaskaskia River at 30 feet. The preliminary review of the transportation routes has noted low-hanging lines that will require modification.

Areas where there are high concentrations of low-hanging wires has been pinpointed. It will be assumed that all low lines can be raised and left live with the utility companies having the authority to decide whether they will want to shut down any lines in advance. It is assumed that any obstructions along the route (i.e., signs, poles, trees, etc.) can be moved or adjusted without any issues.

Available Utilities

Utilities that are available for use: natural gas (Ameren), electricity (local grid), potable water (PSGC), and raw untreated water (Kaskaskia River).

Site Ambient Conditions

The nearest long-term weather observation station to the PSGC outside of Marissa, Illinois that has at least 50 years of data and has consistent observations through the end of 2019 is the Belleville SIU Research station in Belleville, IL. This station is approximately 19 miles from the PSGC campus and represents climate conditions over that distance. ***Table 1*** shows Belleville station details.

Table 1. *The nearest long-term weather observations are collected at the Belleville SIU Research station.*

Station Name	Network ID	Latitude	Longitude	Record
Belleville SIU Research	COOP 110510	38.5184°N	89.8408°W	1948 – Present

Table 2 below shows the requested information compiled from precipitation and temperature observations from the Belleville station.

Table 2. *Historical Precipitation and Temperature Data for Belleville Station*

Information	Value
1981-2010 Normal Annual Precipitation	41.7 inches
1990-2019 Average Annual Precipitation	42.8 inches
1981-2010 Normal Summer Maximum Temperature	89.2°F
1990-2019 Average Summer Maximum Temperature	87.2°F
1981-2010 Normal Summer Minimum Temperature	66.0°F
1990-2019 Average Summer Minimum Temperature	65.6°F
1981-2010 Normal Winter Maximum Temperature	45.1°F
1990-2019 Average Winter Maximum Temperature	45.6°F
1981-2010 Normal Winter Minimum Temperature	25.3°F
1990-2019 Average Winter Minimum Temperature	26.5°F
1970-2019 Highest Maximum Temperature	106°F
1970-2019 Lowest Maximum Temperature	-4°F
1970-2019 Highest Minimum Temperature	88°F
1970-2019 Lowest Minimum Temperature	-27°F

Table 3 below outlines 25-year and 50-year storm precipitation totals for different durations in climate section 8 (southwest), which includes all of St. Clair County. This information was sourced from the newly

published Bulletin 75 from the Illinois State Water Survey and is estimated using observations between 1948 and 2017.

Table 3. *25-year and 50-year storm precipitation totals for different durations*

Storm Duration	25-year Total (inches)	50-year Total (inches)
240 hours	10.8	11.95
120 hours	8.79	9.81
72 hours	7.96	8.89
48 hours	7.25	8.15
24 hours	6.3	7.14
18 hours	5.92	6.71
12 hours	5.48	6.21
6 hours	4.73	5.36
3 hours	4.03	4.57
2 hours	3.65	4.14
1 hour	2.96	3.36

Site Specific Design Considerations

The site ambient design conditions that will be used for this project are as follows:

Temperature

Basis for plant performance:

- Design dry bulb: 93°F
- Design coincident wet bulb: 78°F

Basis for design of outdoor equipment

- Design maximum dry bulb: 110°F
- Design minimum dry bulb: 0°F

Elevation and Pressure

- Site elevation, ft above mean sea level (MSL): 454 ft.
- Elevation of coal and ash storage, ft above MSL: 455 ft.
- Barometric pressure (approximate) at 70°F, 29.549 in. Hg (14.513 psia)

Rainfall/Snowfall

Rainfall for 24-hour shall be from Rainfall Frequency Atlas of the United States, Technical Paper No.40, US Department of Commerce, Washington, D.C., May 1961, and NOAA Technical Memorandum NWS HYDRO-35, Five-to 60-Minute Precipitation Frequency for the Eastern and Central United States.

Precipitation

- Annual average: 43.14 in.
- 10 year, 1-hour max: 2.20 in.
- 10 year, 24-hour max: 4.77 in.
- 25 year, 1-hour max: 2.59 in.
- 25 year, 24-hour max: 6.3 in.
- 100 year, 1-hour max: 3.24 in.
- 100 year, 24-hour max: 7.44 in.

Snowfall

- Annual average: 17.7 in.
- Maximum snowfall in 24-hr: 14.8 in.

Storm Water

- Design storm return period: 10 years
- Design storm duration: 24 hours

Frost Penetration

- Feet below grade: 30 inches

Wind

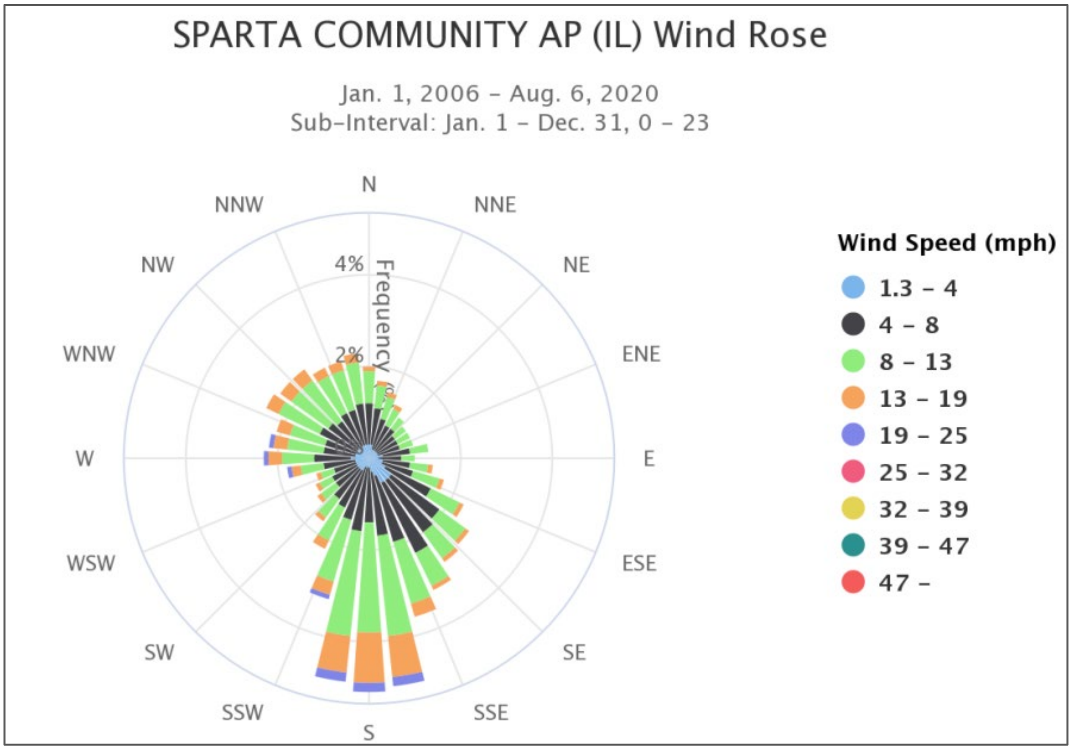

Figure 7. *Sparta Community AP (IL) Wind Rose*

Seismic Data

Table 4. *Seismic Design Parameters*

Risk Category	Building Category III
Seismic Importance Factor, Ie	1.25
Spectral Response Acceleration	
Short Period, 0.2 Second, Ss	0.57 g
1-Second Period, S1	0.17 g
Site Class	C
Design Spectral Response Acceleration Parameter	
Short Period, 0.2 Second, S_{DS}	0.58 g
1-Second Period, S_{D1}	0.20 g
Seismic Design Category	C

Flood Plain

The effective FEMA Flood Insurance Rate Map (170997 0007 A) is dated December of 1980, prior to the original plant construction. Nearby areas of flooding due to a 100-year rainfall event include Mud Creek, which is located south of the existing plant: it is assumed that the plant property where new equipment will be designed is above of the 100-year base flood elevation.

Soil Conditions

Geotechnical investigation of the site was performed by Hanson Engineering Group Inc. (Hanson). The results of the investigation are contained in the final geotechnical report dated June 2021. Hanson's geotechnical investigation included drilling 26 exploratory borings and installing three groundwater level monitoring wells. Bedrock was cored at selected boring locations. In addition, data from previous geotechnical investigations performed by MACTEC, Inc at the facility were reviewed.

Deep foundations will be utilized for the major site structures. Large structures with relatively light loading will be put on mat foundations. Removing and stockpiling the topsoil will be at Owner-designated area(s) for later reuse with Owner's approval.

Noise

The system will be designed such that equipment noise levels in areas where access for operations and maintenance is required, whether on a continuous or intermittent basis, and external to the plant buildings, are of an acceptable level as follows:

- Equipment shall be specified such that the A-weighted sound level resulting from the operation of equipment (including drive motors) shall not exceed a free-field spatial arithmetic average (per piece of equipment) of 85 dBA along the equipment envelope at a height of 1.5 meters above the ground and personnel platforms. The equipment envelope is the perimeter line that completely encompasses the equipment package (including noise control devices) at a distance of 1 meter from the equipment face. Equipment that cannot satisfy the sound requirements will be acoustically insulated as necessary. If after insulating, equipment still cannot satisfy noise requirements, signage will be posted requiring hearing protection in effected area.
- Far field noise requirements are limited to stead state, base load operation. A far field noise study was performed by Hessler Associates, Inc., that provided the noise levels for nearby receptors. Mitigation measures were also identified to comply with Illinois noise requirements.

Maintenance and Accessibility

Adequate space will allow for removal and replacement of components and equipment.

All utility service connections off primary headers have isolation valves for maintenance of individual systems.

Modularization Requirements

The purpose for modularization is to reduce the costs of the project and shorten the overall build schedule. Modularization splits components of a process into parts "modules" that will be fabricated at an offsite workshop and assembled later at the build location.

A preliminary modularization study has been carried out. Process structures and pipe racks will be modularized to fit within the shipping limitations determined by the transportation study. Two key process structures of the CO_2 capture process, the Absorber and Quencher, will be modularized into pieces that will accommodate the shipping limitations. The process area pipe racks will also be modularized and shipped as stackable units. Additional equipment will be modularized and shipped to the build site for assembly.

Fuel Feedstock and Flue Gas Characteristics

Power Plant Fuel Data

PSGC is a mine-mouth plant, burning high-sulfur Illinois coal mined nearby. ***Table 5*** below summarizes the fuel properties for the coal.

Table 5. *Coal Analysis Summary*

	As Received	Dry
Moisture, Total %	13.5	
Ash %	24.63	28.47
Volatile Matter %	31.03	35.87
Fixed Carbon %	30.84	35.66
Sulfur %	3.44	3.97
Gross Calorific Value Btu/lb	8,683	10,039
Carbon %	47.99	55.48
Hydrogen %	3.45	3.99
Nitrogen %	0.93	1.08
Oxygen %	6.06	7.01
Chlorine, Cl %	0.11	0.12
Sulfur, Pyritic %	1.82	2.10

Sulfur, Sulfate %	0.05	0.06
Sulfur, Organic (by diff) %	1.57	1.81
Water Soluble Alkalies - K %	0.011	0.013
Water Soluble Alkalies - Na %	0.183	0.212

Flue Gas Conditions

Table 6 below summarizes the flue gas design conditions (normal operating point) for the existing PSGC Unit 2 coal-fired boiler.

Table 6. *PSGC Flue Gas Analysis Summary*

	Units	Value
Temperature	°F	137
Pressure	inWC	1.0
Volume	MMscfh@68°F	140.189
CO_2	vol %	11.45
O_2	vol %	5.1
N_2	vol %	Balance
SO_2	ppmv	70
NOx	ppmv	37
Moisture	vol %	18.3

Table 7 below summarizes the expected flue gas design conditions (normal operating point) for the natural gas auxiliary boilers.

Table 7. *Natural Gas Auxiliary Boilers Design Basis Summary*

	Units	Value
Temperature	°F	392
Volume (Estimate)	MMscfh@68°F	43.52
CO_2	vol %	8.23
O_2	vol %	2.43
N_2	vol %	Balance
SO_2	ppmv	0
NOx	ppmv	138
Moisture	vol %	18.93

PERMITTING PATHWAY

Air Permitting

In Illinois, two kinds of air pollution control permits exist: 1) construction permits and 2) operating permits. Construction permits are required to be obtained "pre-construction" such that construction of an emission source or air pollution control equipment cannot commence until the construction permit is issued, unless the activity is otherwise exempt from permitting. The list of exemptions for Illinois air construction permitting is relatively limited and most of these are applicable to small emission sources, many of which are located at small businesses. Both new source construction and existing source modification have the ability to trigger construction permitting requirements. Therefore, the carbon capture plant will require a construction permit prior to beginning actual construction on any permanent equipment installations at the proposed site location.

Operating permits are required for operation of an emission source or air pollution control equipment subject to the permit requirements. Operating permits are obtained in the operational phase of the source after some initial compliance obligations specified under the construction permit are satisfied. The primary focus of this briefing document is the air construction permitting options and timelines as this aspect of the overall air permitting process is the most likely to influence the design, costs, and schedule for implementation of the carbon capture plant.

The next relevant concept for evaluating Illinois air permitting applicability is whether the new construction has the potential to emit (PTE) at a major source level under the relevant permitting programs. If the emissions do exceed the major source threshold, then the new emission unit(s) or existing modified emission unit(s) may need to comply with 40 CFR 52.21, the Federal regulations for the Prevention of Significant Deterioration (PSD) of air quality or 35 Ill. Adm. Code (IAC) Part 203, Major Stationary Source Construction and Modification, also known as Nonattainment New Source Review (NNSR). A major source under PSD is defined as:

Any stationary source (or any group of stationary sources that are located on one or more contiguous or adjacent properties, and that are under common control of the same person or persons, and belong to a single major industrial grouping) as described in one of the following:

- When the new or modified source is among a list of 28 specific categories (e.g., chemical process plant, refinery, lime plant), the PTE is 100 tons per year or more of any air pollutant [i.e., particulate matter with an aerodynamic diameter less than 10 microns (PM10), SO_2, NO_X, carbon monoxide (CO), or volatile organic matter (VOM)].
- If the source category is not on that list, the PTE is 250 tons per year or more of any air pollutant.
- In a nonattainment area, when the new or modified source's PTE is 100 tons per year or more for a nonattainment area pollutant.

If the carbon capture plant were to be treated as its own stationary source separate from PSGC, the carbon capture process would be considered a "chemical process plant" under the PSD regulations [refer to 40 CFR 52.21(b)(1)(i)(a)], and thus, the carbon capture would be subject to the reduced major source threshold (MST) (i.e., 100 tpy) applicable to industrial source classifications on the "list of 28." Conversely, if the carbon capture plant were treated as part of the same stationary source as PSGC, the reduce PSD triggering thresholds known as the significant emission rates (SER) would be applicable to emissions increases attributable to the carbon capture process because they would occur at an existing major source.

PSGC is located in Washington County, which has been designated by US EPA as an unclassified/attainment for all criteria pollutants. Therefore, with respect to the federal New Source Review permitting program, only PSD requirements apply to the proposed project.

The annual potential emissions of NO_X from the auxiliary boilers and VOM emissions from amine carryover in the absorbers each have the potential to exceed the PSD major source threshold. If the final annual potential emissions estimates continue to indicate the proposed carbon capture plant generates "new emissions" on a facility-wide basis at or above the 100 tpy MST, then the remaining pollutants would be subject to the reduced SER as the relevant PSD triggering threshold. Once a source is considered major for any regulated pollutant, the source is also considered major for all regulated pollutants and becomes subject to more stringent PSD permitting triggers for these other regulated pollutants.

However, if proactive measures are taken to refine these initial annual potential emissions estimates or additional air pollution controls or mitigation strategies are introduced to the project scope, then it could be possible for the “new emissions” from the carbon capture plant to be designated as either a “true minor” or “synthetic minor” source. Air pollution sources with a PTE that is less than the major source annual emission thresholds for all respective air pollutants are considered minor sources. PTE is defined in Section 39.5 of the Illinois Environmental Protection Act and is used to predict the release of air contaminants from an emission source operating at its maximum rate capacity, 24 hours per day, 365 days per year (8,760 operating hours per year). A “true minor” air pollution source is one that, even operating at its maximum capacity and continuously, cannot exceed the major source annual emission threshold levels without consideration of any “case-by-case” or “voluntary” control requirements, emission limitations, or operating restrictions. In contrast, a synthetic minor source is an air pollution source that is issued an air permit with conditions that legally restrict its PTE to below the MSTs. These enforceable permit conditions can contain limits on the operations of the plant (i.e., types and amounts of material used, production or throughput of emission units, hours of operation, etc.) and associated recordkeeping requirements, which effectively “cap” the PTE of a source to be below major source levels thereby excluding the source from relevant major source permitting program requirements. As the proposed project design effort proceeds, the project team could evaluate the viability of restricting the potential emissions from the carbon capture plant to below the major threshold and introduce a true minor, or synthetic minor, New Source Review permitting strategy.

Under the PSD rules, the owner or operator of the affected source will be subject to PSD review for the new or modified emission unit(s) for each pollutant for which the source triggers PSD requirements. PSD review requires evaluation of the proposed project using several important criteria as summarized below:

- Best Available Control Technology (BACT) Analysis – The proposed facility would need to demonstrate that emissions will be controlled with recognized BACT levels of emission reductions. This is done through a comprehensive technical and economic review of all commercially available emission control methods for each source of each pollutant for which the facility triggers PSD review.

- Air Quality Impact Evaluation – An air quality impact evaluation would need to be conducted through application of air dispersion modeling tools. The primary objective would be to demonstrate no adverse impacts with respect to the National Ambient Air Quality Standards (NAAQS) and PSD Increment thresholds. Impacts need to be examined for general areas surrounding the proposed facility under one set of evaluation criteria (Class II areas), and for any Federally protected areas such as national parks and wilderness areas (Class I areas) under a stricter set of evaluation criteria. While there are no defined Class I areas in Illinois, Class I area impact evaluations for PSD Increments and air quality related values (visibility and acid deposition) can be required for projects located within 300 km of the nearest Class I area. For the PSGC carbon capture project, the Mingo National Wildlife Refuge (Mingo) is located within 144 km south-southeast of the PSGC site, such that a Class I area modeling evaluation could be required for the proposed project if the Federal Land Managers (FLM) determine the emissions levels from the project warrant consideration for potential adverse impacts at Mingo or any other Class I area.
- Additional Impacts Analysis – Impacts on soils, vegetation, crops, and visibility are also required to be evaluated in the PSD review. In addition, under the Endangered Species Act, the US EPA will consult with the US Fish and Wildlife Service (FWS) and/or the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries), to ensure that any permit approvals will not adversely impact federally-listed threatened or endangered species.

Overall, the process of obtaining a PSD permit in Illinois is much more complex and time consuming than any of the minor source permitting options, so sources have a significant incentive to pursue PSD avoidance options wherever such approaches are feasible and cost effective to streamline and shorten the air permitting process.

A final regulatory program of interest for the proposed carbon capture plant's permitting strategy is the HAP (hazardous air pollutants) permitting program. A HAP major source is defined as having potential emissions in excess of 25 tpy for total HAP and/or potential emissions in excess of 10 tpy for any individual HAP. The National Emissions Standards for Hazardous Air Pollutants (NESHAP) for sources regulated under 40 CFR Part 63, are the emission standards for HAPs applicable to major sources of HAPs and some area sources of HAPs in selected source categories. NESHAP allowable emission limits are established based on a maximum achievable control technology (MACT) determination for a particular source. NESHAP requirements apply to major sources in specifically regulated industrial source categories [Clean Air Act Section 112(d)] or on a case-by-case basis [Section 112(g)] for facilities not regulated as a specific industrial source type. US EPA's regulations for case-by-case MACT are detailed in 40 CFR Part 63, Subpart B. Industrial carbon capture plants with the primary purpose of removing CO_2 from gaseous feedstocks are not a listed NESHAP source category, and therefore, case-by-case MACT requirements would be applicable to the proposed carbon capture plant if potential emissions exceed the HAP major source threshold.

Prevention of Significant Deterioration (PSD) Modeling Overview

High-level air dispersion modeling was completed for the proposed plant to evaluate potential compliance with National Ambient Air Quality Standards (NAAQS) of concern. A Preliminary Modeling analysis prepared by Trinity Consultants provides indications that criteria pollutants of concern fall below the NAAQS thresholds.

A typical Prevention of Significant Deterioration (PSD) modeling analysis will include a Significance Analysis, in which modeled emission rates from the project alone are compared against SILs, a NAAQS analysis, in which modeled emission rates from both the project and nearby sources are compared against the NAAQS, and an increment analysis, in which modeled emission rates from the project and nearby increment-consuming sources are compared against the available increment. For this high-level analysis, modeled results were only compared against the SIL and NAAQS. While not a true SIL or NAAQS analysis, this exercise was intended to provide an approximation of SIL and NAAQS modeling to identify any critical issues for the project.

Per EPA guidance, if impacts calculated for a particular pollutant are less than the SILs for all applicable averaging periods, no further analyses are required for that pollutant (i.e., a NAAQS and PSD Increment analysis will not be conducted). If the off-property concentrations of one or more pollutants exceed the corresponding SILs, NAAQS and PSD Increment analyses will be required. The results of the significance analysis are also considered against Significant Monitoring Concentrations (SMCs). If the modeled results exceed the applicable SMC, pre-construction air monitoring may be required.

For this high-level analysis, NO_2 and PM2.5 were identified as the criteria pollutants most likely to exceed the NAAQS. While emissions of NO_X are regulated, the NAAQS applies to concentrations of NO_2 only, not all oxides of nitrogen. ARM2 was utilized to convert modeled NO_X to NO_2.

All source groups also passed the PM2.5 NAAQS analysis. However, this analysis only included the Unit 1 Flue exhaust at PSGC. The addition of other PM2.5 sources with release heights closer to the ground (e.g., raw material and ash handling sources) may have an impact on the results in a more comprehensive analysis. There are no apparent PM2.5 increment issues.

The Trinity Consultants' preliminary modeling analysis indicates that NO_2 is unlikely to be a regulatory concern for the proposed project. This preliminary modeling exercise also shows that modeled results fall below PM2.5 NAAQS thresholds, however air dispersion modeling that will accompany the future PSD application will need to include PSGC PM2.5 emissions sources as well.

Potentially Applicable Air Permitting Scenarios

In the context of this background information, three (3) main air permitting scenarios have been identified. Each warrant evaluation before a recommended permitting strategy can be revealed.

<u>Scenario 1: Carbon Capture Plant as a Single Source with PSGC</u>

This scenario would be applicable if the carbon capture plant were deemed part of the same stationary source permit as PSGC and was required to be permitted as a modification to PSGC's existing major stationary source. For this scenario to apply, Illinois EPA (IEPA) would have to take the position that the carbon capture plant would be considered a support facility to the EGU plant and the carbon capture plant's air permitting applicability determinations would be tied back to PSGC's major stationary source status.

The permitting of the carbon capture plant could be pursued by PSGC as if they are constructing a large expansion project at their own facility, or the permitting could be handled by the third-party owner of the carbon capture plant as long as all relevant regulatory applicability determinations considered the PSGC and carbon capture plants as a single source.

Advantages

- The relevant PSD permitting applicability triggers would be known from the outset. The carbon capture plant's projected emissions increase would be evaluated directly against the SERs like any other physical change, or change in the method of operation, with the potential to increase regulated pollutant emissions as evaluated at the EGU plant. The complexity of determining "ownership" for the emissions released from the carbon absorber flue gas stack would not need to be addressed as all atmospheric emissions from the combined EGU/carbon capture plant, regardless of their origin, would need to be considered for the air permitting applicability evaluation.
- PSGC could take credit for the CO_2, SO_2, and PM emissions reductions offered by the carbon capture plant project as a "creditable emissions decrease" in future PSD applicability analyses of the combined PSGC/carbon capture plant stationary source.
- If there were an increase in utilization of any emission units at PSGC due to the construction and operation of the carbon capture plant, project netting could be used to allow the emissions being controlled by the absorbers to offset any increases that PSGC would have due to the project.

Disadvantages

- PSGC has expressed their desire to keep the permitting of the proposed carbon capture plant separate from the EGU plant's permitting because the carbon capture plant will be entirely owned and operated by a separate entity. PSGC will have no ability to influence operational decisions at the carbon capture plant in terms of environmental compliance or any other business drivers for this separate operation.
- Compared with the preferred and recommended permitting strategy, this scenario increases the likelihood of the proposed project triggering PSD review for NO_X, VOM, and potentially other

regulated pollutants because all emissions increases would have to be compared against the lower SER-based PSD triggering thresholds.

Scenario 2A: Carbon Capture Plant as a Separate Source with Only Emissions Created by the Carbon Capture Plant Subject to Permitting

This scenario would be applicable if the carbon capture plant were designated as a separate stationary source from PSGC with its own fully independent air permit. In this scenario, the carbon capture plant would not be required to address emissions from the absorber flue gas stacks that are attributable directly to PSGC's EGU boilers. The carbon capture plant would only be responsible for permitting the emissions that its operating equipment (i.e., absorbers, auxiliary boilers) have generated. The owner of the carbon capture plant would not be responsible for evaluating the air permitting or regulatory applicability for the CO_2 and other pollutants that ultimately get emitted from the absorber flue gas outlet stacks and that are directly attributable to Unit 2 at PSGC. As a matter of logic, the pollutants in the flue gas feedstock stream to the carbon capture plant have already been permitted under PSGC's air permit and would not need to be "re-permitted" through the development of the carbon capture plant's stand-alone air permit. To fulfill this permitting scenario, a monitoring point would likely need to be added upstream of the take-off point.

Advantages

- In consideration of the entirely separate entities planned to be involved with the EGU and carbon plant, PSGC prefers the carbon capture plant to have its own air permit with no overlapping requirements, or specific obligations, for the EGU plant within the carbon capture plant's stand-alone air permit. This scenario achieves the separate source, stand-alone permitting objective.

  As compared to Scenario 2B (below), the carbon capture plant's air permitting process will be simplified and streamlined as it will only address the relatively small level of emissions generated by the carbon capture plant. This approach maximizes the likelihood of the carbon capture plant's permitting process avoiding PSD review and potentially pursuing a simplified and significantly streamlined true minor or synthetic minor construction permitting pathway.

Disadvantages

- Even if Illinois EPA concedes that the carbon capture plant is only responsible for emissions generated by the carbon capture process, Illinois EPA may choose to impose new requirements within PSGC existing permits concerning the measurement, monitoring, and recordkeeping of discharges from the carbon absorber stacks. This scenario is believed to be unlikely given that the monitoring of emission could be implemented upstream of the divergence of the flue gas to the carbon capture plant, but it is a possibility that must be consider. PSGC will review whether the monitoring of emissions upstream of the divergence of the flue gas to the carbon capture plant will fully demonstrate compliance with applicable EGU regulations such as the Part 75 Acid Rain Program, Mercury and Air Toxics Standards (MATS), and the Cross-State Air Pollution Rule (CSAPR).

Scenario 2B: Carbon Capture Plant as a Separate Source with ALL Emissions from Carbon Capture Plant Subject to Permitting

Like Scenario 2A, this scenario would be applicable if the carbon capture plant were designated as a separate stationary source from PSGC with its own fully independent air permit. In this scenario, the carbon capture plant would be responsible for permitting ALL air emissions discharges from the carbon capture plant regardless of their origin. This approach would be supported by the concept that the flue gas supplied to the carbon capture plant from the PSGC is a "raw material" or "feedstock" for the production of a saleable commodity chemical, CO_2. The permitting status of the flue gas would not be considered since the flue gas stream is re-designated from an air pollutant source to a raw material/feedstock stream upon being transferred to the carbon capture plant.

Advantages

- Refer to Scenario 2A for advantages of achieving PSGC's separate source, stand-alone permitting objective.
- Absorber flue gas outlet stack discharges would be considered emissions from a chemical plant attributable to the use of an incoming raw material/feedstock and not related to PSGC's EGU

process. Therefore, the suite of EGU regulations potentially requiring absorber outlet stack testing and CEMS measurements would not be applicable.

Disadvantages

- The carbon capture plant would be considered a new major stationary source for several regulated pollutants including SO_2, NO_X, PM, PM10, PM2.5, CO, VOM, greenhouse gases (GHG) and potentially other pollutants under the New Source Review program (e.g., lead, sulfuric acid mists, etc.). Obtaining a PSD permit addressing BACT and air quality impacts for this wide range of pollutants would be effectively equivalent to re-permitting a facility similar to PSGC, which was a multi-year endeavor requiring significant expenditures for the air permitting process.
- The carbon capture plant would also likely be considered a new major source of HAP subject to a "case-by-case" MACT review. Evaluating "case-by-case" MACT review for a first of its kind carbon capture plant would be a complex and time-consuming process with many opportunities for Illinois EPA and other third parties to request additional information.

Air Permitting Strategy Recommendation

Based on our current understanding of the carbon capture plant's design and overall project objectives, it is recommended that the project team pursue a permitting approach under Scenario 2A wherein the carbon capture plant is considered a separate stationary source, and only emissions generated by the carbon capture process are required to be evaluated for permitting applicability.

This scenario provides a "win / win" for both parties (PSGC and the owner of the carbon capture plant) as it precludes PSGC from any air permitting responsibility for the carbon capture plant's emissions while allowing the carbon capture plant's air permitting process to be as streamlined and straightforward as possible. It is expected that IEPA will concur with the ultimate desire to permit the carbon capture plant as a separate source from the PSGC's EGU plant.

Another aspect of this scenario that is important to consider is the permitting of only the emissions that are created by the carbon capture plant. Only the emissions that are created by operating equipment belonging to the carbon capture plant owner, and directly associated with the carbon capture process, would need to be considered when applying for the air permit. The pollutants contained in the flue gas coming over from Unit 2 at PSGC, and being treated by the absorbers, would not be included in the air permit for the carbon capture plant. For a facility to have emissions that are exiting stacks at its plant, but that are authorized in a permit at separate source, is a relatively rare and unique situation, but not without precedent. If Illinois EPA were to decide that the carbon capture plant should be responsible for all the pollutants coming out of its four stacks (including the pollutants coming over from PSGC and not created at the carbon capture plant) as under Scenario 2B, a much more intensive permitting effort would be required. This approach also has the potential to make the carbon capture plant subject to a wide range of regulatory requirements that currently apply to Unit 2 at PSGC.

For these reasons, it is recommended that the team present SCENARIO 2A as the project's desired permitting path to the Illinois EPA and ask for their concurrence to this plan for obtaining the air permit for this proposed plant.

Water and Wastewater Permitting

Background

The CO_2 capture process produces several fluid streams, such as condensate collected from the flue gas in the polishing flue gas desulfurization system, floor drains, and dewatering system filtrate. These streams will be blended with water drawn from the Kaskaskia River and recycled for use as cooling tower and steam generator makeup after treatment. Therefore, the wastewater from the CO_2 capture system will consist entirely of cooling tower blowdown. The wastewater will be discharged into the Kaskaskia River from a new outfall, after treatment, to comply with applicable water quality standards.

Makeup Water Permitting

The raw water to supply the CO_2 capture facility will utilize the existing pipeline from the existing PSGC intake structure to a new pond, which serves the same function as the existing Northeast Pond. The existing river intake pumps will be replaced with higher capacity pumps to accommodate the increased flow demand of the CO_2 capture facility. Sufficient Kaskaskia River water will be stored in the new pond to supply the CO_2 capture system while river level is low during a 25-year draught. New pumps deliver water from the new pond to the makeup water treatment system.

The new raw water supply pumps will transfer raw water to a new storage pond. From the storage pond, raw water will be pumped to a new water treatment system supporting the CO_2 capture facility. The new water treatment system will treat the raw water for use as cooling tower makeup as well as for auxiliary boiler makeup and other high-quality water demand within the CO_2 capture facility.

The CO_2 capture facility will need to file a request to use public water from the Kaskaskia River through the Illinois Department of Natural Resources (IDNR). If new construction activities such as installing pumps, building a pump house, or setting pipelines will not occur in the waterway, only a request to use public water is needed to be filed to IDNR. Otherwise, if new construction activities occur in the waterway, a joint permit application to IDNR, Illinois Environmental Protection Agency (IEPA), and the US Army Corps of Engineers (USACE) will be required.

One of the key conditions in the permit to use public water is the determination of the minimum flow, which defines when the river water is not available for withdrawal during drought conditions. IDNR bases this decision of the magnitude of the minimum flow on the existing aquatic biodiversity integrity in the vicinity of the intake in the river.

However, if Baldwin Energy Station or any other Lake Shelbyville and/or Carlyle Lake water allocation holder ceases operations then additional water allocation will be made available for use by the CO_2 capture facility. If this occurs, the carbon capture facility will need to obtain water allocation rights that will allow the entities to release water from the lakes. To obtain water allocation right from Lake Shelbyville and Carlyle Lake, a request needs to be filed with IDNR. IDNR will then evaluate the request and assess the availability of the water storage in both lakes. IDNR will then determine the water allocation amount, water supply release conditions, billing, etc. IDNR then will enter into an agreement with the CO_2 capture facility to allocate the water stored in the two lakes for use by the facility during times of drought.

Wastewater Permitting

To discharge the cooling tower blowdown into the Kaskaskia River will require a National Pollutant Discharge Elimination System (NPDES) permit. It is anticipated that this permit will be issued to the future third party owner/operator of the CO_2 capture system.

Some limitations exist within the current facility and Illinois regulatory environment that will impact the operation and feasibility of the potential wastewater treatment system. This report is based on the following assumptions:

- Removal of trace metals in the cooling tower blowdown to the concentrations indicated in 35 Illinois Administrative Code (IAC) 302 is required to meet Illinois water quality regulations. The study assumes no mixing zone at the new cooling tower blowdown discharge to the Kaskaskia River will be allowed.
- NPDES discharge limitations for total suspended solids (TSS) will be like those for the existing PSGC cooling tower blowdown.

A summary of the NPDES discharge limitations derived from IAC 302 is listed in ***Table 8*** below. These limitations are indicative of the most stringent limits that may be applied.

Table 8. *NPDES Discharge Limitations*

Parameter	IAC 302 Limit	Parameter	IAC 302 Limit
Total Suspended Solids (TSS), ppm	15	Cadmium, ppm	0.002
Arsenic, ppm	0.19	Chromium, ppm	0.011
Barium, ppm	5	Copper, ppm	0.02
Iron, ppm	1	Manganese, ppm	3.36
Mercury, ppm	0.000012	Selenium, ppm	1

Mechanical Draft Cooling Tower

The CO_2 capture process has a significant cooling demand that will be provided by circulating cooling water. The cooling water is heated as it passes through the process heat exchangers and this heat must be rejected to the environment prior to circulating back to the process equipment. This system includes a mechanical draft cooling tower (MDCT).

The evaporation necessary to reject the heat from the CO_2 capture system must be made up with treated river water. The evaporation also concentrates constituents in the circulating water system. The cooling tower blowdown is set to a preliminary flow rate of one-third of the makeup flow to limit concentration to three "Cycles-of-concentration" (COC). Three COC is selected so that the cooling tower blowdown will meet NPDES permit limits for TSS without further wastewater treatment. However, further wastewater treatment has been incorporated to meet the discharge limitations summarized in Wastewater Permitting above. This being the case, some optimizations of the COC due to wastewater treatment should be considered during detailed design. To allow optimization it is recommended that COC not be strictly limited to three.

Wastewater Treatment

The solubility of metal-sulfide complexes is orders of magnitude lower than metal-hydroxide complexes typically achieved in water softening systems. Trace metal removal systems take advantage of metal-sulfide solubility to remove dissolved metals to very low levels.

The wastewater treatment system will have organosulfide dosing into a 20-min hydraulic residence time (HRT) tank, followed by coagulant dosing into a separate 10-min HRT. This corresponds to 75,000-gallon reaction tank and 20,000-gallon coagulation tank, respectively. The pretreatment chemistry and HRT will be confirmed with jar testing.

In order to remove precipitated salts a filtration system with a very small nominal pore size, such as ultrafiltration (UF). The PSGC wastewater treatment system includes UF designed for a feed flow of 3615 gpm at 95% recovery and would generate 3434 gpm permeate. In order to reduce capital costs, the proposed wastewater treatment system includes 3 trains, at N-1 redundancy. This allows two trains to treat the full flow when one train is offline for Clean-In-Place (CIP) or backwash. This results in an instantaneous flux of 25.4 gfd with all three trains online, and 40.9 gfd with two trains online (while the 3rd train is cleaning).

The duration of the high flux flow will be about an hour a day during daily maintenance CIP; and two days a month during recovery CIP for each UF train.

The UF CIP system consists of a tank, electric heater, filter vessel, and recirculating pumps. A UF CIP event typically uses a weak acid and hypochlorite. After a CIP event, the CIP chemicals will be neutralized, and hypochlorite will be reduced to chloride before being sent to the makeup water treatment system equalization tank for recovery.

One key point to confirm is the mercury limit assumption noted above in Wastewater Permitting. The Illinois Water Quality Standard for Mercury (total) is 0.012 ug/L per 35 IAC 302.208(f). While the current PSGC NDPES permit does not include a mercury discharge limit for cooling tower blowdown in Outfall 001, it is anticipated this requirement will be applied to the power plant in the future.

According to the Illinois 2002 Section 303(d) List, the proposed discharge location is located on segment O 97 of the Kaskaskia River which is not impaired for mercury. The closest high-priority stream segment is downstream, segment O 91. It is also not impaired for mercury. Therefore, the risk of IEPA applying a stringent discharge limitation for mercury is low.

BASIC CONTRACTING AND PURCHASING STRATEGY

Procurement Strategy

The project team will use competitive bidding to compare multiple suppliers' pricing offers, availability and commercial terms, identifying the supplier whose offering presents the lowest cost while supporting Prairie State CCS's needs. Project aspects considered during evaluation include technical specifications, delivery date requirements and project specific or companywide standards. Purchase contracts are reviewed to verify that safety, quality, and delivery requirements are met before contracts are signed.

Engineering Interface

The procurement team looks to the project engineers to understand the technical factors that need to be considered when purchasing equipment. As part of their review, engineering provides technical review of bids received, providing a recommendation based on the requirements suppliers meet. The project team has identified the following areas where alignment between engineering and procurement personnel is essential to project success:

- Identifying critical scope that needs to be procured early in order to work with the supplier or subcontractor in their design that will have downstream affects
- Finding solutions to sourcing more domestic materials and scope instead of looking internationally, in order to cut down on logistics and supply issues, while also being aware of the overall cost impact to the project.

Vendor Quality Management

Off-site supplier quality (OSSQ) assists the procurement team in achieving technical compliance of engineered equipment, pipe, and bulk materials with the quality requirements of the prime contract, technical specifications, industry and code standards. OSSQ monitors and enforces supplier compliance with QA/QC requirements through shop visits for the purposes of inspection, testing, examination, performance testing, expediting or to obtain seller production status.

Long-Lead Procurement

Long-lead items are procured during detailed design. ***Table 9*** lists the long lead items that have been identified at this time; however, this list is preliminary.

Table 9. *Identified OSBL Long Lead Items*

Critical Procurement Item	**Delivery Lead Time**
Flue Gas Duct Work	56 Weeks
Auxiliary Boiler	76 Weeks
Switchgear and Enclosures	64 Weeks
Station Service Transformers	70 Weeks

ENGINEERING DESIGN PACKAGES

Process Engineering

The CO_2 capture system will have capacity to treat 100% of the flue gas generated by Unit 2, as well as the flue gas from the auxiliary boilers supplying steam for the CO_2 capture facility but will also have the capability to treat only a part of the plant’s or auxiliary boilers’ flue gas exhaust. The flue gas tie-in will be incorporated downstream to the Unit 2 wet electrostatic precipitator (WESP), upstream of the existing stack. To promote balanced flow, the new ductwork will tie-in to the Unit 2 duct and will transition to an FRP duct to the CO_2 capture facility. A quick-acting modulating/control isolation damper with seal air will be used at the interface point upstream of the stack breaching to control (open up or close off) the flow to the CO_2 capture trains or quickly open in case of a blower trip. The damper will allow some of the flue gas to bypass the CO_2 capture system and exhaust through the existing stack in case of CO_2 capture equipment is operating at part load. A separate isolation on/off damper with seal air will be installed in the new tie-in duct to supply the flow to the CO_2 capture facility. There will be no return ductwork from the CO_2 capture island back to the existing stack; all flue gas will pass through new stack pieces integral to and located at the top of the CO_2 absorber columns. A similar arrangement will be employed for the auxiliary boilers' flue gas tie-in to each train of the CO_2 capture equipment. Auxiliary boiler flue gas duct will tie-in to the incoming flue gas duct of its respective train. MHI will provide new CEMS equipment in each new stack, as required. The flue gas ductwork tie-in and layout will minimize additional loading on existing steel to minimize re-enforcement of the existing steel. The new flue gas ductwork will be routed across existing roads while maintaining throughway access for the railroad loop and all trucks.

The cooling water system will be designed for the most cost-effective approach, considering that PSGC has limited water rights available for consumptive water use.

New steam generation equipment will be installed to provide a medium-pressure, superheated steam to the CO_2 capture equipment. The generated steam will be utilized to drive MHI's steam driven CO_2 compressors using a back-pressure steam turbine. The low-pressure steam exhaust will be utilized in MHI's reboilers for the CO_2 capture process. Auxiliary power for the steam generation island and the CO_2 capture system will be sourced from the electric grid and will require a tie-in to the grid. This tie-in is a new substation connecting to a 69kV overhead line that may be installed nearby as part of a separate project.

The maximum turndown of the CO_2 capture facility will mirror the existing power plant operating range, 420 MW to full load 817 MW. To maximize carbon capture during partial outages of the carbon capture facility, the facility will be capable of partial operation including operation of one train.

Process Flow Diagrams

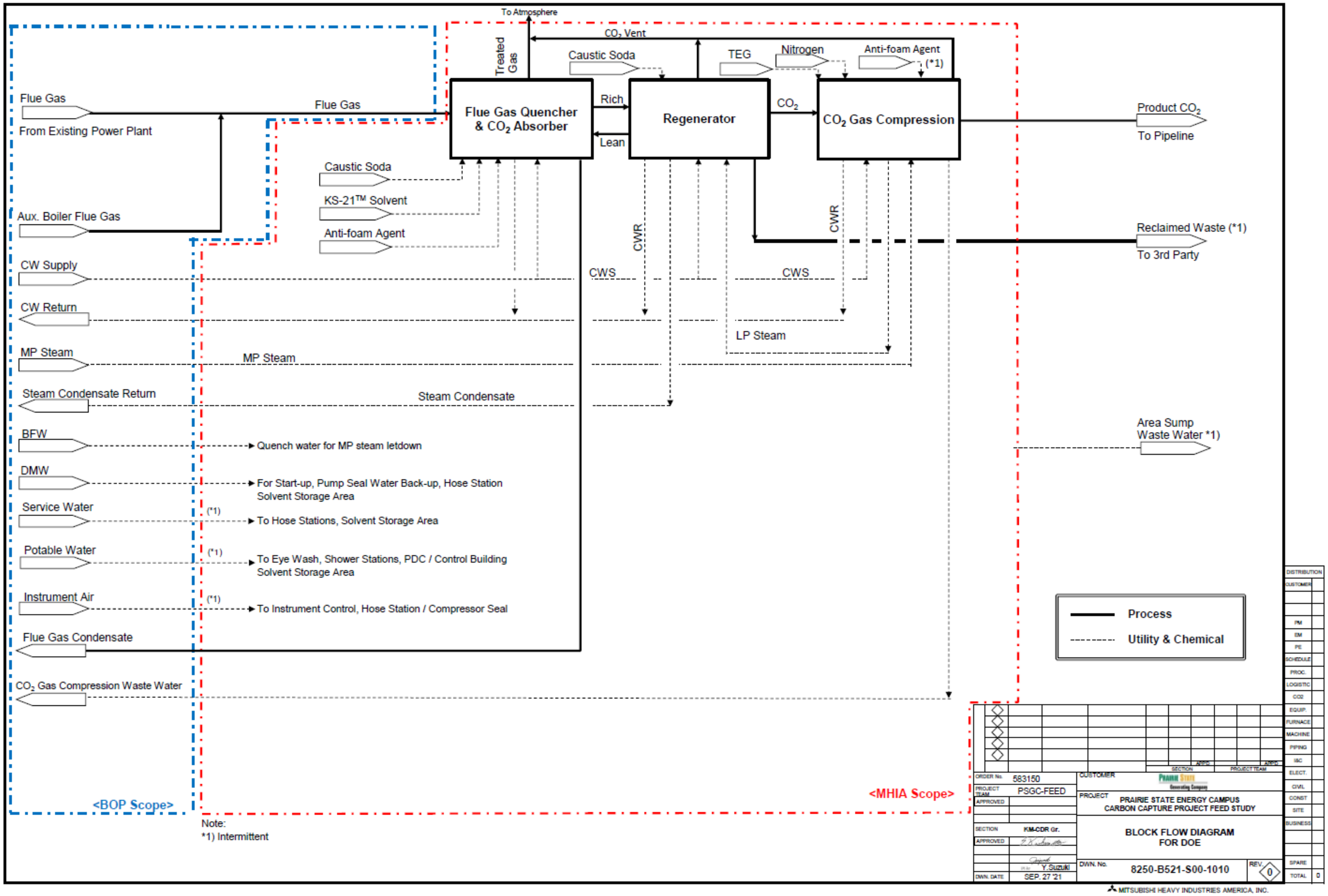

Figure 8. *Block Flow Diagram (BFD)*

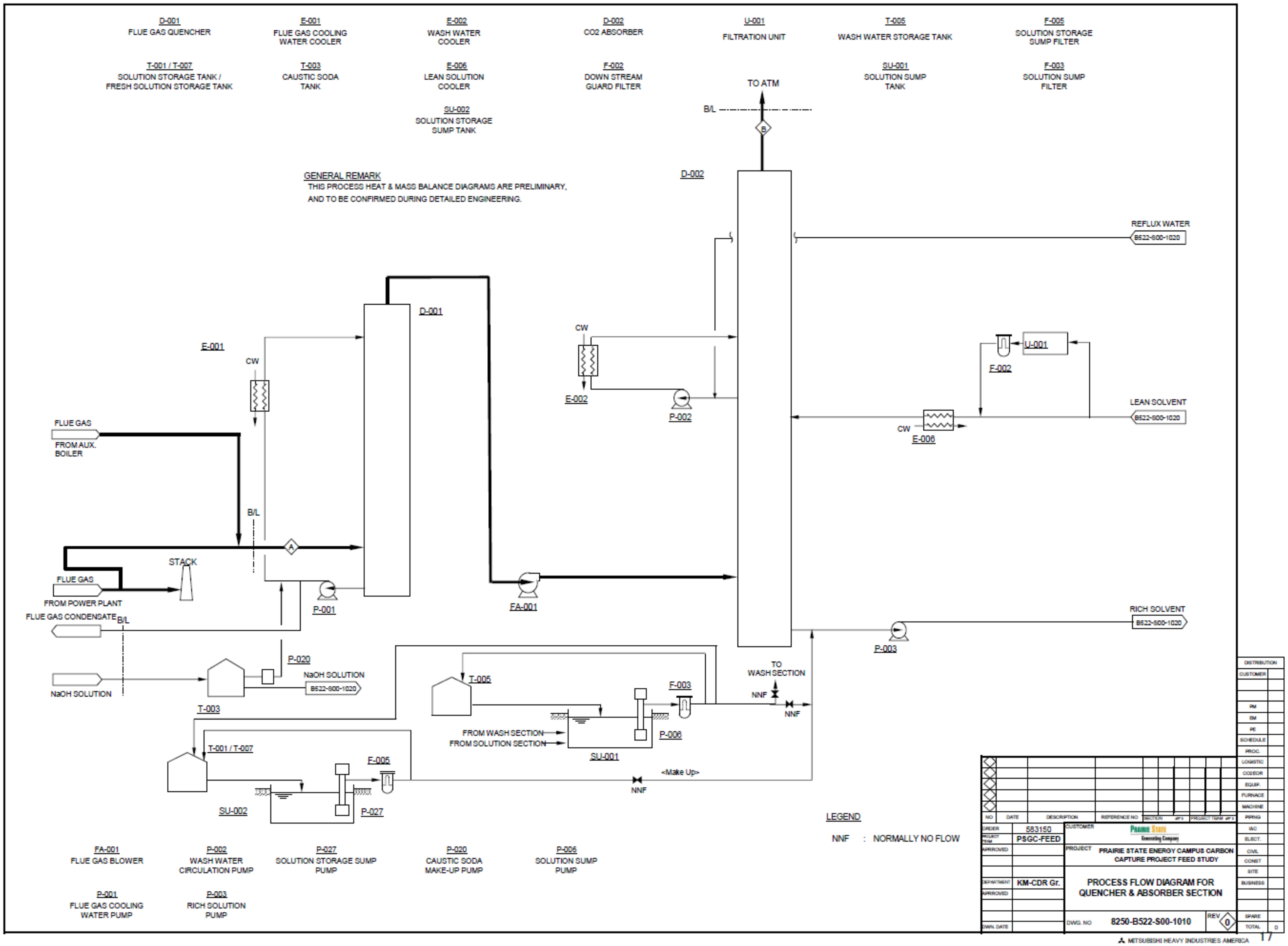

Figure 9. *Process Flow Diagram for Quencher and Absorber Section*

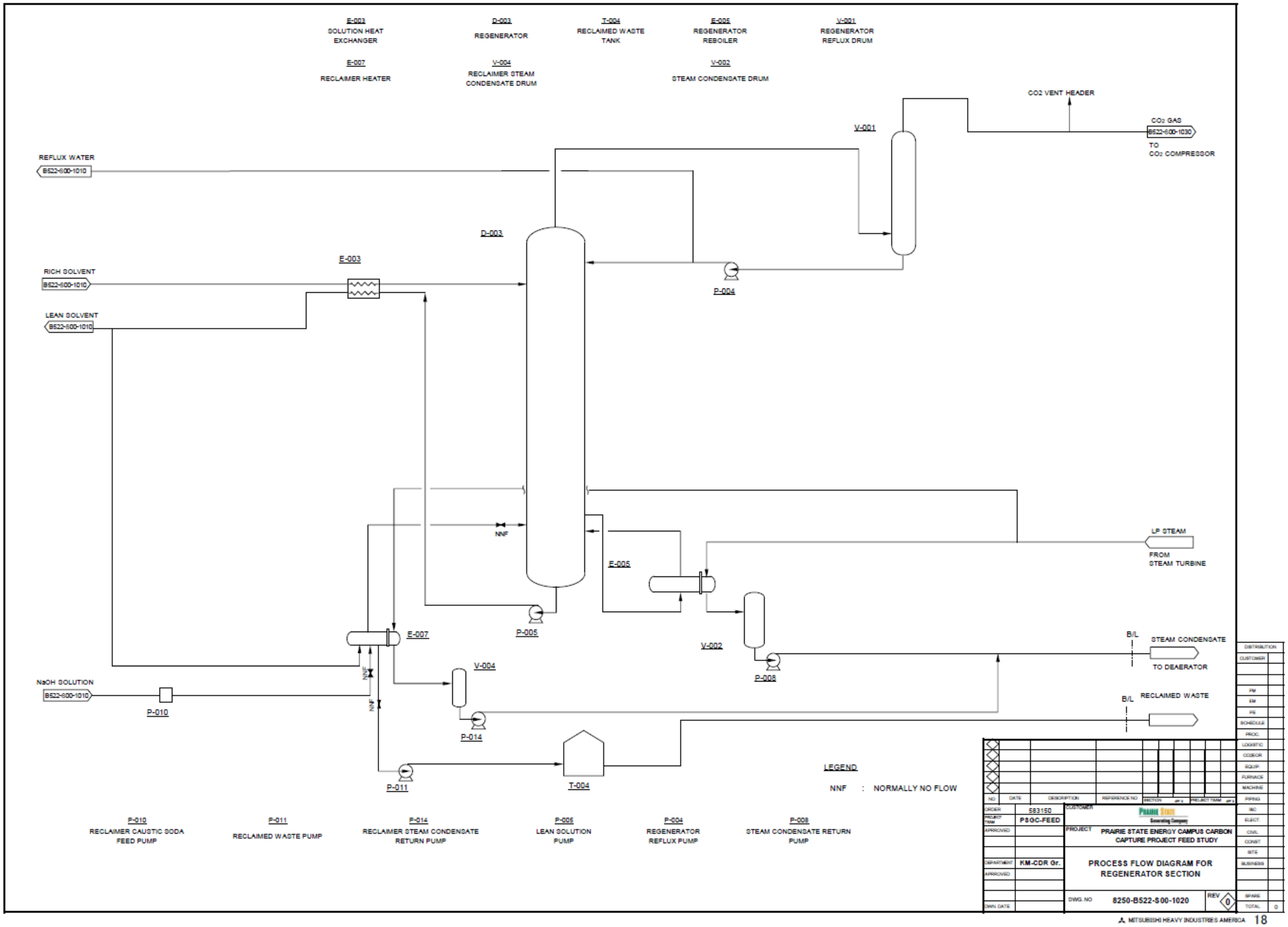

Figure 10. *Process Flow Diagram for Regenerator Section*

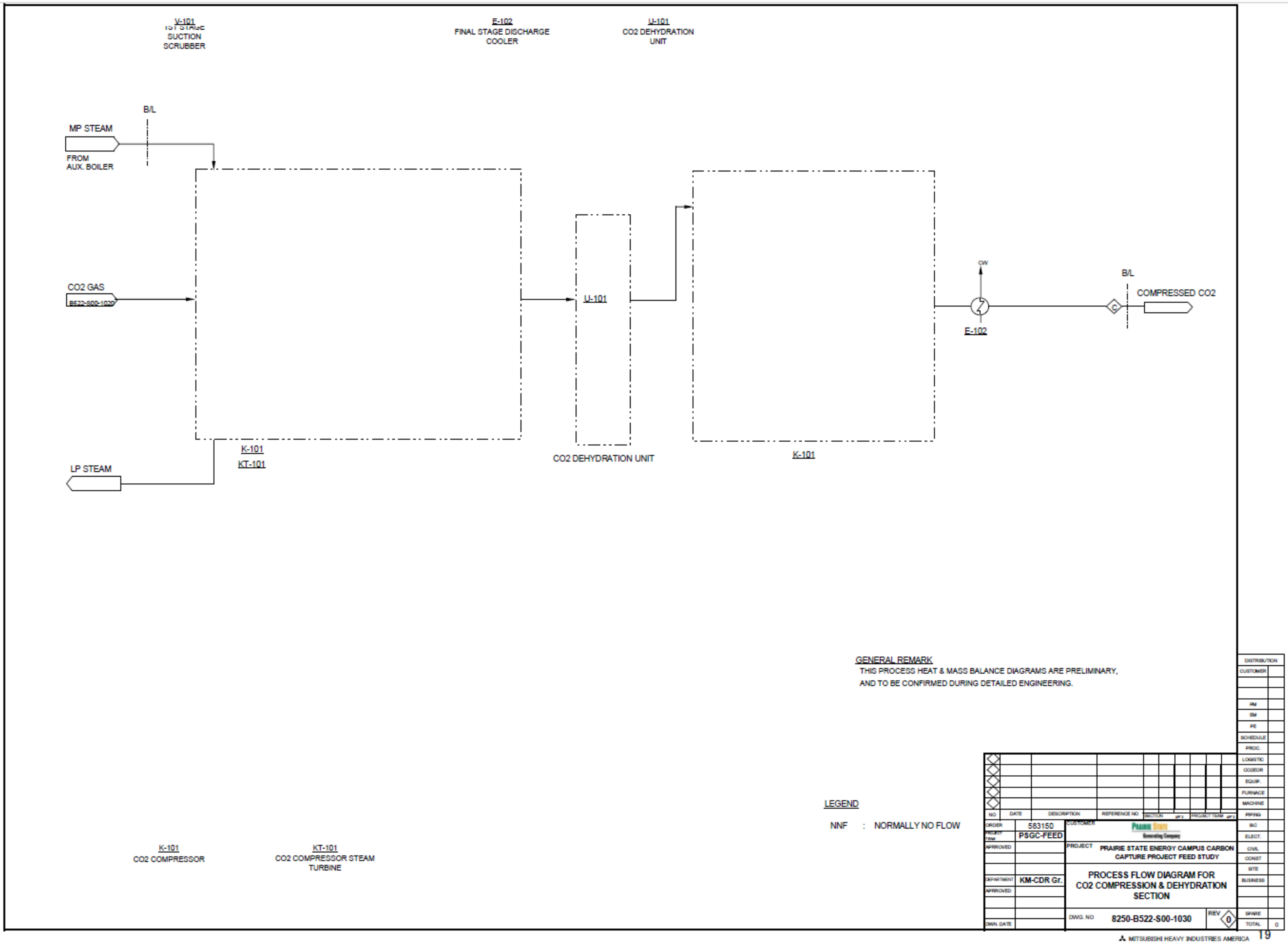

Figure 11. *Process Flow Diagram for CO_2 Compression and Dehydration Section*

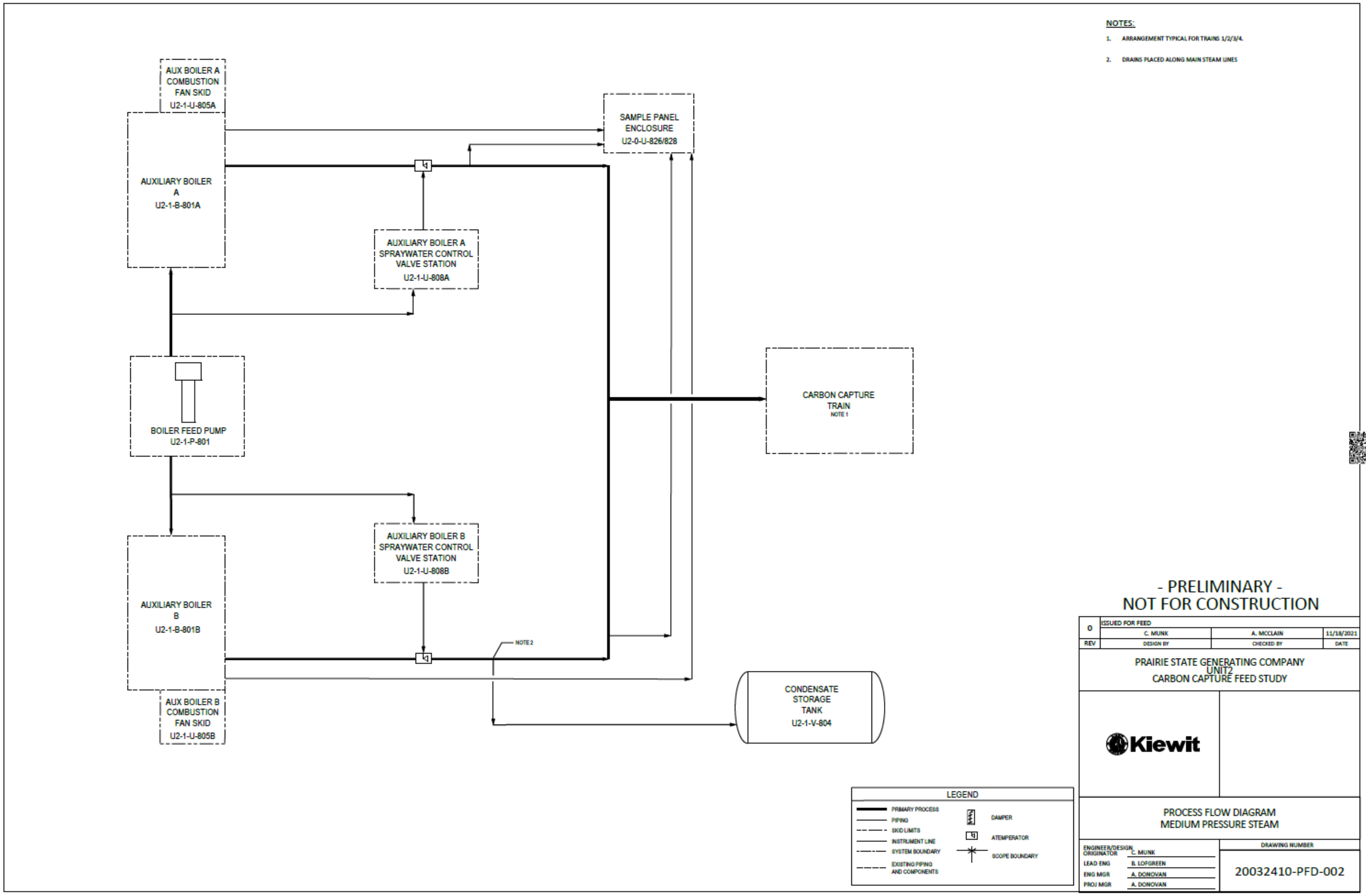

Figure 12. *Process Flow Diagram Medium Pressure Steam*

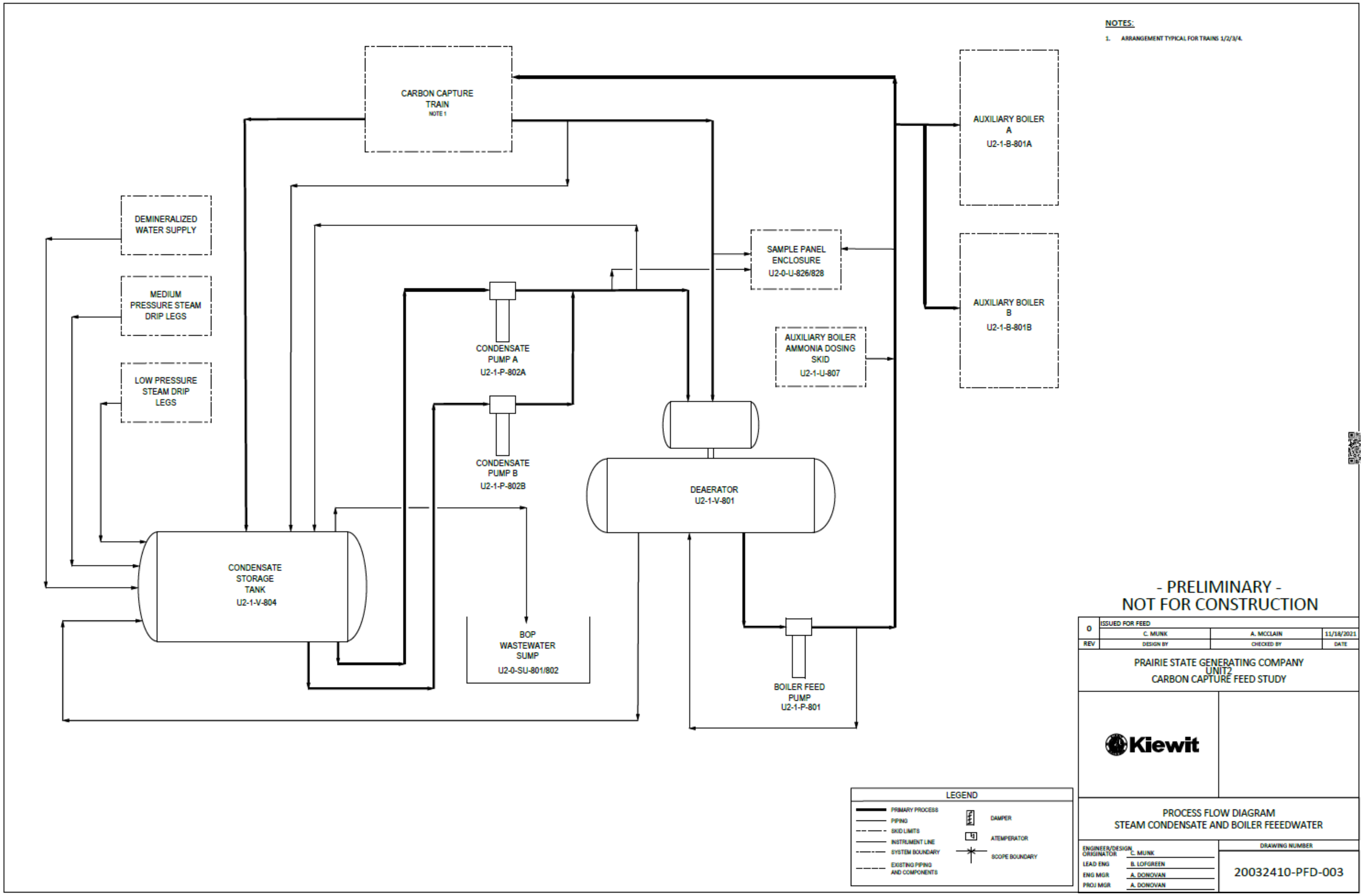

Figure 13. *Process Flow Diagram Steam Condensate and Boiler Feedwater*

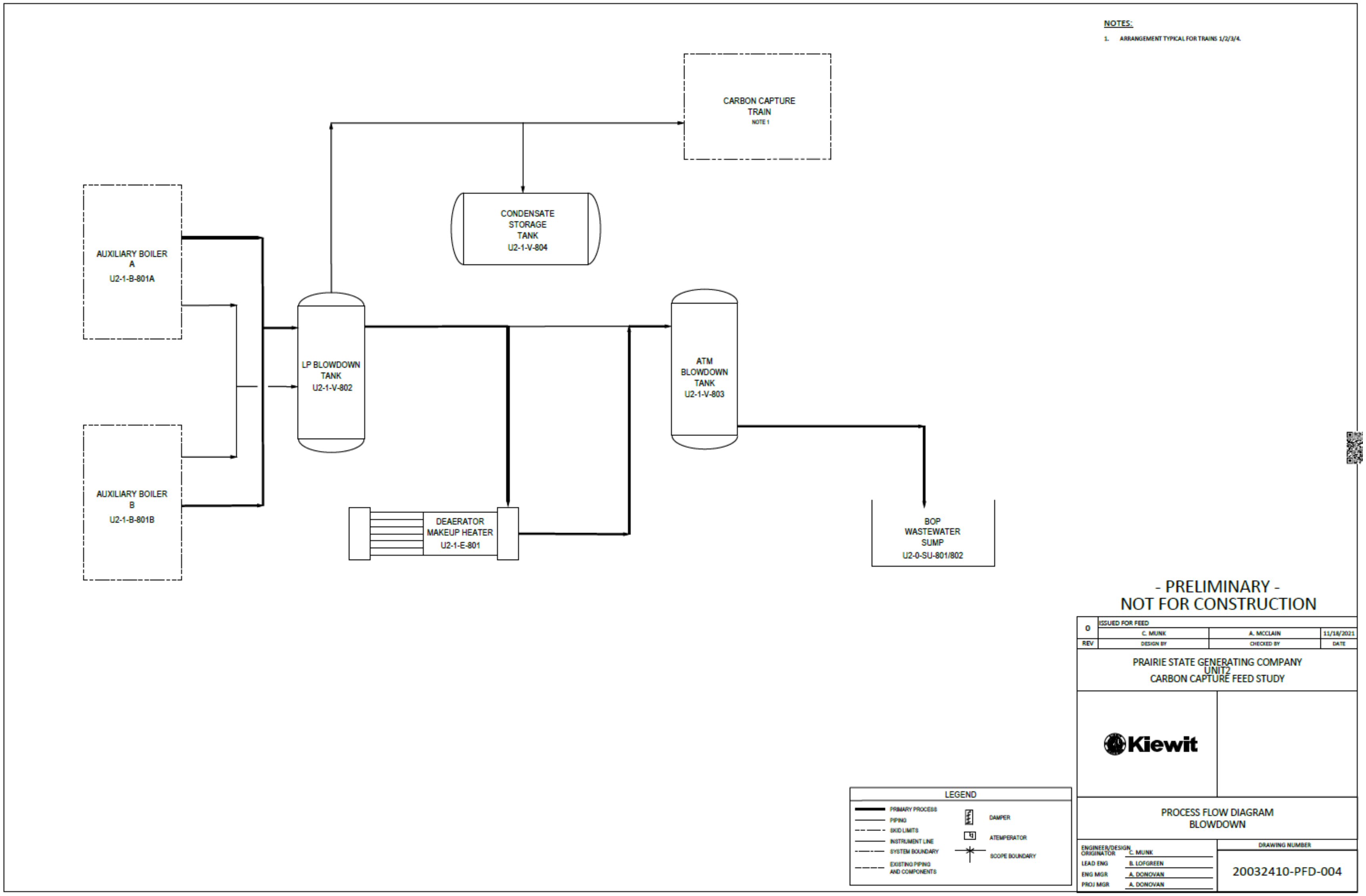

Figure 14. *Process Flow Diagram Blowdown*

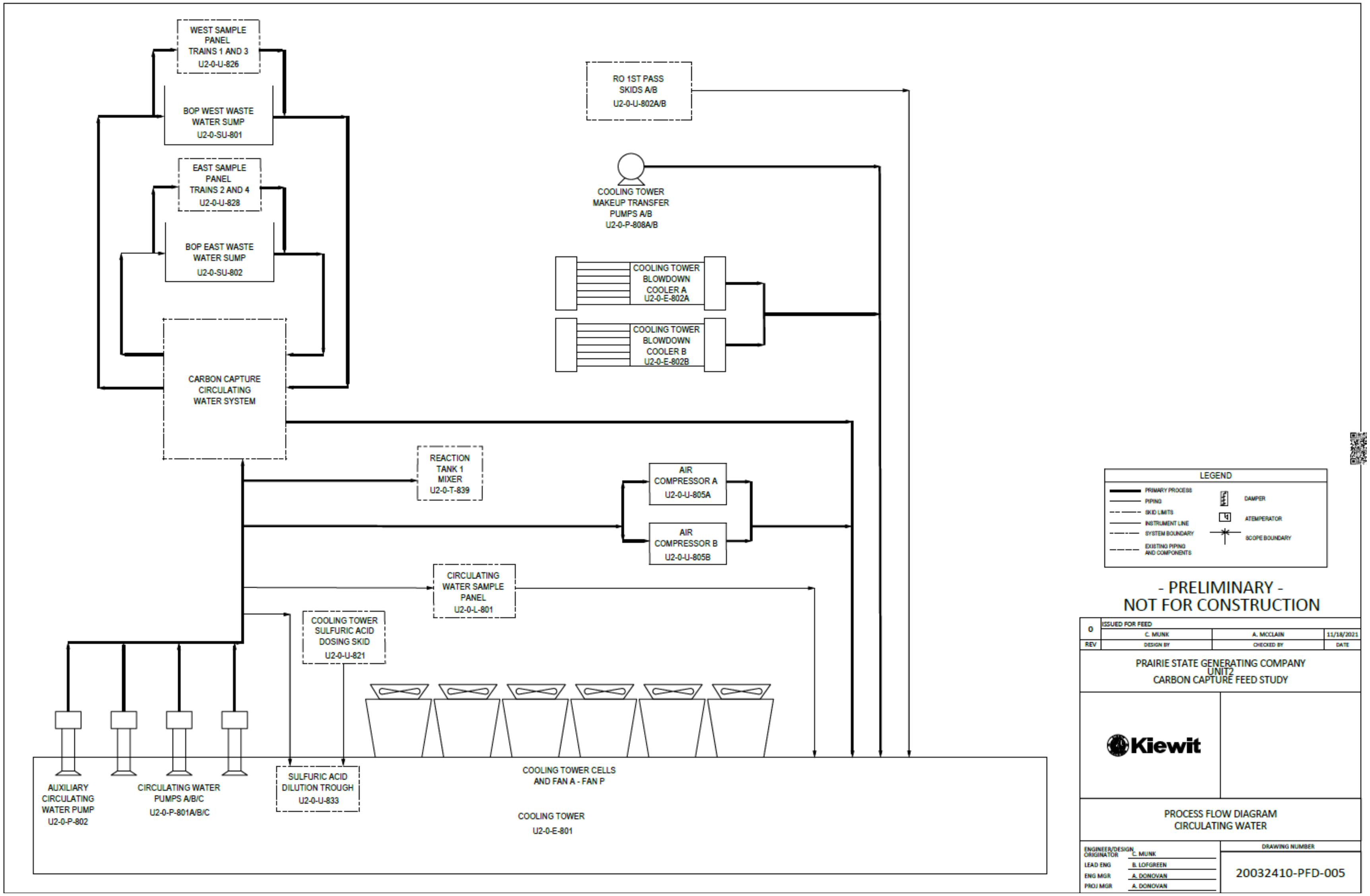

Figure 15. *Process Flow Diagram Circulating water*

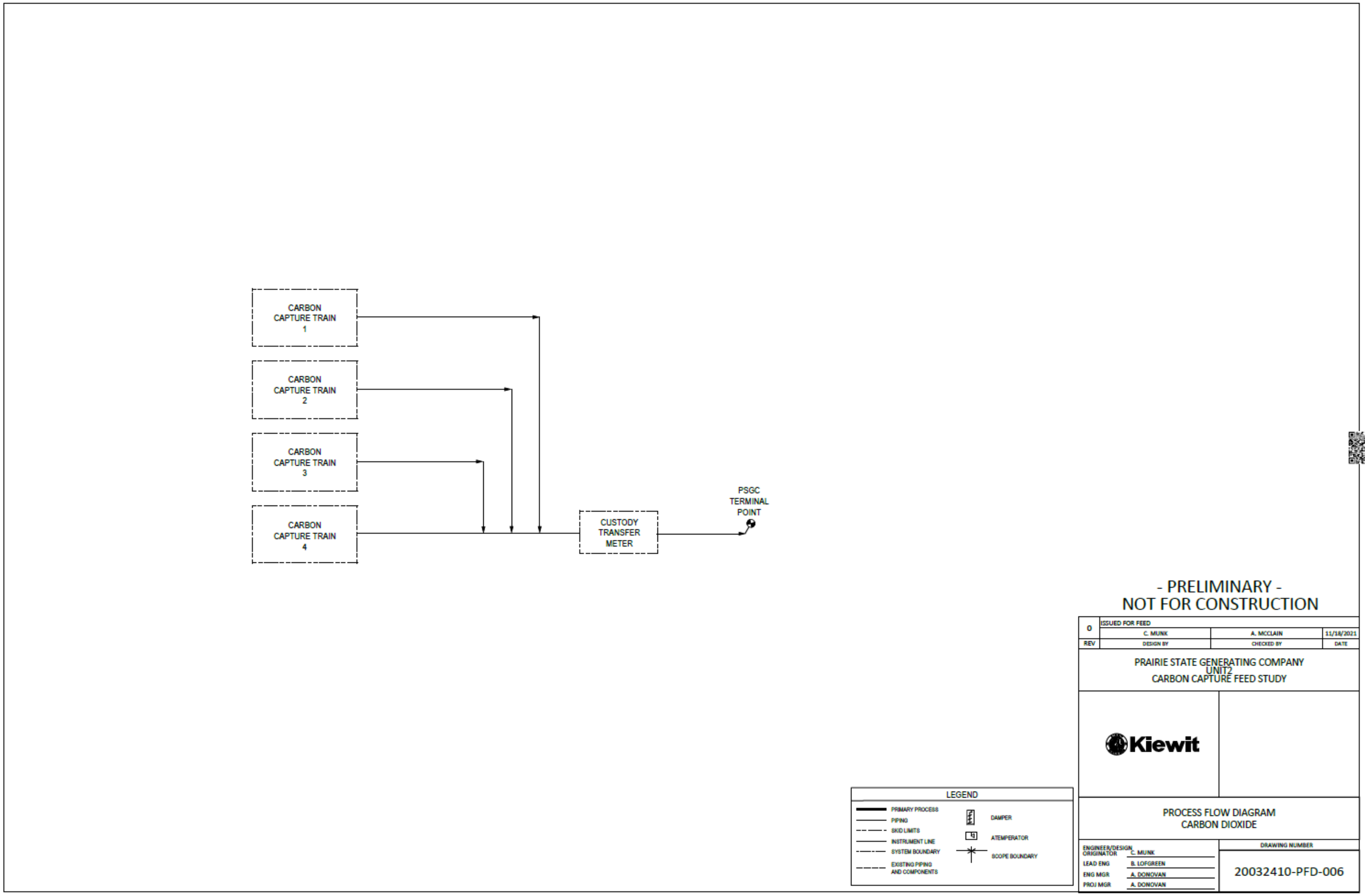

Figure 16. *Process Flow Diagram Carbon Dioxide*

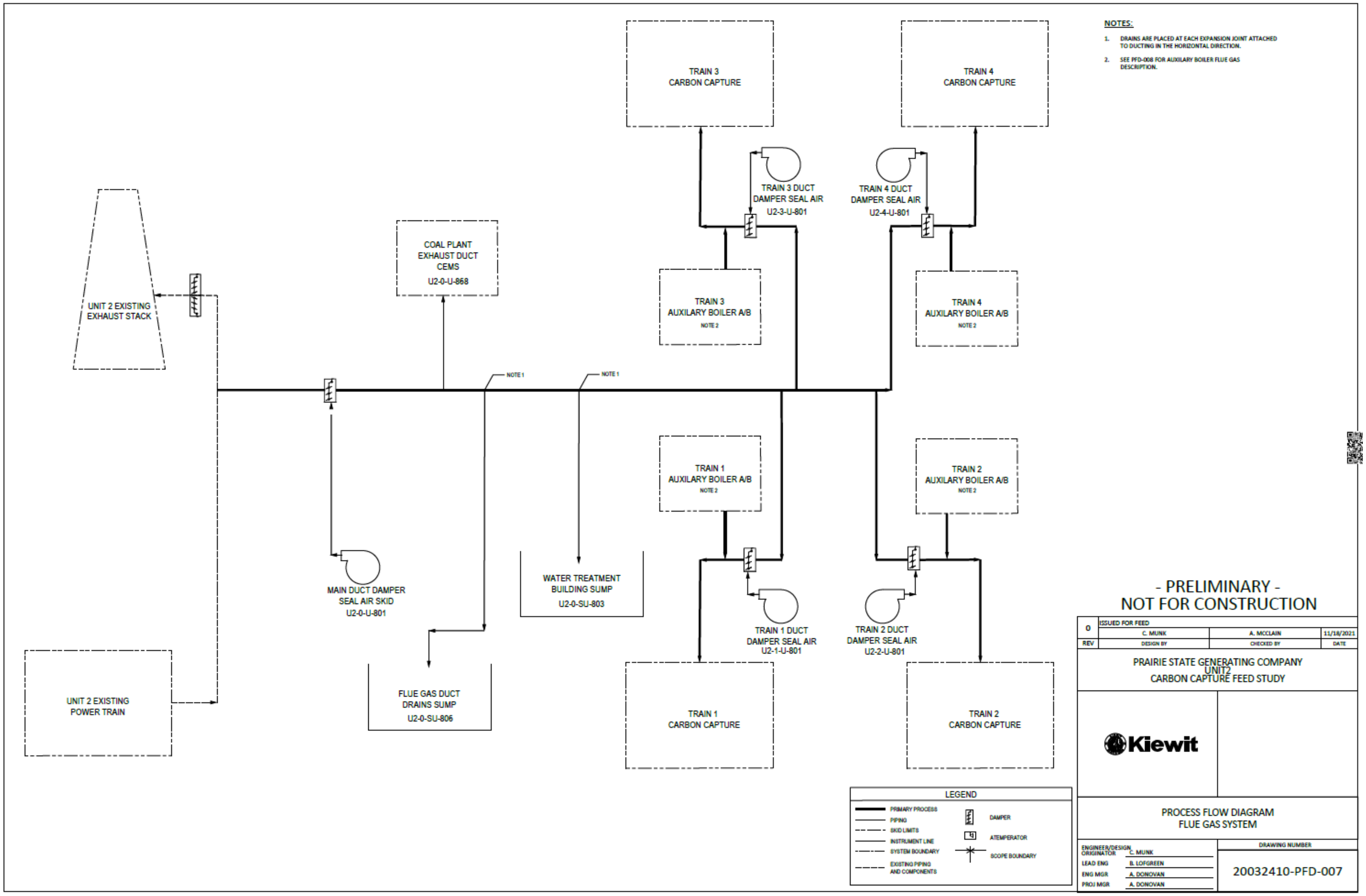

Figure 17. *Process Flow Diagram Flue Gas System*

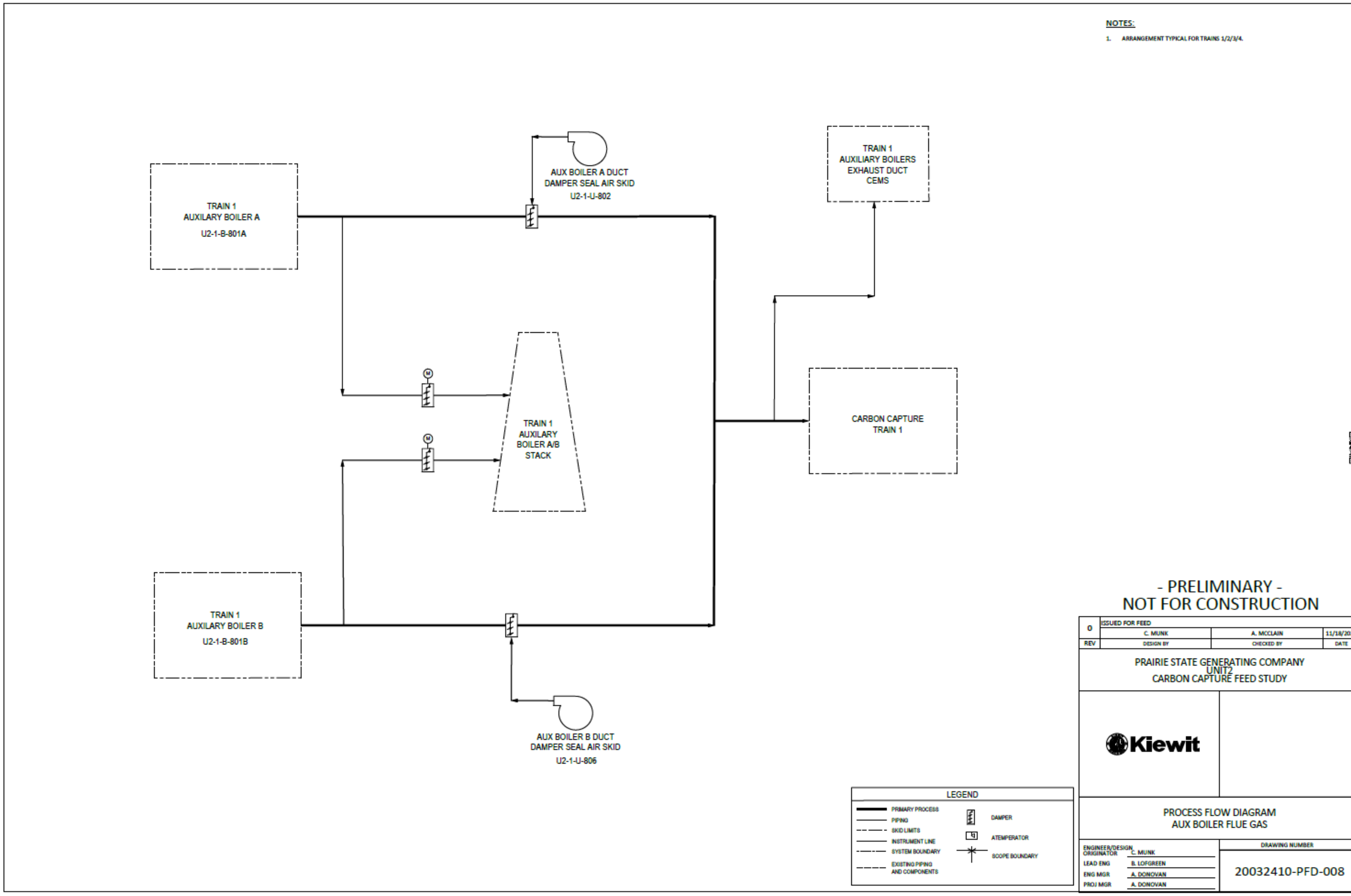

Figure 18. *Process Flow Diagram Aux Boiler Gas*

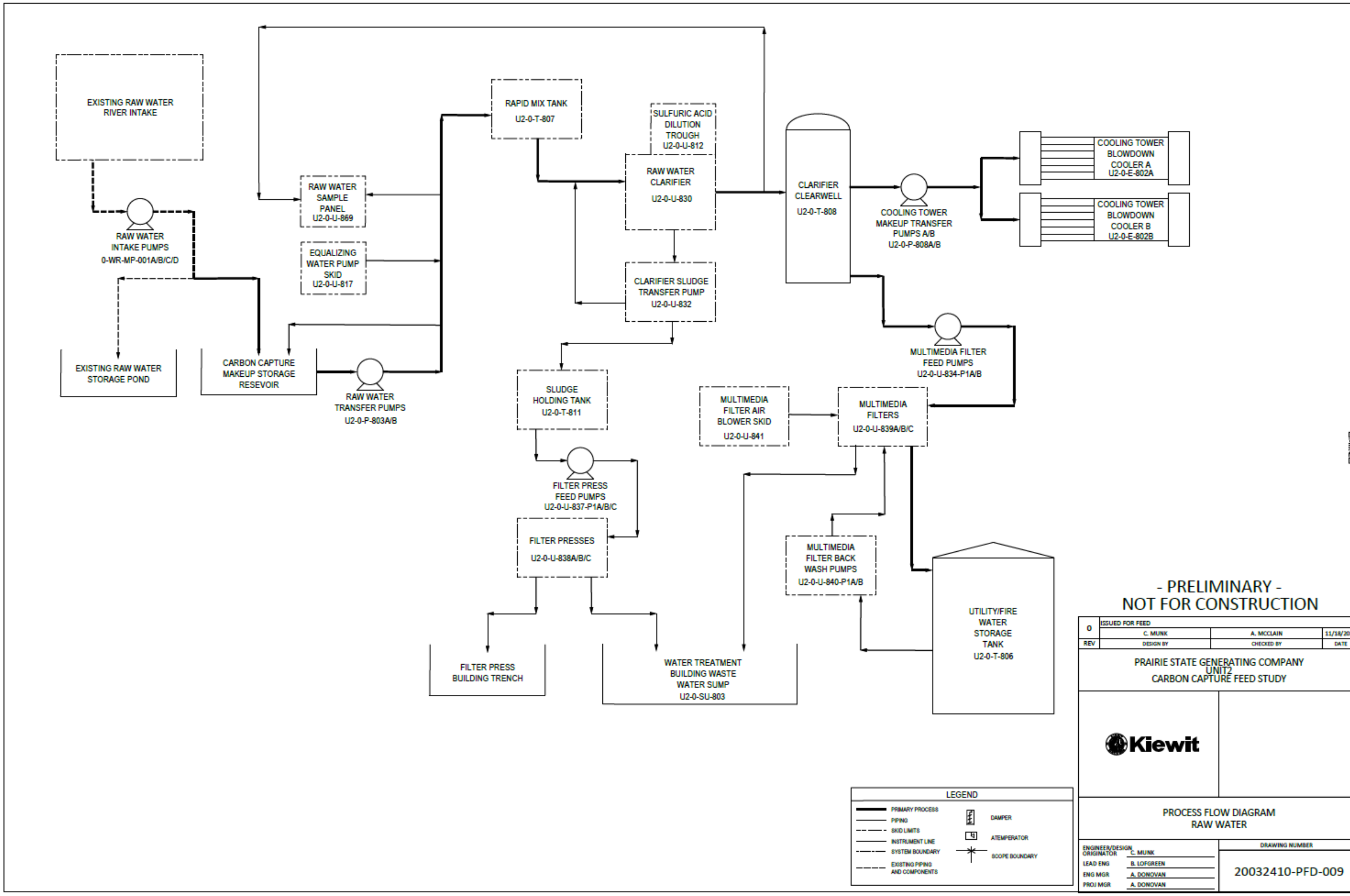

Figure 19. *Process Flow Diagram Raw Water*

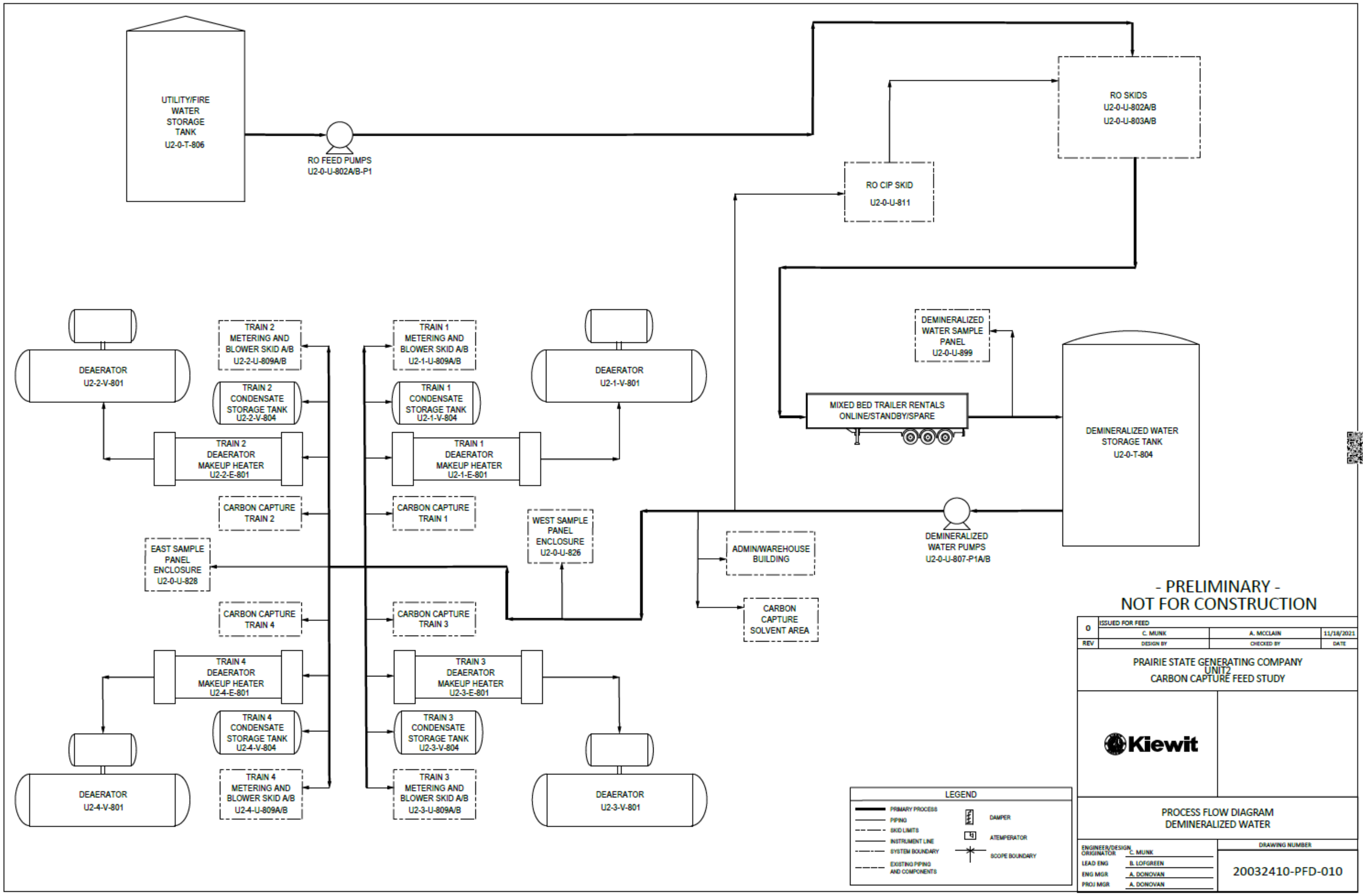

Figure 20. *Process Flow Diagram Demineralized Water*

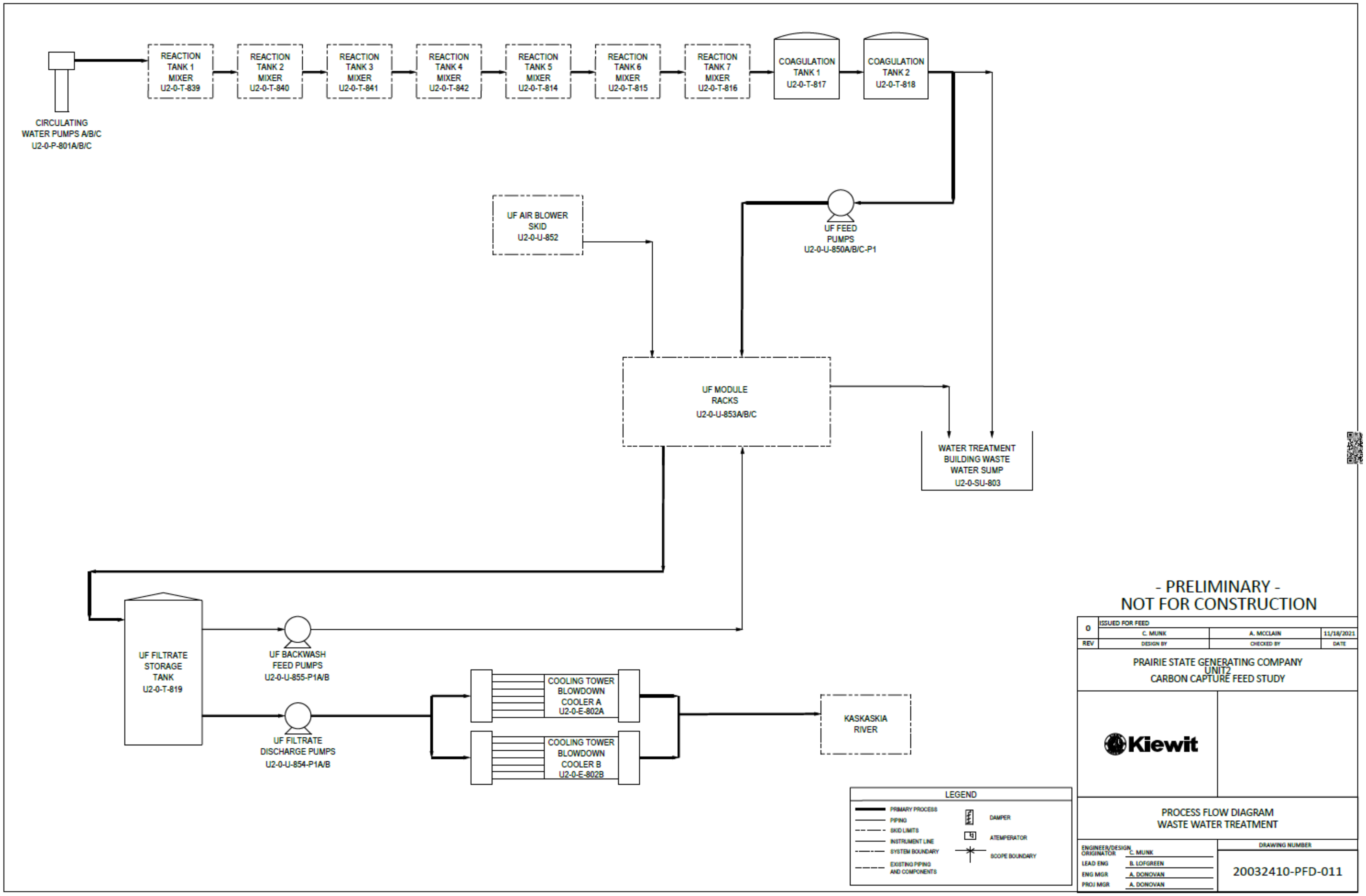

Figure 21. *Process Flow Diagram Wastewater Treatment*

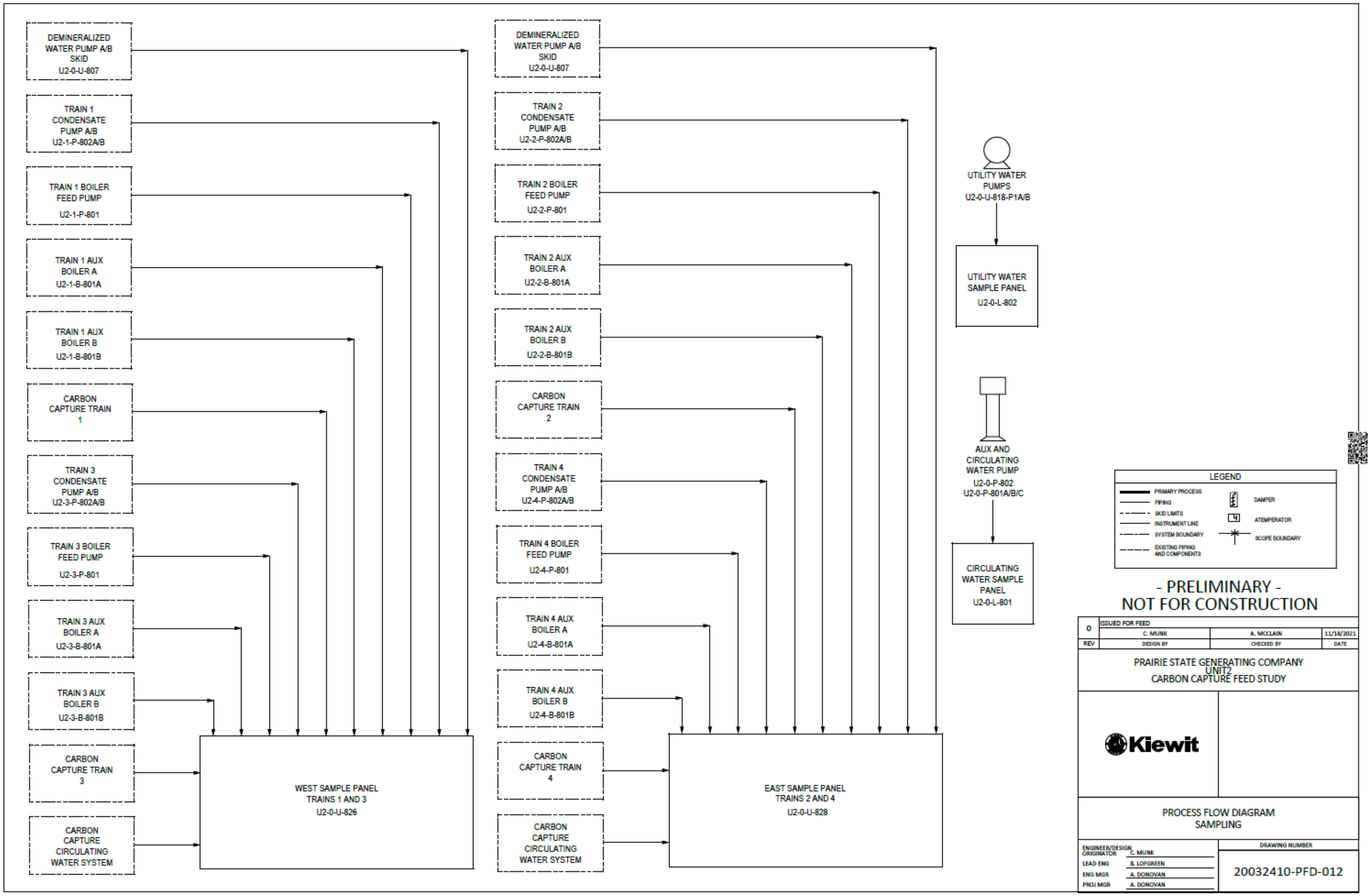

Figure 22. *Process Flow Diagram Sampling*

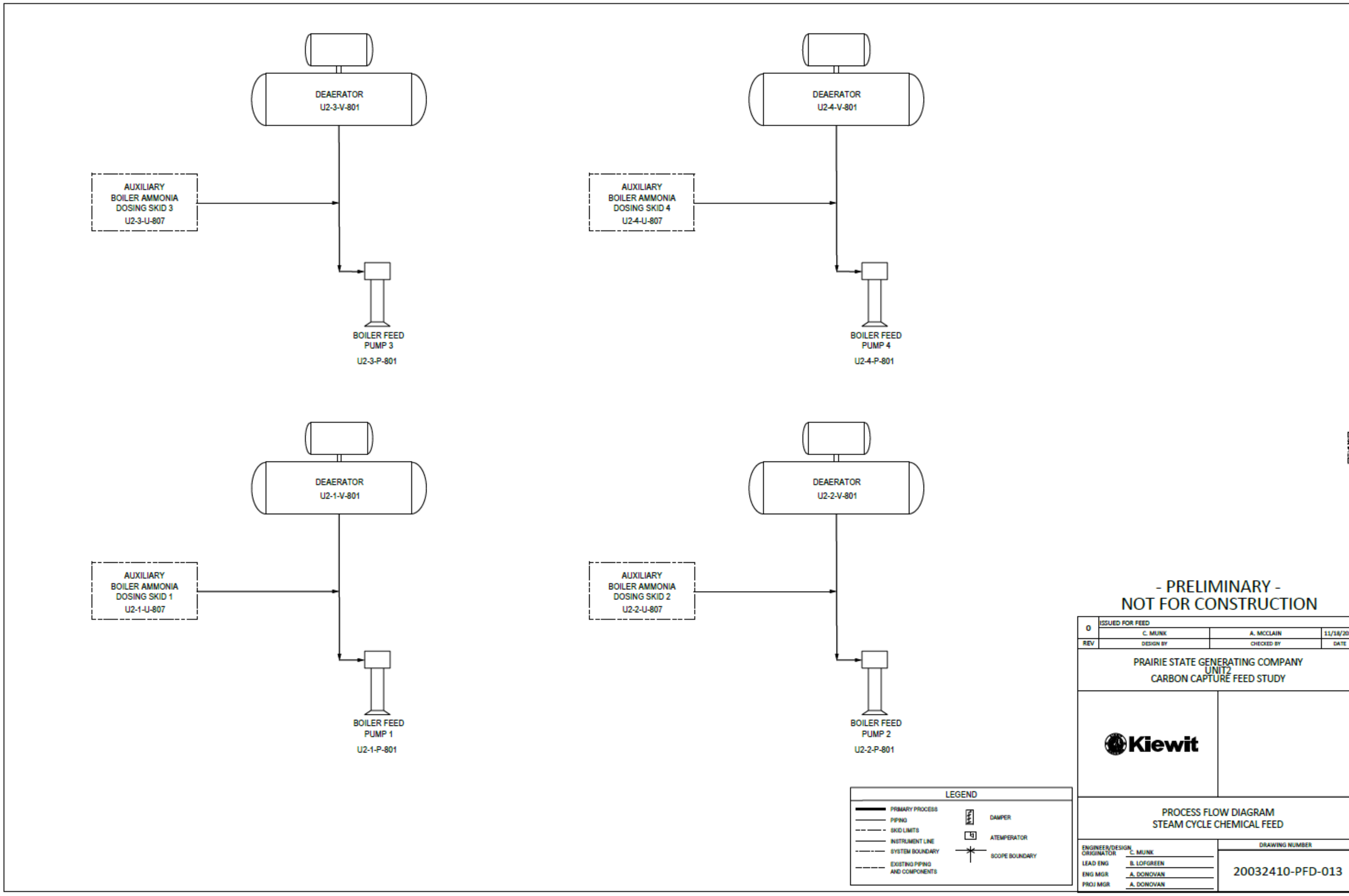

Figure 23. *Process Flow Diagram Steam Cycle Chemical Feed*

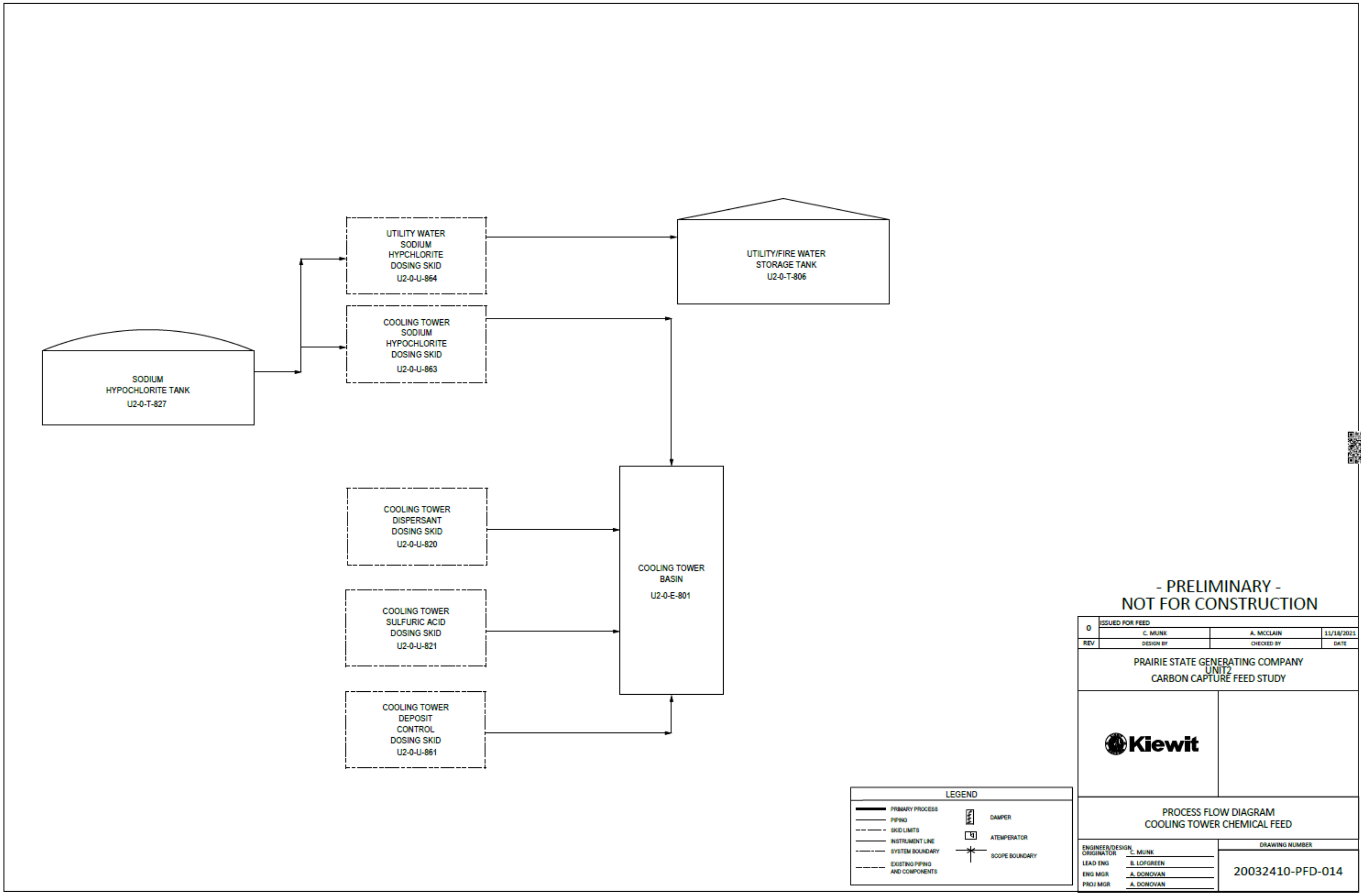

Figure 24. *Process Flow Diagram Cooling Tower Chemical Feed*

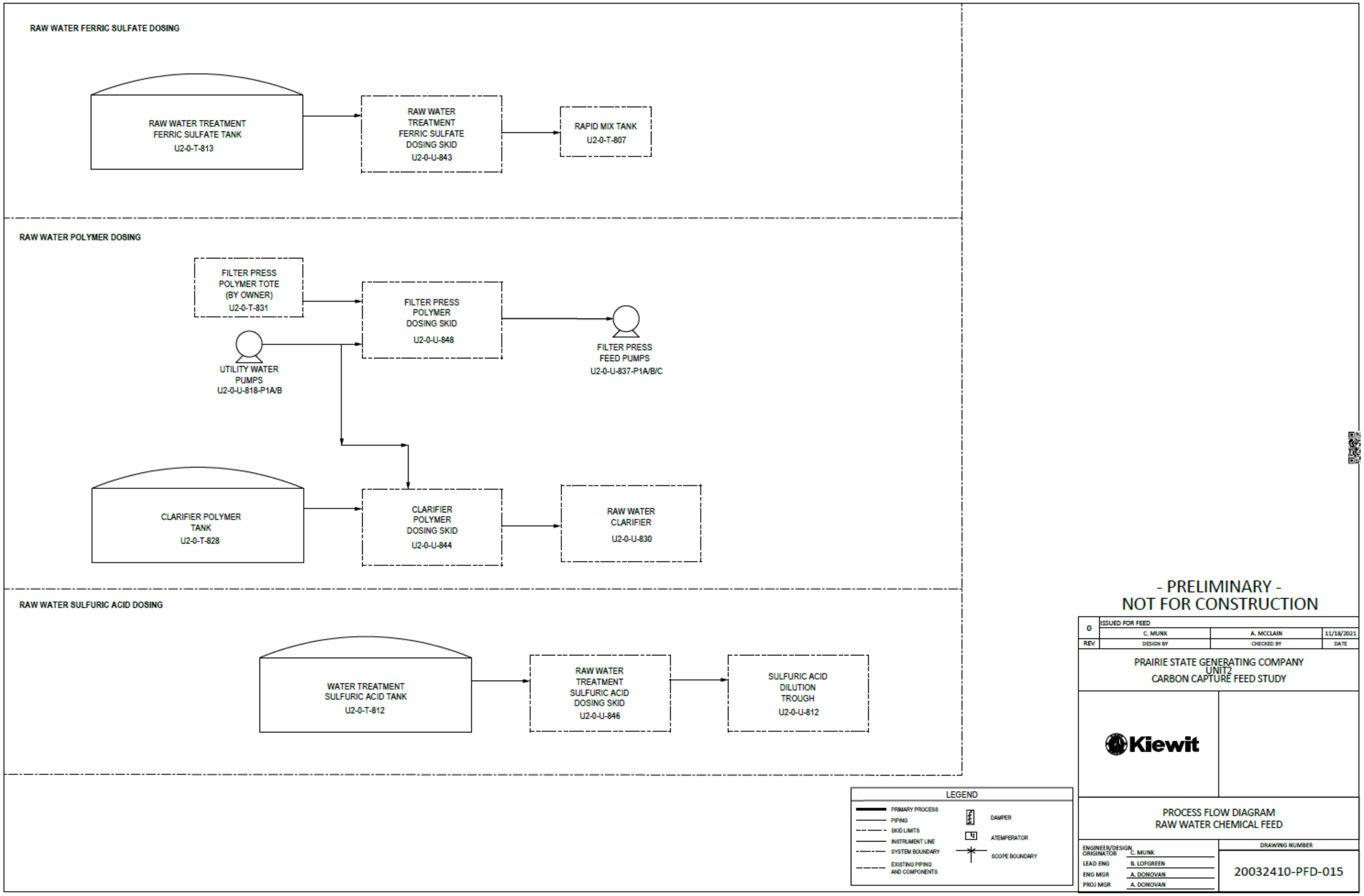

Figure 25. *Process Flow Diagram Raw Water Chemical Feed*

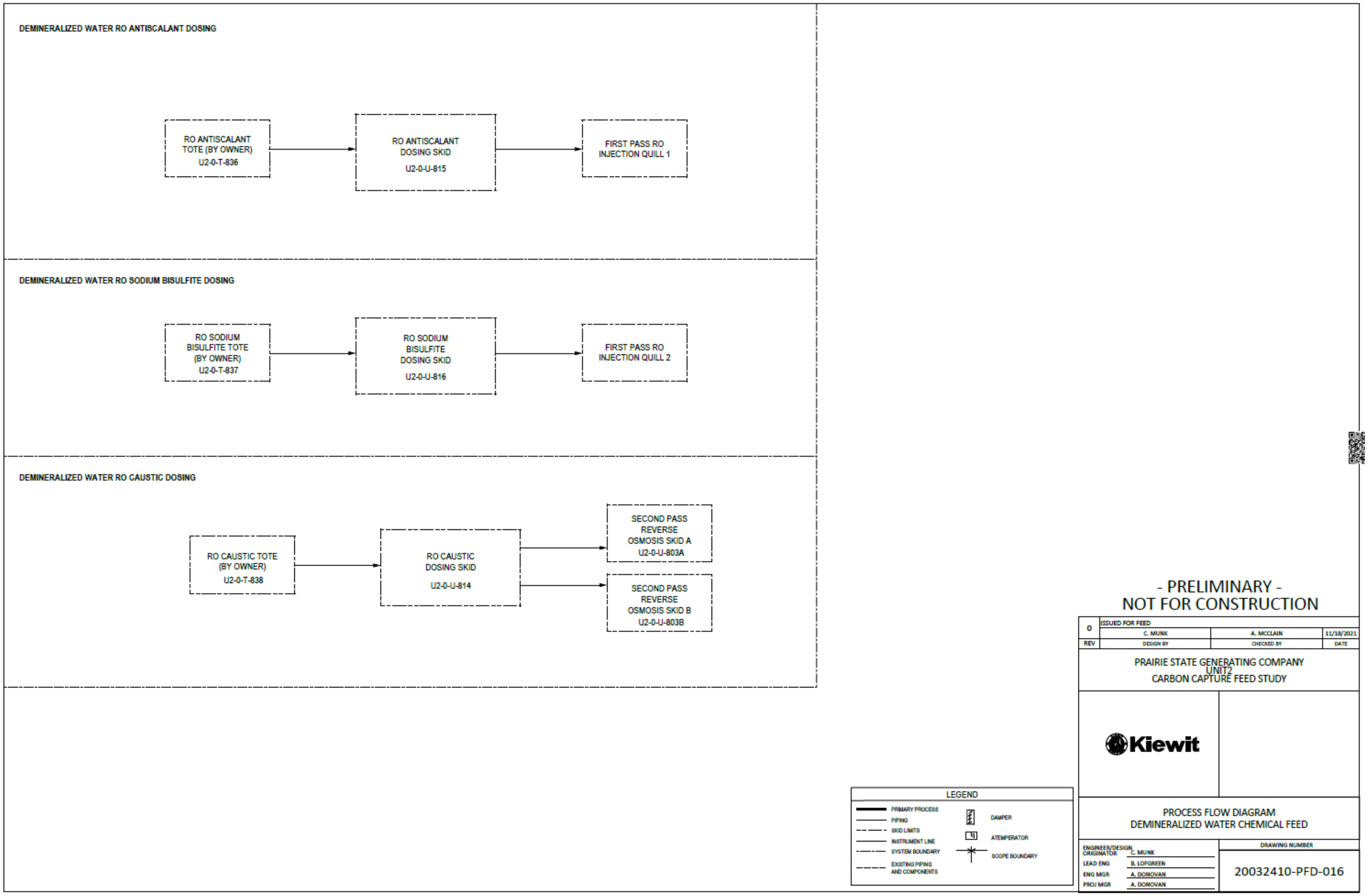

Figure 26. *Process Flow Diagram Demineralized Water Chemical Feed*

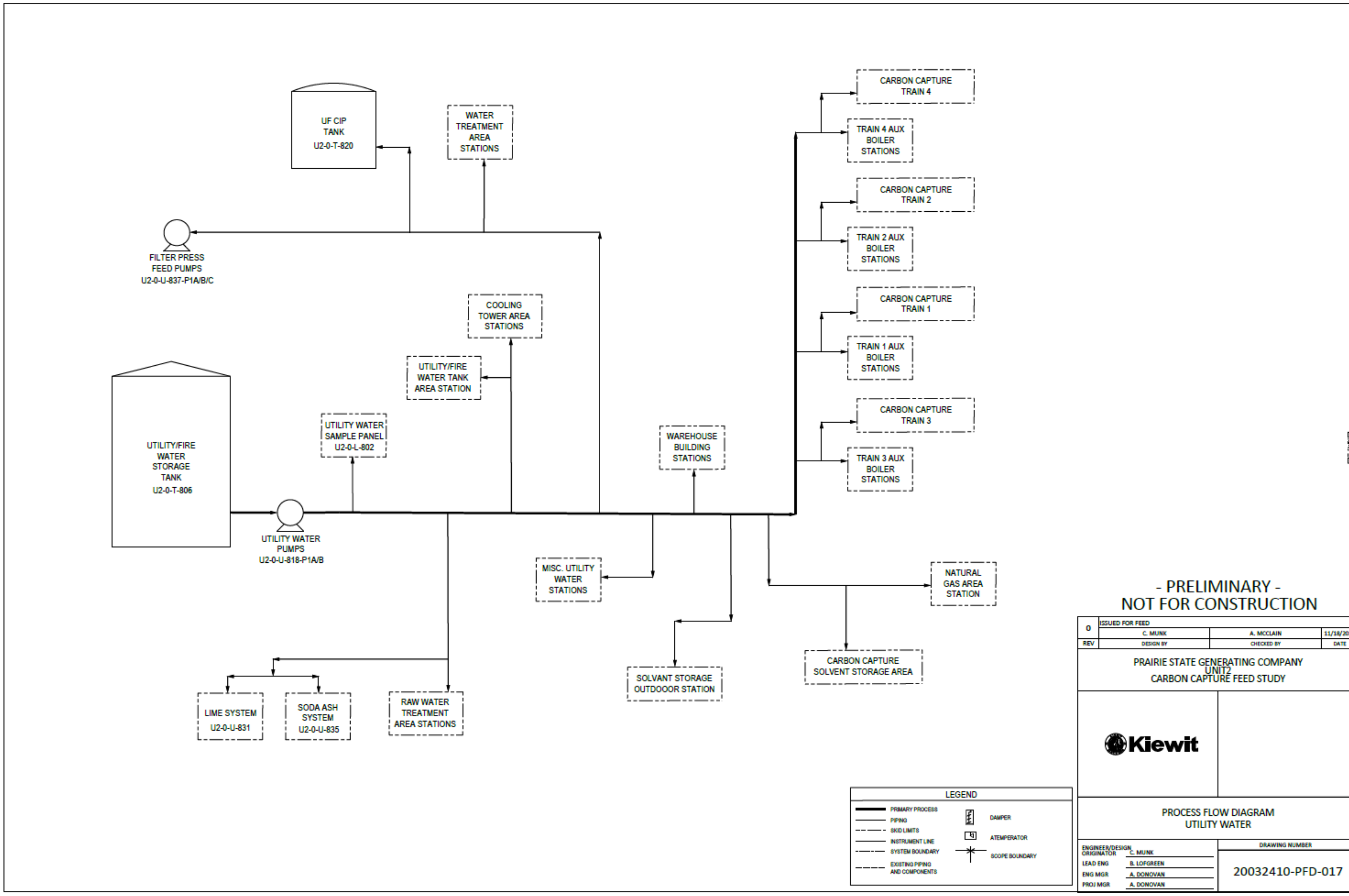

Figure 27. *Process Flow Diagram Utility Water*

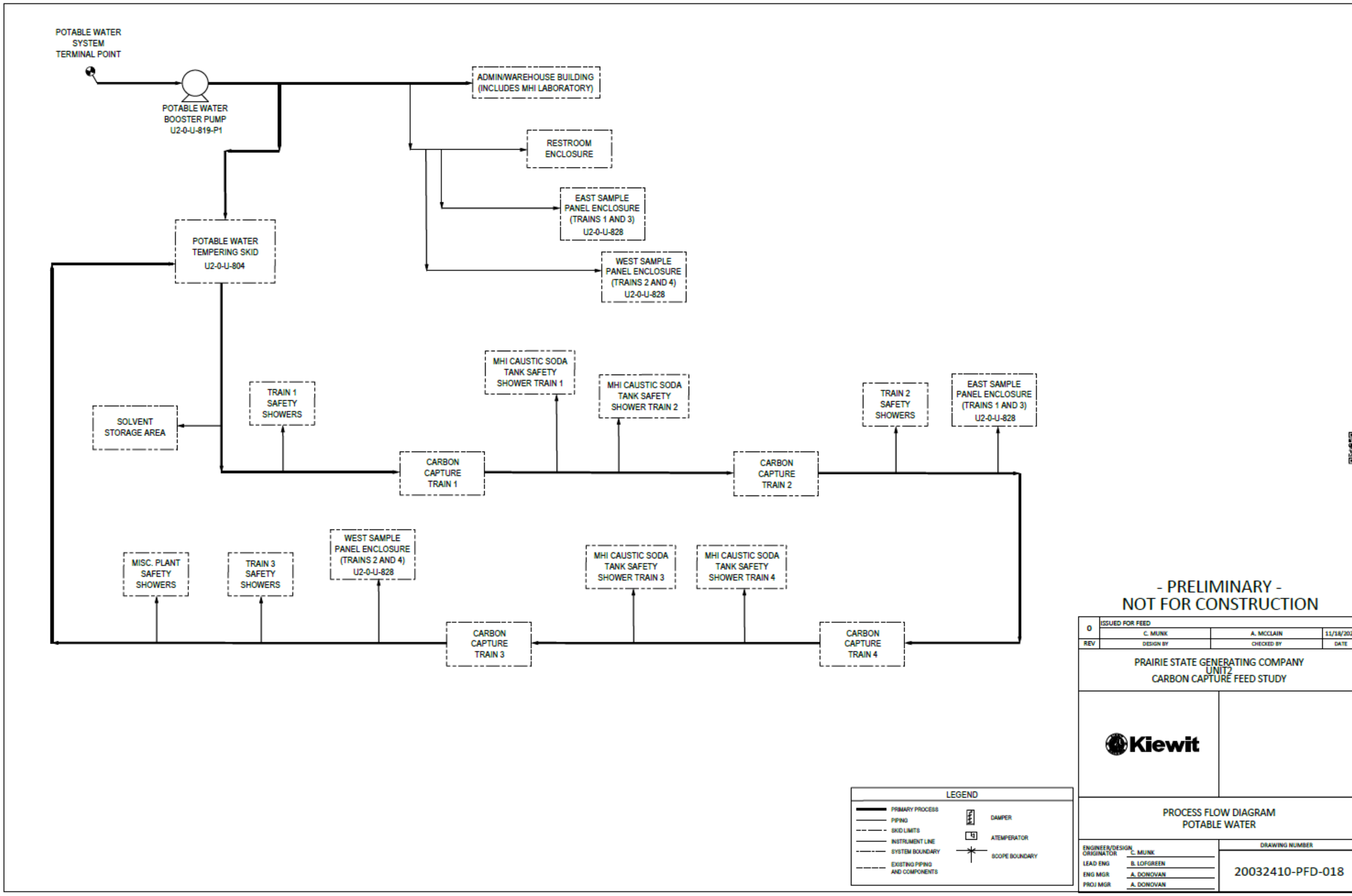

Figure 28. *Process Flow Diagram Potable Water*

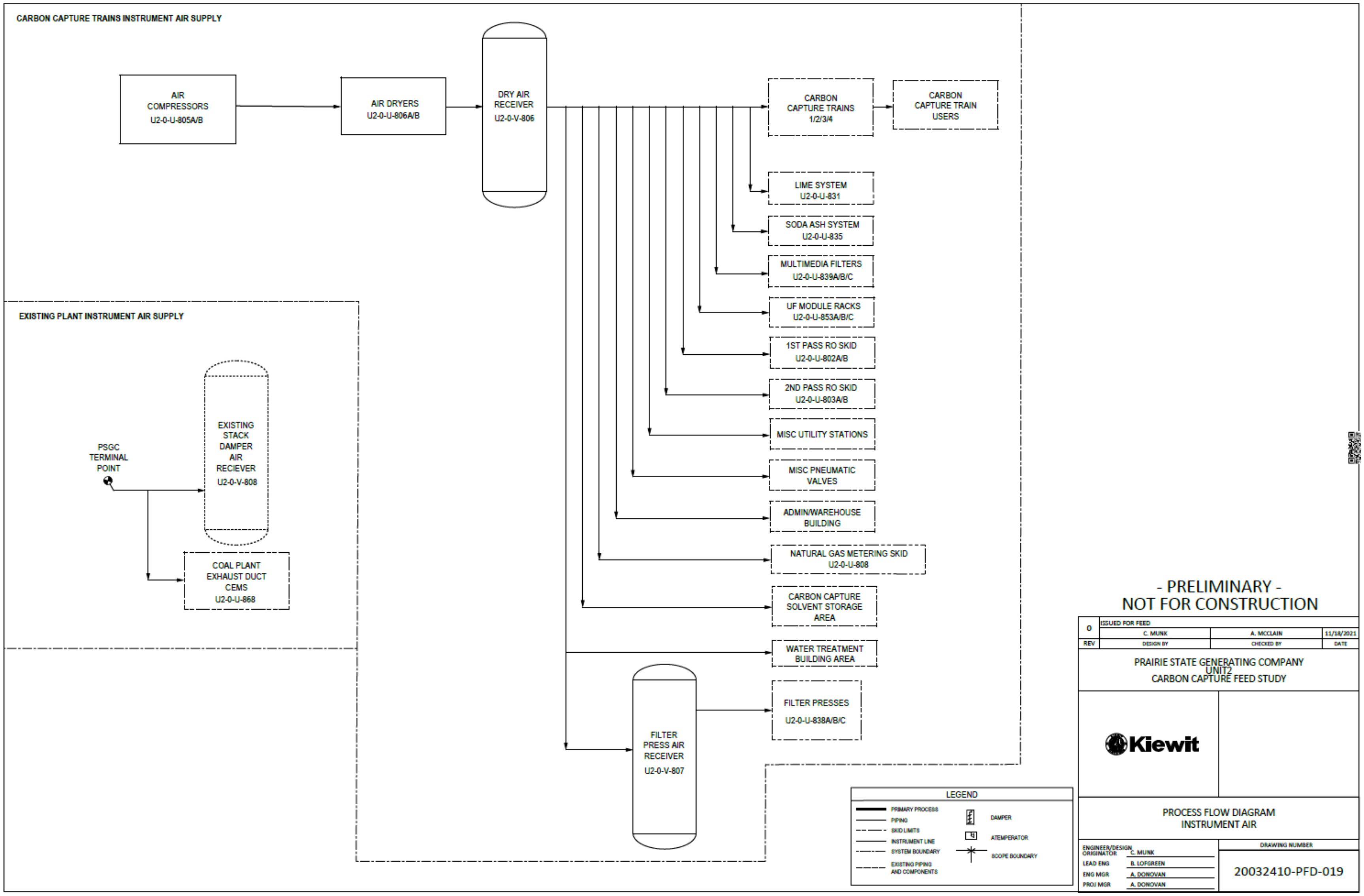

Figure 29. *Process Flow Diagram Instrument Air*

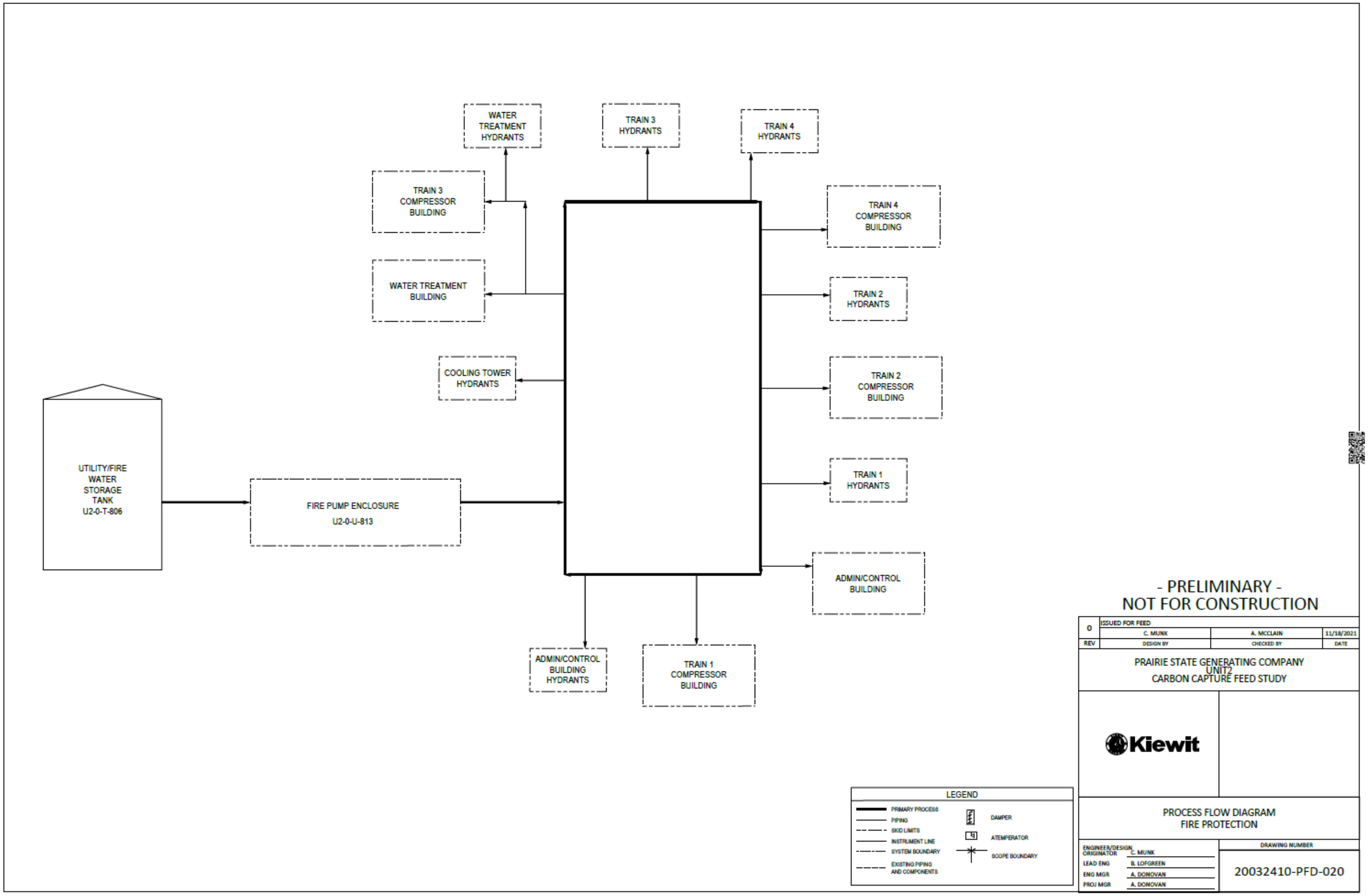

Figure 30. *Process Flow Diagram Fire Protection*

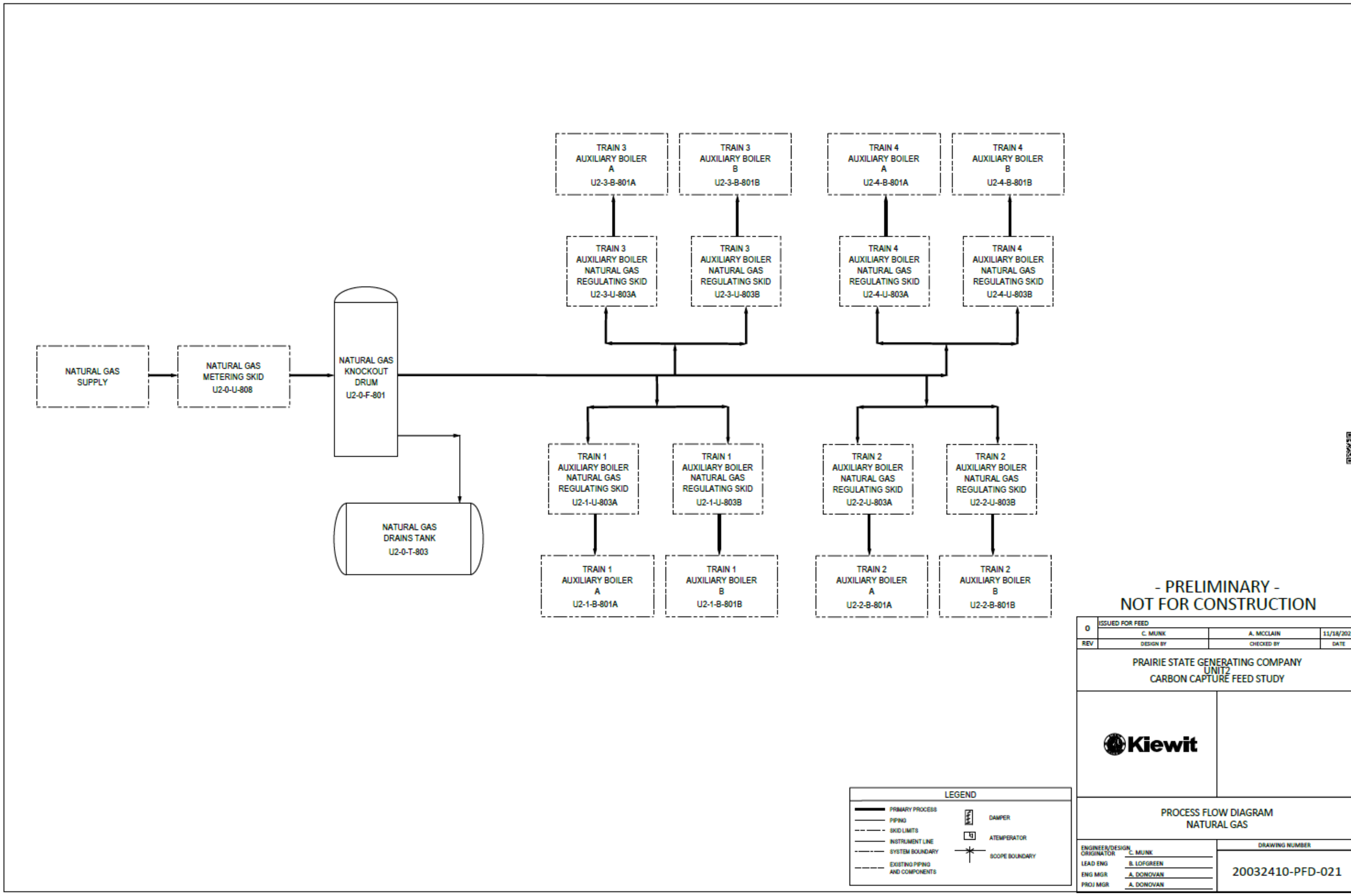

Figure 31. *Process Flow Diagram Natural Gas*

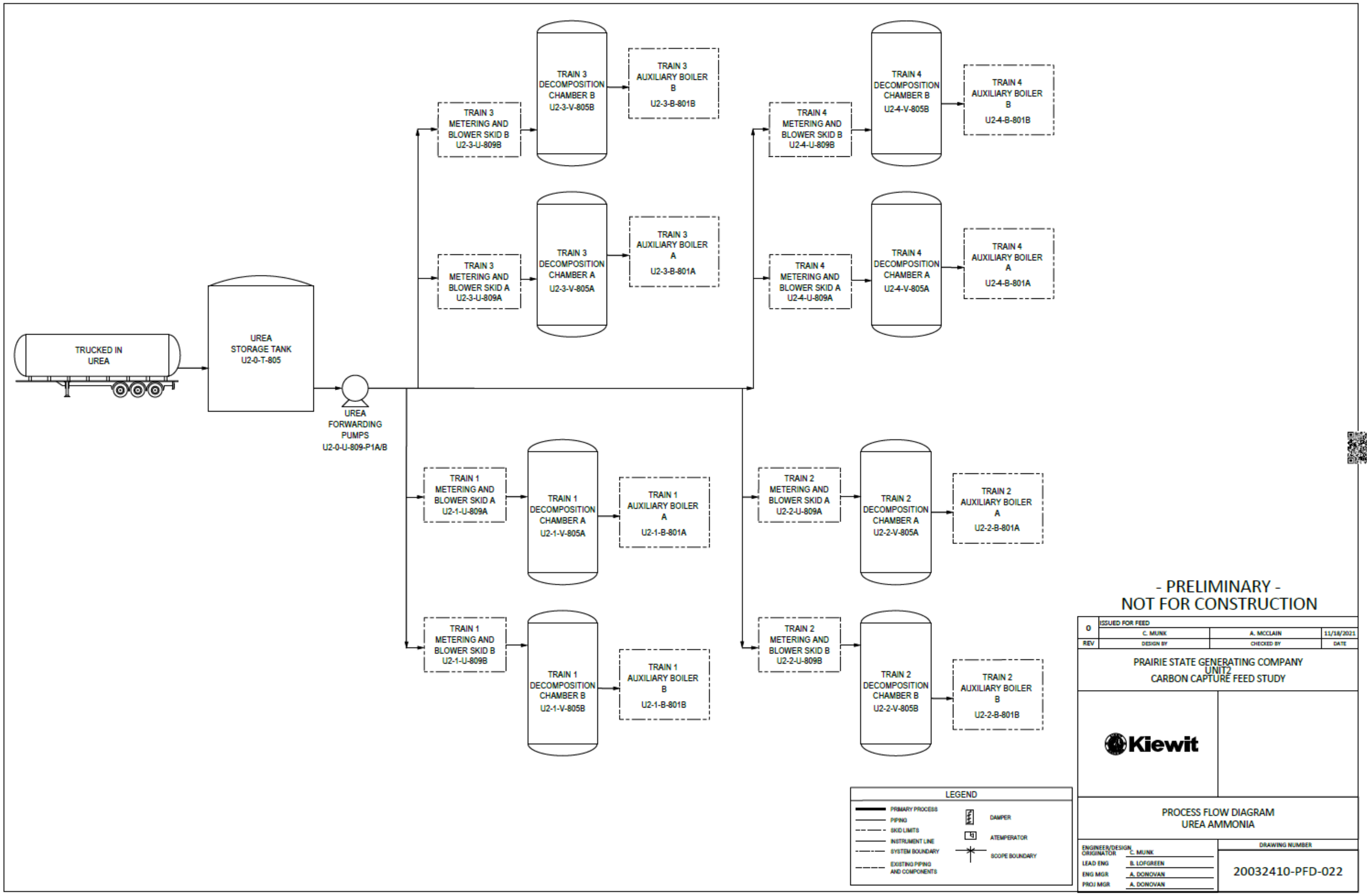

Figure 32. *Process Flow Diagram Urea Ammonia*

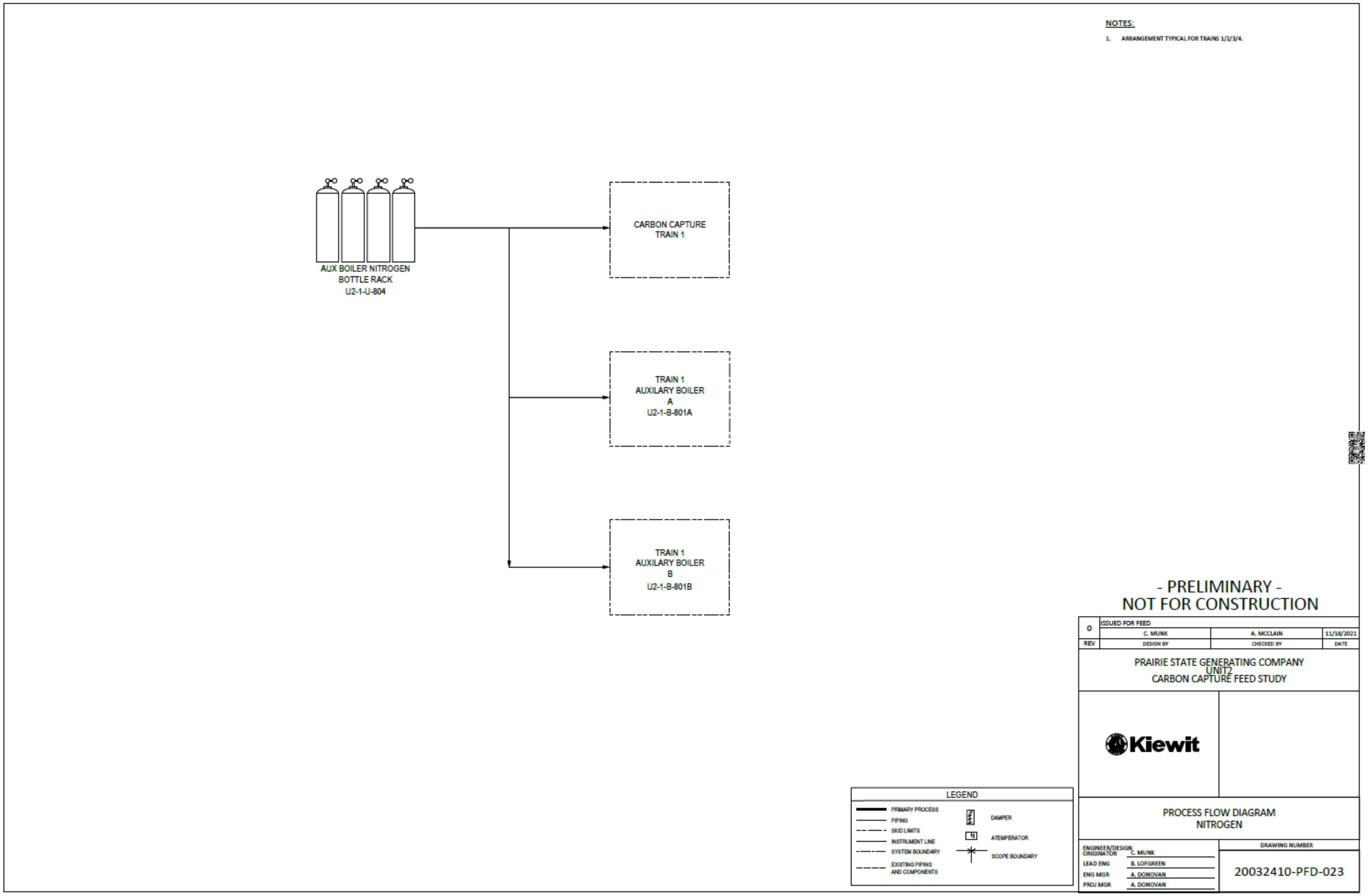

Figure 33. *Process Flow Diagram Nitrogen*

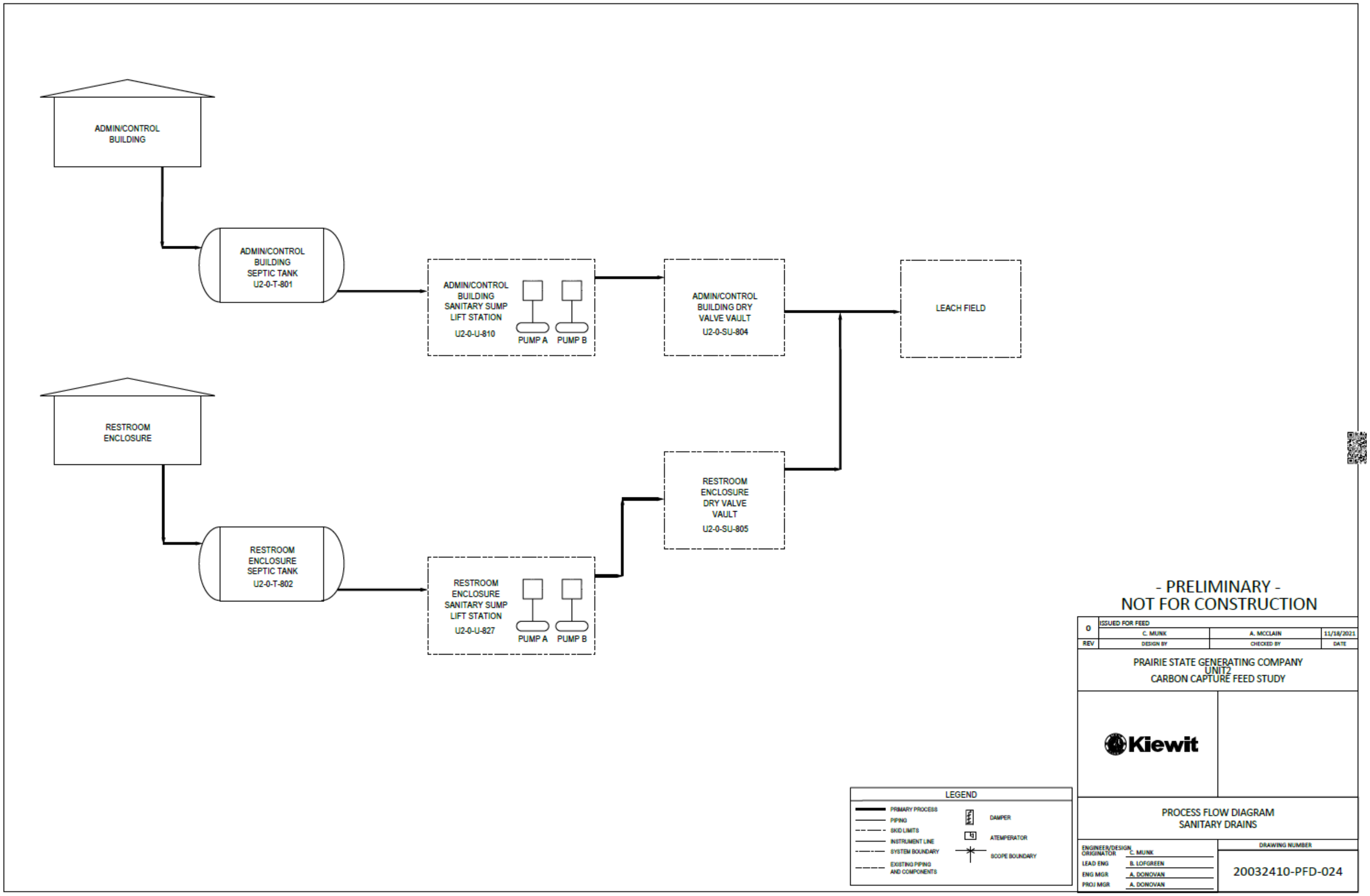

Figure 34. *Process Flow Diagram Sanitary Drains*

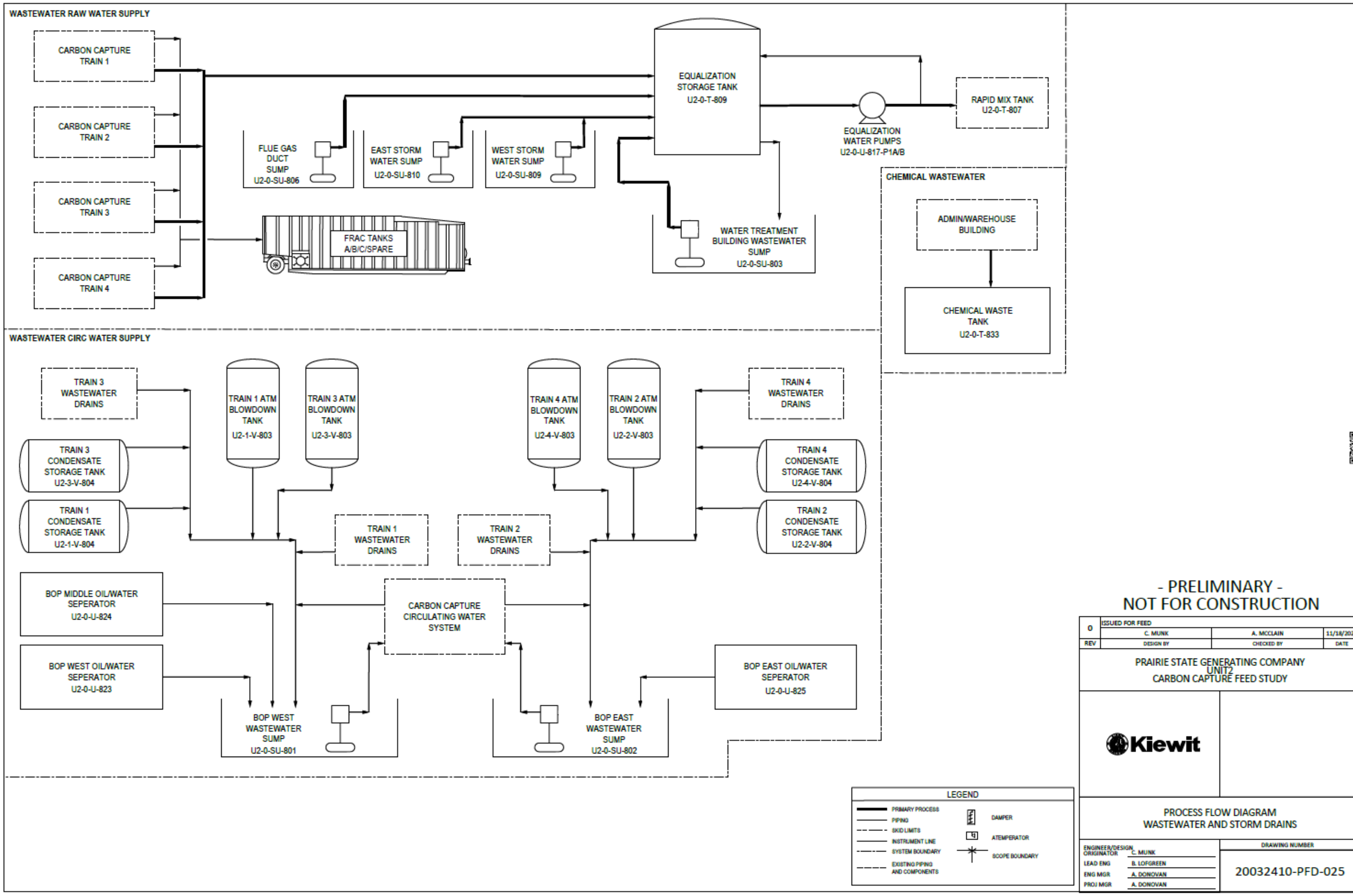

Figure 35. *Process Flow Diagram Wastewater and Storm Drains*

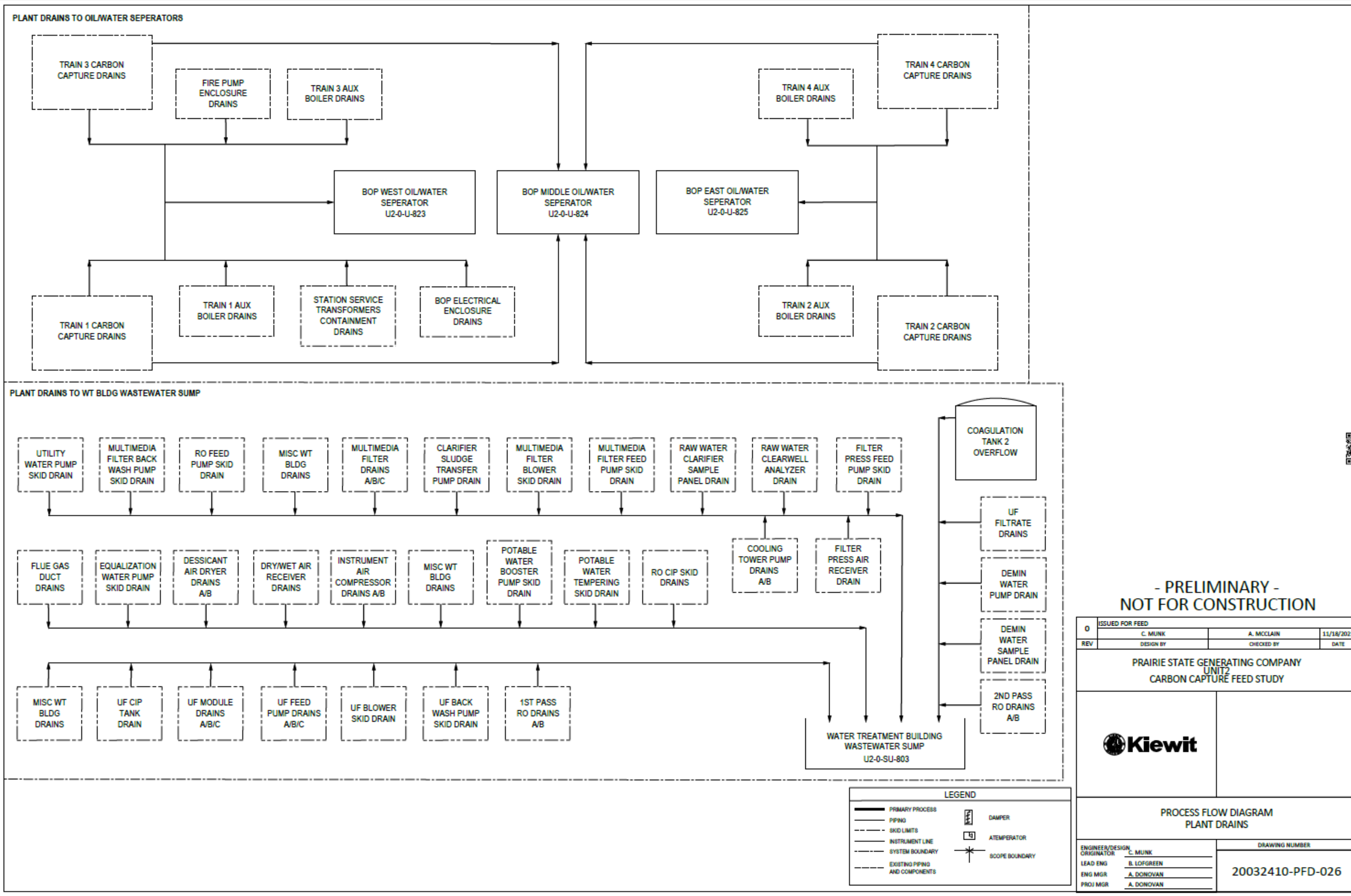

Figure 36. *Process Flow Diagram Plant Drains*

Heat Balance

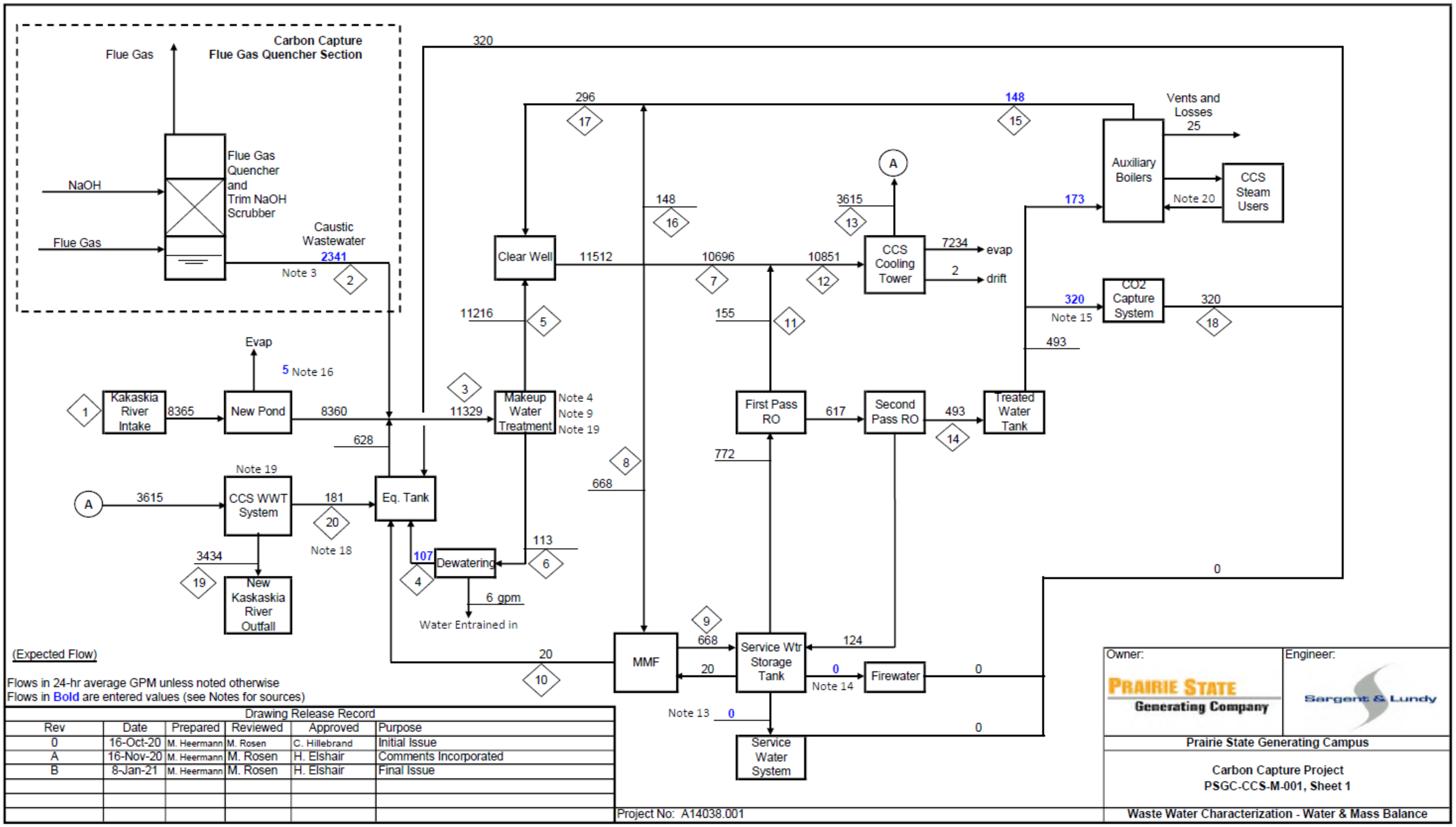

Figure 37. *OSBL Heat Balance Diagram*

Stream Name	Scrubber Waste Water		Kaskaska River Intake		Water Softener Inlet		Thickener Decant		Thickener Sludge	
Stream Designation	2		1		3		4			
Notes	1, 2, 3		5		9				21	
Flow Rates	**2341 gpm**	1,171,436 lb/hr	8,365 gpm	4,185,971 lb/hr	11,329 gpm	5,669,032 lb/hr	107 gpm	53,543 lb/hr	6 gpm	2,900 lb/hr
PARAMETERS										
Cations, ppm										
Calcium (Ca)	0	0.00 lb/hr	**72**	301 lb/hr	55	309 lb/hr	**20**	1 lb/hr		
Magnesium (Mg)	0	0.00 lb/hr	**26.6**	111 lb/hr	20	114 lb/hr	**6**	0 lb/hr		
Sodium (Na)	**1300**	1523 lb/hr	**45**	188 lb/hr	324	1839 lb/hr	325	17 lb/hr		
Potassium (K)	0	0 lb/hr	**12.3**	51 lb/hr	10	55 lb/hr	10	1 lb/hr		
Anions, ppm										
M-Alkalinity ($CaCO_3$)	**479**	561 lb/hr	**215**	900 lb/hr	259	1471 lb/hr	**25**	1 lb/hr		
Chloride (Cl)	**1**	1.2 lb/hr	**47**	197 lb/hr	38	213 lb/hr	38	2 lb/hr		
Sulfate (SO_4)	**2300**	2694 lb/hr	**119**	498 lb/hr	610	3459 lb/hr	611	33 lb/hr		
Phosphate (PO_4)			**2.2**	9 lb/hr	1.7	9 lb/hr	0.6	0 lb/hr		
Nitrate (NO_3)	**25**	29 lb/hr	**11**	46 lb/hr	14	81 lb/hr	14	1 lb/hr		
Fluoride (F)	**0.3**	0.35 lb/hr			0.07	0.38 lb/hr	0.07	0.00 lb/hr		
Silica (SiO_2)	0	0.00 lb/hr	**35**	147 lb/hr	27	153 lb/hr	**18**	0 lb/hr		
Base										
Temperature, °F	**128**		86		80					
pH, std. units	**7**		**8.1**		7-8		**10-11**			
TDS, ppm	**4105**	4809 lb/hr	**485**	2030 lb/hr	1292	7322 lb/hr	1251	56 lb/hr		
TSS, ppm	**65**	76 lb/hr	**350**	1465 lb/hr	291	1651 lb/hr	**1000**	54 lb/hr	**550,000**	1595 lb/hr
Trace, ppm										
Arsenic	**0.003**	0.0035 lb/hr			0.0007	0.0038 lb/hr	0.0007	0.00004 lb/hr		
Barium	**0.035**	0.041 lb/hr			0.008	0.044 lb/hr	0.008	0.0004 lb/hr		
Cadmium	**0.001**	0.0012 lb/hr			0.0002	0.0013 lb/hr	0.0002	0.00001 lb/hr		
Chromium	**0.015**	0.018 lb/hr			0.10	0.566 lb/hr	0.1000	0.0054 lb/hr		
Copper	0	0 lb/hr	**0.02**	0.08 lb/hr	0.039	0.22 lb/hr	0.030	0.0016 lb/hr		
Iron	0	0 lb/hr	**11**	46.0 lb/hr	9	50 lb/hr	1.0	0.05 lb/hr		
Manganese	0	0 lb/hr	**0.83**	3.47 lb/hr	0.7	3.7 lb/hr	0.7	0.04 lb/hr		
Mercury	0.007	0.008 lb/hr			0.002	0.014 lb/hr	0.001	0.00005 lb/hr		
Selenium	**0.300**	0 lb/hr			0.07	0.38 lb/hr	0.07	0.004 lb/hr		

Stream Name	Softened Water		Dewatering Inlet		Clear Well to Cooling Tower		MMF Inlet		MMF Outlet	
Stream Designation	5		6		7		8		9	
Notes	4,5		4,5		4,5		4,5		4,5	
Flow Rates	11,216 gpm	5,612,486 lb/hr	113 gpm	56,545 lb/hr	10,696 gpm	5,352,278 lb/hr	668 gpm	334,267 lb/hr	668 gpm	334,267 lb/hr
PARAMETERS										
Cations, ppm										
Calcium (Ca)	**20**	112 lb/hr	20	1.13 lb/hr	20	107 lb/hr	20	6.69 lb/hr	20	6.69 lb/hr
Magnesium (Mg)	**6**	34 lb/hr	6	0.34 lb/hr	6	33 lb/hr	6	2.04 lb/hr	6	2.04 lb/hr
Sodium (Na)	**325**	1824 lb/hr	309	17 lb/hr	325	1739 lb/hr	325	109 lb/hr	325	109 lb/hr
Potassium (K)	**10**	56 lb/hr	10	0.57 lb/hr	10	54 lb/hr	10	3.3 lb/hr	10	3.3 lb/hr
Anions, ppm										
M-Alkalinity ($CaCO_3$)	**25**	140 lb/hr	25	1.41 lb/hr	25	134 lb/hr	25	8.4 lb/hr	25	8 lb/hr
Chloride (Cl)	**38**	213 lb/hr	38	2.1 lb/hr	38	203 lb/hr	38	12.7 lb/hr	38	13 lb/hr
Sulfate (SO_4)	**685**	3844 lb/hr	685	39 lb/hr	685	3666 lb/hr	685	229 lb/hr	685	229 lb/hr
Phosphate (PO_4)	**0.64**	4 lb/hr	0.6	0.04 lb/hr	1	3 lb/hr	1	0.2 lb/hr	1	0 lb/hr
Nitrate (NO_3)	**14**	79 lb/hr	14	0.79 lb/hr	14	75 lb/hr	14	4.7 lb/hr	14	5 lb/hr
Fluoride (F)	**0.07**	0.40 lb/hr	0.07	0.0040 lb/hr	0.07	0 lb/hr	0.07	0.02 lb/hr	0.07	0 lb/hr
Silica (SiO_2)	**18**	101 lb/hr	18	52 lb/hr	18	96 lb/hr	18	6.0 lb/hr	18	6 lb/hr
Base										
Temperature, °F										
pH, std. units	**11**		7-8		7-8					
TDS, ppm	**1251**	6419 lb/hr	1251	903 lb/hr	1251	6696 lb/hr	1251	418 lb/hr	1251	418 lb/hr
TSS, ppm	**10**	56 lb/hr	28211	1595 lb/hr	10	54 lb/hr	10	3.34 lb/hr	**1**	0.33 lb/hr
Trace, ppm										
Arsenic	**0.0007**	0.0040 lb/hr	0.0007	0.00004 lb/hr	0.0007	0.0038 lb/hr	0.0007	0.00024 lb/hr	0.0007	0.00024 lb/hr
Barium	**0.008**	0.047 lb/hr	0.008	0.00047 lb/hr	0.008	0.044 lb/hr	0.008	0.003 lb/hr	0.008	0.0028 lb/hr
Cadmium	**0.0002**	0.0013 lb/hr	0.0002	0.000013 lb/hr	0.0002	0.0013 lb/hr	0.0002	0.00008 lb/hr	0.0002	0.00008 lb/hr
Chromium	**0.10**	0.561 lb/hr	0.100	0.00565 lb/hr	0.100	0.528 lb/hr	0.1000	0.03343 lb/hr	0.100	0.0334 lb/hr
Copper	**0.030**	0.17 lb/hr	0.030	0.00170 lb/hr	0.030	0.158 lb/hr	0.030	0.0100 lb/hr	0.030	0.0100 lb/hr
Iron	**1.0**	6 lb/hr	1.0	0.06 lb/hr	1.0	3 lb/hr	8.2	2.745 lb/hr	8.2	2.7 lb/hr
Manganese	**0.7**	3.9 lb/hr	0.70	0.04 lb/hr	0.70	3.7 lb/hr	0.62	0.207 lb/hr	0.6	0.21 lb/hr
Mercury	**0.001**	0.0056 lb/hr	0.0010	0.000057 lb/hr	0.0010	0.0053 lb/hr	0.00100	0.000334 lb/hr	0.0010	0.00033 lb/hr
Selenium	**0.07**	0.40 lb/hr	0.071	0.0040 lb/hr	0.071	0.4 lb/hr	0.071	0.024 lb/hr	0.071	0.0239 lb/hr

Owner: Prairie State Generating Company

Engineer: Sargent & Lundy

Drawing Release Record

Rev	Date	Prepared	Reviewed	Approved	Purpose
0	16-Oct-20	M.Heermann	M. Rosen	C. Hillebrand	Initial Issue
A	16-Nov-20	M. Heermann	M. Rosen	H. Elshair	Comments Incorporated
B	8-Jan-21	M. Heermann	M. Rosen	H. Elshair	Final Issue

Parameters in **Bold** are entered values (see Notes for sources)

Project No: A14038.001

Prairie State Generating Campus
Carbon Capture Project

PSGC-CCS-M-001, Sheet 2

Waste Water Characterization - Water & Mass Balance

Figure 38. *OSBL Heat Balance 1*

Stream Name	Multi-media Filter Backwash		RO Stage 1 Reject		Cooling Tower Makeup		Cooling Tower Blowdown		Treated Water	
Stream Designation	10		11		12		13		14	
Notes	6		7				8		7	
Flow Rates	20 gpm	10,008 lb/hr	155 gpm	77,562 lb/hr	10,851 gpm	5,429,840 lb/hr	3,615 gpm	1,808,946 lb/hr	493 gpm	246,697 lb/hr
PARAMETERS										
Cations, ppm										
Calcium (Ca)	20.0	1.1 lb/hr	86	6.68 lb/hr	21	114 lb/hr	63	114 lb/hr	0.0027	0.00067 lb/hr
Magnesium (Mg)	6.1	0.34 lb/hr	26	2.04 lb/hr	6	35 lb/hr	19	35 lb/hr	0.0008	0.00020 lb/hr
Sodium (Na)	325	18 lb/hr	1401	109 lb/hr	340	1848 lb/hr	1022	1848 lb/hr	0.0030	0.011 lb/hr
Potassium (K)	10	0.6 lb/hr	43	3 lb/hr	10	57 lb/hr	31	57 lb/hr	0.0014	0.00033 lb/hr
Anions, ppm										
M-Alkalinity ($CaCO_3$)	25	1.4 lb/hr	108	8 lb/hr	26	142 lb/hr	79	142 lb/hr	0.003	0.0008 lb/hr
Chloride (Cl)	38	2 lb/hr	164	13 lb/hr	40	216 lb/hr	119	216 lb/hr	0.003	0.0013 lb/hr
Sulfate (SO_4)	685	39 lb/hr	2952	229 lb/hr	717	3895 lb/hr	2153	3895 lb/hr	0.003	0.023 lb/hr
Phosphate (PO_4)	1	0.0 lb/hr	3	0.2 lb/hr	1	4 lb/hr	2	4 lb/hr	0.0001	0.000021 lb/hr
Nitrate (NO_3)	14	0.8 lb/hr	60	5 lb/hr	15	80 lb/hr	44	80 lb/hr	0.002	0.0005 lb/hr
Fluoride (F)	0.07	0.004 lb/hr	0.31	0.02 lb/hr	0	0 lb/hr	0	0 lb/hr	0.00001	0.000002 lb/hr
Silica (SiO_2)	18	1.0 lb/hr	78	6	19	102 lb/hr	57	102 lb/hr	0.002	0.0006 lb/hr
Base										
Temperature, °F										
pH, std. units										
TDS, ppm	1251	71 lb/hr	5391	418 lb/hr	1310.14	7114 lb/hr	3933	7114 lb/hr	**0.2**	**0.04**
TSS, ppm	301	3.0 lb/hr	0	0 lb/hr	10	54 lb/hr	97	54 lb/hr	**0.0**	**0.0**
Trace, ppm										
Arsenic	0.001	0.00001 lb/hr	0.003	0.00024 lb/hr	0.0007	0.004 lb/hr	0.002	0.004 lb/hr	**0**	**0.0 lb/hr**
Barium	0.008	0.00008 lb/hr	0.036	0.00279 lb/hr	0.009	0.047 lb/hr	0.026	0.047 lb/hr	**0**	**0.0 lb/hr**
Cadmium	0.0002	0.000002 lb/hr	0.0010	0.00008 lb/hr	0.0002	0.001 lb/hr	0.0007	0.001 lb/hr	**0**	**0.0 lb/hr**
Chromium	0.100	0.00100 lb/hr	0.431	0.03342 lb/hr	0.1034	0.561 lb/hr	0.310	0.561 lb/hr	**0**	**0.0 lb/hr**
Copper	0.030	0.0003 lb/hr	0.129	0.0100 lb/hr	0.0310	0 lb/hr	0.093	0.17 lb/hr	**0**	**0.0 lb/hr**
Iron	8	0.08 lb/hr	35	2.74 lb/hr	1	6 lb/hr	3	6 lb/hr	**0**	**0.0 lb/hr**
Manganese	0.6	0.0062 lb/hr	2.7	0.21 lb/hr	1	4 lb/hr	2.2	4 lb/hr	**0**	**0.0 lb/hr**
Mercury	0.0010	0.000010 lb/hr	0.004	0.0003 lb/hr	0.0010	0.0056 lb/hr	0.0031	0.0056 lb/hr	**0**	**0.0 lb/hr**
Selenium	0.071	0.0007 lb/hr	0.31	0.024 lb/hr	0.07	0.4 lb/hr	0.2	0.4 lb/hr	**0**	**0.0 lb/hr**

Stream Name	Boiler Blowdown		Quench Water		Quenched Boiler Blowdown		Carbon Capture Floor Drains		Carbon Capture WWT Effluent		Carbon Capture WWT Backwash	
Stream Designation	15		16		17		18		19		20	
Notes	10		11				12		17		18	
Flow Rates	148 gpm	74,059 lb/hr	148 gpm	74,059 lb/hr	296 gpm	148,118 lb/hr	320 gpm	160,128 lb/hr	3,434 gpm	1,718,499 lb/hr	181 gpm	90,447 lb/hr
PARAMETERS												
Cations, ppm												
Calcium (Ca)	0	0.0 lb/hr	20	1.5 lb/hr	10	1.5 lb/hr	0.003	0.00043 lb/hr	63	108 lb/hr	63	6 lb/hr
Magnesium (Mg)	0	0.00 lb/hr	6	0.45 lb/hr	3	0.45 lb/hr	0.0008	0.00013 lb/hr	19	33 lb/hr	19	2 lb/hr
Sodium (Na)	3	0.011 lb/hr	325	24.1 lb/hr	163	24.1 lb/hr	0.003	0.0005 lb/hr	1022	1756 lb/hr	1022	92 lb/hr
Potassium (K)	0	0.00 lb/hr	10	0.74 lb/hr	5	0.74 lb/hr	0.0014	0.00022 lb/hr	31	54 lb/hr	31	3 lb/hr
Anions, ppm												
M-Alkalinity ($CaCO_3$)	0.01	0.0008 lb/hr	25	1.9 lb/hr	13	1.9 lb/hr	0.003	0.0005 lb/hr	79	135 lb/hr	79	7 lb/hr
Chloride (Cl)	0.017	0.00127 lb/hr	38	2.8 lb/hr	19	2.8 lb/hr	0.003	0.0005 lb/hr	119	205 lb/hr	119	11 lb/hr
Sulfate (SO_4)	0.3	0.023 lb/hr	685	50.7 lb/hr	343	50.8 lb/hr	0.003	0.0005 lb/hr	2153	3700 lb/hr	2153	195 lb/hr
Phosphate (PO_4)	4	0.30 lb/hr	0.6	0.05 lb/hr	2.3	0.344 lb/hr	0.0001	0.000014 lb/hr	2	3 lb/hr	2.0	0.2 lb/hr
Nitrate (NO_3)	0.006	0.0005 lb/hr	14.0	1.037 lb/hr	7	1.04 lb/hr	0.002	0.00030 lb/hr	44	76 lb/hr	44	4 lb/hr
Fluoride (F)	0.00003	0.000002 lb/hr	0.1	0.005 lb/hr	0.04	0.005 lb/hr	0.00001	0.000002 lb/hr	0.2	0.4 lb/hr	0.2	0.02 lb/hr
Silica (SiO_2)	0.008	0.0006 lb/hr	18	1.33 lb/hr	9	1.33 lb/hr	0.002	0.00039 lb/hr	57	97 lb/hr	57	5 lb/hr
Base												
Temperature, °F							86		86		86	
pH, std. units	**9.8**								6.5-9			
TDS, ppm	**7**	**0.55 lb/hr**	1251	92.6 lb/hr	629	93.2 lb/hr	0.2	0.027 lb/hr	3932.6	6758 lb/hr	3933	356 lb/hr
TSS, ppm	**0**	**0.00 lb/hr**	10.0	0.74 lb/hr	5	0.74 lb/hr	**20**	3.20 lb/hr	**0**	0.00 lb/hr	592	54 lb/hr
Trace, ppm												
Arsenic	**0**	**0.0 lb/hr**	0.0007	0.00005 lb/hr	0.0004	0.00005 lb/hr	0.0007	0.00011 lb/hr	0.002	0.00381 lb/hr	0.002	0.0002 lb/hr
Barium	**0**	**0.0 lb/hr**	0.008	0.0006 lb/hr	0.004	0.0006 lb/hr	0.008	0.0012 lb/hr	0.026	0.0444 lb/hr	0.026	0.0023 lb/hr
Cadmium	**0**	**0.0 lb/hr**	0.0002	0.000018 lb/hr	0.00012	0.000018 lb/hr	0.0002	0.00004 lb/hr	0.0007	0.00127 lb/hr	0.0007	0.0001 lb/hr
Chromium	**0**	**0.0 lb/hr**	0.100	0.00741 lb/hr	0.050	0.00741 lb/hr	0.093	0.0148 lb/hr	**0.011**	0.02 lb/hr	6.00	0.54 lb/hr
Copper	**0**	**0.0 lb/hr**	0.030	0.0022 lb/hr	0.015	0.0022 lb/hr	0.028	0.0044 lb/hr	**0.02**	0.03 lb/hr	1.5	0.13 lb/hr
Iron	**0**	**0.0 lb/hr**	1.0	0.07 lb/hr	0.5	0.074 lb/hr	0.93	0.148 lb/hr	**1**	1.72 lb/hr	43	4 lb/hr
Manganese	**0**	**0.0 lb/hr**	0.7	0.052 lb/hr	0.35	0.052 lb/hr	0.65	0.104 lb/hr	2.2	3.732 lb/hr	2.2	0.2 lb/hr
Mercury	**0**	**0.0 lb/hr**	0.0010	0.000074 lb/hr	0.0005	0.000074 lb/hr	0.00093	0.00015 lb/hr	**0.000012**	0.00 lb/hr	0.062	0.0056 lb/hr
Selenium	**0**	**0.0 lb/hr**	0.07	0.005 lb/hr	0.036	0.005 lb/hr	0.07	0.0106 lb/hr	0.2	0.3809 lb/hr	0.2	0.02 lb/hr

Drawing Release Record

Rev	Date	Prepared	Reviewed	Approved	Purpose
0	16-Oct-20	M.Heermann	M. Rosen	C. Hillebrand	Initial Issue
A	16-Nov-20	M. Heermann	M. Rosen	H. Elshair	Comments Incorporated
B	8-Jan-21	M. Heermann	M. Rosen	H. Elshair	Final Issue

Parameters in **Bold** are entered values (see Notes for sources)

Project No: A14038.001

Engineer: PRAIRIE STATE Generating Company

Engineer: Sargent & Lundy

Prairie State Generating Campus
Carbon Capture Project

PSGC-CCS-M-001, Sheet 3

Waste Water Characterization - Water & Mass Balance

Figure 39. *OSBL Heat Balance 2*

Table 10. *ISBL Heat and Material Balance*

STREAM NO.		A	B	C
FLUID NAME		FLUE GAS	TREATED GAS	COMPRESSED CO2 GAS
TEMPERATURE	°F	199	106	120
PRESSURE	psig	TBD	0.0	1835
VOLUME FLOW	MMscfh at 68°F	185.4	143.7	18.80
COMPOSITION				
H_2O	mol%-wet	18.4	7.8	less than 500 ppmv
N_2+Ar	mol%-wet	66.5	85.8	N2 : less than 4 vol%-dry Ar : less than 4 vol%-dry
O_2	mol%-wet	4.5	5.7	less than 50 ppmw-dry
CO_2	mol%-wet	10.7	0.7	more than 95 vol%-dry
NOx	ppmv-dry	75	86	less than 100
SO_2	ppmv-dry	65	< 1	less than 100

HAZOP/PHA

PHA Process

A FEED Process Hazard Analysis (PHA) was conducted virtually January 18th through 21st and January 25th through 28th to identify hazards associated with the process. Trimeric Corporation facilitated the PHA and provided a summary report upon which this deliverable is based. The method selected for the PHA was a combination of Hazard and Operability Study (HAZOP) and "What If" analysis. The scope of the PHA included a hazard analysis of the process equipment, piping, and components associated with the CO_2 capture portion of the project. The scope did not include the host site equipment beyond duct and piping connections; however, safeguards located in the existing facility were documented where appropriate. The objectives of the PHA were as follows:

- Systematically identify process hazards associated with the operation of the unit
- Evaluate the possible safety, environmental, production, and community consequences in the absence of engineering and administrative controls
- Summarize the design's existing engineering and administrative controls
- Make recommendations for additional controls when needed to reduce the risk in the process.

P&IDs provided to Trimeric were used to develop nodes for the PHA. Nodes were identified by the MHIA engineer and facilitator and were clearly marked on the P&IDs by the facilitator prior to the session. Prior to the PHA, a list of preliminary "What If" questions were sent to the PHA team members, and the team members provided additional questions to consider. Current alarm rationalization and operator response information was provided by core team members during the HAZOP and "What If" sessions. Process hazards were identified by the team for each node and any recommendations were recorded.

A PHA team was selected by MHIA to include personnel knowledgeable of the MHI CO_2 capture process, the host power plant operations, project design engineering, and the method employed for this PHA (HAZOP). Core team members included personnel highly experienced in operations, engineering, I&E, process controls, safety, and PHA facilitation. The team members are listed in ***Table 11***.

Table 11. PHA Team

Name	Title	Company
Tim Thomas	Project Sponsor	Mitsubishi Heavy Industries America
Tiffany Wu	Business Development Manager	Mitsubishi Heavy Industries America
Cole Maas	Process Engineer	Mitsubishi Heavy Industries America
Daisuke Shimada	Process Engineer	Mitsubishi Heavy Industries Engineering
Shinya Kishimoto	Process Engineering Manager	Mitsubishi Heavy Industries Engineering
Hiroaki Ito	Process Engineer	Mitsubishi Heavy Industries Engineering
Tamotsu Nakano	Instrument Engineer	Mitsubishi Heavy Industries Engineering
Daisuke Horiguchi	Mechanical Engineer	Mitsubishi Heavy Industries Engineering
Rich Meyer	Senior Project Engineer	Prairie State Generating Company
Javier Arzola	Project Manager	Prairie State Generating Company
Brian Slavin	Mechanical Engineer	Kiewit Corporation
Jason Broockerd	Lead Instrument and Control Engineer	Kiewit Corporation
Bryan Lofgreen	Lead Mechanical Engineer	Kiewit Corporation
Alan Donovan	Project Manager	Kiewit Corporation
Hatem Elshair	Mechanical Engineer	Sargent & Lundy
Alex Kofler	Mechanical Engineer	Sargent & Lundy

Jason Dietsch	Assistant Scientist	University of Illinois at Urbana-Champaign
Rosalind Jones	Senior Process Engineer Facilitator/Scribe	Trimeric Corporation

The PHA study was performed to identify potential process hazards in the process design. The scope of the PHA included all process equipment and piping associated with the CO_2 capture process. Evaluation of utilities and service systems such as instrument air and steam were not part of this PHA; however, the impact of loss of services such as power and instrument air were discussed as global topics for each node. The potential for utility contamination such as in the case of a heat exchanger leak was discussed where applicable. A list of the nodes and related equipment is shown in ***Table 12.***

Table 12. Project Carbon Node List

Section Number	Unit / Process
1	Flue Gas
2	Flue Gas Quench
3	Flue Gas Washing
4	CO_2 Absorption
5	Regeneration
6	Rich Solvent
7	Lean Solvent
8	Filtration
9	Reflux System
10	CO_2
11	Steam/Condensate
12	Reclaiming
13	Solvent & Water Storage and Sumps
14	Chemical Storage

Methodology

For this hazard analysis, both HAZOP and "What If" methodologies were used. HAZOP was used for nodes that had significant differences in the process design compared to a recent HAZOP of the technology. A "What If" analysis was used for nodes that were previously well analyzed, for vendor-packaged equipment, or where a complete definition of the process was still in progress.

Both methodologies use a systematic approach to identify process hazards, capture the engineering and administrative controls in place, and determine the consequences associated with the failure of those controls. Recommendations are made for implementing additional controls when necessary to reduce the risk in the process. For the application of the “What If” approach, the use of “deviations” in the process was replaced with “What if” questions. Prior to the PHA sessions, the facilitator developed some initial “What if” questions. Team members provided additional questions prior to the sessions as well as during the node evaluation.

Prior to the PHA, the facilitator and MHIA process engineer identified nodes and deviations for the HAZOP. For each node, the HAZOP team identified potential hazards by considering process deviations based on combinations of guide words (high, low, no, reverse, etc.) and process parameters (flow, temperature, pressure, etc.). Examples of deviations that were considered are high pressure, reverse flow, and low temperature.

For each deviation, the team identified possible causes, consequences, and the engineering or administrative controls in place to prevent or mitigate the hazardous scenario. The consequence was ranked by the team assuming a worst-case scenario without any engineering controls and the likelihood was ranked by the team assuming that existing controls in the design were in place.

The consequence and likelihood rankings were then combined to achieve an overall risk ranking, ranging from “A - Critical” to “E - Negligible” – with a risk ranking of “A” representing the highest risk and a risk ranking of “E” representing the lowest risk. Recommendations were made by the team in accordance with the risk ranking guidelines. Recommendations were required for a risk ranking of Critical (A) or Serious (B).

PHA Recommendations

The PHA team developed 18 unique HAZOP recommendations related to the design and operation of the unit. Note that some recommendations were repeated as potential solutions to multiple scenarios. A summary of the 18 unique recommendations is as follows:

- 0 recommendations address “A” - Critical risk items
- 0 recommendations address “B” - Serious risk items
- 13 recommendations address “C” - Moderate risk items

- 0 recommendations address “D” - Minor risk items
- 0 recommendations address “E” - Negligible risk items
- 5 recommendations address “O” - Operating issue items

A summary of recommendations is included in ***Table 13*** below.

Table 13. Summary of Recommendations

Item No.	Risk	Recommendations
1.01	C	Consider how to select and maintain reliable quick-acting damper as this is considered a safeguard that is needed for a level 5 consequence. Review the selected design to determine long-term reliability.
1.02	C	Consider how to select and maintain reliable quick-acting damper as this is considered a safeguard that is needed for a level 5 consequence. Review the selected design to determine long-term reliability.
1.03	C	Consider robust design of the dampers with regard to corrosion. Consider keeping spare parts for fan on hand. Follow-up on the level and robustness of the vibration monitoring on the larger motors and equipment.
1.06	C	Include an item on daily checklist to observe the expansion joint condition.
1.12	C	Consider establishing a schedule for maintenance replacement before failure.
2.06	C	Utilize good maintenance practice to clean exchangers during the regular maintenance cycle. Consider monitoring the cooler performance (re: TV valve position, exchanger outlet temperature, etc.)
2.15	C	Consider spare parts that are kept on hand for pump repair; consider adding pump vibration monitoring; consider developing a pump shutdown logic for P-001.
10.03	C	Verify the piping specification (downstream of the mixing point) vs. higher temperature.
10.27	C	Design pressure of E-102 should greater than or equal to the PSV-1520 CO 01 setting.
10.29	C	Design pressure of E-102 should greater than or equal to the PSV-1520 CO 01 setting. Consider CO_2 monitors installed in the area.
11.05	C	Add note that steam vents and drains that are accessible are routed to a safe location.
11.12	C	Consider how to detect a low level in the case of the return drum transmitter failing, possibility adding a redundant transmitter, etc.
12.47	C	Consider adding a temperature element at the E-012A condenser vapor outlet with a high-temperature alarm.
10.19	O	Consider outside operator wears CO_2 monitors. Evaluate the area around SU-001 for potential of CO_2 to accumulate to concentrations that may impact personnel.
12.17	O	The gas relief path to the regenerator is currently common for V-003 A/B. Determine if these need to be separated or together. Currently being tied together, the piping prevents over pressurization in the case of failure of one vac pump. Need to consider potential problems with having the two systems connected as there is currently no backflow prevention. If separated, then the system has a potential for over pressurization due to vacuum pump failure.
12.58	O	Consider stopping the reclaiming system if the level LS-1350 RW 09A is triggered.
12.59	O	Need to add an interlock for T-004 high-high to close XV-1350 RW 29A.
12.61	O	Review and evaluate the fail position of all the control valves and XVs in this system.

Equipment List and Specifications

Table 14. *ISBL Equipment List and Specifications*

Item Number	Service	Specification / Type
D-001	Flue Gas Quencher	Packed Tower
D-002	CO_2 Absorber	Packed Tower
D-003	Regenerator	Packed Tower
V-001	Regenerator Reflux Drum	Vertical
V-002	Steam Condensate Drum	Vertical
V-004	Reclaimer Steam Condensate Drum	Vertical
SU-001	Solution Sump Tank	Flat Roof / Pit (Cylindrical)
SU-002	Solution Storage Sump Tank	Flat Roof / Pit (Cylindrical)
T-001	Solution Storage Tank	Cone Roof (Cylindrical)
T-003	Caustic Soda Tank	Cone Roof (Cylindrical)
T-004	Reclaimed Waste Tank	Cone Roof (Cylindrical)
T-005	Wash Water Storage Tank	Cone Roof (Cylindrical)
T-007	Fresh Solution Storage Tank	Cone Roof (Cylindrical)
U-001	Filtration Tank	Filter
F-002	Down Stream Guard Tank	Filter
F-003	Solution Sump Filter	Filter
F-005	Solution Storage Sump Filter	Filter
E-001	Flue Gas Cooling Water Cooler	Plate Type
E-002	Wash Water Cooler	Plate Type
E-003	Solution Heat Exchanger	Plate Type
E-005	Regenerator Reboiler	Shell and Tube Type
E-006	Lean Solution Cooler	Plate Type
E-007	Reclaimer Heater	Shell and Tube Type
FA-001	Flue Gas Blower	Blower
P-001	Flue Gas Cooling Water Pump	Centrifugal Pump
P-002	Wash Water Circulation Pump	Centrifugal Pump
P-003	Rich Solution Pump	Centrifugal Pump
P-004	Regenerator Reflux Pump	Centrifugal Pump
P-005	Lean Solution Pump	Centrifugal Pump
P-006	Solution Pump	Centrifugal Pump
P-008	Steam Condensate Return Pump	Centrifugal Pump
P-010	Reclaimer Caustic Soda Feed Pump	Diaphragm Pump
P-011	Reclaimed Waste Pump	Rotary Pump
P-014	Reclaimer Steam Condensate Return Pump	Centrifugal Pump
P-020	Caustic Soda Make-up Pump	Diaphragm Pump
P-027	Solution Storage Sump Pump	Centrifugal Pump
K-101	CO_2 Compressor	Geared Compressor

KT-101	CO_2 Compressor Steam Turbine	Steam Turbine
V-101	1st Stage Suction Scrubber	Vertical
E-102	Final Stage Discharge Cooler	Shell and Tube Type
U-101	CO_2 Dehydration Unit	TEG System

Cause and Effect Diagrams (six diagrams, pages 75-85)

FLUE GAS QUENCHER CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16	
0	CO_2 Capture System Shut Down Signal	1						P		P	P			P						
0		2					X		Xd			X	X							
0	CO_2 Capture System Partial shut down	3									P			P						
0		4					X					X	X							
PSGC PROCESS MONITORING POINTS																				
0	Unit-2 Boiler / FGD	5						P												
0		6					X													
FLUE GAS QUENCHER PROCESS MONITORING POINTS																				
0	POWER PLANT FLUE GAS																			
0		7										X								
0		8									xP									
0		9																		
0		10																		
0	Quencher (D-001)																			
0		11					X													
0		12						xP												
0		13								xP										
0		14							X											
0	Flue Gas Blower (FA-001)																			
0		15						xP												
0		16					X													
FLUE GAS QUENCHER AREA EQUIPMENT STATUS																				
0	CO_2 Capture Inlet Damper A/B	17						P			P									
0		18					X													
0		19																		
0		20										X								
0	Inlet Damper A/B	21						P												
0		22					X													
0		23																		
0		24																		
0	P-001 Flue Gas Cooling Water Pump	25																		
0		26				X													X	
0	FA-001 Flue Gas Blower	27									P			P	P					
0		28				X						X	X			X	X			
0	FA-001 Flue Gas Blower	29																		
0		30																		
0		31						P												
0		32					X													
0	FA-001 Flue Gas Blower																			
0		33					X													
0		34						xP												
0	FA-001 Flue Gas Blower																			
0		35					X													
0		36						xP												
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																				
0	CO_2 Absorber (D-002)																			
0		37					X													
0		38						xP												
0		39																		
0		40																		
0	FG to ATM																			
0		41					X													
0		42						xP												

CO_2 ABSORBER CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		21	22		23		24		25		26	
0	CO2 Capture System Shut Down Signal	1								P		P		P		P		P		P														
0		2					X		X		X		X		X		X		X															
0	CO2 Capture System Partial shut down	3								P		P		P																				
0		4							X		X		X																X		X		X	
CO2 ABSORBER PROCESS MONITORING POINTS																																		
0	CO2 Absorber (D-002)																																	
0		5																																
0		6																																
0		7						xP																										
0		8					X																											
0	CO2 Absorber (D-002)																																	
0		9																																
0		10														xP																		
0		11													X																			
0	CO2 Absorber (D-002)																																	
0		12																																
0		13								xP																								
0		14							X																									
0	CO2 Absorber (D-002)																																	
0		15																																
0		16										xP																						
0		17									X																							
0	CO2 Absorber (D-002)																																	
0		18																																
0		19												xP																				
0		20											X																					
0	Precoat Filter Wash Water Return Drum																																	
0	(V-006)	21																		xP														
0		22																	X															
CO2 ABSORBER AREA EQUIPMENT STATUS																																		
0	P-003 Rich Solution Pump	23																																
0		24		X																					X									
0	P-016 Absorption Intermediate Cooling Solution Pump	25																																
0		26																									X							
0	P-002 1st Wash Water Circulation Pump	27																																
0		28																											X					
0	P-007 2nd Wash Water Circulation Pump	29																																
0		30																													X			
0	P-023 3rd Wash Water Circulation Pump	31																																
0		32																															X	
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																																		
0	FA-001 Flue Gas Blower	33																																
0		34				X																												
0	Lean Solvent to E-009A-F																																	
0		35																xP																
0		36															X																	
0	Regenerator (D-003)																																	
0		37																																
0		38																						X										
0	Regenerator (D-003)																																	
0		39																																
0		40																						X										
0	Regenerator (D-003)																																	
0		41																																
0		42																						X										
0	Pump Seal Header																																	
0		43						xP								xP		xP				xP												
0		44					X								X		X				X													

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE		1	2	3	4	5		6		7		8		9		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
0	CO2 Capture System Shut Down Signal	1																P						P		P														
0		2															X		X				X		X															
0	CO2 Capture System Partial shut down	3																																						
0		4							X		X		X		X																									
REGENERATOR PROCESS MONITORING POINTS																																								
0	Regenerator (D-003)																																							
0		5																																						
0		6																		xP																				
0		7																	X																					
0	Regenerator (D-003)																																							
0		8							X		X		X		X																									
0		9																																						
0	Regenerator (D-003)																																							
0		10							X		X		X		X																									
0		11																																						
0	Regenerator (D-003)																																							
0		12							X		X		X		X																									
0		13																																						
0	Regenerator (D-003)																																							
0		14																																						
0		15																																						
0	Regenerator Reboiler (E-005A)																																							
0		16					X																																	
0		17																																						
0	Regenerator Reboiler (E-005B)																																							
0		18					X																																	
0		19																																						
0	Regenerator Reboiler (E-005C)																																							
0		20					X																																	
0		21																																						
0	Regenerator Reboiler (E-005D)																																							
0		22					X																																	
0		23																																						
0	Steam Condensate Drum (V-002)																																							
0		23																																						
0		24																				xP																		
0		25																			X																			
0	PHE Warm-up Drum (V-008)																																							
0		26																																						
0		27																																						
0		28																										xP												
0		29																									X													
0	Reboiler Reflux Drum (V-001)																																							
0		30							X		X		X		X																									
0		31																																						
0		32																xP						xP																
0		33																																						
0		34															X						X																	
0	Reboiler Reflux Drum (V-001)																																							
0		35																																						
0		36																								xP														
0		37																							X															
0	CO2 TO 1st Stage Suction Scrubber (V-101)																																							
0		38				X			X		X		X		X																									
0		39			xP																																			
0	Pump Seal Header																																							
0		40																		xP										xP		xP								
0		41																	X										X		X									
0	Reclaimer Drum (V-003A)																																							
0		42																																						
0		43																																						
0		44																												xP										
0		45																											X											
0	Reclaimer Drum (V-003B)																																							
0		46																																						
0		47																																						
0		48																														xP								
0		49																													X									
0	Reclaimer Vapor Condensate Drum (V-005A)																																							
0		50																																xP						
0		51																															X							
0	Reclaimer Vapor Condensate Drum (V-005B)																																							
0		52																																		xP				
0		53																																	X					
0	Reclaimer Steam Condensate Drum (V-004A)																																							
0		54																																				xP		
0		55																																			X			
0	Reclaimer Steam Condensate Drum (V-004B)																																							
0		56																																						xP
0		57																																					X	
REGENERATOR AREA EQUIPMENT STATUS																																								
0	P-005 Lean Solution Pump	58																																						
0		59		X																																				
0	P-008 Steam Condensate Return Pump	60																																						
0		61																																						
0	P-009 Reflux Cooling Water Circulation Pump	62																P																						
0		63															X																							
0																																								
0		64																																						
0	P-004 Regenerator Reflux Pump	65																																						
0		66																																						
0	P-024 CO2 Gas wash Water Pump	67																																						
0		68																																						
0	P-011A Reclaimed Waste Pump	69																																						
0		70																																						
0	P-011B Reclaimed Waste Pump	71																																						
0		72																																						
0	P-012A Reclaimer Vapor Condensate Return Pump	73																																						
0		74																																						
0	P-012B Reclaimer Vapor Condensate Return Pump	75																																						
0		76																																						
0	P-014A Reclaimer Steam Condensate Return Pump	77																																						
0		78																																						
0	P-014B Reclaimer Steam Condensate Return Pump	79																																						
0		80																																						

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE	SERVICE	1	2	3	4	5		6		7		8		9		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																																								
0	CO2 Absorber (D-002)																																							
0		81																	X																					
0		82																		xP																				
0		83																																						
0		84																																						
0	T-004 Reclaimed Waste Tank																																							
0		85																												X		X								
0		86																													xP		xP							
0		87																																						
0		88																																						
0	K-101 CO2 Compression Unit	89																																						
0		90																																						
0	Pressure Transmitter																																							
0		91																																						
0																																								
0		92																																						
0		93																																						
0	BOP SC Tank																																							
0		94																																						

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
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P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE	SERVICE	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
0	CO2 Capture System Shut Down Signal	1		P		P		P		P										P		P				
0		2	X		X		X		X										X		X					
0	CO2 Capture System Partial shut down	3																		P		P				
0		4																	X		X					
REGENERATOR PROCESS MONITORING POINTS																										
0	Regenerator (D-003)																									
0		5																								
0		6																								
0		7																								
0	Regenerator (D-003)																									
0		8																	X		X					
0		9																		xP		xP				
0	Regenerator (D-003)																									
0		10																	X		X					
0		11																		xP		xP				
0	Regenerator (D-003)																									
0		12																	X		X					
0		13																		xP		xP				
0	Regenerator (D-003)																									
0		14																								
0		15																								
0	Regenerator Reboiler (E-005A)																									
0		16	X																							
0		17		xP																						
0	Regenerator Reboiler (E-005B)																									
0		18			X																					
0		19				xP																				
0	Regenerator Reboiler (E-005C)																									
0		20					X																			
0		21						xP																		
0	Regenerator Reboiler (E-005D)																									
0		22							X																	
0		23								xP																
0	Steam Condensate Drum (V-002)																									
0		23																								
0		24																								
0		25																								
0	PHE Warm-up Drum (V-008)																									
0		26																								
0		27																								
0		28																								
0		29																								
0	Reboiler Reflux Drum (V-001)																									
0		30																	X		X					
0		31																		xP		xP				
0		32												xP												
0		33											X													
0		34																								
0	Reboiler Reflux Drum (V-001)																									
0		35																								
0		36																								
0		37																								
0	CO2 TO 1st Stage Suction Scrubber (V-101)																									
0		38																	X		X					
0		39																		xP		xP				
0	Pump Seal Header																									
0		40															xP	X								
0		41																								
0	Reclaimer Drum (V-003A)																									
0		42																								
0		43																								
0		44																		xP				xP		
0		45																	X				X			
0	Reclaimer Drum (V-003B)																									
0		46																								
0		47																								
0		48																		xP				xP		
0		49																	X				X			
0	Reclaimer Vapor Condensate Drum																									
0	(V-005A)	50																								
0		51																								
0	Reclaimer Vapor Condensate Drum																									
0	(V-005B)	52																								
0		53																								
0	Reclaimer Steam Condensate Drum																									
0	(V-004A)	54																								
0		55																								
0	Reclaimer Steam Condensate Drum																									
0	(V-004B)	56																								
0		57																								
REGENERATOR AREA EQUIPMENT STATUS																										
0	P-005 Lean Solution Pump	58																								
0		59																								
0	P-008 Steam Condensate Return Pump	60																								
0		61																								
0	P-009 Reflux Cooling Water Circulation Pump	62																								
0		63																								
0																										
0		64																								
0	P-004 Regenerator Reflux Pump	65												P		P	P									
0		66											X		X			X								
0	P-024 CO2 Gas wash Water Pump	67																								
0		68																								
0	P-011A Reclaimed Waste Pump	69																						P		
0		70																					X			
0	P-011B Reclaimed Waste Pump	71																						P		
0		72																					X			
0	P-012A Reclaimer Vapor Condensate Return Pump	73																								
0		74																								
0	P-012B Reclaimer Vapor Condensate Return Pump	75																								
0		76																								
0	P-014A Reclaimer Steam Condensate Return Pump	77																								
0		78																								
0	P-014B Reclaimer Steam Condensate Return Pump	79																								
0		80																								

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE	SERVICE	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																										
0	CO2 Absorber (D-002)																									
0		81																								
0		82																								
0		83																								
0		84																								
0	T-004 Reclaimed Waste Tank																									
0		85																								
0		86																								
0		87																								
0		88																								
0	K-101 CO2 Compression Unit	89																								
0		90																								
0	Pressure Transmitter																									
0		91																								
0																										
0		92											X	xP												
0		93																								
0	BOP SC Tank																									
0		94																	X	xP						

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE	SERVICE	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
0	CO2 Capture System Shut Down Signal	1																							
0		2		X	X	X	X									X	X								
0	CO2 Capture System Partial shut down	3									P														
0		4								X		X	X	X	X	X	X							X	
REGENERATOR PROCESS MONITORING POINTS																									
0	Regenerator (D-003)																								
0		5																							
0		6																							
0		7																							
0	Regenerator (D-003)																								
0		8														X	X								
0		9																							
0	Regenerator (D-003)																								
0		10														X	X								
0		11																							
0	Regenerator (D-003)																								
0		12														X	X								
0		13																							
0	Regenerator (D-003)																								
0		14																							
0		15																							X
0	Regenerator Reboiler (E-005A)																								
0		16		X																					
0		17																							
0	Regenerator Reboiler (E-005B)																								
0		18			X																				
0		19																							
0	Regenerator Reboiler (E-005C)																								
0		20				X																			
0		21																							
0	Regenerator Reboiler (E-005D)																								
0		22					X																		
0		23																							
0	Steam Condensate Drum (V-002)																								
0		23																							
0		24																							
0		25																							
0	PHE Warm-up Drum (V-008)																								
0		26																							
0		27																							
0		28																							
0		29																							
0	Reboiler Reflux Drum (V-001)																								
0		30							X		X					X	X								
0		31						xP		xP															
0		32							xP		xP														
0		33						X		X		X	X	X	X										
0		34																							
0	Reboiler Reflux Drum (V-001)																								
0		35																							
0		36																							
0		37																							
0	CO2 TO 1st Stage Suction Scrubber (V-101)																								
0		38										X	X	X	X	X	X							X	
0		39																							
0	Pump Seal Header																								
0		40																							
0		41																							
0	Reclaimer Drum (V-003A)																								
0		42										X		X											
0		43																							
0		44																							
0		45														X									
0	Reclaimer Drum (V-003B)																								
0		46											X		X										
0		47																							
0		48																							
0		49															X								
0	Reclaimer Vapor Condensate Drum																								
0	(V-005A)	50																							
0		51																							
0	Reclaimer Vapor Condensate Drum																								
0	(V-005B)	52																							
0		53																							
0	Reclaimer Steam Condensate Drum																								
0	(V-004A)	54																							
0		55																							
0	Reclaimer Steam Condensate Drum																								
0	(V-004B)	56																							
0		57																							
REGENERATOR AREA EQUIPMENT STATUS																									
0	P-005 Lean Solution Pump	58																							
0		59	X									X	X												
0	P-008 Steam Condensate Return Pump	60																							
0		61																X							
0	P-009 Reflux Cooling Water Circulation Pump	62																							
0		63																							
0																									
0		64																						X	
0	P-004 Regenerator Reflux Pump	65							P		P														

0		57																																								
REGENERATOR AREA EQUIPMENT STATUS																																										
0	P-005 Lean Solution Pump	58																																								
0		59	X														X		X																							
0	P-008 Steam Condensate Return Pump	60																																								
0		61																									X															
0	P-009 Reflux Cooling Water Circulation Pump	62																																								
0		63																																								
0																																										
0		64																																							X	
0	P-004 Regenerator Reflux Pump	65												P		P																										
0		66											X		X						X		X																			
0	P-024 CO2 Gas wash Water Pump	67																																								
0		68																												X												
0	P-011A Reclaimed Waste Pump	69																																								
0		70																																								
0	P-011B Reclaimed Waste Pump	71																																								
0		72																																								
0	P-012A Reclaimer Vapor Condensate Return Pump	73																																								
0		74																														X										
0	P-012B Reclaimer Vapor Condensate Return Pump	75																																								
0		76																																X								
0	P-014A Reclaimer Steam Condensate Return Pump	77																																								
0		78																																		X						
0	P-014B Reclaimer Steam Condensate Return Pump	79																																								
0		80																																				X				

REGENERATOR CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

SERVICE

Rev. #	SERVICE		58		59		60		61		62		63	64	65	66	67		68		69		70		71		72		73		74		75		76		77		78		79	80
OUTSIDE AREA PROCESS AND EQUIPMENT STATUS																																										
0	CO2 Absorber (D-002)																																									
0		81																																								
0		82																																								
0		83																																								
0		84																																								
0	T-004 Reclaimed Waste Tank																																									
0		85																																								
0		86																																								
0		87																																								
0		88																																								
0	K-101 CO2 Compression Unit	89																																								
0		90																																							X	
0	Pressure Transmitter																																									
0		91																																							X	
0																																										
0		92																																								
0		93																																								
0	BOP SC Tank																																									
0		94																							X		X															

TANK AREA CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16		17	18	19	20
0	CO2 Capture System Shut Down Signal	1						P		P		P		P										
0		2					X		X		X		X											
0	CO2 Capture System Partial shut down	3										P		P										
0		4									X		X											
TANK PROCESS MONITORING POINTS																								
0	Solution Sump Tank (SU-001)																							
0		5															X				X	xP		
0		6		xP																				
0		7	X																					
0	Solution Sump Tank (SU-001)																							
0		8															X				X	xP		
0	Solution Storage Sump Tank (SU-002)																							
0		9																	X		X			
0		10				xP																xP		
0		11			X																			
0	Solution Storage Sump Tank (SU-002)																							
0		12																	X		X	xP		
0	Caustic Storage Tank (T-003)																							
0		13																			X		X	
0		14																				xP		xP
0		15																						
0	TEG Storage Tank (T-101)																							
0		16																						
0		17														xP								
		18													X									
TANK AREA EQUIPMENT STATUS																								
0	P-020A Caustic Soda Make-up Pump	19																						
0		20																						
0	P-020 Caustic Soda Make-up Pump	21																						
0		22																						
0	P-101A Reclaimer Caustic Soda Feed Pump	23																						
0		24																						
0	P-101B Reclaimer Caustic Soda Feed Pump	25																						
0		26																						
OUTSIDE TANK AREA PROCESS POINTS AND EQUIPMENT																								
0	Reclaimer Drum (V-003)																							
0		27									X		X											
0		28										xP		xP										
0		29																						
0		30																						
0	P-001 Flue Gas Cooling Water Pump	31						xP		xP														
0		32					X		X															

CO_2 COMPRESSION CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate
Xd - Activate w/ time delay

Rev. #	SERVICE	SERVICE	1	2	3	4	5	6		7	8	9	
0	CO2 Capture System Shut Down Signal	1									P		
0		2								X			
0	CO2 Capture System Partial shut down	3									P		
0		4								X			
0	CO2 Compression System Shut Down Signal	5				P					P		
0		6			X					X		X	
COMPRESSOR PROCESS MONITORING POINTS													
0	1st Stage Suction Scrubber (V-101)												
0		7			X								
0		8				xP							
0	Dehydration Unit (V-101)												
0		9						X				X	
0		10											
0	Final Stage Cooler (E-102)												
0		11						X				X	
0		12											
0	Final Stage Cooler (E-102)												
0		13		X									
0		14	xP										
0	CO2 Tie-in												
0		15						X				X	
0		16											
0		17											
0		18						X				X	
0	CO2 Tie-in												
0		19											
0		20						X				X	
COMPRESSOR AREA EQUIPMENT STATUS													
0	K-101 CO2 Compression Unit	21	P										
0		22		X									
0		23											
0		24					X						
0		25					X						
0		26					X						
0	U-101 Dehydration Unit	27											
0		28		X									
0													
0		29								X	xP		
OUTSIDE COMPRESSOR AREA PROCESS POINTS AND EQUIPMENT													
0													
0		30								X	xP		
0	CO2 TO 1st Stage Suction Scrubber (V-101)												
0		31								X			
0		32									xP		
0	Aux. Boiler A/B												
0		33			X	xP							

UTILITIES CAUSE & EFFECT

LEGEND
OP - Open
NOP - Not Open
CL - Close
NCL - Not Close
P - Permissive at "Set" condition of CAUSE
xP - Permissive at "Reset" condition of CAUSE
X - Activate
Xd - Activate w/ time delay

Rev.#	SERVICE	SERVICE	1	2	3	4	5		6		7		8	9	10	11
0	CO2 Capture System Shut Down Signal	1														
0		2														
0	CO2 Capture System Partial shut down	3														
0		4														
UTILITIES AREA PROCESS MONITORING POINTS																
0	Instrument Air															
0		5	xP		xP											
0		6		X		X										
0	CO2 Capture Area Sump Pit (SU-401)															
0		7														
0		8												xP		
0		9											X			
0	CO2 Compression Area Sump Pit (SU-402)															
0		10														
0		11														xP
0		12													X	
OUTSIDE UTILITIES AREA EQUIPMENT STATUS																
0	K-101 CO2 Compression Unit	13														
0		14					X		X							
0	Cooling Water Pump (BOP)	15	P		P											
0		16		X		X										
0	Cooling Water (BOP)															
0		17		X		X										
0		18	xP		xP											
0	Electricity (BOP)	19	P		P											
0		20		X		X										

Overpressure Relief Study

Introduction

The following overpressure relief study summary is based on the carbon capture plant designed by Mitsubishi Heavy Industries (MHI) for installation at the Prairie State Energy Campus. Contained herein is a description of the relief philosophy, an explanation of the method for determining pressure relief requirements within the carbon capture island. This summary is provided for information only – detailed calculations are not included.

Relief Philosophy

Generally, pressure relief is design possible. For example, PSV's for liquid solvent would normally be relieved by routing the liquid to another location in the process that can safely relieve the pressure without resulting in losses.

MHI utilizes many common industrial pressure relief methods such as relief around a potential block or relief to atmosphere from a pressure vessel. Typical relief locations such as these are considered common practice and are included in the design but not described in detail here.

Systems containing CO_2 are designed with consideration for oxygen displacement and suffocation when CO_2 is released in sufficient quantities. MHI applies a common vent header for CO_2 that must be relieved to the atmosphere. All process equipment containing CO_2 PSV's and Pressure Control Valves (PV) discharge to this header. The header is routed to the CO_2 Absorber (D-002) stack where the CO_2 will mix with treated flue gas and be carried into the atmosphere with enough elevation and velocity to eliminate the potential for accumulation at ground level.

Evaluation Method

Pressure relief evaluations are based on API 520 and API 521. In accordance with these standards, MHI considered the following potential causes: thermal expansion, tube rupture, cooling water failure, fire (vapor or liquid), block out, and control valve (CV) failure. Special causes that do not fit any of these are grouped together as "Others".

First, each of the seven causes above are considered for all equipment in the capture acidity, including rare or abnormal occurrences. This process produces a list of equipment that is considered to have potential for overpressure along with the cause(s) for that equipment. Next, the relief needs for each cause for an equipment are evaluated to determine the case with the highest flow rate required to relieve pressure. Then a PSV will be sized and incorporated into the system to prevent a hazardous situation where necessary. Finally, the original list is reviewed to make sure the PSV's added to the system can safely relieve all of the potential causes identified in the first step.

Civil Engineering

Geologic and Soil Load Assessment

Geotechnical Investigation

Hanson Engineering Group Inc. (Hanson) performed geotechnical investigation of the site. The results of the investigation are contained in the final geotechnical report dated June 2021. Hanson's geotechnical investigation included drilling 26 exploratory borings and installing three groundwater level monitoring wells. Bedrock was cored at selected boring locations. In addition, data from previous geotechnical investigations performed by MACTEC, Inc at the facility were reviewed.

Subsurface Conditions

Soil – Three general soil types were encountered at the boring locations: specifically, from ground surface downward, topsoil, loess, and glacial till. Topsoil was generally one foot thick. The loess encountered extends to depths of 10 to 15 feet below ground surface and is typically composed stiff silty clay. Glacial till present beneath loess is typically composed of very stiff silty clay and continues to bedrock encountered at depths ranging between 38 and 48 feet at the boring locations.

Bedrock – Bedrock encountered at the boring locations consists of silty and clayey shale. The water content of shale was typically less than 10 percent. Reported unconfined compressive strengths of the shale were low but we believe this is due to poor sample quality.

Groundwater – Groundwater levels reported in the borings ranged between 5 and 35 feet below ground surface. Groundwater levels in the three groundwater level monitoring wells were measured approximately monthly from April 16 to June 16, 2021, and ranged between 3 and 10 feet below ground surface (elevation 456.7 to 460.6). The Hanson report recommends that a groundwater level of three feet below existing ground surface be used for final design.

The Hanson report contains capacity versus depth plots for pipe pile, H-pile, auger cast-in-place pile (ACIPs) and drilled shafts, and states that rigid inclusions are a technically viable ground improvement technique for the project. Rigid inclusions can be considered where the combination of the sustained pressure on the foundation and friction coefficient along the base of the foundation are adequate to resist lateral forces. Rigid inclusions can be designed using the Hanson charts for ACIPs.

Frost Protection

The geotechnical report states the minimum foundation embedment for frost protection is 30 inches. Use of a non-frost susceptible fill (a granular material having six percent or less fines) is acceptable if the material can be drained either through granular backfill placed for utilities or in drains specifically constructed to drain the non-frost fill. A two-inch-thick layer of insulation is an acceptable alternative to non-frost fill. The insulation layer must be underlain by a six-inch-thick (min.) layer of non-frost fill that drains. A mud mat can be poured on top of the non-frost fill or insulation at the contractor's discretion.

Storm Water Runoff and Spill Containment Assessment

Table 15. Containment, Drains, and Discharge Index 1

Tag Number Associated	Containment Description	Qty	Location	Containment Type	Fluid Type (Include Concentration)	Maximum Temperature (°F)	Water-Stops Chemical Compatibility	Interior Dimensions (LxWxD) (ft)	Liquid Volume to be Contained (gal)	Total Containment Volume (gal)	Containment Criteria (Maximum Sizing)	Flow (gpm)	Source Reference /Deliverable (include P&ID)	Containment Disposal Method	Process Intermediate Discharge Location	Process Final Discharge Point	Scope Responsibility	Notes
U2-0-T-101	TEG Storage Tank Containment	1	West of Train 1 Aux Boilers	Concrete Containment Curb	TEG, rain water	125	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	N/A	MHI Drawing Number 8250-8610-S40-0430	Per MHI	Per MHI	Per MHI	MHI	None
U2-0-T-001/007	Solution/Fresh Solution Storage Tanks Containment	1	West of Train 1 Aux Boilers	Concrete Containment Curb	Solution, rain water	150	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	N/A	MHI Drawing Number 8250-8610-S40-0405, 8250-V510-V51-T001-	Per MHI	Per MHI	Per MHI	MHI	None
FLD0920DR03/04	Station Service Transformer Containment(s)	2	Southwest of Water Treatment Building	Concrete Containment Wall	Transformer Oil, Firewater, rain water	120	No	40'L x 30'W x 3'H	18,595	22,064	See Kiewit Calc SF0079	500	Kiewit Calc SF0079	Oil leaks will be trucked off site. Rain water will be drained through NC drain valve to the OWS.	N/A	OWS tank	Kiewit	Discharge valve normally closed. Only rain water will be discharged to OWS
TR-CC-101A/102A/103A/101B/102B/103B, TR-CC-201A/202A/203A/201B/202B/203B, TR-CC-301A/302A303A/301B/302B303B, TR-CC-401A/402A/403A/401B/402B/403B	Train Transformers Containment(s)	4	South of Trains 1 and 2 PDC Buildings, and North of Trains 3 and 4 PDC Buildings	Concrete Containment Curb	Transformer Oil, Firewater, rain water	120	No	Per MHI	Per MHI	Per MHI	Per MHI	500	MHI Draiwing Number 8250-8620-SA7-1071	Oil leaks will be trucked off site. Rain water will be drained through NC drain valve to the OWS.	N/A	OWS tank	MHI	None
U2-0-U-824	BOP Middle Oil/Water Separator (OWS)	1	Northeast of Train 1	Underground Double-Walled Tank (with leak detection)	Oil/Water/Firewater	140	No	TBD - Vendor	5,517	TBD - Vendor	Sized to contain 10 min of max flow	552	PD-0921, Calc PDR-E	Oil Trucked off site, water pumped out	N/A	Equalization Tank	Kiewit	None
U2-0-U-825	BOP East Oil/Water Separator (OWS)	1	Southeast of Train 4	Underground Double-Walled Tank (with leak detection)	Oil/Water/Firewater	140	No	TBD - Vendor	5,517	TBD - Vendor	Sized to contain 10 min of max flow	552	PD-922 Calc PDR-E	Oil Trucked off site, water pumped out	Wastewater Collection Sump	Cooling Tower Basin	Kiewit	None
U2-0-U-823	BOP West Oil/Water Separator (OWS)	1	West of solution storage tanks	Underground Double-Walled Tank (with leak detection)	Oil/Water/Firewater	140	No	TBD - Vendor	2,731	TBD - Vendor	Sized to contain 10 min of max flow	273	PD-0920 Calc PDR-E	Oil Trucked off site, water pumped out	Wastewater Collection Sump	Cooling Tower Basin	Kiewit	None
U2-1/2/3/4-FA-001	Flue-gas Blower and Lube Oil Containment(s)	4	West of Trains 1 & 3, and East of Trains 2 & 4	Underground Double-Walled Tank (with leak detection)	Oil/Water	Per MHI	No	Per MHI	Per MHI	Per MHI	Per MHI	N/A	MHI Drawing Number 8250-8610-S10-1130	Oil leaks will be trucked off site. Rain water will be drained through NC drain valve to the OWS.	N/A	Oil/oily-water trucked off site via OWS. Rainwater to grade	MHI	None
U2-1/2/3/4-T-004	Reclaimed Waste Storage Tank Containment(s)	4	West of Trains 1 & 3, and East of Trains 2 & 4	Concrete Containment Curb	Reclaimed Waste , rain water	302	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	N/A	MHI Drawing Number 8250-V510-V61-T004-001	Chemical leaks will be trucked off site. Rain water will be drained through drain valve to grade.	N/A	Grade	MHI	None
U2-1/2/3/4-E-005A/B/C/D	Regenator Reboiler Containment(s)	8	SE Quadrent of Train 1, SW Quadrent of Train 2, NE Quadrent of Train 3, and NW Quadrent of Train 4	Concrete Containment Curb	Solution, rain water	325	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	MHI Drawing Number 8250-8610-S30-1331	Chemical leaks will be trucked off site. Rain water will be drained through drain valve to grade.	N/A	Grade	MHI	None
U2-1/2/3/4-D-003	Regenerator Containment(s)	4	SE Quadrent of Train 1, SW Quadrent of Train 2, NE Quadrent of Train 3, and NW Quadrent of Train 4	Concrete Containment Curb	Solution, rain water	325	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	MHI Drawing Number 8250-8610-S30-1300	Chemical leaks will be trucked off site. Rain water will be drained through drain valve to grade.	N/A	Grade	MHI	None
U2-1/2/3/4-T-005 U2-1/2/3/4-T-006A/B	1st, 2nd, and 3rd Wash Storage Tank Containment(s)	4	SE Quadrent of Train 1, SW Quadrent of Train 2, NE Quadrent of Train 3, and NW Quadrent of Train 4	Concrete Containment Curb	1stand 2nd/3rd Wash Waster (respecivally, rain water	150	Per MHI	Per MHI	Per MHI	Per MHI	Per MHI	N/A	MHI Drawing Number 8250-V510-V61-T005-001 and 8250-V510-V61-T006-001	Chemical leaks will be trucked off site. Rain water will be drained through drain valve to grade.	N/A	Grade	MHI	None
U2-0-E-801	Cooling Tower Basin	1	Northwest campus	Concrete Basin	Water	120	No	TBD'L x TBD'W x 5.5'H	TBD - Vendor	TBD - Vendor	Basin was sized to have the Cooling Tower fit in it with edge distances (from tower footprint to inside wall) and considering the requirements of HI 9.8 as well as an appropriate freeboard.	TBD - Vendor	PD- 660, 663, 664, 665, and 666	N/A	None	CT Blowdown	Kiewit	None
U2-0-U-813-2A/B	Fire Pump Diesel Tank Containment	1	Southwest of Cooling Tower	Metal Containment Wall/Double Wall Tank	Diesel	120	No	TBD - Vendor	TBD - Vendor (Assume 400-500 gal if value is needed per Fire Protection Engineer)	TBD - Vendor	TBD - Vendor	TBD	PD-830	Leaked diesel will be removed by truck	None	Trucked off Site	Kiewit	Containment tank to be double-walled in accordance with NFPA codes/regulations.

Table 16. Containment, Drains, and Discharge Index 2

Tag Number Associated	Containment Description	Qty	Location	Containment Type	Fluid Type (Include Concentration)	Maximum Temperature (°F)	Water-Stops Chemical Compatibility	Interior Dimensions (LxWxD) (ft)	Liquid Volume to be Contained (gal)	Total Containment Volume (gal)	Containment Criteria (Maximum Sizing)	Flow (gpm)	Source Reference /Deliverable (include P&ID)	Containment Disposal Method	Process Intermediate Discharge Location	Process Final Discharge Point	Scope Responsibility	Notes
U2-1/2/3/4-T-003	Caustic Soda Storage Tank Containment(s)	4	NE of Train 1, NW of Train 2, SE of Train 3, and SW of Train 4	Concrete Containment Curb	Caustic Soda, rain water	125	Per MHI	Per MHI	Per MHI	Per MHI	Sized for 110% capacity of one tank failure; plus 25-year 24-hour storm; plus 6" free board.	N/A	MHI Drawing Number 8250-V510-V51-T003-001	Chemical leaks will be trucked off site. Rain water will be drained through drain valve to grade.	N/A	Grade	MHI	None
U2-0-T-828	Clarifier Polymer Tote Containment	1	Water Treatment Building	Concrete Containment Wall	Polymer, fire water	130	N/A	14'L x 6'W x 3'H	843	1018	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0760	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-829 U2-0-T-831	Thickener/Filter Press Polymer Tote Containment	1	Water Treatment Building	Concrete Containment Wall	Polymer, fire water	130	N/A	12'L x 10'W x 3'H	1,016	1,186	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0760 Kiewit PID PD-0761	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-830	MMF Sodium Hypochlorite Tote Containment	1	Water Treatment Building	Concrete Containment Wall	12% Sodium Hypochlorite, fire water	130	N/A	10'L x 8'W x 3'H	824	984	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0761	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-812	Raw Water Sulfuric Acid Storage Tank Containment	1	North of Water Treatment Building	Concrete Containment Wall	93% Sulfuric Acid, rain water	120	N/A	30'L x 18'W x 5'H	10,000	14,810	Sized for 110% capacity of one tank failure; plus 25-year 24-hour storm; plus 6" free board.	N/A	Kiewit PID PD-0761	Chemical leaks will be trucked off site. Rain water will be drained through locked closed UG drain valve to storm water piping.	N/A	Storm Water	Kiewit	Truck unloading pad to be sloped towards tank containment. Locked closed valve will be opened during tank fills to allow any spills/leaks to drain into tank containment.
N/A	RWT Sulfuric Acid Containment	1	Water Treatment Building	Concrete Containment Curb	93% Sulfuric Acid, fire water	130	N/A	7'L x 6'W x 0.5'H	N/A	N/A	Sized to contain minor leaks/spills.	N/A	Kiewit PID PD-0761	Chemical leaks will be trucked off site. Fire water will drain to grade.	N/A	Grade	Kiewit	N/A
U2-0-T-813 U2-0-T-824	RWT/WWT Ferric Sulfate Storage Tank Containment	1	North of Water Treatment Building	Concrete Containment Wall	Ferric Sulfate (60%-80%), rain water	120	N/A	65'L x 18'W x 5'H	22,000	32,990	Sized for 110% capacity of one tank failure; plus 25-year 24-hour storm; plus 6" free board.	N/A	Kiewit PID PD-0760 Kiewit PID PD-0727	Chemical leaks will be trucked off site. Rain water will be drained through locked closed UG drain valve to storm water piping.	N/A	Storm Water	Kiewit	Truck unloading pad to be sloped towards tank containment. Locked closed valve will be opened during tank fills to allow any spills/leaks to drain into tank containment.
N/A	RWT/WWT Ferric Sulfate Containment	1	Water Treatment Building	Concrete Containment Curb	Ferric Sulfate (60%-80%), fire water	130	N/A	12.5'L x 5'W x 0.5'H	N/A	N/A	Sized to contain minor leaks/spills.	N/A	Kiewit PID PD-0760 Kiewit PID PD-0727	Chemical leaks will be trucked off site. Fire water will drain to grade.	N/A	Grade	Kiewit	N/A
U2-0-T-823	Organo Sulfide Storage Tank Containment	1	North of Water Treatment Building	Concrete Containment Wall	Organo Sulfide (Proprietary Mixture), rain water	120	N/A	30'L x 18'W x 5'H	10,000	14,810	Sized for 110% capacity of one tank failure; plus 25-year 24-hour storm; plus 6" free board.	N/A	Kiewit PID PD-0727	Chemical leaks will be trucked off site. Rain water will be drained through locked closed UG drain valve to storm water piping.	N/A	Storm Water	Kiewit	Truck unloading pad to be sloped towards tank containment. Locked closed valve will be opened during tank fills to allow any spills/leaks to drain into tank containment.
N/A	Organo Sulfide Containment	1	Water Treatment Building	Concrete Containment Curb	Organo Sulfide (Proprietary Mixture), fire water	130	N/A	6'L x 5'W x 0.5'H	N/A	N/A	Sized to contain minor leaks/spills.	N/A	Kiewit PID PD-0727	Chemical leaks will be trucked off site. Fire water will drain to grade.	N/A	Grade	Kiewit	N/A
U2-0-T-832	Wastewater Treatment Sodium Bisulfite Tote Containment	1	Water Treatment Building	Concrete Containment Wall	38% Sodium Bisulfite, fire water	130	N/A	11.5'L x 7'W x 3'H	826	988	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0726	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-822	Wastewater Treatment Sodium Hydroxide Tote Containment	1	Water Treatment Building	Concrete Containment Wall	50% Sodium Hydroxide (Caustic), fire water	130	N/A	11.5'L x 7'W x 3'H	826	988	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0726	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-825	Wastewater Treatment Sodium Hypochlorite Tote Containment	1	Water Treatment Building	Concrete Containment Wall	12% Sodium Hypochlorite, fire water	130	N/A	11.5'L x 7'W x 3'H	826	988	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0728	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-826	Wastewater Treatment Citric Acid Tote Containment	1	Water Treatment Building	Concrete Containment Wall	Citric Acid (TBD%), fire water	130	N/A	11.5'L x 7'W x 3'H	826	988	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0728	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-827	Cooling Tower Sodium Hypochlorite Storage Tank Containment	1	South of Cooling Tower	Concrete Containment Wall	12% Sodium Hypochlorite	120	N/A	25'L x 25'W x 3'H	7,000	9,080	Sized for 110% capacity of one tank failure; plus 6" free board. Rain water is not accounted for since a canopy will cover the entire area of the containment.	N/A	Kiewit PID PD-0751	Chemical leaks will be trucked off site. Any small amounts of rain water will be drained through locked closed AG drain valve to grade.	N/A	Grade	Kiewit	Truck unloading pad to be sloped towards normally open drain valve. Drain valve to be closed during tank fills to contain any minor spills/leaks.
U2-0-T-805 U2-0-T-861	Cooling Tower Dispersant/ Deposit Control Tote Containment	1	South of Cooling Tower	Concrete Containment Wall	Dispersant/Deposit Control	120	N/A	13'L x 10'W x 3'H	951	1,298	Sized for 110% capacity of one tank failure; plus 6" free board. Rain water is not accounted for since entire skid will be covered.	N/A	Kiewit PID PD-0750 Kiewit PID PD-0752	Chemical leaks will be trucked off site. Any small amounts of rain water will be drained through locked closed AG drain valve to grade.	N/A	Grade	Kiewit	N/A
U2-0-T-811	Cooling Tower Sulfuric Acid Tote Containment	1	South of Cooling Tower	Concrete Containment Wall	93% Sulfuric Acid	120	N/A	13'L x 5'W x 3'H	696	799	Sized for 110% capacity of one tank failure; plus 6" free board. Rain water is not accounted for since entire skid will be covered.	N/A	Kiewit PID PD-0750	Chemical leaks will be trucked off site. Any small amounts of rain water will be drained through locked closed AG drain valve to grade.	N/A	Grade	Kiewit	N/A

Table 17. Containment, Drains, and Discharge Index 3

Tag Number Associated	Containment Description	Qty	Location	Containment Type	Fluid Type (Include Concentration)	Maximum Temperature (°F)	Water-Stops Chemical Compatibility	Interior Dimensions (LxWxD) (ft)	Liquid Volume to be Contained (gal)	Total Containment Volume (gal)	Containment Criteria (Maximum Sizing)	Flow (gpm)	Source Reference /Deliverable (include P&ID)	Containment Disposal Method	Process Intermediate Discharge Location	Process Final Discharge Point	Scope Responsibility	Notes
U2-0-T-862	Cooling Tower Sodium Bisulfite Tote Containment	1	South of Cooling Tower	Concrete Containment Wall	38% Sodium Bisulfite	120	N/A	13'L x 5'W x 3'H	696	799	Sized for 110% capacity of one tank failure; plus 6" free board. Rain water is not accounted for since entire skid will be covered.	N/A	Kiewit PID PD-0752	Chemical leaks will be trucked off site. Any small amounts of rain water will be drained through locked closed AG drain valve to grade.	N/A	Grade	Kiewit	N/A
U2-1-T-807	Aux Boiler Ammonia Storage Tote Containment(s)	4	One (1) skid near each train's aux boilers.	Concrete Containment Wall	19% Aqueous Ammonia	120	N/A	TBD - Vendor	TBD - Vendor	TBD - Vendor	Sized for 110% capacity of one tank failure; plus 6" free board. Rain water is not accounted for since entire skid will be covered.	N/A	Kiewit PID PD-1740	Chemical leaks will be trucked off site. Any small amounts of rain water will be drained through locked closed AG drain valve to grade.	N/A	Grade	Kiewit	N/A
U2-0-T-836	RO Antiscalant Tote Containment	1	Water Treatment Building	Concrete Containment Wall	Antiscalant, fire water	130	N/A	15'L x 5.5'W x 3'H	836	1005	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0770	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-837	RO Sodium Bisulfite Tote Containment	1	Water Treatment Building	Concrete Containment Wall	38% Sodium Bisulfite, fire water	130	N/A	15'L x 5.5'W x 3'H	836	1005	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0770	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A
U2-0-T-838	RO Caustic Tote Containment	1	Water Treatment Building	Concrete Containment Wall	50% Sodium Hydroxide (Caustic), fire water	130	N/A	15'L x 5.5'W x 3'H	836	1005	Sized for 110% capacity of one tank failure; plus fire water; plus 6" free board.	N/A	Kiewit PID PD-0770	Chemical leaks will be trucked off site. Fire water can be pumped from low point in containment using portable sump pump (By Others).	N/A	N/A	Kiewit	N/A

Structural Engineering

The Structural design accounts for all loads applied, including dead, live, snow, impact, wind, thermal, dynamic, settlement, movement, seismic, friction due to thermal expansion, and other loading conditions where appropriate. Temporary loads during maintenance and erection will be considered. Loads will be determined in accordance with IBC 2018 and ASCE 7 or latest documents.

The structural and civil design criteria summary is presented in Attachment D (Structural Design Criteria). These documents are organized as follows:

- Site specific data (Part of this Criteria)
- Structural and civil design basis (Part of Overall Design Basis Document and this Criteria)
- Structural steel and concrete design codes
- Structural steel and concrete materials
- Design requirement dead, live, wind, seismic, snow, and utility loads for structural steel
- Most foundations will be supported on soil supported mat foundations. Deep foundation supported mats will be used where required. Deep foundations will be auger cast piles or rigid inclusions.
- Structural design basis pressures and temperatures for new ductwork and reassessment of existing ductwork will be provided part of this Design Criteria.
- The flues downstream of the WESP are designed to limit the flue gas velocity to less than 75 fps at design flue gas flow rates. The flues downstream of the WESP are designed to carry a minimum load of material at a depth of 6 inches. The material upstream of the FGD

absorber is assumed to be fly ash with a density of 80 lb/ft^3, and the material downstream of the FGD absorber including the WESP is assumed to be slurry carryover with a density of 120 lb/ft^3.

- Ductwork live loads is 40 psf. To be applied over 60-degree arc at top of duct.
- Ductwork materials for existing ductwork modifications will be 2205 Stainless steel for duct plates and internal stiffeners and A992 for external stiffeners. Material for new ductwork is provided part of this Design Criteria.

The CO_2 capture facility and equipment will require the installation of various new buildings. A Building Code Analysis will be performed to determine the following:

- Occupancy Type
- Construction Type
- Building or Floor Area
- Building Height
- Egress Paths
- Passive Fire Protection (including hour ratings for structure, area, or occupancy separation
- Ratings and flame spread and smoke generation) Fire Protection, Detection and Suppression Systems (sprinkler systems, deluge systems, standpipes, fire detection systems, and fire alarm systems).

Egress from all buildings and structures (i.e., enclosed, partially enclosed, or un-enclosed) will comply with the International Building Code, NFPA 101 and OSHA, where deemed appropriate by PSGC and approved by the Building Official.

Stairs or ladders and platforms will be used to provide access within and to all buildings and structures for inspection and maintenance of the functioning equipment parts. These stairs or ladders and platforms will be in compliance with NFPA 101 and OSHA. Ladders with safety systems and swing gates may be allowed for infrequently accessed small platforms or as a secondary means of egress from infrequently used large platforms.

Stairs and exit passageways serving as the means of egress from continually occupied areas will exit directly to the exterior or will be separated from other facility areas with fire-rated barriers or enclosures as required by applicable codes.

Fire-rated separation barriers will be provided where required by building codes or as recommended by NFPA 850 where deemed appropriate by PSGC and approved by the Building Official.

Personnel and Equipment Access Requirements:

- For horizontal trusses limit the span to depth ratio (L/D) to 10 (as needed)
- All galleries will be a minimum 2’-6” wide
- All stairs will be 3’-0” wide minimum
- Limit the maximum grating span of 1 ¼” deep serrated grating to 5’-0”.

Support steel framing systems will consist of steel beams, columns, vertical bracing, horizontal bracing, base plates, anchor bolts, and shop welded/field bolted connections. The materials consist of structural steel sections, plate, angles, and bolts. Additional loading on existing steel structures will be minimized.

Bracing will be provided as necessary and will consist of structural sections with gusset plate connections. Moment frames may be utilized in order to minimize interferences or where the use of braced frames is not feasible.

The ductwork will be supported by new or existing structural steel framing. The new Fiber Reinforced Plastic (FRP) ductwork will be bottom-supported or side-supported for long vertical runs (as required). Ductwork supports should be furnished with flat or spherical slide plates to reduce friction reactions during thermal expansion and contraction cycles. New FRP flue gas ductwork will be routed across existing roads. A damper without seal air will be installed upstream of stack breaching, and an additional damper will be installed in the common ductwork header with seal air and access platforms, if deemed necessary.

External wide-flange and channel stiffeners, duct plate, base plates, soles plates, and misc. plate should be designed using ASTM A572 Gr. 50 materials (A992 for shapes) and/or FRP materials. Gusset plates and corner angles, if any, will be designed using ASTM A572 Gr. 50 materials. Pipes and test ports will be designed using ASTM A53 Gr. B materials and/or FRP materials.

Materials used in the construction of existing ductwork are identified on the existing ductwork drawings. External stiffener shapes shall be A992 and/or ASTM 572 Gr. 50. Ductwork plate and internal stiffeners shall be Stainless Steel A2205.

The following systems should be used for the design of new foundations. Information regarding the design of existing foundations can be found on the existing plant drawings.

- Spread footings
- Grade beams (as required)
- Slabs on grade
- Soil supported mats
- Auger cast-in-place pile or Rigid Grouted Inclusion supported mats.

Mechanical Engineering

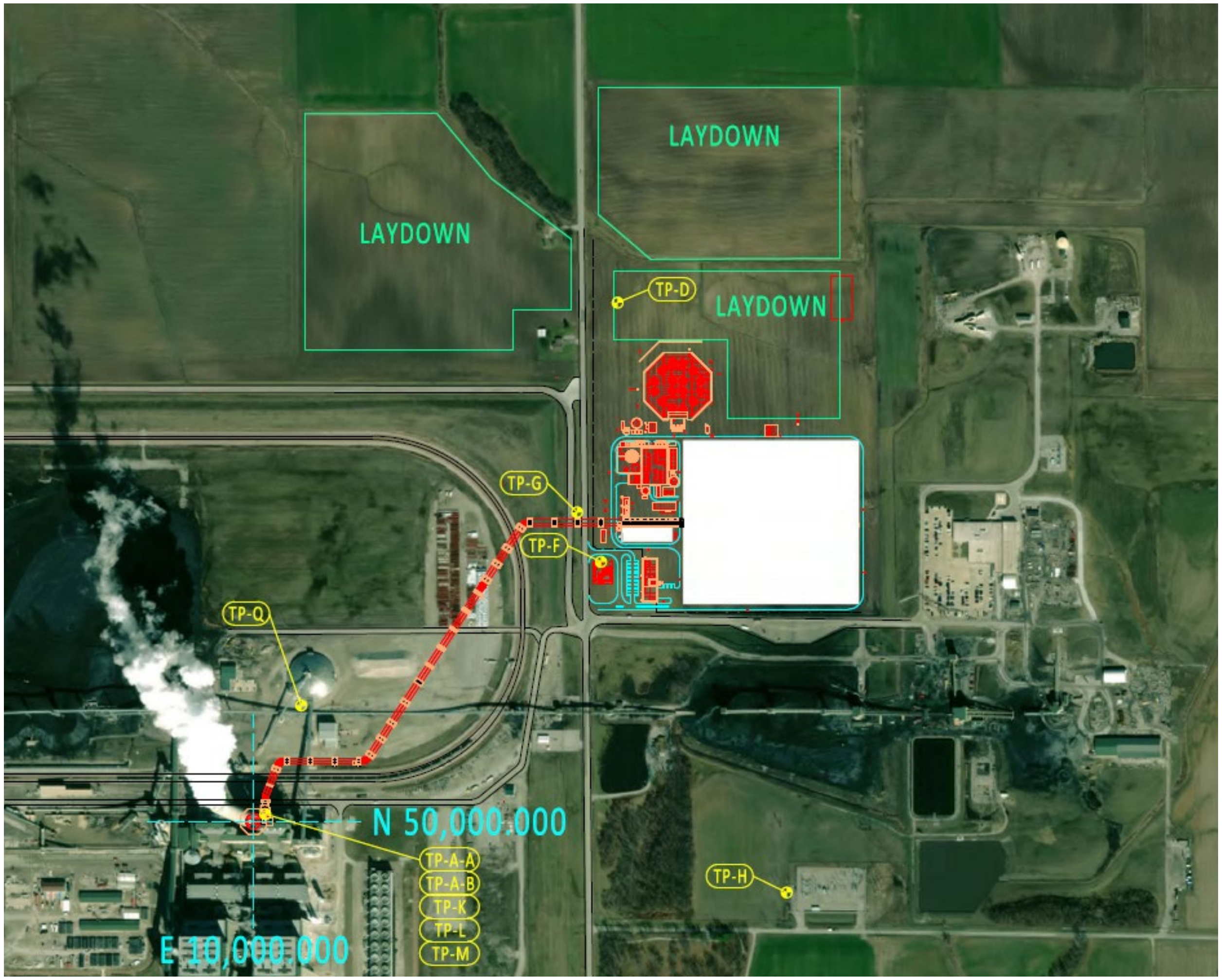

Figure 40. *General site plan view*

3D model and/or equipment elevation sections & plan drawings

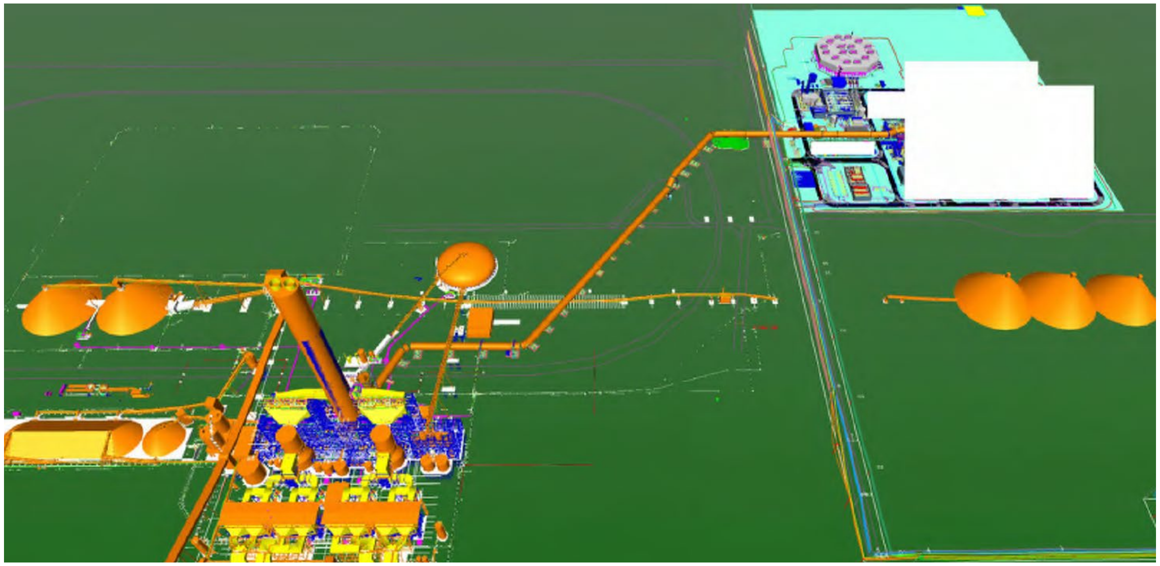

Figure 41. *General site plan view*

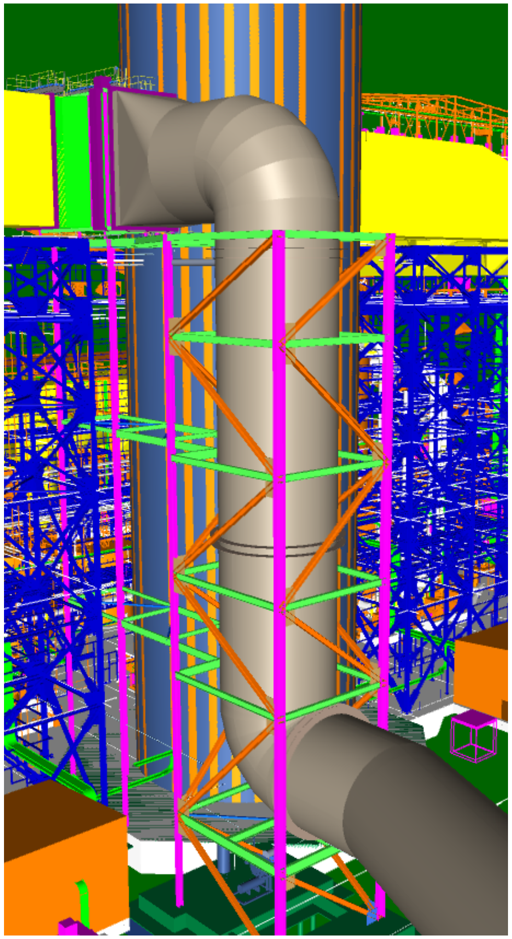

Figure 42. *Duct Tie-in*

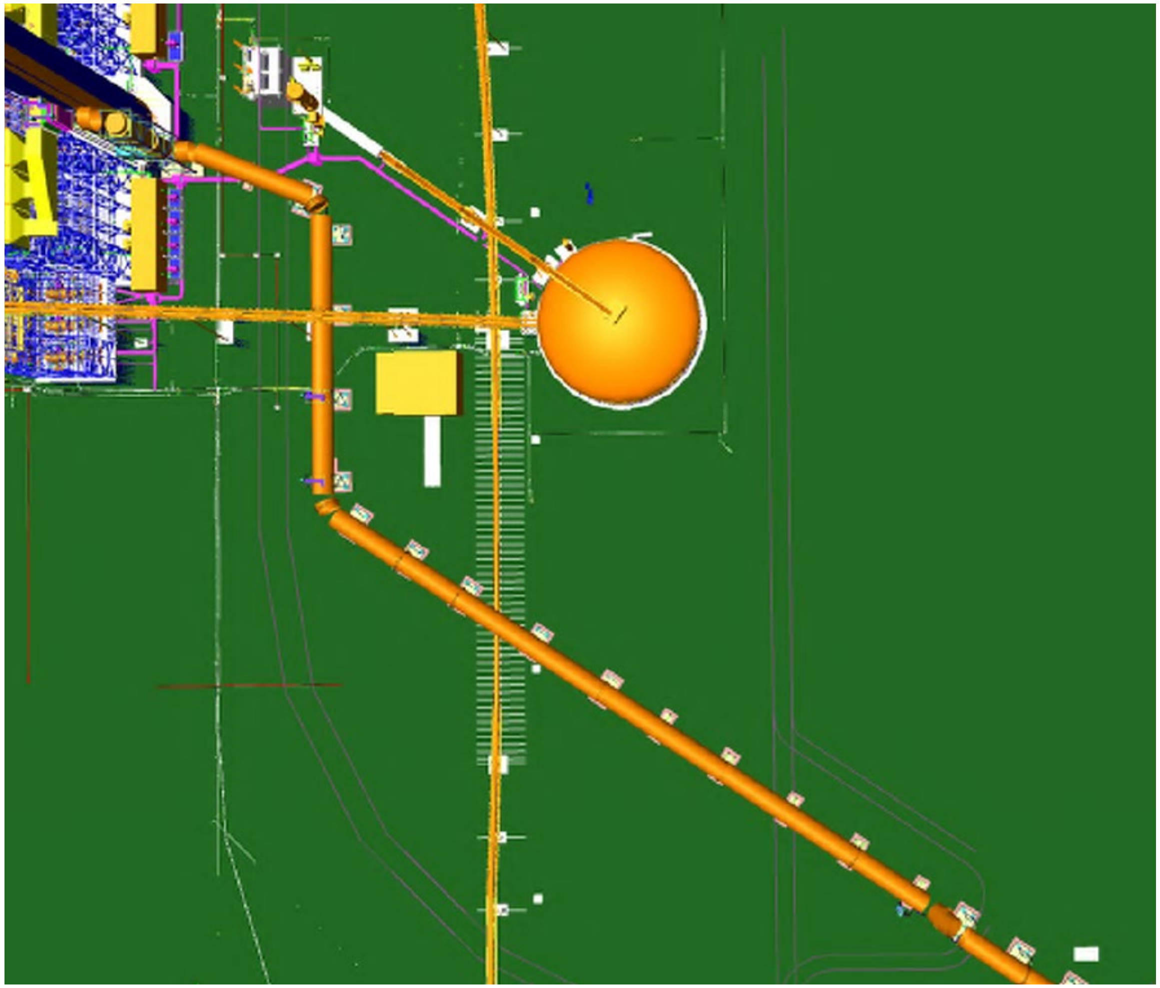

Figure 43. Duct Routing from Tie-in to Capture Facility

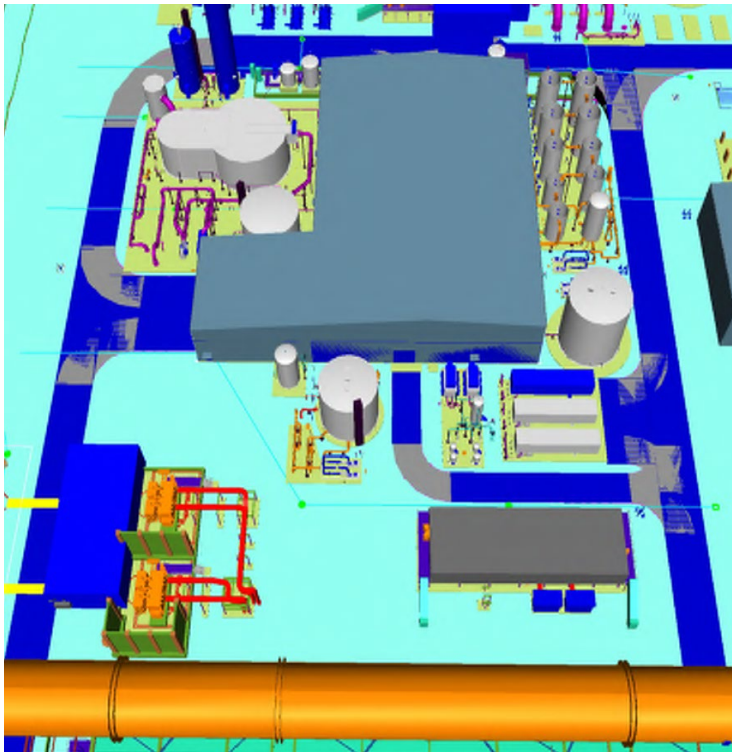

Figure 44. *Water Treatment Building*

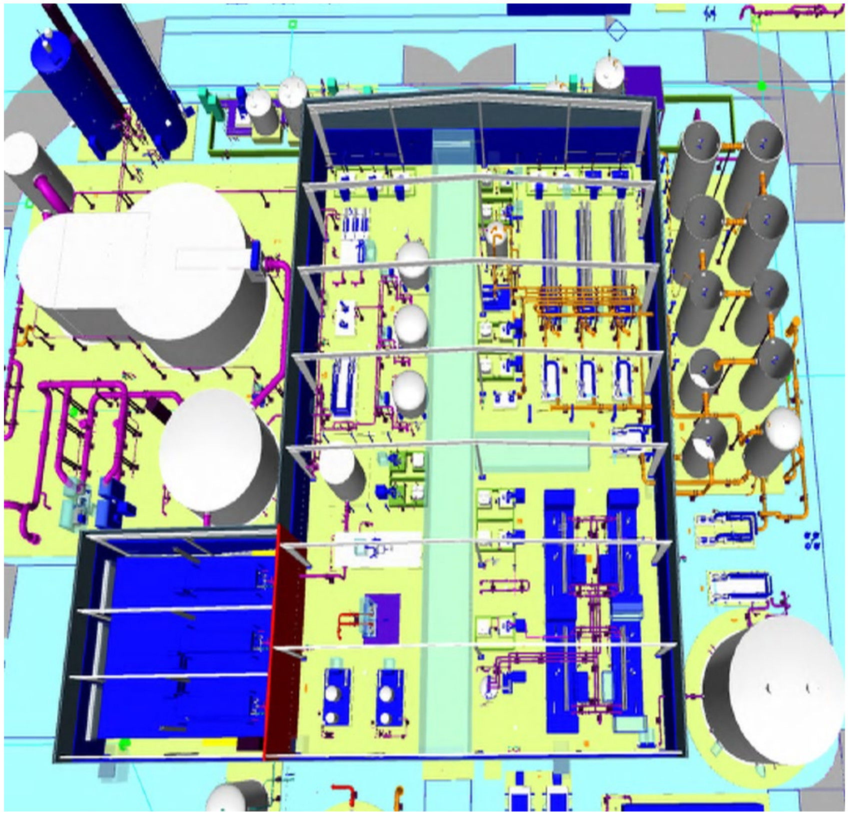

Figure 45. *Internal Layout of Water Treatment Building*

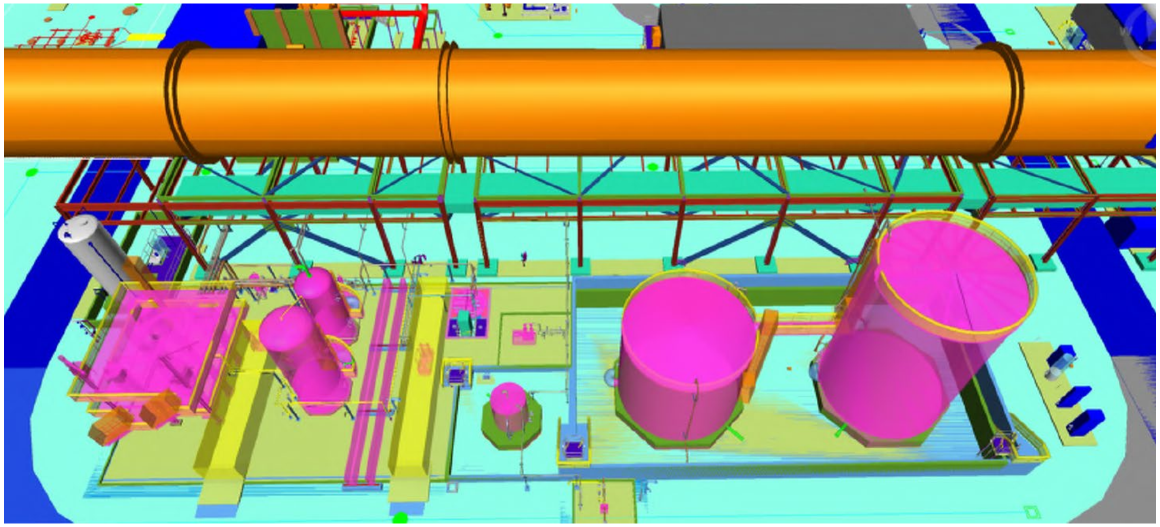

Figure 46. *Tank Positions*

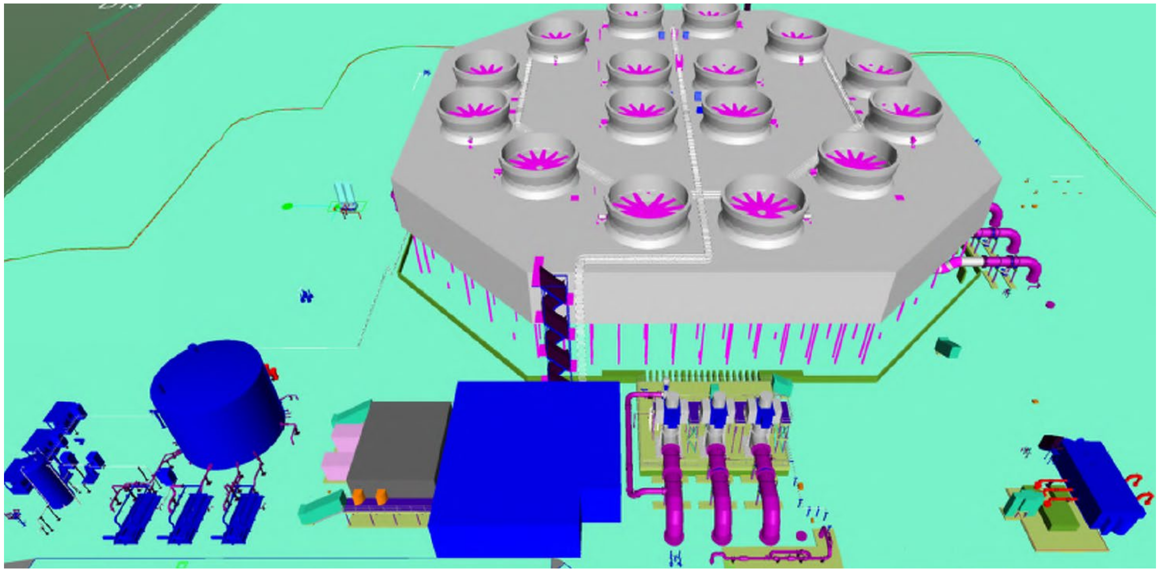

Figure 47. *Cooling Tower*

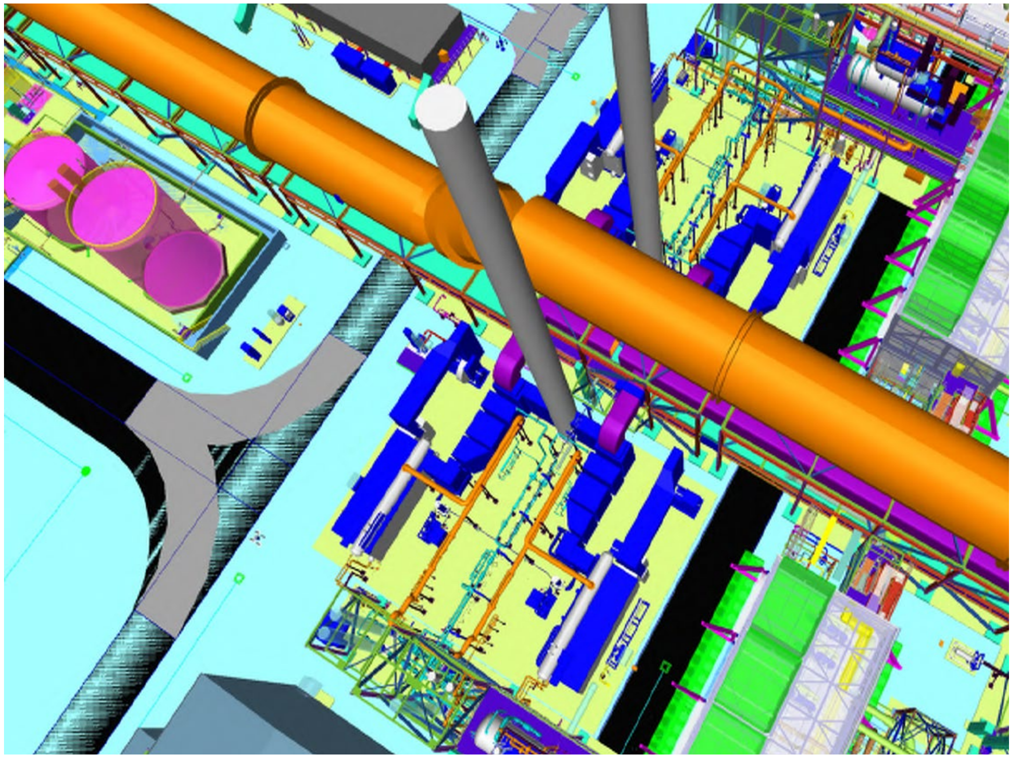

Figure 48. *Duct Tie-in for Auxiliary Boilers*

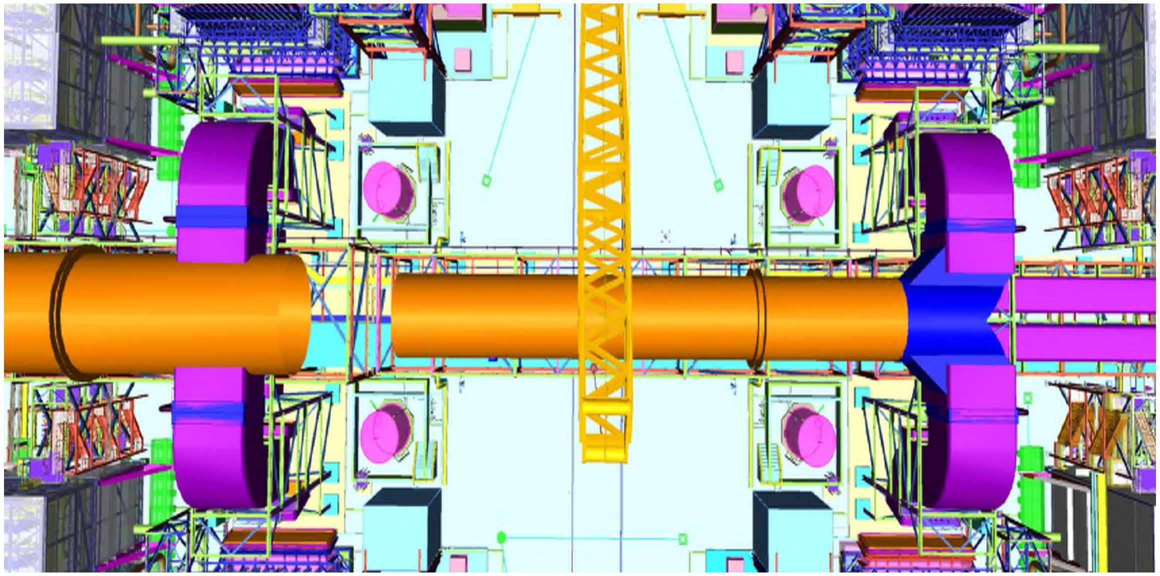

Figure 49. *Duct Takeoff to Capture Unit*

Electrical Engineering

Electrical load lists

Table 18. 15KV Switchgear

15KV SWITCHGEAR																	
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY																	
LOAD	TAG ID	HP	VOLTS	FL KW	FL KVA	FL AMPS	FL EFF.	FL P.F.	DEMAND	FRAME SIZE	ROUTE	DEMAND HP	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS	
50 KA	HSG-BOP-01A																
FLUE GAS BLOWER TRAIN 1	U2-1-FAM-001	8270	13200	6423.9	7137.7	312.2	0.960	0.900	0.90	1200.00	DB	7443.0	5781.5	6423.9	270.2		
FLUE GAS BLOWER TRAIN 2	U2-2-FAM-001	8270	13200	6423.9	7137.7	312.2	0.960	0.900	0.90	1200.00	DB	7443.0	5781.5	6423.9	270.2		
CIRCULATING WATER PUMP 1	U2-0-P-801A	8630	13200	6675.7	7303.8	319.5	0.964	0.914	0.90	1200.00	DB	7767.0	6008.1	6573.5	276.5		
CIRCULATING WATER PUMP 3	U2-0-P-801C	8630	13200	6675.7	7303.8	319.5	0.964	0.914	0.00	1200.00	DB	0.0	0.0	0.0	0.0		
TRANSFORMER LOAD TRAIN 1	TR-CC-101		13800	2125.0	2500.0	104.6	0.900	0.850	0.55	1200.00	DB		1175.6	1383.1	57.9		
TRANSFORMER LOAD TRAIN 1	TR-CC-102		13800	2125.0	2500.0	104.6	0.900	0.850	0.50	1200.00	DB		1059.4	1246.3	52.1		
TRANSFORMER LOAD TRAIN 1	TR-CC-103A		13800	2125.0	2500.0	104.6	0.900	0.850	0.38	1200.00	DB		802.5	944.1	39.5		
TRANSFORMER LOAD TRAIN 2	TR-CC-201		13800	2125.0	2500.0	104.6	0.900	0.850	0.42	1200.00	DB		890.7	1047.9	43.8		
TRANSFORMER LOAD TRAIN 2	TR-CC-202		13800	2125.0	2500.0	104.6	0.900	0.850	0.48	1200.00	DB		1025.4	1206.3	50.5		
TRANSFORMER LOAD TRAIN 2	TR-CC-203A		13800	2125.0	2500.0	104.6	0.900	0.850	0.34	1200.00	DB		727.3	855.6	35.8		
TRANSFORMER LOAD TRAIN 3	TR-CC-303B		13800	2125.0	2500.0	104.6	0.900	0.850	0.33	1200.00	DB		711.5	837.0	35.0		
TRANSFORMER LOAD TRAIN 4	TR-CC-403B		13800	2125.0	2500.0	104.6	0.900	0.850	0.33	1200.00	DB		711.5	837.0	35.0		
BOP LSG-BOP-02A XMFR	TR-BOP-02A		13800	2826.3	3325.0	139.1	0.900	0.850	0.36	1200.00	DB		1028.9	1210.4	50.6		
BOP LSG-BOP-03A XMFR	TR-BOP-03A		13800	2826.3	3325.0	139.1	0.900	0.850	0.38	1200.00	DB		1066.1	1254.2	52.5		
COOLING TOWER LSG-BOP-11A XFMR	TR-BOP-11A		13800	4533.1	5333.0	223.1	0.900	0.850	0.31	1200.00	DB		1400.4	1647.6	68.9		
HSG-BOP-01A SUBTOTALS													28170	31891	1338	BUS PF	0.88
50 KA	HSG-BOP-01B																
FLUE GAS BLOWER TRAIN 3	U2-3-FAM-001	8270	13200	6423.9	7137.7	312.2	0.960	0.900	0.90	1200.00	DB	7443.0	5781.5	6423.9	270.2		
FLUE GAS BLOWER TRAIN 4	U2-4-FAM-001	8270	13200	6423.9	7137.7	312.2	0.960	0.900	0.90	1200.00	DB	7443.0	5781.5	6423.9	270.2		
CIRCULATING WATER PUMP 2	U2-0-P-801B	8630	13200	6675.7	7303.8	319.5	0.964	0.914	0.90	1200.00	DB	7767.0	6008.1	6573.5	276.5		
TRANSFORMER LOAD TRAIN 3	TR-CC-301		13800	2125.0	2500.0	104.6	0.900	0.850	0.42	1200.00	DB		890.7	1047.9	43.8		
TRANSFORMER LOAD TRAIN 3	TR-CC-302		13800	2125.0	2500.0	104.6	0.900	0.850	0.48	1200.00	DB		1025.4	1206.3	50.5		
TRANSFORMER LOAD TRAIN 3	TR-CC-303A		13800	2125.0	2500.0	104.6	0.900	0.850	0.34	1200.00	DB		727.3	855.6	35.8		
TRANSFORMER LOAD TRAIN 4	TR-CC-401		13800	2125.0	2500.0	104.6	0.900	0.850	0.42	1200.00	DB		890.7	1047.9	43.8		
TRANSFORMER LOAD TRAIN 4	TR-CC-402		13800	2125.0	2500.0	104.6	0.900	0.850	0.48	1200.00	DB		1025.4	1206.3	50.5		
TRANSFORMER LOAD TRAIN 4	TR-CC-403A		13800	2125.0	2500.0	104.6	0.900	0.850	0.34	1200.00	DB		727.3	855.6	35.8		
TRANSFORMER LOAD TRAIN 1	TR-CC-103B		13800	2125.0	2500.0	104.6	0.900	0.850	0.34	1200.00	DB		727.3	855.6	35.8		
TRANSFORMER LOAD TRAIN 2	TR-CC-203B		13800	2125.0	2500.0	104.6	0.900	0.850	0.34	1200.00	DB		727.3	855.6	35.8		
BOP LSG-BOP-02B XMFR	TR-BOP-02B		13800	2826.3	3325.0	139.1	0.900	0.850	0.36	1200.00	DB		1015.3	1194.5	50.0		
BOP LSG-BOP-03B XMFR	TR-BOP-03B		13800	2826.3	3325.0	139.1	0.900	0.850	0.38	1200.00	DB		1066.2	1254.4	52.5		
COOLING TOWER LSG-BOP-11B XFMR	TR-BOP-11B		13800	4533.1	5333.0	223.1	0.900	0.850	0.30	1200.00	DB		1354.3	1593.3	66.7		
HSG-BOP-01B SUBTOTALS													27748	31394	1318	BUS PF	0.88

				+20% MARGIN
	KW	KVA	AMPS	AMPS
HSG-BOP-01A	28170	31891	1338	1606.167
TIE CLOSED	55918	63285	2656	3187.404
HSG-BOP-01B	27748	31394	1318	1581.237

Table 19. 5KV Switchgear

5KV SWITCHGEAR																
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY																
LOAD	TAG ID	HP	VOLTS	FL KW	FL KVA	FL AMPS	FL EFF.	FL P.F.	DEMAND	FRAME SIZE	ROUTE	DEMAND HP	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
63 KA	MSG-BOP-01A															
BOILER FEEDWATER PUMP 1	U2-1-P-802	1100	4000	911.4	1072.2	154.8	0.900	0.850	0.90	1200.00	DB	990.0	820.3	965.0	133.9	
BOILER FEEDWATER PUMP 3	U2-3-P-802	1100	4000	911.4	1072.2	154.8	0.900	0.850	0.90	1200.00	DB	990.0	820.3	965.0	133.9	
AUXILIARY CIRCULATING WATER PUMP	U2-0-P-802	610	4000	505.4	594.6	85.8	0.900	0.850	0.00	1200.00	DB	0.0	0.0	0.0	0.0	
AIR COMPRESSOR 1	U2-0-U-805A	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 1 AUXILIARY BOILER A COMBUSTION FAN SKID	U2-1-U-805A	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 1 AUXILIARY BOILER B COMBUSTION FAN SKID	U2-1-U-805B	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 2 AUXILIARY BOILER A COMBUSTION FAN SKID	U2-2-U-805A	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 2 AUXILIARY BOILER B COMBUSTION FAN SKID	U2-2-U-805B	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 1 4.16KV SWITCHGEAR	MSG-CC-101		4160	4200.0	4941.2	685.8	0.900	0.850	0.84	1200.00	DB		3528.0	4150.6	576.0	
TRAIN 2 4.16KV SWITCHGEAR	MSG-CC-201		4160	4200.0	4941.2	685.8	0.900	0.850	0.84	1200.00	DB		3528.0	4150.6	576.0	
MSG-BOP-01A SUBTOTALS													12052	14179	1968	BUS PF 0.85
63 KA	MSG-BOP-01B															
BOILER FEEDWATER PUMP 2	U2-2-P-802	1100	4000	911.4	1072.2	154.8	0.900	0.850	0.90	1200.00	DB	990.0	820.3	965.0	133.9	
BOILER FEEDWATER PUMP 4	U2-4-P-802	1100	4000	911.4	1072.2	154.8	0.900	0.850	0.90	1200.00	DB	990.0	820.3	965.0	133.9	
AIR COMPRESSOR 2	U2-0-U-805B	900	4000	745.7	877.3	126.6	0.900	0.850	0.00	1200.00	DB	0.0	0.0	0.0	0.0	
TRAIN 3 AUXILIARY BOILER A COMBUSTION FAN SKID	U2-3-U-805A	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 3 AUXILIARY BOILER B COMBUSTION FAN SKID	U2-3-U-805B	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 4 AUXILIARY BOILER A COMBUSTION FAN SKID	U2-4-U-805A	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 4 AUXILIARY BOILER B COMBUSTION FAN SKID	U2-4-U-805B	900	4000	745.7	877.3	126.6	0.900	0.850	0.90	1200.00	DB	810.0	671.1	789.6	109.6	
TRAIN 3 4.16KV SWITCHGEAR	MSG-CC-301		4160	4200.0	4941.2	685.8	0.900	0.850	0.84	1200.00	DB		3528.0	4150.6	576.0	
TRAIN 4 4.16KV SWITCHGEAR	MSG-CC-401		4160	4200.0	4941.2	685.8	0.900	0.850	0.84	1200.00	DB		3528.0	4150.6	576.0	
MSG-BOP-01B SUBTOTALS													11381	13389	1858	BUS PF 0.85

	KW	KVA	AMPS	+20% MARGIN AMPS
MSG-BOP-01A	12052	14179	1968	2361.42595
TIE CLOSED	23433	27569	3826	4591.35516
MSG-BOP-01B	11381	13389	1858	2229.9292

Table 20. Low Voltage Switchgear

LOW VOLTAGE SWITCHGEAR															
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY															
LOAD	TAG ID	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	DEMAND	DEMAND HP	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
85 KA	LSG-BOP-11A														
COOLING TOWER MCC 11A	LMCC-BOP-11A		480	858.7	938.2	1165.1		1.000	1.000	1.00		858.7	938.2	1165.1	
COOLING TOWER MCC 12A	LMCC-BOP-12A		480	629.9	709.4	890.4		1.000	1.000	1.00		629.9	709.4	890.4	
LSG-BOP-11A SUBTOTALS												1489	1648	2055	BUS PF 0.90
85 KA	LSG-BOP-11B														
COOLING TOWER MCC 11B	LMCC-BOP-11B		480	802.4	881.9	1097.4		1.000	1.000	1.00		802.4	881.9	1097.4	
COOLING TOWER MCC 12B	LMCC-BOP-12B		480	631.7	711.4	892.8		1.000	1.000	1.00		631.7	711.4	892.8	
LSG-BOP-11B SUBTOTALS												1434	1593	1990	BUS PF 0.90

	KW	KVA	AMPS	+20% MARGIN AMPS
LSG-BOP-11A	1489	1648	2055	2466.565
TIE CLOSED	2923	3241	4046	4854.851
LSG-BOP-11B	1434	1593	1990	2388.286

Table 21. Low Voltage Motor Control Centers 1

LOW VOLTAGE MOTOR CONTROL CENTERS

PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY

LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
LMCC-BOP-02A																				
BUS SIZE (AMPS) = 2000																				
UF CIP TANK HEATER A	U2-0-T-820-EH1A			480	2.0	2.0	2.4		1.000	1.000	FVC	1	-	2	0.90	3.01	1.8	1.8	2.2	
UTILITY/FIRE WATER STORAGE TANK HEATER A	U2-0-T-806-EH1A			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	1.00	37.59	25.0	25.0	30.1	
REACTION TANK 1 HEATER	U2-0-T-839-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
REACTION TANK 2 HEATER	U2-0-T-840-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
~~ORGANOSULFIDE MIXER 1~~	~~U2-0-A-814~~	~~NO~~	~~7.5~~	~~460~~	~~6.2~~	~~7.5~~	~~9.4~~	~~11.0~~	~~0.895~~	~~0.830~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~13.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~BOP WEST WASTE WATER SUMP PUMP MOTOR A~~	~~U2-0-P-804A-M1A~~		~~25~~	~~460~~	~~20.2~~	~~23.2~~	~~29.1~~	~~34.0~~	~~0.924~~	~~0.870~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~42.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
BOP WEST WASTE WATER SUMP PUMP MOTOR SKID				480	40.0	40.0	48.1		1.000	1.000	Dual Bkr	125	70	1	0.50	70.00	20.0	20.0	24.1	
TRAIN 1 CONDENSATE PUMP MOTOR A	U2-1-U-802A	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
TRAIN 2 CONDENSATE PUMP MOTOR A	U2-2-U-802A	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
FILTER PRESS A	U2-0-U-838A	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.00	24.2	27.5	34.5	
MULTIMEDIA FILTER FEED PUMP A	U2-0-U-834-M1A	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
MULTIMEDIA FILTER AIR BLOWER MOTOR A	U2-0-U-841-M1A	YES	25	460	20.2	23.2	29.1	34.0	0.924	0.870	FVNR	2	-	2	1.00	42.50	20.2	23.2	29.1	
MULTIMEDIA FILTER AIR BACK WASH MOTOR A	U2-0-U-840-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	1.00	155.00	78.9	90.7	113.8	
POTABLE WATER BOOSTER PUMP	U2-0-U-~~805~~819-M1	NO	7.5	460	6.2	7.5	9.4	11.0	0.895	0.830	FVNR	1	-	2	1.00	13.75	6.2	7.5	9.4	
SP RO BOOSTER PUMP MOTOR	U2-0-U-803A-M1	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	1.00	300.00	157.0	180.4	226.5	
~~SP RO BOOSTER PUMP MOTOR 2A~~	~~U2-0-U-803A-M2A~~	~~YES~~	~~75~~	~~460~~	~~59.4~~	~~69.9~~	~~87.8~~	~~96.0~~	~~0.941~~	~~0.850~~	~~FVNR~~	~~4~~	~~-~~	~~0~~	~~0.00~~	~~120.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
EQUALIZATION WATER PUMP A	U2-0-U-817-M1A	YES	40	460	32.1	37.3	46.8	52.0	0.930	0.860	FVNR	3	-	3	0.50	65.00	16.0	18.6	23.4	
~~FIRST PASS RO SKID 1~~	~~U2-0-U-802A~~	~~YES~~	~~100~~	~~460~~	~~78.9~~	~~90.7~~	~~113.8~~	~~124.0~~	~~0.945~~	~~0.870~~	~~FVNR~~	~~4~~	~~-~~	~~0~~	~~0.00~~	~~155.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~RWT SULFURIC ACID DOSING PUMP MOTOR A~~	~~U2-0-U-845-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~MMF SODIUM HYPOCHLORITE FEED PUMP 1~~	~~U2-0-U-847-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
MMF SODIUM HYPOCHLORITE FEED PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~RO SODIUM BISULFITE DOSING PUMP A~~	~~U2-0-U-816-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
RO SODIUM BISULFITE DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~RO CAUSTIC DOSING PUMP A~~	~~U2-0-U-814-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WASTEWATER TREATMENT CITRIC ACID DOSING PUMP MOTOR A~~	~~U2-0-U-860-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT CITRIC ACID DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WASTEWATER TREATMENT FERRIC SULFATE DOSING PUMP A~~	~~U2-0-U-858-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
UF FILTRATE DISCHARGE PUMP MOTOR A	U2-0-U-854-M1A	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	1.00	377.50	196.9	221.7	278.2	
UF AIR BLOWER MOTOR A	U2-0-U-852-FA1A	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.00	24.2	27.5	34.5	
~~UTILITY WATER SODIUM HYPOCHLORITE DOSING FEED PUMP MOTOR A~~	~~U2-0-U-864-M1A~~	~~NO~~	~~1.5~~	~~460~~	~~1.3~~	~~1.8~~	~~2.2~~	~~3.0~~	~~0.840~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~3.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
UTILITY/FIRE WATER PUMP MOTOR A	U2-0-U-818-M1A	YES	75	460	59.4	69.9	87.8	96.0	0.941	0.850	FVNR	4	-	4	1.00	120.00	59.4	69.9	87.8	
~~AUXILIARY BOILER AMMONIA DOSING PUMP MOTOR A~~	~~U2-1-U-807-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~EAST SANITARY PUMP A~~	~~U2-0-U-827-M1A~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WATER TREATMENT BUILDING SUMP PUMP MOTOR A~~	~~U2-0-P-806A~~		~~50~~	~~460~~	~~40.1~~	~~46.1~~	~~67.8~~	~~65.0~~	~~0.930~~	~~0.870~~	~~FVNR~~	~~3~~	~~-~~	~~0~~	~~0.00~~	~~81.25~~	~~0.0~~	~~0.0~~	~~0.0~~	
WATER TREATMENT BUILDING SUMP PUMP MOTOR SKID				480	80.0	80.0	96.2		1.000	1.000	Dual Bkr	125	125	1	0.50	125.00	40.0	40.0	48.1	
~~WEST STORMWATER SUMP PUMP A MOTOR~~	~~U2-0-P-809A-M1~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WEST STORMWATER SUMP PUMP B MOTOR~~	~~U2-0-P-809B-M1~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
WEST STORMWATER SUMP PUMP MOTOR SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
REACTION TANK 1 MIXER MOTOR	U2-0-T-839-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.00	9.50	0.0	0.0	0.0	
REACTION TANK 2 MIXER MOTOR	U2-0-T-840-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.00	9.50	0.0	0.0	0.0	
WASTEWATER TREATMENT UF CAUSTIC DOSING PUMP A MOTOR	U2-0-U-866-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	2	1.00	2.63	0.9	1.2	1.5	
~~WASTEWATER TREATMENT SULFURIC ACID DOSING PUMP A MOTOR~~	~~U2-0-U-870-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT SULFURIC ACID DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WASTEWATER TREATMENT CAUSTIC DOSING PUMP A MOTOR~~	~~U2-0-U-872-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
TRAIN DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-1-U-801-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
TRAIN DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-1-U-801-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-1-U-802-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-1-U-802-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-1-U-806-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-1-U-806-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
DILUTION AIR BLOWER A MOTOR	U2-1-U-809A-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-1-U-809A-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-1-U-809A-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
DILUTION AIR BLOWER A MOTOR	U2-1-U-809B-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-1-U-809B-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-1-U-809B-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
WATER TREATMENT AREA HEAT TRACE TRANSFORMER	LATER			480	75.0	75.0	90.2		1.000	1.000	Dual Bkr	125	125	1	0.00	125.00	0.0	0.0	0.0	
BOP 480V PANEL 1	LDB-BOP-01			480							BKR	250	225	3		225.00	119.7	119.7	144.0	

Table 22. Low Voltage Motor Control Centers 2

LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
LOW VOLTAGE MOTOR CONTROL CENTERS																				
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY																				
WATER TREATMENT 480V PANEL 1	LDB-BOP-21			480							BKR	250	225	3		225.00	120.0	120.0	144.0	
CLARIFIER CLEARWELL TANK HEATER	U2-0-T-808-EH1A			480	2.0	2.0	2.4		1.000	1.000	FVC	1	-	2	1.00	3.01	2.0	2.0	2.4	
SPARE SIZE 5 STARTER				460							FVNR	5		6						
~~SPARE SIZE 5 STARTER~~				~~460~~							~~FVNR~~	~~5~~		~~0~~						
~~SPARE SIZE 4 STARTER~~				~~460~~							~~FVNR~~	~~4~~		~~0~~						
~~SPARE SIZE 4 STARTER~~				~~460~~							~~FVNR~~	~~4~~		~~0~~						
SPARE SIZE 4 STARTER				460							FVNR	4		4						
SPARE SIZE 3 STARTER				460							FVNR	3		3						
~~SPARE SIZE 3 STARTER~~				~~460~~							~~FVNR~~	~~3~~		~~0~~						
~~SPARE SIZE 2 STARTER~~				~~460~~							~~FVNR~~	~~2~~		~~0~~						
SPARE SIZE 2 STARTER				460							FVNR	2		2						
~~SPARE SIZE 1 STARTER~~				~~460~~							~~FVNR~~	~~1~~		~~0~~						
~~SPARE SIZE 1 STARTER~~				~~460~~							~~FVNR~~	~~1~~		~~0~~						
SPARE SIZE 1 STARTER				460							FVNR	1		2						
SPARE 30A BKR				480							Dual Bkr	125	30	1						
SPARE 50A BKR				480							Dual Bkr	125	50	1						
LMCC-BOP-02A SUBTOTALS									**NUMBER OF SECTIONS (W/O MAIN BREAKER)**					**12**			**1095**	**1210**	**1501**	**BUS PF** **0.90**
																	PERCENT LOADED=		**75.1%**	**PERCENT CONSTANT KVA** **72%**
LMCC-BOP-02B																				
BUS SIZE (AMPS) = 2000																				
UF CIP TANK HEATER B	U2-0-T-820-EH1B			480	2.0	2.0	2.4		1.000	1.000	FVC	1	-	2	1.00	3.01	2.0	2.0	2.4	
CLARIFIER CLEARWELL TANK HEATER	U2-0-T-808-EH1B			480	2.0	2.0	2.4		1.000	1.000	FVC	1	-	2	1.00	3.01	2.0	2.0	2.4	
UTILITY/FIRE WATER STORAGE TANK HEATER B	U2-0-T-806-EH1B			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	1.00	37.59	25.0	25.0	30.1	
COMPRESSED AIR DRYER 1	U2-0-U-806A			480	25.0	25.0	30.1		1.000	1.000	Dual Bkr	125	50	1	0.50	50.00	12.5	12.5	15.0	
REACTION TANK 3 HEATER	U2-0-T-841-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
REACTION TANK 4 HEATER	U2-0-T-842-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
~~ORGANOSULFIDE MIXER 2~~	~~U2-0-A-816~~	~~NO~~	~~7.5~~	~~460~~	~~6.2~~	~~7.5~~	~~9.4~~	~~11.0~~	~~0.895~~	~~0.830~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~13.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~ORGANOSULFIDE MIXER 3~~	~~U2-0-A-816~~	~~NO~~	~~7.5~~	~~460~~	~~6.2~~	~~7.5~~	~~9.4~~	~~11.0~~	~~0.895~~	~~0.830~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~13.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
COAGULANT MIXER 1	U2-0-A-817	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	1.00	9.50	4.3	5.2	6.5	
COAGULANT MIXER 2	U2-0-A-818	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	1.00	9.50	4.3	5.2	6.5	
~~BOP WEST WASTE WATER SUMP PUMP MOTOR B~~	~~U2-0-P-804A-M1B~~		~~25~~	~~460~~	~~20.2~~	~~23.2~~	~~29.1~~	~~34.0~~	~~0.924~~	~~0.870~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~42.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
TRAIN 1 CONDENSATE PUMP MOTOR B	U2-1-U-802B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
TRAIN 2 CONDENSATE PUMP MOTOR B	U2-2-U-802B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
FILTER PRESS B	U2-0-U-838B	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.00	24.2	27.5	34.5	
FILTER PRESS C	U2-0-U-838C	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	0.00	50.00	0.0	0.0	0.0	
MULTIMEDIA FILTER FEED PUMP B	U2-0-U-834-M1B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
MULTIMEDIA FILTER AIR BLOWER MOTOR B	U2-0-U-841-M1B	YES	25	460	20.2	23.2	29.1	34.0	0.924	0.870	FVNR	2	-	2	1.00	42.50	20.2	23.2	29.1	
MULTIMEDIA FILTER AIR BACK WASH MOTOR B	U2-0-U-840-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	1.00	155.00	78.9	90.7	113.8	
POTABLE WATER RECIRCULATING PUMP	U2-0-U-804-M1	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	1.00	17.50	8.3	9.9	12.4	
SP RO BOOSTER PUMP MOTOR	U2-0-U-803B-M1	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	1.00	300.00	157.0	180.4	226.5	
~~SP RO BOOSTER PUMP MOTOR 2B~~	~~U2-0-U-803A-M2B~~	~~YES~~	~~75~~	~~460~~	~~59.4~~	~~69.9~~	~~87.8~~	~~96.0~~	~~0.941~~	~~0.850~~	~~FVNR~~	4	~~-~~	4	~~0.00~~	~~120.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
CLARIFIER SLUDGE RECYCLE PUMP	U2-0-U-832-M1	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	0.50	50.00	12.1	13.8	17.3	
RO FEED PUMP MOTOR A	U2-0-U-842-M1A	YES	25	460	20.2	23.2	29.1	34.0	0.924	0.870	FVNR	2	-	2	0.50	42.50	10.1	11.6	14.6	
~~RO ANTISCALANT DOSING PUMP A~~	~~U2-0-U-815-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~RO CAUSTIC DOSING PUMP B~~	~~U2-0-U-814-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
RO CAUSTIC DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~SECOND PASS RO SKID 1~~	~~U2-0-U-803A~~	~~YES~~	~~75~~	~~460~~	~~59.4~~	~~69.9~~	~~87.8~~	~~96.0~~	~~0.941~~	~~0.850~~	~~FVNR~~	~~4~~	~~-~~	~~0~~	~~0.00~~	~~120.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~UTILITY WATER SODIUM HYPOCHLORITE DOSING FEED PUMP MOTOR B~~	~~U2-0-U-864-M1B~~	~~NO~~	~~1.5~~	~~460~~	~~1.3~~	~~1.8~~	~~2.2~~	~~3.0~~	~~0.840~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~3.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
UTILITY/FIRE WATER PUMP MOTOR B	U2-0-U-818-M1B	YES	75	460	59.4	69.9	87.8	96.0	0.941	0.850	FVNR	4	-	4	1.00	120.00	59.4	69.9	87.8	
~~SANITARY LIFT STATION PUMP 1~~	~~U2-0-U-8XX-M1A~~	~~NO~~	~~1.5~~	~~460~~	~~1.3~~	~~1.8~~	~~2.2~~	~~3.0~~	~~0.840~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~3.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
UF FILTRATE DISCHARGE PUMP MOTOR B	U2-0-U-854-M1B	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	1.00	377.50	196.9	221.7	278.2	
UF AIR BLOWER MOTOR B	U2-0-U-852-FA1B	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.00	24.2	27.5	34.5	
~~WASTEWATER TREATMENT CITRIC ACID DOSING PUMP MOTOR B~~	~~U2-0-U-860-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WASTEWATER TREATMENT FERRIC SULFATE DOSING PUMP B~~	~~U2-0-U-858-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT FERRIC SULFATE DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~EAST SANITARY PUMP B~~	~~U2-0-U-827-M1B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
EAST SANITARY PUMP SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
~~WATER TREATMENT BUILDING SUMP PUMP MOTOR B~~	~~U2-0-U-806B~~		~~50~~	~~460~~	~~40.1~~	~~46.1~~	~~57.8~~	~~65.0~~	~~0.930~~	~~0.870~~	~~FVNR~~	~~3~~	~~-~~	~~0~~	~~0.00~~	~~81.25~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~EAST STORMWATER SUMP PUMP A MOTOR~~	~~U2-0-P-810A-M1~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~6.2~~	~~6.6~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~EAST STORMWATER SUMP PUMP B MOTOR~~	~~U2-0-P-810B-M1~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~6.2~~	~~6.6~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
EAST STORMWATER SUMP PUMP MOTOR SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	

Table 23. Low Voltage Motor Control Centers 3

LOW VOLTAGE MOTOR CONTROL CENTERS																				
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY																				
LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
REACTION TANK 3 MIXER MOTOR	U2-0-T-841-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.90	9.50	3.8	4.7	5.9	
REACTION TANK 4 MIXER MOTOR	U2-0-T-842-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.90	9.50	3.8	4.7	5.9	
WASTEWATER TREATMENT UF CAUSTIC DOSING PUMP B MOTOR	U2-0-U-866-M1B	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	2	0.00	2.63	0.0	0.0	0.0	
~~WASTEWATER TREATMENT SULFURIC ACID DOSING PUMP B MOTOR~~	~~U2-0-U-870-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WASTEWATER TREATMENT CAUSTIC DOSING PUMP B MOTOR~~	~~U2-0-U-872-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT CAUSTIC DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
TRAIN DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-2-U-801-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
TRAIN DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-2-U-801-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-2-U-802-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-2-U-802-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-2-U-806-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-2-U-806-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
DILUTION AIR BLOWER A MOTOR	U2-2-U-809A-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-2-U-809A-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-2-U-809A-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
DILUTION AIR BLOWER A MOTOR	U2-2-U-809B-M1	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-2-U-809B-M11A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-2-U-809B-M1B	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
BOP 480V PANEL 2	LDB-BOP-02			480							BKR	250	225	3		225.00	120.0	120.0	144.0	
WATER TREATMENT 480 V PANEL 2	LDB-BOP-22			480							BKR	250	225	3		225.00	120.0	120.0	144.0	
SPARE SIZE 5 STARTER				460							FVNR	5		6						
~~SPARE SIZE 5 STARTER~~				~~460~~							~~FVNR~~	~~5~~		~~0~~						
~~SPARE SIZE 4 STARTER~~				~~460~~							~~FVNR~~	~~4~~		~~0~~						
SPARE SIZE 4 STARTER				460							FVNR	4		4						
SPARE SIZE 3 STARTER				460							FVNR	3		3						
~~SPARE SIZE 3 STARTER~~				~~460~~							~~FVNR~~	~~3~~		~~0~~						
~~SPARE SIZE 2 STARTER~~				~~460~~							~~FVNR~~	~~2~~		~~0~~						
SPARE SIZE 2 STARTER				460							FVNR	2		2						
~~SPARE SIZE 1 STARTER~~				~~460~~							~~FVNR~~	~~1~~		~~0~~						
SPARE SIZE 1 STARTER				460							FVNR	1		2						
SPARE 20A BKR				480							Dual Bkr	125	20	1						
SPARE 30A BKR				480							Dual Bkr	125	30	1						
SPARE 50A BKR				480							Dual Bkr	125	50	1						
LMCC-BOP-02B SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					13			1075	1194	1483	BUS PF 0.90
																		PERCENT LOADED=	74.2%	PERCENT CONSTANT KVA 75%
LMCC-BOP-03A																				
BUS SIZE (AMPS) = 2000																				
DEMIN WATER STORAGE TANK HEATER	U2-0-804-EH1A			480	50.0	50.0	60.1		1.000	1.000	FVC	3	-	3	0.00	75.18	0.0	0.0	0.0	
EQUALIZATION STORAGE TANK HEATER	U2-0-T-810-EH1A			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
CIP TANK HEATER	U2-0-T-810-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
REACTION TANK 5 HEATER	U2-0-T-814-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
LIME FEED PUMP A MOTOR	U2-0-U-831-M1AB	NO	8	460	6.7	8.0	10.1	11.0	0.895	0.830	FVNR	1	-	2	1.00	13.75	6.7	8.0	10.1	
~~SLUDGE RAKE~~	~~U2-0-836-A1~~	~~NO~~	~~0.75~~	~~460~~	~~0.7~~	~~1.0~~	~~1.3~~	~~1.6~~	~~0.788~~	~~0.680~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
SLUDGE COLLECTION RAKE	U2-0- U-830-A2	NO	7.5	460	6.2	7.5	9.4	11.0	0.895	0.830	FVNR	1	-	2	1.00	13.75	6.2	7.5	9.4	
~~BOP EAST WASTE WATER SUMP PUMP MOTOR A~~	~~U2-0-P-805A-M1A~~		~~25~~	~~460~~	~~20.2~~	~~23.2~~	~~29.1~~	~~34.0~~	~~0.924~~	~~0.870~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~42.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
BOP EAST WASTE WATER SUMP PUMP MOTOR SKID				480	40.4	40.4	48.6		1.000	1.000	Dual Bkr	125	70	1	0.50	70.00	20.2	20.2	24.3	
TRAIN 3 CONDENSATE PUMP MOTOR A	U2-3-U-802A	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
TRAIN 4 CONDENSATE PUMP MOTOR A	U2-4-U-802B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
DEMINERALIZED WATER PUMP MOTOR A	U2-0-U-807-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	1.00	155.00	78.9	90.7	113.8	
FLUE GAS DUCT DRAINS SUMP MOTOR A	U2-0-P-807A-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	1.00	9.50	4.3	5.2	6.5	
~~FERRIC SULFATE DOSING PUMP MOTOR A~~	~~U2-0-P-843-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
FERRIC SULFATE DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~FILTER PRESS POLYMER DOSING PUMP A MOTOR~~	~~U2-0-P-848-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	–	~~2~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
FILTER PRESS POLYMER DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
THICKENED SLUDGE FORWARDING PUMP MOTOR A	U2-0-U-837-M1A	YES	75	460	59.4	69.9	87.8	96.0	0.941	0.850	FVNR	4	-	4	1.00	120.00	59.4	69.9	87.8	
~~THICKENER POLYMER DOSING PUMP MOTOR A~~	~~U2-0-P-845-M1A~~	~~NO~~	~~1.5~~	~~460~~	~~1.3~~	~~1.8~~	~~2.2~~	~~3.0~~	~~0.840~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~3.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
FPRO MOTOR BOOSTER PUMP	U2-0-U-802A-M1	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	1.00	300.00	157.0	180.4	226.5	
~~FPRO MOTOR BOOSTER PUMP 2A~~	~~U2-0-U-802B-M1A~~	~~YES~~	~~100~~	~~460~~	~~78.9~~	~~90.7~~	~~113.8~~	~~124.0~~	~~0.945~~	~~0.870~~	~~FVNR~~	~~4~~	–	~~0~~	~~0.00~~	~~155.00~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~CLARIFIER POLYMER DOSING PUMP MOTOR A~~	~~U2-0-U-844-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	

Table 24. Low Voltage Motor Control Centers 4

LOW VOLTAGE MOTOR CONTROL CENTERS

PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY

LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
CLARIFIER POLYMER DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
EQUALIZATION WATER PUMP B	U2-0-U-817-M1B	YES	40	460	32.1	37.3	46.8	52.0	0.930	0.860	FVNR	3	-	3	0.50	65.00	16.0	18.6	23.4	
~~FIRST PASS RO SKID 2~~	U2-0-U-802B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	0	0.00	155.00	0.0	0.0	0.0	
ELECTRIC FIRE PUMP	U2-0-U-813-P1	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	0.00	300.00	0.0	0.0	0.0	
~~RWT SULFURIC ACID DOSING PUMP MOTOR A~~	U2-0-U-845-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
RWT SULFURIC ACID DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~MMF SODIUM HYPOCHLORITE FEED PUMP 1-2~~	U2-0-U-847-M1BA	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
UF BACKWASH MOTOR A	U2-0-U-855-M1A	YES	35	460	28.2	32.1	40.3	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.36	28.2	32.1	40.3	
UF FEED PUMP MOTOR A	U2-0-U-850A-M1	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
UF FEED PUMP MOTOR B	U2-0-U-850B-M1	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
~~RO SODIUM BISULFITE DOSING PUMP B~~	U2-0-U-816-M1B	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
~~WASTEWATER TREATMENT ORGANOSULFIDE FEED PUMP A~~	U2-0-U-857-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
~~WASTEWATER TREATMENT SODIUM BISULFITE DOSING PUMP A~~	U2-0-U-871-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
~~WASTEWATER TREATMENT SODIUM HYDROXIDE DOSING PUMP A~~	U2-0-U-866-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
~~WASTEWATER TREATMENT SODIUM HYPOCHLORITE DOSING PUMP A~~	U2-0-U-859-M1A	NO	1	460	0.9	1.2	1.5	2.1	0.825	0.760	FVNR	1	-	0	0.00	2.63	0.0	0.0	0.0	
WASTEWATER TREATMENT SODIUM HYPOCHLORITE DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WEST SANITARY PUMP A~~	U2-0-U-810-M1A	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	0	0.00	9.50	0.0	0.0	0.0	
WEST SANITARY PUMP SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
COOLING TOWER MAKEUP TRANSFER PUMP MOTOR A	U2-0-U-808A-M1A	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	0.90	300.00	141.3	162.4	203.8	
~~AUXILIARY BOILER AMMONIA DOSING PUMP MOTOR B~~	U2-1-U-807-M1B	NO	1.5	460	1.3	1.8	2.2	3.0	0.840	0.760	FVNR	1	-	0	0.00	3.75	0.0	0.0	0.0	
~~BOP WEST OIL/WATER SEPARATOR PUMP MOTOR A~~	U2-0-U-823-M1A	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	0	0.00	9.50	0.0	0.0	0.0	
BOP WEST OIL/WATER SEPARATOR PUMP MOTOR SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
~~BOP MIDDLE OIL/WATER SEPARATOR PUMP MOTOR A~~	U2-0-U-824-M1A	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	0	0.00	9.50	0.0	0.0	0.0	
BOP MIDDLE OIL/WATER SEPARATOR PUMP MOTOR SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
~~BOP EAST OIL/WATER SEPARATOR PUMP MOTOR A~~	U2-0-U-825-M1A	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	0	0.00	9.50	0.0	0.0	0.0	
BOP EAST OIL/WATER SEPARATOR PUMP MOTOR SKID				480	8.6	8.6	10.3		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	4.3	4.3	5.2	
REACTION TANK 5 MIXER MOTOR	U2-0-T-814-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.90	9.50	3.8	4.7	5.9	
REACTION TANK 6 MIXER MOTOR	U2-0-T-815-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.90	9.50	3.8	4.7	5.9	
UREA FORWARDING PUMP A MOTOR	U2-0-U-809-M1A	NO	3	460	2.6	3.1	3.9	4.8	0.875	0.820	FVNR	1	-	2	0.90	6.00	2.3	2.8	3.5	
SODA ASH FEED PUMP A MOTOR	U2-0-U-835-M1A	NO	3	460	2.6	3.1	3.9	4.8	0.875	0.820	FVNR	1	-	2	0.90	6.00	2.3	2.8	3.5	
UF CIP FEED PUMP MOTOR	U2-0-U-856-M1	NO	15	460	12.3	14.8	18.6	21.0	0.910	0.830	FVNR	2	-	2	0.90	26.25	11.1	13.3	16.7	
TRAIN DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-3-U-801-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
TRAIN DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-3-U-801-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-3-U-802-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-3-U-802-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-3-U-806-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-3-U-806-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
DILUTION AIR BLOWER A MOTOR	U2-3-U-809A-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-3-U-809A-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-3-U-809A-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
DILUTION AIR BLOWER A MOTOR	U2-3-U-809B-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
DILUTION AIR BLOWER B MOTOR	U2-3-U-809B-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2	
UREA DOSING PUMP MOTOR	U2-3-U-809B-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8	
WATER TREATMENT AREA HEAT TRACE TRANSFORMER	LATER			480	75.0	75.0	90.2		1.000	1.000	Dual Bkr	125	125	1	0.90	125.00	67.5	67.5	81.2	
BATTERY CHARGER 1	CHG-BOP-01A			481	144.0	144.0	172.8		1.000	1.000	BKR	250	225	3	0.90	225.00	129.6	129.6	155.6	
AD MIN 480 V PANEL 1	LDB-BOP-03			480							BKR	250	225	3		225.00	150.0	150.0	180.0	
EQUALIZATION STORAGE TANK RAPID MIXER MOTOR	U2-0-T-809-M1	YES	50	460	40.1	46.1	57.8	65.0	0.930	0.870	FVNR	3	-	3	0.00	81.25	0.0	0.0	0.0	
SPARE SIZE 5 STARTER				460							FVNR	5		6						
~~SPARE SIZE 5 STARTER~~				460							FVNR	5		0						
~~SPARE SIZE 4 STARTER~~				460							FVNR	4		0						
SPARE SIZE 4 STARTER				460							FVNR	4		4						
SPARE SIZE 3 STARTER				460							FVNR	3		3						
~~SPARE SIZE 3 STARTER~~				460							FVNR	3		0						
~~SPARE SIZE 2 STARTER~~				460							FVNR	2		0						
SPARE SIZE 2STARTER				460							FVNR	2		2						
SPARE SIZE 1 STARTER				460							FVNR	1		2						
~~SPARE SIZE 1 STARTER~~				460							FVNR	1		0						
SPARE 20A BKR				480							Dual Bkr	125	20	1						
SPARE 30A BKR				480							Dual Bkr	125	30	1						
SPARE 50A BKR				480							Dual Bkr	125	50	1						
LMCC-BOP-03A SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					14			1132	1254	1553	BUS PF 0.90

Table 25. Low Voltage Motor Control Centers 5

LOW VOLTAGE MOTOR CONTROL CENTERS																				
PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY																				
LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
																PERCENT LOADED=		77.7%		PERCENT CONSTANT KVA 69%
LMCC-BOP-03B																				
BUS SIZE (AMPS) = 2000																				
DEMIN WATER STORAGE TANK HEATER	U2-0-804-EH1B			480	50.0	50.0	60.1		1.000	1.000	FVC	3	-	3	1.00	75.18	50.0	50.0	60.1	
EQUALIZATION STORAGE TANK HEATER	U2-0-809-EH1B			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
~~CIP TANK HEATER~~	~~U2-0-820-EH1B~~			~~480~~	~~25.0~~	~~25.0~~	~~30.1~~		~~1.000~~	~~1.000~~	~~FVC~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~37.59~~	~~0.0~~	~~0.0~~	~~0.0~~	
COMPRESSED AIR DRYER 2	U2-0-U-806B			480	25.0	25.0	30.1		1.000	1.000	Dual Bkr	125	50	1	0.50	50.00	12.5	12.5	15.0	
REACTION TANK 6 HEATER	U2-0-T-815-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
REACTION TANK 7 HEATER	U2-0-T-816-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
COAGULATION TANK 1 HEATER	U2-0-T-817-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
COAGULATION TANK 2 HEATER	U2-0-T-818-EH1			480	25.0	25.0	30.1		1.000	1.000	FVC	2	-	2	0.00	37.59	0.0	0.0	0.0	
RAPID MIXER	U2-0- U-830-A1	NO	15	460	12.3	14.8	18.6	21.0	0.910	0.830	FVNR	2	-	2	1.00	26.25	12.3	14.8	18.6	
TRAIN 3 CONDENSATE PUMP MOTOR B	U2-3-U-802B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
TRAIN 4 CONDENSATE PUMP MOTOR B	U2-4-U-802B	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
~~FLUE GAS DUCT DRAINS SUMP MOTOR B~~	~~U2-0-P-807B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~1.00~~	~~9.50~~	~~4.3~~	~~5.2~~	~~6.5~~	
DEMINERALIZED WATER PUMP MOTOR B	U2-0-U-807-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	1.00	155.00	78.9	90.7	113.8	
~~BOP EAST WASTE WATER SUMP PUMP MOTOR B~~	~~U2-0-P-805A-M1B~~		~~25~~	~~460~~	~~20.2~~	~~23.2~~	~~29.1~~	~~34.0~~	~~0.924~~	~~0.870~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~42.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~FERRIC SULFATE DOSING PUMP MOTOR B~~	~~U2-0-U-843-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~FILTER PRES POLYMER DOSING PUMP B MOTOR~~	~~U2-0-U-848-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
THICKENED SLUDGE FORWARDING PUMP MOTOR B	U2-0-U-837-M1B	YES	75	460	59.4	69.9	87.8	96.0	0.941	0.850	FVNR	4	-	4	1.00	120.00	59.4	69.9	87.8	
THICKENED SLUDGE FORWARDING PUMP MOTOR C	U2-0-U-837-M1BC	YES	75	460	59.4	69.9	87.8	96.0	0.941	0.850	FVNR	4	-	4	0.00	120.00	0.0	0.0	0.0	
~~THICKENER POLYMER DOSING PUMP MOTOR B~~	~~U2-0-U-845-M1B~~	~~NO~~	~~1.5~~	~~460~~	~~1.3~~	~~1.8~~	~~2.2~~	~~3.0~~	~~0.840~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~1.00~~	~~3.75~~	~~1.3~~	~~1.8~~	~~2.2~~	
FPRO MOTOR BOOSTER PUMP 1B	U2-0-U-802A-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
FPRO MOTOR BOOSTER PUMP 2B	U2-0-U-802B-M1B	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	1.00	300.00	157.0	180.4	226.5	
~~CLARIFIER POLYMER DOSING PUMP MOTOR B~~	~~U2-0-U-844-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
CLARIFIER SLUDGE DUTY PUMP	U2-0-U-832-M2	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	0.50	50.00	12.1	13.8	17.3	
CLARIFIER SLUDGE SPARE DUTY/RECYCLE PUMP	U2-0-U-832-M3	YES	30	460	24.2	27.5	34.5	40.0	0.924	0.880	FVNR	3	-	3	0.50	50.00	12.1	13.8	17.3	
RO FEED PUMP MOTOR B	U2-0-U-842-M1B	YES	25	460	20.2	23.2	29.1	34.0	0.924	0.870	FVNR	2	-	2	0.50	42.50	10.1	11.6	14.6	
RO FEED PUMP MOTOR C	U2-0-U-842-M1C	YES	25	460	20.2	23.2	29.1	34.0	0.924	0.870	FVNR	2	-	2	0.50	42.50	10.1	11.6	14.6	
~~RO ANTISCALANT DOSING PUMP B~~	~~U2-0-U-815-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
RO ANTISCALANT DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~CIP ACID FEED PUMP~~	~~U2-0-U-811-P3~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~CIP BASE FEED PUMP~~	~~U2-0-U-811-P1~~	~~NO~~	~~20~~	~~460~~	~~16.4~~	~~20.2~~	~~25.4~~	~~27.0~~	~~0.910~~	~~0.810~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~33.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~CIP FEED PUMP MOTOR~~	~~U2-0-U-811-M12~~	~~NO~~	~~20~~	~~460~~	~~16.4~~	~~20.2~~	~~25.4~~	~~27.0~~	~~0.910~~	~~0.810~~	~~FVNR~~	~~2~~	~~-~~	~~0~~	~~0.00~~	~~33.75~~	~~0.0~~	~~0.0~~	~~0.0~~	
CIP FEED PUMP MOTOR CONTROL PANEL				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
UF BACKWASH MOTOR B	U2-0-U-855-M1B	YES	35	460	28.2	32.1	40.3	40.0	0.924	0.880	FVNR	3	-	3	1.00	50.36	28.2	32.1	40.3	
UF FEED PUMP MOTOR C	U2-0-U-850C-M1	YES	60	460	47.8	56.2	70.6	77.0	0.936	0.850	FVNR	4	-	4	1.00	96.25	47.8	56.2	70.6	
~~SANITARY LIFT STATION PUMP 2~~	~~U2-0-U-8XX-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WASTEWATER TREATMENT ORGANOSULFIDE FEED PUMP B~~	~~U2-0-U-857-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT ORGANOSULFIDE FEED PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WASTEWATER TREATMENT SODIUM BISULFITE DOSING PUMP B~~	~~U2-0-U-871-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT SODIUM BISULFITE DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WASTEWATER TREATMENT SODIUM HYDROXIDE DOSING PUMP B~~	~~U2-0-U-866-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
WASTEWATER TREATMENT SODIUM HYDROXIDE DOSING PUMP SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~WASTEWATER TREATMENT SODIUM HYPOCHLORITE DOSING PUMP B~~	~~U2-0-U-859-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~WEST SANITARY PUMP B~~	~~U2-0-U-810-M1B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
COOLING TOWER MAKEUP TRANSFER PUMP MOTOR B	U2-0-U-808B-M1B	YES	200	460	157.0	180.4	226.5	240.0	0.950	0.870	FVNR	5	-	6	0.90	300.00	141.3	162.4	203.8	
JOCKEY PUMP MOTOR	U2-0-U-813-M3	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	1.00	9.50	4.3	5.2	6.5	
~~BOP WEST OIL/WATER SEPARATOR PUMP MOTOR B~~	~~U2-0-U-823-M1B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~BOP MIDDLE OIL/WATER SEPARATOR PUMP MOTOR B~~	~~U2-0-U-824-M1B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
~~BOP EAST OIL/WATER SEPARATOR PUMP MOTOR B~~	~~U2-0-U-825-M1B~~	~~NO~~	~~5~~	~~460~~	~~4.3~~	~~5.2~~	~~6.5~~	~~7.6~~	~~0.875~~	~~0.820~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~9.50~~	~~0.0~~	~~0.0~~	~~0.0~~	
REACTION TANK 7 MIXER MOTOR	U2-0-T-816-M1	NO	5	460	4.3	5.2	6.5	7.6	0.875	0.820	FVNR	1	-	2	0.00	9.50	0.0	0.0	0.0	
UREA FORWARDING PUMP B MOTOR	U2-0-U-809-M1B	NO	3	460	2.6	3.1	3.9	4.8	0.875	0.820	FVNR	1	-	2	0.00	6.00	0.0	0.0	0.0	
SODA ASH FEED PUMP B MOTOR	U2-0-U-835-M1B	NO	3	460	2.6	3.1	3.9	4.8	0.875	0.820	FVNR	1	-	2	0.00	6.00	0.0	0.0	0.0	
LIME FEED PUMP B MOTOR	U2-0-U-831-M1B	NO	8	460	6.7	8.0	10.1	11.0	0.895	0.830	FVNR	1	-	2	1.00	13.75	6.7	8.0	10.1	
~~FILTER PRESS POLYMER DOSING PUMP B MOTOR~~	~~U2-0-P-848-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.750~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~	
TRAIN DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-4-U-801-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
TRAIN DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-4-U-801-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-4-U-802-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER A DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-4-U-802-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER A MOTOR	U2-4-U-806-M1A	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0	

Table 26. Low Voltage Motor Control Centers 6

LOW VOLTAGE MOTOR CONTROL CENTERS

PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY

LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS	
AUX BOILER B DUCT DAMPER SEAL AIR BLOWER B MOTOR	U2-4-U-806-M1B	YES	100	460	78.9	90.7	113.8	124.0	0.945	0.870	FVNR	4	-	4	0.00	155.00	0.0	0.0	0.0		
DILUTION AIR BLOWER A MOTOR	U2-4-U-809A-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2		
DILUTION AIR BLOWER B MOTOR	U2-4-U-809A-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2		
UREA DOSING PUMP MOTOR	U2-4-U-809A-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8		
DILUTION AIR BLOWER A MOTOR	U2-4-U-809B-M1A	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2		
DILUTION AIR BLOWER B MOTOR	U2-4-U-809B-M1B	NO	10	460	8.3	9.9	12.4	14.0	0.895	0.840	FVNR	1	-	2	0.90	17.50	7.5	8.9	11.2		
UREA DOSING PUMP MOTOR	U2-4-U-809B-M2	NO	0.5	460	0.5	0.7	0.9	1.1	0.788	0.680	FVNR	1	-	2	0.90	1.38	0.4	0.6	0.8		
BATTERY CHARGER 2	CHG-BOP-01B			480	144.0	144.0	173.2		1.000	1.000	BKR	250	225	3	0.90	225.00	129.6	129.6	155.9		
PLANT UPS	UPS-BOP-01			480	75.0	75.0	90.2		1.000	1.000	Dual Bkr	125	125	1	0.90	125.00	67.5	67.5	81.2		
ADMIN 480 V PANEL 2	LDB-BOP-04			480							BKR	250	225	3		225.00	150.0	150.0	180.0		
RAPID MIX TANK REACTOR MIXER MOTOR	U2-0-T-807-M1	NO	15	460	12.3	14.8	18.6	21.0	0.910	0.830	FVNR	2	-	2	0.90	26.25	11.1	13.3	16.7		
SPARE SIZE 4 STARTER				460							FVNR	4		4							
SPARE SIZE 4 STARTER				460							FVNR	4		4							
SPARE SIZE 3 STARTER				460							FVNR	3		3							
SPARE SIZE 2 STARTER				460							FVNR	2		2							
SPARE SIZE 2STARTER				460							FVNR	2		2							
SPARE SIZE 1 STARTER				460							FVNR	1		2							
SPARE SIZE 1 STARTER				460							FVNR	1		2							
SPARE 30A BKR				480							Dual Bkr	125	30	1							
SPARE 50A BKR				480							Dual Bkr	125	50	1							
LMCC-BOP-03B SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					14			1137	1254	1552	BUS PF	0.91
LMCC-BOP-11A																					
BUS SIZE (AMPS) = 2000																					
HVAC-1	LATER			480	30.0	30.0	36.1		1.000	1.000	Dual Bkr	125	50	1	0.75	50.00	22.5	22.5	27.1		
COOLING TOWER AREA HEAT TRACE TRANSFORMER	LATER			480	75.0	75.0	90.2		1.000	1.000	Dual Bkr	125	125	1	0.75	125.00	56.3	56.3	67.7		
COOLING TOWER 480V-24/120V TRANSFORMER AND PANEL 1	LDB-BOP-11			480							BKR	250	225	3		225.00	150.0	150.0	180.0		
COOLING TOWER FAN 1	U2-0-E-801-FA1A	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 2	U2-0-E-801-FA1B	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 3	U2-0-E-801-FA1C	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 4	U2-0-E-801-FA1D	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
SPARE SIZE 6 STARTER				460							FVNR	6		8							
LMCC-BOP-11A SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					5			859	938	1165	BUS PF	0.92
																		PERCENT LOADED=	58.3%	PERCENT CONSTANT KVA	76%
LMCC-BOP-11B																					
BUS SIZE (AMPS) = 2000																					
HVAC-1	LATER			480	30.0	30.0	36.1		1.000	1.000	Dual Bkr	125	50	1	0.75	50.00	22.5	22.5	27.1		
COOLING TOWER 480V PANEL 2	LDB-BOP-12			480							BKR	250	225	3		225.00	150.0	150.0	180.0		
COOLING TOWER FAN 5	U2-0-E-801-FA1E	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 6	U2-0-E-801-FA1F	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 7	U2-0-E-801-FA1G	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 8	U2-0-E-801-FA1H	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
SPARE SIZE 6 STARTER				460							FVNR	6		8							
LMCC-BOP-11B SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					5			802	882	1097	BUS PF	0.91
																		PERCENT LOADED=	54.9%	PERCENT CONSTANT KVA	97%
LMCC-BOP-12A																					
BUS SIZE (AMPS) = 2000																					
COOLING TOWER FAN 9	U2-0-E-801-FA1I	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	VFD	VFD	-	12	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 10	U2-0-E-801-FA1J	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	VFD	VFD	-	12	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 11	U2-0-E-801-FA1K	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	VFD	VFD	-	12	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 12	U2-0-E-801-FA1L	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	VFD	VFD	-	12	0.80	377.50	157.5	177.4	222.6		
~~COOLING TOWER SODIUM HYPOCHLORITE DOSING PUMP MOTOR A~~	~~U2-0-U-863-M1A~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~0~~	~~0.00~~	~~2.63~~	~~0.0~~	~~0.0~~	~~0.0~~		
LMCC-BOP-12A SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					5			630	709	890	BUS PF	0.89
																		PERCENT LOADED=	44.5%	PERCENT CONSTANT KVA	100%
LMCC-BOP-12B																					
BUS SIZE (AMPS) = 2000																					
COOLING TOWER FAN 13	U2-0-E-801-FA1M	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 14	U2-0-E-801-FA1N	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		
COOLING TOWER FAN 15	U2-0-E-801-FA1O	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6		

Table 27. Low Voltage Motor Control Centers 7

LOW VOLTAGE MOTOR CONTROL CENTERS

PRAIRIE STATE - CARBON CAPTURE PROJECT FEED STUDY

LOAD	TAG ID	MOTOR SPACE HTR REQUIRED?	HP	VOLTS	FL KW	FL KVA	FL AMPS	NEC 430.250 FLA	FL EFF.	FL P.F.	TYPE	FRAME SIZE	BREAKER SIZE	SPACE	DEMAND	SIZING AMPS	DEMAND KW	DEMAND KVA	DEMAND AMPS	COMMENTS
COOLING TOWER FAN 16	U2-0-E-801-FA1P	YES	250	460	196.9	221.7	278.2	302.0	0.947	0.888	FVNR	6	-	8	0.80	377.50	157.5	177.4	222.6	
COOLING TOWER SODIUM HYPOCHLORITE DOSING PUMP MOTOR SKID				480	1.8	1.8	2.2		1.000	1.000	Dual Bkr	125	20	1	0.50	20.00	0.9	0.9	1.1	
~~COOLING TOWER SODIUM HYPOCHLORITE DOSING PUMP MOTOR B~~	~~U2-0-U-863-M1B~~	~~NO~~	~~1~~	~~460~~	~~0.9~~	~~1.2~~	~~1.5~~	~~2.1~~	~~0.825~~	~~0.760~~	~~FVNR~~	~~1~~	~~-~~	~~2~~	~~0.90~~	~~2.63~~	~~0.8~~	~~1.1~~	~~1.3~~	
SPARE SIZE 6 STARTER				460							FVNR	6		8						
LMCC-BOP-12B SUBTOTALS									NUMBER OF SECTIONS (W/O MAIN BREAKER)					5			632	711	893	BUS PF 0.89

PERCENT LOADED=	44.6%	PERCENT CONSTANT KVA	100%

	KW	KVA	AMPS	+20% MARGIN AMPS
LMCC-BOP-12A	630	709	890	1068
TIE CLOSED	1262	1421	1783	2140
LMCC-BOP-12B	632	711	893	1071

One-line diagram(s)

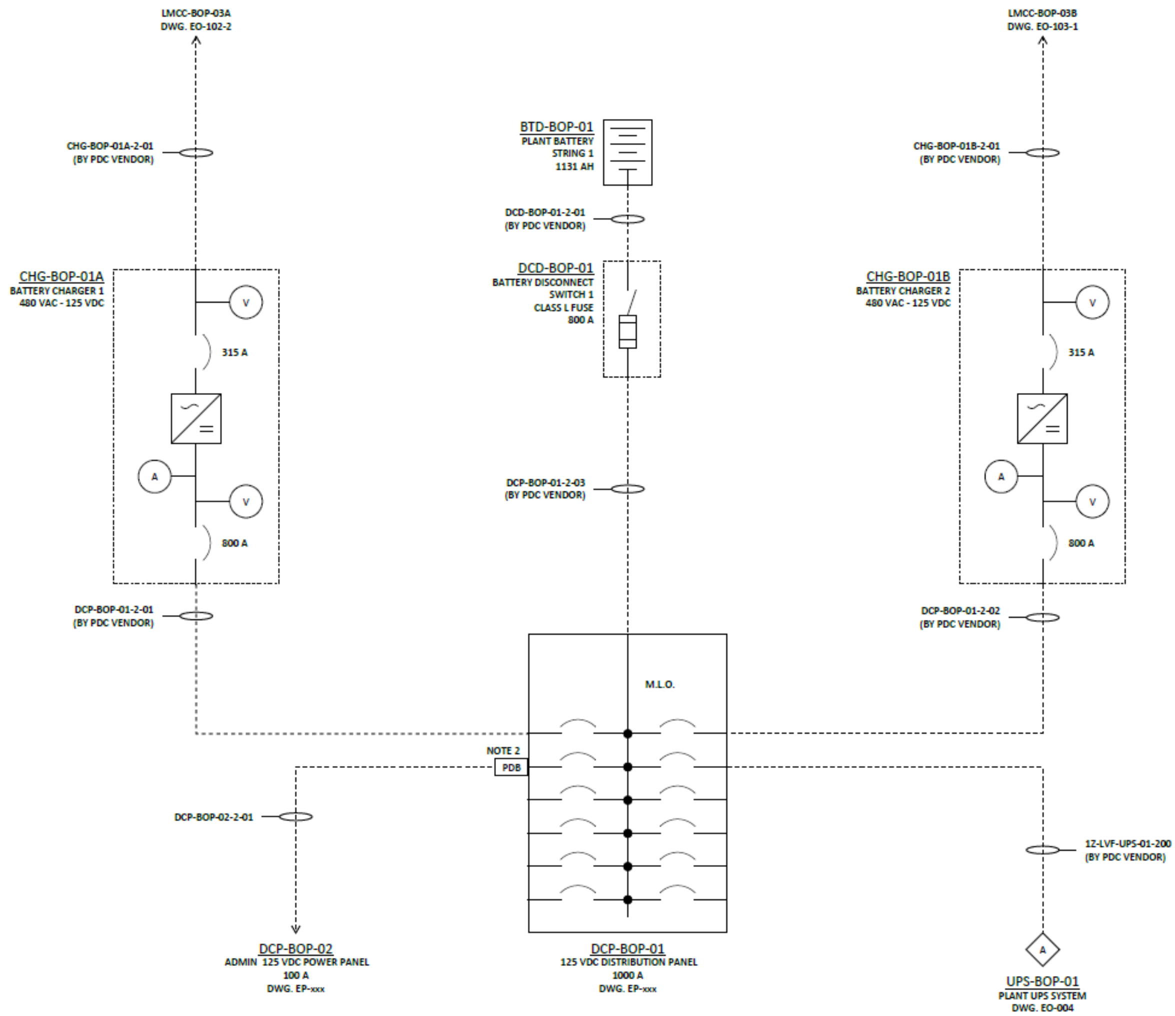

Figure 50. *125VDC BOP Battery System One-Line Diagram*

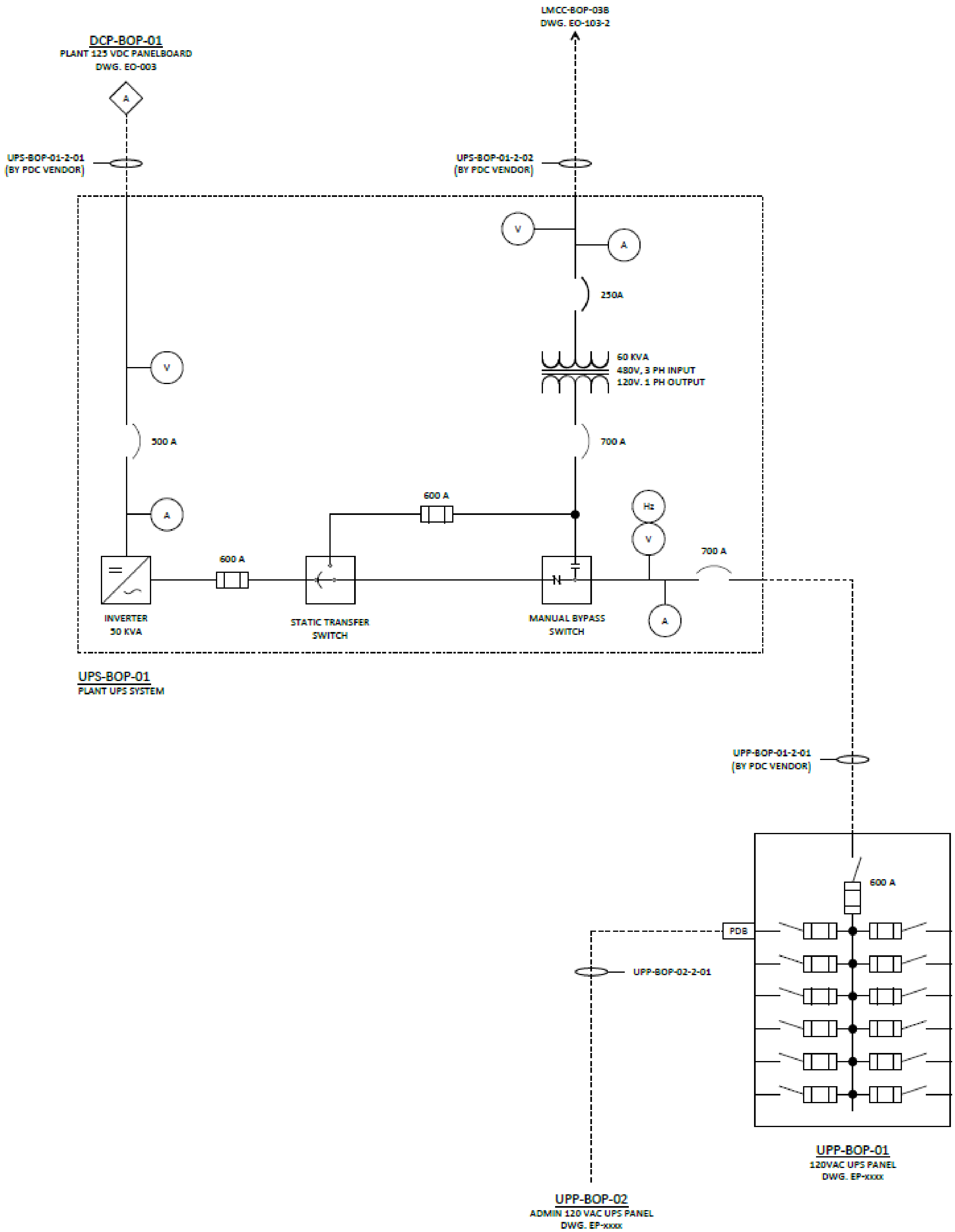

Figure 51. *120VAC BOP UPS One-Line Diagram*

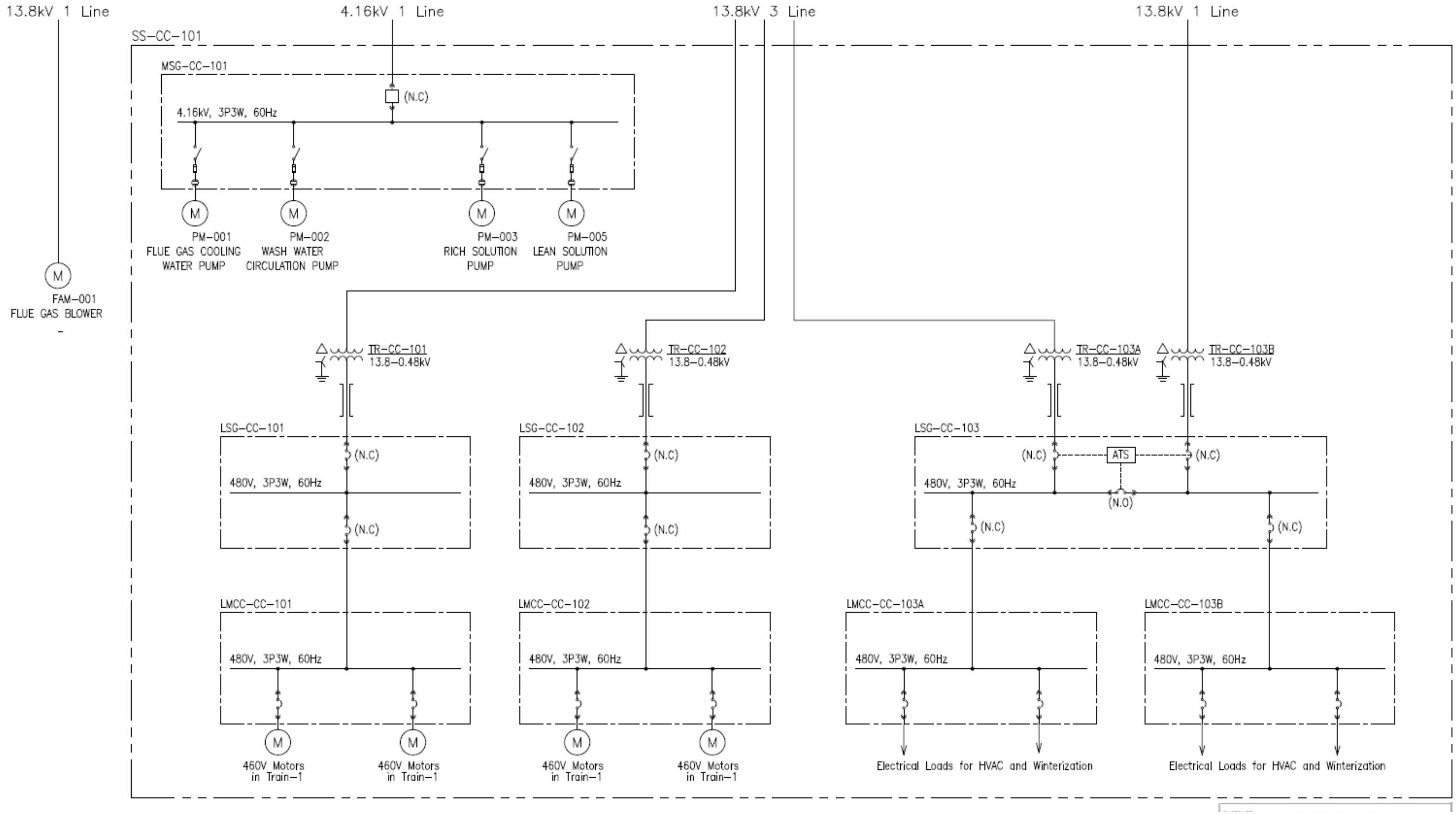

Figure 52. *ISBL Key Line Diagram*

Instrumentation & Controls Engineering (System Integration)

The addition of the CO_2 Capture and Compression System and its auxiliaries at PSGC Unit 2 will require a new Distributed Control System (DCS). The control and supervision of BOP systems will be integrated into the new DCS. The new DCS will be independent but will supply supervisory status to the existing DCS used by PSGC Unit 2.

The new control scheme will employ dedicated redundant DCS controllers. The CO_2 capture facility system and subsystems installation requires a minimum of one (1) pair of process controllers. The new DCS controllers will be located in the new Administration Building, Rack Room.

New Operator Workstations (OWS) will be provided for control and monitoring, to be located in the new Administration Building, CO_2 Capture Control Room with new Human Machine Interface (HMI) graphics, also made available in existing PSCG control room operator workstations where required, to provide operator monitoring of CO_2 capture facility. Engineering Workstations (EWS) will be located in the new Administration Building Rack Room.

New packaged equipment that is procured with the vendor's standard microprocessor-based control systems or Programmable Logic Controllers (PLC) will interface with the new DCS using serial / ethernet interface for monitor and/or hardwired signals for control and supervisory.

The new main fire alarm control panel will be located in the Administration Building, CO_2 Capture Control Room. The control panel will not have any communication interface with the new DCS. Individual fire detector status monitoring is not required for the new DCS. However, the new DCS will require general fire trouble/alarm signals from local fire control panel per train.

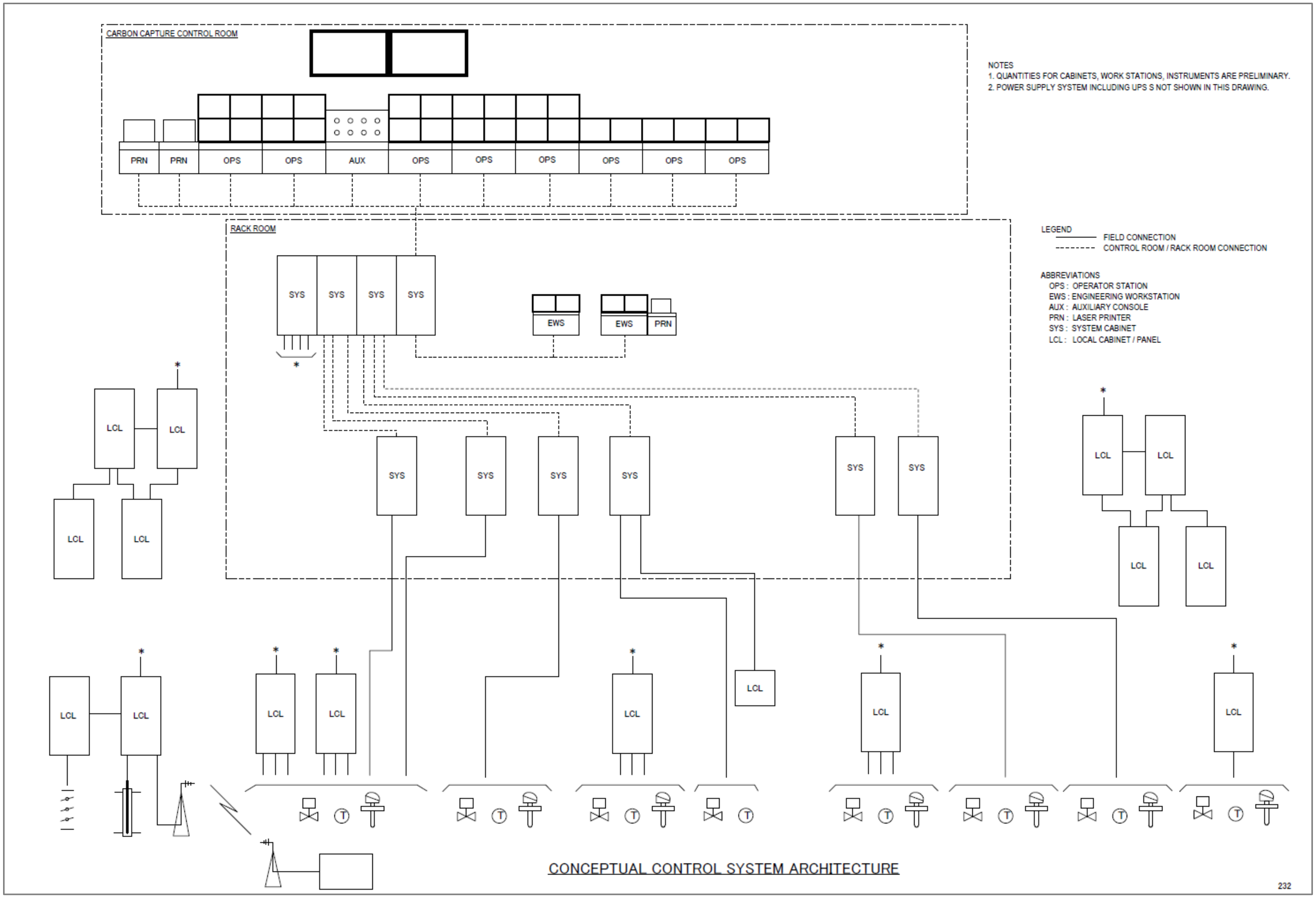

Figure 53. *Conceptual Control System Architecture*

Communications Infrastructure

The plant communication system consists of the following major components: control cabinet, call stations, amplifiers, horns, drivers, system cables, and junction boxes. The stations have been located in high traffic areas where communication with others may be required. The horns have been placed to provide full, outdoor coverage for areas within the plant.

Control Cabinet

The system includes a Control Cabinet for supervision of system components and operation integrity. The cabinet provides the ability to make public address announcements from call stations and emergency live voice paging during an alarm condition.

Call Station

The system utilizes nine outdoor and indoor, wall-mounted handset call stations. The handset and telephones have a system-wide paging capability. Plant personnel may make a page using the handset by lifting the station handset and depressing the page button. The plant also has six desktop indoor call stations placed in the admiration building with the same control as the wall mounted models.

Bi-Directional Loudspeaker

The admin building has two bi-directional loudspeakers designed for the reproduction and broadcast of voice communications and pre-recorded tones and speech messages. These assemblies can be mounted in the ceiling of the building.

Line Balance Assembly

The Line Balance Assembly has been designed to properly load both page and party line circuits of the communication system. The Line Balance Assembly can be used in single or multiple (up to five) party line systems.

Amplifiers

Each outdoor driver/horn assembly is installed with a standalone speaker amplifier that powers the assemblies. The configuration is a distributed amplifier system, which allows an amplifier to be removed for whatever reason without affecting the other speakers on the system. The system is also electrically paralleled allowing the system to be expanded by simply connecting a new station to the nearest existing station.

Horn and Driver Assemblies

The horns are designed for the reproduction and broadcast of voice communications and prerecorded tones and speech messages. Each horn has a compression driver associated with it. Mounting assemblies are provided to allow full vertical and horizontal adjustment. Horn volumes can be individually configured as needed.

Junction Boxes

Junction boxes will be placed throughout the plant as a means to branch power/communication cables to the horns, driver assemblies, and amplifiers. The quantity of junction boxes will be determined at a later time.

Fire Protection Engineering

Authority Having Jurisdiction

The Authority Having Jurisdiction (AHJ) is typically the building code official or the state or local Fire Marshal. The AHJ normally ensures that the applicable codes are followed and implemented into the design. The AHJ has the authority to omit code requirements and is involved in the design phase of the project. As the project is currently within a Front-End Engineering and Design (FEED) phase, the project AHJ has not been confirmed at this point, nor has any design coordination and/or discussions occurred with the AHJ at this time. However, the existing plant currently acts as their own AHJ, so design coordination and preliminary design basis items were reviewed with the PSGC team. As the project progresses toward detail design, coordination with the appropriately designated AHJ shall be required. Additional stakeholders in the development of the fire protection program are the Prairie State Generating Company (PSGC), the Owner's insurance carrier, and the responding fire department.

Building and Fire Codes

The editions of the applicable NFPA standards and other codes referenced throughout this section are listed below. In the event conflicts arise between the codes, standards of practice, specifications or manufacturer recommendations the most stringent code will apply.

- NFPA 10: Standard for Portable Fire Extinguishers (2018)
- NFPA 13: Standard for the Installation of Sprinkler Systems (2016)
- NFPA 14: Standard for the Installation of Standpipe and Hose Systems (2016)
- NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances (2019)
- NFPA 30: Flammable and Combustible Liquid Code (2018)
- NFPA 72: National Fire Alarm and Signaling Code (2019)
- NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems (2018)
- NFPA 214: Standard on Water-Cooling Towers (2016)
- NFPA 400: Hazardous Materials Code (2016 Edition)
- NFPA 850: Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations (2020)
- NFPA 1963: Fire Hose Connections (2019).

Methodology

All hazards were identified by reviewing the plot plans, MHI furnished equipment drawings and associated documentation, Design Basis Documents, and the general arrangement drawings. Relevant requirements pertaining to each hazard were identified and documented to include design documents such as Design Basis Document specifications; building and fire code requirements; and NFPA 850 recommendations; and other factors that impact the fire protection program.

Review of the facility against the IBC/IFC and NFPA 850 requires a coordinated review of occupancy classification (where applicable), location of hazards relative to other exposures, floor area, building height, and number of stories. These factors dictate the requirements that are necessary to comply with the codes and NFPA 850.

Occupancies

Occupancy classifications, where applicable, for the buildings throughout the site are based on the IBC. IBC Section 503.1.1 identifies that power plants are exempt from height and area limitation indicated in the tables of Chapter 5 of the IBC.

Chemical storage and use has containment and separation in accordance with the International Building and Fire Codes. Containment is in accordance with the maximum of either Chapter 50 of the IFC or NFPA 850 except as otherwise approved by the AHJ. Occupancies where the anticipated quantities of chemicals exceed the amounts permitted by the IBC/IFC are noted. Hazardous materials management plan and inventories are submitted under separate documents as information becomes available.

Fire Alarm System

A new fire alarm system is provided for the carbon capture system(s) (CCS) and BOP areas. The new fire alarm system is a proprietary supervising station system designed in accordance with NFPA 72. The main fire panel is located in the control room of the new Administration Building. The new main fire alarm control panel is not connected to the existing Facility fire alarm system, but interfaces with both independent BOP and CCS DCS systems via datalink for system monitoring purposes. The control room is constantly manned 24 hours a day, seven days a week.

Local control panels are located throughout the CCS and BOP facilities as required to monitor individual suppression and detection systems, to initiate required notification devices, and to monitor emergency alarm systems in areas classified as an ‘H’ occupancy, as applicable, in accordance with the IBC/IFC. The local control panels all report to the main CCS fire panel in such a way that should the communication be lost, they shall still operate in a stand-alone mode.

Water Supply

New underground fire protection piping is installed for the new facility to provide fire protection water to the various suppression systems and fire hydrants. Areas, buildings, enclosures, and structures protected with wet-pipe fire suppression systems are anticipated to be maintained above 40°F in accordance with NFPA. The new fire protection piping is completely independent of the facility's existing fire protection system and supplied by a new combined Service and Fire Water supply tank feeding redundant fire pumps. Two (2) 100% rated capacity fire pumps, one main electric motor driven and one backup diesel engine driven will supply the fire protection systems and hydrants. An electric motor jockey pump is installed to maintain system pressure. Each main pump will independently take suction from a combined service water/fire water storage tank and be enclosed within a new packaged pump enclosure. The OS&Y valve located within each pump suction will be electronically supervised by the fire alarm system. The new packaged fire pump house and all components are designed and installed in accordance with NFPA 20 and UL Listed for their intended use.

Currently the service water / fire water storage tank is sized to have a total capacity required to provide the minimum service water volume anticipated to supply two (2) hydrants flowing 500 gpm for a total volume of no less than 160,000 gallons of firewater. Final required fire water volume required based on fixed fire suppression system demands and or hydrant flows will be calculated during detailed design. The lower portion of the tank shall be dedicated for fire water storage. The tank is designed and installed per NFPA 22 to provide the necessary fire water storage for the most demanding fire suppression system, or combination of systems, that may activate during a single event per NFPA 850.

High density polyethylene (HDPE 4710) pipe system loops around the BOP and CCS areas, supplying water-based suppression systems and fire hydrants. A preliminary fire pump and fire water pipe sizing calculation will be completed during the FEED and therefore the document will be subsequently updated to reference a preliminary pump and pipe size that will require confirmation during detail design. The underground piping is designed, installed, and tested in accordance with NFPA 24. All joints are heat-fused connection, recognized by NFPA 24 as restrained joints. Thrust blocks are not provided. Post-indicating valves (PIV) are placed throughout the site loop in order to minimize system impairments should an event inhibit the ability of a section of the underground piping to convey water. The valves are to be locked in the "Open" position, with breakaway padlocks.

In accordance with NFPA 850, calculations for the available demand at the interface points for individual suppression systems assume that one fire pump is out of service and the hydraulically shortest leg of the new underground main is also out of service.

Fire hydrants are located throughout the site spaced at approximately 300 feet in accordance with NFPA 850.

Facilities Engineering

HVAC

General HVAC Design Criteria

Design Temperatures:

- ASHRAE Weather Station: Hunter Field, IL (WMO: 744653)
- Summer design dry bulb temperature: 95°F
- Summer design wet bulb temperature: 78°F
- Winter design temperature: -2.3°F.

Design Requirements:

1) Design shall be in accordance with ASHRAE standards. The HVAC systems shall be designed per applicable codes and shall be installed to provide an environment within the buildings suitable for continuous equipment operation.
2) These HVAC systems shall be designed to maintain proper levels of temperature, air movement, air removal, and fresh air supply.
3) The HVAC systems shall consist of unitary equipment for building heating, building ventilation for fresh air make-up and cooling, and direct expansion cooling-type air-conditioning as required.
4) The heat rejection of one unit shall not be directed to the inlet of another unit, the general arrangement of units shall maintain sufficient distance between units as directed by the manufacture.

5) Restrooms, janitor's closet, and lab spaces will maintain a negative pressure relative to adjacent spaces.
6) Exterior and interior air conditioning ductwork shall be insulated.
7) Air conditioning shall include both heating and cooling of the inlet filtered air.
8) All outdoor air in air-conditioned spaces shall be filtered with a MERV 8 filter.
9) Louvers shall be fixed and/or operable, with bird screens.
10) For redundant units the BAS shall automatically lead/lag the HVAC units on a seven-day schedule. In the event of an equipment failure, the BAS shall automatically transfer to the stand-by system.
11) All ductwork and piping that penetrates a fire wall shall include fire-rated sealant applicable to the fire rating of the wall that is being penetrated.
12) All buildings on site shall have a full BAS system with graphical floor plans along with individual sequences for each piece of operating equipment.
13) All HVAC alarms shall be connected to the central control room in the Control Building for remote monitoring.

Admin / Warehouse Building HVAC Design

Design Conditions and Load Assumptions:

a. The HVAC design conditions for the building area are based on the Internal Heat Gains, standard equipment and lighting loads, manufacturer cut sheets, process equipment heat rejections, and ASHRAE Handbook Fundamentals standard loads where Internal Heat Gains are not listed.

HVAC System Design:

a) The office portion of the building, which includes all offices except the Control room and DCS room shall be conditioned by two packaged air handler units, which include air filtration, DX cooling, and electric heating. The air handlers shall each have a supply fan with a variable frequency drive (VFD) and provide air to variable air volume (VAV) boxes with electric reheat. The packaged air handler will be mounted outside the building on the ground on an equipment housekeeping pad. Vestibules in the admin areas will be heated by wall mounted cabinet unit heaters.

b) The lab portion of the building shall be conditioned by a packaged unit with electric heating. The system shall be designed such that the sensible cooling capacity, NOT the total cooling capacity, will remain an ambient temperature within the laboratory between 65°F winter and 75°F summer at design conditions. The system shall be provided with an electronic, automatic changeover thermostat. HVAC unit shall be designed for the Fume Hood with exhaust fan to be in operation for twenty-four (24) hours a day. HVAC unit shall be designed for the Fume Hood sash with a design air flow of 525 cfm (1.5 ft sash height).

c) The Control room shall be conditioned by two 100% redundant computer room air conditioning units capable of providing year-round cooling. DCS room shall be conditioned by two 100% redundant computer room air conditioning units capable of providing year-round cooling. The units shall include DX cooling, air filtration and electric resistance heating coils. The units shall include integral controls (alarms) and thermostat.

d) The shop and warehouse ventilation design is based on removing space heat while maintaining a temperature rise of 15°F above the ambient outdoor design temperature listed in Section 6.1. Ventilation shall be provided through combination of horizontal intake storm (wind-driven rain) louver and motorized dampers, and air shall be exhausted through wall-mounted constant speed direct-drive axial exhaust fans with weather hood and motor operated dampers located high on the building nearest the eaves to minimize dead air at the roof level.

e) Heating in ventilation cooled spaces shall be provided by fan-driven, forced-air electric unit heaters with a separate fan speed switch, a factory-wired with integral thermostat to provide perimeter heating and maintain the space at minimum temperature. Unit heaters shall be UL listed and labeled with terminal box and controls. Permanently lubricate the motor with sleeve bearings.

f) A severe weather shelter will be located in the office portion of the building. Emergency ventilation will be provided for each space with FEMA storm louvers at each HVAC opening in the shelter.

g) A dedicated high plume laboratory exhaust fan shall provide exhaust for each fume hood in the laboratory. The Fume Hood with exhaust fan shall be designed to be resistant to chemicals. Exhaust air may contain small amount of chemical vapor such as amine. An air inlet damper or duct shall be provided to an outside safe location. Expected air flow; Intermittent (525cfm for fume hood). The fume hood shall be designed to maintain a face velocity of 100 feet per minute (fpm), +/- 20%, with the sash open 18 inches.

h) Fans and motors will be mounted on anti-vibration bases to isolate the units from the structure. Exposed fan outlets and inlets will be fitted with guards. Wire guards will be specified for belt-driven fans and arranged to enclose the pulleys and belts.

The ventilation rate for conditioned spaces will be per ASHRAE 62.1 standards. Type of HVAC Equipment:

a) Air Handling Unit (AHU)

b) Variable air volume (VAV) boxes

c) Computer room air conditioning (CRAC) unit

d) Dedicated Outdoor Air handling System (DOAS)

e) Cabinet unit heater (CUH)

f) Inline exhaust fan

g) Centrifugal exhaust fan

h) Laboratory fume hood

i) FEMA storm louvers

j) High plume laboratory exhaust fan

k) Louvers with control dampers

l) Axial wall-mount exhaust fans with hoods

m) Electric Unit Heaters (EUH)

HVAC Controls:

a) HVAC controls shall be provided from a centrally located control panel and alarm to the Control Room.

b) The HVAC controls shall include a graphical floor plan and Graphical User Interface (GUI) touch screen panel for control.

Water Treatment Building HVAC Design

Design Conditions and Load Assumptions:

a) The HVAC design conditions for the building area are based on standard equipment and lighting loads, manufacturer cut sheets, process equipment heat rejections, and ASHRAE Handbook Fundamentals standard loads where Internal Heat Gains are not listed.

HVAC System Design:

a) The ventilation design is based on removing space heat while maintaining a temperature rise of 15°F above the ambient outdoor design temperature. Ventilation shall be provided through combination of horizontal intake storm (wind-driven rain) louver and motorized dampers, and air shall be exhausted through wall-mounted constant speed direct-drive axial exhaust fans with weather hood and motor operated dampers located high on the building nearest the eaves to minimize dead air at the roof level.

b) Heating in ventilation cooled spaces shall be provided by fan-driven, forced-air electric unit heaters with a separate fan speed switch, a factory-wired with integral thermostat to provide perimeter heating and maintain the space at minimum temperature. Unit heaters shall be UL listed and labeled with terminal box and controls. Permanently lubricate the motor with sleeve bearings.

c) Makeup air shall be provided to the water treatment building by two 50% capacity outdoor ground mounted electric makeup air units. The makeup air unit shall be capable of providing makeup air to above freezing during cold ambient conditions to prevent localized freezing of equipment and piping systems inside the building.

Type of HVAC Equipment:

a) Louvers with control dampers

b) Axial wall-mount exhaust fans with hoods

c) Electric Unit Heaters (EUH)

d) Makeup Air Unit (MAU).

HVAC Controls:

a) HVAC controls shall be provided from a centrally located control panel and alarm to the central Control Room. DCS network wiring to the control room for all alarms shall be installed by plant contractor.

b) The HVAC controls shall include a graphical floor plan and Graphical User

c) Interface (GUI) touch screen panel for control

HVAC Design Standards / Reference

- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
- ASHRAE Handbooks
- ASHRAE 62.1
- IMC
- SMACNA HVAC Duct Construction Standards
- NFPA 90A.

Site Security

The facility will use several measures to maintain security. A six-foot-high security fencing will be required as the entire work area is located outside the existing plant perimeter fencing. Fencing shall be grounded as required. A primary entrance to the facility will have manned guard. Throughout the facility will be cameras on a closed-circuit system will monitor the facility.

Plant Layout and Construction Access

The new carbon capture facility will consist of the equipment shown in the Plot Plan. A "mirrored" arrangement was selected to allow the construction site to be grouped into smaller unitized areas. Each unit area contains identical process equipment and components to its "mirrored" counterpart area. This "mirrored" arrangement enhances design efficiency, minimizes quantities, and improves construction work area activity planning.

Constructability

Site Work

The new carbon capture facility is to be constructed on a greenfield site located northeast of the existing power generating station. The new carbon capture makeup water storage pond will be on a greenfield site located southwest of the existing power generation station. The new carbon capture ductwork system will be routed through the existing power generation station's northern coal pile area to the new carbon capture facility. The raw water river intake area modifications will be made to the Owner's raw water river intake pumphouse area near the Kaskaskia River.

Site Preparation

All existing site debris, structures, vehicles, trailers, and other deleterious non-native materials will be removed from the greenfield site prior to the start of construction activities. Construction will be responsible for clearing all trees, shrubs, and vegetation to the extent necessary to construct the new facility. Consideration will be given to drainage during construction to ensure that no low-lying areas are left that could accumulate water other than those specified by the Erosion and Sedimentation Control Plans.

Trenching and Excavation

Excavation work will consist of the removal of earth, sand, gravel, vegetation, organic matter, rock, boulders, and debris, etc. to the lines and grades necessary for construction of foundations and underground utilities. Topsoil and materials suitable for backfill will be stockpiled/stored at designated locations. The primary excavation method used on this project will be "bathtub" excavation. This type of excavation involves the removal of large amounts of material using heavy machinery to create a wider and deeper trench for improved personnel access, vehicle access, and equipment access. This allows material to be transported and installed within underground construction working areas in a simpler and more efficient manner.

Joint trenching (or common trenching) of underground pipe, electrical duct bank, and temporary construction power will be used to the greatest extent possible to avoid separate excavations and shortened dig durations. As a result, significant cost savings and schedule relief can be realized. Common trenching also makes it easier to locate underground utilities and know where not to dig for future property improvements.

Where design dictates, a soil treatment will be done in excavated areas to stabilize the ground for deep foundations that will be drilled under foundations.

Backfilling

Backfilling will be done in uniform layers of specified thickness in accordance with the project's approved geotechnical report. All off-site soil materials to be used as fill or backfill will be evaluated and properly conditioned in accordance with specifications and current environmental requirements. Density testing will be performed during backfill activities to verify compaction. Backfill sequencing will be planned based on construction area progress and access requirements.

Grading

Graded areas will be smooth, compacted, and free from irregular surface changes. Specific elevations will be graded to support crane and heavy haul activities. Due to poor ground conditions, Engineering will coordinate the expected surcharge loadings with the Project Design Engineer for the different types of equipment, vehicles, and cranes. This collaboration will allow the Project Design Engineer to design the necessary ground improvements prior to commencement of construction activities.

Roads and Parking

New Facility roads will be designed with appropriate clearances to accommodate traffic for construction, operation, and maintenance vehicles. Plant and laydown areas required to support cranes and other mobile equipment access will be provided with adequate bearing capacity to support expected loads. Crane mats or other materials will be used for additional support based on load size and site conditions at the time of construction. Construction parking will be provided in the designated parking area(s).

Temporary Construction Trailers

Temporary field office trailers and facilities will be selected to accommodate the minimum number of full-time construction field staff (excludes craft) and Owner Carbon Capture facility staff at any given time through completion of all construction and start-up activities. Each trailer will be provided with adequate heat, air conditioning, lights, toilet facilities, office furniture, at least one (1) conference room, telephone service, and broadband internet access. Field offices will be located in the reserved areas.

Temporary Power

The temporary power tie-in location supplies a minimum of 300 kVA for construction activities. Temporary power will be derived from the existing power generation station, or an alternate source will be identified and coordinated with the Owner prior to commencement of work. Upon completion of construction activities, the temporary power service will be converted to a permanent auxiliary and alternate backup power source for the new Facility's critical electrical systems.

Temporary Water

A source of temporary raw water for construction activities will be supplied from the existing power generation station to the new carbon capture facility via temporary piping. The existing power generation station's raw water supply location will be coordinated and agreed upon with the Owner prior to commencement of work. The temporary raw water location will need to supply a minimum of 500 gpm for non-potable water construction activities such as dust control operations, soil compaction work, and equipment washdown/cleaning activities. This connection may be located within the existing power generation station or an alternate source will be identified and coordinated with the Owner prior to commencement of work.

A separate source will be utilized for the permanent potable water for usage in the new Facility. The permanent potable water supply connection will be used for temporary construction trailers and work activities which require clean water.

Waste Disposal

The Project site will be kept free from waste materials or rubbish caused by construction activities to ensure a safe work environment. As soon as practicable, equipment and materials not constituted as part of the new Facility will be properly removed from site. This includes removal of all waste material and rubbish generated by construction activities to a permitted disposal facility in accordance with all applicable Laws, Codes, and Standards.

Construction Stormwater Management

Construction stormwater management includes the use of sumps with submersible pumps at various low point locations within excavated areas for dewatering control of surface runoff, storm water runoff, and/or construction groundwater. These sump pumps will discharge into the Stormwater Retention Pond(s) located within the new carbon capture facility's property boundary to protect the environment from contamination.

Pond water level will be controlled using a temporary effluent pumping system. Stormwater chemistry will be tested and approved prior to discharging to the agreed upon stormwater runoff ditch located between Laydown Areas "B" and "D". Pond water can be reclaimed for construction dust control operations by pumping the pond water into water trucks mounted with a water spray / dust suppression system.

Lay-down Areas

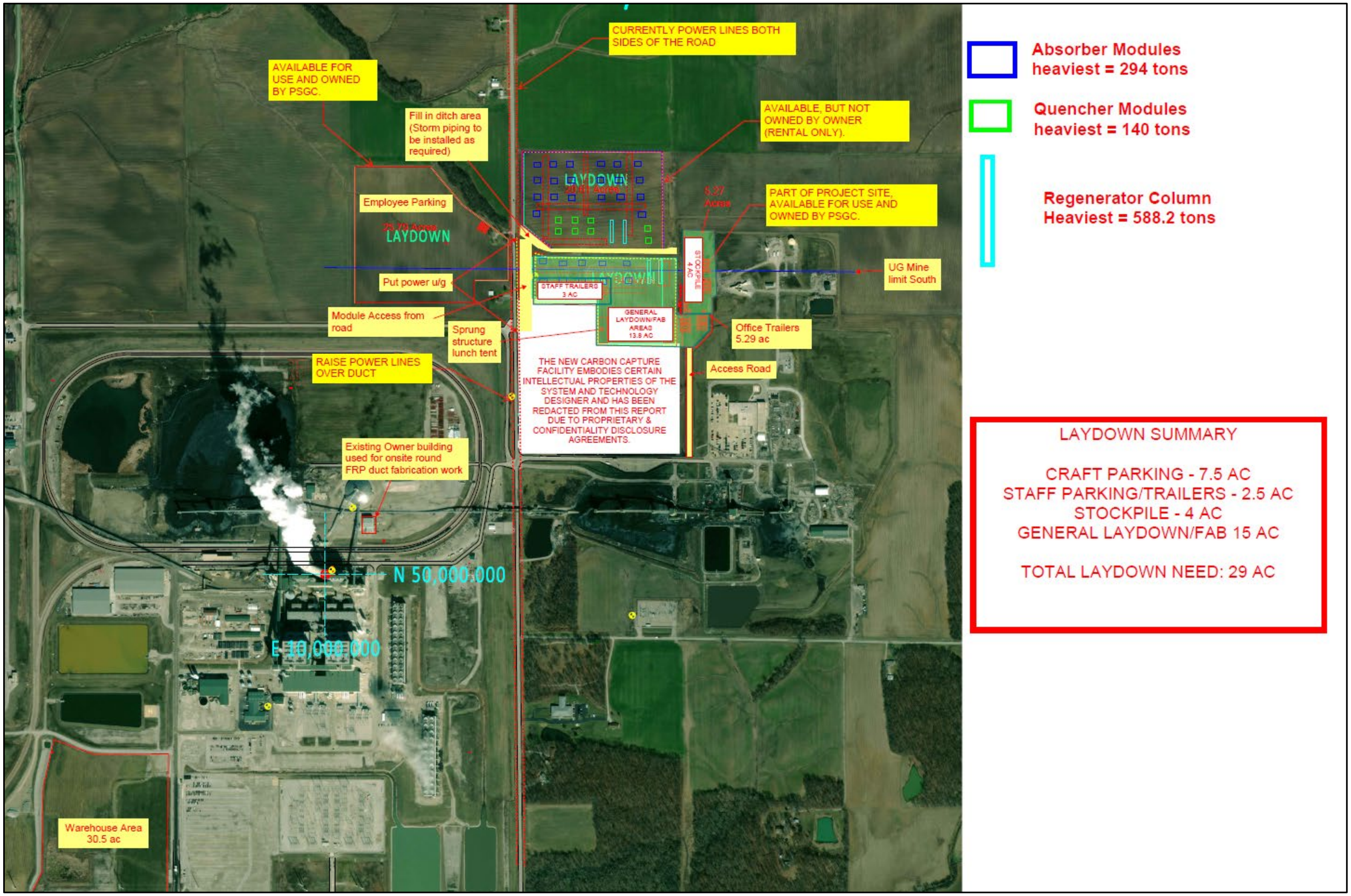

Figure 54. *Construction Laydown Locations*

Construction laydown areas will be provided on the site proper as shown in ***Figure 54*** – Construction Laydown Locations. These laydown areas will be used for storage, staging, parking, and miscellaneous equipment assembly tasks. The following summarizes the functional purpose of each Laydown Area.

- Laydown Area "A" – Reserved for construction parking, material storage, topsoil stock piling, and storage of small ancillary equipment.
- Laydown Area "B" – Reserved for short-term storage of sand, gravel, topsoil, and excavated material. This area will also be used for long term storage and pre-staging of large equipment and pipe rack modules. Of which, equipment will be "dressed" and preassembled with its shipped loose components to the greatest extent possible prior to installation. This will improve personnel safety by keeping as much work close to the ground as possible. Prior to the arrival of large pipe rack modules, the existing overhead transmission lines at the west property boundary between Laydown Area "B" and Highway 12 will need to be buried underground to achieve proper overhead clearances for equipment receiving.
- Laydown Area "C" – Reserved for short term construction material storage, topsoil stockpiling, and short-term storage of small ancillary equipment. Laydown Area "D" – Reserved for short term storage and final staging of large equipment, small ancillary equipment, and pipe rack modules. Area also used as primary site entrance access for construction vehicles. This area may be used to "dress" and pre-assemble equipment with its shipped loose components to the greatest extent possible prior to installation.
- Temporary Warehouse Laydown Yard – Small storage yard reserved for construction materials and ancillary equipment that are fully assembled and do not require pre-staging work.

A temporary warehouse structure will be erected in the abandoned contractor parking lot area located west of the current contractor parking lot in the southwest corner of the existing power generation station's campus. The temporary warehouse will be furnished with adequate climate control measures (where required), lights, telephone service, and broadband internet access for receiving and inventory control. The warehouse property will include a receiving area and small laydown yard for outdoor storage. Indoor storage will be reserved for equipment and components that must be protected from the weather, kept dry, or require special climate control measures.

Sequencing of construction work

Piping

Kiewit Engineering is able to accurately produce detailed piping isometric drawings for both large-bore and small-bore piping. The project team and stakeholders use these isometrics for bulk material take-offs, construction planning, fabrication scheduling, and build sequencing. Thus, improving overall project efficiencies and cost by allowing correct construction and resource estimations.

In general, field routed piping will be limited to localized small-bore piping and non-metallic piping systems. Metallic process piping will be pre-fabricated at an off-site controlled manufacturing environment to the greatest extent possible to minimize on-site logistical challenges, improve quality, reduce material over-runs, improve site safety, and lower construction costs. The pre-fabricated pipe spools will arrive onsite in a pre-planned delivery sequence that supports site installation need-by dates. Pipe construction sequencing will follow a bottom-up approach in which all underground piping will be delivered and installed first. Once above ground, piping will be delivered and installed per the construction work area need-by dates outlined in the project's construction schedule.

Equipment

Skid-mounted equipment systems will be used to the greatest extent possible on this project in lieu of a stick-build approach. Modularizing the equipment scope allows the process connections and equipment components to be designed, fabricated, and installed on a skid (frame) in a controlled environment at an offsite manufacturing facility. The packaged equipment will be transported to site as a complete unit and easily tied into the balance of plant's mechanical and electrical process connections. This "system in a box" approach reduces construction costs by improving construction schedule, build sequence planning, design efficiencies, safety, and quality control.

Pipe Rack Modularization (ISBL)

Pipe rack modularization allows for parallel construction of modules offsite at specialized fabrication facilities while the main site is under construction. The benefits of doing this include improved project efficiency, schedule, safety, quality, cost, and convenience. Each pipe rack module is a pre-designed and pre-fabricated steel structure mounted with process mechanical and electrical equipment, pipes, insulation, instrumentation, valves, and wiring. These pre-fabricated modules will be transported from the off-site fabricator's shop in separate pieces so that they can be assembled per the construction sequence plan. The below generalized construction sequencing approach will be used at site to complete installation of the pipe rack modules.

1) Prior to the arrival of modules, the existing overhead transmission lines at the west property boundary between Laydown Area and Highway 12 will be buried underground to achieve proper overhead clearances for module receiving access. This work will be coordinated ahead of time with the local electric utility company, the Owner, and other authorities having jurisdiction for advance planning of the power grid and mining impacts.
2) Top and bottom pipe rack module sections will be shipped by boat to the nearby receiving dock where they will be offloaded and transported to on-site Laydown Areas via heavy haul vehicles for pre-staging.
3) Top pipe rack module sections will be offloaded from heavy haul vehicles using construction cranes and set on temporary can supports for "dressing" and pre-assembly activities.
4) Bottom pipe rack module sections will remain on heavy haul vehicles during "dressing" and pre-assembly work.
5) Top module section will be lifted off of temporary cans by crane and attached to the corresponding bottom section that is sitting on the heavy haul transportation vehicles.
6) Where required, side-mounted temporary supports will be attached to the assembled top and bottom pipe rack modules that have center load transportation restrictions.

7) After pre-staging, fully assembled modules may be moved to a Laydown Area for short-term storage while final preparations are made for installation.
8) The heavy haul vehicles will transport the module assembly from the laydown area into final position.
9) Module assembly is offloaded from heavy haul equipment by cranes and set in alignment with the foundation's pre-cast anchor bolt holes for final installation work.
10) Repeat Steps 2 through 9 until pipe rack construction is complete. Module erection sequencing will follow a "bottom up" module assembly approach and "inside out" installation plan.

Project Cost Estimate (~ +/- 15%)

The EPC "overnight" Kiewit/MHI project capital cost estimate (+/-15%) of the Prairie State Generating Station Carbon Capture Facility is $2,044,465,000 based on the 95% carbon capture rate[1] producing 25,760 ston/day at 90% capacity factor (CF). This cost estimate is based on an overnight date in Q4 2021 with material pricing current as of November 2021. This cost is for the carbon capture facility and excludes the downstream CO_2 transport and storage (T&S).

The Operating and Maintenance (O&M) costs of the carbon capture facility are estimated at $175,955,928 annually. Refer to the O&M calculation (20032410-SDY-003) for the basis of costs. The Cost of CO_2 Capture is $39.33/metric tonne of CO_2 based on levelized costs for 30 years of operation, 85% capacity factor and includes Interest on Debt and Return on Equity During Operation.

Project Cost of Capture

Calculating Cost of Capture

Cost of Capture (COC) includes costs incurred during the construction phase and throughout the life of the project including costs to finance the project through construction and debt service through the operation of the plant. The sum of Levelized Capital Costs (LCC) and first year operating costs are divided by the nominal carbon captured, in metric tonnes, over the first year.

[1] *Note: The carbon capture rate is defined as the percentage of stack CO_2 captured.*

$$COC = \frac{LCC + First\ Year\ Operating\ Costs}{Nominal\ Facility\ Rating\ x\ 365} \quad \textbf{\textit{(Equation 1)}}$$

First Year Operating Costs: \$175,956,000 annual Operating and Maintenance (O&M) costs. Refer to the O&M Calculation (20032410-SDY-003) for the basis of costs.

Nominal Facility Rating: 25,760 short tons (23,369 metric tonnes) of CO_2 per day

- Includes CO_2 from host power plant and auxiliary boilers for carbon capture system.

Included in Cost Calculation:

- OSBL and ISBL costs per the Division of Responsibility (DOR)
- Operating Costs based on the O&M Cost Estimate
- Owner Costs
- 90% Capacity Factor.

Not Included:

- Property and Income Taxes
- Taxes on Capital Expenditures
- Insurance (on operating facility)
- CO_2 T&S Costs
- Site-Specific Costs.

Calculating Levelized Capital Cost

Normalized Total Capital Cost (NTCC) comprises the entire EPC scope and assumes the project is executed under a consortium agreement between Kiewit and MHI as outlined in the Division of Responsibility (DOR). NTCC is an overnight cost which has been normalized by removing \$155 million of site-specific costs[2] to allow for comparison to generic cost assessments.

Owner Costs (OC) include all owner expenditures before substantial completion not already included in the NTCC. This includes land, utility interconnections outside the EPC scope, inventory capital, non-

[2] *For example, a 15-mile pipeline routing cooling tower blowdown to the outfall, and a water storage pond for cooling tower makeup during drought conditions.*

construction consumables such as chemical feed during commissioning, electricity during construction through commissioning, fuel for startup through commissioning, permitting costs, legal fees, owner contingency, and operator labor for on-the-job training during commissioning. This also includes financing costs, including costs to close and fees but not including interest during construction. OC is an overnight cost calculated as follows:

- Land, permitting costs, legal fees, owners engineer costs, owner contingency, financing costs (w/o interest), and any other owner costs have been approximated as 10% of NTCC[3]. CO_2 T&S costs are not included.
- See the O&M Calculation (20032410-SDY-003) for annual operating costs of consumables, fuel, electricity, and labor during plant operation.

Thus, for the purposes of this study, OC is approximated by the following formula:

$$OC = (Consumables) + (Labor) + (Electric) + (Fuel) + (Other\ Owner\ Costs) \qquad \textit{(Equation 2)}$$

Where,

Consumables = 6 Months of Consumable costs (excluding KS-21 and first fills by Contractor)

Labor = 6 Months of Operator Labor costs

Electric = Electric consumption costs for construction though commissioning

Fuel = Fuel consumption costs for startup and commissioning

Other Owner Costs = 10% of NTCC

<u>Total Overnight Capital</u> (TOC) includes all "overnight" capital expense incurred during the capital expenditure period, except for escalation and interest during construction. This includes the EPC cost and other Owner Costs (OC). TOC is expressed in Q4 (2021) dollars.

$$TOC = OC + NTCC \qquad \textit{(Equation 3)}$$

[3] *NETL-PUB-22530 "Cost Estimation Methodology for NETL Assessments of Power Plant Performance" (February 2021) indicates 17.7% (15% + 2.7%) as typical, based on an EPCM model and including FEED study costs. This calculation has used 10% due to EPC being the expected delivery model (contractor carrying labor/material risk) and the project having already completed the FEED study.*

Total As-Spent Capital (TASC) includes the sum of all capital expenditures as they are incurred during the capital expenditure period for construction including their escalation and the cost of capital. See ***Table 28*** below for construction Return on Equity (ROE) and Cost of Debt assumptions. Real escalation is assumed to be zero (i.e., escalation equals inflation), so all dollar amounts stay the same as in the present year. TASC is expressed in mixed, current-year dollars over the entire capital expenditure period, which for this study is nominally four years. A multiplier must be calculated to convert TOC into TASC, which is calculated as follows:

$$\frac{TASC}{TOC} = Escalation + Cost\ of\ Funding \qquad \textbf{\textit{(Equation 4)}}$$

Where,

$$Escalation = \sum_{n=1}^{y_C}\left[(1+i)^{(n-1)} * \%Capital_n\right] \qquad \textbf{\textit{(Equation 5)}}$$

$$Cost\ of\ Funding = \sum_{n=1}^{y_C} WACC * (y_C - n + 1) * (1+i)^{(n-1)} * \%Capital_n \qquad \textbf{\textit{(Equation 6)}}$$

And,

n = the year of capital expenditure

y_C = total number of years of capital expenditure

i = assumed escalation rate for capital during the expenditure period

$\%Capital_n$ = percent of TOC expenditure for year n.

Taxes are disregarded in determining Weighted Average Cost of Capital during construction (WACC) because no revenue is generated during the capital expenditure period. Income taxes have been excluded and thus the same WACC applies for the operating period. WACC is calculated as follows:

$$WACC = \%Equity * \%Return\ on\ Equity + \%Debt * \%Cost\ of\ Debt \qquad \textbf{\textit{(Equation 7)}}$$

For this calculation, the financial structure shown in ***Table 28*** has been assumed. The debt-to-equity split, cost of debt, and ROE are based on NETL guidelines[4]. ***Table 29*** summarizes how spending is assumed to be nominally distributed over the capital expenditure period.

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[4] See NETL-PUB-22530 "Cost Estimation Methodology for NETL Assessments of Power Plant Performance" (February 2021), Exhibit 3-2 "Real" Rates.

Table 28. *Financial Structure*

Description	Assumption
% Debt	55%
% Cost of Debt	2.94%
% Equity	45%
% Return on Equity	7.84%
WACC	5.14%

Table 29. *Distribution of Capital Expenditure*

Year	Capital Expenditure
1	10%
2	40%
3	30%
4	20%

The TASC is multiplied by Fixed Charge Rate (FCR) to obtain the Levelized Capital Cost (LCC). For the purposes of calculating LCC, the Effective Tax Rate (ETR) is assumed to be 0%. FCR calculation Equation 8 has been simplified accordingly from the formulas provided in the NETL cost estimation guideline[5].

$$FCR = CRF = \frac{WACC*(1+WACC)^{y_O}}{(1+WACC)^{y_O}-1} \qquad \textbf{\textit{(Equation 8)}}$$

Where,

y_O = number of operating years

$$LCC = FCR * TASC \qquad \textbf{\textit{(Equation 9)}}$$

[5] *See NETL-PUB-22530 "Cost Estimation Methodology for NETL Assessments of Power Plant Performance" (February 2021), Equation 9 and Equation 10.*

Cost of Capture Summary

The cost of CO_2 capture is summarized in ***Table 30*** below. Results from the calculation and assumptions discussed above are shown compared to the result obtained when using 85% Capacity Factor and FCR to match the NETL 2019 Bituminous Baseline case B12B. The estimated construction schedule is outlined in ***Figure 55***.

Table 30. *Cost of CO_2 Capture*

Description	**As Calculated**	**CF & FCR to Match NETL B12B**
Base Year Dollars	Q4 2021$	Q4 2021$
Years of Operation, yr	30	30
Capital Expenditure Period, yr	4	4
Capture Rate, %	95%	95%
Capacity Factor (CF), %	90%	85%
CO_2 Transport and Storage (T&S), $	Excluded	Excluded
Site-Specific Costs, $	Excluded	Excluded
Normalized Total Capital Cost (NTCC)	$1,889,465,000	$1,889,465,000
Owner Costs (OC), $	$228,456,000	$228,456,000
Total Overnight Cost (TOC), $	$2,117,921,000	$2,117,921,000
Total As-Spent Cost (TASC), $	$2,379,442,000	$2,379,442,000
Fixed Charge Rate (FCR)	0.0661	0.0707
Levelized Cost of Capital (LCC), $/yr	$157,354,000	$168,227,000
Annual O&M Cost, $/yr	$175,956,000	$166,575,000
Total Annual Cost, $/yr	$333,310,000	$334,802,000
CO_2 Captured, metric tonne/year	7,676,700	7,250,200
Cost of Capture, $/metric tonne CO_2	**$43.42**	**$46.18**

Estimated Project Schedule

Kiewit

Prairie State - L1

Activity Name	Original Duration	Start	Finish
Prairie State CCS EPC	939	16-Aug-23	27-Apr-27
01. Project Milestones	939	16-Aug-23	27-Apr-27
High Voltage Modification Start	0		16-Aug-23*
LNTP	0		16-Aug-23*
EDC	0		16-Aug-23*
Construction Trailers Setup / Site Infrastructure Commence	0		09-Nov-23*
Owner Provided Utilities Available at Site	0		09-Nov-23*
FNTP	0		09-Nov-23*
Mobilize On Site	0		09-Nov-23*
High Voltage Line Modification Complete	0		21-May-25
Backfeed Power Available	0		02-Jan-26*
Mechanical Completion	0		02-Feb-27*
Substantial Completion	0		27-Apr-27*
02. HH High Voltage Modification	443	17-Aug-23	21-May-25
HH High Voltage Modification	443	17-Aug-23	21-May-25
03. Engineering	420	17-Aug-23	17-Apr-25
Kiewit Engineering	420	17-Aug-23	17-Apr-25
04. Procurement	623	12-Sep-23	04-Mar-26
Kiewit - Fab and Delivery	623	12-Sep-23	04-Mar-26
05. MHI Interface	706	15-Oct-23	02-Aug-26
MHI Engineering Interface	310	15-Oct-23	12-Jan-25
MHI Procurement Interface	405	28-Dec-24	02-Aug-26
06. Pond	238	05-Apr-24	19-Mar-25
Pond - Civil	238	05-Apr-24	19-Mar-25
07. Underground	408	09-Nov-23	31-Jul-25
UG - Civil	392	09-Nov-23	08-Jul-25
UG - Electrical	35	13-Jun-24	07-Aug-24
UG - Concrete	236	02-Aug-24	31-Jul-25
UG - Piping	206	06-Aug-24	17-Jun-25
08. Aboveground	512	02-Jan-25	01-Feb-27
AG - Steel	384	02-Jan-25	04-Aug-26
AG - Mechanical	427	23-Jan-25	27-Oct-26
AG - Piping	345	04-Jun-25	30-Oct-26
AG - Electrical	392	02-Jul-25	01-Feb-27
09. Start Up / Commissioning	277	09-Mar-26	31-Mar-27
Start Up / Commissioning	277	09-Mar-26	31-Mar-27

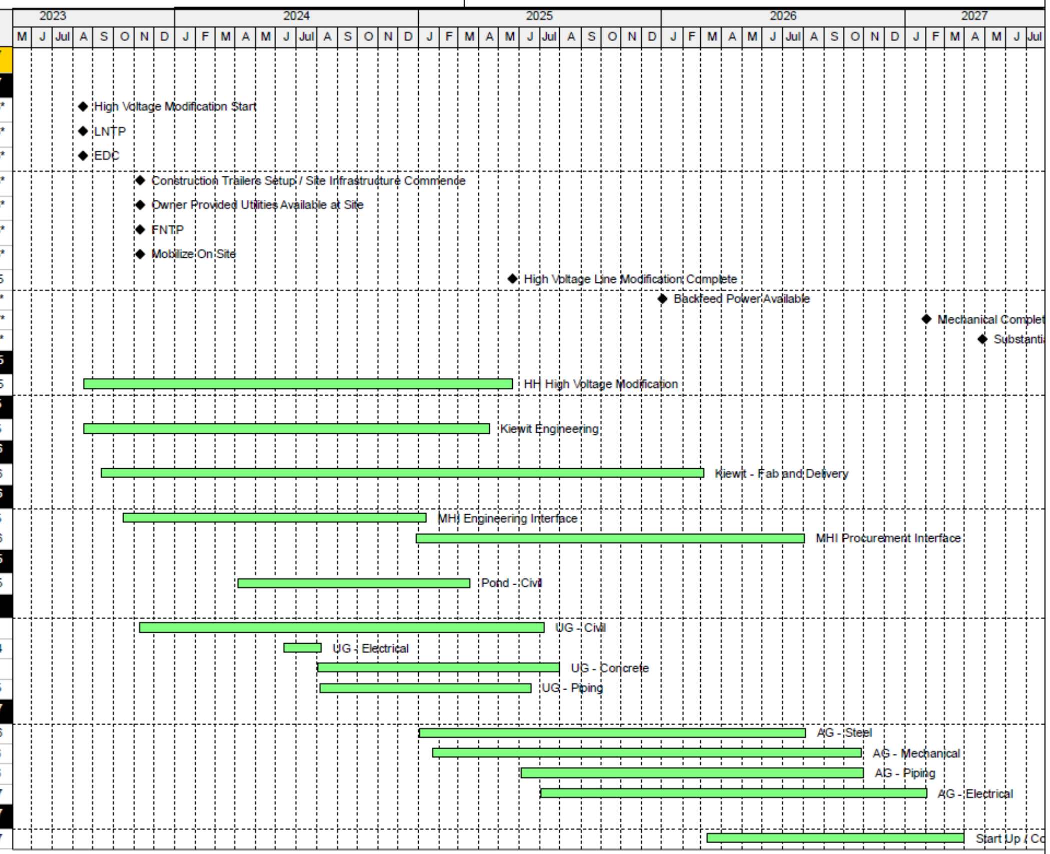

Figure 55. *Project Execution Schedule*