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APPENDIX 2A

Engineering Design Criteria

APPENDIX 2A

Civil & Structural Engineering Design Criteria

EMPOWERING EPCM

Hydrostor A-CAES Project

Gem Energy Storage Center

Civil & Structural Engineering Design Criteria

Document Number: 21-5291-00-3332-001

Date	Revision	Description of Revision	Prepared	Checked	Approved
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Design Criteria

1 CIVIL ENGINEERING DESIGN CRITERIA

This document summarizes the design criteria, standards codes and practices which will be used for civil engineering for the Gem Energy Storage Center. During the detail engineering phase, further specific project information will be developed to support the detailed design, engineering, material procurements, specifications, and construction specifications.

1.1 Codes and Standards

Civil design will be in accordance with the laws, ordinances, and regulations of the federal government, State of California, Kern County as well as applicable industry standards. The required part of the current issue or edition of the codes and standards at the time of filing this Application for Certification (AFC) will apply unless noted otherwise. In case of any conflict between codes and standards, the most stringent standard will govern.

1.1.1 Civil Engineering Codes and Standards

The following codes and standards will be applied in whole or in part:

- Occupational Safety and Health Administration (OSHA)
- International Building Code (IBC)
- California Building Code (CBC)
- American National Standards Institute (ANSI) – Standards
- American Concrete Institute (ACI) – Standards and Recommended Practices
- Concrete Reinforcing Steel Institute (CRSI) – Standards
- Precast Prestressed Concrete Institute (PCI)
- American Institute of Steel Construction (AISC) – Standards and Specifications
- American Association of State Highway and Transportation Officials (AASHTO) – Standards and Specifications
- American National Standards Institute (ANSI) – Standards
- American Society of Testing and Materials (ASTM) – Standards, Specifications, and Recommended Practices
- Process Industry Practices (PIP)
  PIP CVC01015 Civil Design Criteria
- Asphalt Institute (AI) – Asphalt Handbook
- State of California Department of Transportation (Caltrans) Standard Specification
- California Energy Commission (CEC) – Recommended Seismic Design Criteria for Non-Nuclear Generating Facilities in California
- National Fire Protection Association (NFPA) and International Fire Code
- International Plumbing Code (IPC)
- Association of Dam Safety Officials (ASDSO)

- California Department of Water Resources, Division of Safety of Dams (DSOD)
- American Society for Civil Engineering (ASCE)
- U.S Department of Interior Bureau of Reclamation, Embankment Dams
- United States Society on Dams (USSD).
- U.S. Army Corps of Engineers. "Engineer Manuals."
- American Water Works Association (AWWA)

2 STRUCTURAL ENGINEERING DESIGN CRITERIA

This document summarizes the design criteria, standards codes and practices which will be used for structural engineering for the Gem Energy Storage Center. During the detail engineering phase, further specific project information will be developed to support the detailed design, engineering, material procurements, specifications, and construction specifications.

2.1 Codes and Standards

Structural design will be in accordance with the laws, ordinances, and regulations of the federal government, State of California, Kern County as well as applicable industry standards. The required part of the current issue or edition of the codes and standards at the time of filing this Application for Certification (AFC) will apply unless noted otherwise. In case of any conflict between codes and standards, the most stringent standard will govern.

2.1.1 Structural Engineering Codes and Standards

The following codes and standards will be applied in whole or in part:

- Occupational Safety and Health Administration (OSHA)
- International building Code (IBC)
- California Building Code (CBC)
- American Institute of Steel Construction (AISC):
  Manual of Steel Construction
  Specification for Structural Steel Buildings
  Specification for Structural Joints Using High-Strength Bolts
  Code of Standard Practice for Steel Buildings and Bridges
- American Concrete Institute (ACI)
  ACI 351-18, Foundations for Dynamic Equipment
  ACI 318-19, Building Code Requirements for Structural Concrete and Commentary
  ACI 301-20, Specifications for Concrete Construction
  ACI 530, Building Code Requirements and Specification for Masonry Structures and Related
  224, Control of Cracking in Concrete Structures
- Commentaries

- American Society of Civil Engineers (ASCE)
  ASCE 7-16, Minimum Design Loads for Buildings and Other Structures
  ASCE 37-14, Design Loads on Structures During Construction
  Design of Blast Resistant Buildings in Petrochemical Facilities
  Guidelines for Seismic Evaluation and Design of Petrochemical Facilities
  Wind Loads on Petrochemical Facilities
  ASCE 59-11, Blast Protection of Buildings
- American Petroleum Institute (API)
  API 650/620 Welded Steel Tanks
  API 686 Recommended Practice for Machinery Installation and Installation Design
- American Society of Mechanical Engineers (ASME)
  STS-1-2016 Steel Stacks
  A17 Safety Code for Elevators and Escalators
- American Welding Society (AWS)
  D1.1-20—Structural Welding Code—Steel
  D1.3-18—Structural Welding Code—Sheet Steel
  D1.4-18—Structural Welding Code—Reinforcing Steel
- National Association of Architectural Metal Manufacturers (NAAMM)—Metal Bar Grating Manual
- Steel Deck Institute (SDI)—Design Manual for Floor Decks and Roof Decks
- American Association of State Highway and Transportation Officials (AASHTO)
  AASHTO LRFD Design Bridge Design Specifications, 9th Edition, 2020
- Precast Prestressed Concrete Institute (PCI), PCI Design Handbook, 8th Edition
- American Society for Testing and Materials (ASTM)
  All applicable standards including but not limited to A36/A36M, A193/193M, A307, A500/A500M, A615/A615M, A992/A992M, F1554 and F3125/3125M
  D7380 Standard Test Method for Soil Compaction
- Portland Cement Association (PCA)
  EB075 Concrete Floors on Ground
- Crane Manufacturers Association of America, Inc. (CMAA)
  CMAA No.70 Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes
  CMAA No. 74 Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist
- Process Industry Practices
  PIP STC 01015 Structural Design Criteria
- Steel joist Institute (SJI)
  SJI-CJ - Standard Specification for Composite Steel Joists CJ-Series
  SJI-K - Standard Specification for Open Web Steel Joists, K-Series
  SJI-LH/DLH - Standard Specification for Long Span Joists, LH-Series and Deep Long Span

Joists, DLH-Series
SJI-JG - Standard Specification for Joist Girders

2.2 Datum

A topographical survey will be provided for entire site. The existing ground elevations will be based on an elevation survey conducted using known elevation benchmarks.

2.3 Frost Penetration

Bottom of all foundations for the structures and equipment will be extended below the frost line of the locality. The frost depth will be determined by Geotechnical Engineer.

3 DESIGN LOADS

Design loads for structures and foundations will comply with all the applicable building code requirements.

3.1 Dead Load

3.1.1 The dead load for structures shall consist of the self-weight of the structure, the weight of all materials of construction permanently incorporated into the structure, including insulation, fireproofing, fixed partitions, and permanent fixtures.

3.1.2 The dead load for equipment shall consist of the weight of all machinery, equipment, and/or vessels permanently supported by the structure, including insulation, fireproofing, partitions, permanent fixtures, and attachments.

3.1.3 Unless more determinate load information is available and requires otherwise, dead loads for the following items shall be estimated as follows:

a. Uniformly distributed loads for grating, checkered plate, and concrete decking:
Grating: 9.1 psf for 1-1/4 inches x 3/16 inch plain grating
Checkered Plate: 10.23 psf for 1/4-inch checkered plate
Concrete Deck: based upon deck manufacturer's tables

b. Guard systems and ladders and cages
Angle Guard Systems with Toe Plate: 15 lbs/ft of guard length (L 2 ½ x 2 ½ x ¼)
Pipe Guard Systems with Toe Plate: 11 lbs/ft of guard length for pipe guard (NPS 1 ½ STD or HSS 1.900 x 0.145)
Ladders with Cages: 30 lbs/ft of ladder length
Ladders without Cages: 11 lbs/ft of ladder length

3.2 Live Load

Live loads are loads produced by the use and occupancy of the building or structure. These include the weight of all movable loads (e.g., personnel, tools, miscellaneous equipment, movable partitions, wheel loads, parts of dismantled equipment, stored material).

Lateral earth pressures, hydrostatic pressures, and wheel loads from trucks will be considered as live loads.

The minimum uniform live loads will be in accordance with ASCE SEI 7-16, Chapter 4; CBC 2019 Section 1607; IBC 2021 Section 1607; as applicable or other applicable codes and standards but will not be less than the following:

Table 1- Minimum Live Loads

	Uniform (psf)	Concentrated (lbs) (1)
Stairs and Exitways	100	1000
Operating, Access Platforms and Walkways (3)	100 (framing design) 100 (grating Design)	1000 (Framing and Grating Design)
Platforms Used for Bundle/Equipment Repairs	150	1000
Control, I/O, HVAC Room Floor	100	1000
Manufacturing Floors and Storage Areas: Light Heavy	 125 250	 2000 3000
Elevator Machine room and control room grating	100	300
Control or Electrical Enclosure or Module Floor	150	-
Pipe Racks (4)	50 (Average)	As Identified by Engineer
Hand Railing	- (2)	200 applied at any point in any direction
Slab on Grade	250	-
Truck Loading Surcharge Adjacent to Structure	250	-

Truck Support Structure	AASHTO-HS-20-44	-
Laboratories	100	-
Roof	20	-
Fire Escapes	200	-
Office Buildings:		
Corridor above first floor	80	2000
Lobbies and First Floor Corridors	100	2000
Office – Ground and 1st floor	100	2000
Offices above first floor	50	2000

(1) Uniform and concentrated live load listed in Table 1 shall not be applied simultaneously. Use of either uniform or concentrated live loads shall be based on whichever produces the greater load effect. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 ft by 2.5 ft and shall be located to produce the maximum load effects in the members.

(2) Handrail and guardrail system shall also be designed to resist a load of 50 lb/ft (pound-force per linear foot) applied in any direction along the handrail or top rail and to transfer this load through the supports to the structure. This load need not be assumed to act concurrently with the concentrated load.

(3) In addition, a uniform load of 50 psf will be used to account for piping and cable trays, except that where the piping and cable loads exceed 50 psf, the actual loads will be used.

(4) Where the piping and cable tray loads exceed the design uniform load, the actual loads will be used. In addition, a concentrated load of 8 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

(5) Laydown loads from equipment components during maintenance and floor areas where trucks, forklifts, or other transports have access will be considered in the design of live loads.

3.3 Wind Loads

Wind loads shall be computed and applied in accordance with ASCE/SEI 7-16, Chapters 26 through 30; IBC 2021, Section 1609; or CBC 2019, Section 1609 as applicable, and the recommended guidelines in ASCE Wind Loads for Petrochemical and Other Industrial Facilities.

3.4 Snow Load

Snow Load will be calculated according to CBC Section 1603.1.3, Section 1608 and Chapter 7 of ASCE 7.

Rain Load will be applied if concentration on the roof is expected.

The design roof load shall not be less than that determined by CBC Section 1607.

3.5 Seismic Loads

Structures and the reservoir will be designed and constructed to resist the effects of earthquake loads and possible liquefaction as determined in CBC 2019. Site class and liquefaction measures for susceptible soil will be determined by geotechnical investigation report. The occupancy category of the structure is III (per CBC Table 1604.5) and the corresponding important factor is 1.25.

3.6 Earth Pressure

Earth passive and active pressures will be calculated based on geotechnical investigation report recommendations.

3.7 Groundwater Pressure

Based on the depth of groundwater, the hydrostatic pressure attributable to groundwater will be considered. Geotechnical investigation report will provide average depth of the groundwater within the site at the present and historical data.

3.8 Turbine-Generator/Compressor Loads

The heavy equipment loads (for generators/compressors) for platform/foundation design will be furnished by their manufacturers and will be applied according to the equipment manufacturer's specifications, criteria, and recommendations.

3.9 Steel Stacks

Steel stacks will be designed by manufacturer's Engineer to withstand normal and abnormal operating condition in combination with design wind loads and seismic loads and will include the along-wind and across-wind effects on the stacks. The design will meet the requirements of ASME/ANSI STS-1-2000, "Steel Stacks," using allowable stress design method, except that increased allowable stress for wind loads as permitted by AISC will not be used. Supporting foundation will be designed according to stack manufacturer's footprint and loads, specifications, criteria, and recommendations.

3.10 Impact Loads

For structures carrying live loads which induce impact, the static live loads shall be increased sufficiently to cover the impact load.

Crane runways shall be designed for the crane stop forces provided by manufacturer's recommendations or specification.

Table 2- Impact Loads

Category	Vertical Impact (%)	Lateral Impact (%) *
For Support of Elevators	100	-
For Support of Light Machinery, Shaft or Motor Driven	20	-
For Support of Reciprocating Machinery or Power-Driven Units	50	-

*Lateral impact based on the manufacturer recommendation (e.g., lateral impact for cranes =20%)

4 DESIGN BASIS

Reinforced concrete structures shall be designed (strength design method) in accordance with the CBC 2019 and the ACI 318.

Allowable soil bearing pressure for foundation design will be in accordance with the geotechnical investigation report.

Steel structures will be designed by using strength design or allowable strength design methods according to CBC 2019 and AISC Specification for Structural Steel Buildings.

Earthen and rockfill structures will be designed in accordance with the recommendations provided in the geotechnical investigation report; where required, impermeable membranes will be installed on the wetted surface side of water retention structures. Reservoir structures that meet jurisdiction requirements under the Division of Safety of Dams (DSOD) will meet the applicable DSOD requirements.

4.1 Following items shall be considered during the design in accordance with CBC 2019

4.1.1 Serviceability and Stability
4.1.2 Deflection and Drift Criteria
4.1.3 Load Factors and Load Combinations
4.1.4 Important Factors
4.1.5 Clearances

4.2 Factor of Safety

4.2.1 Against overturning: 1.50
4.2.2 Against sliding: 2.0 for wind loads, 1.10 for seismic loads
4.2.3 Against uplift due to wind: 1.50
4.2.4 Against buoyancy: 1.25

4.3 Construction Materials

4.3.1 Concrete (f’c as measured at 28 days):
Structural concrete (f’c) = 4,000 psi (min.), electrical duct bank encasement (f’c) = 2,500 psi and structural grout (f’c) = 5,000 psi

The concrete or grout classes to be determined by design drawings or design specifications

4.3.2 Concrete Reinforcement
Reinforcing steel shall be deformed bars of billet steel conforming to ASTM A615, Grade 60 or A706, Grade 60

4.3.3 Structural Steel

Structural steel shall conform to the standards listed in Table 3.

Table 3 (Structural Steel Standards)

Category	Applicable Standard
Structural and Miscellaneous steel	ASTM A36, ASTM A572 or ASTM A992
High Strength Structural Bolts, Nuts and Washers	ASTM A325, ASTM A490 or ASTM F1554 As Applicable
Bolts other than high-strength structural bolts	ASTM A307, Grade A or As Indicated in Design Drawings

4.3.4 Concrete Masonry

Concrete masonry units will be hollow, normal weight, non-load-bearing Type I, conforming to ASTM C90, lightweight. Mortar will conform to ASTM C270, Type S. Grout will conform to ASTM C476.

APPENDIX 2A

Control Engineering

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EMPOWERING EPCM

Hydrostor Pecho/ Gem Energy Storage Center - AFC Inputs

Appendix 2.5 – Control Engineering

Project Number: 21-5375

TWD Document Number: 21-5375-00-3536-001

Date (y/m/d)	Revision	Description of Revision	Prepared	Checked	Approved
25/08/21	0	Issued for Use	TME	AJS	SEP

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1 OBJECTIVE

1.1 Hydrostor is investigating two potential sites in California for their Advanced Compressed Air Energy Storage (A-CAES) technology. The two sites are Pecho (near Morro Bay), and Gem (near Rosamond).

1.2 TWD is working with Hydrostor and Golder to prepare an Application For Certification (AFC) to the California Energy Commission (CEC) for the two sites. Golder is preparing and will submit the overall AFC, with technical input from TWD.

1.3 This document provides technical input for Golder to develop the following AFC sections for both Pecho and Gem sites:

- Appendix 2.5 - Control Engineering

2 INTRODUCTION

2.1 This appendix summarizes the codes, standards, criteria, and practices that will be generally used in the design and installation of instrumentation and controls. More specific project information will be developed during execution of the project to support detailed design, engineering, material procurement specifications, and construction specifications.

3 CODES AND STANDARDS

3.1 The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, local County, and City, as well as applicable industry standards. A summary of general codes and industry standards applicable to design and control aspects of the power facility follows:

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- The Institute of Electrical and Electronics Engineers (IEEE)
- International Society of Automation (ISA)

- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- American Society for Testing and Materials (ASTM)

4 CONTROL SYSTSM DESIGN CRITERIA

4.1 General Requirements

All signals to and from the Central Control Room shall be electric / electronic. The standard signal shall be analogue 4-20 mA using 2-wire system, standard thermocouple, RTD output, and / or suitable pulse signal.

Instruments located on control panels and central control room (CCR) shall be microprocessor based.

On platforms with processing facilities, a Distributed Control System (DCS) shall be provided for monitoring and controlling the process, and for generating alarms in case of process upsets.

4.2 Process Control System

The process control system will provide all monitoring and control of the facility. The process control system configuration will be justified with the plant engineering contractor based on the facility complexity.

The facility will function automatically with minimum operator intervention. Emphasis will be given to automating routine actions so that the operator has more time to analyse and identify short and medium-term plant performance, efficiency and imminent failures.

Adequate instrumentation shall be installed to enable operations personnel to monitor plant performance from the central control room with minimum field intervention. Field operators will only assist in visual surveillance and intervene only when critical equipment and systems warrant immediate attention. All field functions will require a permissive signal from the control system.

For standalone control packages within the facility where operator action is entirely local, a package common alarm will be connected to the process control system to direct an operator to examine local indicators or panels in order to determine equipment status.

4.3 Monitoring and Controls

The Process Control System shall use solid-state equipment and Programmable Logic Controllers (PLC) or Distributed Control Systems (DCS) to increase reliability and flexibility.

The use of electromechanical control relays shall be avoided, except when required for safety interlocks.

Communications between the PLC and HMI, and PLC to PCS shall be Ethernet TCP/IP or ProfiNet.

Communications to MCC's and VFD's to be Ethernet based. Communications to discrete field contacts to be AS-I complete with limit switch indications.

Wireless communication devices shall be used for communication between control room and operators in the plant.

4.4 Field Instruments

Electronic instruments rather than pneumatic are preferred for operation of the equipment. Electronic instruments shall use 4-20 mA, 24 V DC signals for transmission and control. Smart Transmitters with 'Hart protocol' shall be used as much as possible. The remainder of the transmitters will preferably be of the two-wire type, and each transmitter shall be separately fused.

All instruments shall be rated for the hazardous environment in which they are located. When appropriately rated equipment is not available, intrinsically safe barriers mush be provided and installed in the control panel.

Auxiliary power supplies for instruments shall in the first instant be 24 V DC, however where increased power consumption is required, 120 V AC shall be used. Each instrument shall have its own power disconnect device, and each motorized and solenoid actuated valve shall be separately fused.

4.5 Pressure Instruments

In general, pressure instruments will have linear scales with units of measurement in pounds per square inch, gauge. Pressure gauges will have either a blowout disk or a blowout back and an acrylic or shatterproof glass face. Pressure gauges on process piping will be resistant to plant atmospheres. Pressure test points will have isolation valves and caps or plugs. Pressure devices on pulsating services will have pulsation dampers.

4.6 Temperature Instruments

In general, temperature instruments will have scales with temperature units in degrees Fahrenheit. Exceptions to this are electrical machinery resistance temperature detectors and transformer winding temperatures, which are in degrees Celsius.

Bimetal-actuated dial thermometers will have 4.5- or 5-inch-diameter (minimum) dials and white faces with black scale markings and will consist of every angle-type. Dial thermometers will be resistant to plant atmospheres.

Temperature elements and dial thermometers will be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points will have thermowells and caps or plugs.

Resistance temperature detectors will be 100-ohm platinum, three-wire type. The element will be spring-loaded, mounted in a thermowell, and connected to a cast iron head assembly. Thermocouples will be Type J or K dual-element, grounded, spring-loaded, for general service. Materials of construction will be dictated by service temperatures. Thermocouple heads will be the cast type with an internal grounding screw.

4.7 Level Instruments

Reflex-glass or magnetic level gauges will be used. Level gauges for high-pressure service will have suitable personnel protection. Gauge glasses used in conjunction with level instruments will cover a range that includes the highest and lowest trip/alarm set points.

4.8 Flow Instruments

Flow transmitters will typically be of the differential pressure-type. Alternate type flow transmitters may be used where required to ensure high accuracy measurements. In general, linear scales will be used for flow indication and recording. Magnetic type flow transmitters may be used for liquid flow measurement below 200°F.

4.9 Control Valves

Control valves in throttling service will generally be the globe-body cage type with body materials, pressure rating, and valve trims suitable for the service involved. Other style valve bodies (e.g., butterfly, eccentric disk) may also be used when suitable for the intended service.

Valves will be designed to fail in a safe position.

Control valve body size will not be more than two sizes smaller than line size, unless the smaller size is specifically reviewed for stresses in the piping.

Control valves in 600-Class service and below will be flanged were economical.

Critical service valves will be defined as ANSI 900 Class and higher in valves of sizes larger than 2 inches.

Severe service valves will be defined as valves requiring anti-cavitation trim, low noise trim, or flashing service, with differential pressures greater than 100 pounds per square inch (psi).

In general, control valves will be specified for a noise level no greater than 85 decibels, A-rated (dBA) when measured 3 feet downstream and 3 feet away from the pipe surface.

Valve actuators will use positioners and the highest pressure, smallest size actuator, and will be the pneumatic-spring diaphragm or piston type. Actuators will be sized to shut off against at least 110 percent of the maximum shutoff pressure and designed to function with instrument air pressure ranging from 80 to 125 pounds per square inch gauge.

Hand wheels will be furnished only on those valves that can be manually set and controlled during system operation (to maintain plant operation) and do not have manual bypasses.

Control valve accessories, excluding controllers, will be mounted on the valve actuator unless severe vibration is expected.

Solenoid valves supplied with the control valves will have Class H coils. The coil enclosure will normally be a minimum of NEMA 4 but will be suitable for the area of installation.

Valve position feedback (with input to the supervisory control system for display) will be provided for all control valves.

4.10 Instrument Tubing and Installation

Tubing used to connect instruments to the process line will be seamless stainless steel for primary instruments and sampling systems.

Instrument tubing fittings will be the compression type.

Differential pressure (flow) instruments will be fitted with three-valve manifolds; two-valve manifolds will be specified for other instruments as appropriate.

Instrument installation will be designed to correctly sense the process variable. Taps on process lines will be located so that sensing lines do not trap air in liquid service or liquid in gas service. Taps on process lines will be fitted with a shutoff (root or gauge valve) close to the process line. Root and gauge valves will be main-line class valves.

Instrument tubing will be supported in both horizontal and vertical runs as necessary. Expansion loops will be provided in tubing runs subject to high temperatures. The instrument tubing support design will allow for movement of the main process line.

4.11 Pressure and Temperature Switches

Field-mounted pressure and temperature switches will have either NEMA Type 4 housings or housings suitable for the environment.

In general, switches will be applied such that the actuation point is within the center one-third of the instrument range.

4.12 Field-Mounted Instruments

Field-mounted instruments will be of a design suitable for the area in which they are located. They will be mounted in areas accessible for maintenance and relatively free of vibration and will not block walkways or prevent maintenance of other equipment.

Field-mounted instruments will be grouped on racks. Supports for individual instruments will be prefabricated, off-the-shelf, 2-inch pipe stand type. Instrument racks and individual supports will be mounted to concrete floors, to platforms, or on support steel in locations not subject to excessive vibration.

Individual field instrument sensing lines will be sloped or pitched in such a manner and be of such length, routing, and configuration that signal response is not adversely affected.

Liquid level controllers will generally be the non-indicating, displacement-type with external cages.

4.13 Instrument Air System

Branch headers will have a shutoff valve at the takeoff from the main header. The branch headers will be sized for the air usage of the instruments served but will be no smaller than 3/8 inch. Each instrument air user will have a shutoff valve, filter, outlet gauge, and regulator at the instrument.

APPENDIX 2A

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EMPOWERING EPCM

Hydrostor Pecho/ Gem Energy Storage Center - AFC Inputs

Appendix 2.4 – Electrical Engineering

Project Number: 21-5375

TWD Document Number: 21-5375-00-3636-002

Date (y/m/d)	Revision	Description of Revision	Prepared	Checked	Approved
25/08/21	0	Issued for Use	CAB	TME	SEP

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1.2 TWD is working with Hydrostor and Golder to prepare an Application For Certification (AFC) to the California Energy Commission (CEC) for the two sites. Golder is preparing and will submit the overall AFC, with technical input from TWD.

1.3 This document provides technical input for Golder to develop the following AFC sections for both Pecho and Gem sites:

- Appendix 2.4 – Electrical Engineering

2 INTRODUCTION

2.1 This appendix summarizes the codes, standards, criteria, and practices that will be generally used in the design and construction of electrical engineering systems. More specific project information will be developed prior to construction of the project to support detailed design, engineering, material procurement, and construction specifications as required by CEC.

3 CODES AND STANDARDS

3.1 The design specification of all work will be in accordance with the laws and regulations of the federal government, the State of California, local County, and City, as well as applicable industry standards. The current issue or revision of the documents at the time of the filing of this AFC will apply unless otherwise noted. If there are conflicts between the cited documents, the more conservative requirement shall apply.

The following codes and standards are applicable to the electrical aspects of the power facility:

- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Anti-Friction Bearing Manufacturers Association (AFBMA)

- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- California Electrical Code
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)

4 SUBSTATION AND TRANSFORMERS

4.1 Substation

The substation will be located on the western end of both sites and will interconnect via a 230kV Overhead line to Whirlwind Substation and Morro Bay Substations for Gem and Pecho Sites respectively. The substation will be of the tubular IPS bus type with interconnecting conductors and will consist of high-voltage SF6-insulated dead-tank circuit breakers and no-load switches.

Connections to the aerial conductor cable will be provided from the two dual-winding transformers for the inter-tie to the utility grid. The high-voltage circuit breaker will be equipped with a no-load break, air-insulated, disconnect switch. A transformer circuit breaker and isolating disconnect switch will also be installed in each transformer connection to allow for transformer protection and isolation when the corresponding transformer is out of service. Tubular IPS bus type with interconnecting conductors will be used as the primary interconnection material within the switchyard. The IPS and conductors will be attached to post-insulator columns on structural steel supports. The main substation transforms power from/to 230kV to/from 69kV.

Current and voltage transformers will be located at points within the substation to provide for metering and relaying. Control, protection, and monitoring for the substation will be located in the substation protection and control building. Monitoring and alarms will be available to the supervisory control system operator workstations in the control module. All protection and circuit breaker control will be powered from the station battery-backed 125VDC system.

Each motor/generator substation will have two dual-winding transformers with wye-delta for the generator and delta-wye for the motors. The HV (69kV) side will be fed with underground cables and the 13.8kV side will be ISO Phase Bus Duct connections with SF6 circuit breakers.

The substation designs will meet the requirements of the National Electrical Safety Code—ANSI C2.

A grounding grid will be provided to control step and touch potentials in accordance with IEEE Standard 80, Safety in Substation Grounding. All equipment, structures, and fencing will be connected to the grounding grid of buried copper conductors and ground rods, as required. The substation ground grid will be tied to the main distribution and plant ground grid.

Lightning protection will be provided by shield wires and/or lightning masts for any overhead lines. The lightning protection system will be designed in accordance with IEEE 998 guidelines. All faults will be detected, isolated, and cleared in a safe and coordinated manner as soon as practicable for the safety of equipment, personnel, and the public. Protective relaying will meet IEEE requirements and will be coordinated with PG&E's requirements.

There will be a 10.5-mile-long (approximately) tie-line to the utility substation 230-kilovolt (kV) bus for Gem and a 3.5-mile-long (approximately) tie-line to the utility substation 230kV bus for Pecho. The high-voltage circuit breaker will be provided with a breaker failure relay protection scheme. Breaker failure protection will be accomplished by protective and timing relays. The high-voltage breaker will have two redundant trip coils.

Interface with PG&E's supervisory control and data acquisition system will be provided. Interface will be at the interface terminal box and remote terminal unit. Communication between the facility switchyard and the control building to which it is connected will be included.

Revenue metering will be provided on the 230kV outgoing lines recording net power to or from the PG&E switchyard (bi-directional). The revenue meters and a metering panel will be located in the main switchyard protection and control building.

4.2 Transformers

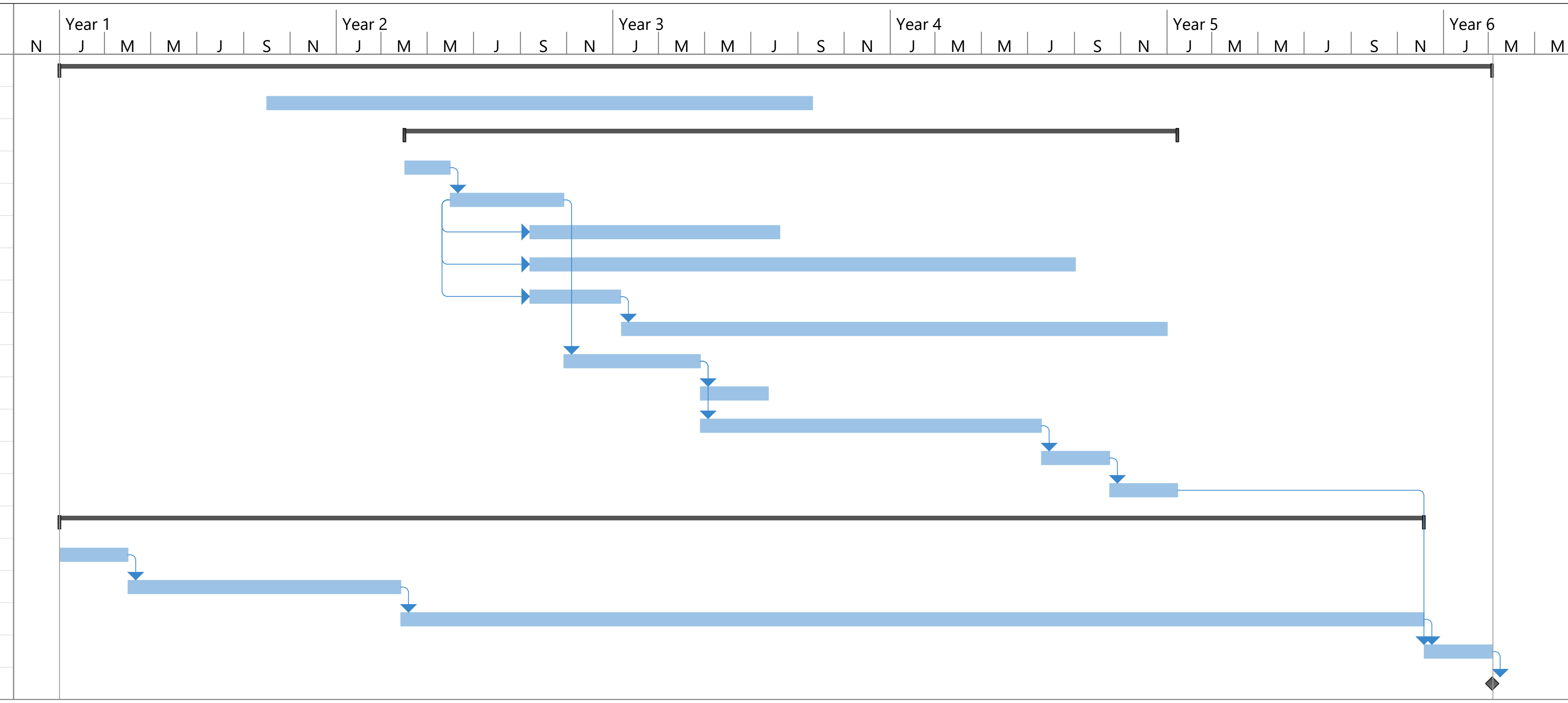
All generators and motors will be rated for 13.8kV and connect to a 69kV distribution system which in turn feeds the 230kV switchyard through step-up transformers. The step-up transformers will be designed in accordance with ANSI/IEEE standards C57.12.00, C57.12.90, and C57.116. The transformers will be dual-winding, delta-wye, ONAN/ONAF, 65°C rise. Grounding of the transformers will be suitable for both generation and motor function. The main substation will be equipped with lightning arrestors and will have manual de-energized ("no-load") tap changers located in the HV windings.

Facility power will be supplied through unit auxiliary transformers connected to the 69kV distribution system. Four two-winding, delta-wye 69kV to 4.16kV transformers with low impedance grounding resistors will be provided.

APPENDIX 2B

Construction Schedule

ID	Task Name	Duration
1	**Gem Energy Storage Center Construction Schedule**	**63 emons**
2	**Transmission Infrastructure Construction**	24 emons
3	**Above Ground A-CAES Plant**	**34 emons**
4	Mobilization	2 emons
5	Site Civil & Foundations	5 emons
6	Turbine Hall	11 emons
7	Spherical Pressure Vessels	24 emons
8	Surface Reservoir	4 emons
9	Reservoir Fill Time	24 emons
10	Install Primary Equipment Modules	6 emons
11	Structural & Architectual	3 emons
12	Piping, Mechanical & Electrical	15 emons
13	Controls	3 emons
14	Pre-Comissioing	3 emons
15	**Subsurface Storage Cavern**	**60 emons**
16	Site Prep & Clearing	3 emons
17	Cavern Shaft Drilling	12 emons
18	Cavern Mining & Conversion	45 emons
19	**Final Comissioing Stage**	3 emons
20	**Commercial Operation Dates**	0 days



APPENDIX 2C

Heat and Mass Balance Average Temperature Case

Project	Calculation No.				
Hydrostor Rosamond	**21-5375-00-3438-003**				
Client					
Hydrostor	Rev.	Date:	By:	Chk'd	App'd
Project No.	0	2021-07-29	ZAH	AKN	JYK
21-5291					

Heat and Material Balance - Gem Unit - Case Average Temperature

Table 1. Heat and Material Balance Table - Air Streams

	Stream Number PFD *		101	102	104	105	108	109	110	111	112	113	114	115	116	117	118	119	120
	Description	**Unit**	Atm. Intake Air to LP Compressors	Air to LP Heat Exchangers	Air to IP Compressors	Air from IP Compressors	Air to HP Compressors	Air from HP Compressors	Air from HP Heat Exchanger to Air Trim Cooler	Air from Air Trim Cooler	All Trains Air to Storage Cavern	Cavern Air to All Trains	Cavern Air to Train 1	Air to HP Turbine	Air from HP Turbine	Air to IP Turbine	Air from IP Turbine	Air to LP Turbine	LP Turbine Outlet/ Vent to Atmosphere
Overall	Vapour Fraction		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Temperature	°F	64.4	523.6	100.00	341.2	126.81	370.15	134.0	104.0	104.0	82.4	82.1	362.8	180.6	353.1	174.3	368.1	56.3
	Pressure	psia	14.5	105.9	104.03	301.7	296.32	831.07	824.9	821.3	821.3	803.1	790.8	779.0	300.2	284.5	109.5	100.6	14.9
	Mass Flow	lb/h	1,382,773	1,382,773	1,382,773	1,382,773	1,379,920	1,379,920	1,379,920	1,379,920	6,881,328	11,154,356	2,230,412	2,230,412	2,230,412	2,230,412	2,230,412	2,230,412	2,230,412
	Molar Flow	lbmole/h	47,876	47,876	47,876	47,876	47,777	47,777	47,777	47,777	237,869	385,494	77,073	77,073	77,073	77,073	77,073	77,073	77,073
	Molecular Weight	lb/lbmole	28.882	28.882	28.88	28.88	28.88	28.88	28.88	28.88	28.93	28.93	28.94	28.94	28.94	28.94	28.94	28.94	28.94
	Mass Density @ T&P	lb/ft³	0.075	0.289	0.50	1.01	1.37	2.67	3.80	4.02	4.01	4.10	4.04	2.53	1.27	0.94	0.47	0.33	0.08
	Enthalpy	MMBTU/hr	-35	119	-24.37	56	-17.29	63.50	-21	-34	-45	-113	-19	140	43	138	42	147	-20

Table 2. Heat and Material Balance Table - Thermal Fluid Streams

	Stream Number PFD *		201	202	203-C	204-C	205-C	206-C	207-C	208-C	209-C	210-C	211-C	203-D	204-D	205-D	206-D	207-D	208-D	209-D	210-D	211-D	214	215
	Description	**Unit**	Cold Thermal Fluid from Cold Tank	Cold Thermal Fluid to All Trains	Cold Thermal Fluid to Train 1 Exchangers	Cold Thermal Fluid to LP Heat Exchangers	Cold Thermal Fluid to IP Heat Exchangers	Cold Thermal Fluid to HP Heat Exchangers	Thermal Fluid from LP Heat Exchangers	Warmed Thermal Fluid from IP Heat Exchangers	Warmed Thermal Fluid from HP Heat Exchangers	Train 1 Warmed Thermal Fluid to Hot Storage Tanks	All Trains Thermal Fluid to Hot Storage Tanks	Thermal Fluid to Thermal Cooler Fin Fans	Cooled Thermal Fluid from LP Heat Exchangers	Cooled Thermal Fluid from IP Heat Exchangers	Cooled Thermal Fluid from HP Heat Exchangers	Hot Thermal Fluid to LP Heat Exchangers	Hot Thermal Fluid to IP Heat Exchangers	Hot Thermal Fluid to HP Heat Exchangers	Train 1 Hot Thermal Fluid from Hot Storage Tanks	Hot Thermal Fluid to All Trains	Cold Thermal Fluid to Thermal Fluid Trim Cooler	Cold Thermal Fluid from Thermal Fluid Trim Cooler
Overall	Vapour Fraction		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Temperature	°F	77.0	77.52	77.5	77.5	77.5	77.5	452.8	330.6	360.6	388.5	388.5	164.3	198.5	198.5	103.0	388.7	388.7	388.7	388.7	388.7	164.33	77.0
	Pressure	psia	14.7	434.70	434.7	434.7	434.7	434.7	434.3	434.3	433.8	433.8	433.8	236.7	238.4	238.4	236.7	239.3	239.3	239.3	239.3	239.3	236.73	218.1
	Mass Flow	lb/h	4,760,966	4,760,966	952,193	371,355	285,658	295,180	371,355	285,658	295,180	952,193	4,760,966	1,561,492	484,063	484,063	546,522	530,907	484,063	546,522	1,561,492	7,807,461	7,807,461	7,807,461
	Molar Flow	lbmole/h	264,271	264271.00	52,854	20,613	15856	16385	20,613	15,856	16,385	52,854	264,271	86,675	26,869	26,869	30,336	29,470	26,869	30,336	86,675	433,375	433,375	433,375
	Molecular Weight	lb/lbmole	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.0	18.02	18.02
	Mass Density @ T&P	lb/ft³	62.24	62.32	62.32	62.32	62.321	62.321	51.09	56.38	55.29	54.19	54.19	60.96	60.20	60.20	62.00	54.12	54.12	54.12	54.12	54.1	60.96	62.28
	Enthalpy	MMBTU/hr	-32,495	-32,487	-6,497	-2,534	-1,949	-2,014	-2,390	-1,876	-1,930	-6,196	-30,981	-10,520	-3,245	-3,245	-3,716	-3,455	-3,150	-3,556	-10,161	-50,806	-52,602	-53,283

Table 3. Heat and Material Balance Table - Cooling Medium Streams

	Stream Number PFD *		301-C	302-C	304-C	305	306-C	307-C	308	309-C	310-C	301-D	302-D	304-D	306-D	307-D	309-D	310-D
	Description	**Unit**	Cooling Medium to Cooling Medium Circulation Pumps	Cooling Medium from Cooling Media Circulation Pumps	Cooling Medium from Cooling Medium Fin Fan Cooler	Cooling Medium to Train 1 Air Trim Cooler	Cooling Medium to Cooling Medium Chiller	Cooling Medium to Turbomachinery Cooling	Cooling Medium Return from Train 1 Air Trim Cooler	Cooling Medium Return from Turbomachinery Cooling	Cooling Medium Return to Cooling Medium Buffer Tank	Cooling Medium to Cooling Medium Circulation Pumps	Cooling Medium from Cooling Media Circulation Pumps	Cooling Medium from Cooling Medium Fin Fan Cooler	Cooling Medium to Cooling Medium Chiller	Cooling Medium to Turbomachinery Cooling	Cooling Medium Return from Turbomachinery Cooling	Cooling Medium Return from Turbomachinery Cooling
Overall	Vapour Fraction		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Temperature	°F	91.9	92.0	76.3	76.3	76.3	76.3	91.0	93.253	92.6	131.0	131.1	77.1	77.1	77.1	130.3	130.3
	Pressure	psia	14.7	87.0	77.8	77.8	77.8	67.9	63.3	65.755	63.3	14.7	87.0	86.1	86.1	76.1	61.1	61.1
	Mass Flow	lb/h	13,888,800	13,888,800	13,888,800	865,029	9,563,655	1,912,731	865,029	1,912,731	13,888,800	2,528,282	2,528,282	2,528,282	2,528,282	505,656	505,656	2,528,282
	Molar Flow	lbmole/h	770,938	770,938	770,938	48,016	530,858	106,172	48,016	106,172	770,938	140,339	140,339	140,339	140,339	28,068	28,068	140,339
	Molecular Weight	lb/lbmole	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.015	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.0
	Mass Density @ T&P	lb/ft³	62.09	62.10	62.26	62.26	62.26	62.26	62.11	62.086	62.09	61.53	61.55	62.26	62.26	62.26	61.56	61.6
	Enthalpy	MMBTU/hr	-94,587	-94,583	-94,801	-5,904	-65,279	-13,056	-5,892	-13023.480	-94,576	-17,120	-17,119	-17,255	-17255	-3,451	-3,424	-17,121

NOTES:

(*) Letters C and D denote Charge and Discharge Cycle, respectively.

APPENDIX 2C

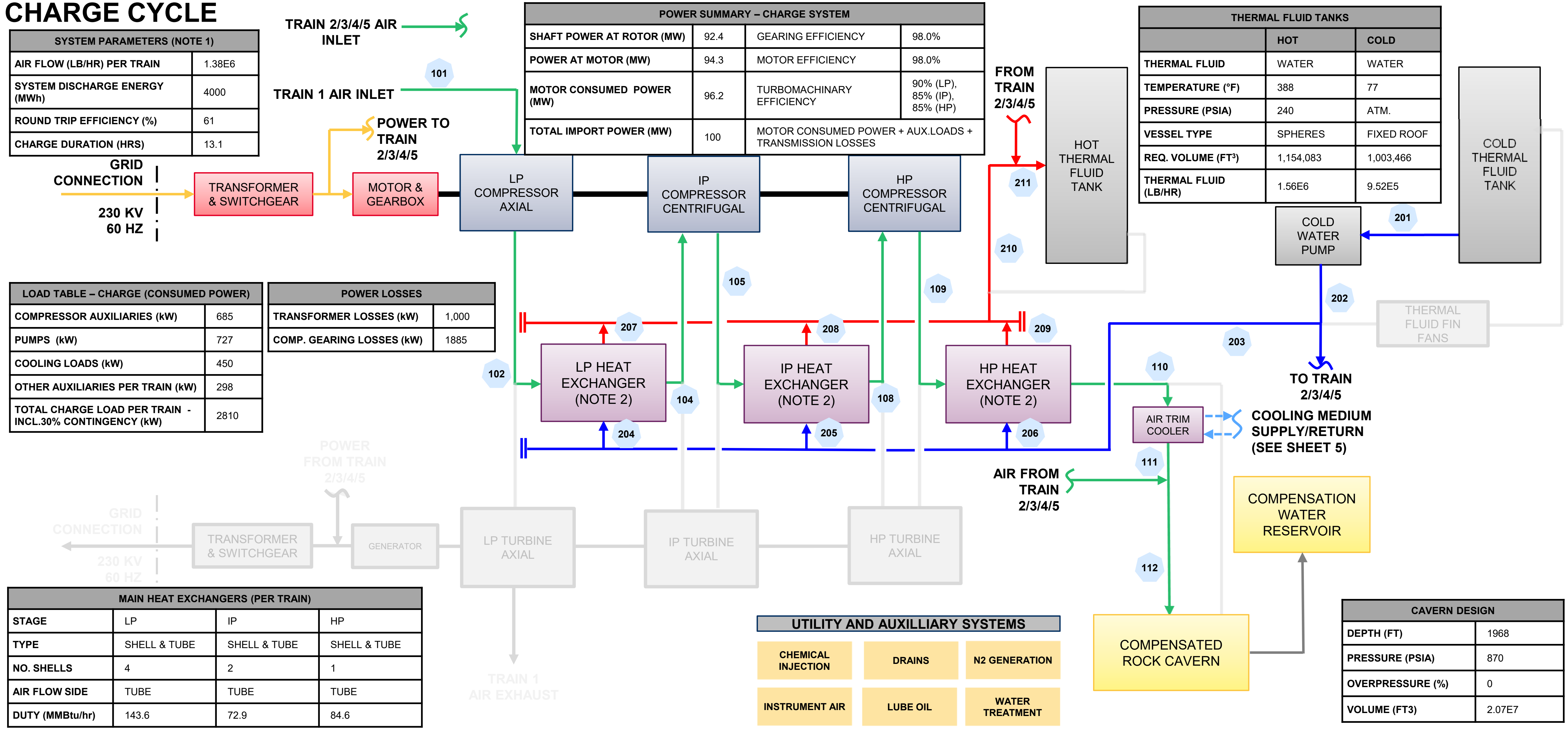
Heat and Mass Balance Diagrams

CHARGE CYCLE

SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	1.38E6
SYSTEM DISCHARGE ENERGY (MWh)	4000
ROUND TRIP EFFICIENCY (%)	61
CHARGE DURATION (HRS)	13.1

POWER SUMMARY – CHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)	92.4	GEARING EFFICIENCY	98.0%
POWER AT MOTOR (MW)	94.3	MOTOR EFFICIENCY	98.0%
MOTOR CONSUMED POWER (MW)	96.2	TURBOMACHINARY EFFICIENCY	90% (LP), 85% (IP), 85% (HP)
TOTAL IMPORT POWER (MW)	100	MOTOR CONSUMED POWER + AUX.LOADS + TRANSMISSION LOSSES	

THERMAL FLUID TANKS	HOT	COLD
THERMAL FLUID	WATER	WATER
TEMPERATURE (°F)	388	77
PRESSURE (PSIA)	240	ATM.
VESSEL TYPE	SPHERES	FIXED ROOF
REQ. VOLUME (FT³)	1,154,083	1,003,466
THERMAL FLUID (LB/HR)	1.56E6	9.52E5



LOAD TABLE – CHARGE (CONSUMED POWER)	
COMPRESSOR AUXILIARIES (kW)	685
PUMPS (kW)	727
COOLING LOADS (kW)	450
OTHER AUXILIARIES PER TRAIN (kW)	298
TOTAL CHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	2810

POWER LOSSES	
TRANSFORMER LOSSES (kW)	1,000
COMP. GEARING LOSSES (kW)	1885

MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	LP	IP	HP
TYPE	SHELL & TUBE	SHELL & TUBE	SHELL & TUBE
NO. SHELLS	4	2	1
AIR FLOW SIDE	TUBE	TUBE	TUBE
DUTY (MMBtu/hr)	143.6	72.9	84.6

CAVERN DESIGN	
DEPTH (FT)	1968
PRESSURE (PSIA)	870
OVERPRESSURE (%)	0
VOLUME (FT3)	2.07E7

LEGEND

(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(dashed blue arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	(dash-dot line)	BATTERY LIMIT
(purple arrow)	COOLING MEDIUM		

HMB NUMBER

WATER SYSTEMS
HEAT EXCHANGER
TURBOMACHINERY
ELECTRICAL SYSTEMS
CAVERN SYSTEM

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HYDROSTOR A-CAES GEM
OVERALL BLOCK FLOW DIAGRAM
MAN LP AXIAL (100MW) – 500MW / 4000MWh AVERAGE CASE

TWD EMPOWERING EPCM
HYDROSTOR

DOCUMENT NO.	REV.
21-5291-00-3443-002 SHT 1 OF 6	0

DISCHARGE CYCLE

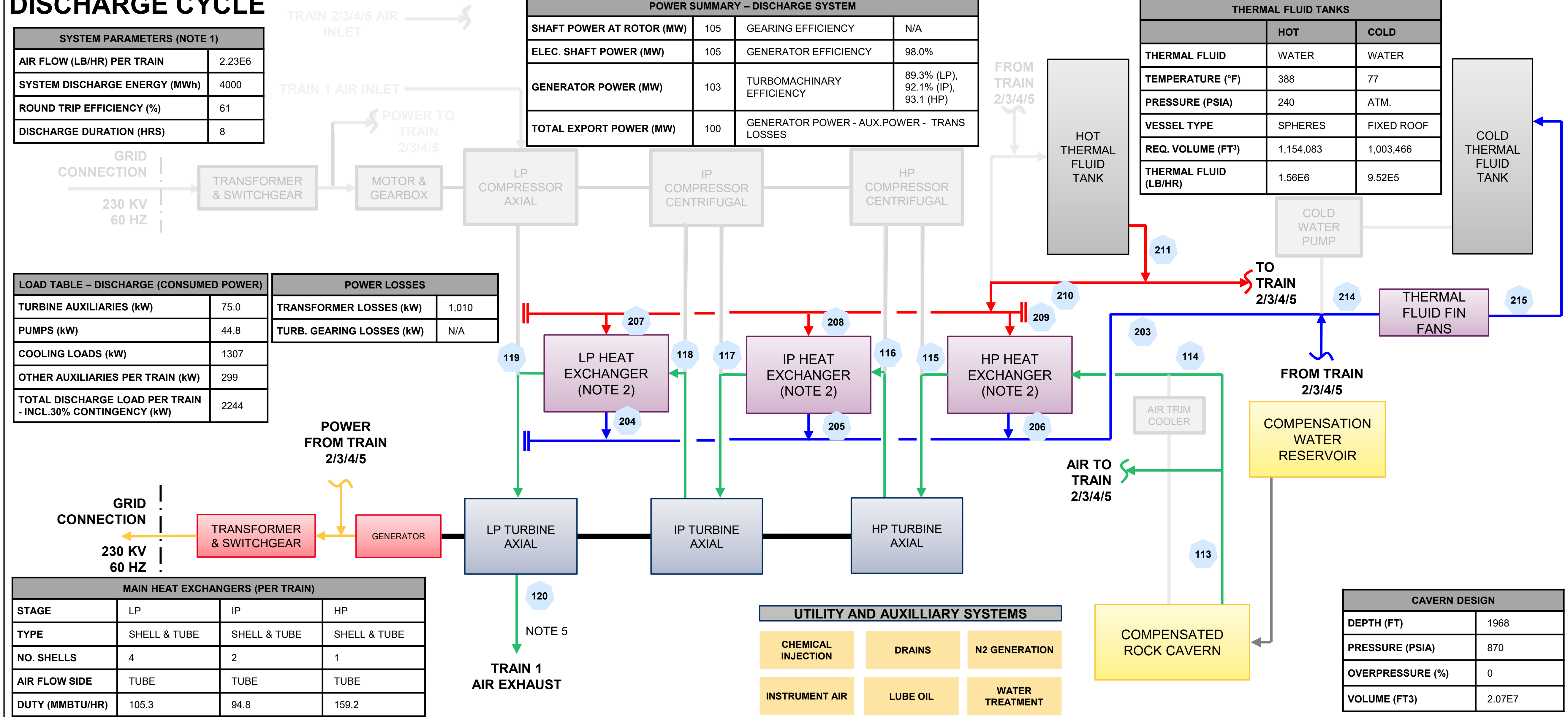
SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	2.23E6
SYSTEM DISCHARGE ENERGY (MWh)	4000
ROUND TRIP EFFICIENCY (%)	61
DISCHARGE DURATION (HRS)	8

POWER SUMMARY – DISCHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)	105	GEARING EFFICIENCY	N/A
ELEC. SHAFT POWER (MW)	105	GENERATOR EFFICIENCY	98.0%
GENERATOR POWER (MW)	103	TURBOMACHINARY EFFICIENCY	89.3% (LP), 92.1% (IP), 93.1 (HP)
TOTAL EXPORT POWER (MW)	100	GENERATOR POWER - AUX.POWER - TRANS LOSSES	

THERMAL FLUID TANKS		
	HOT	COLD
THERMAL FLUID	WATER	WATER
TEMPERATURE (°F)	388	77
PRESSURE (PSIA)	240	ATM.
VESSEL TYPE	SPHERES	FIXED ROOF
REQ. VOLUME (FT³)	1,154,083	1,003,466
THERMAL FLUID (LB/HR)	1.56E6	9.52E5

LOAD TABLE – DISCHARGE (CONSUMED POWER)	
TURBINE AUXILIARIES (kW)	75.0
PUMPS (kW)	44.8
COOLING LOADS (kW)	1307
OTHER AUXILIARIES PER TRAIN (kW)	299
TOTAL DISCHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	2244

POWER LOSSES	
TRANSFORMER LOSSES (kW)	1,010
TURB. GEARING LOSSES (kW)	N/A



MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	LP	IP	HP
TYPE	SHELL & TUBE	SHELL & TUBE	SHELL & TUBE
NO. SHELLS	4	2	1
AIR FLOW SIDE	TUBE	TUBE	TUBE
DUTY (MMBTU/HR)	105.3	94.8	159.2

UTILITY AND AUXILLIARY SYSTEMS		
CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	1968
PRESSURE (PSIA)	870
OVERPRESSURE (%)	0
VOLUME (FT3)	2.07E7

LEGEND

(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(dashed blue arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	(dash-dot line)	BATTERY LIMIT
(purple arrow)	COOLING MEDIUM		

\# HMB NUMBER

- WATER SYSTEMS
- HEAT EXCHANGER
- TURBOMACHINERY
- ELECTRICAL SYSTEMS
- CAVERN SYSTEM

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HYDROSTOR A-CAES GEM
OVERALL BLOCK FLOW DIAGRAM
MAN LP AXIAL (100MW) – 500MW / 4000MWh
AVERAGE CASE

TWD EMPOWERING EPCM — HYDROSTOR

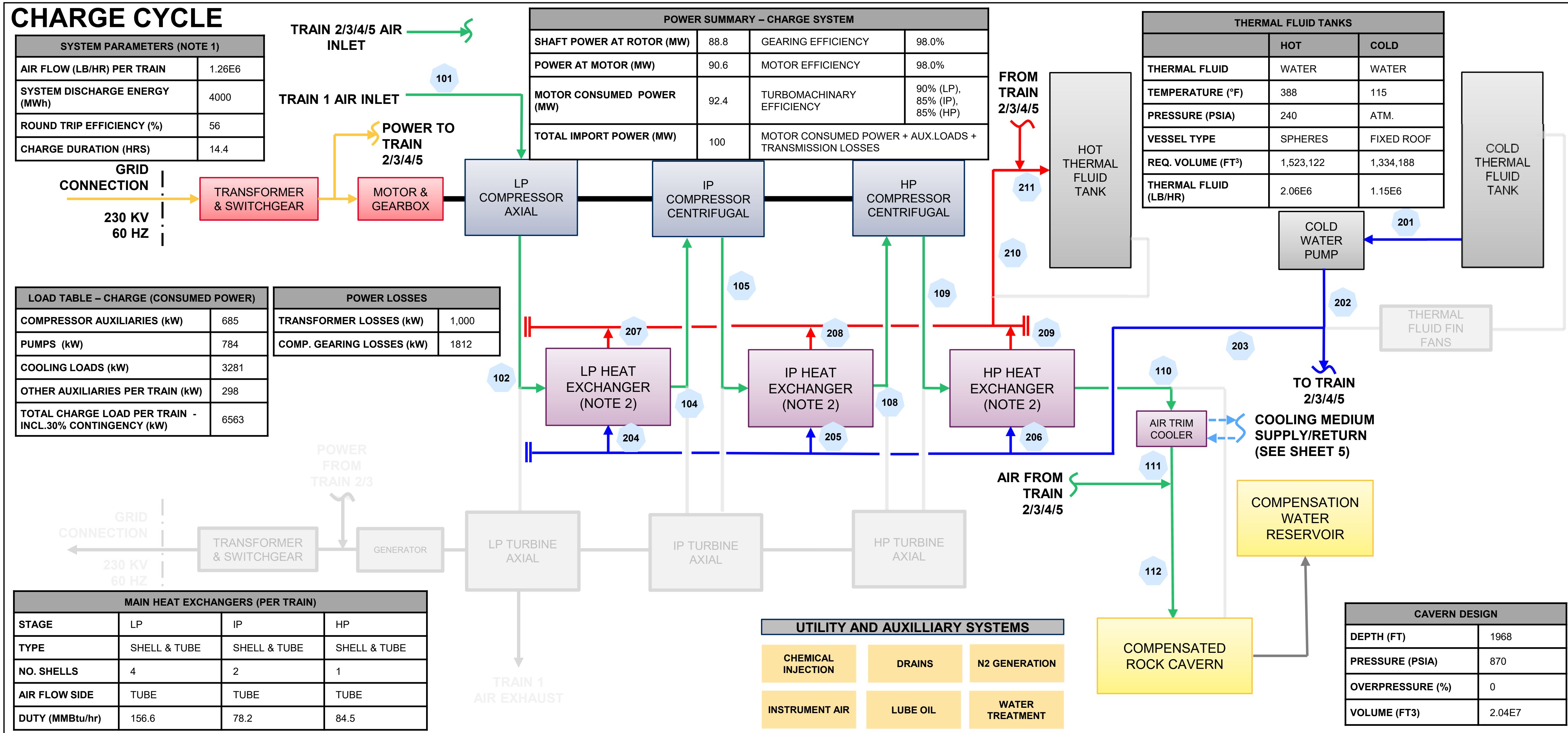
DOCUMENT NO. 21-5291-00-3443-002 SHT 2 OF 6 | REV. 0

CHARGE CYCLE

SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	1.26E6
SYSTEM DISCHARGE ENERGY (MWh)	4000
ROUND TRIP EFFICIENCY (%)	56
CHARGE DURATION (HRS)	14.4

POWER SUMMARY – CHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)	88.8	GEARING EFFICIENCY	98.0%
POWER AT MOTOR (MW)	90.6	MOTOR EFFICIENCY	98.0%
MOTOR CONSUMED POWER (MW)	92.4	TURBOMACHINERY EFFICIENCY	90% (LP), 85% (IP), 85% (HP)
TOTAL IMPORT POWER (MW)	100	MOTOR CONSUMED POWER + AUX.LOADS + TRANSMISSION LOSSES	

THERMAL FLUID TANKS		
	HOT	COLD
THERMAL FLUID	WATER	WATER
TEMPERATURE (°F)	388	115
PRESSURE (PSIA)	240	ATM.
VESSEL TYPE	SPHERES	FIXED ROOF
REQ. VOLUME (FT³)	1,523,122	1,334,188
THERMAL FLUID (LB/HR)	2.06E6	1.15E6



LOAD TABLE – CHARGE (CONSUMED POWER)	
COMPRESSOR AUXILIARIES (kW)	685
PUMPS (kW)	784
COOLING LOADS (kW)	3281
OTHER AUXILIARIES PER TRAIN (kW)	298
TOTAL CHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	6563

POWER LOSSES	
TRANSFORMER LOSSES (kW)	1,000
COMP. GEARING LOSSES (kW)	1812

MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	LP	IP	HP
TYPE	SHELL & TUBE	SHELL & TUBE	SHELL & TUBE
NO. SHELLS	4	2	1
AIR FLOW SIDE	TUBE	TUBE	TUBE
DUTY (MMBtu/hr)	156.6	78.2	84.5

UTILITY AND AUXILLIARY SYSTEMS		
CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	1968
PRESSURE (PSIA)	870
OVERPRESSURE (%)	0
VOLUME (FT3)	2.04E7

LEGEND			
(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(blue dashed arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	(dash-dot line)	BATTERY LIMIT
(purple arrow)	COOLING MEDIUM		

\# HMB NUMBER

WATER SYSTEMS
HEAT EXCHANGER
TURBOMACHINERY
ELECTRICAL SYSTEMS
CAVERN SYSTEM

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HYDROSTOR A-CAES GEM

OVERALL BLOCK FLOW DIAGRAM

MAN LP AXIAL (100MW) – 500MW / 4000MWh PEAK CASE

TWD EMPOWERING EPCM
HYDROSTOR

DOCUMENT NO.	REV.
21-5291-00-3443-002 SHT 3 OF 6	0

DISCHARGE CYCLE

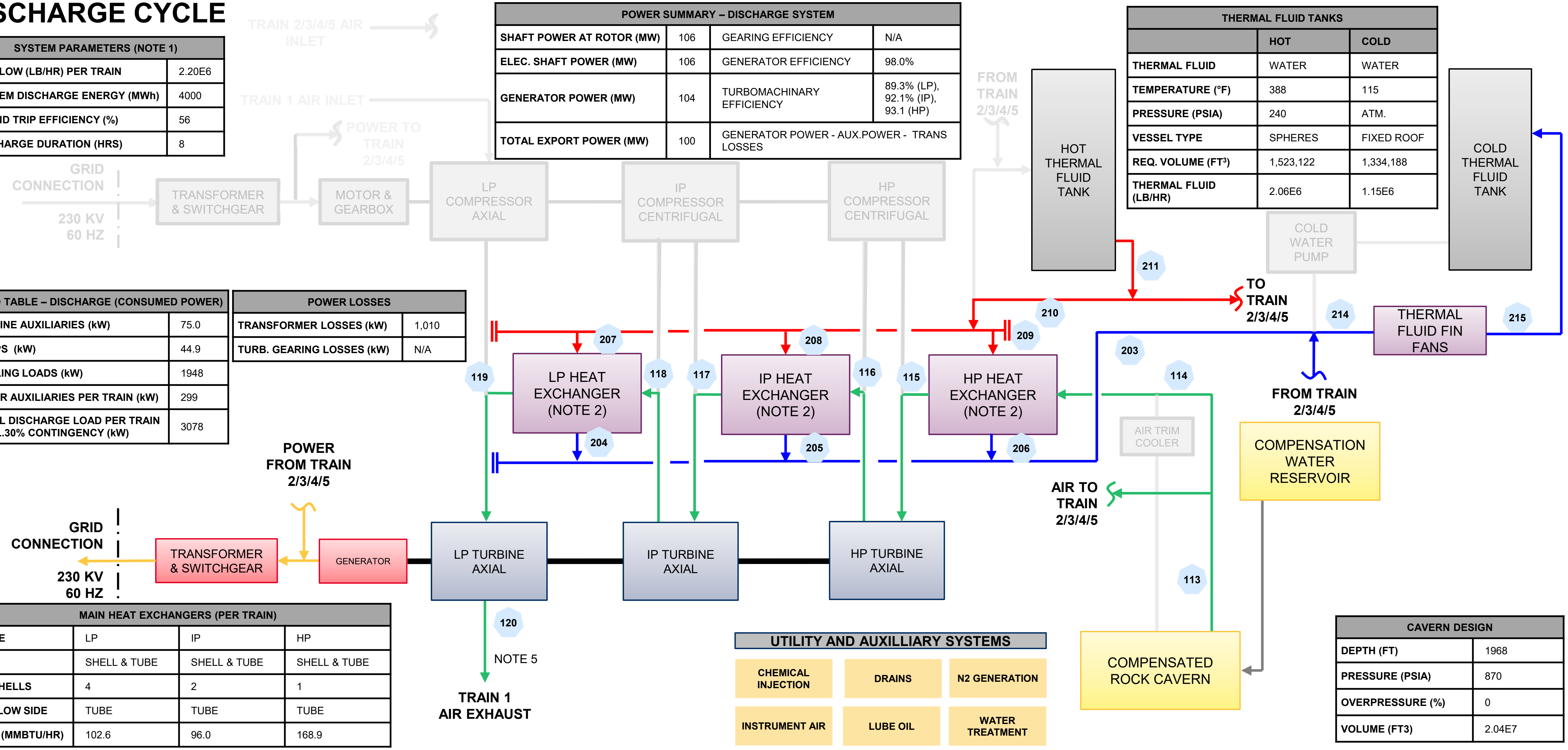
SYSTEM PARAMETERS (NOTE 1)	
AIR FLOW (LB/HR) PER TRAIN	2.20E6
SYSTEM DISCHARGE ENERGY (MWh)	4000
ROUND TRIP EFFICIENCY (%)	56
DISCHARGE DURATION (HRS)	8

POWER SUMMARY – DISCHARGE SYSTEM			
SHAFT POWER AT ROTOR (MW)	106	GEARING EFFICIENCY	N/A
ELEC. SHAFT POWER (MW)	106	GENERATOR EFFICIENCY	98.0%
GENERATOR POWER (MW)	104	TURBOMACHINARY EFFICIENCY	89.3% (LP), 92.1% (IP), 93.1 (HP)
TOTAL EXPORT POWER (MW)	100	GENERATOR POWER - AUX.POWER - TRANS LOSSES	

THERMAL FLUID TANKS		
	HOT	COLD
THERMAL FLUID	WATER	WATER
TEMPERATURE (°F)	388	115
PRESSURE (PSIA)	240	ATM.
VESSEL TYPE	SPHERES	FIXED ROOF
REQ. VOLUME (FT³)	1,523,122	1,334,188
THERMAL FLUID (LB/HR)	2.06E6	1.15E6

LOAD TABLE – DISCHARGE (CONSUMED POWER)	
TURBINE AUXILIARIES (kW)	75.0
PUMPS (kW)	44.9
COOLING LOADS (kW)	1948
OTHER AUXILIARIES PER TRAIN (kW)	299
TOTAL DISCHARGE LOAD PER TRAIN - INCL.30% CONTINGENCY (kW)	3078

POWER LOSSES	
TRANSFORMER LOSSES (kW)	1,010
TURB. GEARING LOSSES (kW)	N/A



MAIN HEAT EXCHANGERS (PER TRAIN)			
STAGE	LP	IP	HP
TYPE	SHELL & TUBE	SHELL & TUBE	SHELL & TUBE
NO. SHELLS	4	2	1
AIR FLOW SIDE	TUBE	TUBE	TUBE
DUTY (MMBTU/HR)	102.6	96.0	168.9

UTILITY AND AUXILLIARY SYSTEMS

CHEMICAL INJECTION	DRAINS	N2 GENERATION
INSTRUMENT AIR	LUBE OIL	WATER TREATMENT

CAVERN DESIGN	
DEPTH (FT)	1968
PRESSURE (PSIA)	870
OVERPRESSURE (%)	0
VOLUME (FT3)	2.04E7

LEGEND

(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(blue dashed arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	— · —	BATTERY LIMIT
(purple arrow)	COOLING MEDIUM		

— HMB NUMBER

WATER SYSTEMS
HEAT EXCHANGER
TURBOMACHINERY
ELECTRICAL SYSTEMS
CAVERN SYSTEM

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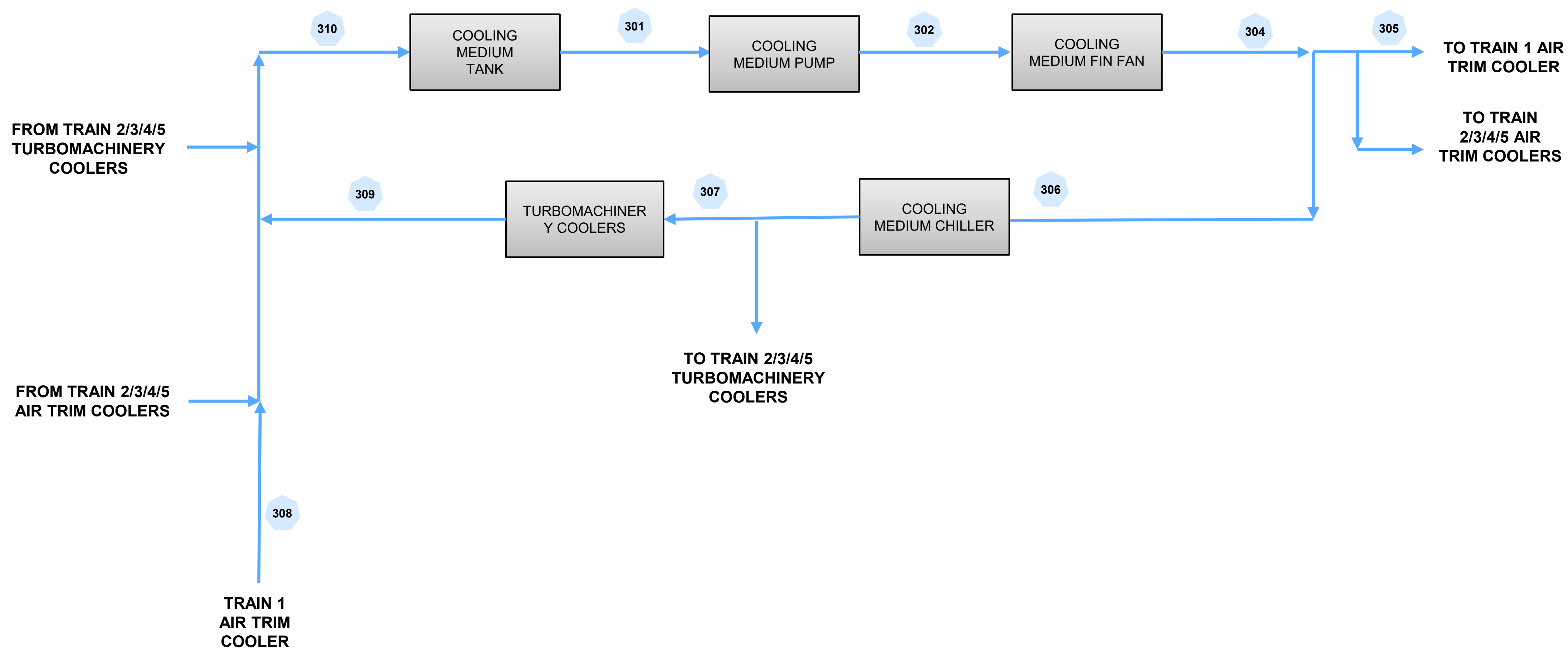
HYDROSTOR A-CAES GEM
OVERALL BLOCK FLOW DIAGRAM
MAN LP AXIAL (100MW) – 500MW / 4000MWh PEAK CASE

TWD EMPOWERING EPCM — HYDROSTOR

DOCUMENT NO.	REV.
21-5291-00-3443-002 SHT 4 OF 6	0

COOLING MEDIUM SYSTEM



LEGEND

(black line)	MECHANICAL DRIVE	(yellow arrow)	ELECTRICAL FLOW
(red arrow)	HOT THERMAL FLUID	(blue dashed arrow)	COOLING MEDIUM
(blue arrow)	COLD THERMAL FLUID	(grey arrow)	RESERVOIR WATER
(green arrow)	AIR	(dash-dot line)	BATTERY LIMIT
(magenta arrow)	COOLING MEDIUM		

\# HMB NUMBER

WATER SYSTEMS
HEAT EXCHANGER
TURBOMACHINERY
ELECTRICAL SYSTEMS
CAVERN SYSTEM

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HYDROSTOR A-CAES GEM

OVERALL BLOCK FLOW DIAGRAM

MAN LP AXIAL (100MW) – 500MW / 4000MWh

TWD EMPOWERING EPCM
HYDROSTOR

DOCUMENT NO.	REV.
21-5291-00-3443-002 SHT 5 OF 6	0

NOTES

1. A SINGLE NOMINAL 100MW COMPRESSION / EXPANSION TRAIN IS SHOWN. 4 X 100 MW TRAINS MAKE UP THE SYSTEM AS A WHOLE. THERMAL FLUID , CAVERN AND UTILITY SYSTEMS BASED ON 500MW FACILITY.
2. LP, IP AND HP HEAT EXCHANGER OPERATION IS REVERSIBLE. THE SAME EXCHANGERS ARE USED ON BOTH THE CHARGE AND DISCHARGE CYCLES. THE EXCHANGER BLOCK SHOWN REPRESENTS MULTIPLE EXHCHANGERS. REFER TO MAIN HEAT EXHCHANGER TABLE FOR NUMBER OF EXCHANGERS
3. ALL VALUES SHOWN ON THIS DRAWING ARE TAKEN FROM THE HYSYS SIMULATION MODEL –
    a) AVERAGE CASE: HMB CASE 6 IU – 420 PSIG - REF CASE – 7.3 BARA – MAN AXIAL – 100MW_GEM
    b) PEAK CASE: HMB CASE 5 IU- 420 PSIG - REF CASE – 7.3 BARA – MAN AXIAL – 100MW_GEM
4. THIS BLOCK FLOW DIAGRAM IS BASED ON THE FOLLOWING PARAMETERS
    a) DISCHARGE DURATION 8 HOURS
    b) LP COMPRESSOR TYPE – AXIAL
    c) TURBOMACHINERY VENDOR – MAN
5. DISCHARGE EXHAUST FREQUENCY EXPECTED TO BE 8 HRS PER DAY

Rev	Date	By	Checked	Approved
0	2021-07-29	ZAH	AKN	JYK

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HYDROSTOR A-CAES GEM

OVERALL BLOCK FLOW DIAGRAM

MAN LP AXIAL (100MW) – 500MW / 4000MWh

TWD EMPOWERING EPCM

HYDROSTOR

DOCUMENT NO. 21-5291-00-3443-002 SHT 6 OF 6

REV. 0

APPENDIX 2C

Heat and Mass Balance Maximum Temperature Case

EMPOWERING EPCM

Project	Calculation No.				
Hydrostor Rosamond	**21-5291-00-3438-002**				
Client					
Hydrostor	Rev.	Date:	By:	Chk'd	App'd
Project No.	0	2021-07-29	ZAH	JYK	JYK
21-5291					

Heat and Material Balance - Gem Unit - Case Peak Temperature

Table 1. Heat and Material Balance Table - Air Streams

	Stream Number PFD *		101	102	104	105	108	109	110	111	112	113	114	115	116	117	118	119	120
	Description	**Unit**	Atm. Intake Air to LP Compressors	Air to LP Heat Exchangers	Air to IP Compressors	Air from IP Compressors	Air to HP Compressors	Air from HP Compressors	Air from HP Heat Exchanger to Air Trim Cooler	Air from Air Trim Cooler	All Trains Air to Storage Cavern	Cavern Air to All Trains	Cavern Air to Train 1	Air to HP Turbine	Air from HP Turbine	Air to IP Turbine	Air from IP Turbine	Air to LP Turbine	LP Turbine Outlet/ Vent to Atmosphere
Overall	Vapour Fraction		1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Temperature	°F	109.4	601.0	122.10	371.4	138.28	385.70	134.2	123.8	123.8	82.4	82.1	384.8	198.2	375.4	192.1	383.8	66.5
	Pressure	psia	14.5	105.9	104.03	301.7	296.32	831.07	824.9	821.3	821.3	803.2	790.9	779.1	300.2	284.5	109.5	100.6	14.9
	Mass Flow	lb/h	1,257,876	1,257,876	1,251,446	1,251,446	1,242,454	1,242,454	1,242,454	1,242,454	6,184,099	10,978,894	2,195,326	2,195,326	2,195,326	2,195,326	2,195,326	2,195,326	2,195,326
	Molar Flow	lbmole/h	43,879	43,879	43,522	43,522	43,088	43,088	43,088	43,088	213,879	379,430	75,861	75,861	75,861	75,861	75,861	75,861	75,861
	Molecular Weight	lb/lbmole	28.667	28.667	28.75	28.75	28.83	28.83	28.83	28.83	28.91	28.93	28.94	28.94	28.94	28.94	28.94	28.94	28.94
	Mass Density @ T&P	lb/ft³	0.068	0.266	0.48	0.97	1.34	2.62	3.81	3.87	3.85	4.10	4.04	2.46	1.23	0.92	0.45	0.32	0.08
	Enthalpy	MMBTU/hr	-109	44	-68.61	7	-31.69	42.59	-42	-46	-39	-111	-19	150	52	147	51	153	-14

Table 2. Heat and Material Balance Table - Thermal Fluid Streams

	Stream Number PFD *		201	202	203-C	204-C	205-C	206-C	207-C	208-C	209-C	210-C	211-C	203-D	204-D	205-D	206-D	207-D	208-D	209-D	210-D	211-D	214	215
	Description	**Unit**	Cold Thermal Fluid from Cold Tank	Cold Thermal Fluid to All Trains	Cold Thermal Fluid to Train 1 Exchangers	Cold Thermal Fluid to LP Heat Exchangers	Cold Thermal Fluid to IP Heat Exchangers	Cold Thermal Fluid to HP Heat Exchangers	Thermal Fluid from LP Heat Exchangers	Warmed Thermal Fluid from IP Heat Exchangers	Warmed Thermal Fluid from HP Heat Exchangers	Train 1 Warmed Thermal Fluid to Hot Storage Tanks	All Trains Thermal Fluid to Hot Storage Tanks	Thermal Fluid to Thermal Cooler Fin Fans	Cooled Thermal Fluid from LP Heat Exchangers	Cooled Thermal Fluid from IP Heat Exchangers	Cooled Thermal Fluid from HP Heat Exchangers	Hot Thermal Fluid to LP Heat Exchangers	Hot Thermal Fluid to IP Heat Exchangers	Hot Thermal Fluid to HP Heat Exchangers	Train 1 Hot Thermal Fluid from Hot Storage Tanks	Hot Thermal Fluid to All Trains	Cold Thermal Fluid to Thermal Fluid Trim Cooler	Cold Thermal Fluid from Thermal Fluid Trim Cooler
Overall	Vapour Fraction		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Temperature	°F	114.8	115.39	115.4	115.4	115.4	115.4	452.8	339.8	350.0	388.4	388.4	215.9	243.7	243.7	160.2	388.7	388.7	388.7	388.7	388.7	215.88	114.8
	Pressure	psia	14.7	434.7	434.7	434.7	434.7	434.7	434.3	434.3	433.8	433.8	433.8	236.7	238.4	238.4	236.7	239.3	239.3	239.3	239.3	239.3	236.73	213.1
	Mass Flow	lb/h	5,735,831	5,735,831	1,147,166	447,395	344,150	355,622	447,395	344,150	355,622	1,147,166	5,735,831	2,061,069	638,931	638,931	721,374	700,764	638,931	721,374	2,061,069	10,305,346	10,305,346	10,305,346
	Molar Flow	lbmole/h	318,384	318384	63,677	24,834	19103	19740	24,834	19,103	19,740	63,677	318,384	114,406	35,466	35,466	40,042	38,898	35,466	40,042	114,406	572,028	572,028	572,028
	Molecular Weight	lb/lbmole	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.0	18.02	18.02
	Mass Density @ T&P	lb/ft³	61.79	61.86	61.86	61.86	61.860	61.860	46.94	56.05	55.68	54.20	54.20	59.78	59.04	59.04	61.04	54.13	54.13	54.13	54.13	54.1	59.78	61.83
	Enthalpy	MMBTU/hr	-38,932	-38,922	-7,784	-3,036	-2,335	-2,413	-2,879	-2,257	-2,329	-7,465	-37,325	-13,780	-4,254	-4,254	-4,863	-4,560	-4,158	-4,694	-13,412	-67,061	-68,899	-69,942

Table 3. Heat and Material Balance Table - Cooling Medium Streams

	Stream Number PFD *		301-C	302-C	304-C	305	306-C	307-C	308	309-C	310-C	301-D	302-D	304-D	306-D	307-D	309-D	310-D
	Description	**Unit**	Cooling Medium to Cooling Medium Circulation Pumps	Cooling Medium from Cooling Media Circulation Pumps	Cooling Medium from Cooling Medium Fin Fan Cooler	Cooling Medium to Train 1 Air Trim Cooler	Cooling Medium to Cooling Medium Chiller	Cooling Medium to Turbomachinery Cooling	Cooling Medium Return from Train 1 Air Trim Cooler	Cooling Medium Return from Turbomachinery Cooling	Cooling Medium Return to Cooling Medium Buffer Tank	Cooling Medium to Cooling Medium Circulation Pumps	Cooling Medium from Cooling Media Circulation Pumps	Cooling Medium from Cooling Medium Fin Fan Cooler	Cooling Medium to Cooling Medium Chiller	Cooling Medium to Turbomachinery Cooling	Cooling Medium Return from Turbomachinery Cooling	Cooling Medium Return from Turbomachinery Cooling
Overall	Vapour Fraction		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Temperature	°F	121.2	121.3	114.3	114.3	114.3	102.2	127.6	119.118	120.3	155.7	155.8	112.6	112.6	102.2	155.6	155.6
	Pressure	psia	14.7	87.0	81.3	81.3	81.3	71.4	66.7	69.213	66.7	14.7	87.0	86.1	86.1	76.1	61.1	61.1
	Mass Flow	lb/h	11,111,300	11,111,300	11,111,300	309,529	9,563,655	1,912,731	309,529	1,912,731	11,111,300	2,516,986	2,516,986	2,516,986	2,516,986	503,397	503,397	2,516,986
	Molar Flow	lbmole/h	616,764	616,764	616,764	17,181	530,858	106,172	17,181	106,172	616,764	139,712	139,712	139,712	139,712	27,942	27,942	139,712
	Molecular Weight	lb/lbmole	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.015	18.02	18.02	18.02	18.02	18.02	18.02	18.02	18.0
	Mass Density @ T&P	lb/ft³	61.69	61.71	61.81	61.81	61.81	61.98	61.60	61.736	61.72	61.09	61.10	61.84	61.84	61.98	61.10	61.1
	Enthalpy	MMBTU/hr	-75,346	-75,343	-75,421	-2,101	-64,916	-13,006	-2,097	-12974.057	-75,355	-16,981	-16,980	-17,089	-17089	-3,423	-3,396	-16,981

NOTES:

(*) Letters C and D denote Charge and Discharge Cycle, respectively.

APPENDIX 2D

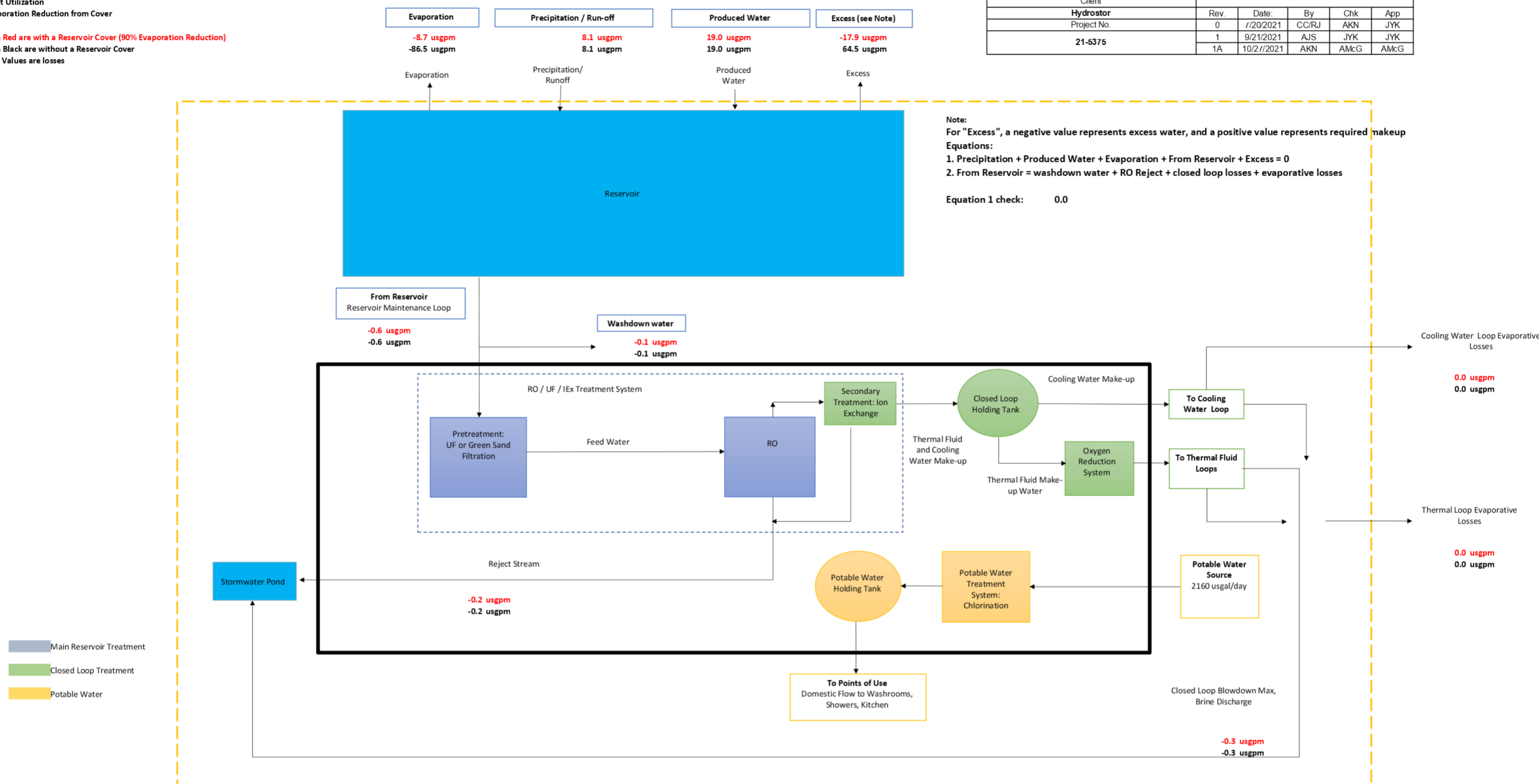
Gem Average Water Balance

Overall BFD for Water Balance

Gem Average Case
50% Plant Utilization
90% Evaporation Reduction from Cover

Values in Red are with a Reservoir Cover (90% Evaporation Reduction)
Values in Black are without a Reservoir Cover
Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	/20/2021	CC/RJ	AKN	JYK
21-5375	1	9/21/2021	AJS	JYK	JYK
	1A	10/2/2021	AKN	AMcG	AMcG



GEM Site
Process Flow Diagram

APPENDIX 2D

Gem Construction Water Use

Table 2 - Construction Water by Month
Site: Gem

Hydrostor Pecho & Gem Energy Storage Center Projects – AFC Permitting Inputs
Item 2.21 – Construction Water
Rev: 19 July 2021

		Estimated Water Consumption by Month																																	
		Cavern	Cavern	Surface & Cavern																														Cavern	Total Water
		Cavern Months 1-4	Cavern Months 5-12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	Cavern Months 43 - 60	
1. Potable Water																																			
Worker use, wash/drinking																																			
Surface Works & Cavern																																			
Assumed 20 gal/day/worker	20 US gal/worker																																		
	20																																		
	Estimated # of workers	14	20	107	331	358	358	358	358	406	426	517	517	452	473	532	564	564	544	491	491	375	447	522	522	392	229	55	55	55	55	55	55	55	
	Water Per month	5,600	8,000	42,842	132,206	143,377	143,377	143,377	143,377	162,331	170,543	206,718	206,718	180,654	189,197	212,635	225,655	225,655	217,443	196,210	196,210	149,963	178,609	208,692	208,692	156,608	91,504	22,000	22,000	22,000	22,000	22,000	22,000	22,000	
	# months/period	4	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	9	
	Total period (US gal)	22,400	64,000	42,842	132,206	143,377	143,377	143,377	143,377	162,331	170,543	206,718	206,718	180,654	189,197	212,635	225,655	225,655	217,443	196,210	196,210	149,963	178,609	208,692	208,692	156,608	91,504	22,000	22,000	22,000	22,000	22,000	22,000	198,000	4,548,991
Transmission	Estimated # of workers		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10														
	Water Per month		4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000														
	# months/period		8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1														
	Total period (US gal)		32,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000														104,000
																																		Total Potable Water for construction	4,652,991
Total Estimated Potable Water Demand by period		22,400	96,000	46,842	136,206	147,377	147,377	147,377	147,377	166,331	174,543	210,718	210,718	184,654	193,197	216,635	229,655	229,655	221,443	200,210	200,210	149,963	178,609	208,692	208,692	156,608	91,504	22,000	22,000	22,000	22,000	22,000	22,000	198,000	
Average flow (if piped from source(s))																																			
Gal/month		5,600	12,000	46,842	136,206	147,377	147,377	147,377	147,377	166,331	174,543	210,718	210,718	184,654	193,197	216,635	229,655	229,655	221,443	200,210	200,210	149,963	178,609	208,692	208,692	156,608	91,504	22,000	22,000	22,000	22,000	22,000	22,000	22,000	
Average flow, gpm																																			
Flow, gpm, based on 40 hours/week		0.58	1.25	4.88	14.19	15.35	15.35	15.35	15.35	17.33	18.18	21.95	21.95	19.23	20.12	22.57	23.92	23.92	23.07	20.86	20.86	15.62	18.61	21.74	21.74	16.31	9.53	2.29	2.29	2.29	2.29	2.29	2.29	2.29	
Flow, gpm, based on 24/7		0.14	0.30	1.16	3.38	3.66	3.66	3.66	3.66	4.13	4.33	5.23	5.23	4.58	4.79	5.37	5.70	5.70	5.49	4.97	4.97	3.72	4.43	5.18	5.18	3.88	2.27	0.55	0.55	0.55	0.55	0.55	0.55	0.55	
Estimated Quantity of Truck Loads																																			
Water truck volume (US gal)	9000																																		
Total # of truck loads		2.49	10.67	5.20	15.13	16.38	16.38	16.38	16.38	18.48	19.39	23.41	23.41	20.52	21.47	24.07	25.52	25.52	24.60	22.25	22.25	16.66	19.85	23.19	23.19	17.40	10.17	2.44	2.44	2.44	2.44	2.44	2.44	22.00	
per month		0.6	1.3	5.2	15.1	16.4	16.4	16.4	16.4	18.5	19.4	23.4	23.4	20.5	21.5	24.1	25.5	25.5	24.6	22.2	22.2	16.7	19.8	23.2	23.2	17.4	10.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	
2. Non-potable Water																																			
Surface Works																																			
General Use	2x2000 gal trucks/day			80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000								
Road de-dusting, washdown, etc	# months/period			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
	Total period			80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000								1920000
Hydrotest	Cold Tank, 7.64 M US gal																									7640000									7640000
	Piping Systems																									Re-use cold Tank Hydrotest									0
	Spheres																									Re-use cold Tank Hydrotest									0
Fire/sprinkler test	Test building fire system																									Re-use cold Tank Hydrotest									0
Excluded	Cement water (assumed at cement plant)																																		
Transmission Infrastructure																																			
General use	1x1000 gal trucks/day		20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000														
			8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1														
			160,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000														520,000
Cavern Works																																			
Site Prep																																			
General use	2x2000 gal trucks/day																																		
	per month	80,000																																	
	Total period	320,000																																	320,000
Shaft Drilling																																			
Shaft drilling water	To be all delivered in month 5		8,776,919																																8,776,919
	See detailed estimate attached																																		
Mining	Avg 35 gpm, 24/7, per month									1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	
	# months/period									1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	
	total per period									1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	1,527,624	27,497,232	64,160,208
Reservoir Fill																																			
Average gpm, 24x7										271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271		
Volume/day																																			
m3										1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475	1475		
gal										389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0	389,695.0		
gpm										270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6	270.6		
Volume/month (24x7)	US gal									11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850	11,690,850		280,580,400
Total Non-Potable Water Demand by month		320,000	8,936,919	100,000	100,000	100,000	100,000	100,000	100,000	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,298,474	13,298,474	13,298,474	13,298,474	20,938,474	13,298,474	13,218,474	13,218,474	13,218,474	13,218,474	13,218,474	13,218,474	27,497,232	363,917,527
																																		Total Non-potable Water for construction	363,917,527
Average flow (if piped from source(s))																																			
Gal/month		80,000	8,936,919	100,000	100,000	100,000	100,000	100,000	100,000	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,318,474	13,298,474	13,298,474	13,298,474	13,298,474	20,938,474	13,298,474	13,218,474	13,218,474	13,218,474	13,218,474	13,218,474	13,218,474	3,055,248	
Average flow, gpm																																			
40 hours/week		8.3	930.9	10.4	10.4	10.4	10.4	10.4	10.4	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,385.3	1,385.3	1,385.3	1,385.3	2,181.1	1,385.3	1,376.9	1,376.9	1,376.9	1,376.9	1,376.9	1,376.9	318.3	
Total Hours		160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	
Total Minutes		9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	9,600.0	
Flow, gpm, based on 40 hours/week		8.3	930.9	10.4	10.4	10.4	10.4	10.4	10.4	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,387.3	1,385.3	1,385.3	1,385.3	1,385.3	2,181.1	1,385.3	1,376.9	1,376.9	1,376.9	1,376.9	1,376.9	1,376.9	318.3	
Flow, gpm, based on 24/7		2.0	221.6	2.5	2.5	2.5	2.5	2.5	2.5	330.3	330.3	330.3	330.3	330.3	330.3	330.3	330.3	330.3	330.3	330.3	330.3	329.8	329.8	329.8	329.8	519.3	329.8	327.8	327.8	327.8	327.8	327.8	327.8	75.8	
Estimated Quantity of Truck Loads																																			
Water truck volume (US gal)	9000																																		
Total # of truck loads		35.6	993.0	11.1	11.1	11.1	11.1	11.1	11.1	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1477.6	1477.6	1477.6	1477.6	2326.5	1477.6	1468.7	1468.7	1468.7	1468.7	1468.7	1468.7	3055.2	
per month		8.9	993.0	11.1	11.1	11.1	11.1	11.1	11.1	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1479.8	1477.6	1477.6	1477.6	1477.6	2326.5	1477.6	1468.7	1468.7	1468.7	1468.7	1468.7	1468.7	339.5	
per day (24x7)		0.3	33.1							49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	77.5	49.3	49.0	49.0	49.0	49.0	49.0	49.0	11.3	
per hour (24x7)			1.4							2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	3.2	2.1	2.0	2.0	2.0	2.0	2.0	2.0	0.5	
Assumed % volume trucked vs GW wells		50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
# trucks per month (for AFC input)		4.4	496.5	5.6	5.6	5.6	5.6	5.6	5.6	739.9	739.9	739.9	739.9	739.9	739.9	739.9	739.9	739.9	739.9	739.9	739.9	738.8	738.8	738.8	738.8	1163.2	738.8	734.4	734.4	734.4	734.4	734.4	734.4	169.7	

Notes:

APPENDIX 2D

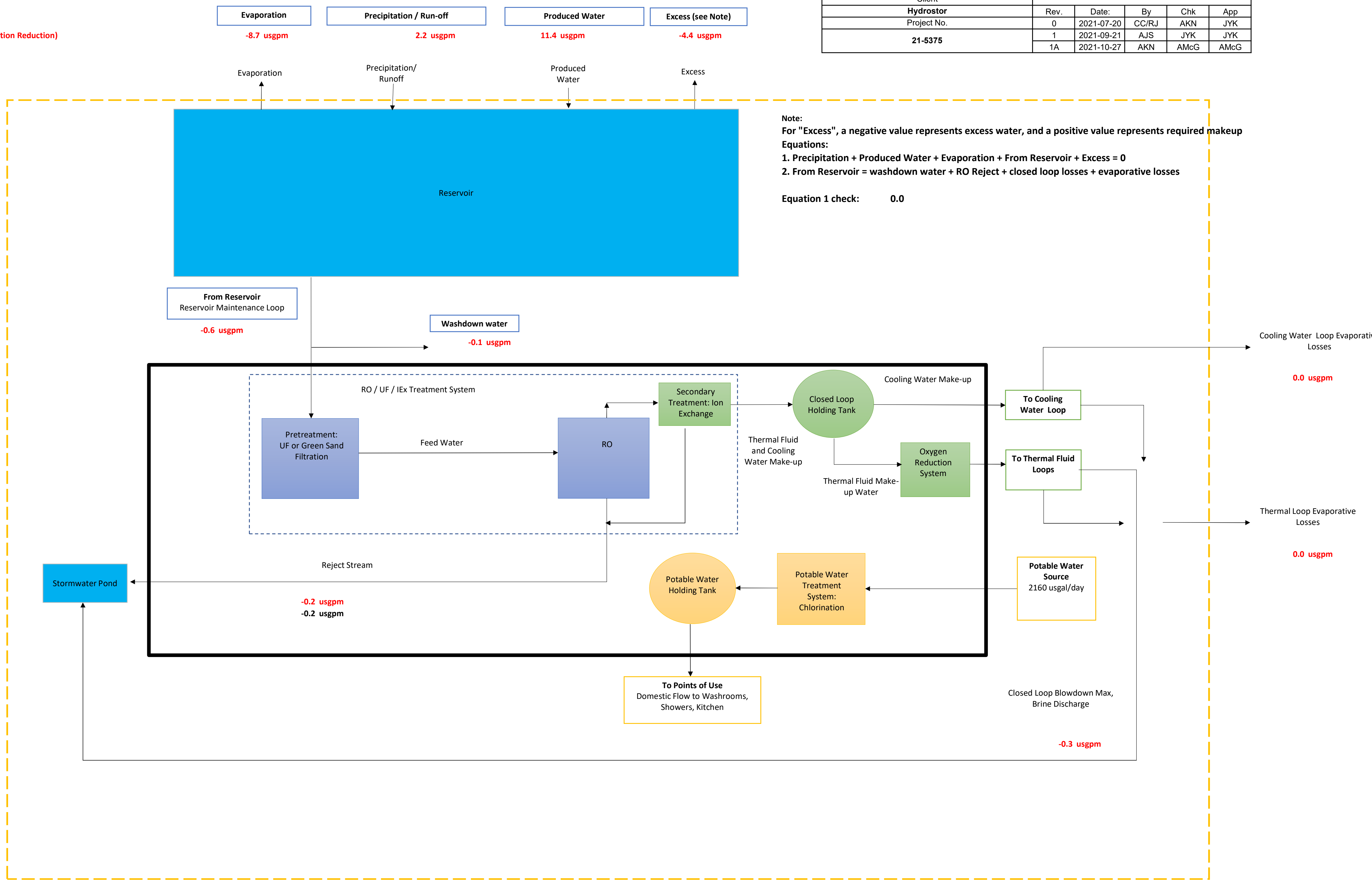
Gem Water Balance – Dry Scenario

Overall BFD for Water Balance

Gem Peak Dry Case (very low excess water production case)
30% Plant Utilization
90% Evaporation Reduction from Cover
5th Percentile Precipitation (i.e. DRY conditions)
Values in Red are with a Reservoir Cover (90% Evaporation Reduction)

Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	2021-07-20	CC/RJ	AKN	JYK
21-5375	1	2021-09-21	AJS	JYK	JYK
	1A	2021-10-27	AKN	AMcG	AMcG



Main Reservoir Treatment

Closed Loop Treatment

Potable Water

GEM Site
Process Flow Diagram

APPENDIX 2D

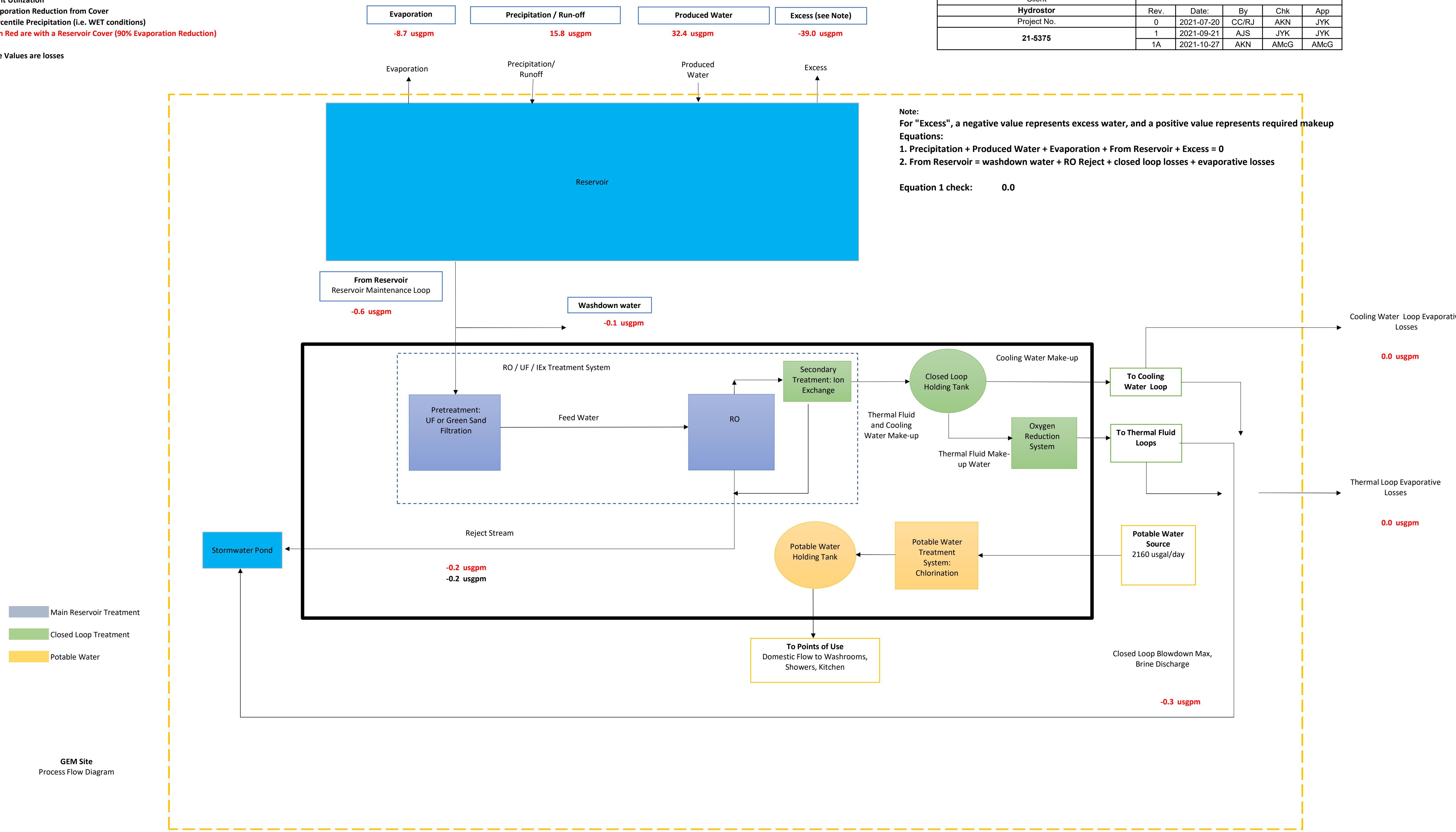
Gem Water Balance – Wet Scenario

Overall BFD for Water Balance

Gem Peak Wet Case (very high excess water production case)
85% Plant Utilization
90% Evaporation Reduction from Cover
95th Percentile Precipitation (i.e. WET conditions)
Values in Red are with a Reservoir Cover (90% Evaporation Reduction)

Negative Values are losses

Project	Calculation No.				
Hydrostor California Gem and Pecho	**21-5375-00-3443-001**				
Client					
Hydrostor	Rev.	Date:	By	Chk	App
Project No.	0	2021-07-20	CC/RJ	AKN	JYK
21-5375	1	2021-09-21	AJS	JYK	JYK
	1A	2021-10-27	AKN	AMcG	AMcG



APPENDIX 2E

Gem Construction Truck Traffic Estimates

Table 2 - Haul and Material Truck Quantities

Site: Gem

Hydrostor Pecho & Gem A-CAES Projects – AFC Permitting Inputs

Item 5.6 – Haul and Material Truck Quantities

Rev: 19 Jul 2021

Task	Duration/Timing	Peak hours/throughout the day	Vehicle Type	Assumptions/Notes	Rev
1. CAVERN WORKS, Months 1 - 60					
Site Clearing - Months 1-4					
Workforce – 12 people = 12 vehicles @ 2 trips per day each x 12 x 5 days x 16 weeks = 1920 trips	Full duration of phase	Daily peak hours	Passenger Car	No carpooling assumed	
Equipment mobilization – 10 tractor trailer loads, 1st week of site prep	Week 1	Throughout the day	Tractor Trailer		
Equipment demobilization – 10 tractor trailer loads, last week of site prep	Week 16	Throughout the day	Tractor Trailer		
Fuel delivery – 1 per day – 80 fuel truck trips, tandem fuel truck	Daily, full duration	Daily peak hours	Fuel truck (tandem)		
Fencing delivery – 2 trucks, tractor trailer	Week 1	Throughout the day	Tractor Trailer		
Concrete trucks – 30 loads, std 10 yd cement mix truck (3 periods x 10 trucks)	Week 1, Week 6, Week 12	Throughout the day	Cement mix truck (10 yd)		
Gravel delivery for 7 acres = 305,000 sq ft x 1 ft thick/27 = 11,300 cubic yards/12 yds/truck = 942 tandem truck loads (1st 3 wee	Week 1, 2, 3	Throughout the day	Tandem truck load (12 yd)		
Trailer delivery – 12 trailers x 2 = 24 trips (1st week)	Week 1	Throughout the day	Tractor Trailer		
Shaft - Months 5-18					
Workforce – 3 rigs x 6 workers per per rig = 18 people x 5 days x 52 weeks x 2 ways = 9360 trips	Full duration of phase	Daily peak hours	Passenger car	No carpooling assumed	
Shaft cuttings for disposal – 19,000 cy / 12cy per truck = 1583 trucks	Full duration of phase	Throughout the day	12 cy dump truck		
Shaft liner delivery – 2000 ft deep shafts / 40' shaft steel = 50 loads per shaft x 4 shafts = 200 loads (30 weeks in, tractor trailer	Week 46	Throughout the day	Tractor trailer		
Rig delivery – 3 rigs x 8 loads per rig = 24 loads x 2 (mobe in and out) = 48 loads (24 mobe, 24 demob)	Week 16	Throughout the day	Tractor trailer		
Mining - Months 19-60					
Workforce					
Rosamond – 55 people/day x 2 trips/day x 1270 days = 139,700 trips	Full duration of phase	Daily peak hours		No carpooling assumed	
Mobe of mining infrastructure –					
Surface equipment – mob x 50 loads = 50 loads (tractor trailers)	Month 19	Throughout the day	Tractor Trailer		
Surface equipment – demob x 50 loads = 50 loads (tractor trailers)	Month 51	Throughout the day	Tractor Trailer		
Subsurface equipment – mob x 35 loads = 35 loads	Month 19	Throughout the day	Tractor Trailer		
Subsurface equipment – demob x 35 loads = 35 loads	Month 51		Tractor Trailer		
Ground support – 1 load every 14 days = Rosamond – 91 loads (wire mesh, etc – flatbed tractor trailer (open))	Biweekly, full duration		Flatbed tractor trailer		
Explosives – 1 load every 14 days = Rosamond – 91 loads	Biweekly, full duration				
Rosamond – 3.8M bbls = 790,200 cy x 1.4 swell X 100% = 1,106,280 truck cy	Full duration (months 26-60)		On road dump trucks (12 yd)	Assumed 100% of waste rock trucked off-site	
On road trucks at 12 cy/truck = 92,190 loads	Full duration (months 26-60)				
2. Surface Works, Months 13-36					
Workforce, average 384 workers per month @ 2 trips per day x 24 months x 20 days = 368,640 trips	Full duration	Daily peak hours	Passenger Car	No carpooling assumed	
Site clearing - overburden - 112,526 cu yd (1 ft depth) x 1.12 swell = 126029 cu yd @ 12 yd trucks = 10,502 trucks	Months 13-16	Throughout the day	12 cy dump truck	Assuming 1' overburden depth; possible opportunity to re-use some for landscaping and other construction tasks	
Civil foundation excavation, 44517 cu yd @ 12 cy dump trucks + 30% allowance = 4822 loads	Month 14, 15, 16	Throughout the day	12 cy dump truck	Preliminary estimates	
Cement Trucks, 33252 cu yd @ 12 yd cement trucks = 2,771 loads	Months 17, 18	Throughout the day	12 cy cement truck	Preliminary estimates	
Equipment and material delivery, 1050 loads (equipment, pipe, building, misc)	Months 19-31	Throughout the day	Flatbed	Preliminary estimates	
3. Water Import, full duration					**Rev 19 Jul 2021**
Potable water	Full duration	Throughout the day	9,000 gal water truck	Average rate over full construction duration	
Assumed trucked to site					
Average trucks per month = 15					
Peak trucks per month = 26					
Non-potable water	Full duration	Throughout the day	9,000 gal water truck		
Assumed 50% of demand is provided by groundwater wells on site, 50% purchased from wholesaler (i.e. AVEK) and trucked to site (5 mile distance, 1 way)					
Average trucks per month = 572				Average rate over full construction duration	
Peak trucks per month = 1163				Peak during reservoir fill and cold tank fill - assumed 24 month duration for fill, values estimated without cover	