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AMERICAN® ELECTRIC POWER

SPECIFICATION COVER SHEET

TITLE: Order of Magnitude/Relative Capital Installed Cost Estimate Specification
SPECIFICATION NUMBER: BS2-FGDSCE-052010

PROJECT:	Big Sandy 2 – FGD Technology Selection
REVISION:	2
DATE:	September 24, 2010

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INTERNAL APPROVAL SIGNATURES

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0	Initial Release	TLH 5/20/2010

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1.0 PURPOSE

The purpose of this specification is to provide the high level design basis requirements for the Big Sandy Unit 2 FGD technology selection process, such that a 3rd party consultant can develop order of magnitude cost estimates for the following four technologies:

1) Wet FGD – Spray Tower & Wet Electrostatic Precipitator (ESP)
2) Dry FGD – Spray Dryer Absorber (SDA) & Fabric Filter (FF)
3) Integrated Air Quality Control System (IAQCS) -- SDA/FF & Wet FGD Spray Tower
4) Dry FGD – NID & Fabric Filter

As consideration for the cost estimates, it is the Owner's intent to install a FGD system that will meet the required performance specifications, operate with a high degree of availability and reliability, provide ease of access for maintenance, and require low maintenance during all modes of operation throughout the life of the facility.

2.0 TECHNICAL REQUIREMENTS

This section of the specification covers the high level design basis and performance requirements, as well as conceptual equipment arrangements for each technology and required unit operating conditions.

2.1 DESIGN BASIS & PERFORMANCE REQUIREMENTS

The following items establish the high level design basis requirements and performance requirements for the FGD technologies being considered.

2.1.1 DESIGN LIFE

It is the intention of the Owner to obtain a FGD System that shall operate safely, reliably and without excessive maintenance for a design life of 25 years.

2.1.2 [redacted]

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2.1.3 OTHER FLUE GAS EMISSIONS

The FGD technology must be able to remove flue gas emissions other than sulfur dioxide, such as sulfur trioxide, mercury, hydrochloric acid and hydrofluoric acid. For removal of these non-SO2 compounds, a Fabric Filter on a Dry FGD or a Wet ESP on a Wet FGD are considered to be equivalent or same relative order of magnitude for removal of these flue gas constituents.

[redacted]

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[redacted]

[redacted]

[redacted]

2.1.3.3 **HYDROCHLORIC AND HYDROFLUORIC ACIDS**

Both wet and dry FGD technologies are capable of achieving low outlet emission rates for hydrofluoric acid (HF) and hydrochloric acid (HCl). (Reference Carmeuse Natural Chemicals FGD FAQs).

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Dry FGD technologies rely on a neutralization reaction between the lime and HF or HCl to form solid products that are captured in the fabric filter. The Wet FGD relies on the solubility of HF and HCl and its absorption for removal in the spray tower.

2.1.4 SYSTEM PRESSURE DROP

The FGD System across the entire vendor supplied equipment shall be designed in such a way to minimize the flue gas pressure drop. Component design such as flow straightening devices, turning vanes, and rounded ductwork corners shall be utilized.

2.1.5 EQUIPMENT MODULARIZATION

In order to minimize field construction costs and on-site storage requirements, the FGD System shall be engineered to maximize the extent of off-site equipment fabrication and component modularization. Owner desires overall least-cost project that includes material/equipment, erection labor and professional services.

2.1.6 STANDARIZED EQUIPMENT

The Consultant shall consider to the greatest extent possible, standard sized equipment and arrangements (pumps, fans, motors, instruments, agitators, etc.) that gives the Owner the capability for interchangeable equipment and spare parts.

[redacted]

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Table 2.1.9A. Big Sandy Unit 2 Fuel Analysis – 1.7 lb/MMBtu SO2.

1.7 lb SO2/mmBTU

100% Central Appalachian Coal

Mine Name: Harris #1

Mine Location: Boone County, W. Va.

Seam Name: Eagle

Proximate Data:	As Received:	Dry Basis: (Calc)
% Moisture:	6.20%	
% Ash :	11.60%	12.37%
% Volatile Matter:	30.20%	32.20%
% Fixed Carbon:	52.00%	55.44%
Total Proximate:	100.00%	100.00%
% Sulfur:	0.94%	1.00%
BTU/#:	12,242	13,521
Moist.-Ash-Free BTU/#:	14893	Ultimate subtotal:
Grindability:	45	

Ultimate:	Dry Basis:	As Rcvd: (Calc)
% Carbon:	74.00%	69.41%
% Hydrogen:	5.00%	4.69%
% Nitrogen:	1.40%	1.31%
% Chlorine:	0.20%	0.19%
% Moisture:		6.20%
% Ash:	12.37%	11.60%
% Sulfur:	1.00%	0.94%
	94.34%	
% Oxygen by Diff.:	6.03%	5.66%
% Total:	100.00%	100.00%

SO2/mmBTU: 1.48

Mineral Ash Data:	Dry Basis		SO3 Free Basis
% SiO_2:	56.50%		56.90%
% Al_2O_3:	28.40%		28.60%
% TiO_2:	1.30%	86.20%	1.31%
% Fe_2O_3:	6.50%		6.55%
% CaO:	0.80%		0.81%
% MgO:	1.30%		1.31%
% K_2O:	3.78%		3.81%
% Na_2O:	0.47%	12.85%	0.47%
% SO_3:	0.70%		
% P_2O_5:	0.10%		0.10%
% SrO:	0.05%		0.05%
% BaO:	0.08%		0.08%
% MnO_2:	0.02%		0.02%
% Undetermined:	0.00%		

Ash Fusion Temperature Data:	
Reducing Temperatures:	
Initial Deformation (ID):	2680
Softening (H=W):	2700
Hemispherical (H=1/2W):	2700
Fluid (Fl):	2700
Oxidizing Temperatures:	
Initial Deformation (ID):	2700
Softening (H=W):	2700
Hemispherical (H=1/2W):	2700
Fluid (Fl):	2700
Other Data:	
T250 Temperature:	2880
Free Swelling Index:	7.50
Sulfur Forms:	
% Pyritic:	0.20
% Sulfate:	0.01
% Organic:	0.70
Equilibrium Moisture %:	1.80

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Table 2.1.9B. Big Sandy Unit 2 Fuel Analysis – 3.0 lb/MMBtu SO2.

3.0 lb SO2/mmBTU

63% Central Appalachian Coal / 37% Illinois Blend

Mine Name: 63% Harris #1 / 37% Radio Hill

Proximate Data:	As Received:	Dry Basis: (Calc)	Ultimate:	Dry Basis:	As Rcvd: (Calc)
% Moisture:	8.35		% Carbon:	73.15%	67.04%
% Ash :	10.31%	11.25%	% Hydrogen:	4.98%	4.56%
% Volatile Matter:	33.30%	36.33%	% Nitrogen:	1.44%	1.32%
% Fixed Carbon:	48.04%	52.41%	% Chlorine:	0.13%	0.12%
Total Proximate:	100.00%	100.00%	% Moisture:		8.35%
% Sulfur:	1.81%	1.97%	% Ash:	11.25%	10.31%
BTU/#:	12007	13101	% Sulfur:	1.97%	1.81%
Moist.-Ash-Free BTU/#:	14,762	Ultimate subtotal:		90.82%	
Grindability:	47		% Oxygen by Diff.:	7.08%	6.49%
			% Total:	100.00%	100.00%

 # SO2/mmBTU: 3.01

Mineral Ash Data:	Dry Basis		SO3 Free Basis
% SiO_2:	52.99%		53.37%
% Al_2O_3:	25.96%		26.14%
% TiO_2:	1.24%	80.19%	1.25%
% Fe_2O_3:	12.73%		12.82%
% CaO:	1.15%		1.15%
% MgO:	1.11%		1.11%
% K_2O:	3.28%		3.31%
% Na_2O:	0.41%	18.67%	0.41%
% SO_3:	0.16%		
% P_2O_5:	0.09%		0.09%
% SrO:	0.%		0.%
% BaO:	0.%		0.%
% MnO_2:	0.%		0.%

Ash Fusion Temperature Data: Reducing Temperatures:	
Initial Deformation (ID):	2473
Softening (H=W):	2496
Hemispherical (H=1/2W):	2540
Fluid (Fl):	2589
Other Data:	
T250 Temperature:	2681

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Table 2.1.9C. Big Sandy Unit 2 Fuel Analysis – 4.5 lb/MMBtu SO2.

4.5 lb SO2/mmBTU

45% Central Appalachian Coal / 55% Northern Appalachian Blend

Mine Name: 45% Harris #1 / 55% McElroy

Proximate Data:	As Received:	Dry Basis: (Calc)
% Moisture:	6.63%	
% Ash :	9.89%	10.59%
% Volatile Matter:	36.15%	38.72%
% Fixed Carbon:	47.33%	50.69%
Total Proximate:	100.00%	100.00%
% Sulfur:	2.69%	2.88%
BTU/#:	12,490	13,376
Moist.-Ash-Free BTU/#:	14,962	
Grindability:	49	

Ultimate:	Dry Basis:	As Rcvd: (Calc)
% Carbon:	74.25%	69.33%
% Hydrogen:	5.00%	4.67%
% Nitrogen:	1.43%	1.34%
% Chlorine:	0.05%	0.05%
% Moisture:		6.63%
% Ash:	10.59%	9.89%
% Sulfur:	2.88%	2.69%
Ultimate subtotal:		94.59%
% Oxygen by Diff.:	5.80%	5.41%
% Total:	100.00%	100.00%

SO2/mmBTU: 4.31

Mineral Ash Data:	Dry Basis		SO3 Free Basis
% SiO_2:	40.59%		41.55%
% Al_2O_3:	20.76%		21.25%
% TiO_2:	0.93%	62.28%	0.95%
% Fe_2O_3:	28.56%		29.24%
% CaO:	2.72%		2.78%
% MgO:	0.72%		0.74%
% K_2O:	1.67%		1.71%
% Na_2O:	0.46%	34.13%	0.47%
% SO_3:	2.32%		
% P_2O_5:	0.46%		0.47%
% SrO:	0.00%		0.00%
% BaO:	0.00%		0.00%
% MnO_2:	0.00%		0.00%
% Undetermined:	0.81%		

Ash Fusion Temperature Data: Reducing Temperatures:	
Initial Deformation (ID):	2265
Softening (H=W):	2310
Hemispherical (H=1/2W):	2395
Fluid (Fl):	2484
Other Data:	
T250 Temperature:	2285

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Table 2.1.9D. Big Sandy Unit 2 Fuel Analysis – 7.5 lb/MMBtu SO2.

7.5 lb SO2/mmBTU

100% Northern Appalachian Coal

Coal Company:	Consolidated Energy
Region:	Northern Appalachian
Mine Name:	McElroy
Seam Name:	Pittsburgh #8

Proximate Data:	As Received:	Dry Basis: (Calc)
% Moisture:	6.73%	
% Ash :	10.40%	11.15%
% Volatile Matter:	37.10%	39.78%
% Fixed Carbon:	46.59%	49.95%
Total Proximate:	100.82%	100.88%
% Sulfur:	4.02%	4.31%
BTU/#:	12,390	13,284
Moist.-Ash-Free BTU/#:	14,951	Ultimate subtotal:
Grindability:	50	

Ultimate:	Dry Basis:	As Rcvd: (Calc)
% Carbon:	72.00%	67.15%
% Hydrogen:	5.10%	4.76%
% Nitrogen:	1.24%	1.16%
% Chlorine:	0.05%	0.05%
% Moisture:		6.73%
% Ash:	11.15%	10.40%
% Sulfur:	4.31%	4.02%
	94.26%	
% Oxygen by Diff.:	6.15%	5.74%
% Total:	100.00%	100.00%

SO2/mmBTU: 6.49

Mineral Ash Data:	Dry Basis		SO3 Free Basis
% SiO_2:	42.17%		42.41%
% Al_2O_3:	17.61%		17.71%
% TiO_2:	0.84%	60.62%	0.84%
% Fe_2O_3:	28.63%		28.79%
% CaO:	4.17%		4.19%
% MgO:	0.65%		0.65%
% K_2O:	1.51%		1.52%
% Na_2O:	0.48%	35.44%	0.48%
% SO_3:	0.56%		
% P_2O_5:	0.75%		0.75%
% SrO:	0.00%		0.00%
% BaO:	0.00%		0.00%
% MnO_2:	0.00%		0.00%
% Undetermined:	2.63%		

Ash Fusion Temperature Data:	
Reducing Temperatures:	
Initial Deformation (ID):	2010
Softening (H=W):	2050
Hemispherical (H=1/2W):	2175
Fluid (Fl):	2340
Oxidizing Temperatures:	
Initial Deformation (ID):	2490
Softening (H=W):	2530
Hemispherical (H=1/2W):	2550
Fluid (Fl):	2575
Other Data:	
T250 Temperature:	2270
Free Swelling Index:	0.00
Sulfur Forms:	
% Pyritic:	0.00
% Sulfate:	0.00
% Organic:	0.00
Equilibrium Moisture %:	0.00

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2.1.10 GENERATING UNIT / STEAM GENERATOR INFORMATION

Big Sandy Plant is located in Louisa, Kentucky along the Big Sandy River. The physical address is 23000 Highway 23, Louisa, KY 41230.

Road Access:	Entrance to the plant is from U.S. Route 23.
Rail Access:	CSX Transportation
Barge Access:	No; however barge access is available less than 10 miles away from the plant for construction purposes.

Big Sandy Unit 2

Full Load Firing Rate	8,180 million BTU/hr
Nominal Unit Rating (Gross / Net)	865 / 800 MW
Full Load Net Unit Heat Rate	10,225 BTU/kW-hr
Boiler Type	Pressurized Dry Bottom
Firing Method	Wall fired
[redacted]	
Annual Starts (Hot / Cold)	6 / 4
[redacted]	
Minimum Load Firing Rate	3,089 million BTU/hr
Minimum Load Net Unit Heat Rate	10,472 BTU/kW-hr
Unit Ramp Rate (SCR in/out of service)	5 / 10 MW/min
Air Heater Type	Ljungstrom Rotary Tri-Sector
Ignition Fuel	#2 Fuel Oil
Particulate Control Device	ESP (cold)
Combustion Control Devices	Low NO_x Burner
Other Emission Control Devices	SCR (High Dust, 2003)
Nominal Flue Gas O_2 @ Economizer Outlet	3.5 % (by volume – wet)
Max (upset) Flue Gas O_2 @ Economizer Outlet	4.5 % (by volume – wet)

The Big Sandy Unit 2 circulating water system is a closed loop system. Therefore, the circulating water is recycled and reused in the steam turbine condensers. The heat transferred to the circulating water in the condenser is rejected to the atmosphere by the evaporation process in the cooling tower.

The river water makeup intake structure at Big Sandy consists of two river intake systems: normal and backup.

The normal system has three vertical double suction type river water makeup pumps that are each rated for 10,000 gpm at 130' TDH and are driven by 400 HP, 1800 rpm, 550V motors. Normally two pumps operate to provide all the water needed for the plant and both cooling tower makeups.

The backup system has two vertical turbine type river water makeup pumps that are each rated for 6,750 gpm at 135' TDH and are driven by 200 HP, 1180 rpm, 550V motors. These backup pumps are used when dirty river conditions cause pluggage to the normal system intake strainers and prevent normal flow of water.

2.1.11 FLUE GAS CONDITIONS

The FGD System shall be designed to treat the expected nominal inlet flue gas conditions downstream of the existing dry side ESP at full load. The flue gas conditions without the existing dry side ESP will be the same with the exception of the particulate loading. See Table 2.1.11 for flue gas particulate loading without the existing dry side ESP.

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Big Sandy Unit 2

Volumetric Flow Rate [redacted]
Average Flue Gas Temperature 350 ° F
Flue Gas Particulate Loading [redacted]
Percent of Flue Gas Treated 100 %

[redacted]

Table 2.1.11. Flue Gas Conditions without the existing Dry ESP.

Flue Gas Conditions - Fly Ash Loading without Dry ESP.					
Sulfur	lb/MMBtu	1.7	3.0	4.5	7.5
High Heating Value	Btu/lb	12,242	12,007	12,490	12,390

[redacted]

[redacted]

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Wet FGD Spray Tower Reagent Properties

Limestone

Product 1 - Landfill Gypsum Product

	Buyer's Minimum Acceptable Standards	Seller's Guaranteed Quality Level (Min or Max)	Test Method
Total $CaCO_3$ (dry wt. %)	[redacted]	[redacted]	ASTM C1301 or ASTM C1271. Reference method ASTM C25, Section 17.
Total $MgCO_3$ (dry wt. %)			ASTM C1301 or ASTM C1271. Reference method ASTM C25, Section 18.
Total Insoluble Matter*			ASTM C25, Section 8
SiO_2 (dry wt. %)			ASTM C1301 or ASTM C1271. Reference method ASTM C25, Section 10
Total Mn (dry wt. %)			ASTM C1301 or ASTM C1271. Reference method ASTM C25, Section 10
Free Moisture (wt. %)			ASTM C25, Section 20.
Bond Work Index (kWh/ST)			EPRI Method B6
Size (inches) (excluding Cardinal Plant) Summer Months (Apr-Nov)			ASTM D422
Size (inches) (excluding Cardinal Plant) Winter Months (Dec-Mar)			ASTM D422
Size (inches) Cardinal Plant only			ASTM D422

*This value will include any insoluble calcium content.

Notes
1) All limestone shipments shall be prequalified to meet these specifications prior to shipment unless the recipient rescinds this requirement.
2) Barge shipments shall be prequalified on a three consecutive barge rolling average prior to shipment.

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Dry FGD SDA Reagent

Pebble Lime

Pebble Lime Reagent Properties

Proximate Analysis, Dry Basis	Units	Nominal	Range
Total Calcium Oxide, CaO	% by wt		
Total Magnesium Oxide, MgO	% by wt		
Inerts	% by wt		
CO2	% by wt		

Pebble Lime Reactivity Analysis

Lime Analysis, Reactivity Average	Average	Min	Max
3 Min Temp. Rise (°C)			
Slaking Rate (°C/min)			
Slaking Residue (% retained on 20 mesh)			

Pebble Lime Physical Analysis

Lime Analysis, Physical Analysis
Size:
Screen Size:
Bulk Density:
Angle of Repose:
Abrasiveness :

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Dry FGD NID Reagent

Crushed Lime

Crushed Lime Reagent Properties

Proximate Analysis, Dry Basis	Units	Range
Total Calcium Oxide, CaO	% by wt	[redacted]
Total Magnesium Oxide, MgO	% by wt	
Inerts	% by wt	
CO_2	% by wt	

Crushed Lime Reactivity Analysis

Lime Analysis, Reactivity Average	Average	Min	Max
3 Min Temp. Rise (°C)	[redacted]		
Slaking Rate (°C/minute)			
Slaking Residue (% remaining on 20 mesh)			

Crushed Lime Physical Analysis

Lime Analysis, Physical Analysis
Size: [redacted]
Screen Size: [redacted]
Bulk Density: [redacted]
Angle of Repose: [redacted]
Abrasiveness : [redacted]

[redacted]

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[redacted]

The normal water supply for process water to the FGD System shall be strained Big Sandy River water as defined by the ranges stated in the following tabulated data.

Table 2.1.13. Big Sandy River Water Analysis.

	Average	Range
Iron, Fe (mg/L)	1.00	0.5-5.39
Copper, Cu (ug/L)	5.43	2-10
Sulfate, SO4 (mg/L)	53.33	32-183
Total Hardness, as CaCO3 (mg/L)	153.14	96-260
Chloride, Cl (mg/L)	18.69	7.7-24
Conductivity @ 25 °C (umho)	450.53	210-697
TSS (mg/L)	178.81	6-1300
PH @ 25 °C	7.66	6-8.1
Aluminum	1.7	0.69-4.97
Manganese (mg/L)	0.11	0.08-0.22
Magnesium (mg/L)	48.82	15-83

[redacted]

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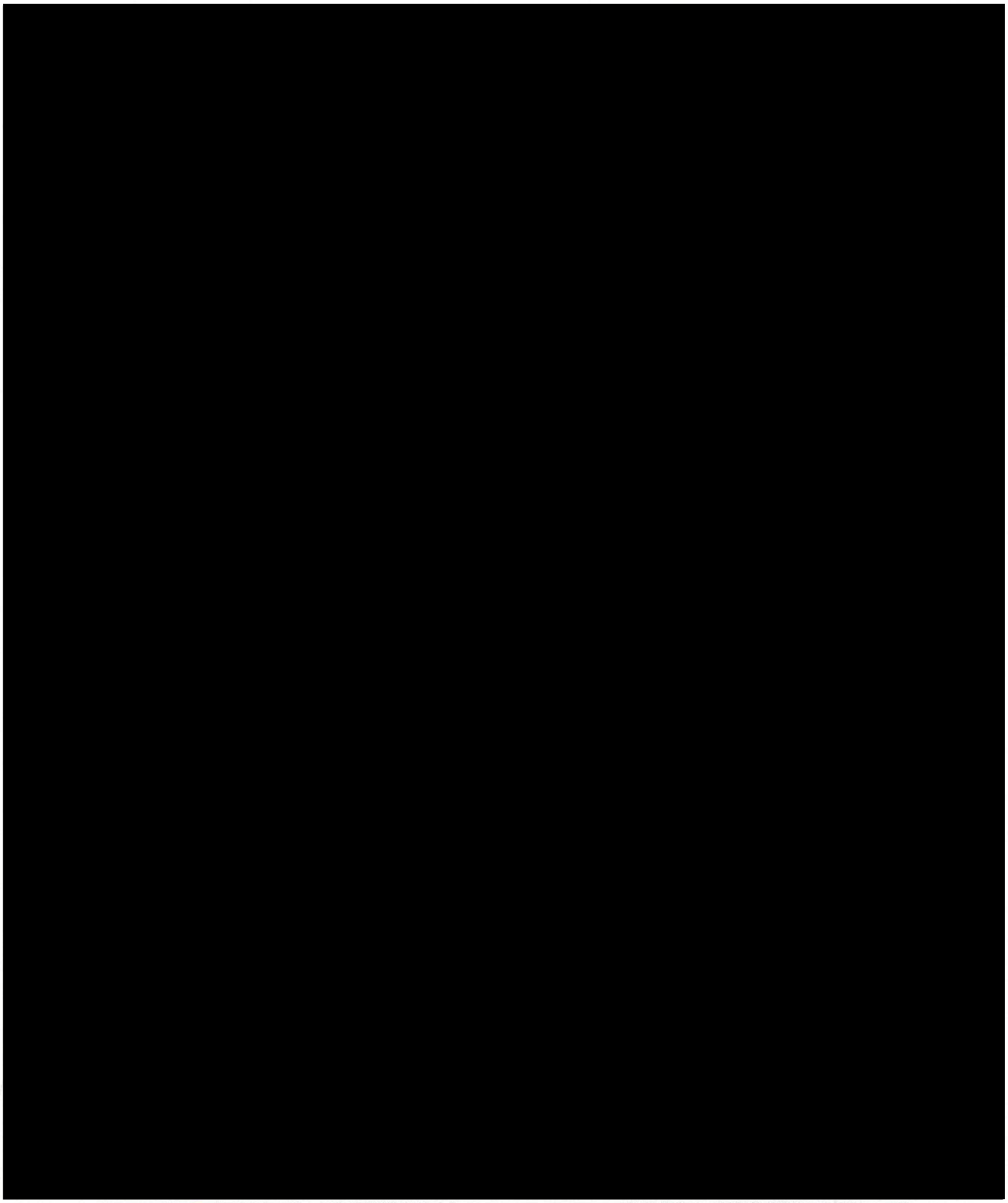

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[redacted]

Consultant shall utilize the Owner's discipline specific design criteria in the development of the cost estimates. For areas where these provided design criteria do not clearly address specific specifications and design criteria required to develop the cost estimates, the Owner intends to also utilize the Consultant's standard specifications and design criteria. Consultant's specifications and design criteria are expected to conform to typical Utility Industrial specifications and practices.

Listed below are the Owner provided discipline specific design criteria:

- [redacted]

2.1.16 AMBIENT NOISE EMISSIONS

Near field noise level from operating equipment shall not exceed 85 dBA (when measured 3 ft in the horizontal plane, and 5 feet above grade or personnel platform) whether from the single or surrounding area operating equipment. Far field noise shall not exceed the current preexisting noise level at the property fence line.

2.1.17 EQUIPMENT REDUNDANCY

Redundant equipment shall require that a stand-by installed spare is always available for service with equipment in normal operation and maintenance requirements. For example: 1) if two pumps are required to be in service at all times, a third installed pump is required to be a spare; 2) if two pumps are required to be in service at all times, but periodic/frequent removal of one pump for maintenance is required, then four pumps are required (2 operating, 1 in routine maintenance, 1 installed ready for service)

The following tables have been developed to communicate the Owner's equipment redundancy requirements for use in the development of the cost estimates.

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Process Area	Description	[redacted]	Capacity
Absorber	Absorber Module w/ agitator		
	ID Fan w/ dampers		
	Recycle Pump		
	Mist Eliminator Pump		
	Bleed Pump		
	Oxidation Air Blower		
	Wet ESP		
	Wet Stack Shell and Liner		
	Maintenance Storage Tank		
	Storm Water Pond		
Reagent Preparation	Limestone Unloading (Rail & Truck)		
	Limestone Reclaim		
	Limestone Emergency Reclaim		
	Limestone Conveyor		
	Limestone Silo w/ feeders		
	Ball Mill w/ Product Tank		
	Ball Mill Product Tank Pump		
	Ball Mill Hydrocyclone		
	Limestone Slurry Tank		
	Reagent Feed Pump		
	Limestone Slurry Loop		
	Service Water Tank		
	Service Water Pumps		
	River Water Booster Pumps		
Dewatering	Hydrocyclone Feed Tank		
	Hydrocyclone		
	Hydrocyclone Feed Pumps		
	Vacuum Belt with accessories		
	Gypsum Conveyor		
	Gypsum Stackout Conveyor		
	Reclaim Water Tank		
	Reclaim Water Pump		
FGD WWT	Equalization Tank		
	Desaturation Tank		
	Primary Clarifier		
	Coagulation Tank		
	Secondary Clarifier		
	Clearwater Sump		
	Clearwater Sump Pumps		
	Sludge Holding Tank		
	Filter Press		
	Transfer Pumps (typical all)		
	Wastewater Sump		
	Wastewater Sump Pumps		
Sumps and Sump pumps	Absorber Sump		
	Absorber Sump Pump		
	Dewatering Area Sump		
	Dewatering Ares Sump Pump		
	Reagent Area Sump		
	Reagent Area Sump Pumps		
Emergency Quench	Diesel Pump		
	Alternative - Fire Protection Tie		
H&V	Reagent Preparation Building		
	Absorber Building		
	Dewatering Building		
	FGD WWT Building		
	FGD Maintenance Shop		
HVAC	Electrical Building - MCC		
	Electrical Building - Ovation		
	FGD Operations Building		
	FGD Lab		
	FGD Control Room		

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[redacted]

Process Area	Description	[redacted]	Capacity %
Absorber	SDA	[redacted]	[redacted]
	Rotary Atomizers		
	Spare Rotary Atomizers including stand		
	Rotary Atomizer Lube System		
	Fabric Filter		
	ID Fan		
	Recycle Byproduct Silo		
	Dry Stack Shell and Liner (new)		
	Byproduct Recycle Silo Fluidizing Air blower		
	Byproduct Recycle Silo Conveying Blower		
	Byproduct Silo Fluidizing Blower		
	Byproduct Silo Pin Mixer		
	Byproduct Conveying Blower		
	SDA outlet hopper collection system		
	SDA outlet hopper enclosure		
	FF pulse air compressor and dryers		
	FF Broken Bag Detectors		
	Process Water Storage Basin		
	Storm Water Settling Pond		
	Process Water Storage Basin Sump		
	Process Water Storage Basin Sump Pumps		
	Byproduct Waste Silo Area Sump		
	Byproduct Waste Silo Area Sump Pumps		
	Recycle Byproduct Premix Tank		
	Recycle Byproduct Makeup Tank		
Reagent	Pebble Lime Silo		
	Pebble Lime Rotary Valve and Feeder		
	Lime Slaker w/ ventilation and grit screen		
	Lime Slurry Transfer Pumps		
	Lime Slurry Storage Tank		
	Lime Slurry Feed Loops and Pumps		
	SDA Feed Tank		
	SDA Feed Loop and Pumps		
	Recycle Area Sump		
	Recycle Area Sump Pumps		
	Reagent Prep Area Sump		
	Reagent Prep Area Sump Pumps		
H&V	Reagent Preparation Building		
	Fabric Filter		
	FGD Maintenance Shop		
	Byproduct Building		
	Byproduct Rec Silo Blower/Vacuum Building		
	SDA Enclosure		
	Air Compressor Building		
HVAC	Electrical Building - MCC		
	Electrical Building - Ovation		
	FGD Operations Building		
	FGD Control Room		
	FGD Lab		
	Byproduct waste control room		
	Lime unloading control room		
	SDA atomizers		

** n = the required number of pieces of equipment to maintain full load operation
* n-1 = the required number of pieces of equipment need to maintain full load operations without derating or impacting SO2 emission with one piece of equipment out of service.

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[redacted]

Process Area	Description	[redacted]	[redacted]
Wet FGD Absorber	Absorber Module w/ agitator		
	ID Fan w/ dampers		
	Recycle Pump		
	Mist Eliminator Pump		
	Bleed Pump		
	Oxidation Air Blower		
	Wet ESP		
	Wet Stack Shell and Liner		
	Maintenance Storage Tank		
	Storm Water Pond		
Wet FGD Reagent Preparation	Limestone Unloading (Rail & Truck)		
	Limestone Reclaim		
	Limestone Emergency Reclaim		
	Limestone Conveyor		
	Limestone Silo w/ feeders		
	Ball Mill w/ Product Tank		
	Ball Mill Product Tank Pump		
	Ball Mill Hydrocyclone		
	Limestone Slurry Tank		
	Reagent Feed Pump		
	Limestone Slurry Loop		
	Service Water Tank		
	Service Water Pumps		
	River Water Booster Pumps		
Wet FGD Dewatering	Hydrocyclone Feed Tank		
	Hydrocyclone		
	Hydrocyclone Feed Pumps		
	Vacuum Belt with accessories		
	Gypsum Conveyor		
	Gypsum Stackout Conveyor		
	Reclaim Water Tank		
	Reclaim Water Pump		
Dry FGD Absorber	SDA		
	Rotary Atomizers		
	Spare Rotary Atomizers including stand		
	Rotary Atomizer Lube System		
	Fabric Filter		
	ID Fan		
	Recycle Byproduct Silo		
	Dry Stack Shell and Liner (new)		
	Byproduct Recycle Silo Fluidizing Air blower		
	Byproduct Recycle Silo Conveying Blower		
	Byproduct Silo Fluidizing Blower		
	Byproduct Silo Pin Mixer		
	Byproduct Conveying Blower		
	SDA outlet hopper collection system		
	SDA outlet hopper enclosure		
	FF pulse air compressor and dryers		
	FF Broken Bag Detectors		
	Process Water Storage Basin		
	Storm Water Settling Pond		
	Process Water Storage Basin Sump		
	Process Water Storage Basin Sump Pumps		
	Byproduct Waste Silo Area Sump		
	Byproduct Waste Silo Area Sump Pumps		
	Recycle Byproduct Premix Tank		
	Recycle Byproduct Makeup Tank		
Dry FGD Reagent	Pebble Lime Silo		
	Pebble Lime Rotary Valve and Feeder		
	Lime Slaker w/ ventilation and grit screen		
	Lime Slurry Transfer Pumps		
	Lime Slurry Storage Tank		
	Lime Slurry Feed Loops and Pumps		
	SDA Feed Tank		
	SDA Feed Loop and Pumps		
	Recycle Area Sump		
	Recycle Area Sump Pumps		
	Reagent Prep Area Sump		
	Reagent Prep Area Sump Pumps		
Wet FGD Sumps/Sump pumps	Absorber Sump		
	Absorber Sump Pump		
	Dewatering Area Sump		
	Dewatering Ares Sump Pump		
	Reagent Area Sump		
	Reagent Area Sump Pumps		

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[redacted]

Process Area	Description	[redacted]	[redacted] %
Emergency Quench	Diesel Pump		
	Alternative - Fire Protection Tie		
H&V	Reagent Preparation Building		
	Absorber Building		
	Dewatering Building		
	FGD WWT Building		
	FGD Maintenance Shop		
	Fabric Filter		
	Byproduct Building		
	Byproduct Rec Silo Blower/Vacuum Building		
	SDA Enclosure		
	Air Compressor Building		
HVAC	Electrical Building - MCC		
	Electrical Building - Ovation		
	FGD Operations Building		
	FGD Lab		
	FGD Control Room		
	Byproduct waste control room		
	Lime unloading control room		
	SDA atomizers		

[redacted]

Process Area	Description	[redacted]	[redacted] %
NID/FF	J Reactor		
	Fabric Filter		
	Fluidizing Trough		
	Lime Hydrator		
	Lime/Byproduct Mixer		
	Crushed Lime Day Silo		
	NID Fluidizing Air Blowers & heaters		
	ID Fan		
	Dry Stack Shell and Liner (new)		
	Byproduct Waste Silo		
	Byproduct Waste Silo Fluidizing Air Blower &		
	Byproduct Waste Silo Pin Mixer		
	Byproduct Waste Conveying System		
	FF pulse air compressor		
	FF Broken Bag Detectors		
	Process Water Storage Basin		
	Byproduct Waste Silo Area Sump		
	Byproduct Waste Silo Area Sump Pumps		
	Storm Water Settling Pond		
Reagent	Crushed Lime Silo		
	Crushed Lime Conveying System		
	Reagent Prep Area Sump		
	Reagent Prep Area Sump Pumps		
H&V	NID Enclosure		
	Fabric Filter		
	FGD Maintenance Shop		
	Byproduct Building		
	Air Compressor Building		
HVAC	Electrical Building - MCC		
	Electrical Building - Ovation		
	FGD Operations Building		
	FGD Control Room		
	FGD Lab		
	Byproduct waste control room		
	Lime unloading control room		

** n = the required number of pieces of equipment to maintain full load operation
* n-1 = the required number of pieces of equipment needed to maintain full load operations without derating or impacting SO2 emission with one piece of equipment out of service.

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[redacted]

Landfill Ash and Byproduct					
Sulfur	lb/MMBtu	1.7	3.0	4.5	7.5

[redacted]

Landfill Ash and Byproduct			
Sulfur	lb/MMBtu	1.7	3.0

[redacted]

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[redacted]

Landfill Ash and Byproduct					
Sulfur	lb/MMBtu	1.7	3.0	4.5	7.5

[redacted]

[redacted]

Landfill Ash and Byproduct					
Sulfur	lb/MMBtu	1.7	3.0	4.5	7.5

[redacted]

[redacted]

2.1.20 EQUIPMENT MAINTENANCE ACCESS

Major motors and equipment shall be accessible for maintenance purposes such as platforms. Overhead cranes or monorails will be provided to facilitate removing and installing components. Buildings shall have access hatches in the operating floors to transport equipment up through the floor to the appropriate elevation. All valves will be remotely operated or accessible from platforms.

[redacted]

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[redacted]

2.1.22 **STORMWATER RUNOFF CONTROLS**

Stormwater shall be collected from all process islands in a stormwater settling pond before discharging to the river. Hard surfaces such as asphalt or concrete will be minimized to only plant roads and work areas (front end loader, operations). All other areas shall be crushed stone. All exposed steel, such as platforms, structural, roofing, etc shall not be galvanized. An inorganic zinc primer with two coats of acrylic paint shall be used.

2.1.23 [redacted]

2.1.23.1 **PEBBLE AND CRUSHED LIME SYSTEM**

The Pebble and Crushed Lime Unloading Systems are designed to unload vacuum pressure pneumatic railcars or positive displacement trailer trucks. The primary delivery mode for these systems will be by rail.

Major Rail Unloading Equipment:

- Air Exhauster System
- Filter Separator
- Exhauster Building & Electrical/Controls room
- Transport piping and associated fittings
- Concrete unloading slab
- Rail scale
- Rail sampling system
- Top of railcar access platform(s)
- Rail sidings to store full and empty railcars

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Major Truck Unloading Equipment:

- Truck Scale
- Truck sampling system
- Concrete unloading slab

Pebble and Crushed Lime Storage Silo:

- [redacted]
- Bin Vent Filter
- Stair tower/elevator
- Local operator's room
- Silo roof shall be fully enclosed.

2.1.23.2 **LIMESTONE SYSTEM**

The Limestone Unloading System is designed to unload gravity discharge hopper railcars or dump trucks. The primary delivery mode of Limestone will be by rail.

Major Limestone handling equipment:

- Under track dump hopper with belt conveyor(s) to feed limestone to the Storage Pile.
- [redacted]
- Rail sidings for full and empty railcars.
- Belt scale

2.1.23.3 **WASTE PRODUCT SYSTEM**

Dry FGD SDA, Dry FGD NID and IAQCS Byproduct

The Waste Byproduct Storage and Loading System are designed to store Waste Reagent and to condition/mix the waste reagent with water for loading into dump trucks for hauling to a waste landfill.

- One flat bottomed, concrete storage silo per unit will be provided to store Waste Reagent.
- [redacted]
- Volumetric storage sizing shall be based upon the loose Bulk Density of the Waste Reagent material, or a combined Waste Reagent and Fly Ash if commingled without an operating precipitator.
- [redacted]
- The truck loading area at the base of the storage silo shall be enclosed with rollup doors, water spray curtains, and a truck wash.

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- Silo to include Bin Vent Filter
- [redacted]
- Stair tower/elevator
- local operator's manbooth
- Truck scale

[redacted]

Fuel Sulfur	1.7	3.0	4.5	7.5	lb/MMBTU

[redacted]

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[redacted]

[redacted]		1.7	3.0	4.5	7.5	lb/MMBTU
[redacted]						
[redacted]						

[redacted]

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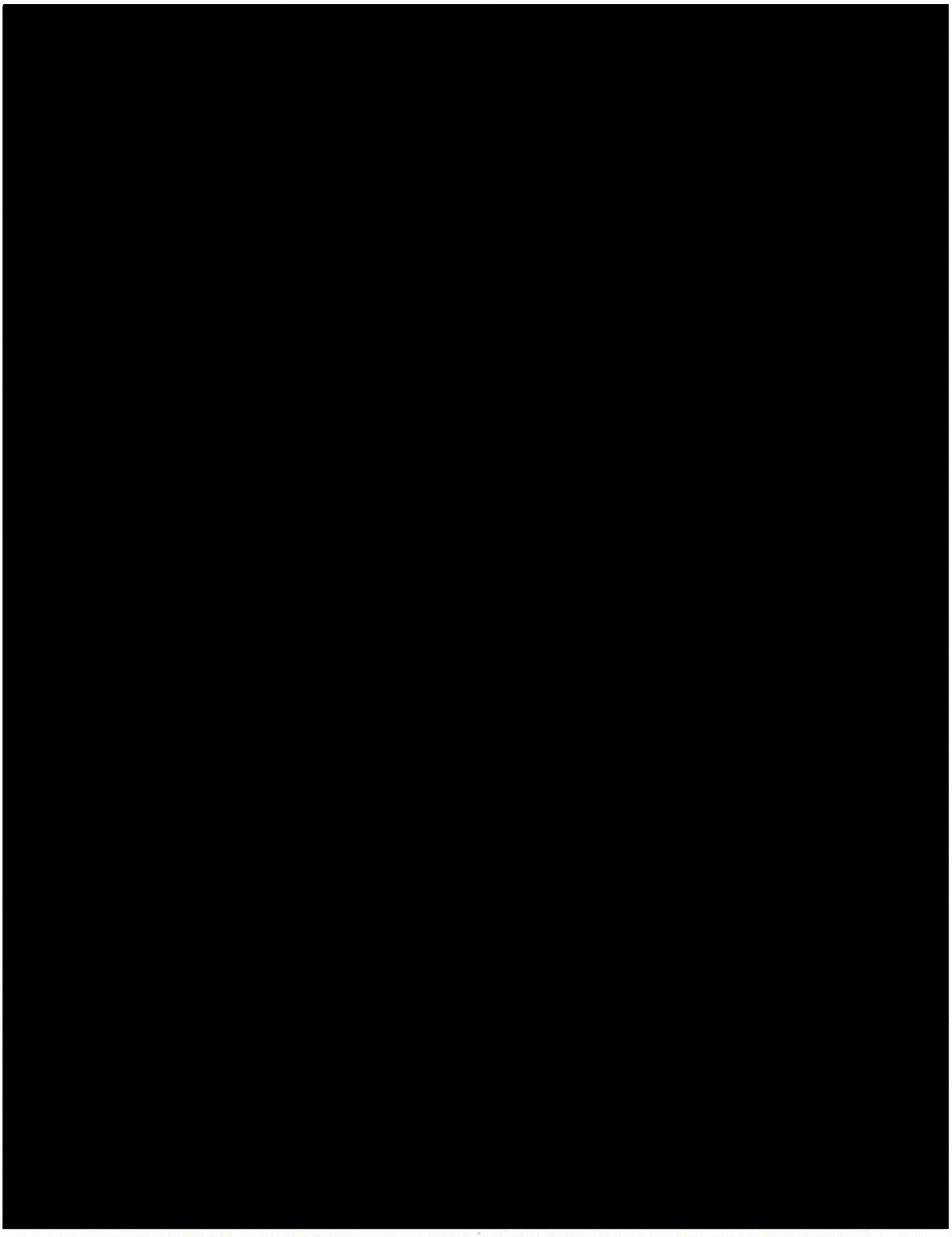

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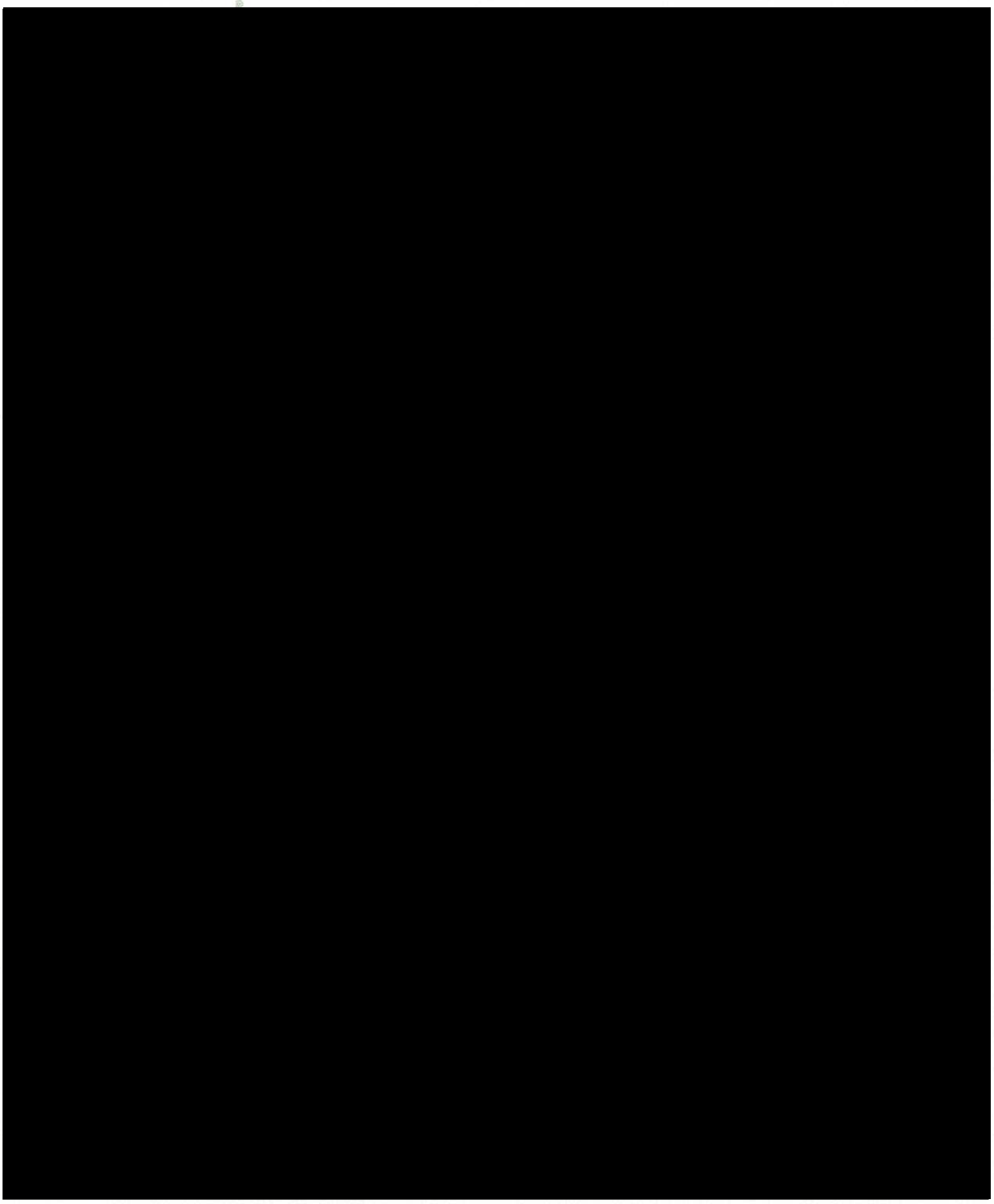

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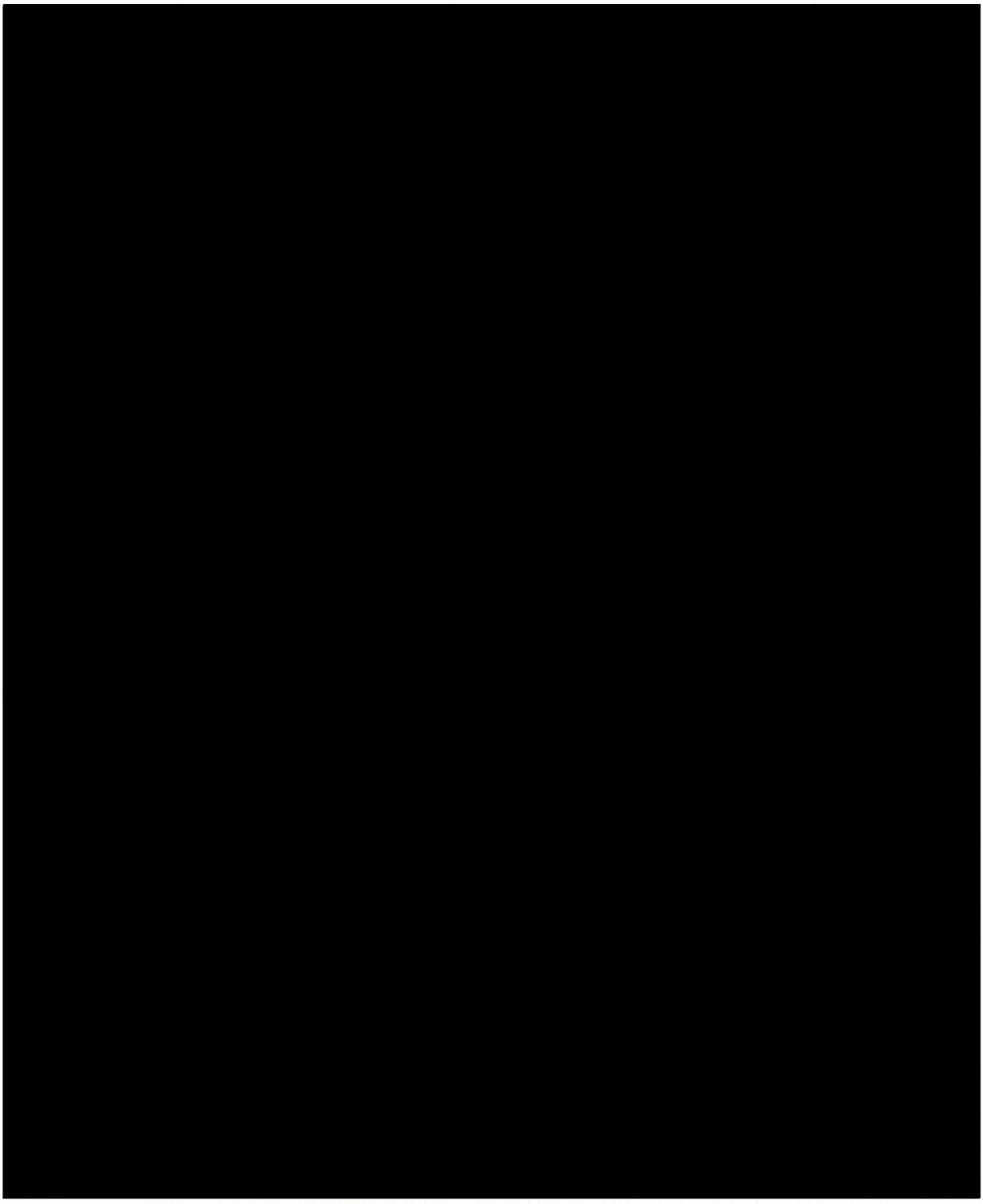

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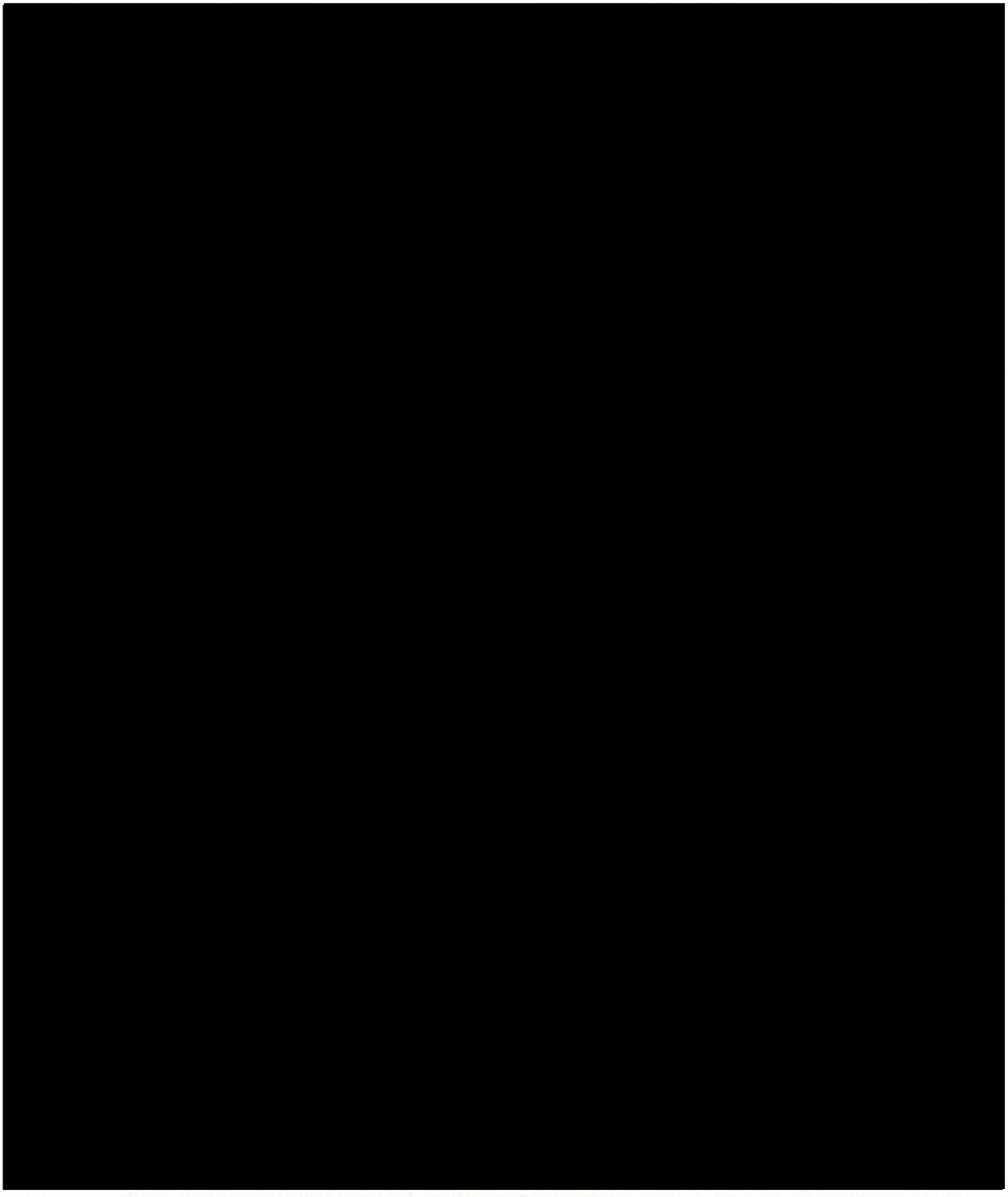

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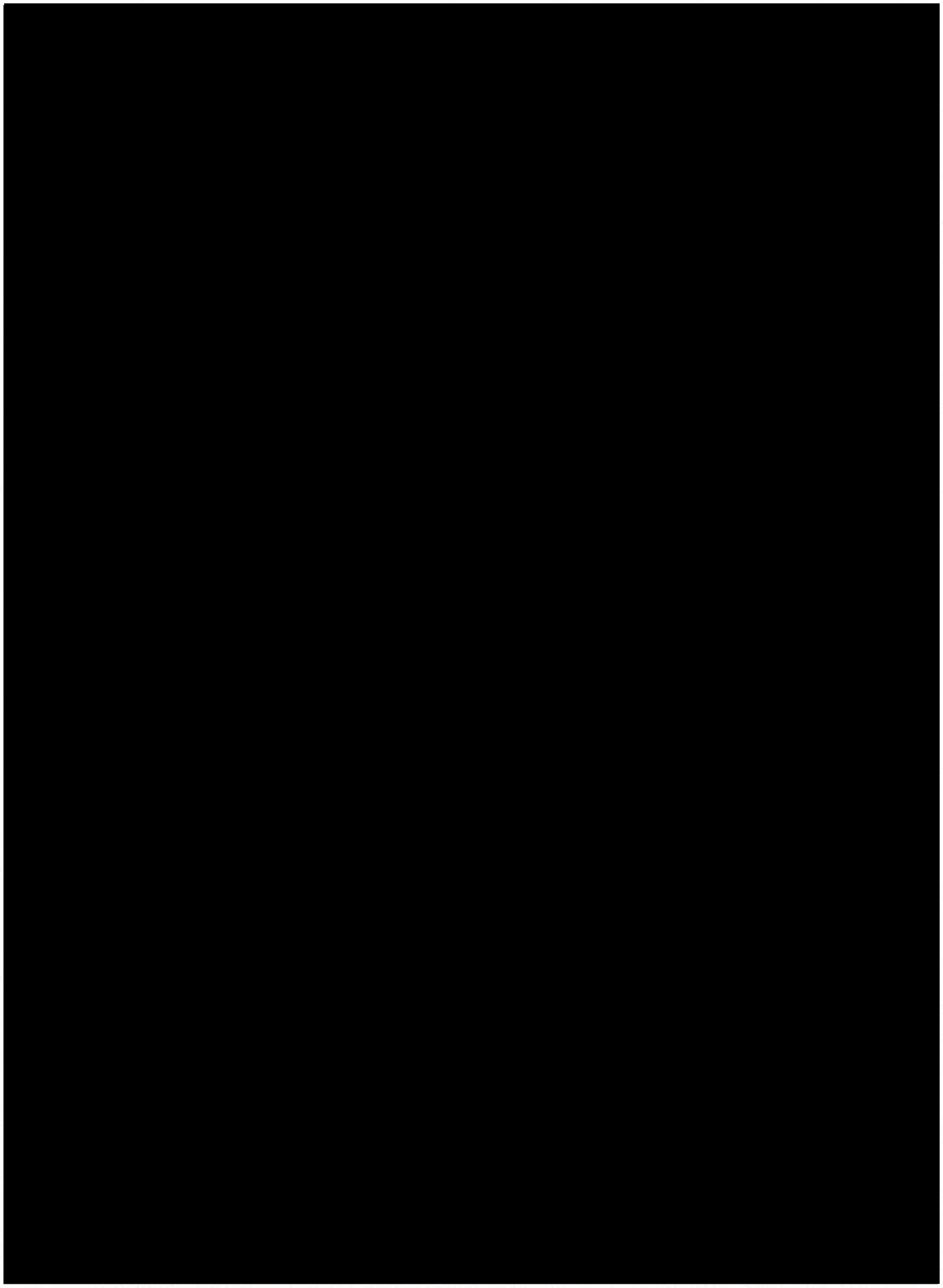

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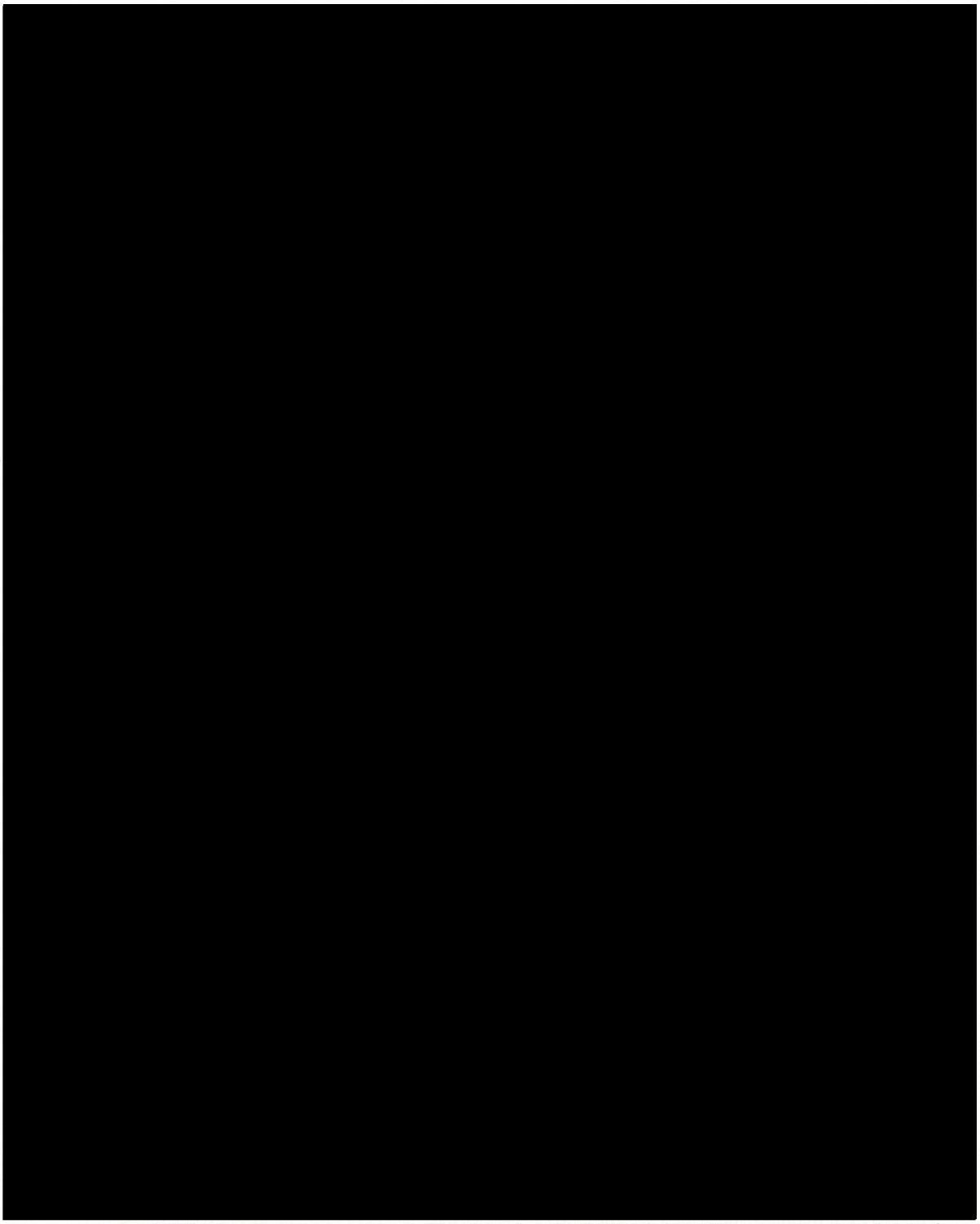

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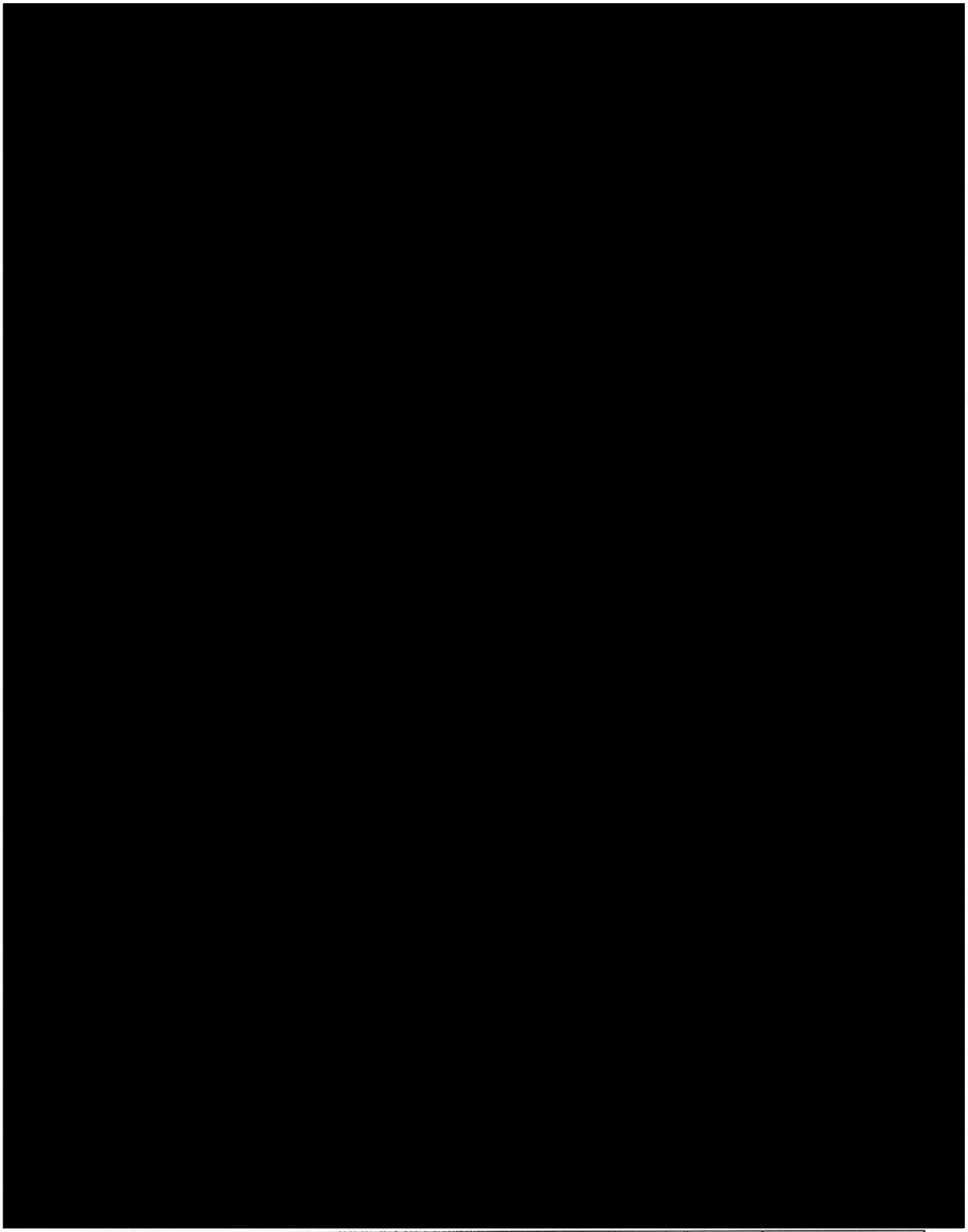

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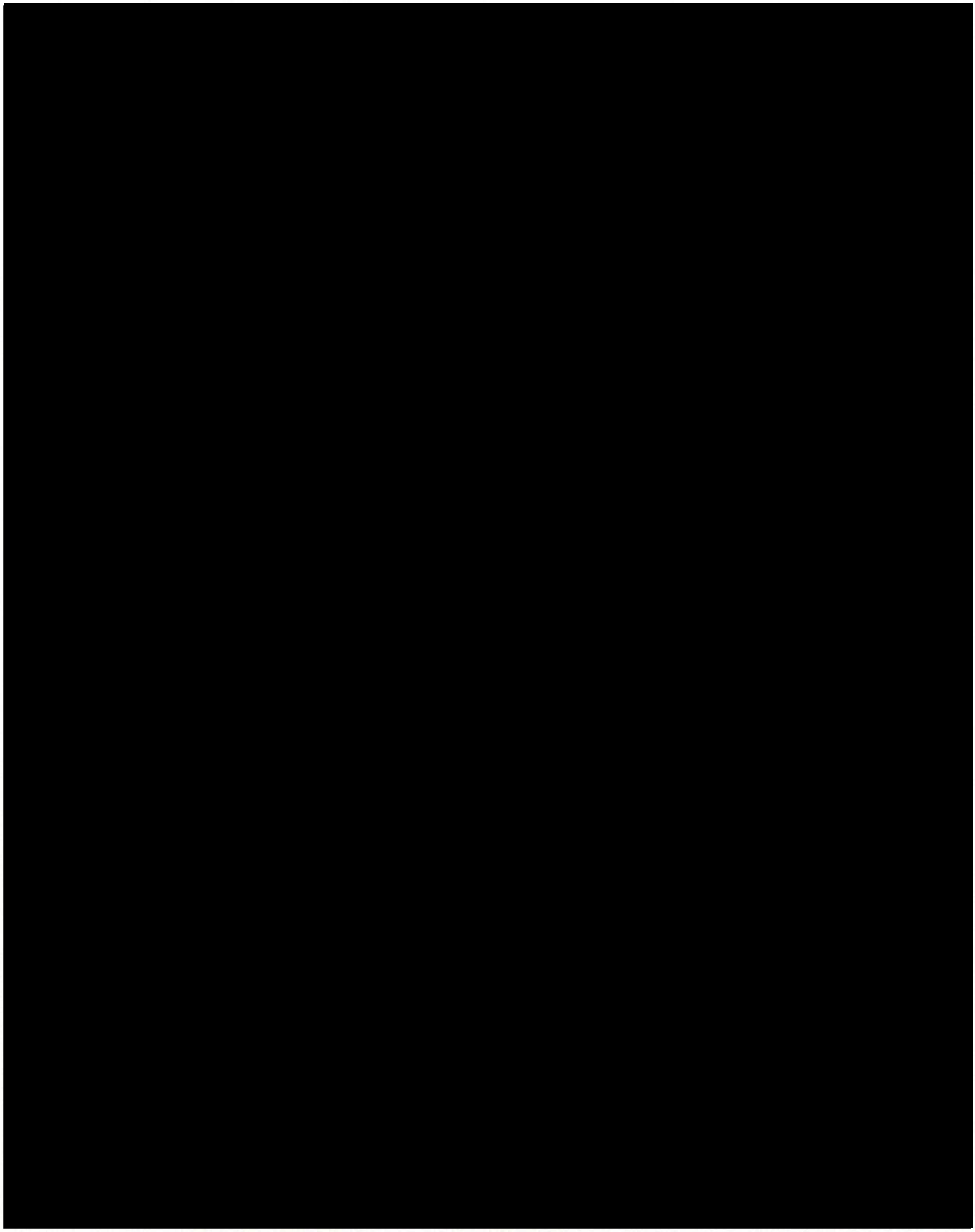

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[redacted]

2.3 OPERATING CONDITIONS

The FGD System shall be designed to operate under each of the following conditions without impeding the normal operation of the steam generator while continuously achieving the specified sulfur dioxide (SO_2) removal efficiency.

- During all periods of steam generator operation from initial start-up to full load.
- Continuous service at the maximum absorber inlet flue gas conditions.
- Continuous service at minimum load.
- During steam generator load swings from 33 to 100 percent of the maximum inlet flue gas flow rate.
- During extended periods of the steam generator start-up while burning No. 2 Fuel Oil, coal, or any combination thereof.
- Weekly start-up, following any weekend shutdown, which lasts approximately 48 hours.

The Owner anticipates that the following type of operating abnormalities may occur to varying degrees throughout the operating life of the plant. While specific design criteria for all possible conditions cannot be defined herein, the Consultant shall be aware of the Owner's concern and consequently make necessary design provisions to insure that the following potential abnormalities do not cause catastrophic failure to the FGD System equipment or its auxiliary equipment.

[redacted]

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2.4 SITE ENVIRONMENTAL CONDITIONS

The table below lists the general Big Sandy Plant site environmental conditions.

Table 2.4. Big Sandy Plant Site Environmental Conditions.

Condition	Value/Range
Plant Elevation at Grade	568 ft above sea level
Ambient Temperature Normal Range, °F	-20 to 97
Ambient Relative Humidity Range, %	25 to 100
Annual Average Temperature, °F	56.1
Annual Average Relative Humidity, %	70
Annual Average Summer Temperature, °F	74.3
Annual Average Winter Temperature, °F	37.5
Average Wind Velocity (mph)	6.7
Prevailing Wind Direction (Degrees)	186
Annual Average Precipitation (inches)	43.06

[redacted]

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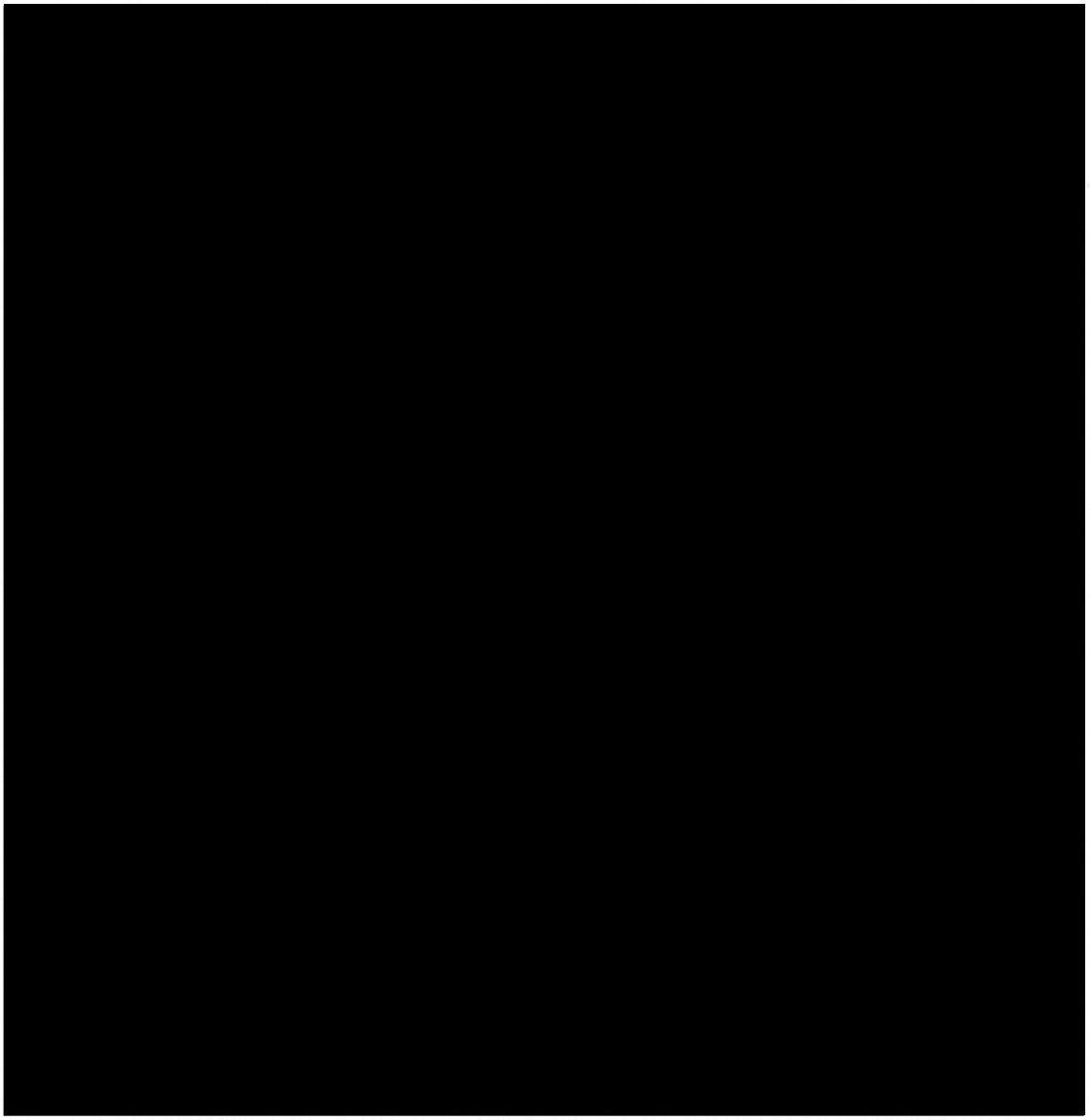

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Technical Specifications Checklist

Project Name: Big Sandy Unit 2 FGD Project - Order of Magnitude Capital Estimate

Originated by: Larry A. Hicks

Checked by: Gregory M. Gibbs Date: 9/24/2010

Description: Revise the specification to include content consistent with the order of magnitude/relative capital installed cost estimates.

Unique Document ID: BS2-FGDSCE-052010 Rev 2

		Checking Engineer's Initials
1.	Purpose of technical specification is identified.	GMG
2.	Technical requirements are identified including: design basis criteria, performance requirements, applicable regulatory, statutory & industrial codes, and ambient environmental conditions.	GMG
3.	Auxiliary services such as power supply (voltage, current, source), air supply (pressure, volume, source), cooling water (pressure, temperature, volume, source), steam (pressure, temperature, volume, source), etc. are identified.	N/A
4.	Off-site fabrication and modular construction requirements are identified.	GMG
5.	Quality, inspection, and testing requirements are identified. This includes testing requirements to determine quality, reliability, or performance of the product are listed and acceptance criteria identified; requirements for bidders to submit documentation of their quality assurance program; requirements for nondestructive examination, including inspections or examinations prior to shipment are identified; and equipment or systems which involve special requirements such as fire protection or special features such as Professional Engineer seals on documents or Underwriter certifications are identified.	N/A
6.	Vendor documentation requirements are identified including: types of documentation required, document submittal requirements, submittal due dates, specific warranty requirements, identify drawings subject to liquidated damages, and document format requirements.	N/A
7.	Shipping and storage requirements are identified including: bill of material requirements, tagging requirements, special shipping & handling requirements, storage requirements such as the use of preservatives and inhibitors, weather protection, etc. are identified.	N/A
8.	Guarantee and guarantee basis are clearly identified.	N/A
9.	Requirements to provide operation and/or maintenance training are identified.	N/A
10.	Requirements for spare parts are identified.	N/A
11.	Requirements to provide field support services such as installation, start up and/or testing assistance are identified.	N/A

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Technical Specification Checklist cont.

		Checking Engineer's Initials
12.	Attachments are included such as: data sheets which contain detail to provide a clear understanding and evaluation of the design parameters (pressure, temperatures, flows, etc.), design features and materials of construction; drawings, industry standards, addenda or other documents, and a list of other documents that form part of the technical specification.	GMG
13.	Verify technical specification cover sheet has a title, a technical specification number, date, and a technical specification revision number.	GMG
14.	Verify revision index includes revision number and description of revision.	GMG
15.	Verify that supporting calculations have been performed and checked.	N/A
16.	Appropriate interdisciplinary review complete.	GMG
17.	The specified materials, parts, equipment, and processes are suitable for the required application.	GMG
18.	The specified materials are compatible with each other and the design environmental conditions to which the material will be exposed.	GMG
19.	Plant specific operating data have been verified and if necessary, incorporated into design basis	GMG
List others below as applicable.		
20.		
21.		

Note: Use N/A to indicate check is not applicable.

G.M. Gibbs	G.M. Gibbs	9/24/2010
Checked by *(Print name legibly)*	*Checked by (Signature)*	Date

Engineering completed in accordance with SOP 730.04, Technical Specifications and reviewed by:

	T&D E&C	9/24/10
Engineering Manager	Department	Date

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