# ANNEXURE 4

**Preliminary Hazard Analysis**

**prepared by**

**Pinnacle Risk Management Pty Ltd**

**22, 24, 171 and 220**
**Bolong Road, Bomaderry**

# PRELIMINARY HAZARD ANALYSIS,

# PROPOSED MODIFICATION APPLICATION TO MP06-0228,

# SHOALHAVEN STARCHES EXPANSION PROJECT,

# PROPOSED NEW SPECIALTY PROCESSING FACILITY,

# NEW GLUTEN DRYER AND OTHER ASSOCIATED WORKS

# AT 22, 24 AND 171 BOLONG ROAD, BOMADERRY, NSW

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***15 May 2018***

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# Preliminary Hazard Analysis, Shoalhaven Starches, Modification to MP06_0228

## Disclaimer



| Rev | Date | Description | Reviewed By |
|---|---|---|---|
| A | 12/3/18 | Draft for Comment | Shoalhaven Starches |
| B | 15/5/18 | Final Issue | Shoalhaven Starches |

# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# EXECUTIVE SUMMARY

The Shoalhaven Starches factory located on Bolong Road, Bomaderry, produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

Shoalhaven Starches intend to undertake further modifications to the Shoalhaven Starches Expansion Project Approval (MP06_0228).

As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required. This report details the results from the analysis.

The risks associated with the proposed modifications to MP06-0228 at the Shoalhaven Starches Bomaderry site have been assessed and compared against the DoP risk criteria.

The results are as follows and show compliance with all risk criteria.

| Description | Risk Criteria | Risk Acceptable? |
|---|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year | Yes |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year | Yes |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year | Yes |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year | Yes |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year | Yes |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 $kW/m^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | $10 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | $50 \times 10^{-6}$ per year | Yes |

| Description | Risk Criteria | Risk Acceptable? |
|---|---|---|
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 $kW/m^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | 50 x $10^{-6}$ per year | Yes |

Societal risk, area cumulative risk, environmental risk and transport risk is also concluded to be acceptable.

The primary reasons for the low risk levels from the modifications are that significant levels of impact from potential hazardous events are contained on-site.

The following recommendation is made from this review.

1. For all explosion vents that vent directly to atmosphere for the modifications, finalise the explosion vent modelling when the design details are known.

2. Review the option for installing initial screening, e.g. a magnetic separator, at the new intake pit to lower the likelihood of foreign objects entering the new bucket elevator and the downstream existing silos.

3. Ensure that all the proposed explosion vents are directed to a safe location to avoid injury to personnel or propagation to other adjacent equipment.

4. It is recommended that the floor of the new switchroom be fire-rated given the risk of a fire in the existing switchroom below. This will also help prevent a fire in the new switchroom propagating to the existing switchroom below.

In addition, there are also actions from the hazardous event identification exercise performed on the modified starches plant. These are shown in Appendix K of this report.

# GLOSSARY

| | |
|---|---|
| ALARP | As Low As Reasonably Practicable |
| AS | Australian Standard |
| ATEX | ATmosphères EXplosibles |
| BPCS | Basic Process Control System |
| CCPS | Center for Chemical Process Safety |
| DoP | NSW Department of Planning |
| DP | Differential Pressure |
| EPA | Environmental Protection Authority |
| GD | Gluten Dryer |
| HCl | Hydrochloric Acid |
| HEART | Human Error Assessment and Reduction Technique |
| HIPAP | Hazardous Industry Planning Advisory Paper |
| HSE | Health and Safety Executive (UK) |
| IBC | Intermediate Bulk Container |
| IDLH | Immediately Dangerous to Life and Health |
| IEC | International Electrotechnical Commission |
| IECEX | International Electrotechnical Commission Explosive |
| IPL | Independent Protection Layer |
| LEL | Lower Explosive Limit |
| LOPA | Layers of Protection Analysis |
| LTI | Lost Time Injury |
| MEC | Minimum Explosive Concentration |
| MIE | Minimum Ignition Energy |
| MTI | Medical Treatment Injury |
| NFPA | National Fire Protection Association |
| PFD | Probability of Failure on Demand |
| PHA | Preliminary Hazard Analysis |

| | |
|---|---|
| PM | Preventative Maintenance |
| PPE | Personal Protective Equipment |
| PRM | Pinnacle Risk Management |
| SD | Starch Dryer |
| SIL | Safety Integrity Level |
| SIS | Safety Instrumented System |
| SOx | Sulphur Oxides |
| STEL | Short-Term Exposure Limit |
| TDS | Total Dissolved Solids |
| TLV | Threshold Limit Value |
| TWA | Time Weighted Average |
| WWTP | Waste Water Treatment Plant |

# REPORT

## 1 INTRODUCTION

### 1.1 BACKGROUND

Shoalhaven Starches is a member of the Manildra Group of companies. The Manildra Group is a wholly Australian owned business and the largest processor of wheat in Australia. It manufactures a wide range of wheat-based products for food and industrial markets both locally and internationally.

The Shoalhaven Starches factory located on Bolong Road, Bomaderry, produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

Shoalhaven Starches intend to undertake further modifications to the Shoalhaven Starches Expansion Project Approval (MP06_0228) as follows:

1. Utilise grain that is currently approved to directly feed the fermentation process in the ethanol production process to instead increase the amount of flour that is produced on site. This will also result in increased starch and gluten production. Shoalhaven Starches propose to install a third flour mill ‘C’ within the existing flour mill B building to further increase the proportion of flour that is manufactured on the site;

2. Undertake modifications to the existing flour mills A and B by modifying the type of ventilation used within the buildings from a vacuum to a pressurised system;

3. Construct a new industrial building that will be located between the remaining “Moorhouse” Maintenance Building and adjoining the Starch Dryer No. 5 building to the west of Abernethy’s Creek. This new industrial building / complex will contain the following processes:

   - The resultant increase in starch and gluten production will require the conversion of two existing gluten dryers (No’s 1 and 2) into starch production and the construction of a new gluten dryer (to replace the capacity lost by the conversion of Dryers No’s 1 and 2 to starch). This new gluten dryer will be housed in the new industrial building;

   - Shoalhaven Starches propose to produce a range of specialised products as an extension to their existing product line. The specialty products will comprise a range of modified starches for both paper manufacturing as well as food production. The plant and equipment associated with the processing of these specialty products will be housed within the new industrial building;

4. Install a new baghouse filter for Starch Dryer No. 5;

5. Construct a coal-fired cogeneration plant to the south of the existing boilerhouse complex that will generate 15 MW of electrical power. This cogeneration plant will include the installation of a new coal fired boiler (No. 8). The construction of this new cogeneration plant and boiler (No. 8) will necessitate the relocation of the existing Boiler No. 7 to the northern side of the overall boilerhouse complex;

6. Construct an indoor electrical substation on the northern side of Bolong Road (No. 171), i.e. adjacent to the BOC Carbon Dioxide Plant, to provide an increase in electrical power to serve the power supply requirements associated with this Modification Proposal;

7. Install an additional rail intake pit for the unloading of rail wagons;

8. Construct an extension to an existing electrical sub-station (second storey extension) that is located within the main factory site. The additional substation is to enable increased power supply to the site to also accommodate the requirements for the modification proposal; and

9. The extension to the height of the Interim Packing Plant building to accommodate additional sifting equipment to enable Shoalhaven Starches meet customer requirements who now require smaller particle size for dried product.

As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required. Shoalhaven Starches requested that Pinnacle Risk Management prepare the PHA for the proposed modifications. This PHA has been prepared in accordance with the guidelines published by the Department of Planning (DoP) Hazardous Industry Planning Advisory Paper (HIPAP) No 6 (Ref 1).

## 1.2 Objectives

The main aims of this PHA study are to:

- Identify the credible, potential hazardous events associated with the proposed modifications;

- Evaluate the level of risk associated with the identified potential hazardous events to surrounding land users and compare the calculated risk levels with the risk criteria published by the DoP in HIPAP No 4 (Ref 2);

- Review the adequacy of the proposed safeguards to prevent and mitigate the potential hazardous events; and

- Where necessary, submit recommendations to Shoalhaven Starches to ensure that the proposed modifications are operated and maintained at acceptable levels of safety and effective safety management systems are used.

## 1.3 SCOPE

This PHA assesses the credible, potential hazardous events and corresponding risks associated with the Shoalhaven Starches proposed 2018 modifications to MP06_0228 with the potential for off-site impacts only.

As there are no significant quantities of Dangerous Good involved with these modifications then off-site transport risk assessment for acute hazardous events is not warranted to be assessed.

## 1.4 METHODOLOGY

In accordance with the approach recommended by the DoP in HIPAP 6 (Ref 1) the underlying methodology of the PHA is risk-based, that is, the risk of a particular potentially hazardous event is assessed as the outcome of its consequences and likelihood.

The PHA has been conducted as follows:

- Initially, the proposed modifications and their location were reviewed to identify credible, potential hazardous events, their causes and consequences. Proposed safeguards were also included in this review;
- As the potential hazardous events are located at a significant distance from other sensitive land users, the consequences of each potential hazardous event were estimated to determine if there are any possible unacceptable off-site impacts;
- Included in the analysis is the risk of propagation between the proposed equipment and the adjacent processes; and
- If adverse off-site impacts could occur, assess the risk levels to check if they are within the criteria in HIPAP 4 (Ref 2).

# 2 SITE DESCRIPTION

The Shoalhaven Starches factory site is situated on various allotments of land on Bolong Road, Bomaderry, within the City of Shoalhaven (see Figure 1). The factory site, which is located on the south side of Bolong Road on the northern bank of the Shoalhaven River, has an area of approximately 12.5 hectares.

The town of Bomaderry is located approximately 0.5 km to the west of the factory site and the Nowra urban area is situated 2.0 km to the south west of the site. The “Riverview Road” area of the Nowra Township is situated approximately 600 metres immediately opposite the factory site across the Shoalhaven River.

The village of Terara is situated approximately 1.5 kilometres to the south east of the site, across the Shoalhaven River. Pig Island is situated between the factory site and the village of Terara and is currently used for cattle grazing.

There are a number of industrial land uses, which have developed on the strip of land between Bolong Road and the Shoalhaven River. Industrial activities include a metal fabrication factory, the Shoalhaven Starches site, Shoalhaven Dairy Co-op (formerly Australian Co-operative Foods Ltd – now owned by the Manildra Group) and the Shoalhaven Paper Mill (also now owned by the Manildra Group). The industrial area is serviced by a privately-owned railway spur line that runs from just north of the Nowra-Bomaderry station via the starch plant and the former Dairy Co-op site to the Paper Mill.

The Company also has an Environmental Farm of approximately 1,000 hectares located on the northern side of Bolong Road. This area is cleared grazing land and contains spray irrigation lines and wet weather storage ponds (total capacity 925 Mega litres). There are at present six wet weather storage ponds on the farm that form part of the waste water management system for the factory. A seventh pond approved in 2002 was converted into the biological section of the new wastewater treatment plant has now been commissioned.

The Environmental Farm covers a broad area of the northern floodplain of the Shoalhaven River, stretching from Bolong Road in the south towards Jaspers Brush in the north. Apart from its use as the Environmental Farm, this broad floodplain area is mainly used for grazing (cattle). The area comprises mainly large rural properties with isolated dwellings although there is a clustering of rural residential development along Jennings Lane (approximately 1 kilometre from the site), Back Forest Road (approximately 500 metres to 1.2 kilometres to the west) and Jaspers Brush Road (approximately 1.2 kilometres to the north).

Security of the site is achieved by a number of means. This includes site personnel and security patrols by an external security company (this includes weekends and night patrols). The site operates 7 days per week (24 hours per day). Also, the site is fully fenced and non-operating gates are locked. Security cameras are installed for staff to view visitors and site activities.

There are approximately 311 staff employed across the Shoalhaven Starches site. However, as the factory operates 24 hours a day with varying shift times, there are typically a maximum of 157 employees on-site during the period between 8:00am and 2:00pm. This can increase to 185 employees on-site for short, peak periods typically coinciding with new infrastructure coming on-line. Information provided by Manildra indicates that an additional 30 contract staff can also be on-site at any one time.

The main natural hazard for the site is flooding. No other significant external events are considered high risk for this site.

See Figure 2 for a site layout drawing showing the locations of the proposed changes.

## Figure 1 - Site Locality Plan

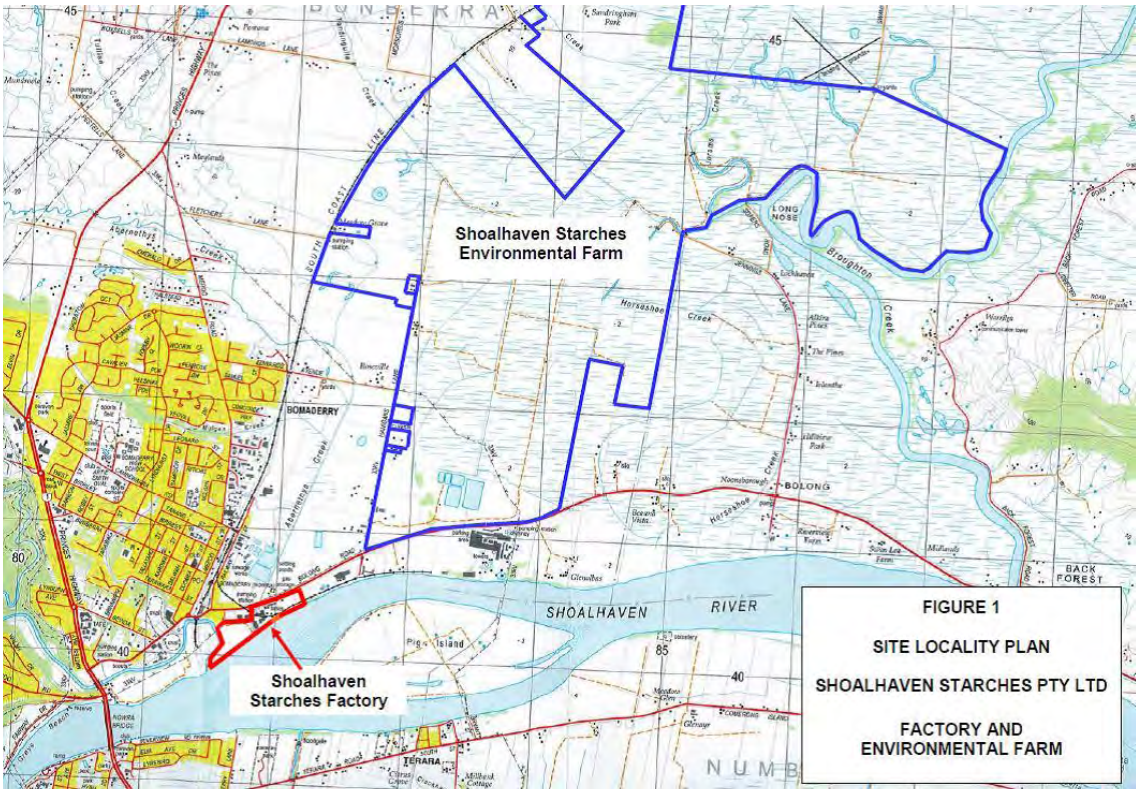
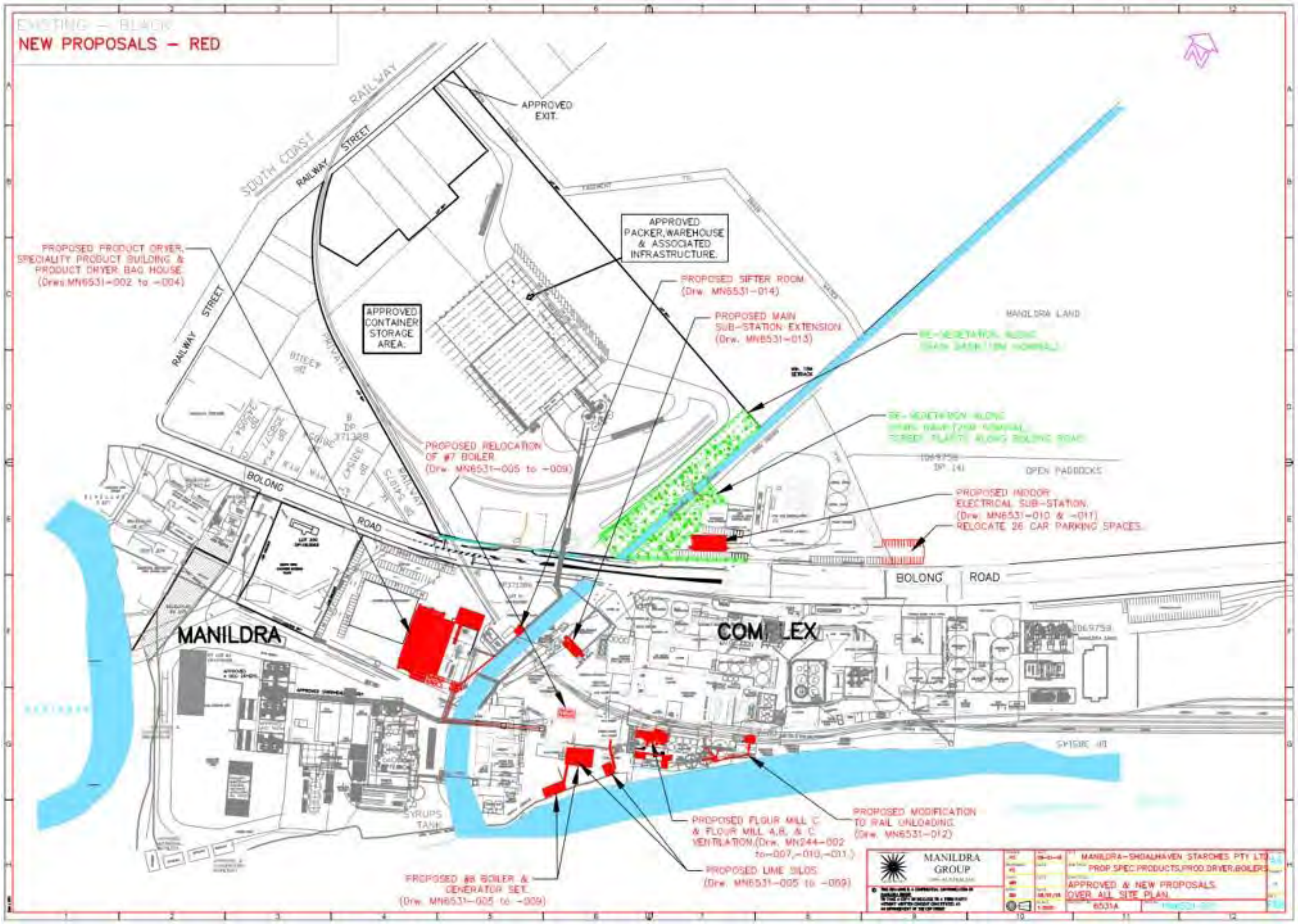


**Figure 2 – Site Layout – Shoalhaven Starches**



# 3 PROCESS DESCRIPTION

A process flow block diagram showing the changes to the existing operations is shown in Figure 3.

## 3.1 RAIL INTAKE PIT CHANGES

At present when rail wagons are unloading grain, given the size of the existing in-take pit, only part of a wagon can unload at any one time. The additional intake pit will allow the whole of a wagon to be unloaded at the one time enabling the unloading process to be completed quicker and more efficiently.

The proposal will involve:

- The installation of an additional intake pit adjacent to the existing intake pit;
- A new bucket elevator (height 43 m) that will transport grain to the existing silos; and
- Associated transfer conveyors and chutes to enable the grain to be taken from the new intake pit up the bucket elevator and distributed to the existing silos.

***Existing Grain Intake System Details:***

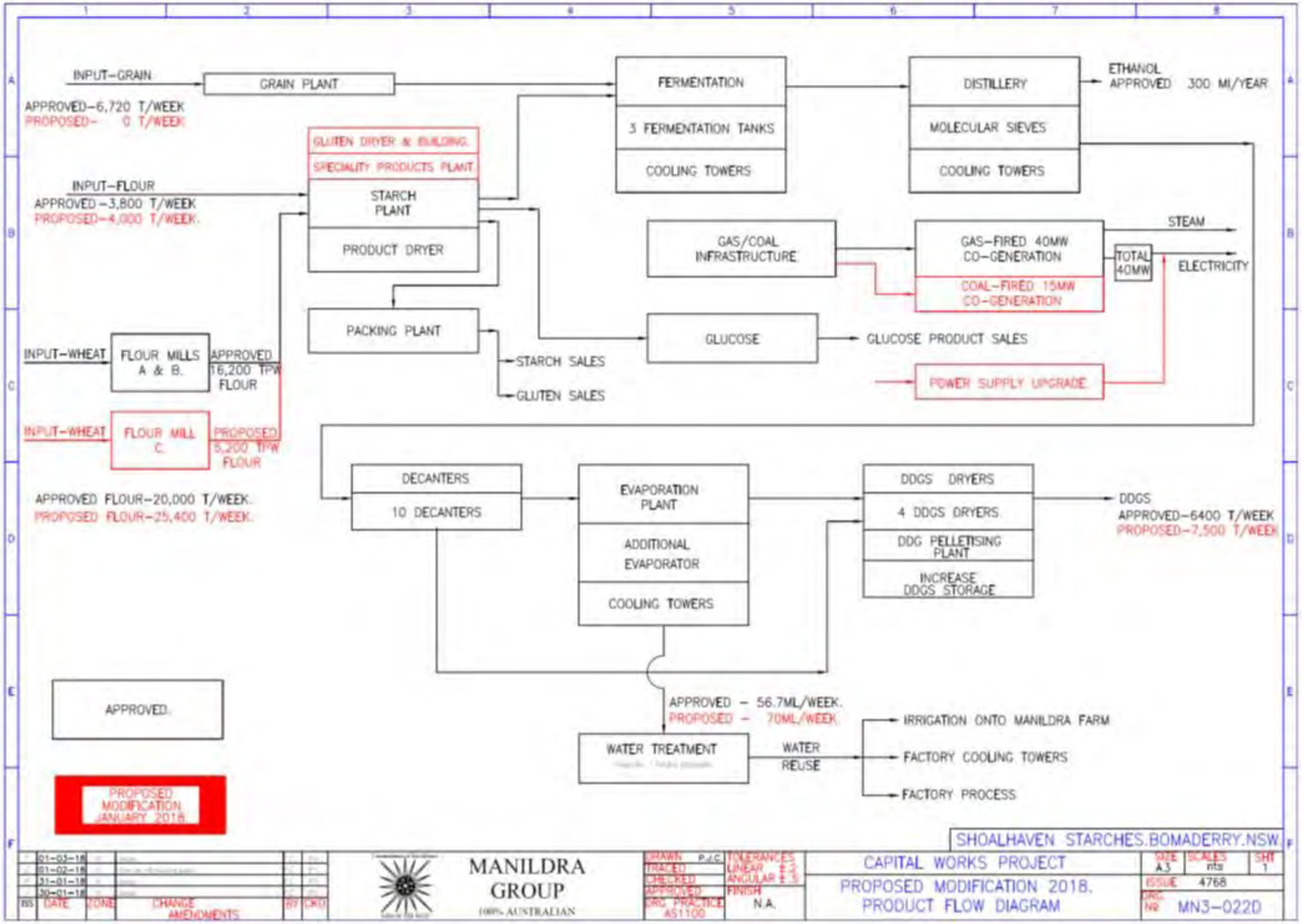
Grain (wheat) trains are unloaded, wagon-by-wagon, during a 6.5 hour window on a one train per day basis.

Each wagon has four gates for unloading. The unloading system comprises a hopper wide enough for only three gates to open, i.e. the wagon is tipped into the hopper with only three gates open. The wagon is then shunted along approximately two metres where the last gate is opened and the remainder of grain in the wagon is unloaded.

Two inclined screw conveyors convey grain out of the hopper and to a vertical bucket elevator. The elevator conveys grain to the first of three drag chain conveyors mounted at the silo top level. The first conveyor can tip grain into the largest silo 101 via a slide gate mounted mid-way along. If grain is not fed to silo 101, it continues on to a traversing conveyor. This traversing conveyor can tip grain into silo 103, the next (third) drag chain or to silo 102. Grain that is delivered to the third drag chain can feed into silos 104 or 105.

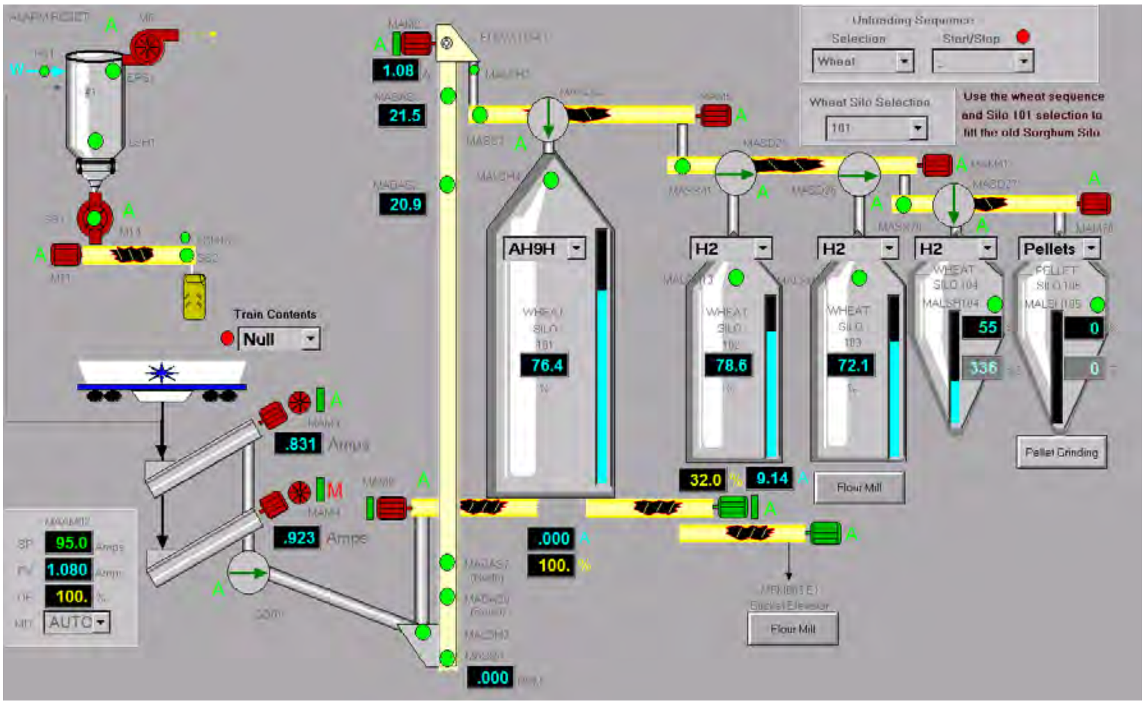
The existing storage capacities are: Silo 101 is 2,200 te, and silos 102, 103, 104 and 105 are each 1,500 te.

**Figure 3 – Process Flow Block Diagram Showing Changes**



The existing grain intake process is shown in the following schematic.

**Figure 4 – Existing Grain Intake Process**




### *Proposed Grain Intake System Details:*

A drawing of the proposed intake system is provided in Appendix A.

A duplicate pit will be installed beside the existing pit. This will allow a wagon to be fully tipped (unloaded) without shunting. Two gates on each wagon will tip into a single hopper. Two new screw conveyors will transfer grain from the new hopper.

Grain will be conveyed to a new bucket elevator erected at the base of silo 103. The new bucket elevator will include belt temperature sensors.

The new bucket elevator will feed grain to silos 101, 102, 103 or the existing final drag chain conveyor (via distributors and spouts). The existing drag chain can then feed to silos 104 or 105. This would only occur if the existing grain unloading system feeds to silos 101, 102 or 103.

The intake system will be started by an operator at the commencement of unloading of the train and will remain running until unloading is completed. Selection of the storage destination can be made by the operator at any time in the unloading process.

The throughput of the new rail intake system is approximately 500 te/hr. The existing operations involve a train every day, i.e. 40 of the current wagons equals 2,340 te per day (16,380 te per week).

The future operations may include one rake of 92 te wagons which, at 40 wagons, allows 3,680 te. Therefore, for 3 trains per week (11,040 te) plus 3.5 services (7 per fortnight) of the current wagons (8,190 te) equals 19,230 te per week, i.e. similar to the existing grain intake to the site.

## 3.2 MILL C

When flour Mill B was designed, the building dimensions allowed for a future mill to be installed, i.e. Mill C. There are no proposed changes to the building structure; all changes are the additional equipment for the Mill C operations within the existing building.

The flour mill will be used to produce industrial grade flour as a raw material feed to the starch plant.

The conversion ratio of wheat to flour is approximately 80%. 6,500 tonnes per week of wheat will be required to produce 5,200 tonnes per week of flour.

The flour mill equipment required for Mill C will include two wheat conditioning silos (already approved under previous Mill B Mod). The process is a duplicate of the Mill B process and will run in parallel to the Mill B process.

The flour process consists of the following unit operations:

- Receiving wheat from rail wagons via the grain intake system;
- Wheat transfer from the silos to the mill building via existing infrastructure, i.e. chain conveyors, bucket elevators and dust collectors;
- Tempering of hard wheat with water in conditioning silos / tempering bins (two new silos are to be installed which will be identical to the existing two Mill B conditioning silos);
- Cleaning of wheat to remove foreign objects and husk (using Combi cleaners);
- Wheat husk (mill feed) is separated in the cleaning stage and transferred to the existing mill feed silo in Mill A for distribution to the main storage silo (adjacent to the DDG (dried distillers grain) drier building) via existing transfer systems;
- Progressive milling of wheat to fine powder (via roller mills, impact detachers, vacuum transfer systems, sifters, cyclones and dust collectors);
- Vacuum transfer systems operate via lift pipes connected to the suction side of the dust collector ductwork (through cyclones). The cyclones are aspirated to the dust collector inlets; and
- Finished product (flour) will be gravity fed to the existing flour transfer system.

Drawings showing Mill C are provided in Appendix B.

Protective measures for dust explosions include:

- All process lines are aspirated to dust collectors to prevent dust accumulation within the processing equipment;
- Dust collectors to have explosion vents fitted;
- Static earthing for all pipework and equipment;
- Magnetic separators installed to capture tramp metal in the feed material;
- Overflow sensors on chain conveyors and screw conveyors are proximity type which are designed to prevent dust release;
- Fully enclosed process eliminates entry points for ignition sources;
- Bucket elevators are to have belt drift sensors fitted;
- Transfer systems are vacuum based, not pressurised, to minimise dust escape;
- Hazardous area zoning performed to identify zoned areas within the plant;
- All electrical equipment in zoned areas will be compliant to the ATEX European standard for dust explosion protection;
- The mill design (from Buhler, i.e. the designers for Mill B) will be ATEX compliant.
- Fire engineering design for building completed; and
- Housekeeping procedures within the existing mills are mature and well managed, e.g. daily cleaning.

As part of the process, three new filters will be installed; two of which will have explosion vents that will vent externally from the building (the other filter will have a flameless vent given the proximity to the ventilation ducting). These explosion vents will be positioned at the same elevation as the existing Mill B explosion vents, i.e. at 30 m above ground level, and will vent to the north of the building.

There will also be new baghouse filters installed on top of the building roof, i.e. at 36.4 m above ground level. These filters will be fitted with explosion vents that vent directly to atmosphere.

## 3.3 MILLS' BUILDINGS VENTILATION

It is proposed to replace the natural induced draft ventilation system with a forced ventilation system for both the flour Mill A and B buildings. A drawing showing the new buildings' ventilation systems is shown in Appendix C.

The forced ventilation system will comprise of a fan enclosure mounted on the roof of the respective buildings:

- Mill A building air requirement: 1,810 $m^3$/min (based on the dust collector filtration fan capacity); and
- Mill B building air requirement (includes the Mill C capacity): 2,890 $m^3$/min.

The existing Mill A building was constructed in 2010 and includes acoustic louvers on three walls fitted with food standard filtration panels. The total filter area for the building is approximately 30 $m^2$. As part of the Mill B installation, a large proportion of these vents were sealed to create a fire wall between the Mill A building and the Mill B building (to meet fire engineering building safety requirements).

The proposal is to install a forced ventilation system to both Mill A and Mill B buildings, with fan rooms mounted on the roofs of each mill, ducted through air ducts on the northern face of Mill B and the eastern face of Mill A.

The fan rooms are designed to include appropriate filtration of the air to meet food manufacturing requirements.

The fans will be centrifugal type and the ducting will be designed to deliver the appropriate amount of air to each level in each of the mill buildings.

From a process perspective, the use of positive pressure in the building will assist in minimising dust escape into the building and maintain a higher level of cleanliness and good manufacturing practice.

As there are no process safety hazards with this component of the proposal then no further analysis is included in this PHA.

## 3.4 GLUTEN DRYERS 1 AND 2 CONVERSION TO STARCH DRYING AND GLUTEN DRYER NUMBER 8

The resultant increase in flour and hence starch and gluten production will require the conversion of two existing gluten dryers (numbers 1 and 2) into starch production and the construction of a new gluten dryer (GD8) to replace the gluten capacity lost by the conversion of dryer numbers 1 and 2 to starch.

The dryers on-site are designed to be switched from gluten to starch and vice versa. The dryers will be operated within the same design envelope and the explosion protections remain unchanged, i.e. the Kst values used are valid for both gluten and starch.

The conversion of the dryers to starch does not introduce any new process safety hazards to the dryers and hence the site. Therefore, these approved dryers are not analysed any further in this PHA.

There are, however, changes to the existing gluten and starch processes that deliver the wet products (i.e. the gluten and starch are in water) to the dryers. The following changes describe dryer number 2 (for information):

- Reinstate the chute between the dryer blender and the starch decanter number 2 so that starch can be fed to the dryers;
- Remove/blank off the gluten feed pipework/fishtail assembly;
- Remove the existing connections for the product blowline to the gluten packing silos;
- Reinstate the connection to the existing blowline to the starch packing silos;
- Change the pulley/belt arrangement on the existing blower to suit the blowline to the starch packing silos; and
- The transfer screw conveyor and rotary seal speeds on the dryers conveying equipment will need to be adjusted to suit starch.

The new gluten dryer (GD8) will be housed in a new industrial building. This building will be located between the remaining "Moorhouse" Maintenance Building and adjoining the Starch Dryer No. 5 building to the west of Abernethy's Creek. See Figure 2 for the location of the new gluten dryer and specialties products building.

Flour will be transferred from the existing flour storage systems to a silo in the new building. The flour will be transferred via a 300 m long blowline. The silo will be fitted with a top-mounted bag filter as per standard designs.

The flour and water will be mixed within a large dough mixer. The wet dough is then transferred to a tricanter. This machine separates the wet feed into wet starch, wet gluten and waste/pentosans (polysaccharides) which will be sent to the ethanol plant for processing.

The wet gluten from the tricanter will be screened. The screened wet gluten will flow to GD8 whilst the waste liquid from the screening stage will also be sent to the ethanol plant for processing.

The wet gluten will flow to the wet gluten hopper and then a screw press. Free moisture will drain from the screen sides and base of the hopper. A conical screw will squeeze and extrude the gluten before discharging into the gluten feed hopper.

De-watered gluten will then be pumped (via a progressive cavity positive displacement type pump) at constant rate into the disintegrator through a fishtail feeder, which extrudes a thin sheet of material over the full disintegrator width and feeds it into a re-circulating stream of hot air and dry powder. The wet material will be dispersed and coated with dry powder before being dried and transported around the ring duct by the drying air.

At the dryer manifold, an adjustable blade allows a predetermined fraction of circulating material to be selectively removed from the system, whilst oversize and semi-dried material is returned to the disintegrator. The disintegrator is a fixed beater impact mill, which breaks down agglomerates and disperses the circulating mass into the drying airstream. This combination of manifold and disintegrator gives screen-less grinding and even moisture distribution to the product.

Gluten is then separated from the exhaust air stream in a reverse jet baghouse filter, complete with a pre-separator section, which ensures that material is quickly removed from the hot airstream when it is dry (to minimise thermal degradation).

Dried material will be discharged through a system of screw conveyors and rotary valves, allowing control of the recycle of coarse material from the pre-separator and fine material from the baghouse filter, or a combination of the two, with the remainder being discharged as final product to the milling system.

An induced draught fan at the baghouse filter outlet will draw process air and gluten through the drying system and will maintain circulation within the ring duct. The air will flow to atmosphere via a stack.

The dryer air is drawn through filters to remove foreign objects. It is heated by hot condensate, steam (10 barg) and then a gas fired burner (to approximately 185$^{o}$C).

After the air passes through a hot air box (used to collect large objects such as product clumps), the air and gluten combine and flow up through the dryer.

Product gluten from the dryer will be held in a buffer hopper, with a variable speed screw discharge, designed to eliminate surges and maintain a constant feed rate to the milling system. Material discharged from the buffer hopper will be passed over a magnet to remove ferrous material and transferred to the classifier mill by an induced draught pneumatic conveyor (using filtered ambient air).

The aspirated grinding mill will incorporate an internal classifying wheel with independent drive. Through varying the speed of this wheel, oversize particles will be deflected back into the mill for further grinding. Milled product will then be transported to the final collection within a second pneumatic conveyor.

Finished product gluten will be separated from the mill exhaust by a dedicated reverse jet baghouse filter and discharged by a rotary valve.

The ground product is then conveyed via a blowline to the existing packaging area. The product is either stored in a buffer bin or sent to truck loadout.

The product gluten is filled into bags, e.g. 1 te bulkabags, at dedicated existing bag filling stations. The bags are stored in 20 foot containers until being loaded onto trucks or trains for delivery to the market.

Cleaning chemicals such as sodium hypochlorite will be used on a batch basis.

A process flow schematic for the flour feed system and a representative gluten dryer process flow diagram are provided in Appendix D.

## 3.5 MODIFIED STARCH PRODUCTION

Dry starch (containing approximately 12 wt% moisture) will be conveyed from SD5 (Starch Dryer 5) via a screw conveyor to the modified starch process. This new process will be installed within the new industrial building as per GD8. The starch feed quantity will be measured via a loss-in-weight feeder.

The following steps summarise the process:

Step 1: Add starch, the cationic reagent 188 and sodium hydroxide into a paddle mixer. This is a batch process. These raw materials are then mixed together. The caustic day tank will be approximately 5 $m^3$ (20wt%) and the reagent (188) will be kept in IBCs (intermediate bulk containers). Dosing pumps will be used to transfer the caustic and reagent to the mixer.

Step 2: The mixture is fed through a heater (with a continuous mixer). The mixture's temperature is increased from 25°C to 70°C. The heater will be a steam jacketed vessel. Heating activates the reagent over the 20 minutes residence time.

Step 3: The mixture is transferred from the heater to one of two insulated 50 $m^3$ silos. The mixture flows through the silo (as plug flow) with a residence time of 4 or 6 hours so that the reaction can be completed. While the first batch is continuing to react in the silo, the subsequent batch is initiated.

Step 4: After the first batch reaction has been completed, the mixture is transferred (screw conveyor and scales) to another mixer and then neutralised with 33wt% hydrochloric acid (HCl). In this step, the water content is again increased in the product. The HCl will be stored in a relatively small (3 $m^3$) day tank.

Step 5: The main stream flow is transferred to an intermediate hopper (nominally 5 $m^3$) and then fed to a dispersion dryer to reduce the moisture as per the product specification, i.e. to 12%. Air to the dispersion dryer is heated. The equipment within the dryer includes a cyclone, baghouse filter and induced draught fan.

Step 6: The product modified starch is sieved (i.e. through a plan sifter). Off-specification material is collected and sent to the ethanol plant for fermentation. The modified starch product is stored in two 70 $m^3$ silos and then sent via a blowline to the existing packaging plant (silo 18). It will be packed as per existing equipment and practices.

The chemicals involved in this process are:

- The cationic reagent;
- Sodium hydroxide (to catalyse the cationic reagent); and

- Hydrochloric acid (to neutralise the batch).

A process flow diagram for the dry starch cationic process is shown in Appendix E. Layout and elevation drawings of the new industrial building are also provided for information.

Chemical usage rates are approximated as 450 kg/hr or 10.8 te/day (each) for caustic (at 20wt%) and the reagent (the HCl rate is currently unknown). This equates to an additional caustic road tanker (carrying 50wt%) every 4 to 5 days (approximately).

## 3.6 STARCH DRYER 5 MODIFICATIONS

It is proposed to replace the secondary cyclones in the starch dryer number 5 plant with a baghouse filter. This baghouse will be a standalone structure on the northern end of starch dryer building.

The baghouse will separate approximately 500 kg per hour of starch (12% moisture content) from the air stream (250,000 $m^3$/minute air flow).

The dimensions of the baghouse filter are roughly 20 m wide, 24 m tall and 6 m long. The final design is yet to be completed.

There will be 1 m x 1 m explosion panels on the eastern face of the baghouse (set pressure of 10 kPa). These panels are currently on the secondary cyclones on the existing starch dryer, i.e. they will be transferred to the baghouse filter.

Process flow diagrams showing the existing design, i.e. with the secondary cyclones, and the proposed design, i.e. with the baghouse filter, are provided in Appendix F.

## 3.7 COAL BOILERS AND CO-GENERATION PLANT

It is proposed to construct a coal-fired cogeneration plant to the south of the existing boilerhouse complex that will generate 15 MW of electrical power. This cogeneration plant will include the installation of a new coal fired boiler (No. 8). The construction of this new cogeneration plant and boiler (No. 8) will necessitate the relocation of the existing Boiler No. 7 to the northern side of the overall boilerhouse complex.

***Existing Coal Supply System and Boilers:***

Black coal is used at the Shoalhaven Starches site. The coal size is 10 to 25 mm and contains approximately 15% ash.

Trucks deliver the coal to the existing large coal stockpile on the western side of the Shoalhaven Site.

It is reclaimed from the large coal stockpile using a frontend loader and trucked via site roads to a smaller coal stockpile adjacent to the boilerhouse. A frontend loader reclaims the coal from this smaller stockpile, when needed, and feeds the coal into an existing hopper and denseveyors (pneumatic transfer machines) that transfer the coal to each of the boilers. Compressed air is used within the denseveyors to transfer the coal to the boiler feed bins.

The coal is used in Boilers 5 and 6. Currently, Boilers 2 and 4 are being converted back to coal use.

All the coal-fired boilers are designed for limited attended operation in compliance with the requirements of AS2593, however, they are operated as attended boilers.

Each of the four existing coal boilers (2, 4, 5 and 6) has an existing feed bin which is level controlled. The coal is gravity fed onto a grate for delivery into each boiler. A door at the coal inlet to each boiler can be closed (manually) to stop the coal and hence the source of heat, e.g. in the event of an emergency.

***Boiler 8:***

The coal delivery system to Boiler 8 will be identical to Boilers 2, 4, 5 and 6.

The coal (on the moving grate) passes through a guillotine door that maintains the desired bed depth. After about 1 m of travel, the coal will be ignited by the heat from the existing coal that is burning. The heat from the burning coal raises the required steam.

The boiler will be ignited during start-up by natural gas burners. These burners can also be used for additional heat load in the furnace and are to be designed to AS3814.

The flue gas containing fly ash from Boiler 8 will pass through a multi-cyclone, steam superheater, economiser (for preheating the boiler feed water) and air heater (for the forced draft, combustion air to the furnace) before passing through a baghouse filter, an induced draft fan and then to the stack.

The baghouse filter socks will be pulsed with air to remove the fly ash (which falls to the bottom of the baghouse). This fly ash, along with the fly ash collected by the multi-cyclones, steam superheater, economiser and air heater, and ridlings ash from the grate, will be conveyed (screw conveyors and a denseveyor) to a receiving hopper located above a pug mill (produces a paste by forcibly combining fly ash with water). This paste will then be dropped directly into the existing ash bin. Ash from this bin is removed from site by truck and disposed of as per the EPA's (Environmental Protection Authority) approval to the Manildra farm.

Combustion gas will be vented to atmosphere via a 40 m high exhaust stack.

The new boiler will be designed to the Australian Standards (e.g. AS2593). It will contain a steam drum and a mud drum.

The steam drum will be fitted with:

- Redundant low level protection;

- Means for sampling the boiler water;
- Overpressure protection (pressure relief valves);
- Means to allow boiler dosing chemicals to be injected into the boiler water; and
- Temperature and pressure monitoring.

The steam pressure will be controlled by varying the amount of coal and air feed, i.e. by vary the coal grate speed and the air fan speed, respectively. A boiler trip will stop the coal feed grate and also the forced-draught fan.

The proposed boiler dosing chemicals are:

- BT3000; a trisodium phosphate chemical. The dosage rate concentration and rate are approximately 1.55 ppm and 1,168 kg/year, respectively. There will be approximately 6 x 200 litre deliveries/year; and
- Surgard1700 Erythorbate. The dosage rate concentration and rate are approximately 3.2 ppm and 2,383 kg/year, respectively. There will be approximately 12 x 200 litre deliveries/year.

Both chemicals will be stored in a self-bunded tanks.

BT3000 is a non-flammable, corrosive material (1 to 5% caustic soda). It is a Dangerous Good Class 8, Packing Group III, material.

Surgard1700 Erythorbate is not legislated as a Dangerous Good. It is not flammable.

Boiler water blowdown will be done manually and automatically from the mud drum.

The new boiler will produce 75 tonnes per hour of steam. The steam pressure will be 63 barg. This steam will be superheated to 510 C in the steam superheater. It will then flow through the steam turbine that will drive a 15 MW generator. The produced power will be used within the Shoalhaven Starches site.

The steam turbine will have both mechanical and electric overspeed protection.

The mechanical protection will be via an industry-standard eccentric bolt design, i.e. the eccentric bolt is held in position by a spring during normal speeds but changes position (by increased centrifugal forces) when the speed is too high. When it changes position, it strikes a linkage assembly that closes the turbine steam trip valve.

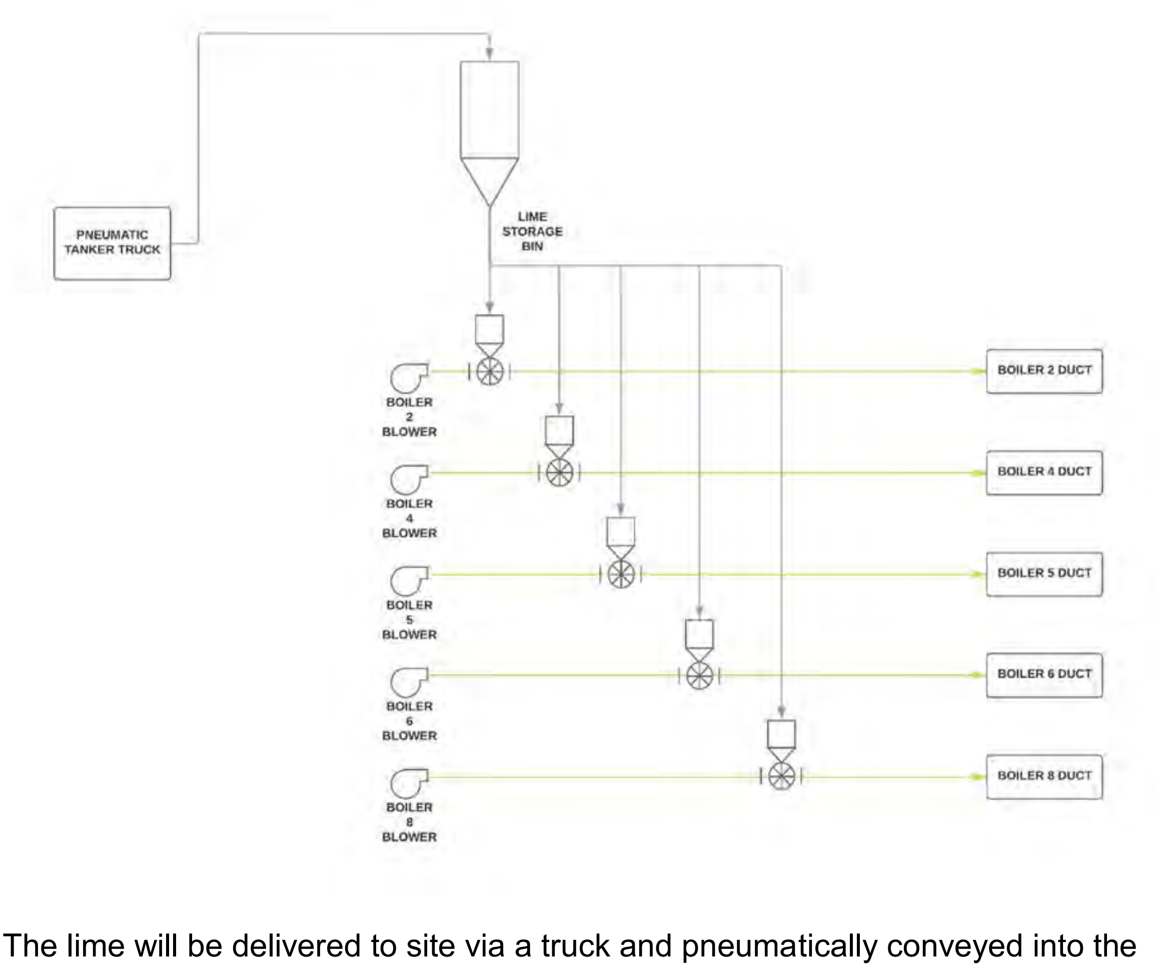
The electrical overspeed protection device will be designed to safely shut down the steam via closing of the inlet steam turbine trip valve. This device monitors turbine rotor speed and acceleration via magnetic pickups and issues a shutdown command to the turbine's trip valve(s) when speed is too high. The device is certified as an IEC61508 SIL-3 (Safety Integrity Level Three) safety device.

### *Boilers Flue Gases Desulphurisation:*

To meet the new EPA requirements for sulphur oxides (SOx) emissions, flue gases from Manildra's coal fired boilers will be required to implement flue gas desulphurisation technology. The proposed technology is called dry sorbent injection (DSI), which is the injection of hydrated lime ($Ca(OH)_2$) into the ductwork between the economiser and the baghouse to reduce the SOx emissions.

The process is shown in Figure 5 below.

**Figure 5 – Boilers Flue Gases Desulphurisation Schematic**




The lime will be delivered to site via a truck and pneumatically conveyed into the silos (x2). The silos will be fitted with a baghouse filter to prevent dust being emitted to atmosphere. The silos will also have over and under pressure protection plus level measurement.

The lime will be metered from the silos into a blowline. It will then enter the relevant ducting where the following reaction will take place:

$$Ca(OH)_2 + SO_2 + 0.5O_2 \rightarrow CaSO_4 + H_2O$$

$CaSO_4$, i.e. gypsum, is a naturally occurring mineral and is used as a fertilizer and is also the main constituent in many forms of plaster, blackboard chalk and wallboard.

The solid calcium sulphate is then collected in the downstream baghouse filters for disposal via the Manildra WWTP (waste water treatment plant).

It is estimated that the lime usage will be approximately 320 kg/hr. It is expected that the storage facility will have a capacity of 120 te to give approximately two weeks of operation without needing to be refilled.

***Boiler 7 Relocation:***

Boiler 7 is a conventional natural gas fired boiler. The fuel gas train is compliant with AS3814. It consists of a main gas and pilot gas supply.

The boiler is started automatically via a dedicated boiler management system. The furnace is purged for a predetermined time, the pilot burner is ignited and then the main burners.

Steam is generated similar to the description provided above for Boiler 8, i.e. via a steam drum and mud drum. The boiler protections are also similar. The steam supply pressure is 10 barg (saturated).

To make room to install Boiler 8 in the proposed location, Boiler 7 will need to be moved to the north side of the boilerhouse.

See the drawings in Appendix G for layout and elevation details for Boilers 7 and 8.

## 3.8 ELECTRICAL MODIFICATIONS

There are two proposed significant electrical modifications:

***Electrical Project 1:***

The Shoalhaven Starches site is currently fed from an Endeavour Energy 33kV outdoor substation located adjacent to the two main 33/11kV transformers and the main 11kV switchroom. With the ongoing expansion of the site, a third 33/11kV transformer will be required to maintain the integrity of the incoming power supply.

This proposal is to install the third transformer in the location of the existing 33kV outdoor substation. An indoor 33kV substation will be built to Endeavour Energy requirements on the north side of Bolong Road to supplement the existing outdoor substation and suitable for the supply of three main 33/11kV transformers. The location of this substation is adjacent to the existing BOC carbon dioxide plant.

***Electrical Project 2:***

The existing main 11kV switchboard has a capacity of 50MVA. With the ongoing expansion of the site, the power supply to the site needs to be capable of supply beyond this capacity. The scope of this project is to install a second main HV switchboard in a new switchroom located above the existing main switchroom. One of the two supplies to the existing main switchboard will be relocated to supply the new switchboard. The existing ring main feeds from the main switchboard will be reconfigured to enable supply from any ring main from either the old or new main switchboard.

Drawings showing the designs for these electrical equipment items are provided in Appendix H.

As there are no process safety hazards with this component of the proposal then no further analysis is included in this PHA.

## 3.9 ADDITIONAL SIFTING EQUIPMENT FOR THE PACKING PLANT

It is proposed to install a larger sifter in the feed stream to the existing starch packer in the Steel Shed. To fit the larger sifter into the shed, the roof (in the immediate area to the sifter) will need to be extended.

The existing design involves product (starch) being blown to silo 18 via pneumatic transfer lines from other parts of the factory (approximately 35 $m^3$/min of air along with 25 tonnes per hour of product). The existing receiving silo has a dust collector which is designed to extract 150 $m^3$/min.

The product will then be transferred via a screw conveyor from the base of the silo at a rate of 20 tonnes per hour to the larger (new) sifter.

The product will then be sifted at 425 micron within a plansifter. This type of sifter is installed elsewhere on site. The sifter will have a design capacity of 30 tonnes per hour.

The product will be collected at the base of the new sifter and transferred into a magnetic separator and then to the packer hopper to be packed in 25 kg bags (as per the existing practice).

The safety control measures include the following:

- There are high level instruments which detect blockages and trip the process;
- Laser probes will be installed to detect if there is a broken sock at the base or the top of the sifters;

- The screw conveyors are designed with a low tip speed, i.e. less than 1 m/s;
- The sifters are earthed to prevent sparks; and
- There are check sifters on the outlet of the starch dryers to prevent foreign objects from being transferred to silo 18.

Figure 6 shows a photograph of the plansifters. The plansifter is also shown in the layout and elevation drawing in Appendix I (the plansifter is shown in the darker blue colour).

**Figure 6 – Plansifter Photograph**

# 4 HAZARD IDENTIFICATION

## 4.1 HAZARDOUS MATERIALS

The hazardous materials associated with this proposal are:

1. Wheat including flour, gluten and starch. The main hazard being dust explosions;
2. Natural gas that will flow to burners for heating purposes. Natural gas is flammable, i.e. if released and ignited, there is a risk of jet fires, flash fires and explosions (if confined);
3. Sodium hydroxide (caustic) which will be stored in a 5 $m^3$ tank at 20wt%. Caustic is a corrosive liquid;
4. Hydrochloric acid (33wt%). The HCl will be stored in a 3 $m^3$ tank. It is a corrosive liquid. HCl vapour is also toxic to the body if inhaled;
5. The cationic starch reagent is not deemed to be a Dangerous Good;
6. Cleaning liquid for sanitisation, e.g. 5% sodium hypochlorite solutions;
7. Hydrated lime; and
8. Coal (a combustible solid).

Further details of these materials hazardous properties are provided in Appendix J.

## 4.2 POTENTIAL HAZARDOUS INCIDENTS REVIEW

In accordance with the requirements of *Guidelines for Hazard Analysis*, (Ref 1), it is necessary to identify hazardous events associated with the facility's operations. As recommended in HIPAP 6, the PHA focuses on "atypical and abnormal events and conditions. It is not intended to apply to continuous or normal operating emissions to air or water".

In keeping with the principles of risk assessments, credible, hazardous events with the potential for off-site effects have been identified. That is, "slips, trips and falls" type events are not included nor are non-credible situations such as an aircraft crash occurring at the same time as an earthquake.

The potential hazardous events have been identified via workshops involving Manildra personnel from process, mechanical, electrical / instrumentation, operations and maintenance. These workshops were facilitated by Pinnacle Risk Management and either held as part of this project or for previous projects.

The identified credible, significant incidents (in particular, with the potential for off-site impacts) for the proposed modifications are summarised in the Hazard Identification Word Diagrams shown in Appendix K.

These diagrams present the causes and consequences of the events, together with major preventative and protective features that are to be included as part of the design.

# 5 RISK ANALYSIS

## 5.1 HIPAP 4 CRITERIA ANALYSIS

The assessment of risks to both the public as well as to operating personnel around the proposed modifications requires the application of the basic steps outlined in Section 1. As per HIPAP 6 (Ref 1), the chosen analysis technique should be commensurate with the nature of the risks involved. Risk analysis could be qualitative, semi-quantitative or quantitative.

The typical risk analysis methodology attempts to take account of all credible hazardous situations that may arise from the operation of processing plants etc.

Having identified all credible, significant incidents, risk analysis requires the following general approach for individual incidents:

Risk = Likelihood x Consequence

The risks from all individual potential events are then summated to get cumulative risk.

The risk criteria applying to developments in NSW are summarised in Table 1 (from Ref 2).

**Table 1 - Risk Criteria, New Plants**

| Description | Risk Criteria |
|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 $kW/m^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year |

| Description | Risk Criteria |
|---|---|
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | 10 x $10^{-6}$ per year |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | 50 x $10^{-6}$ per year |
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 kW/$m^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | 50 x $10^{-6}$ per year |

The consequences of the potential hazardous events in Appendix K are initially assessed to determine if any events have the potential to contribute to the above-listed criteria and hence worthy of further analysis.

## 5.2 FIRES

### 5.2.1 Smouldering Fires

Wheat (and its products) and coal, if ignited, produce smouldering fires. There are flames, however, these are relatively small compared to flammable liquids where the flame height can be up to twice the pool diameter.

The following photographs show typical coal fires, i.e. limited flames and hence limited radiant heat emitted at distance.

**Figure 7 – Small Coal Fire**

**Figure 8 – Large Coal Stockpile Fire**

Given the large distances to the nearest off-site receptors (i.e. approximately 48 m for the new industrial building and 150 m for Boiler 8 to Bolong Road) then it is not credible that significant levels of radiant heat will affect these receptors. Therefore, the risk criteria in Table 1 with respect to radiant heat from potential wheat and coal fires are satisfied.

### 5.2.2 Natural Gas Releases – Fires and Explosions

Releases for the natural gas piping can form a jet fire if ignited. The natural gas pressure throughout the site is 210 kPag.

The analysis of potential jet fires is shown in Table 2. The mass rates were estimated using TNO's EFFECTS program and the flame length via the Considine and Grint equation (Ref 3). The pipe length used was 100 m. An 80 mm diameter pipe is assumed.

**Table 2 – Natural Gas Jet Fires**

| Stream | Estimated Release Rate, kg/s | Estimated Length of Jet, m |
|---|---|---|
| Full bore failure (80 mm) | 0.71 | 9 |
| 50 mm hole | 0.55 | 8 |
| 13 mm hole | 0.053 | 3 |

Notes: Jet flames modelled using methane.

As expected for these size jet fires, no adverse radiant heat levels will be imposed off-site as the nearest natural gas pipe to Bolong Road (for Gluten Dryer 8) is approximately 105 m away.

Potential vapour cloud explosions and flash fires can occur from the natural gas line failures, i.e. delayed ignition.

The effects from explosion overpressures (Ref 2) are summarised in Table 3.

**Table 3 – Effects of Explosion Overpressure**

| OVERPRESSURE, kPa | PHYSICAL EFFECT |
|---|---|
| 3.5 | 90% glass breakage<br><br>No fatality, very low probability of injury |
| 7 | Damage to internal partitions & Joinery<br><br>10% probability of injury, no fatality |
| 14 | Houses uninhabitable and badly cracked |
| 21 | Reinforced structures distort, storage tanks fail<br><br>20% chance of fatality to person in building |
| 35 | Houses uninhabitable, rail wagons & plant items overturned.<br><br>Threshold of eardrum damage, 50% chance of fatality for a person in a building, 15% in the open |
| 70 | Complete demolition of houses<br><br>Threshold of lung damage, 100% chance of fatality for a person in a building or in the open |

For flash fires, any person inside the flash fire cloud is assumed to be fatally injured. As flash fires are of limited duration (typically burning velocity is 1 m/s, Ref 4) then those outside the flash fire cloud have a high probability of survival without serious injury.

The analysis of the potential vapour cloud explosions and flash fires from the natural gas pipe failures is shown in Table 4. The mass calculated in the flammable range is assumed to be 100% confined, i.e. all this gas is involved in the explosion calculations. As methane is not a high reactive flammable gas and the quantities involved are relatively small then a medium deflagration (Curve 5) is assumed in the explosion calculations (multi-energy method – TNO).

**Table 4 - Natural Gas Vapour Cloud Explosions and Flash Fires**

| Stream | Mass of Natural Gas in the Flammable Range, kg | Radius of Flash Fire, m | Distance (m) to 14 kPa Explosion Overpressure | Distance (m) to 7 kPa Explosion Overpressure |
|---|---|---|---|---|
| Full bore failure (80 mm) | 6.5 | 33 m | 13 m | 26 m |
| 50 mm hole | 4.2 | 27 m | 11 m | 22 m |

Notes: 1. Pipeline failures assumed to be isolated within 30 minutes.

2. Radius of flash fires calculated to be the distance to LEL (lower explosion limit) at F weather stability and 2 m/s wind speed.

3. 13 mm holes not modelled as they are too small to generate gas clouds of any significant size.

For these releases of natural gas, choked flow exists and rapid jet mixing with air occurs. The result is a relatively small vapour cloud size with limited consequential impacts if ignited. The 30 minute release duration also has no significant impact on the release. Steady state conditions are reached soon after the release occurs (i.e. after approximately 4 minutes, the distance to the LEL does not change at steady state dispersion conditions).

Given these results for the natural gas vapour cloud explosions and flash fires, no adverse consequential impacts will be imposed off-site. The low likelihoods for these events are supported by the following data.

The following data has been published by the UK HSE (Ref 5).

**Table 5 - Piping Failure Frequencies**

| Failure Rates (per m per year) for Pipework Diameter (mm) | | | | | |
|---|---|---|---|---|---|
| **Hole Size:** | **0 - 49** | **50 - 149** | **150 - 299** | **300 - 499** | **500 – 1,000** |
| **3 mm diameter** | $1 \times 10^{-5}$ | $2 \times 10^{-6}$ | | | |
| **4 mm diameter** | | | $1 \times 10^{-6}$ | $8 \times 10^{-7}$ | $7 \times 10^{-7}$ |
| **25 mm diameter** | $5 \times 10^{-6}$ | $1 \times 10^{-6}$ | $7 \times 10^{-7}$ | $5 \times 10^{-7}$ | $4 \times 10^{-7}$ |
| **1/3 pipework diameter** | | | $4 \times 10^{-7}$ | $2 \times 10^{-7}$ | $1 \times 10^{-7}$ |
| **Guillotine** | $1 \times 10^{-6}$ | $5 \times 10^{-7}$ | $2 \times 10^{-7}$ | $7 \times 10^{-8}$ | $4 \times 10^{-8}$ |

Typical probabilities of gas ignition are shown in the following table (Ref 6).

**Table 6 – Gas Ignition Probabilities**

| Leak | Probability of Ignition |
|---|---|
| | Gas |
| **Minor (<1 kg/s)** | 0.01 |
| **Major (1 to 50 kg/s)** | 0.07 |
| **Massive (>50 kg/s)** | 0.3 |

For example, the frequency of catastrophic (guillotine) pipe failure for an 80 mm pipe is 5 x $10^{-7}$ / m per year. If a probability of ignition of 0.07 is used, i.e. a major leak, then the combined fire and explosion likelihood is:

$$0.07 \times 5 \times 10^{-7} \text{ / m per year} = 3.5 \times 10^{-8} \text{ / m per year.}$$

This is a low level of risk, it is below the risk criteria shown in Table 1 and not considered intolerable. The ALARP (As Low As Reasonably Practicable) principle is achieved; primarily due to compliance with the Australian Standards for piping.

## 5.3 Dust Explosions

An analysis of the equipment where potential dust explosions could occur is summarised below.

- Baghouse filters with the associated piping systems, bins, hoppers and silos. Dust explosions are to be either vented via the fan housings or explosion vents (the larger volume filters are fitted with explosion vents). The explosion vents are to be either vented direct to atmosphere or flameless;
- Bucket elevators and conveyors. Prevention measures are listed in Appendix K, e.g. low belt speeds will be used to minimise the risk of ignition and belt tracking with limit switches will be installed;
- Processing equipment such as mill, rollers and impact detachers. Protection for these unit operations include magnetic separators, grounding and explosion propagation prevention devices;
- Silos, hoppers, bins, cyclones, separators and sifters. These are to be designed to IECEX standards; and
- Aspiration and pneumatic conveying systems. These are to be designed to IECEX standards.

As this is a preliminary hazard analysis and therefore only preliminary information is available then the only external explosion vents that can be modelled are the two associated with the Mill C filters. These are identical to the corresponding Mill B filters. Modelling of these explosion vents from the side of the Mill B and C building is shown in Table 7. All other Mill C explosion vents are to be flameless or at roof level. The modelling results were derived as follows.

From Ref 7, the damage radius of a dust explosion is usually limited to the building (or equipment item) in which it occurs and to a very short range outside. This is supported by the historical incidents involving dust explosions where the majority of fatalities involve on-site personnel.

The majority of dust explosion incidents detailed in Ref 8 resulted in no fatalities. For the incidents where fatalities occurred, these were to on-site personnel. Again, the greater risk for fatality or injury for dust explosions is to on-site personnel as stated in Ref 7.

The maximum explosion overpressures at a distance D (m) from a vent or point of release is given by (Ref 9):

$$P_{blast} = (P_{max} \times C1 \times C2) / D$$

Where:

$P_{blast}$ is the overpressure (or peak blast pressure) at a distance D from the vent, kPag

$P_{max}$ is the pressure within the vessel when the vent opens or the rupture pressure of the vessel (if no vent installed), kPag

$C1 = 10\text{^}((-0.26/A) + 0.49)$

A = vent area, $m^2$

C2 = 1 m

D = distance away from the vent, m

The rupture pressure of weak structures such as silos is typically less than 90 kPag (Ref 8). This reference quotes one experiment where a 500 $m^3$ silo ruptured at 60 kPag with a hole size of 50 $m^2$.

To estimate the possible maximum horizontal flame length from a vented dust explosion, the following equation is used (Ref 9):

$$\text{Flame Length} = 10 \times V^{1/3} \text{ (m)}$$

Where:

V is the volume of the vessel, $m^3$

However, no flame length has ever been measured greater than 37 m (even for large volumes) so this should be taken as the upper limit (Ref 9). Other studies

(Ref 10) also show that effects of thermal radiation from the fireball is limited to the fireball's volume given the short duration.

The flame diameter is typically taken as half the flame length.

Importantly, the proposed explosion vents must therefore be directed to a safe location to avoid injury to personnel or propagation to other adjacent equipment.

## Table 7 - Dust Explosion Modelling Results

| Equipment | Rupture Pressure, kPag | Volume, $m^3$ | Vented Inside or Outside the Building | Vent Area, $m^2$ | Flame Length, m | Distance (m) to the Selected Overpressures: | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 21 kPa | 14 kPa | 7 kPa |
| Mill C Filters | 10 | 10 | Outside | 0.54 | 22 | - | - | <10 |

The effects of explosion overpressures were summarised in Table 3.

Given the estimated impact distances in Table 7 and the distances to off-site areas from the Mill B and C building then no significant off-site impacts are expected from explosion overpressures or radiant heat from flames. Therefore, the risk criteria shown in Table 1 will be satisfied for potential dust explosions within the Mill C filters.

These explosion vents will be positioned at the same elevation as the existing Mill B explosion vents, i.e. at 30 m above ground level, and will vent to the north of the building. The starch plant is the nearest structure; approximately 11 m away. The height of the starch plant is approximately 23 m. The flame diameter is typically half the length, i.e. approximately 11 m for this vent (or a radius of 5.5 m). Therefore, the flames are expected to be above the starch plant roof and propagation is not expected.

There will also be new baghouse filters installed on top of the Mill B and C building roof, i.e. at 36.4 m above ground level. These filters will be fitted with explosion vents that vent directly to atmosphere. This is the tallest structure in the area and hence no ground level or propagation impacts are expected.

## 5.4 PROPAGATION ANALYSIS

Fires were analysed in Section 5.2. The risk of propagation is low due to:

- The fires involving coal or wheat are local, smouldering fires; and
- The jet and flash fires from natural gas releases have acceptably low likelihoods, i.e. below $1x10^{-6}$/year per metre.

There is a more credible risk of propagation from dust explosions; both to and from the proposed modifications.

As stated in Section 5.3, the damage radius of a dust explosion is usually limited to the building (or equipment item) in which it occurs and to a very short range outside (Ref 7).

The following table summarises the proposed and existing processes that are within a short range of each other. Based on anecdotal evidence of dust explosions (e.g. the reported dust explosions in Refs 8 and 10), this is taken to be within 20 m.

## Table 8 – Propagation Analysis Summary

| Proposed Modification | Potential Propagation Events | Comments |
|---|---|---|
| Rail Intake Pit | This process involves wheat grains from the field. Historically, bucket elevators have a relatively higher likelihood of internal dust explosions. These can propagate to the upstream and downstream equipment, e.g. the raw wheat silos.<br><br>The proposed modifications are outside the 12.6 kW/m$^2$ radiant heat contours for fires in the distillery (Figures 7 to 12 in Ref 11). Therefore, distillery fires are not expected to propagate to this area.<br><br>Note: As this is the closest modification to the distillery then propagation from a distillery to the other modifications is also a low risk | Bucket elevators are a known dust explosion hazard. There are numerous bucket elevators on-site with the following controls:<br><br>Bearings are external. Belt drift / mis-alignment sensors. Aspiration system (with interlocks).<br>Equipment designed to ATEX including hazardous area assessment<br>Belt drift sensors.<br>Belts are self-extinguishing, anti-static, flame retardant, oil resistant, very low elongation |
| Mill C | Given the closeness of the Mill A and Mill B/C buildings (they are connected) then a dust explosion within one building would be expected to propagate to the other. This propagation is likely to cause building damage. It may lead to a subsequent release of flour if equipment and piping is damaged. A dust explosion in the Mill B/C building is likely to cause damage to the surrounding plant and infrastructure, e.g. the Starch Plant Building to the north | Building dust explosions (both the primary and secondary explosions) are well-known events. The controls used to prevent these scenarios are summarised in the following section of this report |

| Proposed Modification | Potential Propagation Events | Comments |
|---|---|---|
| Gluten Dryer 8 and the Modified Starch Plant Building | This new building is to be located between the Maintenance Building and the Starch Dryer 5 building. As with the mills buildings, dust explosions in the new building have the potential to cause damage to the Starch Dryer 5 building and vice versa. It can also damage the Maintenance Building where there are offices, i.e. potential for harm to personnel. | As above, building dust explosions (both the primary and secondary explosions) are well-known events. The controls used to prevent these scenarios are summarised in the following section of this report |
| Coal Boilers / Co-gen / Boiler 7 Relocation | Natural gas releases with ignition have the potential for propagation (as discussed at the start of this section).<br><br>Boiler ruptures and steam turbine catastrophic failures (from overspeed and blades being ejected) can result in propagation | The boiler and co-gen plant will be built to comply with the Australian Standards (as detailed in Appendix K). Being on the south side of the site, adjacent to the Shoalhaven River, then propagation from other on-site events to Boiler 8 and the co-gen plant is unlikely |
| Additional Sifting Eqt to the Packing Plant | This modification involves installing a larger sifter where there is an existing unit within the packing shed. There are no new causes for propagation from this change | As above, building dust explosions (both the primary and secondary explosions) are well-known events. The controls used to prevent these scenarios are summarised in the following section of this report |

## 5.5 Building Explosions and Propagation

It is possible that dust explosions could occur in the new and existing buildings, e.g. deposited dust is not removed due to failure of the housekeeping program. This hazard exists at the site now for the existing buildings containing dust processing.

The primary means to prevent this event is to design for containment. This is the basis for the design of the existing dust processes and will be similarly for the proposed dust handling equipment.

The loss of containment likelihood within the flour mills will be lower due to the positive pressure ventilation system being installed, i.e. if a hole in the piping or equipment occurs, air flow will be into the process due to the positive pressure differential.

Should losses of containment of combustible dust occur then controls such as housekeeping, hazardous zoning and permits to work are required. These are discussed in more detail below but are important measures to lower the risk of dust explosions within the existing and new buildings. For the existing buildings containing combustible dust, cleaning is performed daily to help prevent the build-up of combustible dust. This includes sweeping and vacuuming.

***Dust Explosion Safeguarding***

For equipment processing a potentially explosive dust, it is generally not possible to always ensure the concentration of the dust is below the lower explosive limit. Rather, safeguarding is required to prevent and/or control the potential explosions as discussed below.

There are no mandatory standards or regulations that dictate the design criteria and features for equipment where dust explosions can occur. However, the main means for safeguarding against dust explosions are as follows. All of these safeguards are either existing and/or proposed for the Shoalhaven Starches site.

***Dust Control***

Measures to control dust and avoiding the explosive range include:

- Avoid large volumes as much as possible, e.g. to avoid equipment items running empty such as screw conveyors (normally operate with significant quantities of solids);
- Avoid dust formation by limiting the free-fall, e.g. chutes are as close as possible to bins and hoppers;
- Remove the dust at the point of production rather than convey it along ducts where it can accumulate (for example, the processes are aspirated);

- Buildings which contain plant handling combustible dusts are designed to minimise the accumulation of dust deposits, e.g. horizontal beams minimised and located outside the buildings, and to facilitate cleaning; and

- Regular housekeeping to avoid dust build-up. This is a daily occurrence at the site.

### *Control of Ignition Sources*

Measures used to control ignition sources which could give rise to dust explosions include:

- Bonding and earthing for static dissipation;

- Permits to work, training and auditing;

- Regular housekeeping to avoid dusts overheating, e.g. on hot surfaces;

- Hazardous area determination with compliant electrics and instruments;

- Preventative maintenance on equipment to minimise the probability of fault conditions, e.g. rotating equipment bearings;

- Use appropriate electrical equipment and wiring methods;

- Control of smoking, open flames, and sparks; and

- Use separator devices to remove foreign materials capable of igniting combustibles from process materials, e.g. the magnetic separators in the flour mills.

### *Explosion Isolation*

Explosion isolation at the site is achieved via:

- Material chokes such as rotary valves and screw conveyors with baffle plates;

- Spark arrestors; and

- One-way explosion valves are fitted where deemed necessary, e.g. on the inlet ducting to baghouse filters.

### *Explosion Venting*

Explosion venting is an effective and economic way to provide protection against dust explosions. These are installed on higher-risk equipment items such as baghouse filters and large cyclones. Where explosion vents discharge to areas where people can be or onto sensitive equipment then flameless vents are used.

In practice (Ref 8), the assessment of dust explosion hazards is bound to be subjective because the problem is too complex for quantitative analytical methods to yield an indisputable answer. Therefore, the acceptable safeguards for any given design will vary from company to company. Ref 8 quotes work by Pinkwasser and Haberli who suggest most of the dust explosion hazards in the grain, feed and flour industry can be eliminated by soft means such as training, motivation, improving the organisation, good housekeeping and proper maintenance. As above, all of these safeguards are in-place at Shoalhaven Starches.

When these safeguards are combined with the additional measures proposed for the new equipment then further risk reduction is achieved.

The CCPS (Center for Chemical Process Safety) has developed a modified LOPA (Layers of Protection Analysis) methodology for assessing the risk of dust explosions (Ref 12).

LOPA is a simplified semi-quantitative risk analysis tool used to determine how many independent protection layers (IPLs) are needed and how much risk reduction should be applied to each layer. This is achieved by combining the effects of the independent protection layers and comparing the result to risk tolerance criteria.

An IPL is a device, system or action that is capable of preventing a scenario (i.e. not mitigation) from proceeding to its undesired consequence independent of the initiating event or the action of any other layer of protection associated with the scenario. Normally procedural controls such as housekeeping are not allowable as IPLs, however, some of these are taken into consideration in the CCPS dust hazard analysis methodology.

A description of the methodology is given in Appendix L.

For a dust explosion in a building, e.g. Mill B/C, the following initiating event and probabilities are used (see Appendix L for details).

**Table 9 – Building Dust Hazard CCPS Likelihood**

| | Value | Comments |
|---|---|---|
| Initiating Event:<br><br>Loss of containment of dust sufficient to cause a combustible atmosphere | 0.01/yr | The value for "Existence of a combustible atmosphere at a bagging station" is used for other buildings, e.g. the mills |
| IPL 1:<br><br>Area classification to lower the risk of ignition | 0.1 | All equipment is designed to Australian and ATEX Standards |
| IPL 2:<br><br>Preventative maintenance (PM) to maintain bonding and grounding of the equipment | 0.1 | PM are allowed in addition to the design IPL (IPL 1 above) |
| Conditional Modifier 1:<br><br>Occupancy: There are 2 or more people present 50% of the time | 0.5 | Based on site experience |
| Conditional Modifier 2:<br><br>Probability of ignition | 0.1 | Agricultural dusts have a minimum ignition energy of more than 10 mJ. This conditional modifier allows for sources of ignition other than static, and faulty electrics and instruments (as included above) |
| **Total:** | $5 \times 10^{-6}$/yr | |

That is, use of the CCPS methodology yields a likelihood value of approximately $5 \times 10^{-6}$/yr. For a 'Catastrophic' consequence rating (i.e. two or more fatalities), the risk level is II.

This is a moderate level of risk. This area is the beginning of the ALARP region (i.e. as low as reasonably practicable). As the buildings and equipment are designed to the relevant Australian and International Standards then there are no further practical measures recommended to economically lower the risk.

No further safeguarding is recommended for this scenario and hence the risk of propagation from a building explosion is not intolerable.

## 5.6 EXTERNAL HAZARDOUS EVENTS

External events that may lead to propagation of incidents on any site include:

| | |
|---|---|
| Subsidence | Landslide |
| Burst Dam | Vermin/insect infestation |
| Storm and high winds | Forest fire |
| Storm surge | Rising water courses |
| Earthquake | Storm water runoff |
| Breach of security | Lightning |
| Tidal waves | Aircraft crash |

These events were reviewed and none of them were found to pose any significant risk to the proposed modifications given the proposed safeguards. Flooding can occur at this site, however, the structural design for the new buildings and equipment includes allowances for this hazard.

## 5.7 CUMULATIVE RISK

As analysed in this PHA, the proposed changes to the Shoalhaven Starches site will have negligible impact on the cumulative risk results for the local area as the significant radiant heat levels and/or explosion overpressures are local to the equipment and do not reach other sensitive land users.

Therefore, it is reasonable to conclude that the proposed changes do not make a significant contribution to the existing cumulative risk in the area.

## 5.8 SOCIETAL RISK

The criteria in HIPAP 4 for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases, for instance, where the 1 pmpy contour approaches closely to residential areas or sensitive land uses, the potential may exist for multiple fatalities as the result of a single accident. One attempt to make comparative assessments of such cases involves the calculation of societal risk.

Societal risk results are usually presented as F-N curves, which show the frequency of events (F) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding a facility. By combining the results for different risk levels, a societal risk curve can be produced.

In this study of the proposed modifications, the risk of off-site fatality is below the HIPAP 4 risk criteria. As the nearest residential area is approximately 400 m away from the nearest modification (the GD8 building), the concept of societal risk applying to off-site populated areas is therefore not applicable for this project.

## 5.9 Risk to the Biophysical Environment

The main concern for risk to the biophysical environment is generally with effects on whole systems or populations.

As there are limited quantities of Dangerous Goods associated with the proposed modifications, significant environmental impact is not expected. Whilst fires can also affect the environment due to combustion products, these events are low likelihood given the history of these types of processes. Importantly, any spilt material will be contained in the area or via the environmental farm.

Whereas any adverse effect on the environment is obviously undesirable, the results of this study show that the risk of losses of containment impacting the environment is broadly acceptable.

From the analysis in this report, no incident scenarios were identified where the risk of whole systems or populations being affected by a release to the atmosphere, waterways or soil is intolerable.

## 5.10 Transport Risk

There are limited quantities of Dangerous Goods involved with the proposed modifications, e.g. an extra caustic road tanker every 4 to 5 days. Therefore, transport risk has not changed significantly and is deemed broadly acceptable.

# 6 CONCLUSION AND RECOMMENDATIONS

The risks associated with the proposed modifications to MP06-0228 at the Shoalhaven Starches Bomaderry site have been assessed and compared against the DoP risk criteria.

The results are as follows and show compliance with all risk criteria.

| Description | Risk Criteria | Risk Acceptable? |
|---|---|---|
| Fatality risk to sensitive uses, including hospitals, schools, aged care | $0.5 \times 10^{-6}$ per year | Yes |
| Fatality risk to residential and hotels | $1 \times 10^{-6}$ per year | Yes |
| Fatality risk to commercial areas, including offices, retail centres, warehouses | $5 \times 10^{-6}$ per year | Yes |
| Fatality risk to sporting complexes and active open spaces | $10 \times 10^{-6}$ per year | Yes |
| Fatality risk to be contained within the boundary of an industrial site | $50 \times 10^{-6}$ per year | Yes |
| Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 $kW/m^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year | $50 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure | $10 \times 10^{-6}$ per year | Yes |
| Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community | $50 \times 10^{-6}$ per year | Yes |
| Propagation due to Fire and Explosion – exceed radiant heat levels of 23 $kW/m^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities | $50 \times 10^{-6}$ per year | Yes |

Societal risk, area cumulative risk, environmental risk and transport risk is also concluded to be acceptable.

The primary reasons for the low risk levels from the modifications are that significant levels of impact from potential hazardous events are contained on-site.

The following recommendation is made from this review.

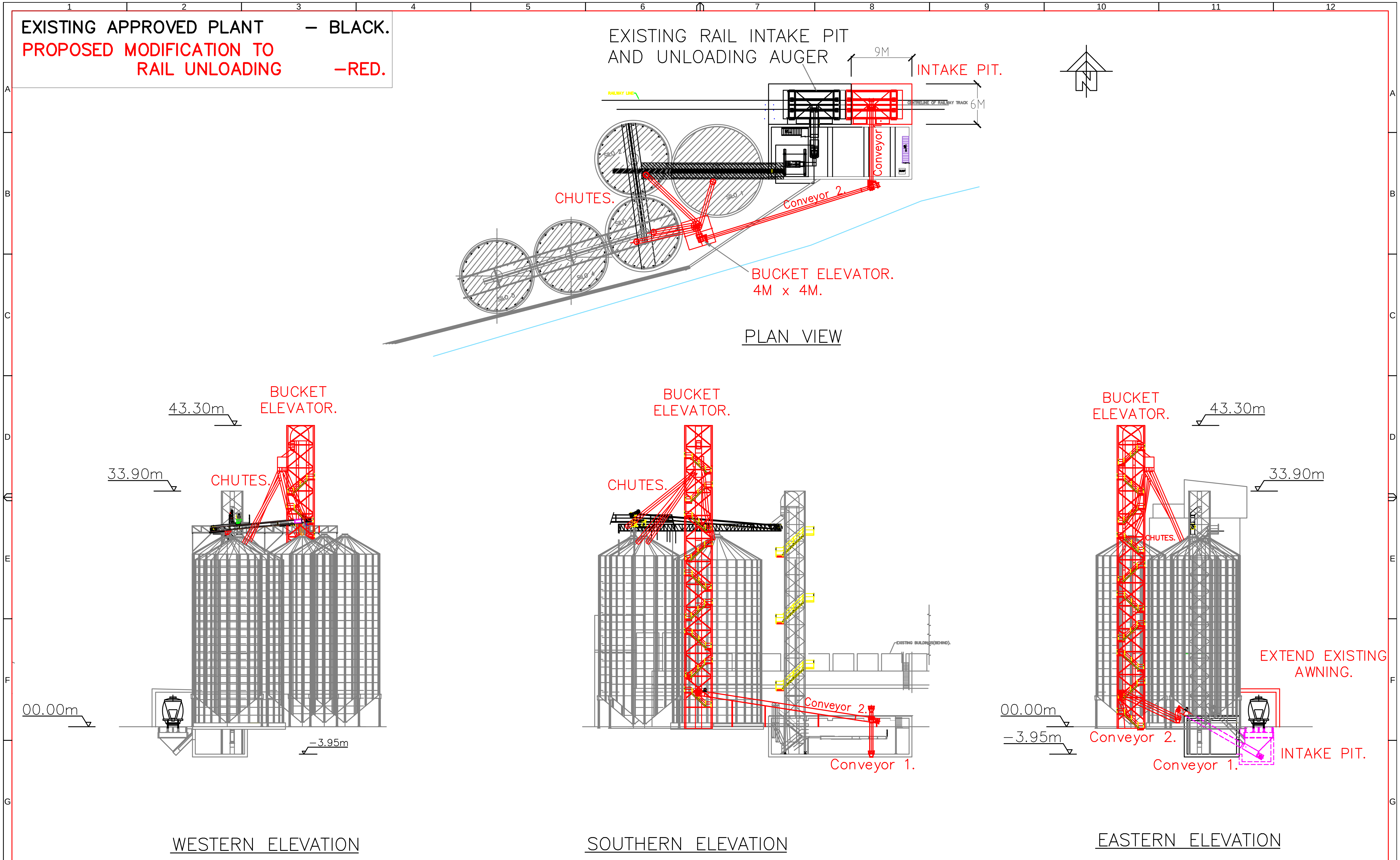
1. For all explosion vents that vent directly to atmosphere for the modifications, finalise the explosion vent modelling when the design details are known.

2. Review the option for installing initial screening, e.g. a magnetic separator, at the new intake pit to lower the likelihood of foreign objects entering the new bucket elevator and the downstream existing silos.

3. Ensure that all the proposed explosion vents are directed to a safe location to avoid injury to personnel or propagation to other adjacent equipment.

4. It is recommended that the floor of the new switchroom be fire-rated given the risk of a fire in the existing switchroom below. This will also help prevent a fire in the new switchroom propagating to the existing switchroom below.

# 7 APPENDIX A - PROPOSED GRAIN INTAKE SYSTEM DETAILS




| REV | ZONE | DETAILS | DRN | DATE | CHKD | APPD |
|---|---|---|---|---|---|---|
| REV1 | ALL | PROPOSAL. | P.C. | 22/02/18 | M.H. | |

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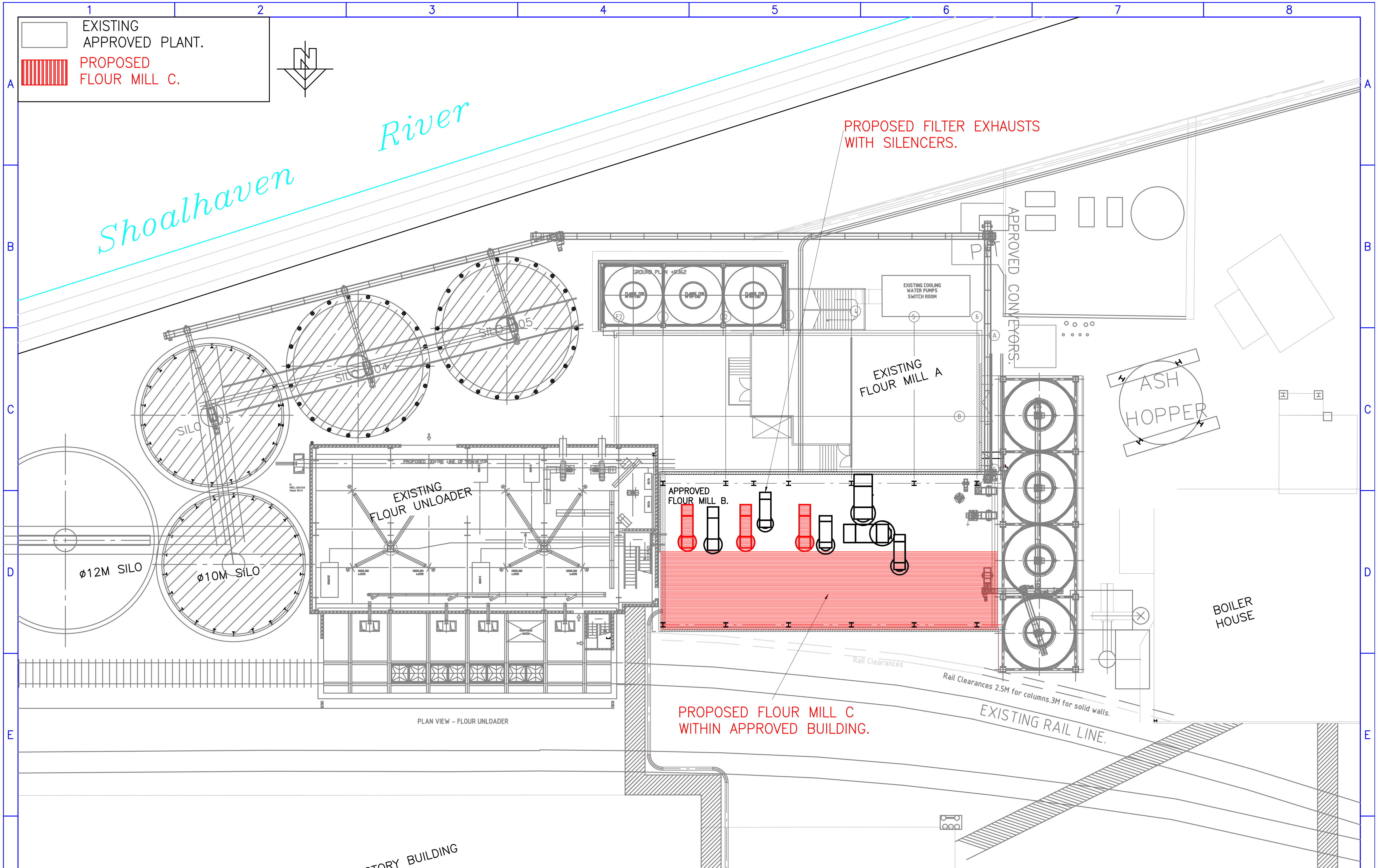
| | | | |
|---|---|---|---|
| DRAWN: Paul Caruana | DATE: 03/02/18 | SITE: MANILDRA – SHOALHAVEN STARCHES PTY LTD | SHT SIZE: A3 |
| DESIGNED. | DATE | JOB TITLE: PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. | SHEET |
| CHKD | DATE | DWG TITLE: PROPOSED MODIFICATION TO RAIL UNLOADING. PLAN & ELEVATIONS. | OF |
| APPD | DATE | | REV. P07 |
| | SCALE: 1 : 500 | PROJECT No. 6531 / DWG No. MN6531-012 | |

# 8 APPENDIX B – MILL C DRAWINGS




| ISS | DATE | ZONE | CHANGE AMENDMENTS | BY | CKD |
|---|---|---|---|---|---|
| J | 08/02/18 | ALL | Filter exhaust tagged & moved south. | P.C. | B.H. |
| H | 07/02/18 | ALL | B mill shown as approved.Ventilation shown separate prop. | P.C. | B.H. |
| G | 19/01/18 | ALL | Mill C added. | P.C. | B.H. |
| F | 23/11/17 | ALL | Ventilation added. | P.C. | M.M. |
| E | 30/9/16 | ALL | Silos highlighted. | P.C. | ALL |
| D | 29/9/16 | ALL | Manildra approval. | P.C. | ALL |
| C | 28/9/16 | ALL | For approval. | P.C. | ALL |

PC Drafting. 0439 436508 Est. 2001

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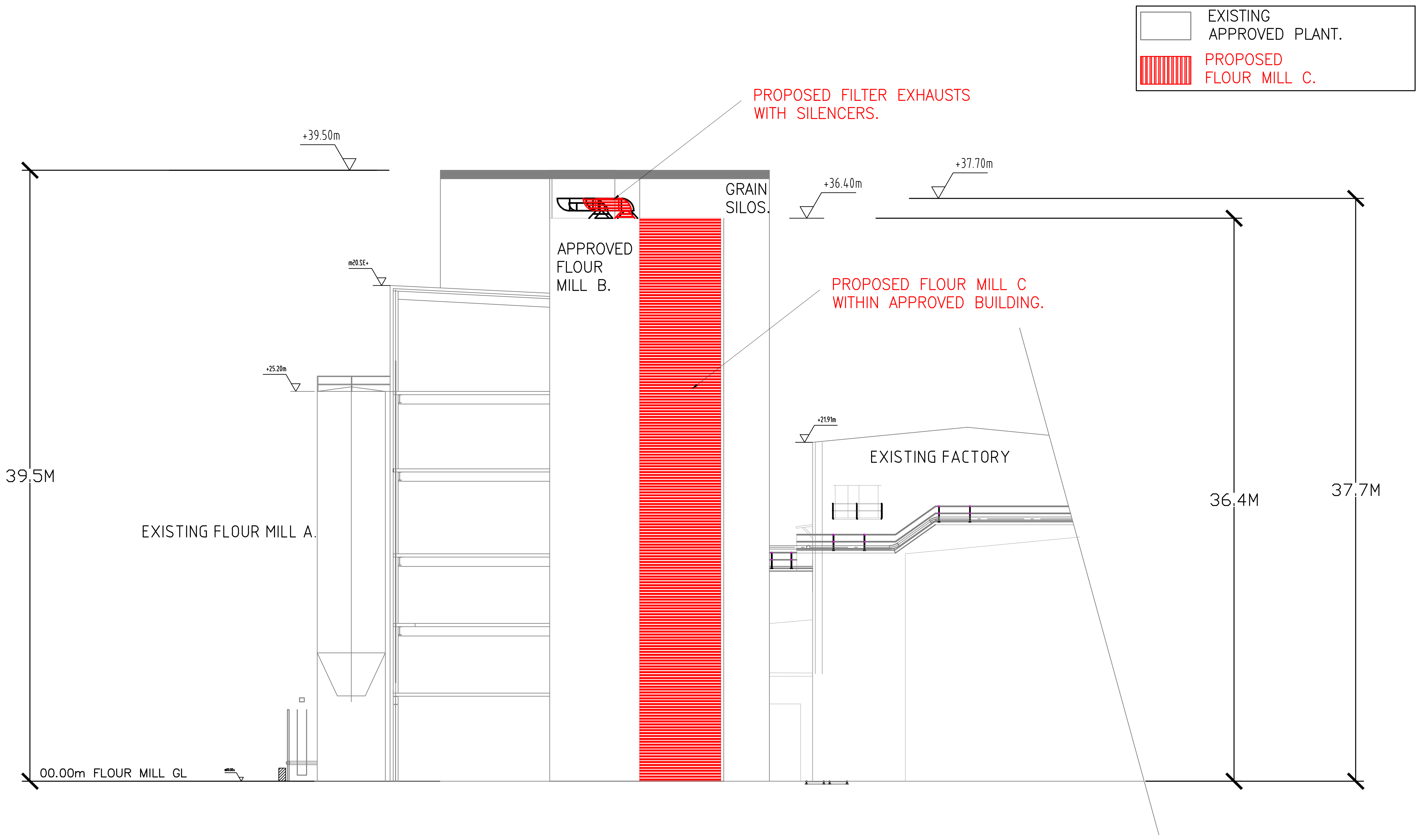
| | | | |
|---|---|---|---|
| DRAWN | P.J.C. | | |
| TRACED | ---- | | |
| CHECKED | | | |
| APPROVED | | FINISH | NA |
| DRG PRACTICE AS1100 | | | |

MATERIAL NA

SHOALHAVEN STARCHES.
TITLE FLOUR MILL C. SITE PLAN.

SIZE A3 | SCALES 1:250 | SHT
ISSUE 5566
DRG. № MN244-003K




EASTERN ELEVATION

| ISS | DATE | ZONE | CHANGE AMENDMENTS | BY | CKD |
|---|---|---|---|---|---|
| J | 08/02/18 | ALL | Filter exhaust tagged & moved south. | P.C. | B.H. |
| H | 07/02/18 | ALL | B mill shown as approved. Ventilation shown separate prop. | P.C. | B.H. |
| G | 19/01/18 | ALL | Mill C added. | P.C. | B.H. |
| E | 30/9/16 | ALL | Wording added. | P.C. | ALL |
| D | 29/9/16 | ALL | Manildra approval. | P.C. | ALL |

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DRAWN P.J.C.
TRACED ----
CHECKED
APPROVED
DRG PRACTICE AS1100

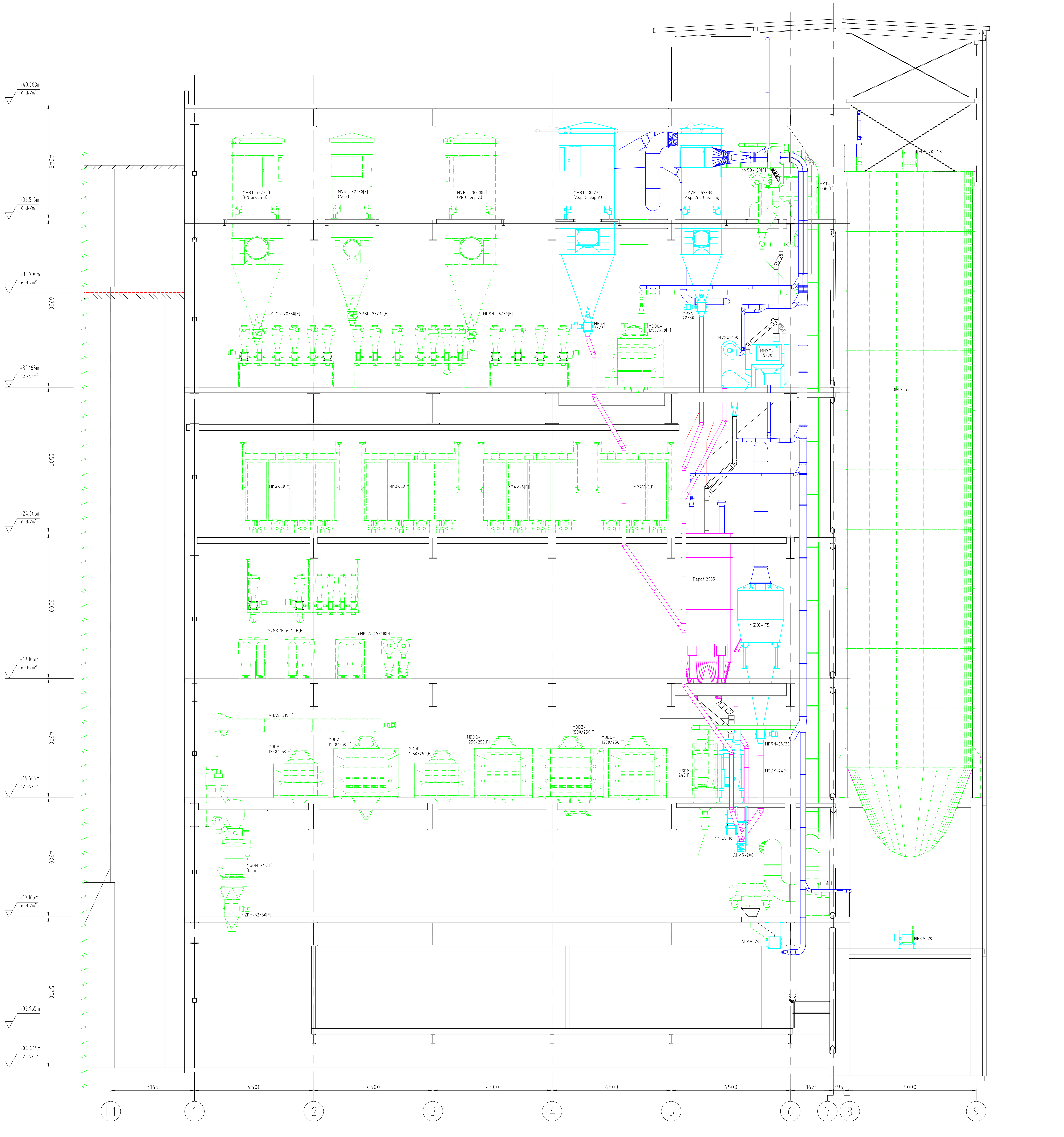
MATERIAL NA

SHOALHAVEN STARCHES.

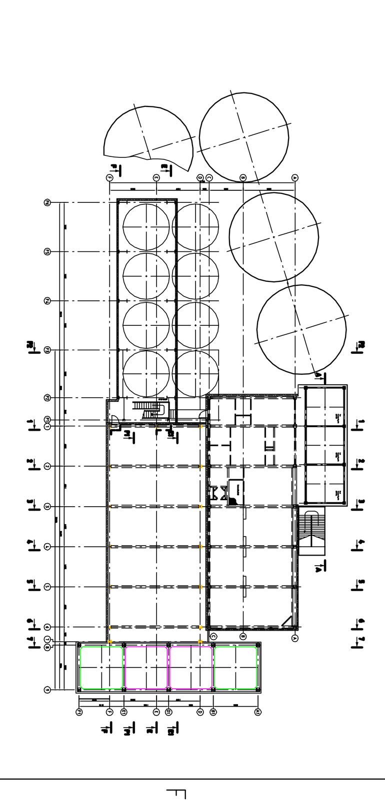
TITLE PROPOSED FLOUR MILL C.
SITE EASTERN ELEVATION

SIZE A3 | SCALES 1:250 | SHT
ISSUE 5566
DRG. Nº MN244-005J

# Longitudinal Section F-F




[F] FUTURE



| REV. | APPD. DATE | DESCRIPTION | DRAWN BY | APPD. BY | ISSUED BY |
|---|---|---|---|---|---|
| 01 | 22.02.2017 | UPDATE AFTER DESIGN MEETING | K. Fuerer | P. Willumsen | |
| 02 | 24.02.2017 | UPDATE DRAWING | K. Fuerer | P. Willumsen | |
| 03 | 14.07.2017 | Manildra Building Added | P. Willumsen | P. Willumsen | |

PLANT OWNER :
MANILDRA GROUP
BOMADERRY, Australia

CONTRACTOR :
BUHLER AG
UZWIL, Switzerland

PROJECT :
PRODUCT /
CAPACITY :
STARCH MILL
HARD WHEAT, 850 t/24h

TITLE:
PROCESS INSTALLATION DRAWING
CLEANING / MILL
Longitudinal section F-F

ISSUE FOR : INSTALLATION STAGE

State

| | | | | |
|---|---|---|---|---|
| Drawn | K. Fuerer | GMFF531 | 07.11.2016 | Contract No. 30184867727 |
| Approved | P. Willumsen | GMFF531 | 14.07.2017 | Replace Drawing No. |
| Issued | | | | Plant Owner Drawing No. |

Project No.
Replaced by Drawing No.

BÜHLER

Scale 1:50

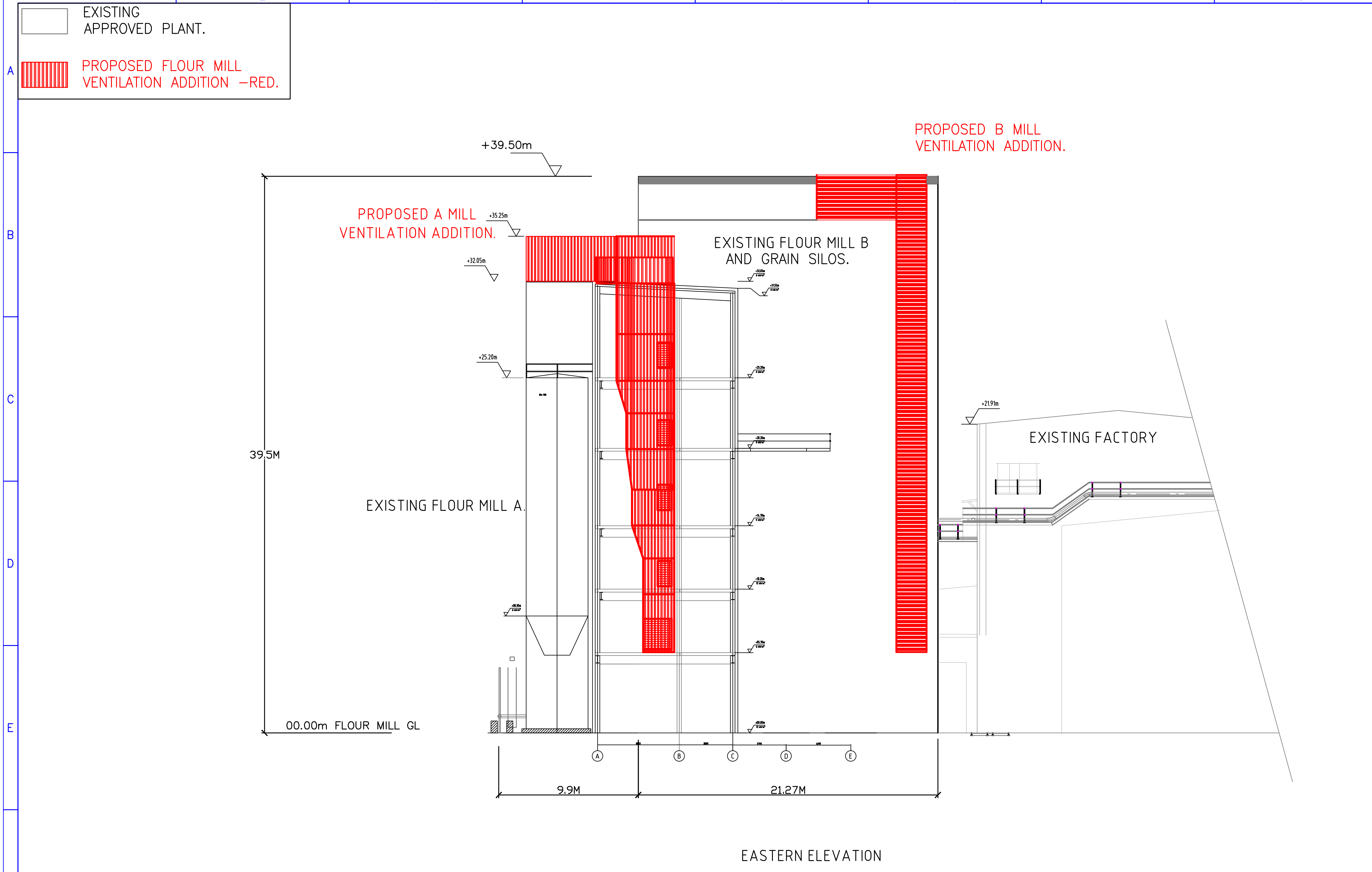
Drawing-Number 02548-INS-0009

Revision 03

BU-IM

CAD DIN A0

# 9 APPENDIX C – MILLS' BUILDINGS VENTILATION SYSTEMS




| | | | | | |
|---|---|---|---|---|---|
| F | 19-12-17 | ALL | Manildra approval. | Paul C. | M.M. |
| ISS | DATE | ZONE | CHANGE AMENDMENTS | BY | CKD |

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| | |
|---|---|
| DRAWN | P.J.C. |
| TRACED | |
| CHECKED | |
| APPROVED | |
| DRG PRACTICE AS1100 | |

MATERIAL NA

SHOALHAVEN STARCHES.

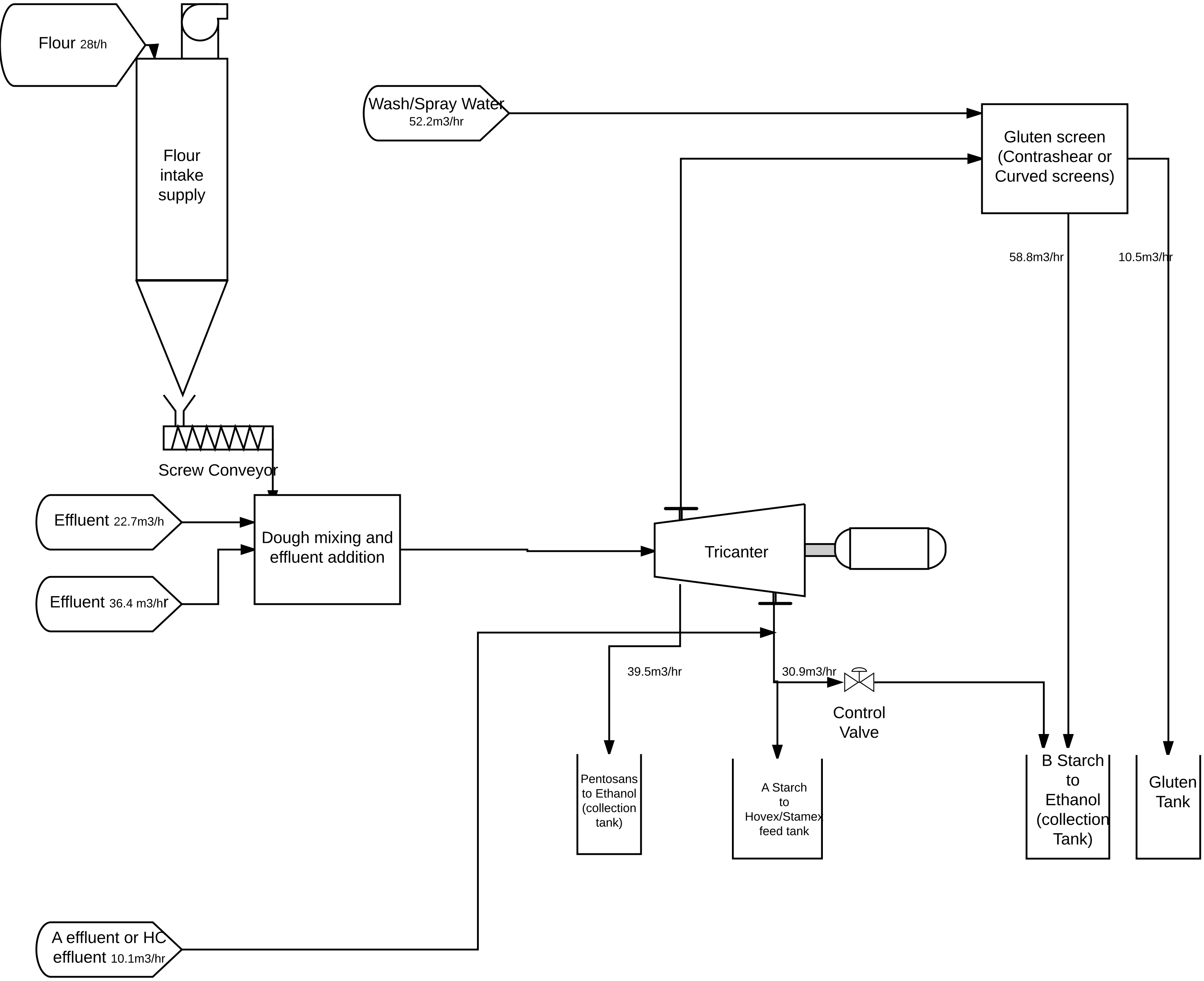
TITLE PROPOSED FLOUR MILL B. SITE EASTERN ELEVATION

SIZE A3 | SCALES 1:250 | SHT

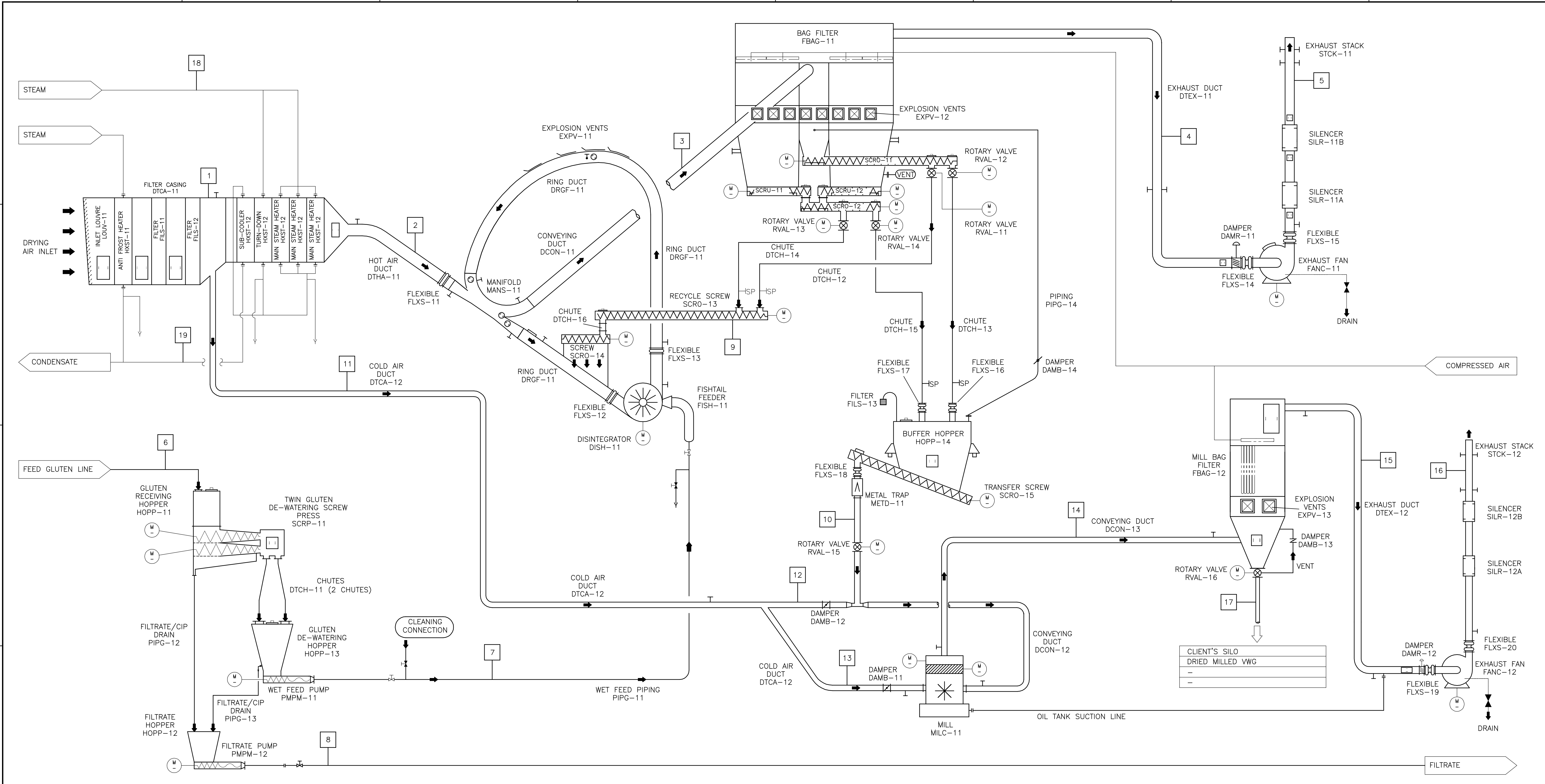
ISSUE

DRG. Nº MN244–011F

# 10 APPENDIX D – GLUTEN DRYER 8 DRAWINGS



Flour 28t/h
Wash/Spray Water 52.2m3/hr
Gluten screen (Contrashear or Curved screens)
Flour intake supply
58.8m3/hr
10.5m3/hr
Screw Conveyor
Effluent 22.7m3/h
Dough mixing and effluent addition
Tricanter
Effluent 36.4 m3/hr
39.5m3/hr
30.9m3/hr
Control Valve
Pentosans to Ethanol (collection tank)
A Starch to Hovex/Stamex feed tank
B Starch to Ethanol (collection Tank)
Gluten Tank
A effluent or HC effluent 10.1m3/hr




MAXIMUM CAPACITY AT MINIMUM AMBIENT TEMPERATURE (0°C) KEY * Dew Point in °C ** Maximum expected values

| ITEM NO. | | 1 | 2 | – | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | – | 14 | 15 | 16 | 17 | 18 | 19 | – |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DESIGNATION | UNITS | DRYING INLET AIR | HOT AIR DUCT | LEAKS INTO DRYER | CONVEYING DUCT TO BAG FILTER | EXHAUST DUCT | EXHAUST STACK | GLUTEN FEED LINE | GLUTEN PIPEWORK TO FISHTAIL | FILTRATE RETURN | RETURN FEED SCREW | PRODUCT CHUTE | COLD AIR DUCT | COLD AIR DUCT TO VENTURI | COLD AIR DUCT TO MILL | LEAKS INTO MILL | EXHAUST DUCT TO MILL BAG FILTER | EXHAUST DUCT | EXHAUST STACK | PRODUCT CHUTE | STEAM | CONDENSATE | – |
| DRY SOLIDS | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| WATER | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| TOTAL SOLIDS | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| DRY AIR | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| WATER IN AIR | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| TOTAL AIR MASS | kg/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| VOLUME | am³/h | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| TEMPERATURE | °C | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| PRESSURE | mbar | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

THIS IS A PRELIMINARY DRAWING NOT FOR FABRICATION

THIS DRAWING IS BASED ON :-

DO NOT SCALE IF IN DOUBT ASK

FIRST ANGLE PROJECTION

WEIGHTS SHOWN ARE APPROXIMATE AND INDICATIVE ONLY. THEY MUST BE CHECKED BEFORE LIFTING OR FOR MATERIAL TAKEOFF, ETC

WEIGHT:- kg

# PFD OF VITAL WHEAT GLUTEN DEWATERING, RING DRYING & MILLING SYSTEM

Sheet 1 OF 1

| | REV. BY | DATE | CHECKED | APPROVED |
|---|---|---|---|---|
| H | | | | |
| G | | | | |
| F | | | | |
| E | | | | |
| D | | | | |
| C | | | | |
| B | | | | |

GEA Barr-Rosin

| | | |
|---|---|---|
| SCALE | NTS at A1 | |
| DRAWN | - | - |
| CHECKED | - | - |
| APPROVED | - | - |



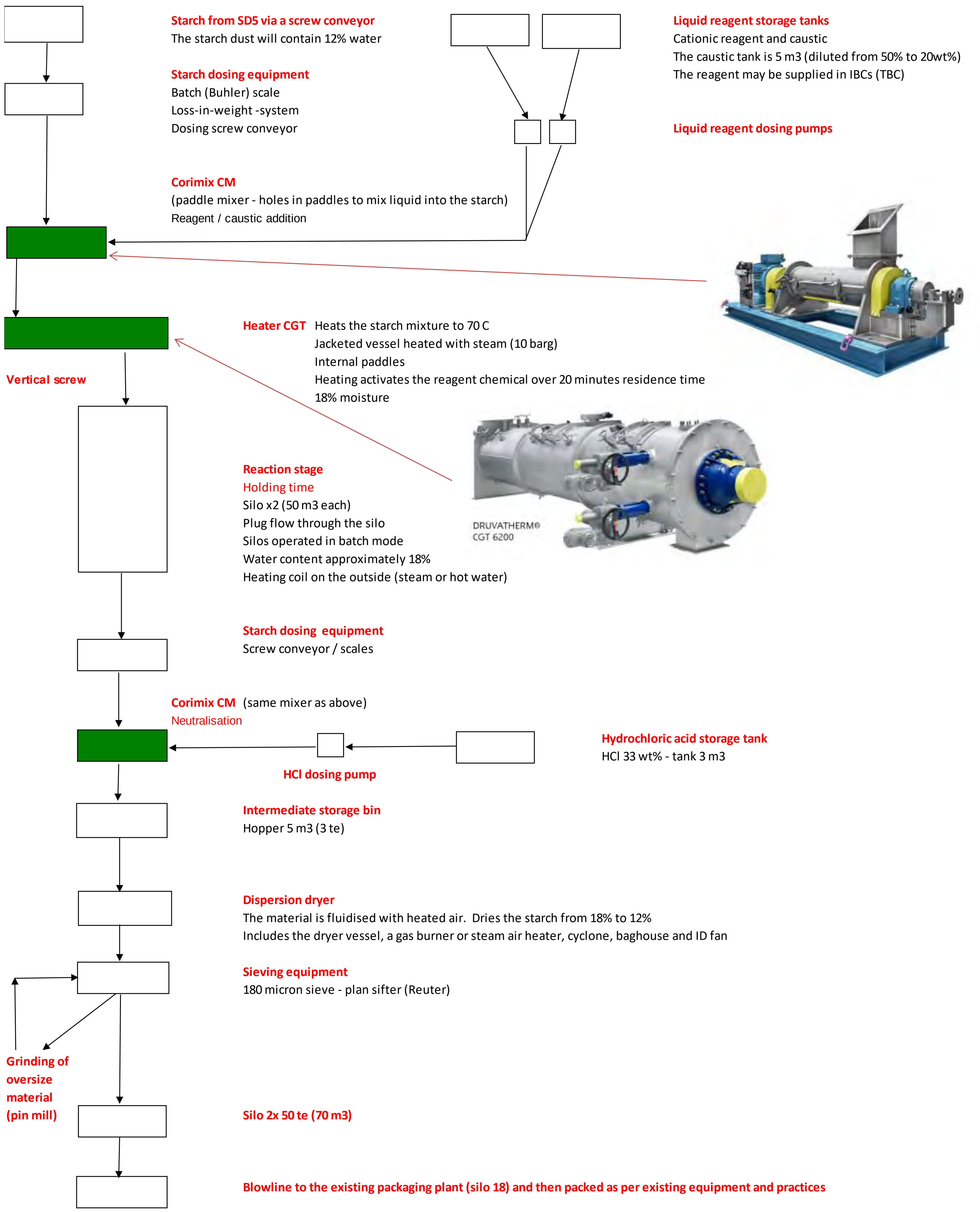
| CONTRACT/ENQUIRY | DRAWING No. | SHEET | REV |
|---|---|---|---|
| CXXXX | 1133-12 | 01 | A |

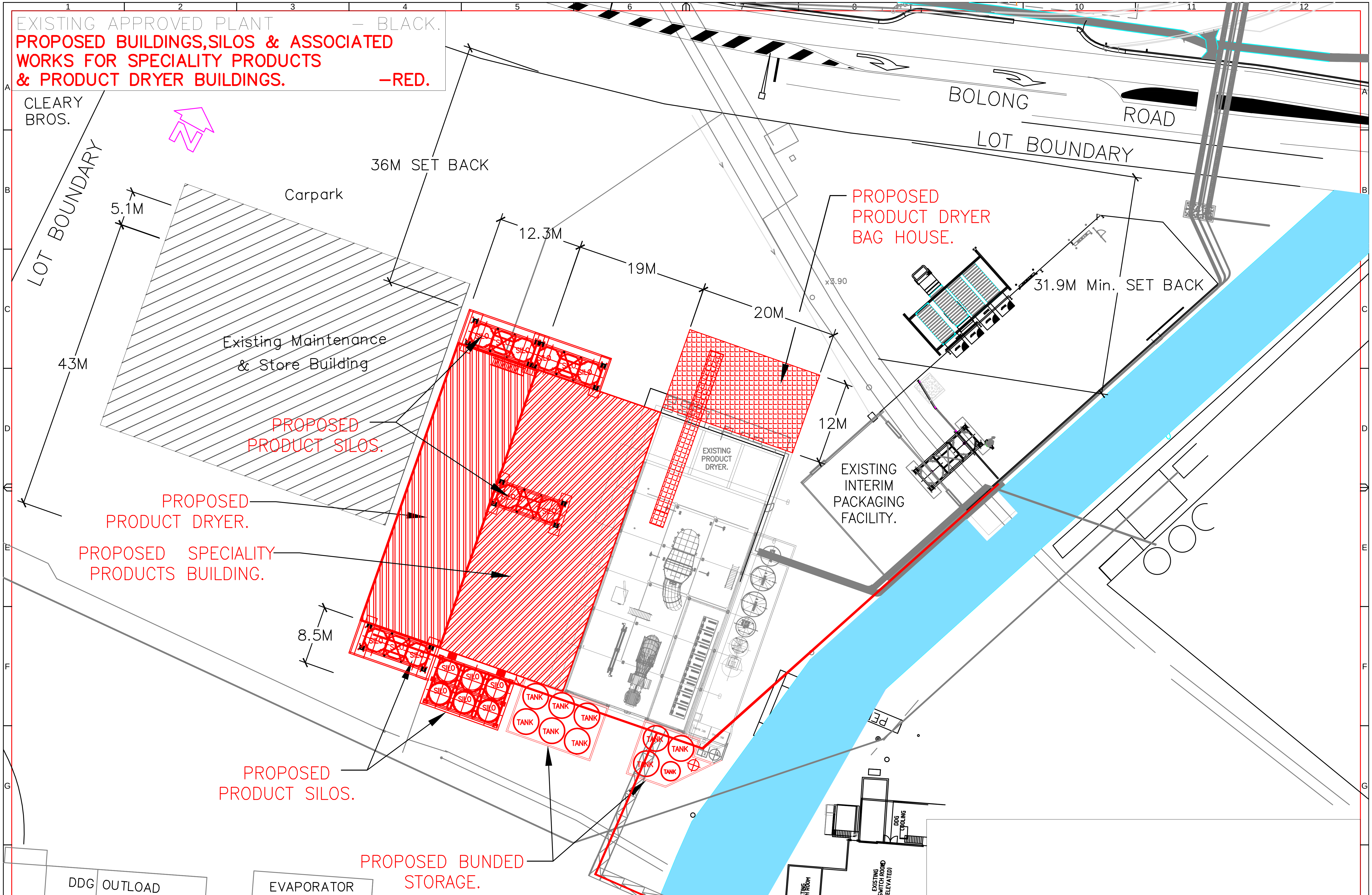
# 11 APPENDIX E – CATIONIC STARCH PROCESS FLOW DIAGRAM

**Preliminary Hazard Analysis, Shoalhaven Starches, Modification to MP06_0228**

## Appendix E - Cationic Starch Process Flow Diagram

**Basic Flow Sheet for the Dry (batch) Cationisation of Starch**



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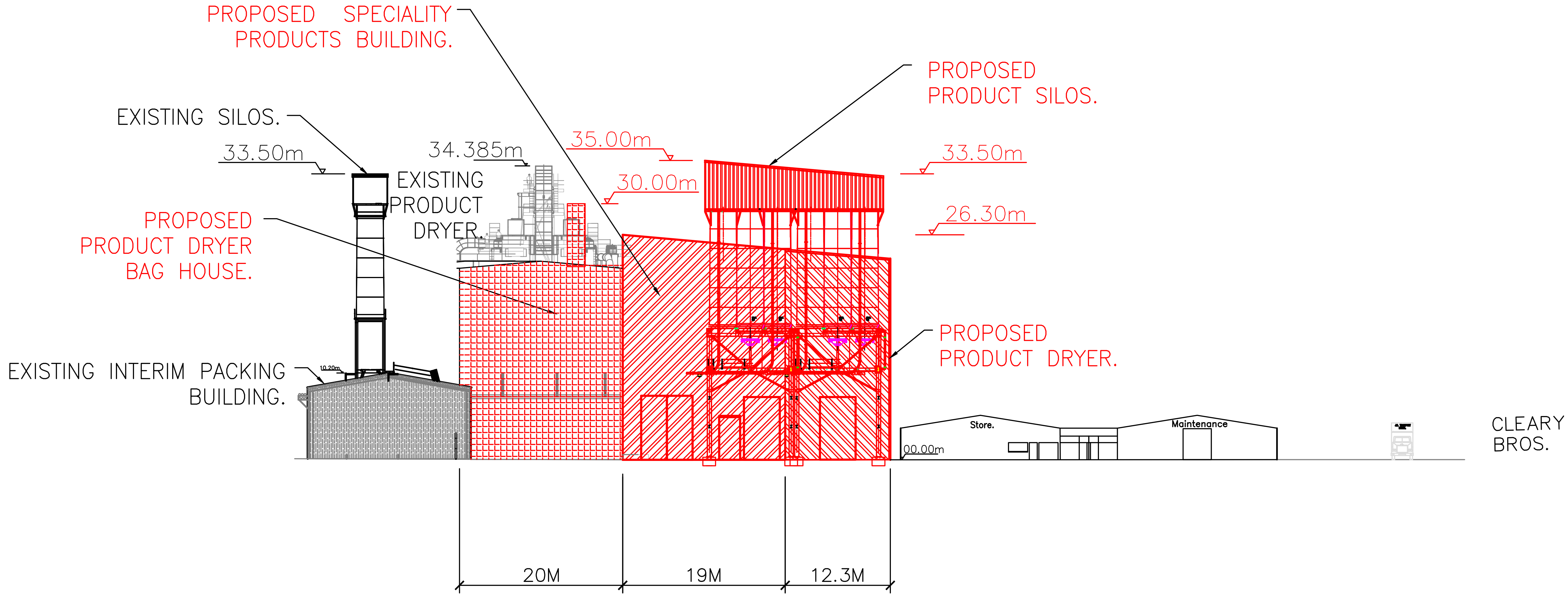
| | | | |
|---|---|---|---|
| DRAWN Paul Caruana | DATE 13/01/17 | SITE MANILDRA – SHOALHAVEN STARCHES PTY LTD | SHT SIZE A3 |
| DESIGNED. | DATE | JOB TITLE PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. | SHEET |
| CHKD | DATE | DWG TITLE PROPOSED EXPANSION STRUCTURES. PLAN VIEW. | OF |
| APPD | DATE | | REV. |
| | SCALE 1 : 500 | PROJECT No. 6531 — DWG No. MN6531-002 | P07 |

| DRG.No. | REV | REFERENCE DRAWING | DRG.No. | REV | REFERENCE DRAWING | REV | ZONE | DETAILS | DRN | DATE | CHKD | APPD | REV | ZONE | DETAILS | DRN | DATE | CHKD | APPD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

EXISTING APPROVED PLANT — BLACK.
PROPOSED BUILDINGS,SILOS & ASSOCIATED WORKS FOR SPECIALITY PRODUCTS & PRODUCT DRYER BUILDINGS. —RED.




NORTHERN ELEVATION(FRONT).

| | | | |
|---|---|---|---|
| DRG.No. | REV | REFERENCE DRAWING | |
| DRG.No. | REV | REFERENCE DRAWING | |
| REV | ZONE | DETAILS | DRN DATE CHKD APPD |
| REV | ZONE | DETAILS | DRN DATE CHKD APPD |

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| | | | |
|---|---|---|---|
| DRAWN: Paul Caruana | DATE: 13/01/17 | SITE: MANILDRA – SHOALHAVEN STARCHES PTY LTD | SHT SIZE: A3 |
| DESIGNED. | DATE | JOB TITLE: PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. | SHEET OF |
| CHKD | DATE | DWG TITLE: PROPOSED EXPANSION STRUCTURES. NORTHERN ELEVATION. | |
| APPD | DATE | | REV. P07 |
| | SCALE: 1 : 500 | PROJECT No. 6531 / DWG No. MN6531-003 | |

# 12 APPENDIX F – STARCH DRYER 5 PROCESS FLOW DIAGRAMS

A1


| Section | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air Mass Flow** | | | | | | | | | | | | | | | | | | | |
| Dry Air | kg/h | | | | | 222,893 | 222,893 | 222,893 | | 114,790 | 114,790 | | | 229,580 | 274,380 | 44,800 | 44,800 | | 44,800 |
| Water Vapour | kg/h | | | | | 670 | 670 | 10,586 | | 5,303 | 5,303 | | | 10,607 | 11,107 | 500 | 500 | | 500 |
| Total | kg/h | | | | | 223,563 | 223,563 | 233,479 | | 120,093 | 120,093 | | | 240,186 | 285,486 | 45,300 | 45,300 | | 45,300 |
| **Air volume Flow** | | | | | | | | | | | | | | | | | | | |
| Total | Am3/h | | | | | 172,981 | 291,286 | 235,369 | | 120,010 | 120,010 | | | 239,994 | 261,071 | 35,051 | 39,547 | | 40,498 |
| **Solids Mass Flow** | | | | | | | | | | | | | | | | | | | |
| Dry Solids | kg/h | 9,350 | 2640 | 9,350 | 2640 | | | 23,980 | 14,960 | 1,870 | 1,870 | 11,990 | 11,990 | | | | 18,700 | 18,700 | |
| Water | kg/h | 6,233 | 360 | 6,233 | 360 | | | 3,270 | 2,040 | 255 | 255 | 1,635 | 1,635 | | | | 2,550 | 2,550 | |
| Total | kg/h | 15,583 | 3000 | 15,583 | 3000 | | | 27,250 | 17,000 | 2,125 | 2,125 | 13,625 | 13,625 | | | | 21,250 | 21,250 | |
| Moisture | % | 40 | 12 | 40 | 12 | | | 12 | 12 | 12 | 12 | 12 | 12 | | | | 12 | 12 | |
| **Temperature** | deg. C | | | | | 0 | 180 | 75 | 55 | 65 | 65 | 52 | 52 | 58 | 50 | 0 | 25 | 35 | 25 |
| **Pressure** | mbar g. | | | | | 0 | -15 | -22 | -25 | -42 | -42 | -9 | -17 | -62 | 1 | 0 | -33 | | -56 |

TT FIELD INSTRUMENT

TIA LOCAL PANEL INSTRUMENT

TIRA CONTROL SYSTEM INSTRUMENT

TIRA HH LL ALARM HIGH HIGH / LOW LOW (SHUTDOWN)

TIRA H L ALARM HIGH / LOW (WARNING ONLY)

TTA HH SAFETY RELATED PART OF CONTROL SYSTEM

DO DIGITAL (DISCRETE) OUTPUT FROM CONTROL SYSTEM

| REV | DESCRIPTION | DATE | BY | CHKD |
|---|---|---|---|---|
| - | REVISION 0 | 30.09.2014 | WH | - |

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A Moret Industries Company
Specialists in Drying Technology - www.VetterTec.co.uk


VetterTec Ltd, Suffolk House, 154 High St, Sevenoaks, Kent, TN13 1XE, England.
Tel:+44 (0) 1732 441440 Fax:+44 (0) 1732 458818 Email: info@vettertec.co.uk


TITLE:
WHEAT STARCH DRYER & COOLER PFD

PROJECT No: DRP4785
CLIENT: MANILDRA
DRAWN BY: WH
DRAWING No:
DRAWN DATE: 30.09.2014
CHECKED BY:
DRG USED ON: ~
SCALE: NTS
DRG DERIVED FROM: ~

A1


| | |
|---|---|
| TT | FIELD INSTRUMENT |
| TIA | LOCAL PANEL INSTRUMENT |
| TIRA | CONTROL SYSTEM INSTRUMENT |
| TIRA HH LL | ALARM HIGH HIGH / LOW LOW (SHUTDOWN) |
| TIRA H L | ALARM HIGH / LOW (WARNING ONLY) |
| TTA HH | SAFETY RELATED PART OF CONTROL SYSTEM |
| DO | DIGITAL (DISCRETE) OUTPUT FROM CONTROL SYSTEM |

| Section | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air Mass Flow** | | | | | | | | | | | | | | | | | | | |
| Dry Air | kg/h | | | | | 222,893 | 222,893 | 222,893 | | 114,790 | 114,790 | | | 229,580 | 274,380 | 44,800 | 44,800 | | 44,800 |
| Water Vapour | kg/h | | | | | 670 | 670 | 10,586 | | 5,303 | 5,303 | | | 10,607 | 11,107 | 500 | 500 | | 500 |
| Total | kg/h | | | | | 223,563 | 223,563 | 233,479 | | 120,093 | 120,093 | | | 240,186 | 285,486 | 45,300 | 45,300 | | 45,300 |
| **Air volume Flow** | | | | | | | | | | | | | | | | | | | |
| Total | Am3/h | | | | | 172,981 | 291,286 | 235,369 | | 120,010 | 120,010 | | | 239,994 | 261,071 | 35,051 | 39,547 | | 40,498 |
| **Solids Mass Flow** | | | | | | | | | | | | | | | | | | | |
| Dry Solids | kg/h | 9,350 | 2640 | 9,350 | 2640 | | | 23,980 | 14,960 | 1,870 | 1,870 | 11,990 | 11,990 | | | | 18,700 | 18,700 | |
| Water | kg/h | 6,233 | 360 | 6,233 | 360 | | | 3,270 | 2,040 | 255 | 255 | 1,635 | 1,635 | | | | 2,550 | 2,550 | |
| Total | kg/h | 15,583 | 3000 | 15,583 | 3000 | | | 27,250 | 17,000 | 2,125 | 2,125 | 13,625 | 13,625 | | | | 21,250 | 21,250 | |
| Moisture | % | 40 | 12 | 40 | 12 | | | 12 | 12 | 12 | 12 | 12 | 12 | | | | 12 | 12 | |
| **Temperature** | deg. C | | | | | 0 | 180 | 75 | 55 | 65 | 65 | 52 | 52 | 58 | 50 | 0 | 25 | 35 | 25 |
| **Pressure** | mbar g. | | | | | 0 | -15 | -22 | -25 | -42 | -42 | -9 | -17 | -62 | 1 | 0 | -33 | | -56 |

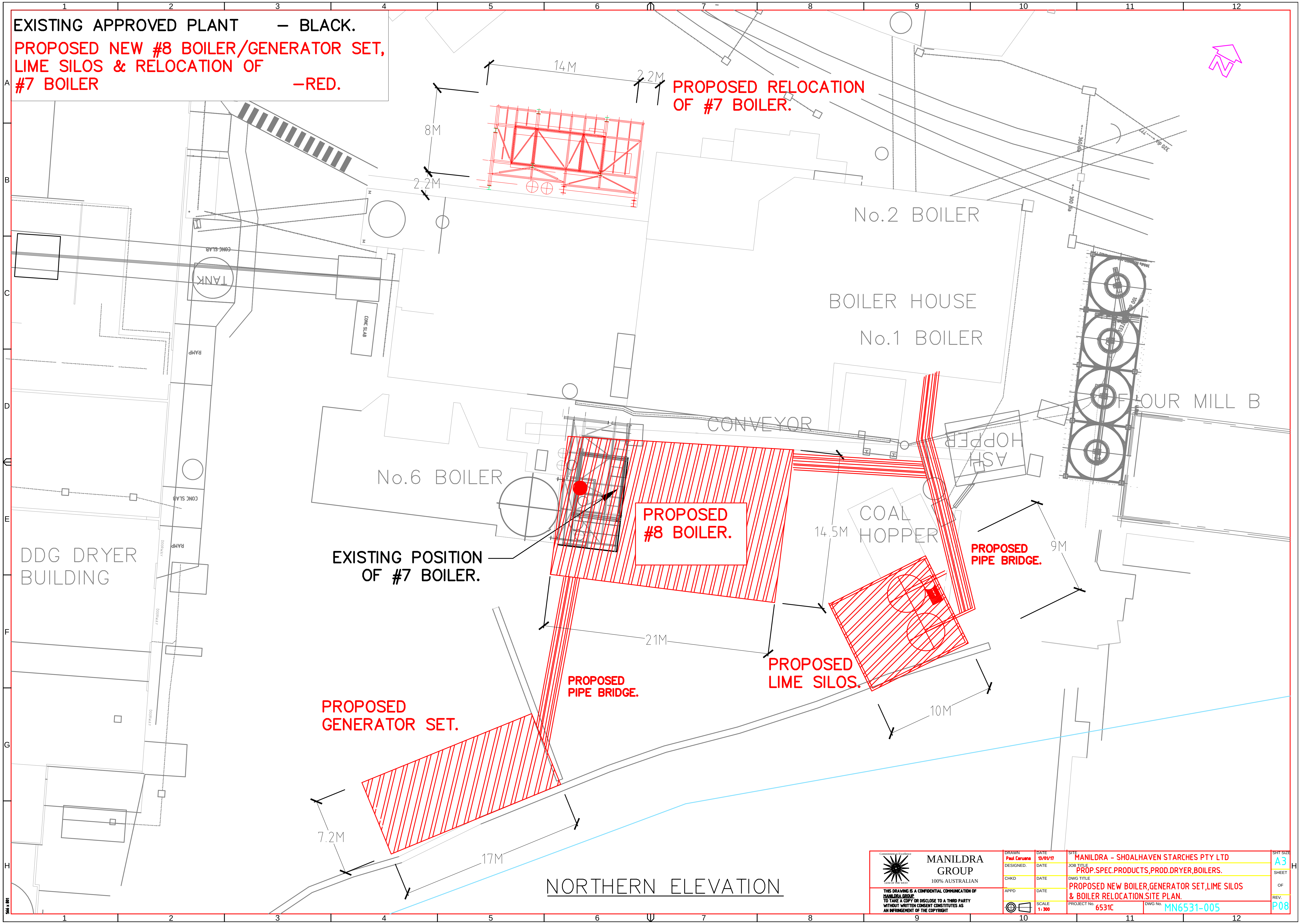
| REV | DESCRIPTION | DATE | BY | CHKD |
|---|---|---|---|---|
| - | REVISION 0 | 30.09.2014 | WH | - |

**VetterTec**
A Moret Industries Company
Specialists in Drying Technology - www.VetterTec.co.uk
VetterTec Ltd, Suffolk House, 154 High St, Sevenoaks, Kent, TN13 1XE, England.
Tel:+44 (0) 1732 441440 Fax:+44 (0) 1732 458818 Email: info@vettertec.co.uk

TITLE:
## WHEAT STARCH DRYER & COOLER PFD

| | | | |
|---|---|---|---|
| PROJECT No: | DRP4785 | CLIENT: | MANILDRA |
| DRAWN BY: | WH | DRAWING No: | |
| DRAWN DATE: | 30.09.2014 | | |
| CHECKED BY: | | DRG USED ON: | ~ |
| SCALE: | NTS | DRG DERIVED FROM: | ~ |

# 13 APPENDIX G – BOILERS DRAWINGS


EXISTING APPROVED PLANT — BLACK.
PROPOSED NEW #8 BOILER/GENERATOR SET, LIME SILOS & RELOCATION OF #7 BOILER —RED.
14M
2.2M
8M
2.2M
PROPOSED RELOCATION OF #7 BOILER.
No.2 BOILER
BOILER HOUSE
No.1 BOILER
FLOUR MILL B
CONVEYOR
ASH HOPPER
TANK
CONC SLAB
RAMP
No.6 BOILER
COAL HOPPER
14.5M
PROPOSED #8 BOILER.
PROPOSED PIPE BRIDGE.
9M
EXISTING POSITION OF #7 BOILER.
DDG DRYER BUILDING
21M
PROPOSED LIME SILOS.
10M
PROPOSED PIPE BRIDGE.
PROPOSED GENERATOR SET.
7.2M
17M
NORTHERN ELEVATION
Commitment to Excellence
MANILDRA GROUP
GEM OF THE WEST
100% AUSTRALIAN
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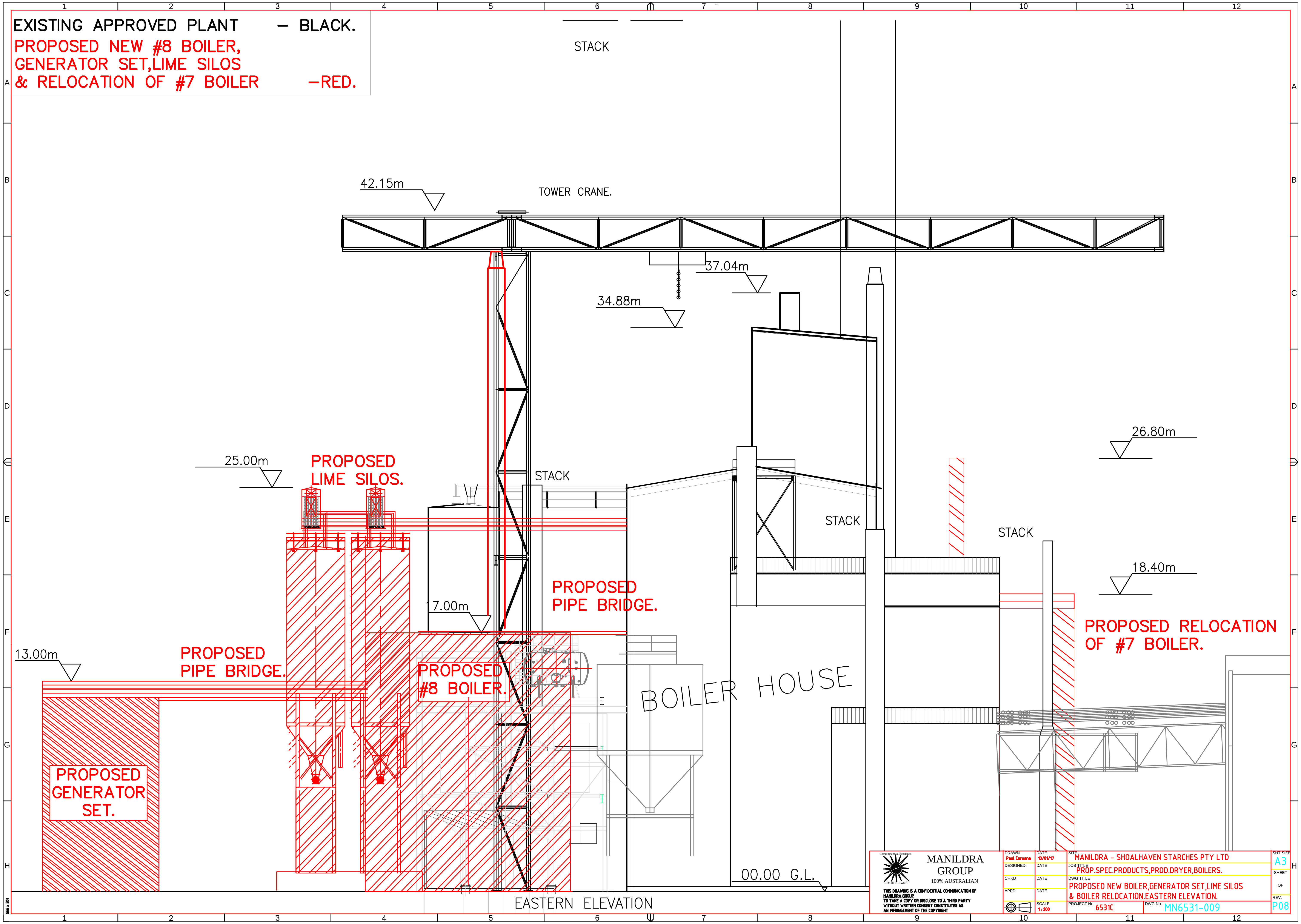
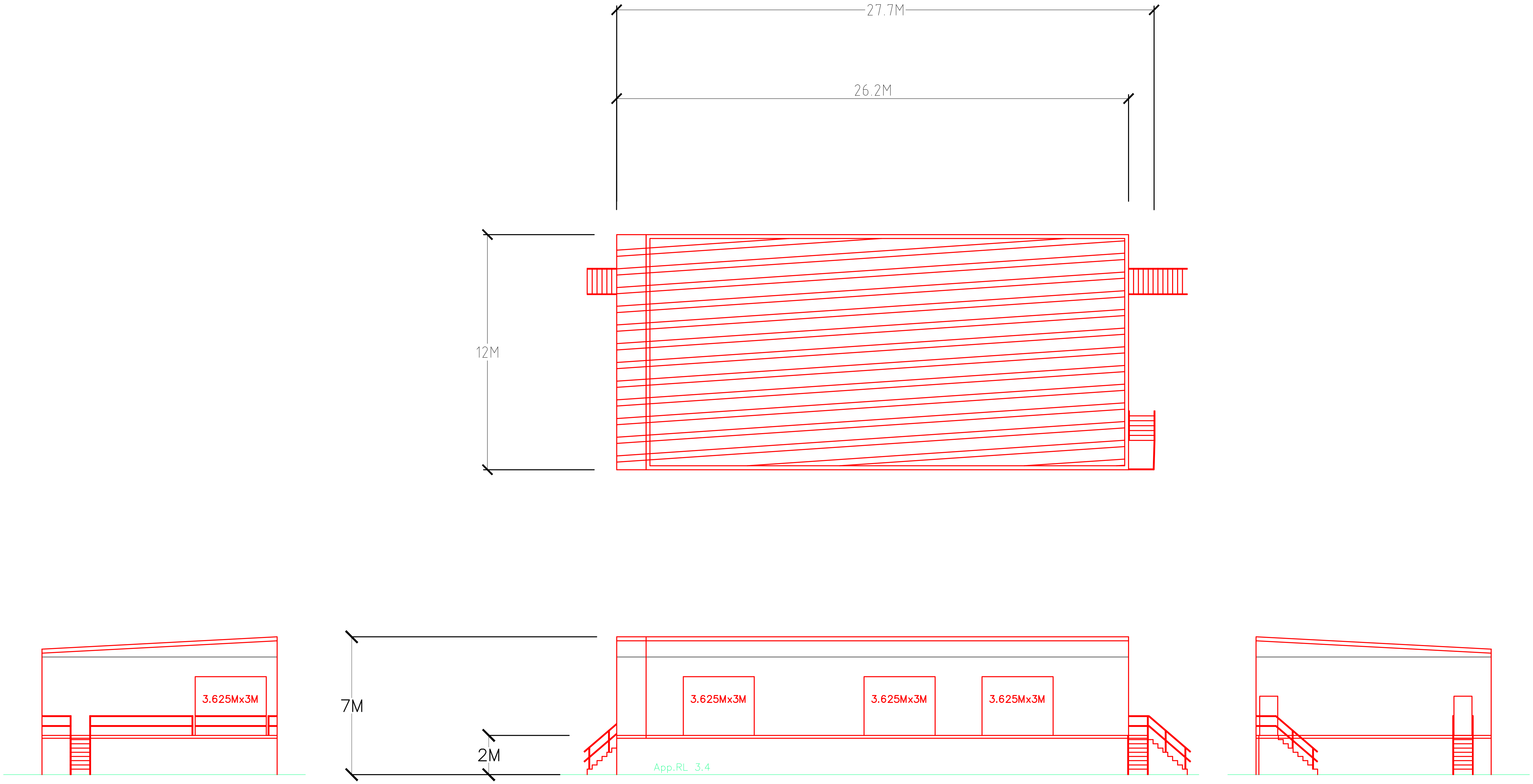
DRAWN Paul Caruana
DATE 13/01/17
DESIGNED.
DATE
CHKD
DATE
APPD
DATE
SCALE 1 : 300
SITE MANILDRA - SHOALHAVEN STARCHES PTY LTD
JOB TITLE PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS.
DWG TITLE PROPOSED NEW BOILER,GENERATOR SET,LIME SILOS & BOILER RELOCATION.SITE PLAN.
PROJECT No. 6531C
DWG No. MN6531-005
SHT SIZE A3
SHEET
OF
REV. P08




| | | | |
|---|---|---|---|
| MANILDRA GROUP 100% AUSTRALIAN | DRAWN Paul Caruana | DATE 13/01/17 | SITE MANILDRA - SHOALHAVEN STARCHES PTY LTD |
| Commitment to Excellence / GEM OF THE WEST | DESIGNED. | DATE | JOB TITLE PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. |
| THIS DRAWING IS A CONFIDENTIAL COMMUNICATION OF MANILDRA GROUP TO TAKE A COPY OR DISCLOSE TO A THIRD PARTY WITHOUT WRITTEN CONSENT CONSTITUTES AS AN INFRINGEMENT OF THE COPYRIGHT | CHKD | DATE | DWG TITLE PROPOSED NEW BOILER,GENERATOR SET,LIME SILOS & BOILER RELOCATION.EASTERN ELEVATION. |
| | APPD | DATE | |
| | | SCALE 1 : 200 | PROJECT No. 6531C / DWG No. MN6531-009 |

SHT SIZE A3 · SHEET OF · REV. P08

# 14 APPENDIX H – ELECTRICAL MODIFICATIONS DRAWINGS

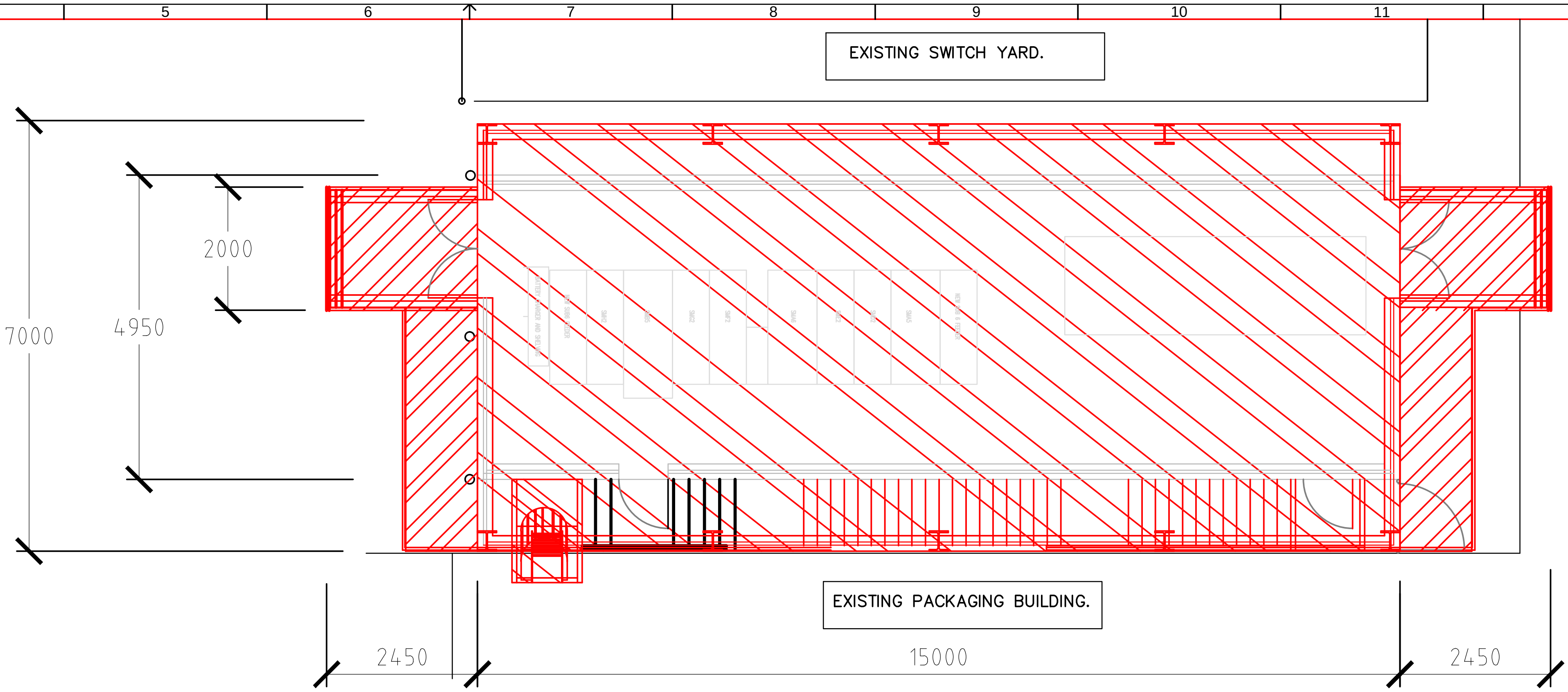



# PROPOSED INDOOR SUB-STATION.

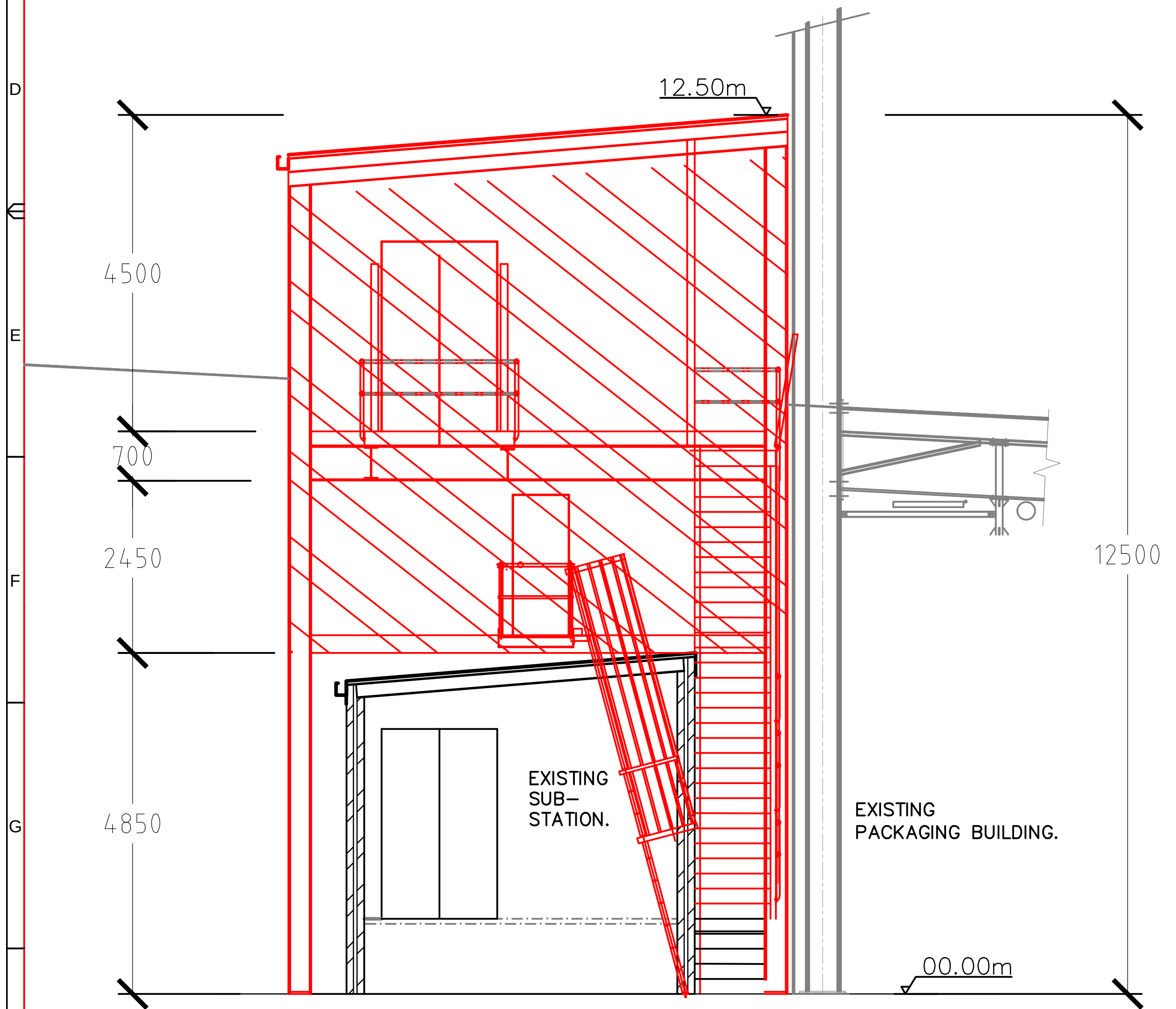
| | | | | | |
|---|---|---|---|---|---|
| MANILDRA GROUP 100% AUSTRALIAN | DRAWN Paul Caruana | DATE 13/01/17 | SITE MANILDRA – SHOALHAVEN STARCHES PTY LTD | | SHT SIZE A3 |
| | DESIGNED. | DATE | JOB TITLE PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. | | SHEET OF |
| | CHKD | DATE | DWG TITLE PROPOSED NEW HV SUB-STATION. BUILDING DETAIL | | |
| THIS DRAWING IS A CONFIDENTIAL COMMUNICATION OF MANILDRA GROUP TO TAKE A COPY OR DISCLOSE TO A THIRD PARTY WITHOUT WRITTEN CONSENT CONSTITUTES AS AN INFRINGEMENT OF THE COPYRIGHT | APPD | DATE | | | REV. |
| | | SCALE 1 : 200 | PROJECT No. 6531 | DWG No. MN6531-011 | P07 |

EXISTING APPROVED PLANT — BLACK.

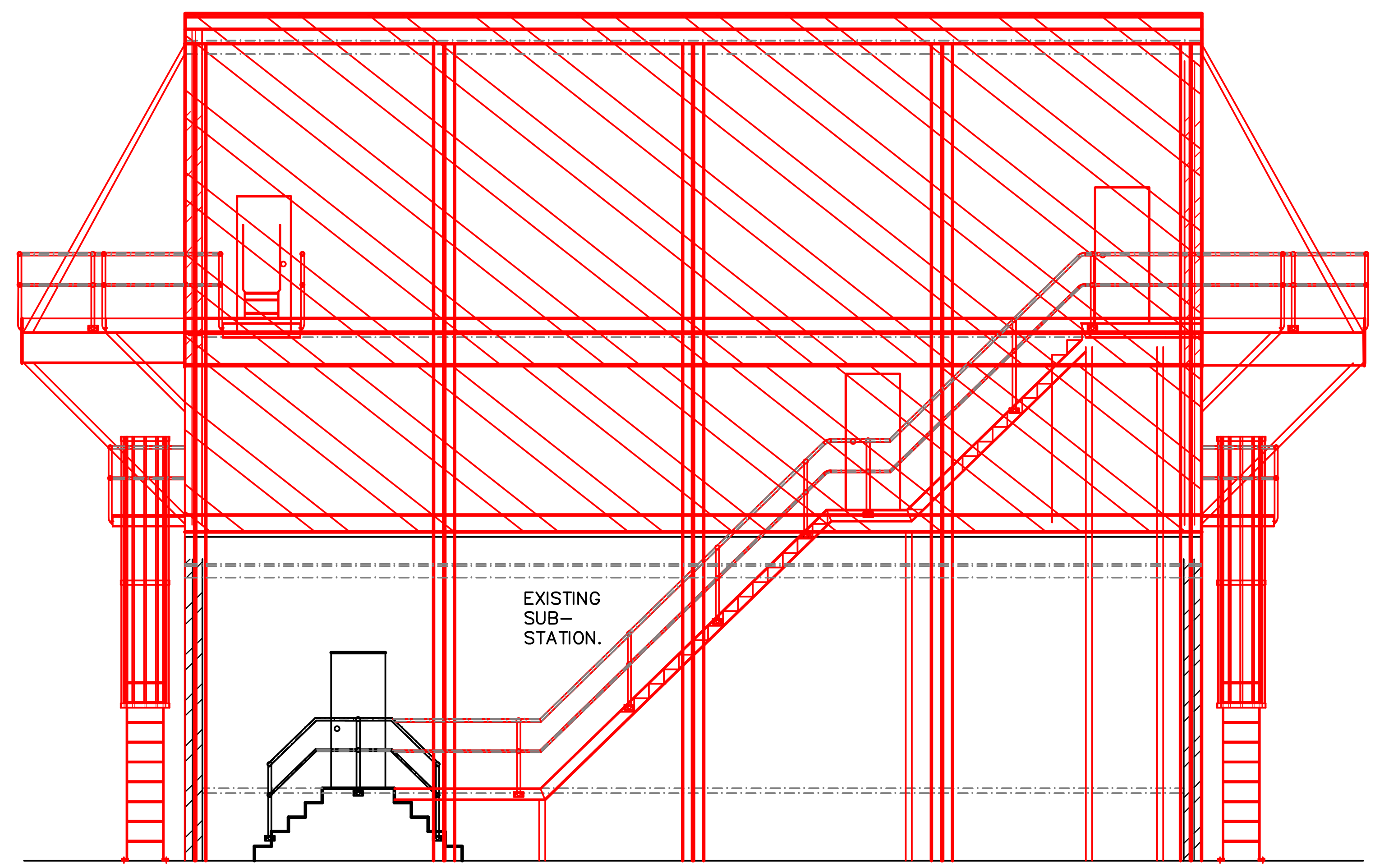
PROPOSED 2ND STOREY EXTENSION TO EXISTING MAIN SUB STATION. — RED.




PLAN VIEW.



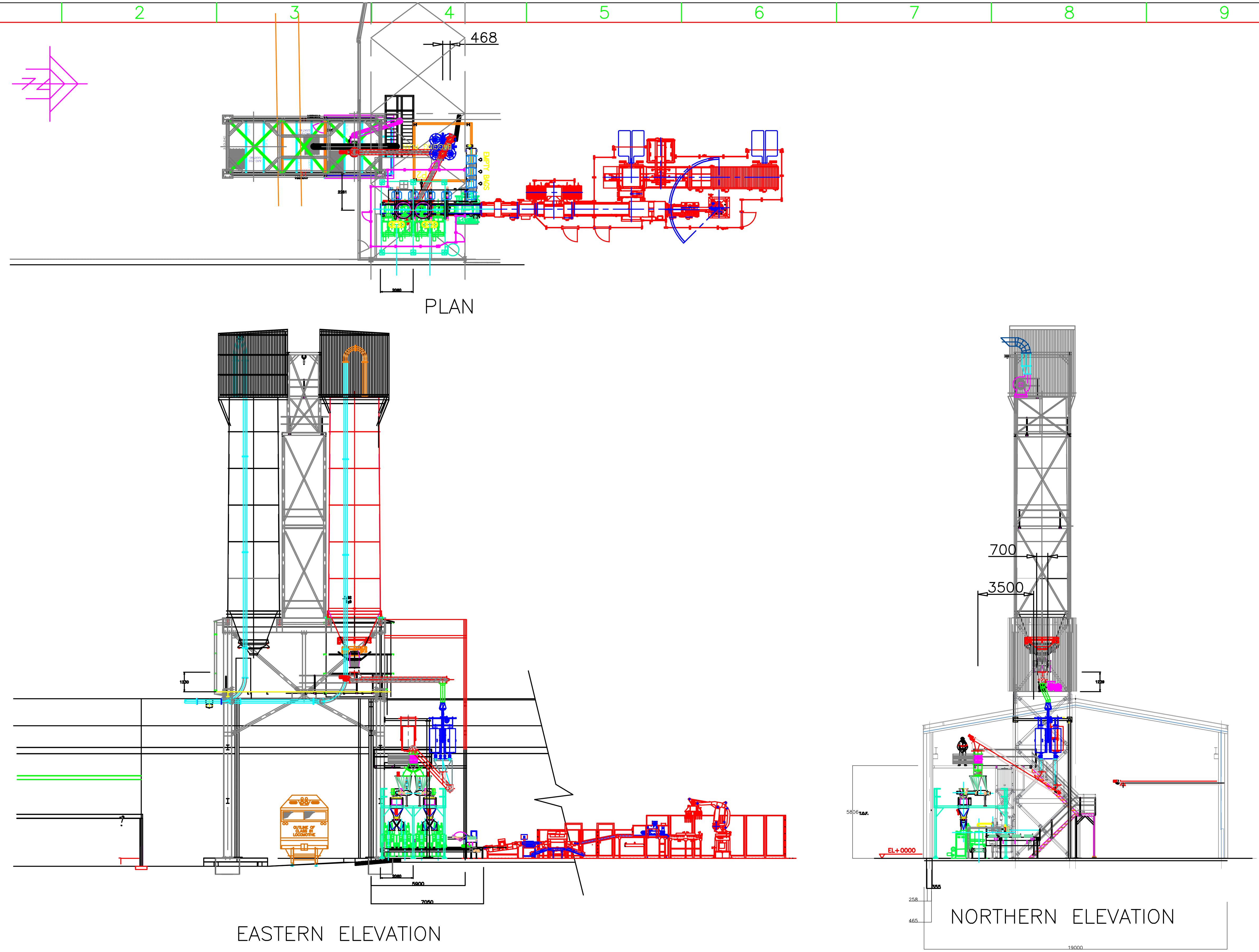

WESTERN ELEVATION.




SOUTHERN ELEVATION.

| | | | | |
|---|---|---|---|---|
| Commitment to Excellence MANILDRA GROUP 100% AUSTRALIAN GEM OF THE WEST | DRAWN Paul Caruana | DATE 02/03/18 | SITE MANILDRA – SHOALHAVEN STARCHES PTY LTD | SHT SIZE A3 |
| | DESIGNED. | DATE | JOB TITLE PROP.SPEC.PRODUCTS,PROD.DRYER,BOILERS. | SHEET |
| | CHKD | DATE | DWG TITLE PROPOSED 2nd STOREY EXTENSION TO MAIN SUB–STATION.PLAN VIEW & ELEVATIONS. | OF |
| THIS DRAWING IS A CONFIDENTIAL COMMUNICATION OF MANILDRA GROUP TO TAKE A COPY OR DISCLOSE TO A THIRD PARTY WITHOUT WRITTEN CONSENT CONSTITUTES AS AN INFRINGEMENT OF THE COPYRIGHT | APPD | DATE | | REV. |
| | | SCALE 1 : 100 | PROJECT No. 6531 / DWG No. MN6531-013 | P08 |

# 15 APPENDIX I – SIFTER (PACKING SHED) LAYOUT AND ELEVATION DRAWING




| REV | ZONE | DETAILS | DRN | DATE | CHKD | APPD |
|---|---|---|---|---|---|---|
| REV1 | ALL | PROPOSAL. | P.C. | 17/02/18 | A.T. | |

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PC Drafting 0439 436508

| | | | |
|---|---|---|---|
| DRAWN P.C. | DATE 17/0/18 | JOB TITLE SHOALHAVEN STARCHES.BOMADERRY. NSW | SHT SIZE A3 |
| CHKD K.T. | DATE | DWG TITLE STARCH PACKER RUTER SIFTER. SITE VIEWS. | REV. |
| APPD | DATE | | |
| | SCALE 1:250 | PROJECT No. 6571 DWG No. MN6571-001 | P01 |

# 16 APPENDIX J – HAZARDOUS MATERIALS PROPERTIES

# Appendix J – Hazardous Materials Properties

## *1. Wheat including Flour*

Wheat, like barley, oats and rye, is a cereal grain. Wheat grains are generally oval shaped although different wheats have grains that range from almost spherical to long, narrow and flattened shapes. The grain is usually between 5 and 9 mm in length and weighs between 35 and 50 mg.

There are three main components to the grain:

Bran:

The outer coating or "shell" of the wheat kernel is made up of several layers. These layers protect the main part of the kernel.

Endosperm:

This is the main part of the wheat kernel and represents about 80% of the kernel weight. It is from this part that white flour is milled. The endosperm is rich in energy-yielding carbohydrate and important protein.

Germ or Embryo:

This part grows into a new plant if sown. The germ lies at one end of the grain and represents only 2% of the kernel. It is a rich source of B vitamins, oil, vitamin E and natural plant fat. It needs to be removed during milling because the fat is liable to become rancid during flour storage.

Dust from wheat can be formed by activities such as loading / unloading, filling a silo, milling and pneumatic conveying. It is a potentially explosive dust when critical parameters exist, e.g. particle size less than 500 micron.

Ignition sources include (Ref 13):

- Smouldering, self-heating or burning dust;
- Open flames, e.g. welding, hot work, cutting and matches;
- Hot surfaces, e.g. hot bearings, dryers, incandescent materials and heaters;
- Lightning;
- Heat from mechanical impact or friction; and
- Electrical discharges and arcs.

$K_{st}$ is a measure of a dust's explosibility classification and is a measure of the maximum rate of pressure rise, i.e. the higher the $K_{st}$ value, the greater the explosive energy. For grain dust (i.e. flour, gluten and starch), the $K_{st}$ value is typically between 0 and 200 bar.m/s. These are deemed potentially weak explosions although it is noted that previous incidents involving grain dust explosions have led to fatalities (Refs 13 and 14).

Whilst grains are combustible when exposed to strong ignition sources, e.g. open flames, they typically burn as a smouldering type of fire and therefore do not pose significant radiant heat hazards. Smouldering grains, however, can be a precursor to dust explosions as the hot grains can provide the ignition energy to cause a dust cloud to deflagrate.

***Starch:***

Starch or amylum is a carbohydrate consisting of a large number of glucose units joined together. The chemical formula for starch is $(C_6H_{10}O_5)n$. It is not defined as a hazardous material or a Dangerous Good.

Starch is produced by most green plants as an energy store. It is the most common carbohydrate in human diets and is contained in large amounts in such staple foods as potatoes, wheat, corn, rice, and cassava.

Papermaking is the largest non-food application for starches globally. In a typical sheet of copy paper, the starch content may be as high as 8%.

Starch is a fine, white, odourless powder. The respiratory TWA (time weighted average) is 5 mg/m$^3$. It is insoluble in water. Starch is not defined as a combustible solid (it will not support combustion) but may form explosive mixtures with air. It is a potentially explosive dust when critical parameters exist, e.g. particle size less than 500 microns.

The $K_{st}$ value for starch is up to 199 bar.m/s. These are deemed potentially weak explosions.

Starch is non-toxic to people and has a low environmental impact potential. It is mildly irritating to eyes and lungs.

***Gluten:***

Gluten is a composite of storage proteins and is stored together with starch in the endosperm of the wheat grain. It is an odourless, slightly yellow powder. It is not defined as a hazardous material or a Dangerous Good.

Gluten is added to various foods to increase the protein concentration.

The $K_{st}$ value for gluten is approximately 149 bar.m/s although a value of 200 bar.m/s may be used for explosion vent sizing. These are deemed potentially weak explosions.

It is slightly hazardous in case of skin contact (irritant), of eye contact (irritant) and inhalation.

## *2. Natural Gas*

Natural gas is a Class 2.1 Dangerous Good (flammable gas).

Natural gas is a colourless hydrocarbon fluid mainly composed of the following hydrocarbons:

- Methane (typically 88.5% or higher);
- Ethane (typically 8%);
- Propane (typically 0.2%);
- Carbon dioxide (typically 2%); and
- Nitrogen (typically 1.3%).

For a typical natural gas, the TLV (threshold limit value) is approximately 1,000 ppm and the STEL (short term exposure limit) is 30,000 ppm (i.e. approaching 5 vol% which is the lower explosive limit).

The hydrocarbons are not considered to represent a significant environmental threat. Their hazard potential derives solely from the fact that they are flammable materials.

To enable ready leak detection, natural gas is normally odorised with mercaptans (sulphur containing hydrocarbons).

The flammability range is typically 5% to 15% v/v in air. The vapours are lighter than air and will normally disperse safely if not confined and/or ignited.

Natural gas ignition can lead to jet fires, flash fires or vapour cloud explosions.

Products of combustion include carbon monoxide and carbon dioxide.

## *3. Caustic Soda, Hydrochloric Acid and Cleaning Chemicals Containing hypochlorite*

Caustic soda, hydrochloric acid and sodium hypochlorite are all Class 8 corrosive liquids, i.e. there is the potential for burn injuries to personnel on contact. Hydrochloric acid and hypochlorite are also corrosive to many common materials of construction, e.g. carbon steel and concrete.

### *Caustic Soda:*

Caustic soda is a colourless liquid. It is highly alkaline and hence corrosive to human tissue and can cause serious injury to skin and eyes. Inhalation of any mist containing caustic soda can result in respiratory irritation and lung conditions such as pulmonary oedema.

It is typically transported as a 46 – 50 wt% solution although lower strengths are also produced.

Caustic soda is corrosive to aluminium, zinc, lead, brass and tin. A product of reaction with metals is hydrogen (i.e. a highly flammable gas). Care is therefore required when maintaining pipework etc containing caustic soda as hydrogen flash fires can occur, e.g. hot work in cutting through pipes.

It reacts vigorously with acids. When mixed with ammonium salts, ammonia gas will be evolved. Caustic soda will react exothermically with water. It will also attack many glasses and ceramic materials. When mixed with some organic matter (e.g. milk residues), carbon monoxide can be evolved.

Caustic soda will absorb carbon dioxide to form solid deposits, e.g. white solid deposits from small valve leaks.

Depending on the production method, caustic soda may contain trace impurities such as mercury. Mercury bioaccumulates and can cause nervous system damage. Therefore, any sludge should be considered for the presence of mercury.

When spilt, caustic soda is very slippery. At low ambient temperatures, higher strength caustic soda can freeze.

***Hydrochloric Acid:***

Hydrochloric acid is normally supplied as a 33wt% solution. It is a clear to slightly yellow fuming solution with a pungent odour.

Hydrochloric acid reacts violently with alkalis and sodium hypochlorite (the latter reaction evolves chlorine gas). It is highly corrosive to most metals with evolution of hydrogen gas (i.e. a highly flammable gas).

Exposure to hydrochloric acid can lead to severe burns and irritation. Prolonged exposure can lead to dermatitic effects.

Hydrochloric acid is not classifiable as a human carcinogen.

Hydrogen chloride gas can be released to the atmosphere by evaporation from spills of concentrated hydrochloric acid. It is toxic and acts as a respiratory irritant. It has a readily noticeable odour at low concentrations (around 0.3 ppm) that do not constitute an acute hazard; therefore, the odour acts as a hazard warning. The Time Weighted Average (TWA) exposure limit for hydrogen chloride for an eight-hour day is 5 ppm. The IDLH (immediately dangerous to life and health) value is 50 ppm.

If involved in a fire, toxic fumes can be evolved.

***Sodium Hypochlorite:***

Sodium hypochlorite is a pale, yellow-green liquid which has a slight odour of chlorine. It is normally supplied as a 10-13% w/v available chlorine solution.

Sodium hypochlorite reacts violently with acids, liberating chlorine gas (a toxic substance with a TWA of 1 ppm).

Sodium hypochlorite has a limited shelf life as it decomposes to oxygen, sodium chlorite and salt. The rate of decomposition is accelerated by exposure to light and heat and the presence of the metal iron, cobalt and nickel. The prevention of exposure of sodium hypochlorite to these elements will minimise but not eliminate the decomposition process.

Sodium hypochlorite is an alkaline oxidising agent and therefore corrosive to human tissue and can cause serious injury to skin and eyes. Inhalation of any mist containing sodium hypochlorite can result in respiratory irritation and lung conditions such as pulmonary oedema.

These materials are used on the Shoalhaven site now and hence the hazards and controls are well-known.

### *4. Cationic Starch Reagent*

The cationic (i.e. positively charged) starch reagent is not deemed to be a Dangerous Good. It is a quaternary ammonium salt ($NR_4^+$). Prolonged exposure to this material is not likely to cause significant skin irritation or impacts due to absorption.

When this reagent is converted to an epoxide (an organic compound whose molecule contains a three-membered ring involving an oxygen atom and two carbon atoms, e.g. ethylene or propylene oxide), exposure to high concentrations (of the epoxide) has produced tumours in mice. Note that the proposed process does not involve an epoxide being formed.

The reagent is a clear, odourless liquid.

Above 150 C, some components of the reagent can breakdown to materials such as chloroacetone, hydrogen chloride, methyl chloride and trimethylamine, i.e. harmful materials.

The reagent is considered to be non-toxic to aquatic organisms on an acute basis.

### *5. Hydrated Lime ($Ca(OH)_2$)*

Hydrated lime is a hazardous substance but not deemed to be a Dangerous Good. It is corrosive and an irritant.

Hydrated lime is a white to off-white powder with a bitter taste. It is a non-combustible material that is insoluble in water.

Hydrated lime is also known as slaked lime, calcium hydrate, lime hydrate, calcium hydroxide, builders lime, garden lime and plasterers lime.

All work with hydrated lime should be carried out in a manner that minimises dust generation, exposure to dust and repeated skin contact. The pH is approximately 12. Contact can severely irritate and burn the skin and eyes (eye damage is possible). Breathing calcium hydroxide can irritate the nose, throat and lungs.

When handling hydrated lime, local mechanical ventilation or extraction should be used in areas where dust could escape into the work environment. Work areas should be cleaned regularly by wet sweeping or vacuuming.

In the presence of moisture, hydrated lime may react with some metals to form hydrogen gas.

### *6. Coal*

Anthracite coal is a hard, compact variety of coal that has a submetallic lustre. It has the highest carbon content, the fewest impurities and the highest calorific content of all types of coal except for graphite.

Coal is not a Dangerous Good but is classified as hazardous according to Safe Work Australia criteria. It is a combustible solid and may form explosive dust mixtures with air. When involved in a fire it may evolve toxic gases, e.g. carbon monoxide, nitrogen and sulphur oxides, and hydrocarbons.

Spontaneous combustion may occur under storage conditions of elevated temperatures and a continuous supply of oxygen. Smouldering combustion of coal can also lead to flammable gases such as methane and carbon monoxide. These can cause explosions when confined and ignited, e.g. in silos.

Coal may also evolve toxic coal ash decomposition products such as mercury, arsenic, selenium, cadmium and lead when burnt.

### *Coal Ash:*

Coal ash is the waste that is left after coal is combusted (burned). It includes fly ash (fine powdery particles in the combustion gas stream and captured by pollution control devices such as cyclones and baghouse filters) as well as coarser materials that fall to the bottom of the furnace.

Depending on where the coal was mined, coal ash typically contains heavy metals including arsenic, lead, mercury, cadmium, chromium and selenium, as well as aluminium, antimony, barium, beryllium, boron, chlorine, cobalt, manganese, molybdenum, nickel, thallium, vanadium, and zinc.

The US Environmental Protection Agency has found that living next to a coal ash disposal site can increase the risk of cancer or other diseases. If eaten, drunk or inhaled, these toxic materials can cause cancer and nervous system impacts such as cognitive deficits, developmental delays and behavioural problems.

### *Boiler Feedwater Chemicals:*

Note: The site's boiler feedwater dosing chemicals will not change as a result of this project.

# 17 Appendix K – Hazardous Event Word Diagrams

**Preliminary Hazard Analysis, Shoalhaven Starches, Modification to MP06_0228**

## Appendix K – Hazardous Event Word Diagrams

### Table 10 – Rail Intake Pit Hazardous Event Word Diagram

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 1. | Ignition of the wheat grains | Strong ignition source, e.g. hot work.<br>Self-heating | Smouldering local fire leading to equipment damage.<br>Potential for the smouldering wheat to propagate to a dust explosion, e.g. within the bucket elevator or receiving silo | Control of ignition sources, e.g. hot work permit.<br>Equipment designed to ATEX including hazardous area assessment.<br>The design will avoid low points / dead-legs where wheat can accumulate and self-heat.<br>Fire water available from the existing fire hydrant system |
| 2. | Ignition of confined wheat dust with the bucket elevator | Foreign object, belt slip, poor belt tracking, friction.<br>Failure of the drive end clutch resulting in high temperatures | Potential for an internal dust explosion, e.g. within the bucket elevator or receiving silo | Bearings are external. Belt drift / mis-alignment sensors. Aspiration system (with interlocks).<br>Equipment designed to ATEX including hazardous area assessment |

## Table 11 – Mill C Hazardous Event Word Diagram

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 3. | Bucket elevators and drag chain conveyors | Ignition of confined wheat dust | Foreign object, belt slip, poor belt tracking, baghouse fire / explosion propagating back to the elevators. Failure of the drive end clutch resulting in high temperatures. Flame will propagate to screw - chain conveyor and spread throughout the mill | Product and equipment fire, potential for internal dust explosion | Bearings are external. Belt drift / mis-alignment sensors. Aspiration system (with interlocks). Equipment designed to IECEX including hazardous area assessment. Foreign objects removed via screen and separators. Belts are self-extinguishing, anti-static, flame retardant, oil resistant, very low elongation |
| 4. | Hazardous Zoning | Explosion | Static electrical explosions | Explosion - fire, loss of life, equipment damage, production downtime | Earthing of equipment, static bonding, preventative maintenance in hazardous areas |
| 5. | Whole Mill | Dust explosion | Loss of containment of dust within the building, e.g. failure of product lift pipe | Dust explosion within the building, loss of life, equipment damage, production downtime | Sealed process systems lowering the likelihood of leaks, aspirated system, instrument and electrics to hazardous zones, housekeeping. Permit to work system requiring adequate cleaning and control of ignition sources. Positive pressure ventilation within the building |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 6. | Magnetic separators | Fire | Failure of magnets | Metal particles through the process - ignition source due to impact or friction | Daily checks, cleaned every morning. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed |
| 7. | Aspiration system | Propagating explosion | Charged particles on the conveyor | Fire / explosion could propagate to other equipment, e.g. dust collectors | Design of process includes explosion vents on the dust collectors. Removal of ferromagnetic materials via magnets |
| 8. | LAAB Cleaning Separator | Static explosion | Static electricity from product flowing over the flour trays (vibrators and motors) | Static fire, causing explosion | All equipment is bonded and earthed |
| 9. | Mill A or B | Fire or Explosion | Fire or explosion event in Mill A or B | Loss of life, equipment damage, production downtime. These events can also propagate to Mill C | Process is designed for containment with foreign object removal, e.g. magnetic separators.<br>Equipment designed to ATEX standards.<br>Interlocks on loss of air flow through the dust collectors and blowlines.<br>Positive pressure ventilation within the building.<br>Mills A and B&C are separated by the building walls |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 10. | Rollers | Dust explosion | Broken roller, failed roller mechanism, failure of equipment | Dumping of product in front of inspection flap, i.e. flour pushed up the inlet chute and a loss of containment from choking of the system. Dust in the area that can settle on motors causing heat build-up. This can result in ignition of product from hot motor. Build-up of product on the roller that continues to roll. Overfill the inlet chute as above, heating of the flour due to the rollers and hence a possible smouldering fire | Covers over motor, high level switch, programmed maintenance every three months, housekeeping, testing of sensors to ensure sensitivity is suitable |
| 11. | Rollers / Impact Detacher (machines) | Hot surfaces – burn hazard to personnel | Rollers running hot, e.g. unable to segregate wheat products, relifts pipes choke and leading to friction causing heat. Internal ignition within the rollers | Potential for burn injury to worker. Also, there is the potential for a fire within the building | Preventative maintenance on all rotating equipment. High level alarm will detect choking, inspections every hour during staffed times, housekeeping within the building, hazardous area zones. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 12. | Rollers | Dust explosion | Foreign object within the rollers, e.g. failure of the magnets, or static | Dust explosion that can propagate to other equipment, injury and production downtime | Maintenance, inspections and housekeeping on the magnets. Procedures for checking the source of particular items (e.g. ball bearings) when they appear on the magnets. Regular walkthroughs during staffed hours would pick up noises in the rollers. Designed to IECEX standards |
| 13. | Detachers | Dust explosion | Foreign object (e.g. detacher pin release), plate contact within the detacher, static | Fire within the detacher which has the potential to propagate to the dust collector via the cyclone | Explosion vent on the dust collector, detacher earthed, magnet prior to the rollers, preventative maintenance on the detacher |
| 14. | Detachers | Fire | Hand hold leak – gravity feed product (vacuum) product will settle on motor and hence will heat up (source of ignition) | Heat from motor causing fire hazard | Operators trained to replace inspection hatch covers, walkthroughs to detect abnormal conditions, housekeeping, hazardous area zones. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed. Positive pressure ventilation within the building |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 15. | Distributors – Cyclones | Dust explosion | High velocity impact / object | Propagate to dust collectors. Dust collector fills up with dust and product | High level switch stops the mill (dust collectors and filtered flour hopper). Magnetic separators before the rollers, explosion vents on dust collectors, earthing and bonding |
| 16. | Sifters | Fire / Explosion | Mechanical / electrical problems, counter weight within sifter coming loose (1 te each), choke underneath one of the sifters leading to too much flour on one side of a sifter | Sifters out of alignment, structural damage to building, worn electrical cables due to excessive vibration which could lead to ignition | When the sifter motors stop, it will be alarmed and the Mill will trip, safety cables (16mm stainless cable) on the sifters, canes (nylon or timber) on each corner of sifter, rotation sensor on top of each of the sifters. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed |
| 17. | Sifters | Explosion | Failure of connecting socks | Loss of containment of flour dust with potential of ignition – explosion in the building | Sensors on each of the bottom socks – if they disconnect – break the beam and stop the mill (bottom socks only – not the top socks). Walkthrough observations |
| 18. | Rotary Valves | Explosion | Surface ignition, e.g. from a foreign object | Potential for a fire / explosion | Magnets and screens |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 19. | Transfer to Flour Bins | Loss of containment of product – enclosed area | High level switch failure on a bin | Overfill bins and the flour is blown into the aspiration lines to the dust collector which fills up and then escapes to the atmosphere via the air inlet line | High pressure trip on the blowers. Level sensor calibration |
| 20. | Dust Collectors | Explosion | Static, carryover spark. Propagation of fire event from elsewhere in the process, e.g. burning embers | Explosion resulting in equipment damage (the dust collectors are located on the roof of the building) | Earthing / bonding of all equipment. Hazardous area zones. The switches on the explosion vents stop the mill including the rotary seals to stop the explosion propagating. Induced draft which keeps the concentration kept below the LEL. All filters are pulsed with air for cleaning, pressure is measured and checked every day. If issues arise the socks are changed. The socks are also changed every 6 months. Anti-static socks.<br>Explosion propagation prevention as per Mill B, e.g. one-way valves |
| 21. | Dust Collector | Release of product | Failed sock | Product release impacting the environment | Visual detection, reporting from outside sources, sock replacement every 6 months – as above. LEL levels not reached, i.e. not considered to be an ignition risk |

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 22. | Silos and bins | Dust explosions and fires | Static, foreign object, hot work | Confined dust explosion with damage to the silos and bins, potential for injury to people | All equipment containing dust are to be designed to IECEX standards.<br>The mill is to be rated for hazardous zones including electrics and instruments are to be suitably rated and all equipment is to be bonded and earthed. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed.<br>Permits to work |
| 23. | Mill feed blowline | Internal dust explosion within the blowline | Low likelihood event, e.g. static | As the blowline is to be designed for containment then the flame front will travel to the downstream bin | Bonding and earthing of the entire blowline, no other sources of ignition present during normal operation, control of ignition sources during maintenance, high pressure trip on the blower |

## Table 12 – Gluten Dryer 8 Hazardous Event Word Diagram

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 24. | Dust explosions within the new equipment, e.g. the grinder, disintegrator, screw conveyers, rotary seal valves and hoppers | Ignition of combustible dust, e.g. due to smouldering, open flames, hot surfaces, lightning, heat from mechanical impact or friction, and electrical discharges and arcs | Damage to the processing equipment and injury to personnel. Potential propagation to the combustible material processed and stored in the building. Products of combustion emitted with the potential to impact people and the environment. The explosion can also travel throughout equipment with the potential for pressure piling and hence more significant explosive energy. Projectiles are possible with the risk of injury to people and damage to equipment | All equipment containing dust is to be designed to ATEX standards including explosion vents and airlocks to separate transfer systems.<br><br>Housekeeping to keep the area dust-free.<br><br>The building is to be rated for hazardous zones including electrics and instruments are to be suitably rated and all equipment is to be bonded and earthed.<br><br>Permit to work system requiring adequate cleaning and control of ignition sources.<br><br>Condition monitoring of equipment and preventative maintenance to limit the probability of hot surfaces from friction occurring.<br><br>Underspeed detection on the screw conveyors, high level detection in the baghouse filters.<br><br>Use of fire hoses and steam to quench smouldering fires.<br><br>As the minimum ignition temperature for gluten is approximately 470 C and higher, maintenance of equipment and possibly |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| | | | | detection by operators may prevent hot surfaces initiating a dust explosion.<br><br>Spark arrester installed upstream of the hot air box to mitigate flames being emitted from the air intake.<br><br>Magnetic separator before the grinder |
| 25. | Explosion in a dust collector | Propagation of fire event from elsewhere in the process, e.g. burning embers drawn into the dust collector | Explosion with the potential for injury and equipment damage | Inducted draft which keeps the concentration below the LEL (lower explosive limit). All filters are to be pulsed with air for cleaning. All filters are to be checked routinely by maintenance for high differential pressure (DP). If issues arise then the socks are changed. Explosion vents installed |
| 26. | Explosion in the dryer | Build-up of solids within the dryer piping, carryover from the hot box | The deposits can self-heat and auto-ignite resulting in a fire / explosion. The flames can be emitted from the air intake, i.e. fire hazard to personnel | Routine cleaning of equipment to prevent material build-up, spark arrester |
| 27. | Fire in the grinder | Blocked dust collector on the grinder | Material heating due it being trapped in the grinder and therefore continuous grinding | High dust collector DP (differential pressure) trip on the grinder.<br><br>High level probe on hopper below the grinder.<br><br>Grinder amps monitored |
| 28. | Dust explosion | Loss of containment of dust within the dryer building, e.g. failure of product lift pipe | Dust explosion within the building, loss of life, equipment damage, production downtime, potential for both a primary and secondary explosion | Sealed system lowering the likelihood of leaks, aspirated system, instruments and electrics rated to hazardous zones, housekeeping.<br><br>No purlins on the inside of the building where dust can accumulate |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 29. | Fire / explosion in the disintegrators | Foreign objects in the disintegrator causing ignition which can propagate to other equipment | Injury to workers, production downtime due to equipment damage and product loss. Secondary explosion possible. Foreign objects can also block the disintegrator feed chute | Temperature sensor, vibration transmitter on the disintegrator.<br><br>Magnetic separator prior to the grinder.<br><br>Equipment designed to ATEX standards |
| 30. | Loss of the dust collectors fans | Potential for the combustible dust concentration to increase and enter the explosive range | The plant will be tripped on loss of the dust collectors fans | Hoerbiger valves installed for explosion protection of the grinder, the equipment is to be rated for hazardous zones including electrics and instruments are to be suitably rated and all equipment is to be bonded and earthed |
| 31. | Blockage of the blowline from the grinder | Material buildup, blower failure, baghouse exhaust fan failure | Material build up in the grinder with potential for heating and hence fire and explosion | Dryer tripped on loss of a blower and other essential drives.<br><br>Pressure monitoring on the blowline.<br><br>High level trips, e.g. in the baghouse filter |
| 32. | Overfilling a silo or bin | Failure of the level instrument monitoring the gluten level within the silos or bins | The gluten level can overflow the silo or bin via the aspiration system. This can lead to dust explosions | Independent high level trip on the silos and bins to stop the filling system, the building is to be rated for hazardous zones including electrics and instruments are to be suitably rated and all equipment is to be bonded and earthed |
| 33. | Release of gluten from the blowline | Erosion, explosion vent opening, gasket failure | Loss of containment of gluten to atmosphere potential for environmental impact and possible ignition | Schedule 40 pipe for extra thickness, long radius elbows used to minimise the risk of erosion |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 34. | Natural gas explosion within the dryer | Natural gas flow when the burners are offline | Buildup of natural gas in the ducting. If ignited, there is the potential for an internal explosion | Burner management system will be certified to Australian Standards which will include the need for adequate natural gas isolation and air purging prior to startup.<br><br>The explosion vents for dust explosions will also limit the developed overpressures for an internal gas explosion |
| 35. | Loss of containment of natural gas from the supply pipe | Pipe failure, e.g. corrosion or weld defect, gasket failure, valve leak, impact | If ignited, potential for a jet fire, flash fire or explosion which can impact personnel and equipment | The natural gas supply pipe is to be tied into the existing natural gas supply pipe system that runs through the site at present. This is an existing site risk.<br><br>The pipe is to be protected from impact by locating it in a piperack.<br><br>Minimum flanges used.<br><br>Pipe to be included in the hazardous zone study.<br><br>Remote isolation of the natural gas is possible at the gas metering station.<br><br>The natural gas supply pipe is to be pressure tested following construction and protected against corrosion by painting.<br><br>The natural gas piping and equipment items are to be compliant with the Australian Standards |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 36. | Overheating of the gluten in the dryer | Loss of temperature control | Potential for autoignition of the gluten | High temperature trip on the dryer outlet (hard wired to the burner).<br><br>Gluten has a relatively high autoignition temperature of 470oC.<br><br>Spark arrestor on the discharge of the air heater |
| 37. | Release of gluten | Failed sock in a dust collector | Gluten release and environmental impact | Visual detection of an emission and response, reporting from outside sources, LEL levels not reached, i.e. not considered to be an ignition risk. Maintenance of the socks to check the integrity |

## Table 13 – Modified Starches Plant Hazardous Event Word Diagram

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 38. | Dust explosion. Smouldering fire | Foreign objects in the feed entering the screw conveyors with other causal events, e.g. magnets failure. Bearing failure.<br>The above causes can initiate fires and dust explosions | Starch ignition and fire through process, loss of production. Potential for an internal explosion | Starch is conveyed from SD5 which has screens, magnetic separators and sieves. Blocked chute detection. Regular preventative maintenance (PMs) on the screw conveyors (typically once every eight weeks) | No further action required |
| 39. | Loss of containment of caustic | Level control failure leading to tank overfill. Pipe leak. Pump leak | Potential for corrosive impact to personnel | High tank level alarm and trip. Pipes to be stainless steel with minimum joints. Tank to be bunded. Site practice is to use mono pumps / positive displacement for caustic. Safety showers and eyewash units | No further action required |
| 40. | Loss of containment of reagent | IBC leak including being dropped from a fork lift truck (FLT) or damaged from the FLT tynes. Pipe or hose leak. Pump leak. Reagent dripping from a pump spear when removed from the IBC | Potential for irritation impact to personnel | All FLT drivers trained. FLTs speed limited to 10 kmh. Stainless steel piping with minimum joints. IBCs to be in a bunded area | No further action required |
| 41. | Burn injury | Person contacts hot equipment (the starch mixture is approximately 70 C) | Burn injury | All equipment and piping to be insulated where the temperature is above 60 C | No further action required |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 42. | Loss of containment of HCL | Level control failure leading to tank overfill. Pipe leak. Pump leak | Potential for corrosive impact to personnel. Corrosive impact to equipment | High level alarm and trip. Pipes to be poly (HCl compatible) with minimum joints. Tank to be bunded. Site practice is to use diaphragm pumps for HCl with pulsation dampeners. Safety showers and eyewash units | Review the source for the HCl supply. Provide Perspex splash guards for the HCl and caustic pumps, i.e. to prevent a sprayed leak contacting personnel |
| 43. | Dust explosion | High velocity impact of an object (e.g. metal) causing a spark and hence ignition | Dust explosion which can propagate to the dust collectors. Impact to people, equipment and the business | Explosion vents on dust collectors, earthing and bonding, yearly inspections and maintenance, sieves in the starch supply plant | No further action required |
| 44. | Explosion | Surface ignition, e.g. from a foreign object | Potential for a fire / explosion which can propagate to connected equipment | Magnets and screens in SD5. Slow speed (15 to 20 rpm) for the rotary valves. Overload trips on the rotary valves | No further action required |
| 45. | Dust explosion | Loss of containment of dust within the building, e.g. failure of containment | Dust explosion within the building, loss of life, equipment damage, production downtime | Sealed system lowering the likelihood of leaks, aspirated system, daily housekeeping. Minimum ledges on the inside of the buildings. Hazardous area assessment. Control of ignition sources (permits) | No further action required |
| 46. | Exposure to rotting product | Buildup of product in non-conveying areas | Illness, e.g. due to biological growth | Maintenance / cleaning. Aspiration to be designed to remove humid air and hence blockages | No further action required |
| 47. | Explosion | Dust collector explosion due to static, hot ember (e.g. from screw conveyors), air lock (rotary valve) failure and hot work | Dust explosion leading to a fire, loss of life, equipment damage and production downtime. The explosion can also propagate throughout the process | Explosion vents on all dust collectors. Interlock between the operation of the dust collector and the modified starches equipment | No further action required |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 48. | Dust explosion within other equipment | Propagation of event from elsewhere in the process, e.g. burning embers or flame front travels to the dust collectors | Explosion that can result in damage to the dust collector and propagation to connected equipment items. Injury to personnel | Induced draft which keeps the concentration below the lower explosion limit (LEL). All dust collectors are pulsed with air for cleaning the socks. If issues arise the socks are changed (differential pressure gauge across the socks). The socks are also changed as needed as determined by the differential pressure monitoring. Explosion vents on all dust collectors that vent outside the building or will be flameless vents | No further action required |
| 49. | Release of product | Failed sock | Product release, i.e. impact to the environment and people | Visual detection, sock replacement as required - as above. LEL levels not reached, i.e. not considered to be an ignition risk | No further action required |
| 50. | Fire / explosion | Mechanical / electrical problems, choke underneath the sifter leading to too much starch on one side of the sifter | Sifter out of alignment, structural damage to building, worn electrical cables due to excessive vibration which could lead to ignition if a sock fails | Sifter motors trip the plant, safety cables on the sifter, canes (nylon or timber) on each corner of sifter, out-of-balance sensor on top of each of the sifter will trip the sifter, spill detectors (i.e. dust detection monitors), flexible electrical cables, overload trips, PMs for the sifters bearings | No further action required |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 51. | Explosion | Failure of connecting socks | Loss of containment of dust with potential of ignition and hence an explosion in the building. This is more likely for a top sock failure with the dust falling on to the moving sifter. Impact to people, equipment and the business | Walkthrough observations by the operators, operators respond to a loss in plant yield, spill detectors | No further action required |
| 52. | Hit by moving object | Human factors, e.g. person concentrating on a task beside a sifter | Operator injury if struck by a sifter | Procedures for attaching socks. Vigilance in that area to remain away from the sifter when in operation. Signage to state that machine starts automatically | No further action required |
| 53. | Dust explosion | Ignition of combustible dust cloud, e.g. tramp metal, hot work, foreign object and hot ember | Dust explosion within the bin resulting in equipment damage and harm to people | Low likelihood of ignition due to removal of foreign objects via the sifter, hot work permits, regular bin turn-over, moisture content is approximately 18%, all bins are aspirated | No further action required |
| 54. | Release of starch | Overfilling the bins | Product loss impacting the environment | High level alarms and trips. Blocked chute detection (trips) installed on screw conveyors. Conveyors have trips on the motors | No further action required |
| 55. | Deadhead the blower | Material hold-up, discharge valves in the closed position | Maximum pressure within the pipe and hence the potential for a loss of containment. Fire or explosion if ignited. Impact to people, equipment and the business | Pressure safety valve on the blower which will only release air, not starch. High pressure trips the process. Steel pipe. Belt driven blower | No further action required |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 56. | Air pollution | Loss of containment of starch from a failed blowline (erosion) outside the building | Pollution - starch could be blown off site and hence environmental impact | Blowline made from stainless steel (i.e. hard wearing). Not a confined area, open to elements, no explosion risks. Historically, the holes start small and hence allow corrective action. Long radius elbows with routine inspection | No further action required |
| 57. | Explosion | Low likelihood event, e.g. static or friction | As the blowline is designed for containment then the flame front will travel to the downstream bin | Bonding and earthing of the entire blowline. The blower is a rotary lobe machine and hence mitigate reverse flow out through the air inlet. Dust concentration normally below the approximate lower explosion limit (LEL). NRVs on the rotary lobe blower ## | No further action required |
| 58. | Ignition of starch | Foreign object, contact between the paddles and the mixer shell, i.e. these can cause sparks | Potential for ignition of the starch leading to a fire and explosion | Clearance gap for mixer design with PMs | Include a magnetic separator on the starch feed as the starch is sourced from the SD5 final product hopper, i.e. before the SD5 magnetic separator |
| 59. | External fire / explosion involving natural gas | Leak of natural gas, e.g. piping failure | Jet, flash fire or explosion if the natural gas is ignited, i.e. injury to people and damage to equipment | Australian Standard compliant piping system, routine piping inspections, large building with ventilation to avoid confinement | No further action required |

| Event Number | Hazardous Event | Causes | Possible Consequences | Safeguards - Prevention Detection Mitigation | Actions |
|---|---|---|---|---|---|
| 60. | Internal explosion | Natural gas passing into the dryer when it is off-line | If ignited (e.g. at startup), there is the potential for an internal explosion leading to equipment damage and missiles. Potential for injury to personnel | Burner to be designed and certified to the relevant Australian Standards (e.g. AS3814). Note that a steam heater may be used in place of the burner | No further action required |
| 61. | Internal explosion | Broken pin, shaft out-of-alignment, bearing failure, too much feed / choking, foreign object | If ignited, there is the potential for an internal explosion leading to equipment damage and missiles. Potential for injury to personnel | Casing temperature and vibration monitored via the PLC, regular PMs including balance checks, motor overload trip, high level switch within the casing, casing rated for 10 barg (i.e. designed for an internal dust explosion) | Include a speed sensor with a low alarm for the case when the belt fails and hence material will choke inside the pin mill and hence cause friction (an ignition hazard) |
| 62. | Chlorine formation | Mixing HCl and the cleaning liquid which contains hypochlorite | HCl and hypochlorite react to form chlorine gas which is a toxic gas, i.e. impact to people | Spill response procedures when a leak occurs, i.e. the spill is to be immediately handled and hence avoid another (later) spill mixing with it | No further action required |

## Table 14 – Starch Dryer 5 Modifications Hazardous Event Word Diagram

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 63. | Explosion | Dust collector explosion due to static, hot ember (e.g. from screw conveyors), air lock (rotary valve) failure and hot work | Dust explosion leading to a fire, loss of life, equipment damage and production downtime. The explosion can also propagate throughout the process | Explosion vents on the dust collector. Interlock between the operation of the dust collector and the dryer |
| 64. | Dust explosion within other equipment | Propagation of event from elsewhere in the process, e.g. burning embers or flame front travels to the dust collector from the dryer | Explosion that can result in damage to the dust collector and propagation to connected equipment items. Injury to personnel | Induced draft which keeps the concentration below the lower explosion limit (LEL). All dust collectors are pulsed with air for cleaning the socks. If issues arise the socks are changed (differential pressure gauge across the socks). The socks are also changed as needed as determined by the differential pressure monitoring. Explosion vents on the dust collector that vent outside the building or will be flameless vents |
| 65. | Release of product | Failed sock | Product release, i.e. impact to the environment and people | Visual detection, routine sock replacement. LEL levels not reached, i.e. not considered to be an ignition risk |

**Table 15 – Boiler 8 and the Co-Generation Plant Hazardous Event Word Diagram**

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 66. | Coal dust explosion (this is an existing hazard for Boilers 5 and 6 and also for Boilers 2 and 4 when they were previously operated on coal) | Attrition of coal particles and ignition of the fine particulates e.g. static in the denseveyor, hopper, hot work adjacent to the denseveyor seals where losses of containment of particles can occur | Equipment damage, injury (engulfment) from dust fire / explosion | Unlikely event given the limited quantities of coal dust expected as per the history of operation for Boilers 2, 4, 5 and 6 and hence operating below the lower explosion limit.<br><br>Earthing of equipment.<br><br>Sprinklers will be installed over the denseveyor so product is moist (not dusty).<br><br>Control of ignition sources (hot work permit). |
| 67. | Coal stockpile fire (this is an existing hazard for Boilers 5 and 6 and also for Boilers 2 and 4 when they were previously operated on coal) | Source of ignition such as hot work, lightning strike and self-heating | Local coal fire resulting in equipment damage and products of combustion (i.e. environmental impact) which could include methane and carbon monoxide | Control of ignition sources (hot work permit).<br><br>Direct water injection to the coal bunkers and isolations on the chutes.<br><br>Hydrant system and hoses for fire attack response.<br><br>Emergency Response Team on site.<br><br>Operator response to the initial combustion, i.e. by smell and/or sight.<br><br>Water sprinklers on coal stockpile (adjacent to the boilerhouse) |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 68. | Fugitive coal dust emissions | Dust build-up on pipes and structures within the coal fired boiler houses | Destruction of boiler house due to a coal dust explosion and significant injury to workers | Regular housekeeping / cleaning of coal dust build-up |
| 69. | Fire propagation back through the coal feed system | Fire from grate burns upward to the coal bunker, in particular, when the feed system is shutdown | Equipment damage, injury coal fire | Steam sparge system that will extinguish a fire, controlled automatically via thermocouples.<br><br>Guillotine door closes when feed system stops |
| 70. | Natural gas explosion within the boiler | Natural gas flow when the burners are offline | Buildup of natural gas in the furnace. If ignited, there is the potential for an internal explosion | Burner management system will be certified to Australian Standards which will include the need for adequate natural gas isolation and air purging prior to startup |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 71. | Loss of containment of natural gas from the supply pipe | Pipe failure, e.g. corrosion or weld defect, gasket failure, valve leak, impact | If ignited, potential for a jet fire, flash fire or explosion which can impact personnel and equipment | The natural gas supply pipe is to be tied into the existing natural gas supply pipe system that runs through the site at present. This is an existing site risk.<br><br>The pipe is to be protected from impact by locating it in a piperack.<br><br>Minimum flanges used.<br><br>Pipe to be included in the hazardous zone study.<br><br>Remote isolation of the natural gas is possible at the gas metering station.<br><br>The natural gas supply pipe is to be pressure tested following construction and protected against corrosion by painting.<br><br>The natural gas piping and equipment items are to be compliant with the Australian Standards |
| 72. | Boiler rupture | Low level, loss of boiler feed water pumps, high and low factory demand for steam, failure of level control, control valve stuck closed, low level in deaerator | Catastrophic failure of the boiler, i.e. equipment damage and injury to personnel. Potential for missiles | Australian Standard compliant low level protection, standby boiler feed water pumps, low and low-low level alarms, boiler trip on low-low level, maintenance on the valves and instruments), low level alarm and trip on the deaerator, operator checks on the boiler and deaerator sight glasses |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 73. | High pressure within the furnace | Tube failure within the furnace, loss of the induced draught fan | Potential for flames to be emitted from the furnace openings and hence injure personnel and damage equipment | PMs on the tubes (annual inspection), furnace trip logic to prevent high pressure (trips the forced draught fan as well as the furnace air fan), common alarm sounds on high pressure (control room roof), fan maintenance |
| 74. | Boiler rupture | Corrosion, e.g. poor boiler feed water chemistry.<br><br>Erosion, e.g. from two phase flow | Catastrophic failure of the boiler, i.e. equipment damage and injury to personnel | Water softeners on all boiler feedwater circuits, dosing of corrosion inhibitor and oxygen scavenger, daily sampling, pH and TDS (total dissolved solids) checks, routine equipment inspections (weekly, monthly and yearly) |
| 75. | Failure of the steam drum or high pressure piping | Corrosion (e.g. under lagging corrosion), weld defect, safety relief valves stuck closed, failure of letdown valves, on low level when the tubes are heated and water is added then the water can flash to develop high pressure | Catastrophic failure of the steam drum or piping, i.e. equipment damage and injury to personnel (potential fatality as steam can fill the building very quickly). Note that superheated steam has a near-invisible jet close to the leak, i.e. difficult to detect | Routine inspections (piping and equipment), operator inspections, operator training (boiler emergency procedure to delay the re-introduction of water following a low-low water level event), redundant safety valves, certifications on equipment, high pressure alarm for operator response |
| 76. | Corrosive burns from caustic dosing to the boiler feed water | Losses of caustic containment e.g. gasket failure | Corrosive burn to personnel | System designed for containment, PPE (personal protective equipment), safety shower / eye wash station, bunded area |
| 77. | Environmental impact from loss of containment of dosing chemicals | Leaks from IBCs, e.g. forklift tynes impact, hose / joint failures | Environmental impact from loss of containment of dosing chemicals | Bunded area, maintenance procedures, operator inspections, losses pumped to the WWTP |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 78. | Steam turbine overspeed | Coupling failure, high steam flow, load rejection | Potential for the turbine blades to be ejected from the casing and hence cause injury and equipment damage. Catastrophic turbine failure | Mechanical (eccentric bolt) and SIL rated electronic overspeed protection.<br><br>Overspeed trip testing.<br><br>Maintenance on the steam flow control valve |
| 79. | Release of fly ash | Failed sock within a baghouse filter, e.g. due to sock blockage and high differential pressure, and wear and tear of socks | Potential impact to people due to inhaled dust, e.g. silicosis, as well as exposure to heavy, toxic metals, e.g. may cause cancer or nervous system damage for long term exposure.<br><br>Potential to impact the environment, i.e. increase in background dust levels | Maintenance (e.g. regular sock replacement and filter inspections at major shutdowns).<br><br>Replacement socks to meet the original equipment manufacturers specifications.<br><br>Air pulsing used to reduce high differential pressure across the socks.<br><br>Visual detection of a fail sock and hence maintenance.<br><br>Reporting from observations.<br><br>Pressure differential measured across the baghouse filters and hence operator inspections.<br><br>Obscuration meter and impact detectors on top of the stack.<br><br>Regular operator check to confirm warm screw conveyor temperature |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|
| 80. | Release of fly ash when it is deposited on the roads at the Shoalhaven Starches farm | Fly ash drying and moved by the wind or vehicles | Potential impact to people due to inhaled dust, e.g. silicosis, as well as exposure to heavy, toxic metals, e.g. may cause cancer or nervous system damage for long term exposure.<br><br>Potential to impact the environment, i.e. increase in background dust levels | Water, syrup and calcium chloride are used to manage road dust levels associated with the ash (fly and bottom).<br><br>The farm roads are also sealed with coal wash.<br><br>This disposal method is EPA approved |
| 81. | Fire in a baghouse | Ignition of carryover fly ash and socks smouldering | Damage to equipment, environmental impact, loss of production | Obscuration meter in the stacks.<br><br>Alarm on high temperature in the baghouses.<br><br>Hydrant system and hoses for fire attack response.<br><br>Emergency Response Team on site |
| 82. | Failure of the lime addition desulphurisation process | Blockage, air blower failure, no lime in the silos | Breach of SOx emissions targets | Two silos with level monitoring.<br><br>Lime dosing system monitoring with alarms.<br><br>Analysis of flue gas composition |

| Event Number | Hazardous Event | Causes | Consequences | Safeguards -<br>Prevention<br>Detection<br>Mitigation |
|---|---|---|---|---|
| 83. | Loss of containment of lime | Silo filter bag failure, eroded hose or pipe, pipe or joint failure | Corrosive impact to people and the environment | Lime storage and handling system to be designed to industry good practice, e.g. long-radius bends in piping.<br><br>Emergency response will include sweeping and/or vacuuming of any spills to avoid impact to people and the environment.<br><br>Silo's filters to be air pulsed with routine inspection and replacement of the bags |

## Table 16 – Additional Sifting Equipment for the Packing Plant Hazardous Event Word Diagram

| Event Number | Facility Area / Activity | Hazardous Event | Causes | Consequences | Existing Safeguards - Prevention Detection Mitigation |
|---|---|---|---|---|---|
| 84. | Magnetic separators | Fire | Failure of magnets | Metal particles through the process to the product, i.e. business reputation and customer impact | Daily checks, cleaned every morning |
| 85. | Sifters | Fire / Explosion | Mechanical / electrical problems, counter weight within sifter coming loose, choke underneath one of the sifters leading to too much flour on one side of a sifter | Sifters out of alignment, structural damage to building, worn electrical cables due to excessive vibration which could lead to ignition | When the sifter motors stop, it will be alarmed and the process will trip, safety cables (16mm stainless cable) on the sifters, canes (nylon or timber) on each corner of sifter, rotation sensor on top of each of the sifters. Fire sprinkler system, fire hose reels, hydrants and fire extinguishers installed |
| 86. | Sifters | Explosion | Failure of connecting socks | Loss of containment of flour dust with potential of ignition – explosion in the building | Sensors on each of the bottom socks – if they disconnect – break the beam and stop the process. The packing shed is occupied when operational and hence any releases will be immediately observed |

# 18 APPENDIX L – DUST HAZARD ANALYSIS DESCRIPTION

## Appendix L – Dust Hazard Analysis Description

For each identified cause-consequence combination of interest for an identified hazardous event, the risk, i.e. consequence times likelihood, is assessed using the CCPS dust hazard analysis methodology and Pinnacle Risk Management's risk matrix.

The Pinnacle Risk Management risk matrix is shown in Figure 9.

### Figure 9 – Risk Matrix

| | Severity of Consequences | | | | | |
|---|---|---|---|---|---|---|
| Likelihood | Minor 1 | Significant 2 | Severe 3 | Serious 4 | Extremely Serious 5 | Catastrophic 6 |
| Frequent > 1/yr | II | II | I | I | I | I |
| Probable $>10^{-1}$ to 1/yr | III | II | II | I | I | I |
| Possible $>10^{-2}$ to $10^{-1}$/yr | III | III | II | II | I | I |
| Unlikely $>10^{-4}$ to $10^{-2}$/yr | III | III | III | III | II | I |
| Very Unlikely $>10^{-6}$ to $10^{-4}$/yr | III | III | III | III | III | II |
| Extremely Unlikely $<=10^{-6}$/yr | III | III | III | III | III | III |

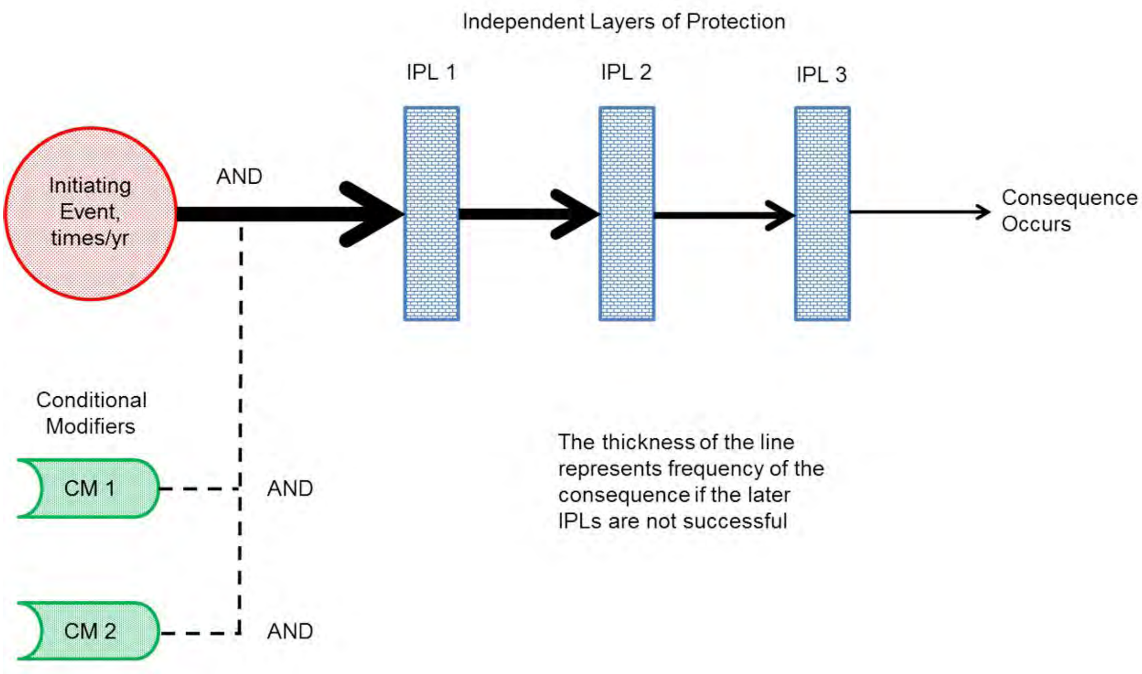
The consequences are determined qualitatively using the guidelines in Figure 10.

## Figure 10 – Consequence Ratings

| | Consequence Ratings | | | | | |
|---|---|---|---|---|---|---|
| | **Minor 1** | **Significant 2** | **Severe 3** | **Serious 4** | **Extremely Serious 5** | **Catastrophic 6** |
| **Safety and Health** | One minor injury, First Aid | Recordable or single MTI | Multiple MTI or one LTI | Permanent disability casualty or multiple LTI | Multiple permanent disabilities or one fatality | Multiple fatalities |
| **Environment** | Very minor pollution. No offsite escape of material (contained within the operational areas). Onsite nuisance value only | Minor local pollution. Nuisance offsite effect, typically of short duration, e.g. noise, odours, dust and/or visible plumes for less than one hour | Evident pollution, local concern. Minimal duration offsite effects (e.g. waterway slightly discoloured, turbid etc around the point of release with no or very few fish killed) | Significant local pollution. For example, waterways discoloured 10s of metres, fire or smoke affecting people near to the site | Major local pollution. Observable offsite effect (e.g. waterways discoloured 10s to 100s of metres for a few weeks with a significant number of aquatic life adversely affected) | Extremely severe pollution. Ecosystems at high risk of destruction. Only resolved via long term solutions (potentially taking years) |
| **Public Relations** | Minor issue, one complaint | Local issue, 10 complaints | Local media, 100 complaints | Regional or state media | Wide media national coverage | Headlines, corporate damage |
| **Financial Impact** | < $25,000 | $25,000 to $100,000 | > $100,000 to $1 million | > $1 million to $20 million | > $20 million to $100 million | > $100 million |

The estimated likelihood of the cause of each potential hazardous event, i.e. the initiating event, is multiplied by the probabilities for the conditional modifiers (if any, e.g. the probability of 2 or more people being present) and the probabilities of failure on demand (PFD) for the IPLs. This is summarised in Figure 11.

**Figure 11 – Event Likelihood**




The resulting likelihood for each potential hazardous event is compared to the acceptable risk levels on the risk matrix. The risk should preferably be below the line between risks levels II and III for each consequence rating.

The target and upper likelihoods for each consequence category are shown in the Table 17.

**Table 17 – Likelihood Limits**

| Consequence Category | Target Likelihood for Tolerable Risk, times/year | Acceptable Likelihood Range if ALARP, times/year |
|---|---|---|
| Minor | 1 | 1 to 10 |
| Significant | 0.1 | 0.1 to 10 |
| Severe | 0.01 | 0.01 to 1 |
| Serious | 0.01 | 0.01 to 0.1 |
| Extremely Serious | 0.0001 (or $10^{-4}$) | $10^{-4}$ to 0.01 |
| Catastrophic | 0.000001 (or $10^{-6}$) | $10^{-6}$ to $10^{-4}$ |

The data presented in the CCPS methodology is used to determine the likelihood of the hazardous events. The data in the following tables summarise the allowable initiating events and IPLs for dust hazard analyses.

**Table 18 – Dust Hazard Analysis Initiating Events**

| Item | Description | Frequency |
|---|---|---|
| BPCS Control Loop | The process parameter controlled by the BPCS (Basic Process Control System) control loop deviates without the ability to recover on its own, resulting in a consequence of concern | 0.1/yr |
| Safety Controls, Alarms and Interlocks | The spurious operation of any safety control, alarm or interlock may lead to an upset or other consequences of concern | 0.1 - 1/yr |
| Human Error (routine task performed once or more per week) | A human error occurs on a task that is performed at a frequency of once per week or more often. The consequences are dependent on the task being performed by the person | 1/yr |
| Human Error (task performed 1/week to 1/month) | A human error occurs on a task that is performed at a frequency of once per week to once per month. The consequences are dependent on the task being performed by the person | 0.1/yr |
| Human Error (task performed less than once per month) | A human error occurs on a task that is performed at a frequency of less than once per month. The consequences are dependent on the task being performed by the person | 0.01/yr |
| Screw Conveyor Failure | The failure of the screw conveyor stops the process flow, resulting in an upstream and/or downstream upset or other consequence of concern | 1 to 10/yr |
| Screw Conveyor Overheating of Materials | Overheating of the conveyed material potentially resulting in ignition or decomposition of material within the conveyor. This value can be used for other mechanical failures resulting in ignition (Table 8.19 in Ref 12) | 0.1/yr |
| Fan or Blower Failure | This loss of operation could result in a process upset with a number of possible consequences as a result of the process deviation | 0.1/yr |
| Mill | Explosion within a mill that has safeguards (Table 8.23 in Ref 12). This is within processing equipment | 0.1/yr |
| Baghouse Filter Bags | Failure of the filters bags resulting in combustible dust entering the downstream blower (Table 8.25 in Ref 12) | 0.1/yr |
| Packaging Unit | Existence of a combustible atmosphere at a bagging station | 0.01/yr |

## Table 19 – Dust Hazard Analysis IPLs 1

| Item | Description | Probability of Failure on Demand |
|---|---|---|
| Safety interlock or trip | Safety interlocks prevent progression of a scenario to the consequence of concern following an initiating event. This is in the BPCS (basic process control system). For example, a dryer high temperature or high carbon monoxide trip | 0.1 |
| SIS loop | A SIS loop prevents progression of a scenario following an initiating event, e.g. a high temperature or vibration trips on a hammer mill | SIL 1 - 0.1<br>SIL 2 - 0.01<br>SIL 3 - 0.001 |
| Explosion isolation valve | An explosion isolation valve protects against the propagation of flame between interconnected equipment. This includes rotary valves<br>PRM Comment: The PFD may be lower, e.g. 0.01, if the suppression system is well-designed (SIL rated) | 0.1 |
| Explosion panels on process equipment | Proper operation of explosion panels during an internal dust/vapour/gas explosion can protect a vessel or duct from excessive overpressure | 0.01 |
| Vent panels on enclosures | Vent panels prevent damage to an enclosure or room. However, activation of the panel does result in a pressure wave and loss of containment of dust/vapour/gas. If the vent panel relieves into an occupied area, a vent panel may not be an effective IPL against impact to nearby workers | 0.01 |
| Automatic fire suppression system | Within process equipment:<br>An automated fire suppression system prevents propagation of a fire outside of the process equipment<br>PRM Comment: The PFD may be lower, e.g. 0.01, if the suppression system is well-designed (SIL rated) | 0.1 |
| Automatic fire suppression system | For local applications:<br>Fire suppression systems for local applications mitigate fires in small areas<br>PRM Comment: The PFD may be lower, e.g. 0.01, if the suppression system is well-designed (SIL rated) | 0.1 |
| Automatic fire suppression system | For a room:<br>Fire suppression systems mitigate fire in a room or small enclosure<br>PRM Comment: The PFD may be lower, e.g. 0.01, if the suppression system is well-designed (SIL rated) | 0.1 |
| Human response to an abnormal condition | Human response to an abnormal condition can prevent a variety of possible consequences of concern.<br>PRM Comment: It is also possible to use data that takes into account stress and time of response, e.g. the HEART methodology | 0.1 |

| Item | Description | Probability of Failure on Demand |
|---|---|---|
| Automated explosion suppression system for process equipment | An explosion suppression system protects against explosions that could cause equipment damage including rupture. More quantitative analysis may support a lower PFD value for a specific system than the generic PFD provided<br>PRM Comment: The PFD may be lower, e.g. 0.01, if the suppression system is well-designed (SIL rated) | 0.1 |
| Inerting | Inert a vessel or bin, e.g. with nitrogen, and install an oxygen detector with an interlock if the oxygen concentration exceeds a defined value (e.g. 2 vol% below the LEL). That is, a SIL 1 function | 0.01 |
| Personal Protective Equipment (PPE) | PPE prevents consequences associated with exposure of people within the area of potential impact to a hazard of concern.<br>PRM Comment: This is not normally taken as an IPL in LOPAs but this approach for dust fires and explosions appears to allow such risk reductions | 0.1 |
| Bonding and earthing | Failure of the bonding and earthing (NFPA 654 - 9.3.2) | 0.1 |

The following safeguards are used by the CCPS in their dust hazard analysis LOPA methodology even though they are not traditionally considered IPLs. This could be due to the definition of the methodology, i.e. a risk-based dust hazard analysis where safeguards (not IPLs) are taken into consideration. That is, the CCPS use the LOPA technique in a less formal way to allow safeguards to be included in the dust risk assessment. Independence rules for the Basic Process Control System (BPCS) and (Safety Instrumented System) SIS functions still apply though.

## Table 20 - Dust Hazard Analysis IPLs 2

| Item | Description | Probability of Failure on Demand |
|---|---|---|
| Bulk bag | Use of a standard design bulk bag (NFPA 654 - 9.3.4.3) reduces the probability of a release if dropped | 0.1 |
| PMs and training | PMs and training on a specific task (NFPA 654 - Sections 11 and 12) | 0.1 |
| Area classification | Proper area classification, e.g. to prevent hot surfaces on electrical equipment | 0.1 |
| PM for bonding | PM to maintain bonding and grounding of the equipment (NFPA - 12.1.2).<br>PRM Comment: This is taken into account as well as an IPL for having bonding and earthing in the CCPS methodology, i.e. effectively a PFD of 0.01 (0.1 x 0.1) | 0.1 |
| Procedures | Dedicated, specific procedures with supervisory controls, e.g. emptying and cleaning a tank during a shutdown | 0.1 |
| Housekeep-ing | Written checklist for cleaning and ignition control procedures are in-place | 0.1 |
| Fugitive dust collection system | Installation of a fugitive dust collection system, e.g. extraction hood, ducting and fan (NFPA 654 - 8.1.1) | 0.1 |
| Fugitive dust collection system | Probability of a dust concentration above the MEC (minimum explosive concentration) within a fugitive dust collector only occurs during pulsing. Therefore, take a PFD = 0.1 (this is not applicable to a baghouse filter given the high dust concentrations in the feed streams) | 0.1 |
| Occupancy | Restrict the area around a hazardous equipment item, e.g. hammer mill, when it is running. Need a formal procedure | 0.1 |
| Occupancy | Restrict the area around a hazardous equipment item, e.g. hammer mill, when it is running. Need a formal procedure. Install a means to alert personnel that the equipment is running, e.g. flashing light | 0.01 |
| Hot sealing system for bag sealing | Ensure the temperature is below the auto-ignition temperature of the product. Note that a lower PFD can be used (e.g. 0.01) if the maximum temperature is physically limited (e.g. low power supply) | 0.1 |

The following data (Ref 15) can be used to estimate the ignition probabilities.

Note: This data is used for LOPA studies and assumes there are no safeguards in-place, i.e. further risk reduction can be taken for the safeguards that do exist, e.g. area classification.

**Table 21 – Ignition Probabilities**

| MIE | Probability of Ignition |
|---|---|
| 0 < MIE < 10 mJ | 1 |
| 10 < MIE < 100 mJ | 0.1 |
| MIE > 100 mJ | 0.01 |
| Hot work, failed bearing, dust entering a fan etc (unless other data exists) | 1 |

MIE = Minimum Ignition Energy

The following table shows typical MIEs for dusts (Refs 16, 17, 18 and 19). As dust explosibility values will vary, e.g. different particle size distributions, the probability of ignition for the main agricultural dusts should be taken as 0.1.

**Table 22 – Typical Minimum Ignition Energies**

| Material | MIE (mJ) |
|---|---|
| Wheat Dust | > 20 |
| Flour | > 50 |
| Starch | > 20 |
| Gluten | 30 - 100 |
| Glucose | > 30 |

To calculate the risk, the likelihood is estimated by multiplying the initiating event likelihood by the probabilities for any conditional modifiers and IPLs failing. This value is then combined with the qualitatively determined consequence on the risk matrix to determine the acceptably of risk and hence whether any further controls are required.

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