Document:	**Redbank Power Station – Description of Proposed Modifications for Conversion to Fire Biomass fuels**
Prepared for:	Verdant Earth Technologies Limited
Subject:	Proposed Conversion of Redbank Power Station to fire Biomass fuel Report for Further Appeal for the LEC.
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View of the Redbank Site looking South

EXECUTIVE SUMMARY

The scope of this document includes the description of the plant functional operation and main equipment, and a description of the proposed modifications to the plant and equipment to enable Biomass fuel firing.

Particular reference is made to the original Development Consent (1994), and where necessary to the 1997 Development Consent. The Amended EIS of 1993 forms part of the basis for the original Development Consent (1994 Consent).

In summary it is proposed to use the Biomass fuel in the equipment and locations designated for the "Supplementary fuel" described in the EIS and associated Consent documents. Due to the nature of the Biomass fuel, some equipment modifications to the Supplementary fuel handling systems are proposed as described in this document.

Summary of proposed plant modifications

The following summarises the extent of the modifications listed by plant functional areas to enable the plant to use Biomass fuels.

Modifications proposed:

- Internal roadways including new weigh bridges
- Supplementary fuel receival, storage & reclaim
- Supplementary fuel transport equipment

No modification proposed:

- Site buildings and infrastructure works
- Boiler plant
- Steam turbine equipment
- Tailing (BDT) fuel system
- Water and waste-water treatment systems
- Ash Handling plant
- Switchyard and electrical transmission equipment
- Cooling water systems
- Steam and water systems Balance of Plant
- Hunter River water make-up and discharge systems
- Control System equipment

Refer to the site plan on the following page marked up to illustrate the location of the plant modifications proposed to enable the plant to handle Biomass fuel.

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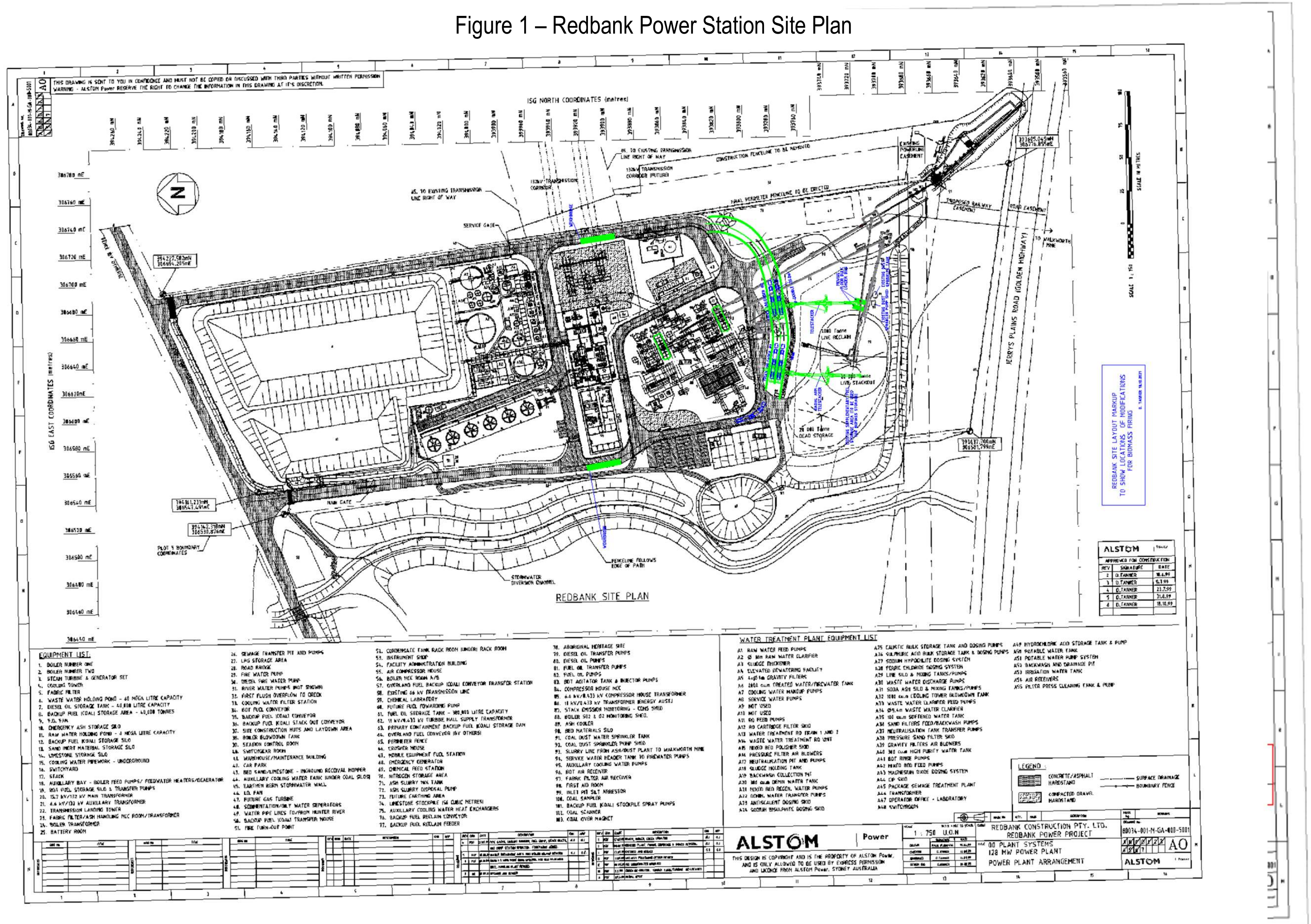
Figure 1 – Redbank Power Station Site Plan



Abbreviations used in this document

1994 Consent	Development consent ordered in the LEC November 1994
1997 Consent	Development consent ordered in the LEC dated 27.03.1997
Biomass fuel	Wood chips as specified in Appendix A to this document
BDT	Beneficiated Dewatered Tailings
BOP	Balance of Plant
db	Dry Basis
EIS	Amended Environmental Impact Statement No. 21333 of Nov. 1993.
GSE	Gross Specific Energy (same as GCV)
GCV	Gross Calorific Value (same as Gross Specific Energy)
HBD	Heat Balance Diagram
HP	High Pressure
LEC	Land and Environment Court of NSW
LHV	Lower Heating Value (or NCV)
LP	Low Pressure
kV	Kilovolts
MCR	Boiler Maximum Continuous Rating (261 t/h at full steam temperature)
MW	Megawatt
Net Output	Difference between the metered export power and metered import power
OEM	Original Equipment Manufacturer
ROM	Run of Mine Coal (Supplementary fuel)
ST	Steam Turbine
t/h	tonnes/hour

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1 INTRODUCTION AND OVERVIEW

1.1 Plant overview

The Redbank Power Project is a 128 MW power plant located near the Warkworth Mine in the Hunter Valley, west of Newcastle, New South Wales (NSW), Australia. The primary fuel is derived from coal washery tailings. The Redbank Power Station burns coal tailings and supplementary fuel to produce electricity.

The Redbank Power Station was commissioned in 2001 to burn beneficiated dewatered coal (BDT) tailings as main fuel and run of mine coal as the Supplementary (or Run of Mine ROM) fuel. The plant consists of two fluidised bed combustion steam generator units of FiCirc™ design and a single 151MW steam turbine and associated balance of plant equipment. The station has been out of operation since October 2014 and the current owners plan to convert of the plant to fire Biomass fuel (uncontaminated wood waste) as part of a recommissioning process. A view of the site appears below.

Figure 2 - View of Redbank Site from South

The following summary is extracted from the 1993 Amended EIS, with footnotes to indicate the significant changes which resulted from the 1997 Development Consent which were due to improvements to the tailings fuel quality by integrating the coal dewatering in the Warkworth mine operations.

2 Summary of the 1994 Consent Description of Plant

Paragraphs shown below in Italic text are extracts from the Amended EIS (1993). This formed the basis for the 1994 Development Consent.

2.1 Plant Operation

> *"The major features of the design of the Redbank Power Project include: a nominal rating of 120 megawatts[1] (MWe) (gross), approximately 100MW net output; fuel for the plant*

[1] The current plant rating of 128 MW is due to a higher plant efficiency from the higher quality fuel from 1997.

would be coal washery tailing supplied from the Warkworth and Lemington[2] coal preparation plants, augmented as necessary by existing tailing dams and supplemental fuel.

"Tailing would be transferred by slurry pipeline[3] from the Warkworth and Lemington washeries (and, as needed, from the Warkworth and Lemington tailing dams) to the Project site where the tailing would be stored for use as boiler fuel.

"Supplemental fuel would be trucked a short distance[4] to the Project site, where it would be stored and used as necessary to supplement the tailing fuel.

"The boiler station would consist of two atmospheric-pressure, hybrid bubbling/circulating bed type boilers of the 'FiCirc™" design of Combustion Power Company, a subsidiary of National Power. Tailing fuel would be mechanically dewatered and introduced into the boilers in paste form.

"The power generating unit would be a turbo-alternator generating at 11 kilovolts (kV). Connection to the Shortland electrical system would be via a new 132 kV electrical interconnect line of less than one kilometre (km) in length.

"This would connect with Shortland's existing 132 kV line from Singleton to Kurri Kurri.

"The objectives of the Project are to:

(1) improve the utilisation of natural (fuel) resources.

(2) introduce an alternative, environmentally responsible method of tailing disposal; and

(3) operate in a way that minimises or eliminates environmental impacts."

2.1.1 Process Flow Diagram from the 1994 Development Consent.

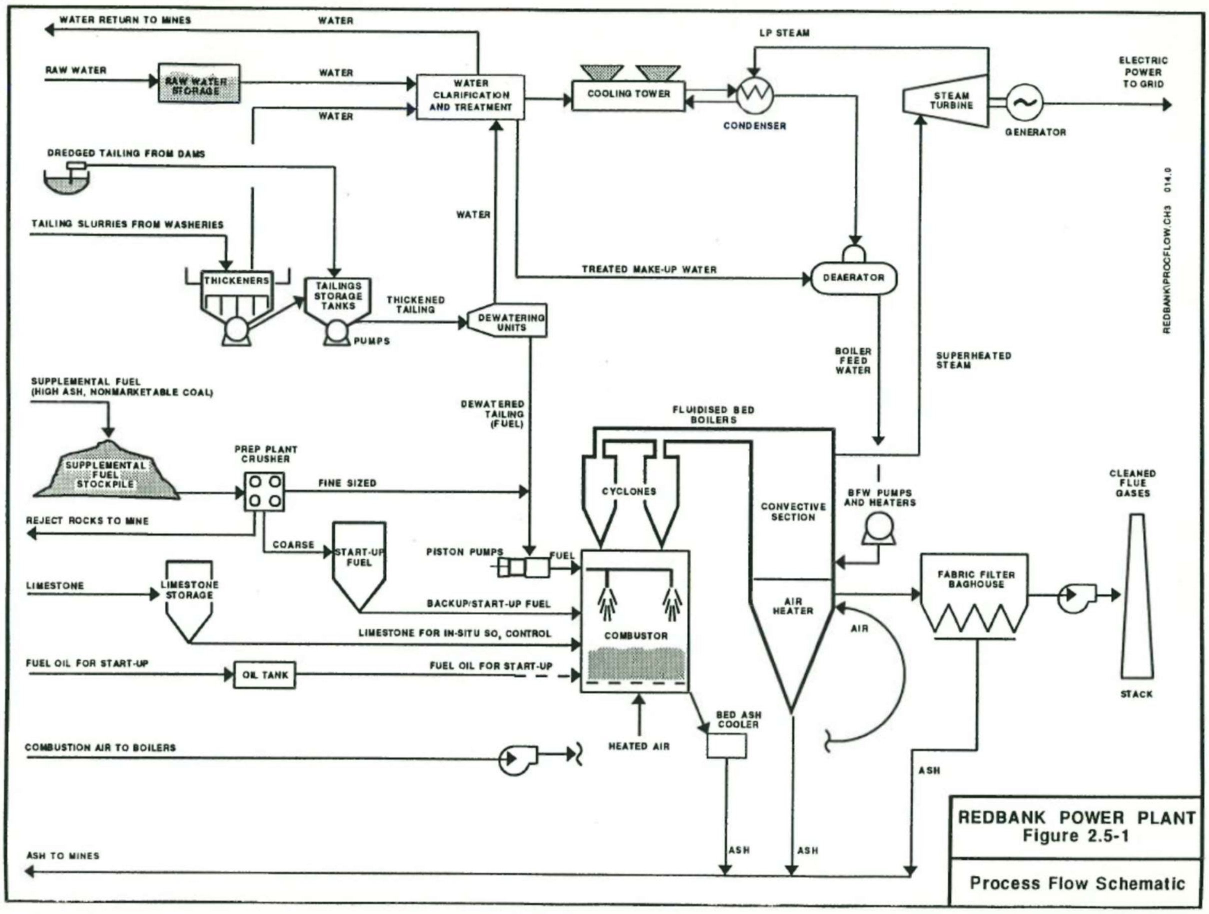
The following Process Flow Schematic is the Figure 2.5.1 from Amended EIS 1993 which forms a part of the 1994 Development Consent.

[2] Fuel sourced only from Warkworth mine

[3] Tailing fuel supplied by overland conveyor

[4] Supplementary fuel supplied by overland conveyor

<u>Figure 3 – Redbank Process Flow Schematic (Fig 2.5-1 from Amended EIS)</u>



2.2 Description of the Plant based on the 1994 Development Consent.

The following description of the Redbank plant is consistent with the 1994 consent, of which the Amended EIS of 1993 is a part with minor editing to the original wording to include:

- Change of tense to clarify current plant configuration
- Ignoring stated options in the EIS which were not included in the plant design
- Provision of explanatory comments to explain variations from the 1994 Consent.

The plant operating description is divided into a number of functional areas, and the corresponding sections of the Amended EIS (1993) are given for reference.

2.2.1 <u>Amended EIS Para 2.6.1 - Fuel supply and materials handling</u>

The fuel supply consists of two major fuel streams, designated “Tailings” and “Supplementary Fuel” in the Amended EIS.

Fuel Receiving

> *Tailing reclaimed from dams and other emplacements would be transferred by slurry pipeline from the moveable tailing reclaim system to the plant receiving tanks/thickeners.*

> *The supplemental/startup fuels would be received on site by trucks or belt conveyor from the individual mines.*

Fuel Storage

This system would receive, thicken and store approximately 96 hours supply of tailing in slurry form.

Supplemental fuel storage consists of a truck unloading station and stockpile with a belt conveyor and stacker arrangement having multiple discharge points. Maximum storage capacity is approximately 35,000-40,000 tonnes of material. Reclaim is by front-end loader.

The addition of supplementary fuel occurs when the tailings are not available in sufficient quantities.

Supplemental Fuel Preparation

Supplemental fuel is transferred from the stockpile to the crusher by a combination of front-end loader and by conveyor where it is crushed to approximately 2 mm size. The crushing and screening station reduces the supplemental fuel size for feeding to the power plant boiler station.

The crushed coal is then be transferred by covered conveyor to (silos) to supply fuel to the two boilers

2.2.2 (Boiler) Combustor and Steam Generator (Amended EIS para 2.6.2)

The fuels are then prepared as necessary and fed to the two FiCirc™ boilers which are a circulating fluidised bed boiler. The heat released from this process is collected in a high pressure steam header and fed to the condensing steam turbine generator [item 3.].

The combustor/ boiler system fires the dewatered tailing from the dewatering station with addition of supplemental fuel as required to raise steam suitable for supplying the turboalternator system. The anticipated steam design conditions are 400-450 tonnes per hour (tph) of steam at 10-12 Megapascals gauge (MPa.(g)) and 515-540°C from nominally 160°C feedwater.

The boilers would meet the required emission limits of particulates, SO_2 and NOx while firing the dewatered tailing fuel and supplemental fuel. The low emission boilers are two FiCirc™ fines circulating fluidised-bed boilers as designed by Combustion Power Company. The major components of the combustor/ boilers are as follows:

Boiler Fuel Feed System

The tailings fuel feed system consists of (four) positive displacement hydraulically operated type pumps. The combustor feed pumps force dewatered tailing into the combustion chambers of the boilers through multiple injection ports. Jets of compressed air are used to disperse the fuel in the combustor.

Fluidised Bed Boilers

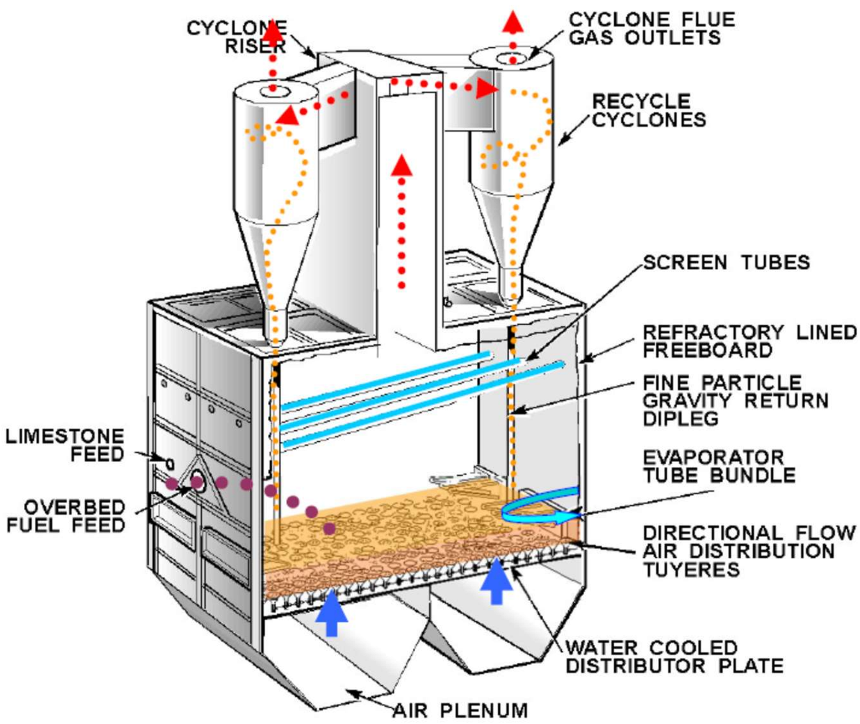
Each of the two identical fluidised bed boilers are designed for delivery of combustion air to the plenum of the combustor by a Forced Draught (FD) fan system. The dense phase bed of suspended particles act as the primary combustion zone with secondary combustion/afterburning occurring in the freeboard above the bed. The fluidised bed contains evaporator heat exchanges in the steam generation circuit.

The flue gas proceeds from the combustion zone to cyclones operating in parallel flow, to recycle all but the finest particles back into the fluidised bed. From the cyclones, the flue gases proceed to the convective section I which contains the superheaters, the remainder of the evaporator and the economiser sections of the boiler.

A combustion air preheater on the flue gas exhaust is used to enhance boiler efficiency. The flue gases pass through the air preheater and then to the baghouse for particulate clean up. From the baghouse the flue gases proceed through an Induced Draught (ID) fan and from the ID fan to the stack.

Limestone is fed to the combustor to capture SO_2 and SO_3 as solid calcium sulphate ($CaSO_4$). The $CaSO_4$ becomes part of the particulates which are removed from the boilers.

FI CIRC™ Fluidised Bed Furnace Segment



Boiler Start-Up System

A bed preheating system (fired by distillate fuel oil) is used for boiler start-up and restarts after shutdowns. The oil start-up system includes a storage tank (e.g. 400,000 litres) which is surrounded by a bund wall to ensure that spillage or leakage is contained and prevented from causing soil or ground water contamination. As required, the ground beneath the tank is sealed to prevent soil or groundwater contamination. After initial heating with oil or gas, the boilers are further heated to operating temperature with the start-up fuel.

Flue Gas Cleaning

The flue gas from the boilers are cleaned of particulate/ dust by fabric filter baghouses. The particulate emissions from each boiler (via the stack) is within the requirements of the NSW EPA.

The baghouses consist of multiple chambers containing large numbers of fabric filter "bags. The gases flow through the bags and the particulates are removed by filtration. The collected particulate matter/ash is discharged periodically (by shaking the dust from the outside of the filter bags with pulses of compressed air, which then is collected*) in individual chambers and transferred to the ash handling system.*

The dust is transferred from the individual chambers via a pressurised dense phase pneumatic ash conveying system to the ash storage silo.

Fluidising Air, Secondary Air and Induced Draught Fans

Fans are driven by electric motors. As needed, inlet and discharge silencers are fitted to limit fan noise for personnel hearing protection. Silencing material would also be applied to the fan inlet and outlet ducts and fan housings, as required.

Boiler Forced Circulation Pumps

Pumps are used to maintain water circulation rates within the main evaporators. Each boiler is fitted with redundant pumps, with one pump always in standby mode. Pumps are of the single-stage centrifugal type, driven by electric motors.

Boiler Feedwater Pumps

The boiler feedwater pumps raise the pressure of boiler feedwater from the deaerator to pressures in excess of the operating pressure of the boilers. There are redundant pumps, with one pump in standby mode. Pumps are of the multi-stage centrifugal type, driven by electric motors.

2.2.3 Turboalternator, Condenser and Feedwater Heating (Amended EIS para 2.6.3)

To generate electricity, the high-pressure superheated steam produced in the boiler station is expanded in a condensing steam turbine, which in turn drives an alternator. Steam is bled from the turbine for boiler feedwater heating and deaerating, as required. The exhaust steam from the turbine is condensed in a condenser subsystem. From the condenser, pumps transfer the condensate to the deaerator, where additional steam would strip out dissolved gases and heat the feedwater.

The Turboalternator

The steam turbine is a condensing machine driving a high-voltage alternator. The turbine consists of a high and low pressure section, rotating at synchronous speed, suitable for directly driving the alternator.

The alternator is of air-cooled type, in which heat was transferred via a closed air circuit to a water-cooled heat exchanger.

Low-Pressure Condensate Pumps

There are redundant, e.g. 2 X 100% capacity pumps of the centrifugal type, each driven by an electric motor and used to return condensate from the condenser.

Low-Pressure Feedwater Heater

This is of the shell and tube type to heat condensate between the condenser and deaerator.

Deaerator

This strips oxygen from the feedwater and heat the feedwater to a temperature suitable for feeding to the boilers.

2.2.4 Cooling System (Amended EIS para 2.6.4)

The Project uses two major cooling water systems: the Main Cooling Water System and the Auxiliary Cooling Water System.

The main cooling water system is used to reject waste heat from the power cycle. This waste heat represents the energy in the steam exiting the turbo-alternator that cannot be recovered as useful work. The Redbank Project, like most thermal power stations, would use a cooling tower to reject this waste heat to the atmosphere.

Acceptable water chemistry is maintained in the main cooling water system largely by discharging a portion of the cooling water on a continuous basis as cooling tower blowdown. Small quantities of biocides and sulphuric acid are added to the basin to control biological growth and pH, respectively. Corrosion inhibitors and dispersants may also typically be added, depending on the actual cooling water chemistry. Makeup water is added to the cooling tower system to make up for the losses due to blowdown and evaporation.

The auxiliary cooling water system provides cooling water to numerous minor auxiliary heat loads located throughout the plant.

2.2.5 Ash Handling (Amended EIS para 2.6.5)

The ash handling system transports all ash from the plant to a location on the Warkworth mine lease convenient for disposal by Warkworth.

Ash Collection System

Ash is collected from the baghouse hoppers under the economizer and air preheater and from the combustor via an ash cooler. Ash from these points is collected and discharged through control valves into a pipework system to transport the ash to the ash storage silo.

Ash Storage Silo

The storage silo is located on the site[5] *and would act as a transfer station for loading ash into trucks.*

Ash Conditioner

The ash conditioning station utilising water spray is used for dust control upon discharge. Water is added to moisten the ash to prevent fugitive dusting.

*Dense phase (*slurry*) transport moves ash from the ash cooler to a mixing tank on the Project site. The ash is mixed in this tank with water to achieve a water/ash ratio of approximately 35% / 65%. This dense phase mixture is then pumped from the Project site via small diameter pipe to open cut areas on the Warkworth lease.*

2.2.6 Water Treatment (Amended EIS para 2.6.6)

Water for the Project is purchased from outside water agencies and piped to the Project site. Over ninety-five percent of the water used by the Project requires softening and/or filtration to make the supply water suitable for Project use. (These major uses for water include cooling tower make-up, service water and firewater.) Additional water uses (e.g. boiler make-up) and the associated water treatment is relatively small.

[5] This silo is located on the Redbank site not the mine site.

Cooling Tower Make-up/Service Water/Firewater

The influent water is softened in a large solids-contact-type clarifier. Lime, soda ash, flocculants, and sulphuric acid are be added in the clarifier to reduce the hardness of the water. Softened water exiting the clarifier is filtered in a gravity sand filter. Filtered make-up water is stored in an above-ground storage tank. This water storage tank allows the plant to operate during brief interruptions in the make-up water supply system. The storage I tank would also supply water to the Project service water system.

A dedicated firewater storage tank stores filtered water for use in the event of a fire on the Project site. Fire pumps distribute I firewater to underground distribution piping, fire hydrants, hose stations and building sprinkler systems located throughout the Project.

Boiler Make-up Water

High purity water is required for make-up to the boiler feedwater system. This water is needed to prevent scaling and corrosion in the boiler tubes and to prevent carry-over of contaminants into the steam turbine.

The high purity boiler make-up water is generated by passing water from the make-up water storage tank sequentially through filtration elements, a Reverse Osmosis (RO) system, and a mixed bed demineraliser system.

High purity water is then be piped to the boiler make-up water storage tank. From this tank the boiler make-up water is piped to the deaerator as needed to make up for losses in the boiler feedwater system.

Chemical Feed and Storage Systems

Storage tanks and associated feed systems are located on-site to supply the necessary chemicals to the various water streams. For example sulphuric acid, biocides, corrosion inhibitors, and dispersants are added to the main and auxiliary cooling water to control pH, control biological growth (algae), reduce corrosion, and keep particulate matter in suspension, respectively. Oxygen scavengers, corrosion inhibitors, and other chemicals are be added to the boiler feedwater system to maintain boiler water quality. Lime, soda ash, flocculant, and sulphuric acid are needed for the pre-treatment softener.

2.2.7 Electrical System (EIS para 2.8)

The turboalternator would generate power at 11 kV. An 11 kV feeder would tee off the load side of the alternator circuit breaker to feed an 11 kV auxiliaries switchboard. This arrangement would enable the plant auxiliaries to be back-fed from the utility interconnect line for plant start-up. Output would be stepped up via a generator transformer to 132 kV to connect to the Singleton to Kurri Kurri overhead transmission line. The plant electrical system would consist of:

Main Switchyard

This would consist of main step-up transformer, distribution-side breakers, isolators and protection gear as necessary. The substation would also contain the utility metering and protective devices.

High-Voltage Power Supplies

This would be required for major drives for the draught fans and boiler feed water pumps.

Low-Voltage Supply

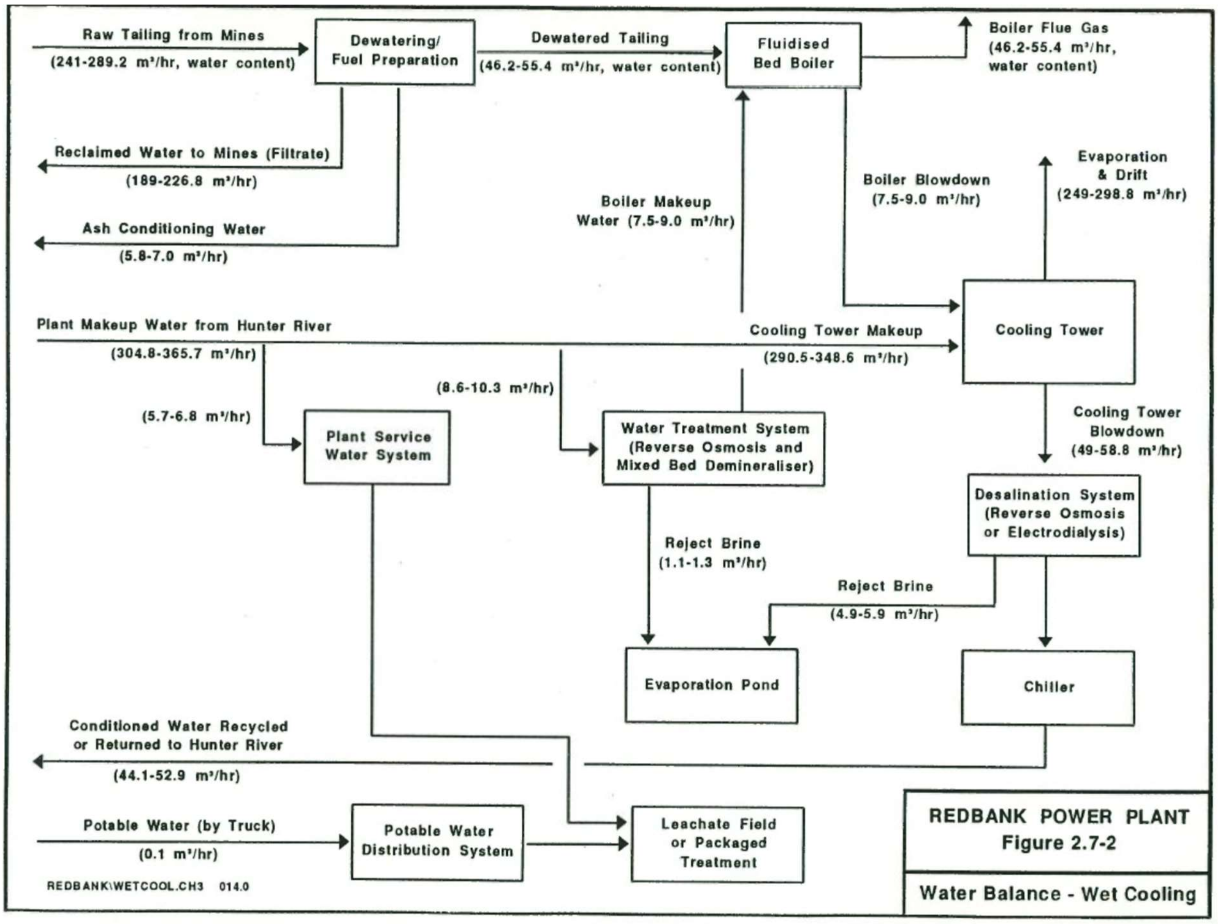
This would be for all other drives and power supply needs in the plant, including lighting and general power outlets.

2.2.8 Plant water system (EIS Para 2.7)

Figure 2.7-2 shows the water requirements for the Project based on an evaporative cooling system. In this scenario, water extracted from the tailing would be returned to the tailing ponds at the mines. Process water for the Project would be purchased from water agencies (e.g. Department of Water Resources) and supplied from the Glenbawn and Glennies Creek Dams via the Hunter River. Service water would be used directly, while boiler make-up water would undergo treatment. …. this water would be returned to the Hunter River but this would occur only if the water returned were desalinated to a point where it was of higher quality (i.e. lower salinity) than the river itself at the discharge point… Potable water for domestic consumption would be trucked to the Project site from outside sources. It is estimated that one to two weekly truck deliveries would be sufficient for those requirements. The potable water would be stored on site in an above ground storage tank.

(S)anitary wastewater would be treated in a small I (e.g. package type) treatment system.

<u>*Figure 4 – Water Balance – wet cooling EIS Fig. 2.7-2*</u>



3 CHANGES FROM 1994 CONSENT TO 1997 CONSENT (AS BUILT PLANT)

The 1994 Development Consent is based on the Amended EIS of 1993. This section of the document compares the "as built" modifications to the description of the plant from the 1994 Development Consent. The "as built" plant incorporated a number of process and physical equipment alterations which arose from the 1997 Development Consent.

Comments are made "by exception", thus where no comment is made, then no substantial change has occurred, however, each significant change is only described once in the following and not re-iterated each time the item is reference in the 1994 Consent.

The major difference between the 1994 Consent and the 1997 Consent is that the "Tailings Slurry Thickening" occurs at Warkworth mine, and this process incorporates a beneficiation process which separates excess ash from the tailings in the dewatering process, and improvers the fuel quality.

3.1 The use of BDT Fuel

The 1994 Consent describes the fuel resource as tailings from Warkworth or Lemington mines which represents very wet and high-ash tailing product which is an inherent characteristic of coal mine washery waste.

The improved fuel preparation facilities associated with the 1997 Consent and built at the Warkworth mine included the provision of Jameson (froth flotation) Cells which provided the beneficiated and dewatered tailings (BDT) which was the basis of the fuel burned at Redbank during its operation until shut down in 2014. The 1997 Consent process is based on included the following considerations relating to the BDT fuel compared to the Tailing fuel described in the 1994 Development Consent.

- Improved Fuel Preparation
- Same fuel energy consumption (annual)
- Improved Thermal Efficiency
- Less ash to emplace
- Fuel Preparation integrated with Mine Coal Preparation Facilities
- Improved Fuel Handling and Storage
- Increased plant net output
- Output of CO2 will be reduced by over 15% per MW-h of output, and 10% per year.
- Annual emissions of SO2 and NOx remain the same

3.2 Fuel Transfer Systems

The use of tailings fuel (as BDT) enabled the use (sharing) of the conveyor transport system designated for the Supplementary fuel in the 1994 Consent without the need for a separate slurry pipeline.

This has resulted in the conveyor arrangement shown on the plant conveyor drawings which are included in Appendix C to this document. The function of the individual conveyors within the development is as described below:

Figure 5 – Table of plant conveyors

Conveyor	Function
V8700 Overland conveyor	Provides the tailings (as BDT) and the Supplementary (as BUF) fuels from the Warkworth washery facility to the fuel receival transfer point on the Redbank site. The fuels are provided in separate delivery runs (and not simultaneously)

Conveyor	Function
CV34 Tailings and Supplementary fuel	Transports the fuels from the overland conveyor delivery point to the following locations: - Tailings mode – fuel directly to the tailings (as BDT) storage silos located between the two boilers. - Supplementary fuel mode – fuel is transported to the transfer house local to the coal stockpile where it is tripped off the conveyor onto the stockpile stacker conveyor (CV36), see below. The conveyor does not carry both fuels simultaneously.
CV36 stacker conveyor (Supplementary fuel)	Transports the Supplementary fuel from the transfer house to the stockpile, and discharges fuel onto the stockpile.
CV76 Reclaim conveyor	Collects the Supplementary fuel from the stockpile and transports it to the crusher house.
CV35 Supplementary fuel conveyor	Transports the crushed Supplementary fuel from the crusher house to the Boiler 1 and Boiler 2 fuel silos.

3.3 Increased Thermal Efficiency and Electrical Output

Based on the use of BDT fuel as described above rather than tailings results in a higher thermal efficiency, and electrical output. The difference is summarised below:

Figure 6 – Redbank plant performance 1994 Consent vs. 1997 Consent (as built)

Item	Units	1994 Consent	1997 Consent
Annual Fuel Heat Input	Million GJ/annum	12.7	12.7
Net electrical output	MW	100	128

The Gross Fuel Heat Input is the product of (annual fuel delivery) x (Gross Specific Energy) of the Fuel. The 1994 Consent provides for 975,000 te/annum of fuel of GSE of 13 GJ/te.

3.4 Water Requirements (Amended EIS ref.2.7)

The plant water requirements are substantially as shown on the water balance in the Amended EIS labelled “Water Balance Wet Cooling”, except that:

- The dewatering associated with the tailing fuel preparation is located within the Warkworth mine
- Wastewater is stored on site in a storage pond of 60ML and returned to the Hunter River as part of the Hunter River Salinity Trading Scheme (HRSTS).

A Redbank “as built” water balance (Process Flow Balance Diagram) is provided in Appendix C to this document, as approved by the EPA during the plant construction phase.

4 EFFECTS OF MODIFICATIONS TO FIRE BIOMASS FUEL - 2021

This section considers the effect of biomass fuel (in the place of the ROM Coal, or supplementary fuel) on the plant operation. The plant will remain capable of firing BDT fuel, and it is not intended to fire BDT and Biomass fuel at the same time in any FiCirc™ combustion chamber.

The fuel preparation (drying, chipping, screening etc…) is performed off site such according to the fuel specification in Appendix A to this document. The fuel sizing is nominally 50mm maximum size, with typically 4% less than as fines of <1mm.

4.1 Biomass fuel Effect on Plant Performance

The plant net electrical output will not change when firing biomass fuel, however Biomass fuel will have the following effects on the plant performance.

Figure 7 – Redbank anticipated performance – Biomass fuel firing

	Units	1994 Consent	1997 Consent	Proposed Mods
Fuel Type	-	Coal tailings	BDT	Biomass fuel
Reference fuel moisture	%	dry basis	25	25
Net Plant Output (reference)	MW	100	128	128
Fuel gross specific energy	GJ/te	13 (dry)	21 (wet)	15.21 (wet)
Fuel energy consumption (annual)	GJ/annum	12.7 million	12.7 million	12.7 million
Approximate fuel consumption[6]	Te/annum	975,000 (dry)	600,000 (wet)	835,000 (wet)
Approximate fuel consumption	Te/annum	975,000	450,000	626,000
Calculated efficiency (GSE basis)	%	*22.7%* [7]	29.9%	27.2%

4.2 Boiler Plant Operation

The FiCirc™ boilers at Redbank were designed to fire coal tailings (as BDT) and Supplementary Fuel (as ROM coal). The boilers are suitable for Biomass fuel firing without change as demonstrated overseas (refer below), and the following gives an overview of their performance firing Biomass fuel.

4.2.1 FiCirc™ Boilers

CFB boilers are widely used and well suited for power generation due to the following characteristics:

- Able to utilise a wide variety of fuels
- Lower combustion temperatures result in lower oxides of nitrogen emissions
- In-situ removal of sulphur oxides by reaction with limestone sorbent if required
- High combustion efficiency

In B&PPS experience the Redbank FiCirc™ boilers and similar units are widely used to fire Biomass fuel and we:

- are familiar with the Redbank boilers
- have done extensive performance modeling of FiCirc™ boilers
- are familiar with a similar FiCirc™ boiler firing Biomass fuel
- have visited the Schiller Plant in Portsmouth, NH, USA

Schiller Plant

The Schiller plant which operated until 2018 included a FiCirc™ boiler having the following characteristics

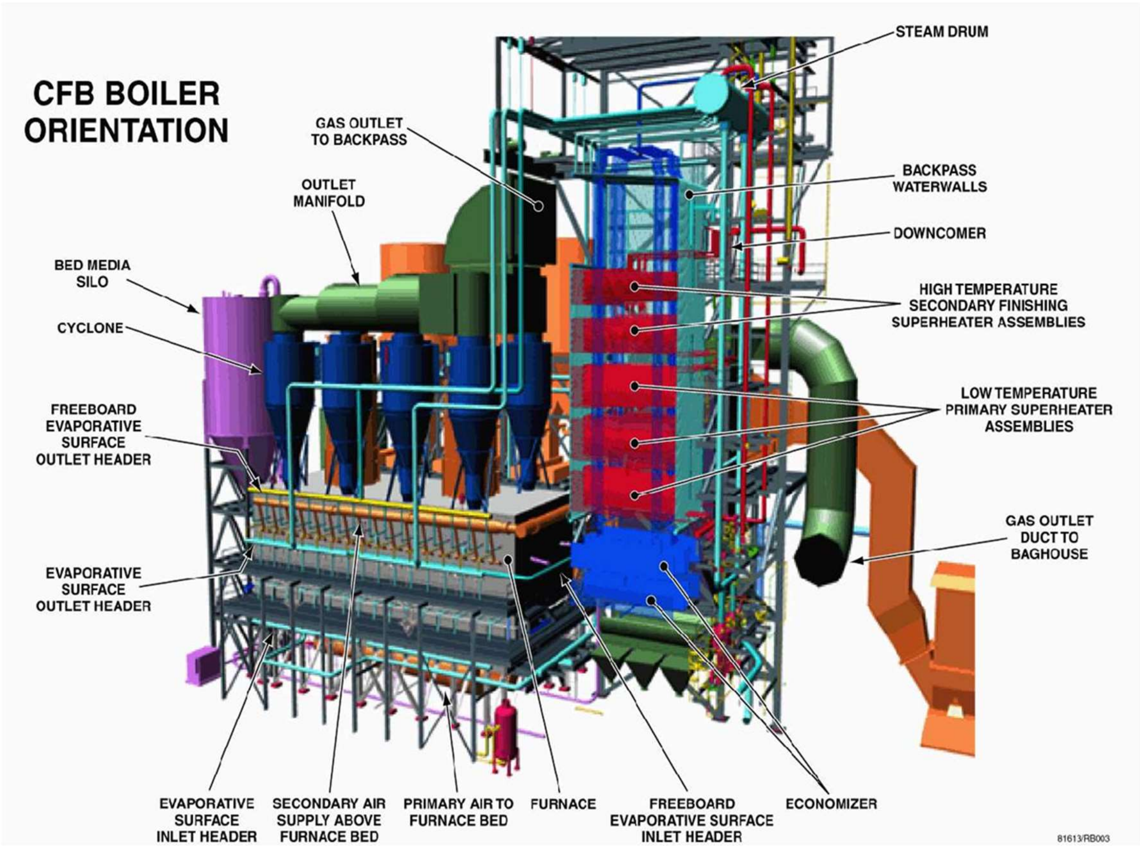
- Boiler Type FiCirc™
- Fuel Biomass fuel (forest product residue)

[6] 1994 fuel properties on dry basis as delivered fuel moisture was uncontrolled and dewatering occurred on the Redbank site. Where "dry basis" is stated, it means bone dry (with no moisture).
[7] Not explicitly stated but implied from the data given.

- Location Portsmouth, NH, USA
- Electrical Generating Capacity 50 MW electrical

There are also a large number of fluidized bed units of similar design by other manufacturers which fire Biomass fuel. This includes plants at Visy in Tumut, NSW, and at Worsley Alumina in W.A.

Figure 8 – Redbank FICirc™ CFB Boiler Orientation



The figure above shows an illustration of the CFB FiCirc™ Boilers at Redbank. No modifications are required to the boiler to fire Biomass fuel.

4.2.2 Boiler operation with different Biomass fuel moisture levels

During Biomass fuel firing, the FiCirc™ boiler steam output (and hence the plant net electrical output) will depend on the Biomass fuel moisture level as shown in the table below. At Biomass fuel moisture levels above about 25%, the plant electrical output is be reduced due to the flue gas system limitations.

Figure 9 – Boiler response to different Biomass fuel moistures

Moisture	-	10%	15%	25%	35%	45%
GCV	GJ/te	18.25	17.2	15.2	13.2	11.2
Gross heat release	GJ/h	1,643	1,660	1,700	1,675	1,600
Flue gas flow	Te/h	700	715	750	750	750
Steam flow	%MCR	100%	100%	100%	94%	85%
Fuel flow	Te/h	89.8	96	112	127	143

From the above table, the maximum heat input (Gross heat release) occurs at 25% fuel moisture content.

4.2.3 Plant operating range

The plant can operate in a number of operating modes. In normal automatic control mode with both boilers in service, the plant can accept electrical output load changes between 70% and 100%. The plant can also operate with only one boiler in service. This means that depending on the operating configuration, the normal plant operating electrical output range can be considered as follows:

Figure 10 – Table of plant operating ranges

Mode	Net Plant Electrical Output Range
Two boilers normal operation	90 – 128 MW
One boiler out of service operation	50 – 64 MW

Plant electrical output outside of this range are not considered routine operations.

4.2.4 Flue Gas Emissions

The existing flue gas cleaning equipment will be used for Biomass fuel. The FiCirc™ boilers are inherently able to control the NOx and SOx as discussed in the section previously.

The Fabric Filter bags are used to reduce the particulate emissions as required by the EPA.

The existing cyclones located at the outlet of the FiCirc™ combustion chamber are designed to prevent all but the finest particles (typically <15 micron) from passing through to the back pass where the gases are cooled prior to entry to the fabric filter bags. This prevents burning cinders from entering the baghouse which is a problem with other types of firing such as stokers and bubbling fluidized beds.

4.2.5 Ash Handling

The 1994 Consent provided for the return of the Redbank boiler ash to Warkworth mine by a slurry pipeline. This is not proposed for the Biomass fuel conversion as Warkworth are not able to accept ash from Biomass from the Redbank plant.

The collection and storage of the ash (primarily fly-ash from the boiler combustion process collected by the bag filters) will not change. The ash it will be loaded into trucks by either of the following two systems which are located at the discharge of the 500 cubic meter capacity ash silo:

- Wet paddle mixer discharge into a truck.
- Dry ash transfer via telescopic chute to dry product handling truck.

The existing slurry pumping equipment will be stored on site enable future use. No new equipment is required.

5 EQUIPMENT MODIFICATIONS TO UTILISE BIOMASS FUEL -

This section of the document describes the physical alterations to the plant and process equipment necessary to fire Biomass fuel.

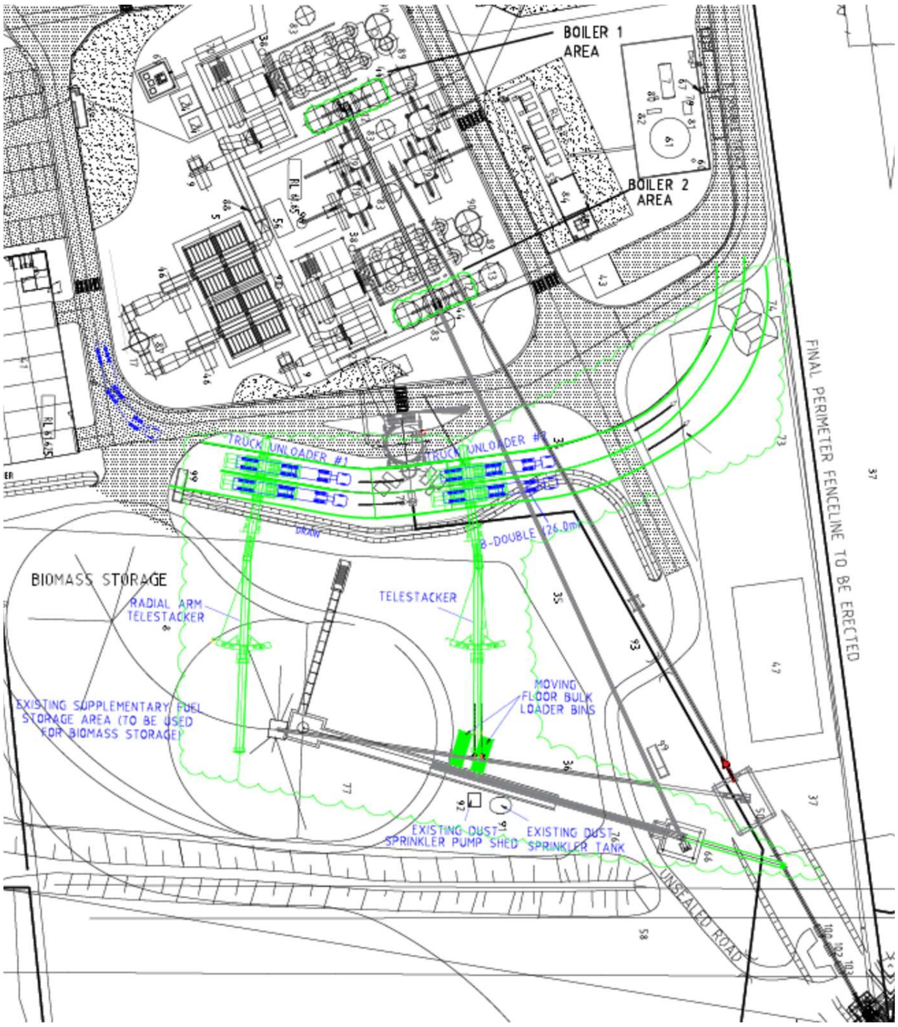
The modifications are necessary as Biomass is much less dense than coal, and has a lower Calorific Value, and tends to arch or bridge over outlet openings and cause blockages. Additional conveyor volume capacity is required, and some modification to silos and transfer systems which are designed according to the following principles.

- The Supplementary fuel as envisaged in the Amended EIS (unmarketable coal) will not be used for the plant as supplementary fuel.
- The Biomass fuel will be transported and stored in the equipment and locations which were designated for the Supplementary fuel.
- The Supplementary fuel equipment will be modified as necessary to accommodate the characteristics of the Biomass fuel. Such modifications are not irreversible.

- The BDT fuel capability will be maintained.
- The existing dust collection equipment associated with the fuel handling system will be reused and where new transfer points are proposed, new dust filter systems will be provided.
- Existing equipment that is not required for biomass firing will be left in-situ or stored on the site to enable future re-use.

A Key Plan of the proposed works is provided below and in Appendix C.

Figure 11 - Key Plan of Proposed Works



The following outlines the key features of the proposed system.

- Installation of an additional weighbridge and internal road works
- Biomass fuel supply, stockpile and reclaim
- Conveyor system modifications
- Boiler silo and feed system modifications

5.1 Fuel Receiving and Distribution

Biomass fuel will be delivered by B-Double vehicles via two dual truck unloading stations near the existing ash silo and the stations will feed the Biomass fuel onto either:

- A mobile stacker feed conveyor from the delivery area to the stockpile stacker unit, with an elevated discharge chute and with stockpile reclaim via front-end loader to “moving floor bulk unloader bins”.

- A separate unloading conveyor to feed the CV76 reclaim conveyor directly via "moving floor bulk unloader bins" as shown below (per Keith manufacturing)

Figure 12 - Moving Floor Bulk Unloader Bin

These devices replace the existing stacking conveyor CV36, as it is not of sufficient dimension or capacity for handling Biomass fuel.

5.2 Fuel Storage Area

The Biomass fuel stockpile will occupy the area dedicated to the Supplementary Fuel storage, and its tonnage capacity is reduced due to the lower density of the Biomass fuel compared to coal. The stockpile area accommodates 3 days storage capacity.

Biomass fuel storage will be stored in an uncovered area. Covered storage is more commonly used overseas in colder, wetter climates for protection against the elements and to maintain a more consistent moisture content fuel.

We draw your attention to some local examples. The large industrial sized woodchip fired power plant at Visy Tumut in NSW uses uncovered storage of approximately 28,000 m^3/ 11,000 te as shown below and they are in a wetter climate than Redbank.

Figure 13 - View of Visy Tumut Stacker (AMECO)

Another example is Rocky Point in Gold Coast, 30 MWe power plant in QLD, it fires wood waste in the off season and does not have any covered storage.

Based on the considerations above and Redbank FiCirc™ Fluidised bed boiler combustion capability to handle various moisture content woodchips an outdoor uncovered stockpile is proposed.

5.3 Fuel Conveyors

The Biomass fuel proposal considers the re-use of both the BDT and Supplementary fuel conveyors. A substantial portion of fuel transport equipment may be re purposed for Biomass fuel including.

- CV76 Existing reclaim conveyor
- CV34 Existing tailing/ supplementary fuel conveyor (from tripper house to Boiler 1)
- CV35 Existing Supplementary Fuel (BUF) conveyor (from crusher house to Boiler 2)

In order to transport the necessary quantity of Biomass fuel form the stockpile to the boilers, it is necessary to use both conveyors CV34 and CV35 simultaneously. Conveyor CV34 (also the tailings conveyor) will be used to feed boiler 1, and CV35 (the Supplementary fuel conveyor) will be sed to feed boiler 2.

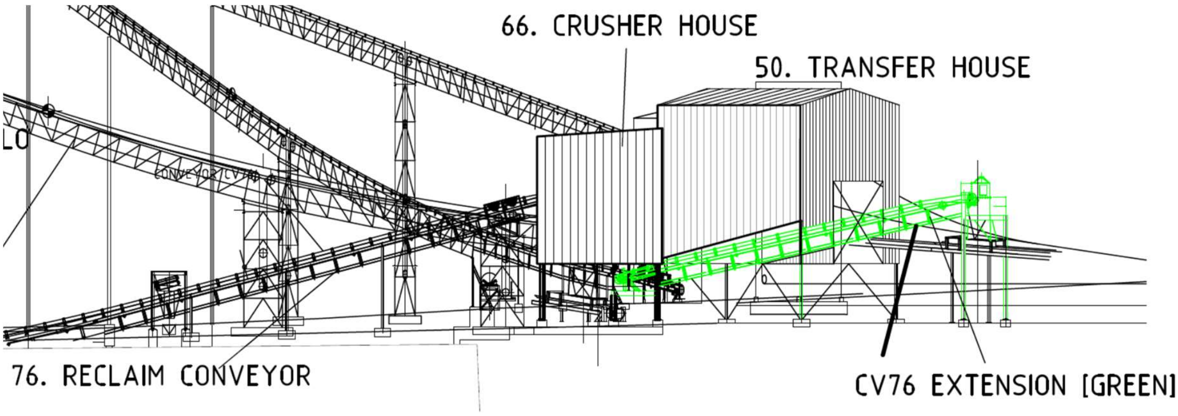
The following sections describe the changes necessary to accomplish the above.

5.3.1 Transfer - Crusher house transfer point

The transfer from the Supplementary fuel reclaim conveyor (CV76) to the main Supplementary fuel conveyor (CV35) occurs at the crusher house. As the crusher is no longer needed, a new chute is required to replace the coal crusher assembly and remove the coal crusher from service.

A Biomass fuel flow splitter will be provided at the outlet of the conveyor CV76 (in the crusher house) to split the Biomass fuel stream to feed both the existing conveyor CV35 and the proposed new extension of CV76 to feed conveyor CV34.

Figure 14 – Showing extension to Supplementary Fuel reclaim Conveyor CV76



5.3.2 Fuel transfer at the boiler silo roof areas

The current system of chutes discharging Supplementary fuel from conveyor CV35 to the boiler fuel silos is not suitable for use with Biomass fuel as the fuel is likely to hang up or choke in the chutes, and so to feed Biomass fuel from the existing CV34 and CV35 conveyors into the fuel silos the following modifications are proposed:

A new fixed tripper (diverter) pulley set and transfer chute-work for the tailings conveyor (CV34) in the Boiler Unit 1 silo roof area to allow either of the following to occur:

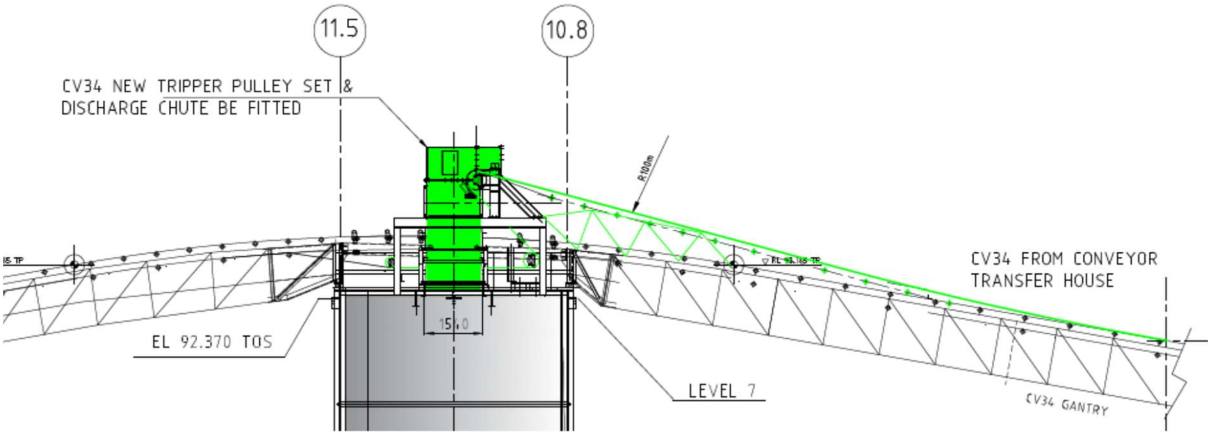
- Provide Biomass fuel to the reversing conveyor system, OR
- Allow BDT to continue its travel to the BDT silos located between Boiler Units 1 and 2.

The existing Supplementary fuel conveyor (CV35) then feeds the reversing conveyor system for boiler unit 2 only.

The reversing conveyors distribute the fuel from the delivery points for boiler 1 and boiler 2 from CV34 and CV35 respectively and distribute the fuel into the existing fuel silos.

The following diagrams illustrate the above description:

<u>Figure 15 – Fixed tripper (diverter) allows Biomass fuel transfer from CV34</u>



<u>Note</u> - The above sketch indicates modification to tailings conveyor local to boiler 1. Grey equipment (including conveyor gantries, silo cylinder and roof) is existing, and modifications for Biomass fuel are shown with green shading.

<u>Figure 16 - Reversing Conveyor Concept – Boiler 1</u>

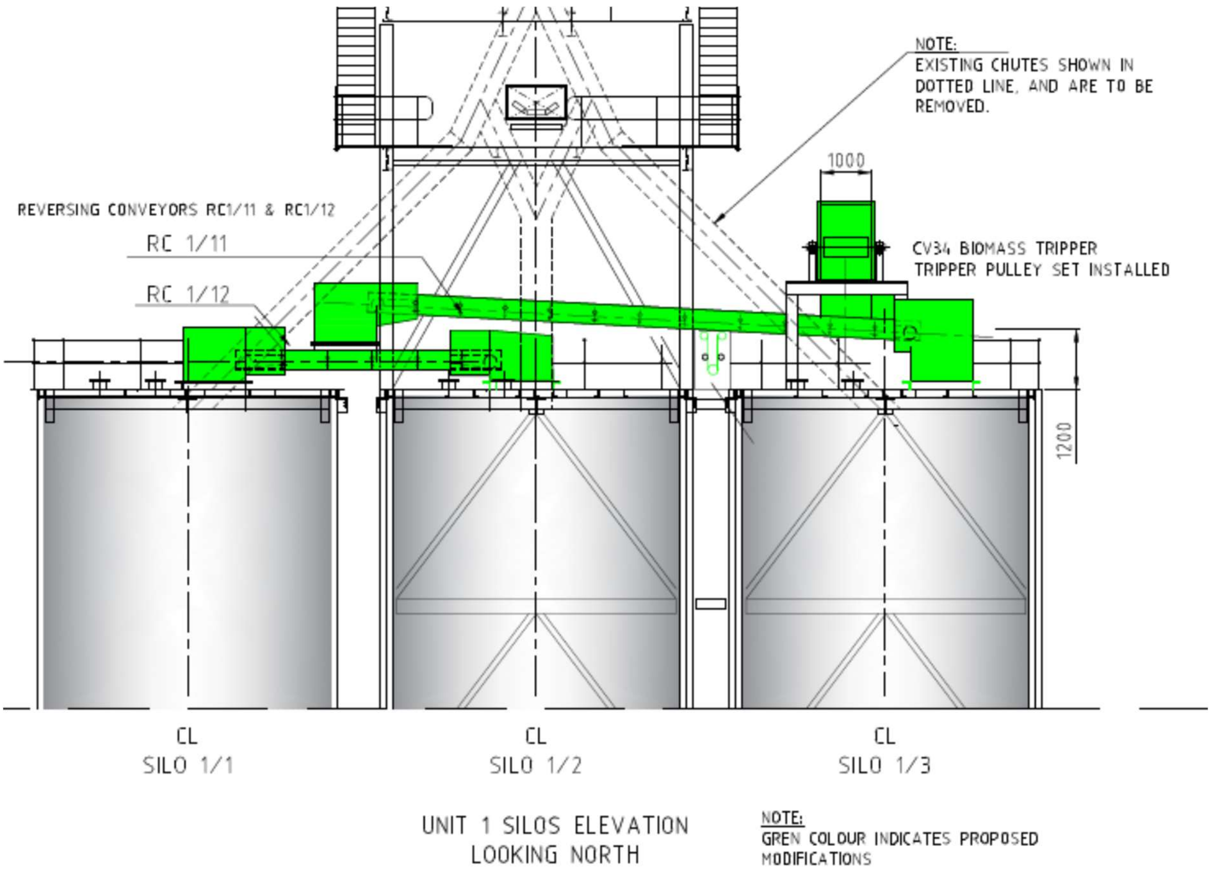
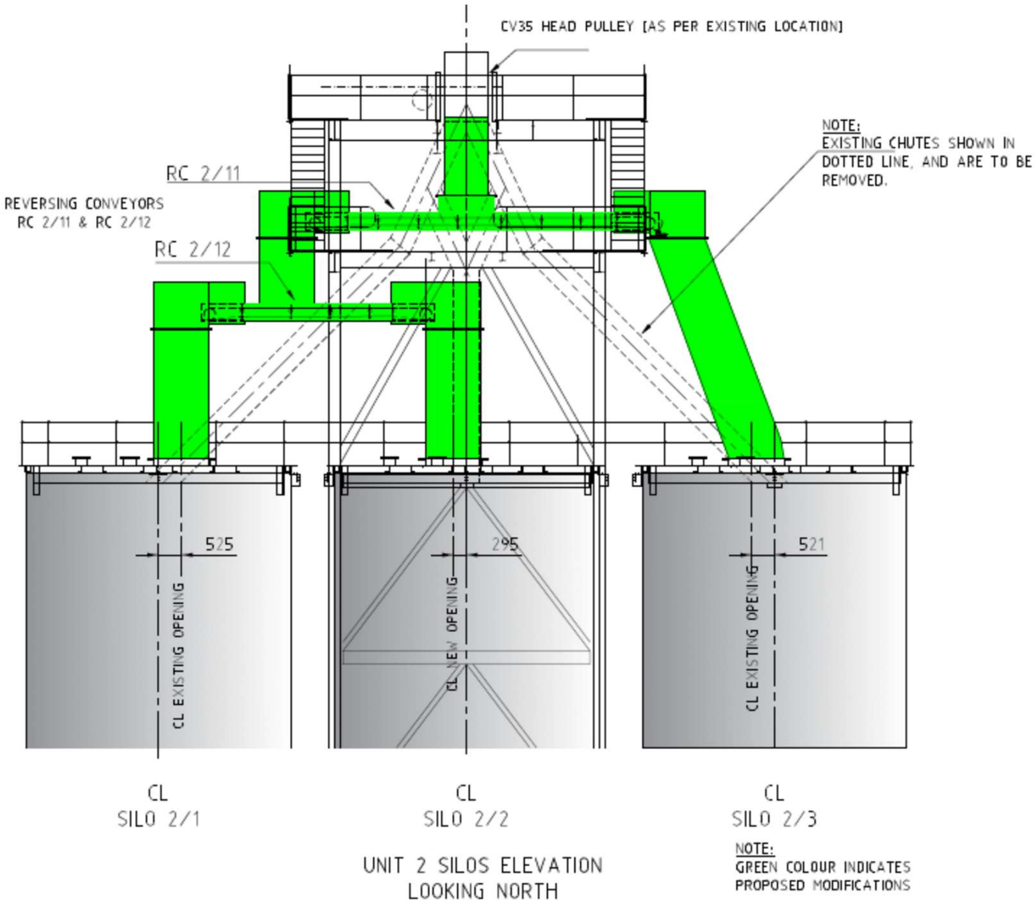


Figure 17 - Reversing Conveyor Concept – Boiler 2



5.4 Boiler Supplementary Fuel Feed System

5.4.1 Fuel Silos

The existing boiler fuel silos have dual-outlet trouser-leg hoppers designed for Supplementary fuel. The base of the existing silos will be converted to be suitable for Biomass fuel by the replacement the portion of the silo below the existing construction joint to include a flat-bottom bin with a rotary screw auger. The rotary screw augers provide Biomass fuel for the boiler fuel feeding system. Fire deluge nozzles will be fitted to each of the existing silos.

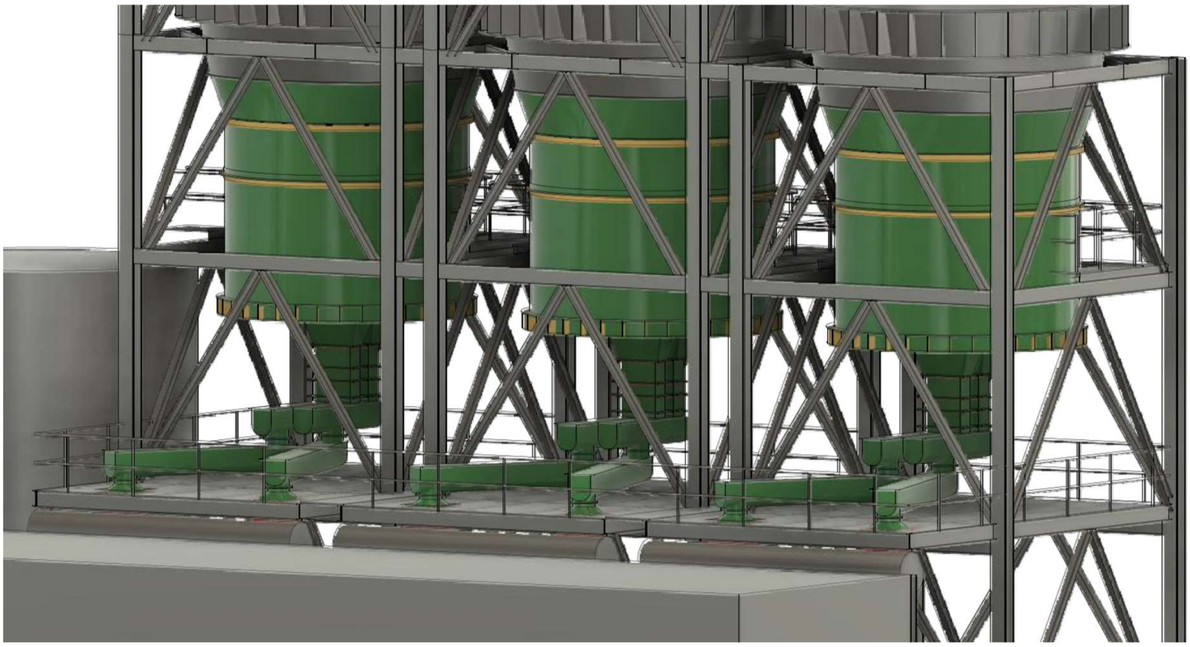
Figure 18 - Fuel Silo Modification Specification

No. of silos	3 per boiler (six total)
Nominal diameter	6000mm (existing portion)
	4676mm (new bottom portion)
Storage capacity (nominal)	250m^3 each
Residence time (nominal)	4 hours
Biomass fuel outlet feeder	600mm auger screw type

5.4.2 Fuel feeding system (from silo to feeder)

The existing Supplementary fuel weigh feeders are not of sufficient capacity for the Biomass fuel volume and will be replaced by screw feeders to deliver Biomass fuel from the bin auger discharge to the existing boiler feed chutes.

Figure 19 – View of modified silo bases and Biomass fuel feeders



The above sketch shows (in green colour) the new bottom portion of the silos and the Biomass fuel boiler screw feeders. The grey components including steelwork remain unchanged.

The above feed system discharges into six fuel spreaders located on the side wall of the FiCirc™ combustion chamber. These fuel spreaders will be retained as they are suitable for Biomass fuel.

APPENDIX A – FUEL ANALYSIS

The following is the specification for the "Design Biomass" fuel analysis which has used for the design basis for the conversion of the Redbank plant to fire biomass.

Type of fuel: Wood chip or equivalent Biomass fuel consistent with the requirements of the EPA NSW document "Eligible Waste Fuel Guidelines" of December 2016.

The following table specifies the range of fuel properties consistent with the boiler plant design capabilities.

Figure 20 - Design Biomass Fuel (analysis by mass%).

Parameter	Units	Design	Range or Limit
General Properties			
Calorific Value	MJ/kg (dry ash free)	20.2	19 - 22
Moisture	% (as fired)	25	10 to 50
Ash	% (as fired)	0.5	0.3 - 4
Chlorine	% (dry ash free)	0.02	up to 0.05
Sulphur	% (dry ash free)	0.1	up to 0.2
Particle size (Comply with P45A EN 15149-1)			
≥ 120 mm	% mass	0	
< 120 mm & > 100 mm	% mass	≤ 3.5%	
< 100 mm & > 63 mm	% mass	≤ 6%	
< 45 mm & > 8 mm	% mass	≥ 75%	
< 3.15 mm	% mass	≤ 8%	
Physical Properties (Note 1)			
Bulk Density	kg/m3		160 - 490
Ash Analysis (dry basis) (Typical)			
Silicon as SiO_3	% in ash		10 to 30
Aluminium as AL_2O_3	% in ash		5 to 30
Iron as Fe_2O_3	% in ash		3 to 12
Calcium as CaO	% in ash		10- to 30
Magnesium as MgO	% in ash		5 to 22
Sodium as Na_2O	% in ash		0.3 to 1.7
Potassium as K_2O	% in ash		5 to 15
Titanium as TiO_2	% in ash		0.1 to 1
Manganese as Mn_2O_4	% in ash		0.3 to 8
Sulphur as SO_3	% in ash		1 to 9
Phosphorus as P_2O_5	% in ash		1 to 5
Ash Fusion Temperatures			
Initial Deformation	ºC		>1200
Hemispherical	ºC		>1230
Trace Elements (dry fuel basis)			
Mercury (Hg)	mg/kg in fuel		<0.1
Cadmium + Thallium (Cd + Tl)	mg/kg in fuel		<1
Zinc (Zn)	mg/kg in fuel		<100
Lead (Pb)	mg/kg in fuel		<20
Chromium (Cr), Copper (Cu), Arsenic (As)	mg/kg in fuel		<21

The following table gives a range of fuel properties which may be considered. Typical values for Tailings (as BDT) and for Supplementary Fuel (as ROM). The properties are tabled for reference purposes.

Figure 21 – Typical fuel ultimate analysis by mass%.

Comparison of analyies of Wood, BDT & ROM Coal		Hunter Energy SGS Wood	Hunter Energy SGS Wood	Hunter Energy SGS Wood	Hunter Energy SGS Wood	Typical Wood Chips	BDT (tailing) Mean HRL 2005	ROM Coal HRL 2005
BASIS		As Fired 15%	As Fired 25%	As Fired 35%	As Fired 45%	As Fired 25%	As Fired 33.4%	As Fired 9.7%
Carbon	% Mass	43.94	38.77	33.60	28.43	36.68	39.03	52.24
Hydrogen	% Mass	5.11	4.51	3.91	3.31	4.44	2.41	3.30
Nitrogen	% Mass	0.15	0.14	0.12	0.10	0.28	0.89	1.13
Sulphur	% Mass	0.04	0.04	0.03	0.03	0.02	0.32	0.42
Oxygen	% Mass	35.30	31.15	27.00	22.84	32.85	4.88	7.16
H2O	% Mass	15.00	25.00	35.00	45.00	25.00	33.40	9.70
ASH	% Mass	0.45	0.40	0.35	0.29	0.73	19.08	26.05
TOTAL	% Mass	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ASH	% Mass db	0.53	0.53	0.53	0.53	0.97	28.65	28.85
GCV	MJ/Kg	17.24	15.21	13.18	11.15	15.07	16.01	21.40
NCV	MJ/Kg	15.74	13.60	11.46	9.32	13.48	14.66	20.44
GCV daf	MJ/Kg	20.39	20.39	20.39	20.39	20.29	33.68	33.31

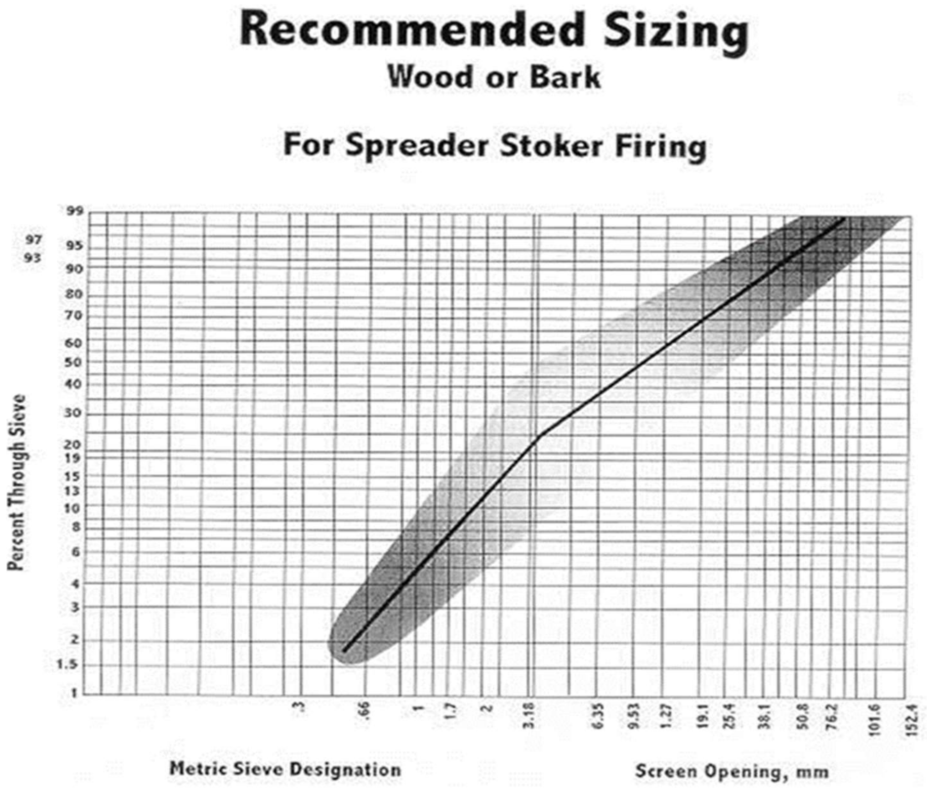
- where GCV.daf in the above table indicates Gross Calorific Value on a dry as-free basis.

The “Design Biomass” fuel used for the Redbank plant performance calculations firing biomass is the Wood fuel listed in the “As fired 25%”(moisture)” column in the figure above.

Fuel Sizing

Fuel will be sized and screened off site and be prepared in accordance with the boiler requirements.

- Wood chipped and screened to 50 mm nominal size
- Maximum of the sum of three dimensions to be less than 150 mm (length+width+thickness)
- Recommended Sizing is Indicated by the dark line
- Acceptable Sizing is indicated by the Shaded Band


Recommended Sizing
Wood or Bark
For Spreader Stoker Firing
Percent Through Sieve
99
97
95
93
90
80
70
60
50
40
30
20
19
15
13
10
8
6
4
3
2
1.5
1
.3
.66
1
1.7
2
3.18
6.35
9.53
1.27
19.1
25.4
38.1
50.8
76.2
101.6
152.4
Metric Sieve Designation
Screen Opening, mm

APPENDIX B – FUEL CALORIFIC VALUE

B1.0 Calorific value

This Appendix explains the basis of the calculation of the Gross Calorific Value (or GCV) for woody Biomass fuels such as these proposed for use at the Redbank Power Station.

The Calorific Value of a fuel is the amount of heat liberated by its complete combustion expressed as kJ/kg (or MJ/kg or GJ/t) for solid fuels. The terms Higher Heating Value, or Gross Specific Energy may also be used but are synonymous with GCV in relation to solid fuels.

The calorific value can be either a Gross Heating Value or a Net Heating Value and are by convention calculated with respect to a standard reference temperature.

Gross Calorific Value (GCV) is also known as Higher Heating Value (HHV)

Net Calorific Value (NCV) is also known as Lower Heating Value (LHV)

The difference between GCV and NCV above is that the GCV includes, and the NCV excludes the energy used to vaporise water contained in the original energy form or created during the combustion process. Thus the difference for a solid fuel may be expressed as:

NCV = GCV – (Latent heat of water x (Water in fuel + 8.94 x Hydrogen in fuel))

Where the water and hydrogen in fuel are expressed as mass fractions.

B2.0 Basis of Gross Calorific Value for the Redbank Plant

For a consistent basis of determining the anticipated power plant performance and stack emissions a “Design Biomass fuel” fuel must be defined.

The basis for B&PPS documents prepared for Hunter Energy is a Design Biomass fuel having a Gross Calorific Value of 15.21 MJ/kg (GJ/t) and containing a moisture content of 25%. This value was determined from an average (arithmetic mean) of samples analysed by SGS during June 2020 and the average moisture content of the Biomass fuel that will be supplied to Redbank. The SGS analytical report and Biomass fuel moisture were provided to B&PPS by Costa Tsiolkas of Hunter Energy.

B&PPS were subsequently provided with another analytical report prepared by HRL dated October 2020.

A comparison for the laboratory analyses is provided in Table 1.

Table 1 – Results of Laboratory Samples of Woody Biomass fuel

Fuel: Biomass Laboratory Analysis for Redbank by SGS and HRL

Biomass Analysis for Redbank 2020		SGS Sample Average 5 Jun 20	SGS Sample 1 Top 5 Jun 20	SGS Sample 2 Middle 5 Jun 20	SGS Sample 3 Bottom 5 Jun 20	HLR Sample Average 21 Oct 20	HRL Karuah - Shavings/ Sawdust 21 Oct 20	HRL Heron Creek Sample 2 Boral 21 Oct 20	HRL Buladelah Newells Creek Sawmill 21Oct 20	HRL Buladelah Relts 21 Oct 20	HRL Sweetmans Sawmill 21 Oct 20
BASIS		As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%	As Fired 25%
C	% Mass	38.77	38.42	38.94	38.95	38.21	38.18	38.03	38.25	38.33	38.25
H	% Mass	4.51	4.54	4.49	4.50	4.19	4.13	4.35	4.20	4.13	4.13
N	% Mass	0.14	0.20	0.10	0.10	0.13	0.12	0.08	0.12	0.14	0.21
S	% Mass	0.04	0.05	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01
O	% Mass	31.15	31.23	31.10	31.11	32.24	31.92	32.49	32.31	32.25	32.22
H2O	% Mass	**25.00**	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
ASH	% Mass	0.40	0.56	0.32	0.32	0.24	0.66	0.07	0.12	0.15	0.20
TOTAL	% Mass	100.00	100.00	100.00	100.00	100.01	100.00	100.01	100.01	100.00	100.00
Gross CV	MJ/Kg	**15.21**	14.87	15.47	15.28	15.00	14.85	14.85	15.08	15.08	15.15
Nett CV	MJ/Kg	13.60	13.26	13.86	13.68	13.46	13.33	13.28	13.53	13.55	13.63
GCV daf	MJ/Kg	20.39	19.98	20.71	20.47	20.06	19.98	19.82	20.13	20.14	20.25

Notes
Anayses brought to same 25% moisture basis
SGS Sample Average used for Design Biomass Fuel

daf = oven dried ash free basis. This is a method of comparing calorific value of Biomass fuel with varying moisture and ash contents.

The following References for the SGS and HRL reports are given below:

SGS Analytical Report NCM20-01874 RO Dated 1 June- 2020	HRL Report 201187-1 Dated 21 October 2020
SGS Australia – Mayfield West 6A Metal Pit Drive Steel River Industrial Estate	HRL Technology Group Pty Ltd Unit 4, level 1, 677 Springvale Road Mulgave Victoria 3070

The HRL results are not substantially different from SGS and they all fall within the expected variation for woody Biomass fuel which varies between tree species, growing location, soil types, method of harvesting etc.

B3.0 Comparison of Calorific Value with Published Data for Woody Biomass fuel

The variation in Higher Heating Value (HHV) or GCV for dry woody Biomass fuel is shown in Table IX below. This is an extract from "Combustion Fossil Power", a reference book on fuel burning and steam generation published by Combustion Engineering, fourth edition 1991.

Note that the Gross Calorific Values for the SGS and HRL samples fall within the same range of typical values when compared on a dry basis to those in Table IX. The SGS and HRL values (last row of table 1) range between 19.98 and 20.71 MJ/kg and the typical values in table 2 (last column) range between 19.03 and 22.35 if the outlier 26.33 is disregarded.

It is B&PPS experience that wood Biomass fuel on a dry ash free basis found in Australia is normally in the range of 20 to 20.4 MJ/kg if the sample population is of reasonable size.

Table IX. Typical Analyses of Dry Wood 1 Btu/lb = 2.326 kJ/kg

	% by Weight						HHV,	HHV **
	C	H_2	S	O_2	N_2	Ash	Btu/Lb	GJ/t dry
Softwoods†								
Cedar, white	48.80	6.37	...	44.46	...	0.37	8400*	19.54
Cypress	54.98	6.54	...	38.08	...	0.40	9870*	22.96
Fir, Douglas	52.3	6.3	...	40.5	0.1	0.8	9050	21.05
Hemlock, western	50.4	5.8	0.1	41.4	0.1	2.2	8620	20.05
Pine, pitch	59.00	7.19	...	32.68	...	1.13	11320*	26.33
white	52.55	6.08	...	41.25	...	0.12	8900*	20.70
yellow	52.60	7.02	...	40.07	...	0.31	9610*	22.35
Redwood	53.5	5.9	...	40.3	0.1	0.2	9040	21.03
Hardwoods†								
Ash, white	49.73	6.93	...	43.04	...	0.30	8920*	20.75
Beech	51.64	6.26	...	41.45	...	0.65	8760*	20.38
Birch, white	49.77	6.49	...	43.45	...	0.29	8650*	20.12
Elm	50.35	6.57	...	42.34	...	0.74	8810*	20.49
Hickory	49.67	6.49	...	43.11	...	0.73	8670*	20.17
Maple	50.64	6.02	...	41.74	0.25	1.35	8580	19.96
Oak, black	48.78	6.09	...	44.98	...	0.15	8180*	19.03
red	49.49	6.62	...	43.74	...	0.15	8690*	20.21
white	50.44	6.59	...	42.73	...	0.24	8810*	20.49
Poplar	51.64	6.26	...	41.45	...	0.65	8920*	20.75

*Calculated from reported high heating value of kiln-dried wood assumed to contain 8-percent moisture.

†The terms "hard" and "soft" wood, contrary to popular conception, have no reference to the actual hardness of the wood. According to the *Wood Handbook*, prepared by the Forest Products Laboratory of the U.S. Department of Agriculture, hardwoods belong to the botanical group of trees that are broad-leaved whereas softwoods belong to the group that have needle or scalelike leaves, such as evergreens: cypress, larch, and tamarack are exceptions.

** Conversion to GJ/t added by B&PPS

Note GJ/t = MJ/kg

However, while it is convenient to compare Biomass fuel on an oven dry basis, woody Biomass fuel in nature contains moisture ranging from about 15% to 25% for seasoned air-dried logs to over 50% for freshly cut green timber. For the 25% moisture and 0.4% ash in fuel as fired, the Fuel Gross Calorific Value on a DAF (Dry Ash Free) is calculated as follows:

Parameter	Value
Fuel moisture content	25%
Fuel Ash Content	0.4%
Fuel Gross Calorific Value (measured)	15.21 MJ/kg
Fuel DAF Calorific Value (calculated)	20.39 MJ/kg

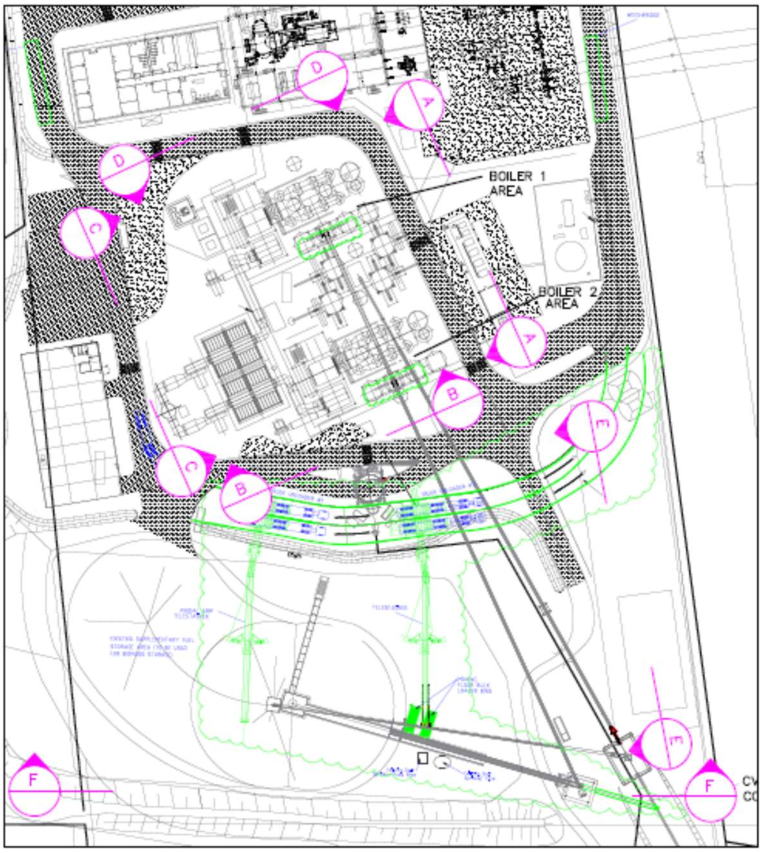
Thus the measured calorific value is consistent with the values noted in Table IX, and with the considerations above.

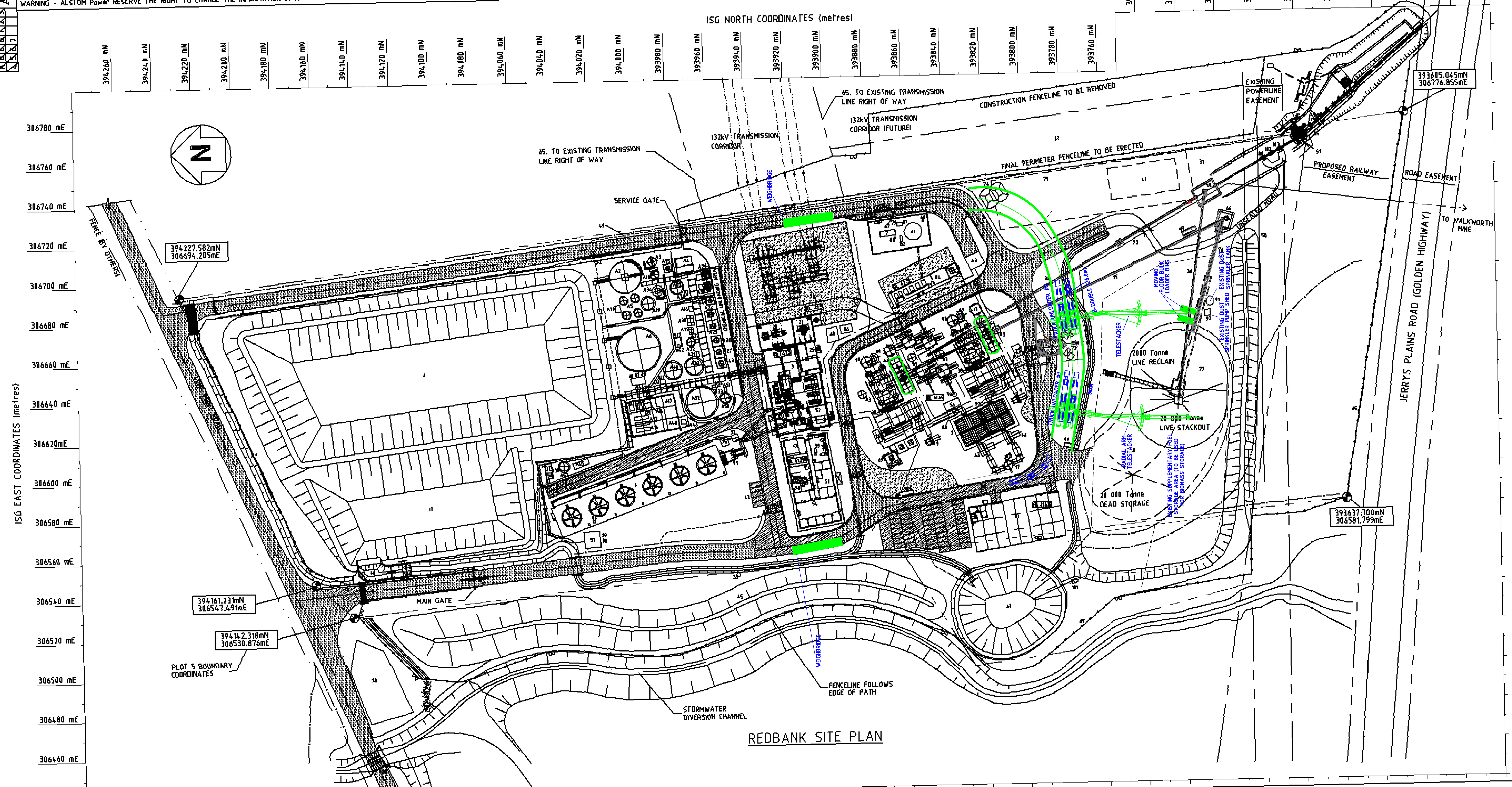
APPENDIX C – DRAWINGS

The following drawings are provided as a part of this document.

Drawing No.	Rev	Dated	Description
80034-000-5001	7	18.10.2021	ALSTOM drawing marked-up to show proposed changes.
80034-007-P-PI-063-8551	2	29.09.1999	ABB/ USF Water Treatment Plant – Flow Balance Diagram
C12198-000-010	B	18.10.2021	Key Plan Showing Proposed Modifications
C12198-000-100	D	20.10.2021	Boiler Plant Area East Elevation “View A-A”
C12198-000-120	B	18.10.2021	Boiler Plant Area South Elevation “View B-B”
C12198-000-130	A	18.10.2021	Boiler Plant Area West Elevation “View C-C”
C12198-000-140	A	18.10.2021	Boiler Plant Area North Elevation “View D-D”
C12198-121-105	A	18.10.2021	Biomass Plant Area East Elevation “View E-E”
C12198-121-110	C	20.10.2021	Biomass Plant Area South Elevation “View F-F”
C12198-121-111	E	18.10.2021	Boiler Plant Area Conveyor System Plan
C12198-PFD-001	E	19.10.2021	Material Handling Process Flow Diagram

Figure 22 - Key Plan of Site Views in this report





REDBANK SITE LAYOUT MARKUP
TO SHOW LOCATIONS OF MODIFICATIONS
FOR BIOMASS FIRING

D. TANNER 18.10.2021

ALSTOM | Power

APPROVED FOR CONSTRUCTION

REV	SIGNATURE	DATE
2	D.TANNER	10.6.99
3	D.TANNER	8.7.99
4	D.TANNER	23.7.99
5	D.TANNER	31.8.99
6	D.TANNER	18.10.99

EQUIPMENT LIST:

1. BOILER NUMBER ONE
2. BOILER NUMBER TWO
3. STEAM TURBINE & GENERATOR SET
4. COOLING TOWER
5. FABRIC FILTER
6. WASTE WATER HOLDING POND - 60 MEGA LITRE CAPACITY
7. DIESEL OIL STORAGE TANK - 40,000 LITRE CAPACITY
8. BACKUP FUEL (COAL) STORAGE AREA - 40,000 TONNES
9. F.D. FAN
10. EMERGENCY ASH STORAGE SILO
11. RAW WATER HOLDING POND - 6 MEGA LITRE CAPACITY
12. BACKUP FUEL (COAL) STORAGE SILO
13. SAND INERT MATERIAL STORAGE SILO
14. LIMESTONE STORAGE SILO
15. COOLING WATER PIPEWORK - UNDERGROUND
16. SWITCHYARD
17. STACK
18. AUXILLARY BAY - BOILER FEED PUMPS/ FEEDWATER HEATERS/DEAERATOR
19. BOT FUEL STORAGE SILO & TRANSFER PUMPS
20. 15.7 kV/132 kV MAIN TRANSFORMER
21. 6.6 kV/132 kV AUXILLARY TRANSFORMER
22. TRANSMISSION LANDING TOWER
23. FABRIC FILTER/ASH HANDLING MCC ROOM/TRANSFORMER
24. BOILER TRANSFORMER
25. BATTERY ROOM
26. SEWAGE TRANSFER PIT AND PUMPS
27. LPG STORAGE AREA
28. ROAD BRIDGE
29. FIRE WATER PUMP
30. DIESEL FIRE WATER PUMP
31. RIVER WATER PUMPS (NOT SHOWN)
32. FIRST FLUSH OVERFLOW TO CREEK
33. COOLING WATER FILTER STATION
34. BOT FUEL CONVEYOR
35. BACKUP FUEL (COAL) CONVEYOR
36. BACKUP FUEL (COAL) STACK OUT CONVEYOR
37. SITE CONSTRUCTION HUTS AND LAYDOWN AREA
38. BOILER BLOWDOWN TANK
39. STATION CONTROL ROOM
40. SWITCHGEAR ROOM
41. WAREHOUSE/MAINTENANCE BUILDING
42. CAR PARK
43. BED SAND/LIMESTONE - INGROUND RECEIVAL HOPPER
44. AUXILLARY COOLING WATER TANK (UNDER COAL SILOS)
45. EARTHEN BERM STORMWATER WALL
46. I.D. FAN
47. FUTURE GAS TURBINE
48. SEDIMENTATION/OILY WATER SEPERATORS
49. WATER PIPE LINES TO/FROM HUNTER RIVER
50. BACKUP FUEL (COAL) TRANSFER HOUSE
51. FIRE TURN-OUT POINT
52. CONDENSATE TANK RACK ROOM (UNDER) RACK ROOM
53. INSTRUMENT SHOP
54. FACILITY ADMINISTRATION BUILDING
55. AIR COMPRESSOR HOUSE
56. BOILER MCC ROOM A/B
57. OVERLAND FUEL BACKUP (COAL) CONVEYOR TRANSFER STATION
58. EXISTING 66 kV TRANSMISSION LINE
59. CHEMICAL LABRATORY
60. FUTURE FUEL FOWARDING PUMP
61. FUEL OIL STORAGE TANK - 300,000 LITRE CAPACITY
62. 11 kV/0.433 kV TURBINE HALL SUPPLY TRANSFORMER
63. PRIMARY CONTAINMENT BACKUP FUEL (COAL) STORAGE DAM
64. OVERLAND FUEL CONVEYOR (BY OTHERS)
65. PERIMETER FENCE
66. CRUSHER HOUSE
67. MOBILE EQUIPMENT FUEL STATION
68. EMERGENCY GENERATOR
69. CHEMICAL FEED STATION
70. NITROGEN STORAGE AREA
71. ASH SLURRY MIX TANK
72. ASH SLURRY DISPOSAL PUMP
73. FUTURE EARTHING AREA
74. LIMESTONE STOCKPILE (56 CUBIC METRES)
75. AUXILLARY COOLING WATER HEAT EXCHANGERS
76. BACKUP FUEL RECLAIM CONVEYOR
77. BACKUP FUEL RECLAIM FEEDER
78. ABORIGINAL HERITAGE SITE
79. DIESEL OIL TRANSFER PUMPS
80. DIESEL OIL PUMPS
81. FUEL OIL TRANSFER PUMPS
82. FUEL OIL PUMPS
83. BOT AGITATOR TANK & INJECTOR PUMPS
84. COMPRESSOR HOUSE MCC
85. 6.6 kV/0.433 kV COMPRESSOR HOUSE TRANSFORMER
86. 11 kV/0.433 kV TRANSFORMER (ENERGY AUST.)
87. STACK EMISSION MONITORING - CEMS SHED
88. BOILER SO2 & O2 MONITORING SHED.
89. ASH COOLER
90. BED MATERIALS SILO
91. COAL DUST WATER SPRINKLER TANK
92. COAL DUST SPRINKLER PUMP SHED
93. SLURRY LINE FROM ASH/DUST PLANT TO WALKWORTH MINE
94. SERVICE WATER HEADER TANK TO FIREWATER PUMPS
95. AUXILLARY COOLING WATER PUMPS
96. BOT AIR RECEIVER
97. FABRIC FILTER AIR RECEIVER
98. FIRST AID ROOM
99. INLET PIT SILT ARRESTOR
100. COAL SAMPLER
101. BACKUP FUEL (COAL) STOCKPILE SPRAY PUMPS
102. COAL SCANNER
103. COAL OVER MAGNET

WATER TREATMENT PLANT EQUIPMENT LIST

A1 RAW WATER FEED PUMPS
A2 Ø 16m RAW WATER CLARIFIER
A3 SLUDGE THICKENER
A4 ELEVATED DEWATERING FACILITY
A5 4xØ4m GRAVITY FILTERS
A6 2000 cu.m TREATED WATER/FIREWATER TANK
A7 COOLING WATER MAKEUP PUMPS
A8 SERVICE WATER PUMPS
A9 NOT USED
A10 NOT USED
A11 RO FEED PUMPS
A12 RO CARTRIDGE FILTER SKID
A13 WATER TREATMENT RO TRAIN 1 AND 2
A14 WASTE WATER TREATMENT RO UNIT
A15 MIXED BED POLISHER SKID
A16 PRESSURE FILTER AIR BLOWERS
A17 NEUTRALISATION PIT AND PUMPS
A18 SLUDGE HOLDING TANK
A19 BACKWASH COLLECTION PIT
A20 300 cu.m DEMIN WATER TANK
A21 MIXED BED REGEN. WATER PUMPS
A22 DEMIN. WATER TRANSFER PUMPS
A23 ANTISCALENT DOSING SKID
A24 SODIUM BISULPHITE DOSING SKID
A25 CAUSTIC BULK STORAGE TANK AND DOSING PUMPS
A26 SULPHURIC ACID BULK STORAGE TANK & DOSING PUMPS
A27 SODIUM HYPOCHLITE DOSING SYSTEM
A28 FERRIC CHLORIDE DOSING SYSTEM
A29 LIME SILO & MIXING TANKS/PUMPS
A30 WASTE WATER DISCHARGE PUMPS
A31 SODA ASH SILO & MIXING TANKS/PUMPS
A32 1000 cu.m COOLING TOWER BLOWDOWN TANK
A33 WASTE WATER CLARIFIER FEED PUMPS
A34 Ø5.4m WASTE WATER CLARIFIER
A35 100 cu.m SOFTENED WATER TANK
A36 SAND FILTERS FEED/BACKWASH PUMPS
A37 NEUTRALISATION TANK TRANSFER PUMPS
A38 PRESSURE SAND FILTER SKID
A39 GRAVITY FILTERS AIR BLOWERS
A40 300 cu.m HIGH PURITY WATER TANK
A41 BDT RINSE PUMPS
A42 MIXED BED FEED PUMPS
A43 MAGNESIUM OXIDE DOSING SYSTEM
A44 CIP SKID
A45 PACKAGE SEWAGE TREATMENT PLANT
A46 TRANSFORMER
A47 OPERATOR OFFICE - LABORATORY
A48 SWITCHROOM
A49 HYDROCHLORIC ACID STORAGE TANK & PUMP
A50 POTABLE WATER TANK
A51 POTABLE WATER PUMP SYSTEM
A52 BACKWASH AND DRAINAGE PIT
A53 IRRIGATION WATER TANK
A54 AIR RECEIVERS
A55 FILTER PRESS CLEANING TANK & PUMP

LEGEND :

CONCRETE/ASPHALT HARDSTAND
COMPACTED GRAVEL HARDSTAND
SURFACE DRAINAGE
BOUNDARY FENCE

ALSTOM | Power

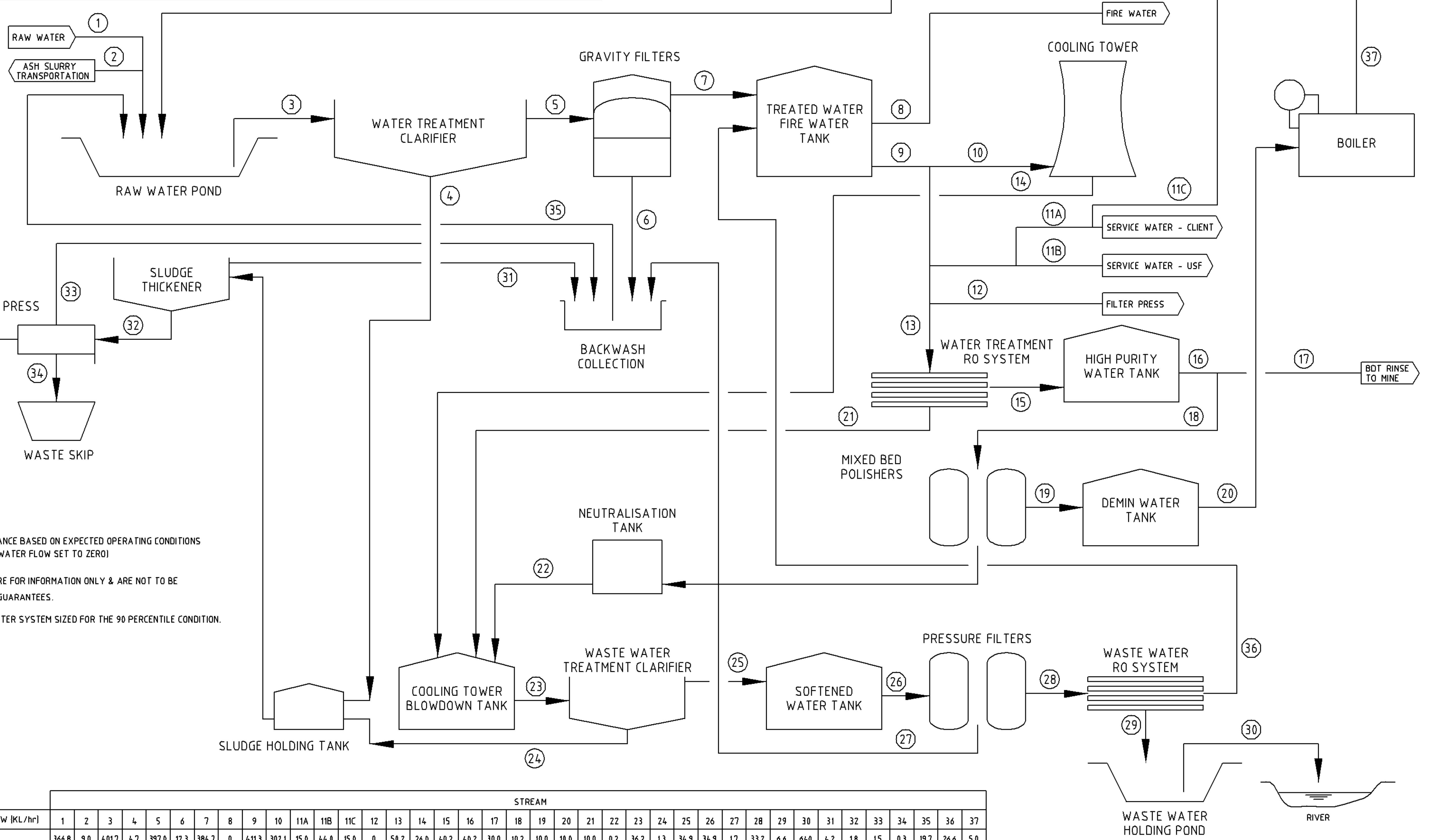
SCALE 1 : 750 U.O.N

CLIENT REDBANK CONSTRUCTION PTY. LTD.
REDBANK POWER PROJECT

TITLE 00 PLANT SYSTEMS
128 MW POWER PLANT
POWER PLANT ARRANGEMENT

DRAWING No. 80034-001-M-GA-000-5001 A0

DRAWING No. 80034-007-P-PI-063-8551 A1



NOTES:

- FLOW BALANCE BASED ON EXPECTED OPERATING CONDITIONS (E.G. FIRE WATER FLOW SET TO ZERO)
- FIGURES ARE FOR INFORMATION ONLY & ARE NOT TO BE USED FOR GUARANTEES.
- WASTE WATER SYSTEM SIZED FOR THE 90 PERCENTILE CONDITION.

STREAM

DESIGN FLOW (KL/hr)	1	2	3	4	5	6	7	8	9	10	11A	11B	11C	12	13	14	15	16
MEAN	366.8	9.0	401.7	4.7	397.0	12.3	384.7	0	411.3	302.1	15.0	44.0	15.0	0	50.2	26.0	40.2	40.2
90 PERCENTILE	368.1	9.0	405.1	6.7	398.4	12.3	386.1	0	418.7	309.5	15.0	44.0	15.0	0	50.2	33.5	40.2	40.2
MAXIMUM	300.2	9.0	404.2	8.4	395.7	12.3	388.4	0	430.2	321.0	15.0	44.0	15.0	0	50.2	45.0	40.2	40.2

DESIGN FLOW (KL/hr)	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
MEAN	30.0	10.2	10.0	10.0	10.0	0.2	36.2	1.3	34.9	34.9	1.7	33.2	6.6	640	4.2	1.8	1.5	0.3	19.7	26.6	5.0
90 PERCENTILE	30.0	10.2	10.0	10.0	10.0	0.2	43.7	1.2	42.5	42.5	1.7	40.8	8.2	640	5.5	2.4	1.9	0.5	21.4	32.6	5.0
MAXIMUM	30.0	10.2	10.0	10.0	10.0	0.2	55.2	1.3	53.9	53.9	1.7	52.2	10.4	640	6.8	2.9	2.4	0.5	23.2	41.8	5.0

REVISIONS

REV	DRN	DATE	DESCRIPTION	CHK	APP
A	IR	23.7	ORIGINAL ISSUE		
1	BC	26.7	DESIGN REVIEW		
2	GG	29.9	REVISED TO CLIENT COMMENTS	MM	MM

ABB POWER GENERATION LIMITED

A US FILTER COMPANY
U.S. FILTER (AUSTRALIA) PTY LTD A.C.N. 000 178 698
UNIT 1A 6-8 LYON PARK ROAD, NORTH RYDE, NSW 2113, AUSTRALIA
Tel :61 2 8875 2800 Fax:61 2 8875 2700 Email: usf@usfilter.com.au

USF CAD FILE g:\aaacad\ip1001\pa\ip1001pa01.dwg
USF DRAWING No. IP1001-PA01 ISSUE 2

SCALE NTS (N.T.S = NOT TO SCALE)

	SIGNATURE	DATE
DRAWN	IR	2.6.99
CHECKED	MM	25.10.99
APPROVED	CH	25.10.99
DESIGN ENG	MM	25.10.99

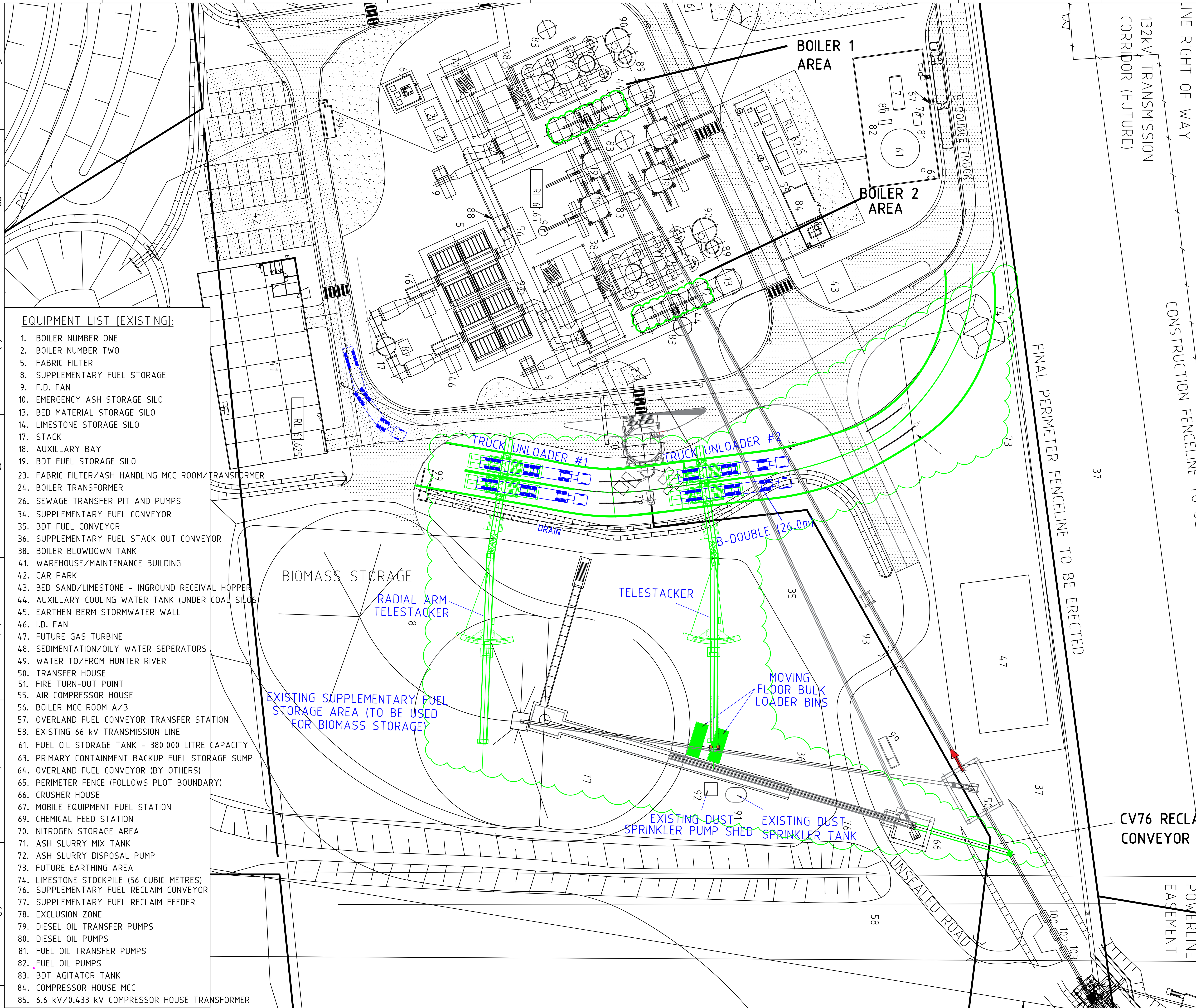
CLIENT REDBANK CONSTRUCTION PTY. LTD.
REDBANK POWER PROJECT

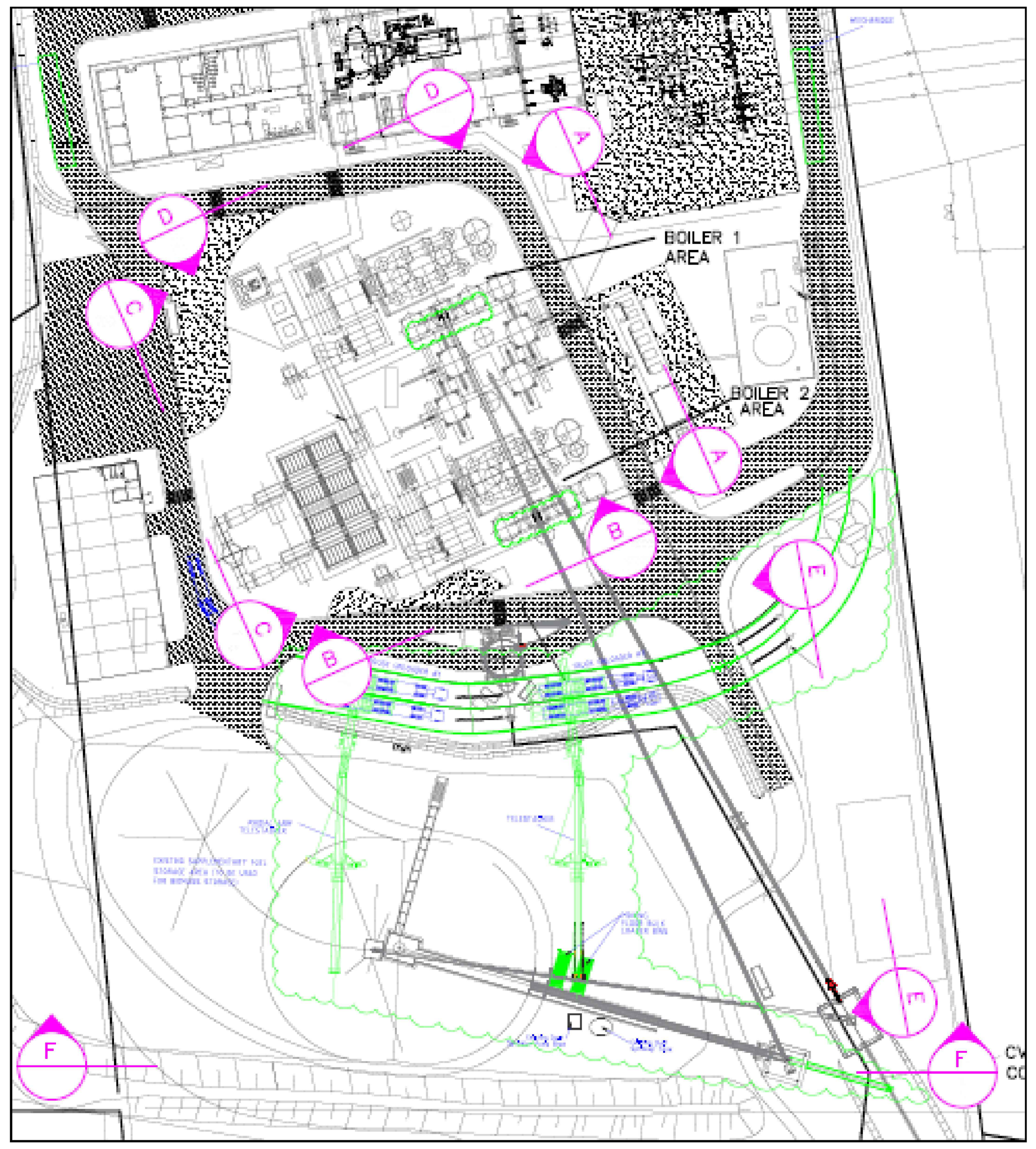
TITLE AREA 05 WATER TREATMENT PLANT

WATER TREATMENT PLANT
PROCESS FLOW BALANCE DIAGRAM

DRAWING No. 80034-007-P-PI-063-8551
A 1 2 A1

ABB POWER GENERATION LIMITED





KEY TO ELEVATION VIEWS

EQUIPMENT LIST (EXISTING):

1. BOILER NUMBER ONE
2. BOILER NUMBER TWO
5. FABRIC FILTER
8. SUPPLEMENTARY FUEL STORAGE
9. F.D. FAN
10. EMERGENCY ASH STORAGE SILO
13. BED MATERIAL STORAGE SILO
14. LIMESTONE STORAGE SILO
17. STACK
18. AUXILLARY BAY
19. BDT FUEL STORAGE SILO
23. FABRIC FILTER/ASH HANDLING MCC ROOM/TRANSFORMER
24. BOILER TRANSFORMER
26. SEWAGE TRANSFER PIT AND PUMPS
34. SUPPLEMENTARY FUEL CONVEYOR
35. BDT FUEL CONVEYOR
36. SUPPLEMENTARY FUEL STACK OUT CONVEYOR
38. BOILER BLOWDOWN TANK
41. WAREHOUSE/MAINTENANCE BUILDING
42. CAR PARK
43. BED SAND/LIMESTONE - INGROUND RECEIVAL HOPPER
44. AUXILLARY COOLING WATER TANK (UNDER COAL SILOS)
45. EARTHEN BERM STORMWATER WALL
46. I.D. FAN
47. FUTURE GAS TURBINE
48. SEDIMENTATION/OILY WATER SEPERATORS
49. WATER TO/FROM HUNTER RIVER
50. TRANSFER HOUSE
51. FIRE TURN-OUT POINT
55. AIR COMPRESSOR HOUSE
56. BOILER MCC ROOM A/B
57. OVERLAND FUEL CONVEYOR TRANSFER STATION
58. EXISTING 66 kV TRANSMISSION LINE
61. FUEL OIL STORAGE TANK - 380,000 LITRE CAPACITY
63. PRIMARY CONTAINMENT BACKUP FUEL STORAGE SUMP
64. OVERLAND FUEL CONVEYOR (BY OTHERS)
65. PERIMETER FENCE (FOLLOWS PLOT BOUNDARY)
66. CRUSHER HOUSE
67. MOBILE EQUIPMENT FUEL STATION
69. CHEMICAL FEED STATION
70. NITROGEN STORAGE AREA
71. ASH SLURRY MIX TANK
72. ASH SLURRY DISPOSAL PUMP
73. FUTURE EARTHING AREA
74. LIMESTONE STOCKPILE (56 CUBIC METRES)
76. SUPPLEMENTARY FUEL RECLAIM CONVEYOR
77. SUPPLEMENTARY FUEL RECLAIM FEEDER
78. EXCLUSION ZONE
79. DIESEL OIL TRANSFER PUMPS
80. DIESEL OIL PUMPS
81. FUEL OIL TRANSFER PUMPS
82. FUEL OIL PUMPS
83. BDT AGITATOR TANK
84. COMPRESSOR HOUSE MCC
85. 6.6 kV/0.433 kV COMPRESSOR HOUSE TRANSFORMER

NOTES

REFERENCE DRAWINGS
- ALSTOM SITE LAYOUT 80034-000-5001

REV	DRN	DATE	DESCRIPTION	APP
B	DT	18.10	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE: NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	11.10.21
REVIEW		
APP.		

CLIENT: REDBANK POWER STATION

TITLE: BIOMASS CONVERSION PROJECT KEY PLAN SHOWING PROPOSED PLANT MODIFICATIONS

DRAWING No. C12198-000-010

REVISION B

A1

Boiler & Power Plant Services Pty Ltd

NOTES
REFER TO DRAWING C12198-000-010 FOR: - KEY PLAN TO SECTIONAL VIEWS - NUMBERED EQUIPMENT LOCATION IN PLAN VIEW

REV	DRN	DATE	DESCRIPTION	APP
C	DT	18.10	FOR ISSUE	
D	DT	20.10	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE: NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	11.10.2021
REVIEW		
APP.		

CLIENT: REDBANK POWER STATION

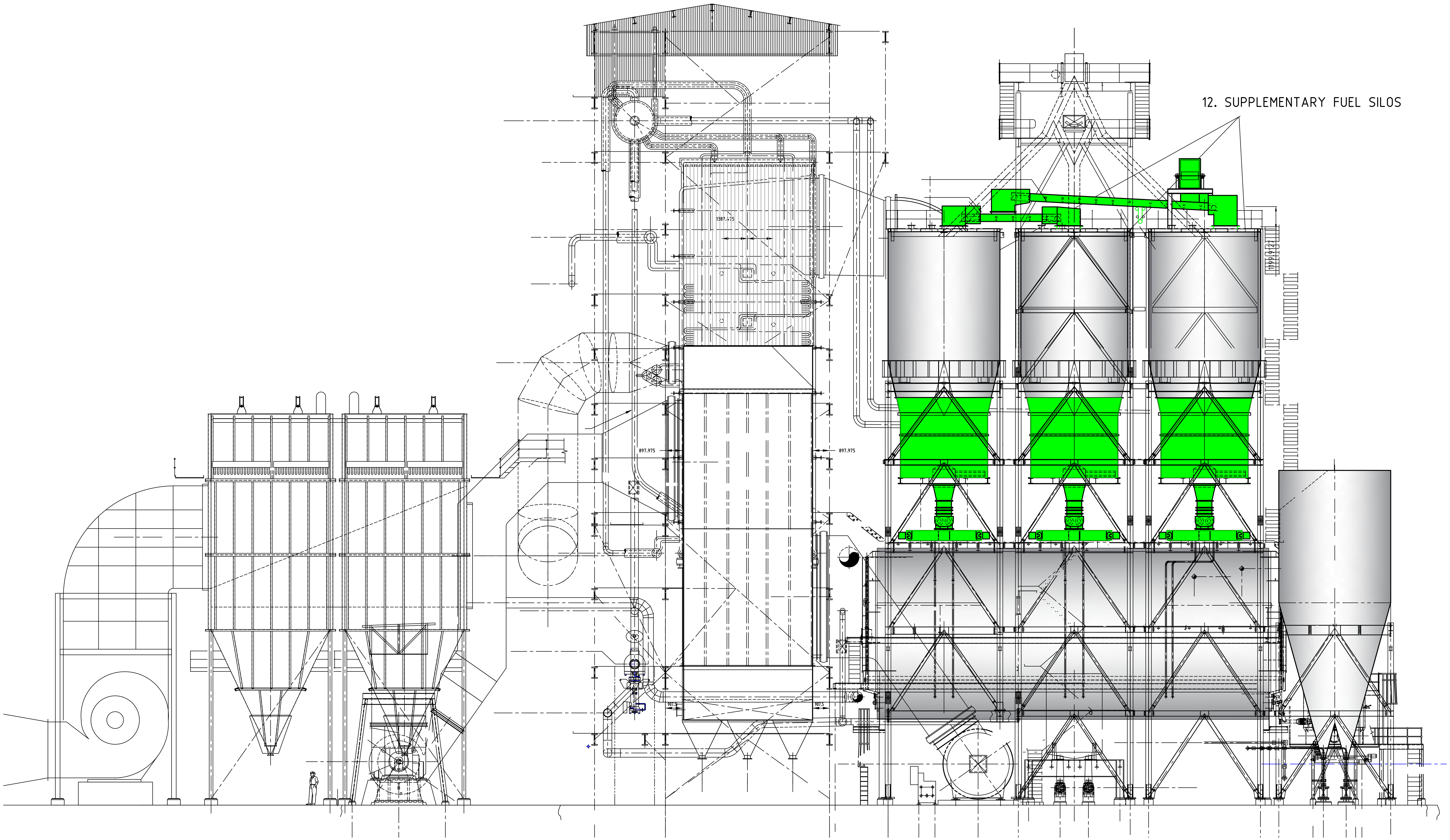
TITLE: BIOMASS CONVERSION PROJECT
BOILER PLANT AREA
EAST ELEVATION VIEW A-A

DRAWING No. C12198-000-100

REVISION D

A1

Boiler & Power Plant Services Pty Ltd



NOTES

REFER TO DRAWING C12198-000-010 FOR:
- KEY PLAN TO SECTIONAL VIEWS
- NUMBERED EQUIPMENT LOCATION IN PLAN VIEW

REV	DRN	DATE	DESCRIPTION	APP
B	DT	18.10	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE: NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	18.10.21
REVIEW		
APP.		

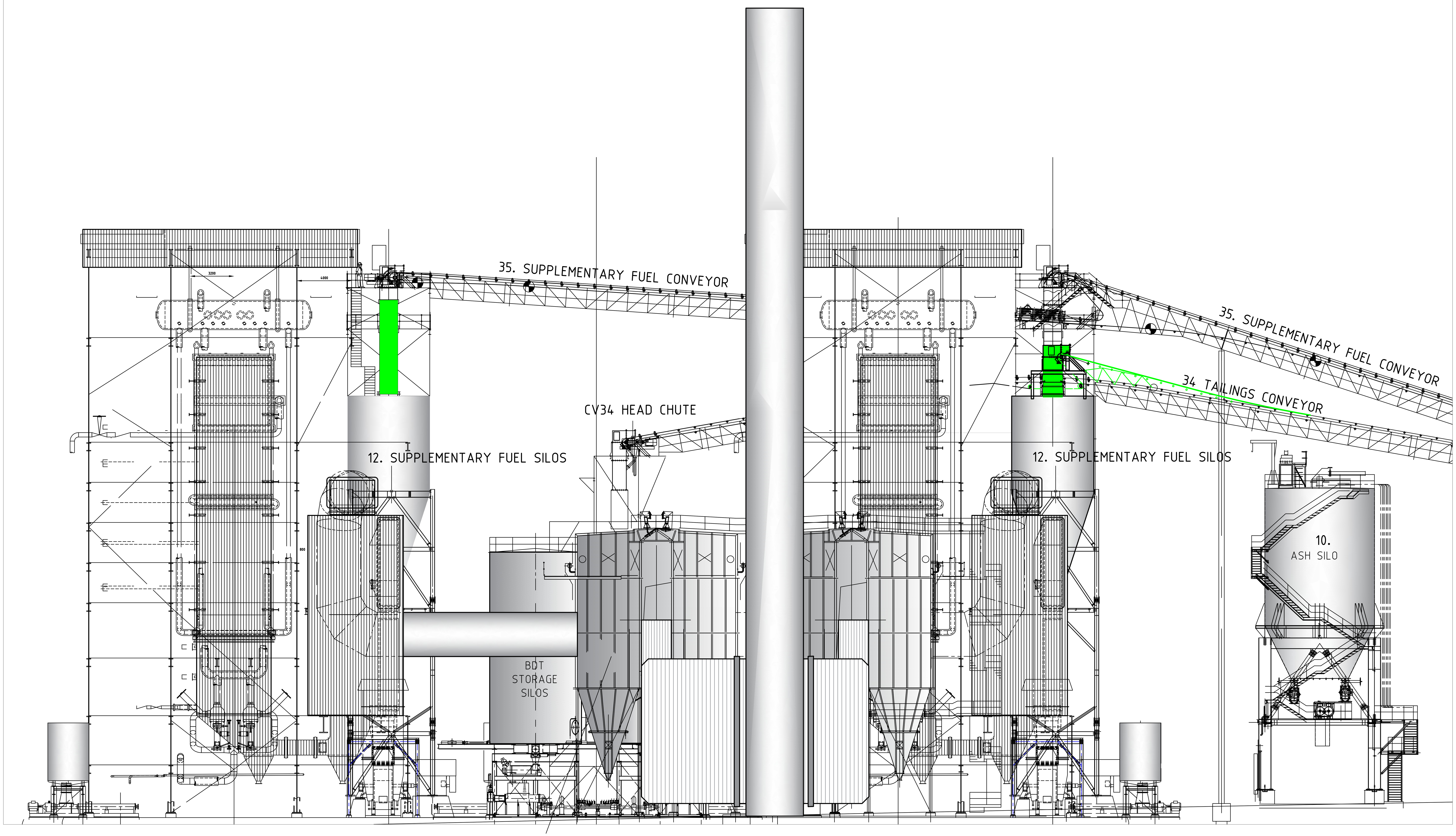
CLIENT: REDBANK POWER STATION

TITLE: BIOMASS CONVERSION PROJECT
BOILER PLANT AREA
SOUTH ELEVATION VIEW B-B

DRAWING No. C12198-000-120

REVISION B — A1

Boiler & Power Plant Services Pty Ltd



NOTES	REV	DRN	DATE	DESCRIPTION	APP
REFER TO DRAWING C12198-000-010 FOR: - KEY PLAN TO SECTIONAL VIEWS - NUMBERED EQUIPMENT LOCATION IN PLAN VIEW	B	DT	18.10	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE: NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	18.10.21
REVIEW		
APP.		

CLIENT: REDBANK POWER STATION

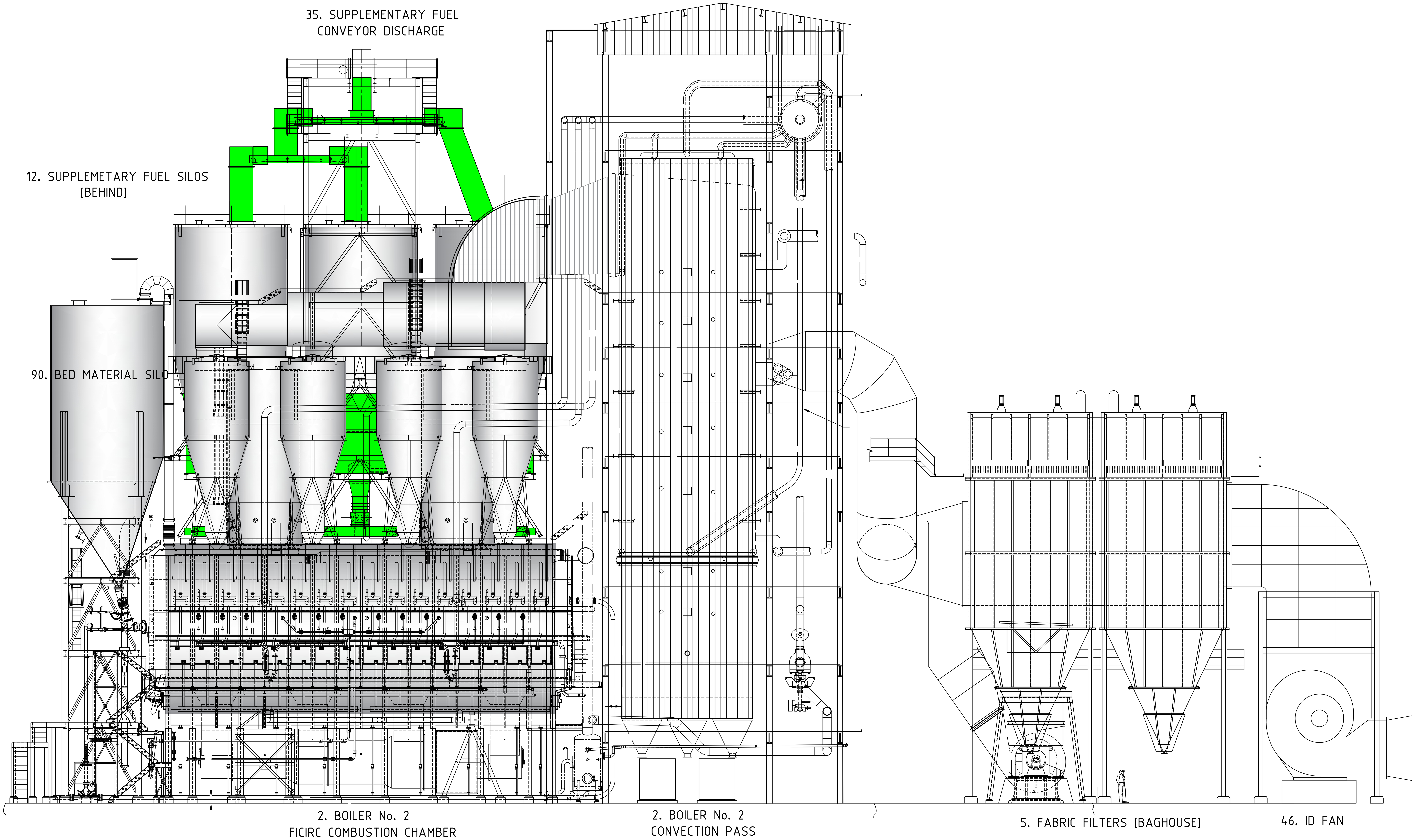
TITLE: BIOMASS CONVERSION PROJECT
BOILER PLANT AREA
WEST ELEVATION VIEW C-C

DRAWING No. C12198-000-130

REVISION A

A1

Boiler & Power Plant Services Pty Ltd



NOTES

REFER TO DRAWING C12198-000-010 FOR:
- KEY PLAN TO SECTIONAL VIEWS
- NUMBERED EQUIPMENT LOCATION IN PLAN VIEW

REV	DRN	DATE	DESCRIPTION	APP

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE: NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	18.10.21
REVIEW		
APP.		

CLIENT: REDBANK POWER STATION

TITLE: BIOMASS CONVERSION PROJECT
BOILER PLANT AREA
NORTH ELEVATION VIEW D-D

DRAWING No. C12198-000-140

REVISION A

A1

Boiler & Power Plant Services Pty Ltd

NOTES

REFER TO DRAWING C12198-000-010 FOR:
- KEY PLAN TO SECTIONAL VIEWS
- NUMBERED EQUIPMENT LOCATION IN PLAN VIEW

REV	DRN	DATE	DESCRIPTION	APP

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE NOT TO SCALE

	SIGNATURE	DATE
DRN.	DT	18.10.2021
REVIEW		
APP.		

CLIENT REDBANK POWER STATION

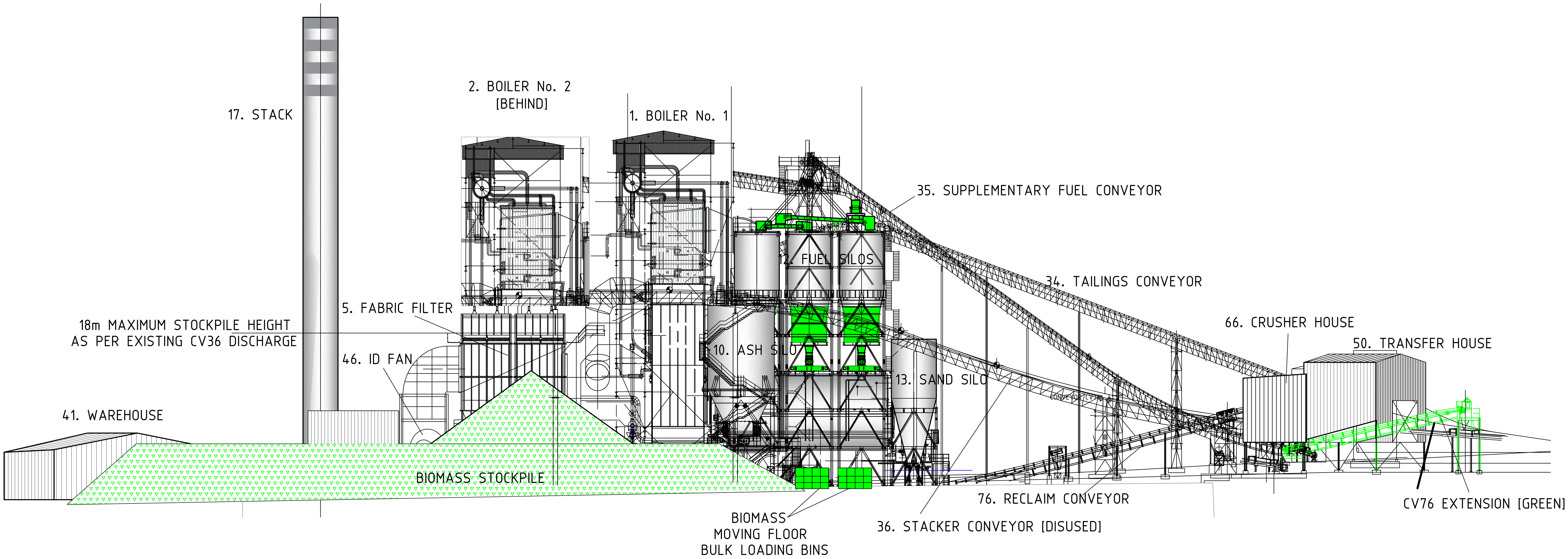
TITLE BIOMASS CONVERSION PROJECT
BIOMASS PLANT AREA
EAST ELEVATION VIEW E-E

DRAWING No. C12198-121-105

REVISION A

A1

Boiler & Power Plant Services Pty Ltd



NOTES

REFER TO DRAWING C12198-000-010 FOR:
- KEY PLAN TO SECTIONAL VIEWS
- NUMBERED EQUIPMENT LOCATION IN PLAN VIEW

REV	DRN	DATE	DESCRIPTION	APP
B	DT	18.10	FOR ISSUE	
C	DT	20.10	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE	NOT TO SCALE	
	SIGNATURE	DATE
DRN.	DT	13.10.2021
REVIEW		
APP.		

CLIENT: REDBANK POWER STATION

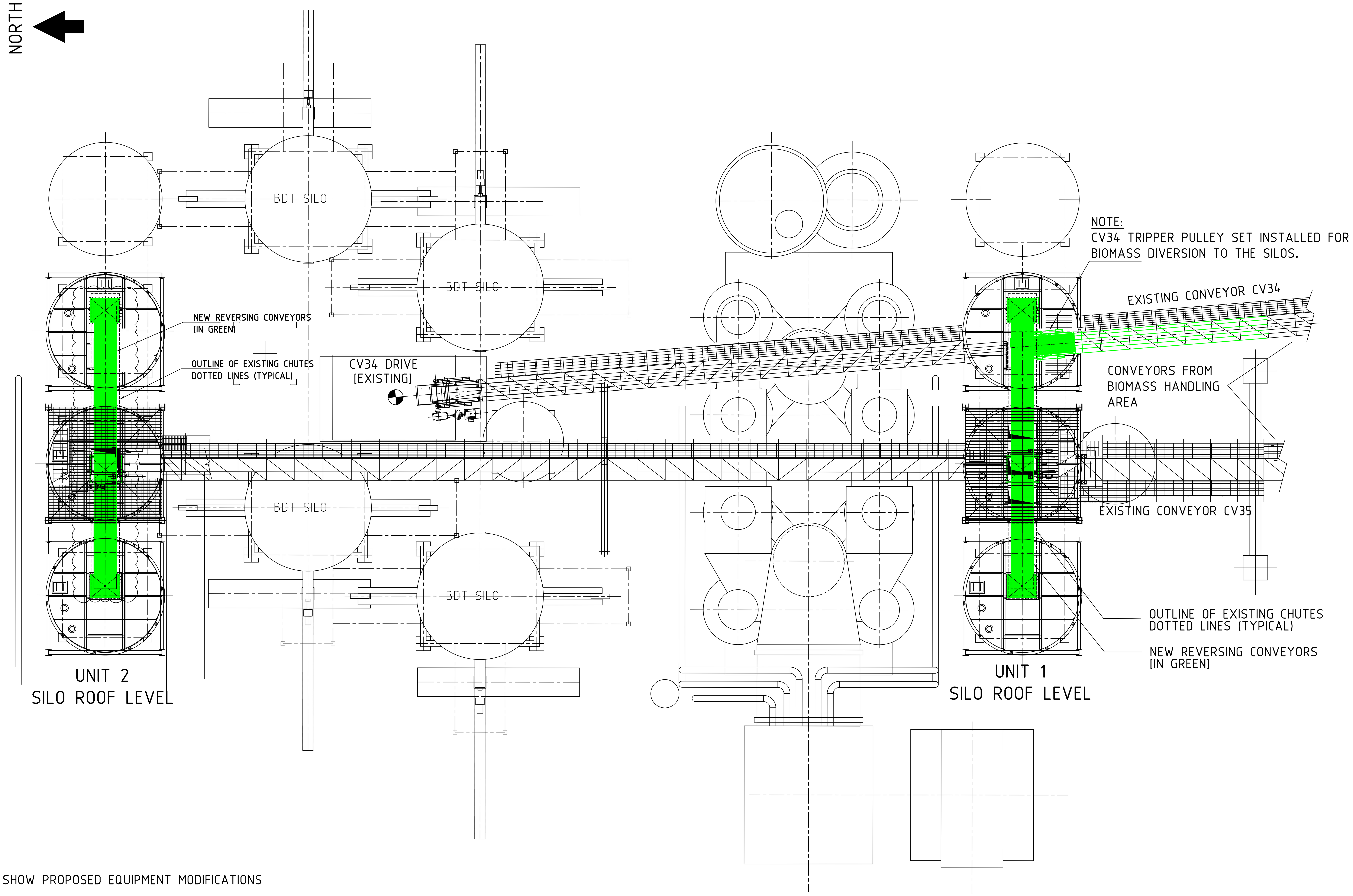
TITLE: BIOMASS CONVERSION PROJECT
BIOMASS PLANT AREA
SOUTH ELEVATION VIEW "F-F"

DRAWING No. C12198-121-110

REVISION C

A1

Boiler & Power Plant Services Pty Ltd



NOTE:
GREEN AREAS SHOW PROPOSED EQUIPMENT MODIFICATIONS

NOTES	REV	DRN	DATE	DESCRIPTION	APP
	E	DT	18.10.21	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE	NOT TO SCALE	
	SIGNATURE	DATE
DRN.	DT	28.07.21
REVIEW		
APP.		

CLIENT
REDBANK POWER STATION

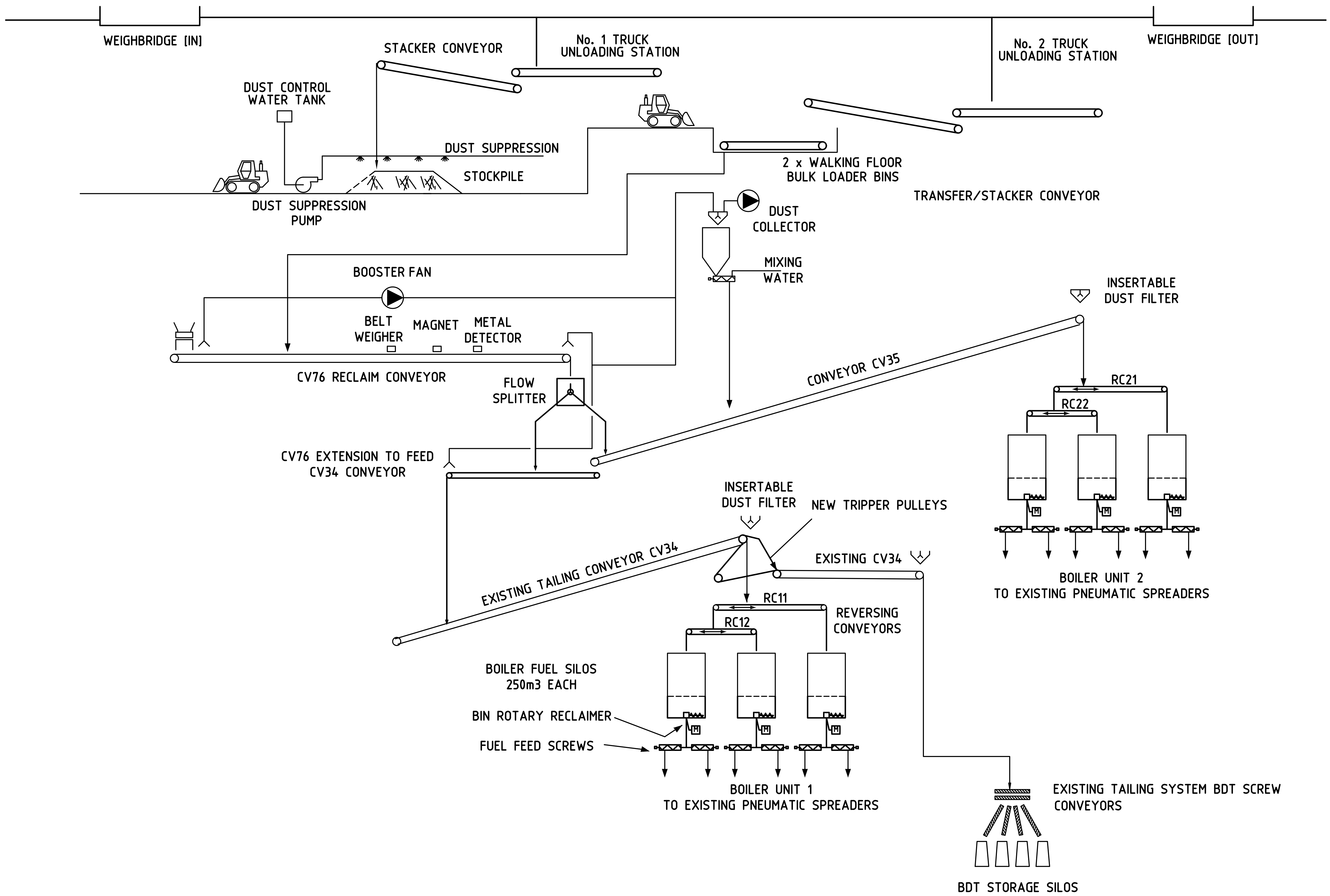
TITLE
BIOMASS CONVERSION PROJECT
BOILER PLANT AREA
CONVEYOR SYSTEM PLANS

DRAWING No.
C12198-121-111

REVISION
E

A1

Boiler & Power Plant Services Pty Ltd



NOTES

REVISIONS

REV	DRN	DATE	DESCRIPTION	APP
E	DT	19.10.21	FOR ISSUE	

B&PPS Boiler & Power Plant Services Pty Ltd

SCALE	NOT TO SCALE	
	SIGNATURE	DATE
DRN.	DT	17.08.2020
REVIEW		
APP.		

CLIENT
REDBANK POWER STATION

TITLE
BIOMASS CONVERSION PROJECT
BIOMASS HANDLING PLANT
PROCESS FLOW DIAGRAM

DRAWING No. C12198-PFD-001

REVISION E

A3

Boiler & Power Plant Services Pty Ltd