Final Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Final Report

Bio-resource Recovery Centres

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1.0 Executive Summary

The Bio-resource Recovery Centres (BRRC) project introduces a new approach to managing wastewater and organic wastes at red meat processing facilities, integrating the production of recycled water, renewable energy, fertiliser, CO_2 as dry ice and a reduced carbon footprint. This innovative system generates impacts beyond the processing facility, including benefits to the community and capacity building. This project proposes to perform detailed engineering and cost assessments, a peer review and a comparison of business models, aiming to de-risk and optimise the proposed model and increase the likelihood of adoption. This project will help establish the first bio-resource recovery centres through the following actions:

- Create a design for a modern integrated WWTP and organic waste management at a red meat processor plant. The designs will include cost and revenue estimates with financial analysis
- Engage a third-party peer review and consider feedback
- Review the designs and select the most appropriate project for further optimisation and implementation
- Conduct a mapping and analysis exercise of potential stakeholders (i.e. site owners, investors, funders, off-takers, technology providers, partners, tenants, and authorities) for the selected project
- Approach, present and discuss the project opportunity with stakeholders
- Finalise the optimised design and stakeholder support
- Complete a comparison of the levelised cost of resource recovery based on various funding models
- Select the funding model and negotiate any heads of agreement that support the funding model, design, investment structure and funding model to the owner of the site to enable the adoption of the first of two Bio-resource Recovery Centres

The project focuses on the feasibility and design of integrated BRRCs at two case study facilities in Western Australia (WA) and New South Wales (NSW), aiming to provide a model for broader adoption across Australia's red meat processors. The methodology includes comprehensive analyses of water and solid wastes, engineering designs for Wastewater Treatment Plant (WWTP), Anaerobic Digestion (AD), CO_2 recovery, and Biofertiliser components, carbon abatement assessments, cost estimates, revenue estimates, financial modelling, and business case development. The BRRC considers potential income from the production of recycled high-quality non-potable water, energy, biofertiliser, dry ice and carbon credits, in addition to reduced disposal issues and costs. A peer review validated the project's approach, and extensive stakeholder engagement ensured alignment with industry needs. The methodology provides a robust foundation for implementing BRRCs at red meat processing facilities in Australia, promising significant environmental, social, and economic benefits.

Key findings include:

1. Facility Throughput and Waste Management
    a. The BRRC design accommodates an annual red meat processing throughput of 73,921 t.HSCW/year for the WA case study facility and 135,200 t.HSCW/year for the NSW case study facility.
    b. The facilities manage significant wastewater and solid by-products, transforming them into valuable resources like biogas, biofertiliser, and CO_2 for use as dry ice.
2. Energy Production
    a. The biogas plants can produce 4 million Nm^3/year at the WA case study facility and 8 million Nm^3/year at the NSW case study facility, generating significant electrical and thermal energy.
    b. The produced energy can offset onsite natural gas, coal and grid electricity consumption, resulting in financial and production reliability benefits, in addition to environmental stewardship.
3. CO_2 Recovery
    a. The CO_2 recovery plant planned for the NSW case study facility recovers CO_2 for dry ice production, ensuring supply reliability and reducing costs. This approach can be extended to other facilities.

4. Biofertiliser Production
    a. The biofertiliser plant processes digestate, produced from the biogas plant, into high-quality biofertiliser pellets, providing an additional revenue stream, reducing disposal issues and costs, and supporting a circular economy.
5. Reduced Carbon Footprint
    a. Implementing a BRRC significantly reduces a red meat processor's carbon footprint, helping them transition towards net-zero goals.
6. Financial Viability
    a. The financial model projects strong returns on investment (ROI) for the BRRCs, with a payback period of nine years and a 25-year design life Net Present Value (NPV) of $70 million for a facility processing 40,000 tHSCW/yr. The larger the facility, the greater the potential for financial returns and environmental benefits.
    b. Implementing the BRRC helps red meat processors turn necessary upgrades into profitable ventures, reducing reliance on potable water, generating a reliable, economical source of renewable energy, carbon credits and producing valuable by-products.
7. Main Benefits
    a. The key benefits of implementing a BRRC at red meat processing facilities include significant environmental, social and economic benefits.

The Bio-Resource Recovery Centre model not only addresses critical aspects of sustainability but also ensures that the Australian red meat processing industry is well-equipped to meet future challenges and opportunities in a sustainable, economically viable, and socially responsible manner.

The Bio-resource Recovery Centres initiative not only supports red meat processors in achieving net zero carbon targets but also enhances environmental sustainability and economic viability. The project's comprehensive design offers significant social, economic, and environmental benefits, providing investor confidence and making a strong case for implementing a Bio-resource Recovery Centres at the case study facilities and other red meat processors across Australia.

2.0 Introduction

The implementation of a Bio-resource Recovery Centres (BRRC) in Australia promises well-managed resource recovery and robust environmental compliance. This initiative not only aligns with circular economy principles but also future-proofs red meat processors, contributing to the red meat sector's commitment to sustainability. Additionally, the facility stands to gain from potential offsets such as production of high-quality non-potable water, energy, CO_2 as dry ice, biofertiliser, and carbon credits, in addition to reduced disposal costs and issues.

The Bio-resource Recovery Centres include integration of a Wastewater Treatment Plant (WWTP), Anaerobic Digestion (AD), CO_2 recovery for dry ice and Biofertiliser production components. The WWTP treats the wastewater to a high quality suitable for a variety of reuse options, improving environmental compliance and disposal issues currently seen at red meat processors.

Biogas is produced from anaerobic digestion of underutilised solid byproducts and wastewater sludges. The biogas provides thermal and electrical energy to the facility via combustion in combined heat and power (CHP) engines. This approach ensures that the wastewater, biogas, and biofertiliser plant can operate self-sufficiently on the renewable energy produced from the biogas. This reduces red meat processors' reliance on external fossil-fuel derived energy providers, increasing reliability of power supply, reducing their carbon footprint and mitigating the impact of rising electricity costs.

Additionally, the study explores innovative CO_2 recovery of the carbon dioxide produced from the biogas plant, along with CO_2 from the biogas combustion exhaust in the CHP units. The CO_2 recovery plant will purify the captured carbon dioxide gas to food-grade dry ice, which can be sold to third-party off-takers, or used at the red meat processor for meat packaging and transport of their final, processed meat product. Producing this valuable resource onsite will generate significant revenue for the facility since the market price for this resource has considerably increased due to market instabilities.

To close the loop of the bioresource recovery facility and minimise waste disposal, the liquid digestate from the biogas plant can be used as a valuable product for fertiliser or soil amendment application. Through a dewatering, drying and pelleting process, the biofertiliser plant converts the digestate into pelletised biofertiliser. Pelletised biofertiliser retains a higher nutrient content than other product options (such as biochar), and is logistically easier and cheaper to store, transport and apply to land, particularly during winter. The typical agricultural land uses nearby red meat processors offer a local demand for biofertiliser, facilitating a favourable market for product offtake. The biofertiliser can also be used for a variety of markets or for retail sale, which can create a strong revenue stream. When commercialised, this recovered resource adds meaningful income to the facility.

In addition to Front End Engineering Designs (FEED) for the Bio-resource Recovery Centre components of wastewater, biogas, CO_2 recovery and biofertiliser production plants, a financial model of a BRRC, suitable for 40,000 tHSCW/yr red meat processing throughput, was carried out through the evaluation of the capital and operational cost of the plants as well as the revenue from potential offsets such as treated water, energy, CO_2, biofertiliser, carbon credits and reduced disposal costs. Sensitivity analysis was conducted for various scenarios, including with commodity prices significantly higher or lower than initial estimates.

To source information for the project, a desktop review of relevant documentation and communications with the WA and NSW case study facilities were conducted, along with market research. This Final Report presents the outcomes of the Bio-resource Recovery Centres project, offering red meat processors the confidence to adopt the initiative. This adoption supports their environmental goals, brings economic and social benefits, and utilises the concept of recovering valuable resources by diverting valuable by-products from waste, moving red meat processors towards a circular economy.

3.0 Project Objectives

The project objective is to present an optimised design, investment structure, and funding model for two bio-resource recovery centres, thereby enabling the owners of the sites to commence an adoption process. The general objective of the project is to further improve the concept design for a modern integrated wastewater treatment plant at a red meat processing facility. The designs will include cost and revenue estimates with financial analysis. The specific objectives include:

- Engage a third-party peer review of the hypothetical studies and consider feedback
- Review the designs and select the most appropriate project for further optimisation
- Conduct a mapping and analysis exercise of potential stakeholders (i.e. site owner, investors, funders, off-takers, technology providers, partners, tenants, and authorities) in the selected project
- Approach, present and discuss the project opportunity with stakeholders
- Assess opportunities to aggregate a learning institution at the bio-resource recovery centre, such as TAFE and/or University, to increase community value, and stimulate regional STEM capacity building
- Finalise the optimised design and stakeholder support
- Complete a comparison of the levelised cost of resource recovery (or similar) based on various funding models
- Select the most appropriate funding model and negotiate any heads of agreement that support the funding model, design, investment structure and funding model to the owner of the site to enable the adoption

4.0 Methodology

To undertake the design of the integrated facility and cover all aspects required for a successful and concise outcome, the project comprises of the following methodology:

Technology Refresher Trip: The technology refresher consists of targeted technical visits to Europe including:

- May 30–June 3, 2022: IFAT - World's Leading Trade Fair for Water, Sewage, Waste and Raw Materials Management. Messe München. https://ifat.de/en.
- June 06 – June 10, 2022: Visits to EVO factory in Germany and experiences tailored site visits showcasing the equipment used in Hydrogen, Biomethane, Biogas storage, Cogeneration and CO_2 abatement.
- May – June 2024: European technology refreshers as per Project 2024-1092 Bioresource recovery centres – EU technology scan, site visits, and case studies, including IFAT 2024, visits to biomethane facilities, visits to technology suppliers and equipment providers

Water Sampling Campaign and Updated Flows Estimate: A sampling campaign and flow investigation was undertaken for the WA case study facility, including updated flow data and concentration data. A water sampling campaign and flows assessment was undertaken for the NSW case study facility. Since the initial assessment, data provided by the facility was revised and then used for the design. Furthermore, since the wastewater treatment plant FEED was completed, information provided by the facility and assumptions were further updated, resulting in a sensitivity analysis to confirm if the design would treat wastewater under different flowrate and concentration conditions.

Organic Solid Wastes Audit and BMP Tests: Organic by-products produced at two case study facilities underwent physicochemical analysis by a certified laboratory to determine Biomethane Potential (BMP), Volatile Solids (VS), and Total Solids (TS), plus additional analytes. The results were compared with existing data from literature and other red meat facility case studies. Additionally, the volume of organic by-products were reported by the case study facilities' plant personnel. The laboratory results, combined with the byproduct production volumes, were used to estimate the quantity of biogas production for the biogas plant design.

Wastewater Treatment Plant Design: The methodology used for revising the biological nutrient removal assumptions and design for the WA case study facility, involved review and optimisation of the BNR design from PIP2021-1226. The WA facility's process calculations were updated with more recent flow and chemical composition analysis data, in addition to a revision of assumptions and robust sensitivity analysis to account for a range of operational scenarios.

The methodology for summarising the recently completed Wastewater Treatment Plant Front-End Engineering Design in Stage 1 for the NSW case study facility, involved Excel-based process and hydraulic calculations, followed by BioWin modelling. Real sampling data was used, and the BioWin model, validated through sensitivity analyses, informed the selection of major equipment sizes and process components. Concept design drawings, an equipment list, and a cost estimate (based on supplier information) were created.

Biogas Plant Design: A review of the biogas plant design was undertaken on the WA case study facility for system optimisation. The process design was updated with a larger range of data and byproduct analysis than the initial FEED study. Additionally, the design was optimized with a reduction of the hydraulic retention time of the reactors (minimizing CAPEX and optimizing biogas production), and the implementation in modules was adopted to increase robustness and redundancy in the system, as well as to cope with gradual increase of substrate production (as production increase over the years).

For the NSW case study, a summary of the recently completed Biogas Plant FEED was completed, by using feedstock characteristics and process calculations, resulting in FEED drawings and an equipment list, including equipment specification and design throughput.

The NSW case study also involved the innovative approach of recovering and purifying CO_2 to produce dry ice, as an extension to the biogas plant. One shortlisted process for capturing and purifying CO_2 to food-grade, dry ice quality for the NSW facility was identified. In collaboration with an equipment manufacturer of CO_2 recovery, the concept design of the CO_2 recovery plant was created along with technical drawings, an equipment list and a feasibility study.

Biofertiliser Plant Design: For the WA case study facility, an updated design of the biofertiliser plant was conducted by revising assumptions initially used in the FEED Report PIP2021-1226 (Tessele, 2021). The process design was updated based on a narrowed down technology selection from 2022-1081 Milestone 3 Literature Review (Tessele, 2022a), with a larger range of data and complementary analysis of the anaerobic digester substrates than was used previously in the FEED study. Additionally, equipment selection, sizing and design parameters were revised for the medium-sized case study facility.

For the NSW case study, a summary of the recently completed Biofertiliser Plant FEED was provided, by quantifying and characterising the anticipated digestate, then providing a design for the conversion of that into biofertiliser, resulting in FEED drawings and an equipment list, including equipment specification and design throughput.

Cost Estimate of Integrated System: Existing cost estimates were updated with preferred suppliers. Drawings were updated to include the new level of details. Operation costs were estimated based on a factor which takes into consideration labour, services, and consumables.

Carbon Emission Reduction: A detailed assessment of carbon emissions of the WA case study facility before and after implementation of a Bio-resource Recovery Centre was conducted. A carbon assessment was also conducted for the NSW case study facility for use in the economic assessment.

Revenues Estimates: Several revenue streams were considered in the analysis included recycled water, energy (from biogas), biofertiliser (from processed digestate), savings on waste disposal, and carbon credit offsets.

Peer Review: An external reputable consultant was engaged for a third-party peer review of the design and cost estimate. The feedback was considered and incorporated into the BRRC project.

Stakeholder Engagement Meetings: A mapping and analysis exercise of potential stakeholders included but was not limited to the site owners, investors, funders, off-takers, technology providers, partners, tenants, relevant government agencies and local authorities.

Consolidated Model: Based on the outcomes of the stakeholders' mapping and analysis, the optimised design was completed, and a comparison of the Levelized cost of resource recovery based on various funding models was produced. Funding models considered included private investment, government grants and incentives (both state and federal), and discussions with potential service providers. A combination of funding models was also assessed.

Funding and Financial Modelling: Funding models were proposed and assessed. The financial modelling considered the implementation of all bio-resource recovery components (wastewater treatment, biogas, CO_2 and biofertiliser plant) and a single staged capital investment. It included an assessment of the recovered bioresource quantities and potential revenues. Potential revenue offsets were included such as treated water, energy, CO_2, biofertiliser and carbon credits. The economic analysis was accomplished using a Microsoft Excel spreadsheet. It encompassed the capital expenditure costs combined with operational costs at 6% of CAPEX, and revenue from recovered bioresources. The Net Present Value (NPV) and Return on Investment (ROI) of each scenario were analysed and suitability of investment was identified.

Draft Business Case Report and Internal Presentation: A draft business case report was developed, including an internal presentation.

Final Report and Investor Package: The final project outcomes were collated into a "Business Case package" that includes a sufficient level of detail for investors to decide on the way forward. The package includes a full document, a summary report, and a PowerPoint presentation.

5.0 Project Outcomes

The below summary table captures the key elements of each scope of work item and the respective outcomes achieved in this project.

Table 1. Scope of works summary table

Milestone	Scope of Works	Outcome
1	Technology refresher and desktop review – consists of targeted technical visits to Europe	IFAT 2022 2022 visits to Evo Energy Technologies factory in Germany and experiences tailored site visits showcasing the equipment used in Hydrogen, Biomethane, Biogas storage, Cogeneration and CO_2 abatement IFAT 2024 as per Project 2024-1092 Bioresource recovery centres, visits to biomethane facilities, visits to technology suppliers and equipment providers
2	Water sampling campaign and updated flows estimate, and benchmark with industry	Updated water sampling campaign and updated flow estimates conducted and used for designs
3	Solid Streams Audit and Characterisation – includes organic solid wastes audit and BMP tests	Pre-selected solid organic streams on-site exhibit potential as substrates for anaerobic digestion, offering prospects for biogas production. Generated biogas holds the potential to offset a portion of the facility's energy consumption and contribute towards red meat processors' carbon neutrality objectives.
4	Wastewater Treatment Plant Design, drawings and equipment list	Revision of assumptions used for the WA case study facility Biological Nutrient Removal (BNR) portion of the Front-End Engineering Design (FEED) from PIP2021-1226. Process calculations updated with more recent flow and chemical composition analysis data, plus refined assumptions and sensitivity analysis BioWin. Summary of the recently completed WWTP FEED for the NSW case study facility. Included process and hydraulic calculations, and sensitivity analysis in BioWin. Both modular WWTP designs have high process control flexibility, focusing on improved nutrient removal, recycling for other uses, environmental compliance and resolving current wastewater disposal issues. Design considers nutrient and other compound removal from wastewater, with the possibility of irrigation and cattle wash.
5	Biogas Plant Design (and CO_2 Recovery Plant Concept Design as an extension addition)	Revision of assumptions used for the WA case study facility Biogas Plant FEED from PIP2021-1226. Process calculations updated with wider range of data and byproduct analysis than initial FEED study. Optimised design with reduction of HRT and modular implementation.
	Anaerobic Digestion design, drawings and equipment list	Summary of the recently completed Biogas FEED for the NSW case study facility. Included process and hydraulic calculations, equipment list and drawings.
	Inclusion of CO_2 Recovery Plant Design for NSW case study facility, including drawings and equipment list	NSW case study facility also includes a design for a CO_2 recovery plant. The recommended method for the NSW case study facility is amine-based chemical absorption for biogas combustion exhaust post-CHP engine.
6	Biofertiliser Plant Design, including drawings and equipment list	Revision of assumptions used for the WA case study facility Biofertliser Plant FEED from PIP2021-1226. Process design was updated based on a finalised technology selection from 2022-1081 Milestone 3 Literature Review (Tessele, 2022a), using a larger range of data and analysis. Equipment selection, sizing and design parameters were reviewed.

Milestone	Scope of Works	Outcome
		Summary of the recently completed Biofertiliser FEED for the NSW case study facility. Included process and hydraulic calculations, equipment list and drawings. Recommended recovery technology is mechanical dewatering, drying and pelletising digestate into bio-based fertiliser pellets for third-party offtake for both case study facilities. The option to convert the digestate into biochar instead should be decided on a case-by-case basis depending on individual red meat processor facility variables.
7	Cost Estimate of integrated system – including WWTP, Biogas (including CO_2 recovery), Biofertiliser Plants	Existing cost estimates were updated with preferred suppliers.
8	Assessment of overall carbon emission reduction – includes all 3 stages of the integrated system	Detailed assessment of carbon emissions of the WA case study facility before and after implementation of the Bio-resource recovery centre. A carbon assessment was also conducted for the NSW case study facility for use in the economic assessment.
9	Revenue estimates for the five streams: water, biogas, biochar, disposal and carbon credits	Five revenue streams considered in the analysis included recycled water, energy (from biogas), biofertiliser, savings on waste disposal, and carbon credits offset. Furthermore, CO_2 was used as part of the financial modelling.
10 & 11	Peer review report, followed by updated design and cost estimates.	A third-party peer review was undertaken, with affirmative feedback for the BRRC overall design concepts, equipment sizing and costs, providing confidence for project implementation. Minor refined design details and cost estimate improvements were made.
12	Stakeholder engagement meetings – report of the outcomes	Stakeholder meetings were conducted throughout the project, including site owners, investors, funders, recovered resource product off-takers, technology providers, partners, tenants, relevant government agencies and local authorities. The mapping will be based on verbal communication, via meetings (online or presential). The stakeholder consultation will include presenting and discussing the project opportunity with the relevant stakeholders.
13	Consolidated model, including peer review and stakeholders' inputs	Finalised design, and a comparison of the cost of resource recovery was conducted, evaluating various funding models.
14	Funding and financial modelling	Implementing the BRRC with all components (wastewater, biogas, CO_2, and biofertiliser plants) yields a positive return on investment for most facilities.
15	Draft business case report and internal presentation	A business case package was developed for investors to decide on the way forward.
16	Final report and "investor package"	Final report and investor package, including brochure and PowerPoint, were created

The project drivers for the Bio-resource Recovery Centres project are presented in detail below.

5.1. Project drivers

Table 2: BRRC project drivers

Driver	Case Study Facility	Project Drivers	BRRC Solution
Water – Limiting Factor for Expansion	WA	Existing WWTP is at capacity and insufficiently treating the treated wastewater quality to regulatory standards. It is unable to handle increased flows from expanded processing, limiting facility growth potential.	BRRC presents improved wastewater treatment to a higher-quality, suitable for reuse options and irrigation, facilitating facility expansion.

Driver	Case Study Facility	Project Drivers	BRRC Solution
	NSW	Limited processing water supply due to supplier infrastructure limitations, possibly restricting facility expansion.	BRRC produces high-quality non-potable water for reuse, such as livestock washdown and onsite irrigation, reducing the demand on the limited potable water supply which can be reserved for required site potable-water needs, enabling facility expansion.
Power	WA	Occasional power outages occur due to interruptions in electricity supply from the grid, leading to financial losses from wasted produce and operational disruptions.	BRRC will generate surplus energy to the needs of the BRRC, enabling BRRC self-sufficiency with behind-the-meter electricity and reducing dependence on the grid. It has the potential to fully meet its energy needs independently with co-digestion or supplementing with other renewable energy initiatives.
	NSW	High energy costs and market volatility in recent years, particularly in eastern Australia, have increased operational costs.	BRRC will provide a source of self-sufficient behind-the-meter energy supply, reducing costs and exposure to market fluctuations. It has the potential to fully meet its energy needs independently with co-digestion or supplementing with other renewable energy initiatives.
CO_2 Recovery	NSW	Reliance on unreliable external supply for food-grade CO_2 for dry ice leads to production disruptions. Supply shortages have been seen from the limited number of CO_2 producers in Australia and significant price surges have occurred in recent years.	On-site recovery of food-grade CO_2 through BRRC provides a reliable and cost-effective supply, also reducing Scope 3 emissions from transportation of externally supplied CO_2.

5.1.1. Key priorities

For the WA facility, the primary focus is on resolving wastewater disposal issues, particularly nitrogen removal and managing hydraulic load, to support significant processing capacity expansion. Addressing power reliability issues is also of interest.

For the NSW facility, the main drivers include securing a reliable supply of food-grade CO_2, addressing water availability limitations for processing, and managing high energy costs.

5.1.2. Objectives for Expansion

Both facilities are interested in expanding their operations to increase revenue, boost local economic development, and reduce reliance on live exports. The successful implementation of the BRRC is essential for overcoming current challenges and achieving these expansion goals. Improved water quality and self-generated energy, in addition to a self-supply of food-grade CO_2, will improve environmental regulatory compliance, improve the reliability of continuous production operations, create additional revenue streams and increase profitability, making the facilities more resilient to external market conditions.

Furthermore, all red meat processors will be interested in the BRRC's ability to provide the Environmental (E), Social (S), and Economic ($) benefits outlined below.

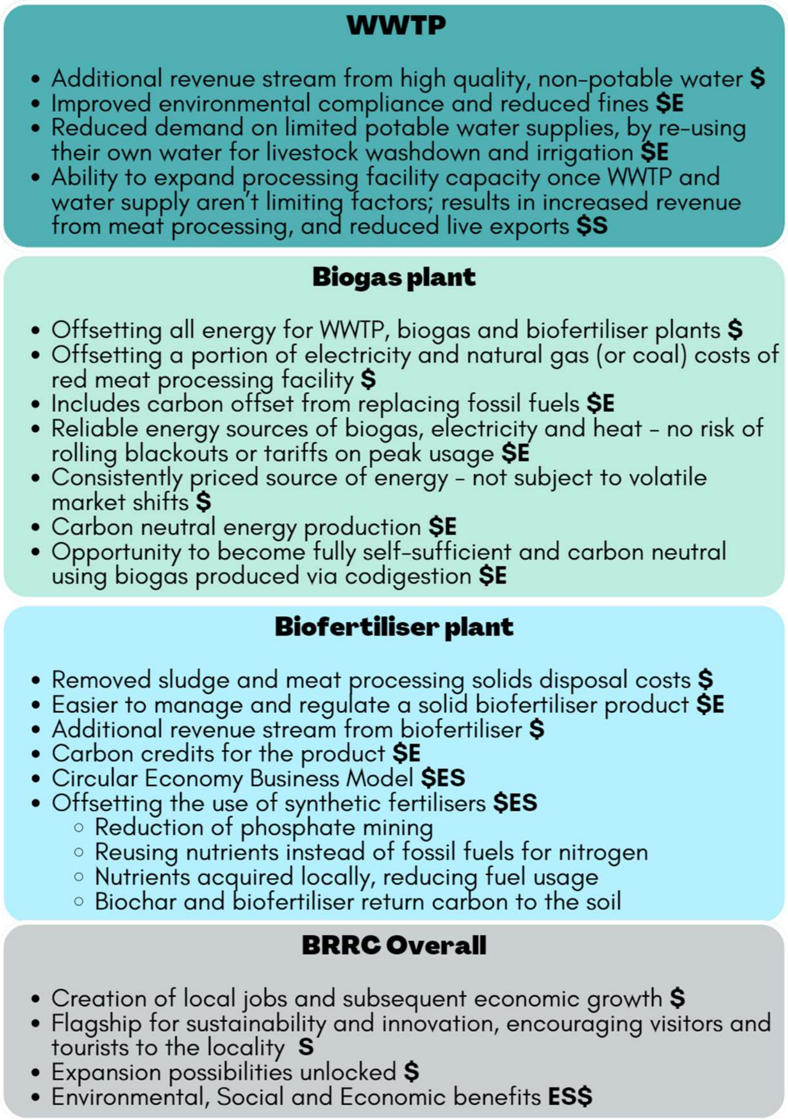


Figure 1 BRRC benefits, by component

5.2. Consolidated model

Recovering resources from by-products in red meat processing plants offers substantial benefits aligned with the three pillars of sustainability: environmental, economic, and social, as outlined below.

Table 3: High level BRRC benefits

Environmental	Economic	Social
• Reduces waste of by-products and lessens the demand on natural resources. • Recovers water, biogas, electricity, heat, and CO_2. • Diminishes ecological footprint and promotes renewable energy. • Mitigates GHG emissions, reducing pollution, conserving resources and enhancing environmental health.	• Cost savings and new revenue streams. • Biogas and surplus electricity reduces energy costs and can generate income. • Biofertiliser production offers a cost-effective alternative to chemical fertilisers. • Biofertiliser improves soil health and reduces agricultural expenses. • A BRRC enhances financial stability and profitability of the processing plants.	• Improves community health by reducing pollution and disposal issues. • Creates jobs in by-products management and green technology sectors. • Contributes to local economic development. • Provides opportunities for workforce upskilling in new technologies and sustainable practices. • Enhances job satisfaction and career advancement.

This holistic approach supports a more sustainable and resilient community. By addressing these three pillars, the recovery of resources from by-products in red meat processing plants exemplifies a comprehensive approach to sustainability, fostering environmental stewardship, economic resilience, and social well-being.

5.2.1. Tangible benefits

The diagram presented in Figure 2. depicts the overall concept of bio-resource recovery in the red meat industry, based on the extensive research, concept engineering, peer review and stakeholder engagement conducted.

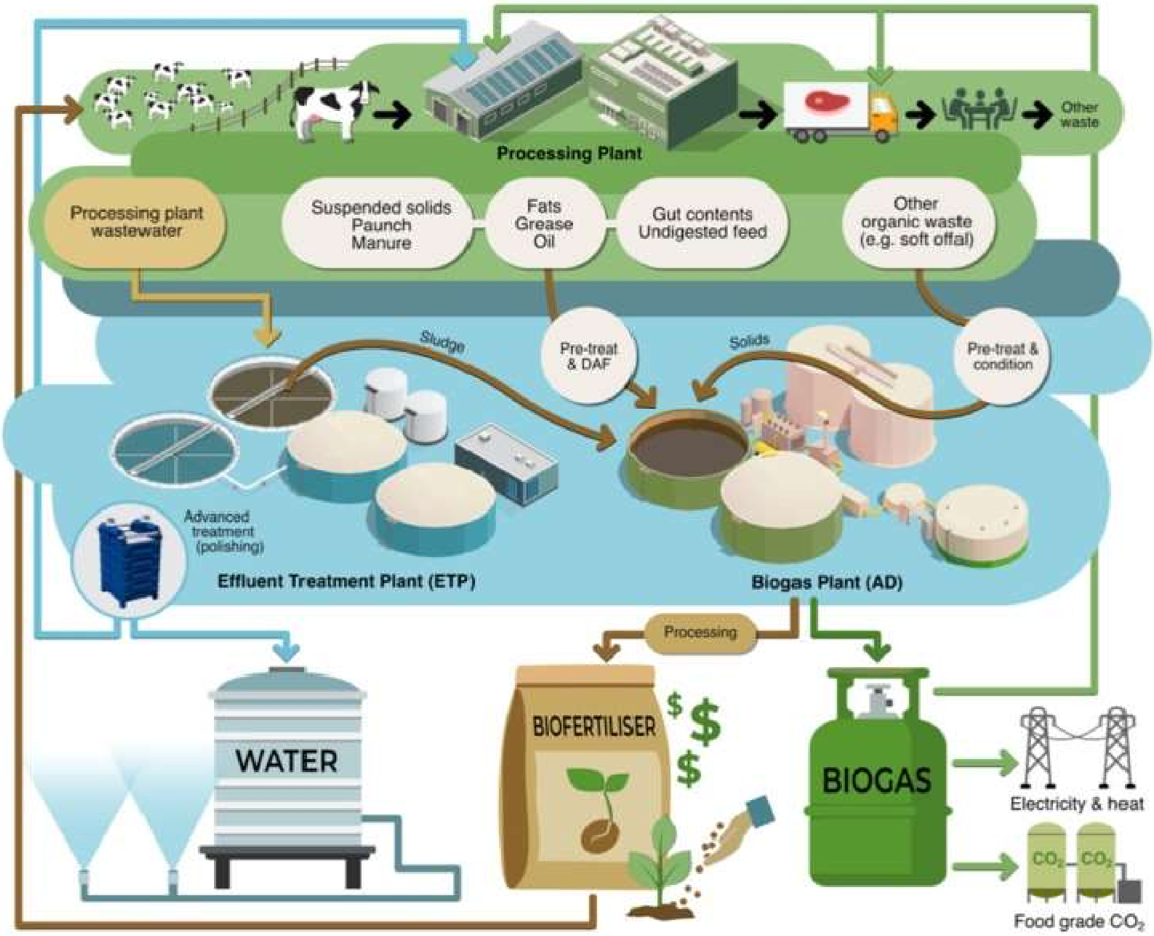


Figure 2. Consolidated model of the Bio-resource recovery centres

The recovery of these resources demonstrates a comprehensive approach to sustainability within the red meat industry. This includes water conservation, renewable energy generation, Bio-CO_2 recovery, soil health enhancement, by-products reduction, and carbon credit generation. Each aspect contributes to reducing environmental impact and promoting a circular economy. Table 4 presents a summary of each stream of recovered resource considered for the consolidated model, along with a checklist of the enablers for effective utilisation of those resources.

Table 4. Summary of each recovered resource considered in the consolidated model and their enablers checklist

Resource	Enablers Checklist
Non-potable Water	
The production of non-potable water offers significant potential, with the ability to recycle substantial volumes annually. This recycled water can be reused within the processing plant, reducing the demand for fresh water and alleviating pressure on local water resources.	✓ Regulatory Framework ✓ Superior Water Quality Standard ✓ Approved Uses ✓ Monitoring and Reporting ✓ Infrastructure and Technical Requirements ✓ Sustainability Goals ✓ Economic and Environmental Benefits
Renewable Energy - Biomethane	
Biogas production presents a substantial opportunity for the industry, generating large volumes of biogas annually. This biogas can be utilised in Combined Heat and Power (CHP) units, resulting in the production of substantial amounts of electricity and corresponding thermal energy. The surplus energy generated can be utilised within the processing plant, reducing reliance on fossil fuels and decreasing greenhouse gas emissions.	✓ Organic Substrates Availability ✓ Advanced Technology and Equipment ✓ Economic Incentives and Support ✓ Regulatory Framework ✓ Technical Expertise and Training ✓ Integration with Existing Infrastructure ✓ Environmental and Social Benefits ✓ Economic Viability
Food grade Bio-CO_2	
Bio- CO_2 recovery is a viable option, capturing significant volumes annually. This recovered CO_2 can be repurposed for various applications, including meat packaging and refrigeration, contributing to a circular economy and reducing atmospheric emissions.	✓ Technological Advancements ✓ Economic Incentives and Support ✓ Regulatory Framework ✓ Sustainability Goals ✓ Industry-Specific Applications ✓ Technical Expertise and Training ✓ Infrastructure and Logistics ✓ Environmental and Economic Benefits
Biofertiliser	
The production of biofertiliser is another key opportunity, with the potential to produce substantial quantities each year. These biofertilisers can enhance soil health and reduce the need for chemical fertilisers, promoting sustainable agricultural practices.	✓ Organic Substrate Availability ✓ Advanced Technology and Equipment ✓ Economic Incentives and Support ✓ Regulatory Framework ✓ Sustainability Goals ✓ Technical Expertise and Training ✓ Integration with Agricultural Practices ✓ Environmental and Economic Benefits ✓ Community and Consumer Engagement
Carbon Credits	
The revenue from carbon credits can be substantial, with the potential to earn a significant number of credits each year. These credits can be traded in carbon markets, incentivising further reduction in emissions and promoting environmental sustainability.	✓ Emission Reduction Initiatives ✓ Advanced Monitoring and Reporting ✓ Certification and Verification ✓ Economic Incentives and Support ✓ Carbon Market Participation ✓ Sustainability Goals ✓ Technical Expertise and Training ✓ Collaboration and Partnerships ✓ Public and Stakeholder Engagement ✓ Economic and Environmental Benefits

The Bio-Resource Recovery Centres model offers a comprehensive approach to sustainability, tailored specifically for the Australian red meat processing industry. By integrating Circular Economy principles, this model addresses environmental, economic, and social sustainability in a cohesive and efficient manner.

Environmental Sustainability: The implementation of advanced wastewater treatment processes ensures that water is recycled and reused within the facility, significantly reducing dependence on external water sources and conserving local ecosystems. Organic waste, such as manure, blood, fat, and trimmings, is processed through anaerobic digestion to produce biogas. This biogas is utilised in Combined Heat and Power (CHP) units to generate electricity and heat, improving energy efficiency and reducing greenhouse gas emissions. Bio- CO_2 from biogas is captured, purified, and converted into liquid form for use in meat packaging and refrigeration. This practice contributes to a circular economy by reusing a by-product that would otherwise be emitted into the atmosphere. Nutrient-rich digestate from anaerobic digestion is processed into biofertilisers, promoting sustainable agriculture and reducing reliance on chemical fertilisers.

Embracing and implementing the resource recovery concept will drive the industry forward, fostering innovation, sustainability, and resilience, ultimately benefiting the environment, economy, and society.

Economic Sustainability: The integration of waste management processes within the facility creates significant economic value by converting waste into resources, reducing operational costs, and generating new revenue streams. Recycling water reduces costs associated with fresh water procurement and wastewater disposal. On-site energy production through biogas utilisation decreases utility expenses and provides a buffer against energy price volatility. Surplus biogas can be sold or used to produce additional electricity, creating further income opportunities. The captured and purified liquid CO_2 can be marketed as an industrial gas or used in packaging and refrigeration, enhancing revenue generation. The production and sale of biofertilisers create new business opportunities, transforming by-products into valuable products. Optimised resource use and waste minimisation lead to increased operational efficiency and profitability, while investments in sustainable technologies enhance market competitiveness and brand reputation.

Social Sustainability: Sustainable operations benefit both the community and the workforce, ensuring long-term social viability. Reduced environmental pollution and resource conservation contribute to healthier ecosystems and communities. High-quality biofertilisers support local agriculture, fostering food security and promoting sustainable farming practices. Employee engagement in sustainability initiatives boosts morale and job satisfaction. Training and development opportunities related to new technologies and sustainable practices enhance workforce skills and knowledge. Partnerships with TAFE and local universities can further improve skilled labour in regional areas, providing specialised training programmes, apprenticeships, and research opportunities. Corporate social responsibility efforts, including transparency and accountability in environmental practices, build trust with stakeholders such as customers, suppliers, and regulatory bodies. Demonstrating a commitment to sustainability improves public and governmental relationships, garnering support and ensuring regulatory compliance.

Peer Review and Stakeholder Consultation: Extensive peer review and stakeholder consultation played a critical role in shaping the Bio-Resource Recovery Centres model. Industry experts, economic analysts, environmental scientists, and local community leaders were engaged to provide comprehensive feedback and insights. Economic analysts emphasised the potential for significant cost savings and new revenue streams, advocating for robust economic models to maximise financial benefits. Environmental scientists and local environmental groups highlighted the importance of maintaining high environmental standards, ensuring that the practices implemented would benefit the broader community and ecosystems.

Community leaders and educational institutions stressed the need for local workforce development, suggesting partnerships with TAFE and local universities to provide specialised training programmes, apprenticeships, and research opportunities. This collaboration aims to build a skilled labour force in regional areas, enhancing job opportunities and supporting the local economy. Additionally, stakeholders, including regulatory bodies and industry associations, underscored the necessity for transparent reporting and accountability in environmental practices to build trust with customers, suppliers, and regulatory bodies. This collaborative approach ensured that the model not only meets the industry's sustainability goals but also addresses the concerns and expectations of various stakeholders, creating a well-rounded and effective strategy for sustainable development.

Pathway to Carbon Neutrality: Adopting Circular Economy practices underpinned by resource recovery can significantly contribute to the Australian red meat processing sector's goal of achieving carbon neutrality by 2030. Implementing anaerobic digestion and biogas production can drastically reduce methane emissions from organic waste, while using renewable energy sources such as biogas and recovered heat further reduces reliance on fossil fuels and lowers carbon emissions. Efficient resource use, including water and nutrient recycling, aligns with the carbon-neutral objective. Developing sustainable packaging and reducing food waste through redistribution efforts also contribute to a lower carbon footprint. Developing supportive regulations and incentives will encourage Circular Economy practices in the red meat sector, and collaboration with research institutions and industry stakeholders can drive innovation and the effective implementation of these practices.

By integrating these inputs, the Bio-Resource Recovery Centres model not only addresses the critical aspects of sustainability but also ensures that the Australian red meat processing industry is well-equipped to meet future challenges and opportunities in a sustainable, economically viable, and socially responsible manner.

5.3. Technology refresher

The technology refresher served to confirm there is proven technology operating robustly to assist red meat processors, along with alternative business models that will enable the adoption of the next generation of resource recovery. The technology refresher consisted of targeted technical visits to Europe, including:

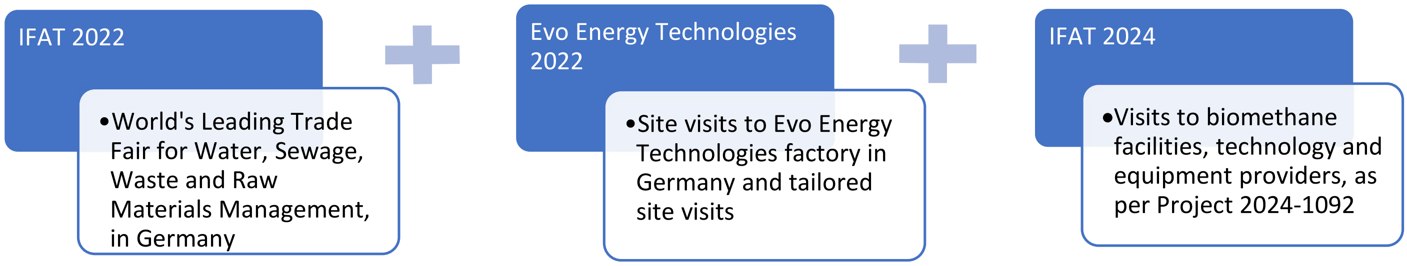


Figure 3 Technology refresher

The desktop review of the existing situation and the definition of the main project drivers for each facility included meeting with the two red meat processors and refining the business's needs, as well as reviewing updated information about the facilities.

5.4. Water sampling campaign and updated flows

A wastewater sampling campaign, flow investigation, and industry benchmarking were conducted for the two case study facilities. An initial site assessment was done via desktop analysis and site visits. Sampling points were defined and used for analysis and flowrate measurement. The results were used to design wastewater treatment and water recovery plants for future Bio-resource Recovery Centres, based on the case study facilities at WA and NSW.

Refer to the table below for raw wastewater quality characteristics and flow rates used for the WWTP component design. Refer to the Milestone 2 and 4 reports for more details on wastewater characterisation, flows and engineering designs for the facilities.

Table 5: Design raw wastewater quality characteristics and flowrates

Parameter	WA Facility Average Concentration (mg/L)	NSW Facility Average Concentration (mg/L)
BOD	1,660	6,360 mg/L[3]
COD	3,740	9,090 mg/L
TKN	240	350 mg/L
TP	42	50 mg/L
Flowrate Design (kL/day)[1]	1,316	2,520
Flowrate Peak (kL/day)[2]	1,646	3,024
Flowrate Peak (kL/year)	480,340	919,800
Red Meat Processor Throughput for BRRC Design (tHSCW/year)	73,921	135,200

[1] For biological reactions and physical/chemical separation processes.

[2] For calculating hydraulic retention time in the equalisation tank and other hydraulic components.

[3] The COD ratio is higher than optimal for nutrient removal due to fat, oils, and grease. Jar tests confirmed adequate dosing significantly improves TSS and O&G removal, thus it is assumed about 50% of total COD will be removed in the primary DAF, resulting in more suitable C:N ratios for biological nutrient removal.

A sensitivity analysis was conducted using current average flow rates, weekend-only flow rates, and updated wastewater quality concentrations to ensure system robustness. BioWin analysis confirmed the design's resilience under various scenarios, including standard flowrate and concentration, half the current flowrate, and half the flowrate with double the concentration. Additional variables tested included temperature, mixed liquor suspended solids concentration, dissolved oxygen, reactor volumes, recycle stream ratios, sludge retention times, flowrates, raw wastewater concentration, and filtrate return. Accurate flow measurement and future flowrate confirmation are critical for detailed design.

5.4.1. Treated effluent quality targets

The treated wastewater can be used for irrigation and livestock wash (excluding the final wash). Therefore, the required effluent quality standards are outlined below according to the Australian Guidelines for Water Recycling (Environment Protection and Heritage Council et al. 2006) and the Water Reuse Guideline from NSW Food Authority for the NSW Case Study Facility. The Guidelines for Non-Potable Uses of Recycled Water in Western Australia informs the treated effluent quality required for the WA Case Study Facility. The required treated effluent quality is shown in the table below.

Table 6. Treated final effluent quality requirements.

Parameter	Unit	Non-potable water for irrigation - WA	Non-potable water for irrigation - NSW
Soluble BOD	mg/L	10	<20
TSS	mg/L	10	<30
pH	---	6 - 8	6.5 - 8.5
Turbidity	NTU	<5	<5
UV dose	mJ per cm2	40-70	*
Residual chlorine	mg/L	0.2 - 2	*
E.coli	cfu per 100 mL	<1	<1
Virus	log reduction	-	6
Protozoa	log reduction	-	5

Parameter	Unit	Non-potable water for irrigation - WA	Non-potable water for irrigation - NSW
Bacteria	log reduction	-	5
TN	mg/L	20	<19**
TP	mg/L	1.5	<1.4***

*Minimum disinfection that aims to demonstrate reliability to consistently achieve microbial quality.

**TN concentration estimated based on calculation for 70kg TN/hectare provided by NSW Case Study Facility.

***TP concentration was estimated by applying a factor based on another red meat processing facility.

5.5. Wastewater treatment plant

This section provides an overview WWTP design components of Bio-resource Recovery Centres project. A modular wastewater treatment plant for each of the WA and NSW case study facilities was developed to address current wastewater disposal issues and accommodate future expansion, focussing on nutrient removal and reuse opportunities.

A biological nutrient removal activated sludge system was selected for the treatment of wastewater at both red meat processing facilities. While common in Europe, this is a novel implementation for red meat processors in Australia.

WA case study facility

- **Previous Work:** Developed a Concept Design followed by Front-End Engineering Design (FEED) (PIP1021-1226).
- **Current Focus:** This project reviews and optimises the existing FEED by verifying assumptions and process calculations to ensure design robustness, which will inform revised cost estimates for a comprehensive business case.

NSW case study facility

- **Concept Design:** Conducted process and hydraulic calculations followed by BioWin modelling (PIP2023-1028).
- **Report Inclusion:** The results of the FEED are summarised as part of this project.

Overall, the aim is to confirm the viability and effectiveness of the wastewater treatment designs, ensuring accurate cost estimates and robust implementation plans. The below figure summarises the wastewater treatment sections included as part of the Bio-resource Recovery Centres.

Figure 4. Summary of the WWTP design

The WA case study facility WWTP will be implemented as a two-module process, and the NSW case study facility will involve the same process, sized slightly differently and in three modules. This design provides a level of redundancy and allows for staged implementation, if desired.

Table 7 Summary of the wastewater treatment plant process design at both case study facilities

Section	Equipment	Purpose	WA case study facility	NSW case study facility
Pre-treatment	**Screens**	Rotary drum screen for preventing large inorganic solids from entering wastewater treatment plant	1 screen	3 screens
	Grit removal	Vortex grit tank for preventing grit, such as sand, from entering the wastewater treatment plant	2 grit tanks 1 grit classifier	3 grit tanks 2 grit classifiers
	Balancing tanks	To balance flowrates between peak-hour and non-peak, and over production days and weekends	2 tanks	3 tanks
Primary treatment	**Primary Dissolved Air Flotation**	Removes fats, oils, grease, and suspended solids, assisted by coagulation and flocculation	2 DAF units	1 DAF unit*
Secondary Treatment – A2O	**Anaerobic Bioreactors**	Biological phosphorus removal and COD reduction	2 tanks	3 tanks

Section	Equipment	Purpose	WA case study facility	NSW case study facility
biological nutrient removal and activated sludge process	**Anoxic Bioreactors**	Denitrification	2 tanks	3 tanks
	Aerobic Bioreactors	Removes soluble BOD and enables nitrification, requiring significant oxygen supply	2 tanks	3 tanks
	BNR Recirculation and RAS Pumps	Recirculates nitrified mixed liquor and Return Activated Sludge (RAS)	-	-
	Secondary Dissolved Air Flotation (DAF)	Separates, thickens, and removes waste activated sludge (WAS)	2 DAF units	3 DAF units
Tertiary Treatment	**Buffer Tank and Chemical Dosing**	Allows for chemical dosing to remove residual phosphorus, supplementing biological phosphorus removal	1 tank	1 tank
	Ceramic Membranes (Ultrafiltration)	Polishes treated water, removing excess solids and ensuring high-quality effluent	2 modules	3 modules
	UV Disinfection	Removes remaining viruses, protozoa, and bacteria after ultrafiltration, ensuring safety	2 modules	3 modules
	Chlorination Disinfection	Maintains chlorine residual for pathogen removal	-	-
Sludge Handling	**Primary DAF Sludge Pit**	Collects sludge for biogas plant	-	-
	Secondary DAF Sludge Pit	Collects sludge from secondary DAF for biogas plant or disposal	-	-
Miscellaneous	**Chemical Storage**	Stores chemicals for coagulation, flocculation, pH adjustment, and disinfection	-	-

* For the NSW case study facility, their preference is to utilise their existing large DAF unit for primary DAF needs. For other red meat processing facilities, and for this Bio-resource Recovery Centres project, it is recommended to utilise new equipment in several modules. In this case, for a plant of this size, it would be recommended to utilise three new DAF units for this purpose, for redundancy and scalability.

Rotary drum screen/s handle fat, oil, and grease, removing approximately 30% of suspended solids, with collected solids transported to a biogas plant. Screened wastewater is then de-gritted using vortex tanks, which decrease the velocity to allow grit to settle, followed by grit classifiers to wash and dewater the grit before disposal. The pre-treated wastewater is then pumped to equalisation tanks. The equalisation tanks manage anticipated fluctuations in influent wastewater flow and quality, improving treatment performance and reducing costs. From there, the wastewater undergoes primary treatment in parallel modules using DAF systems to remove additional fats, oils, grease, and suspended solids. The DAF systems are designed to operate efficiently using coagulants, flocculants, and with potential pH adjustment where required.

From here, the primary effluent undergoes secondary treatment via a biological nutrient removal process in the A2O reactors, which further reduces biochemical oxygen demand (BOD), suspended solids (SS), total nitrogen (TN), and total phosphorus (TP). This is achieved through an activated sludge process that utilises microbiological activity and aeration to complete the nitrogen cycle.

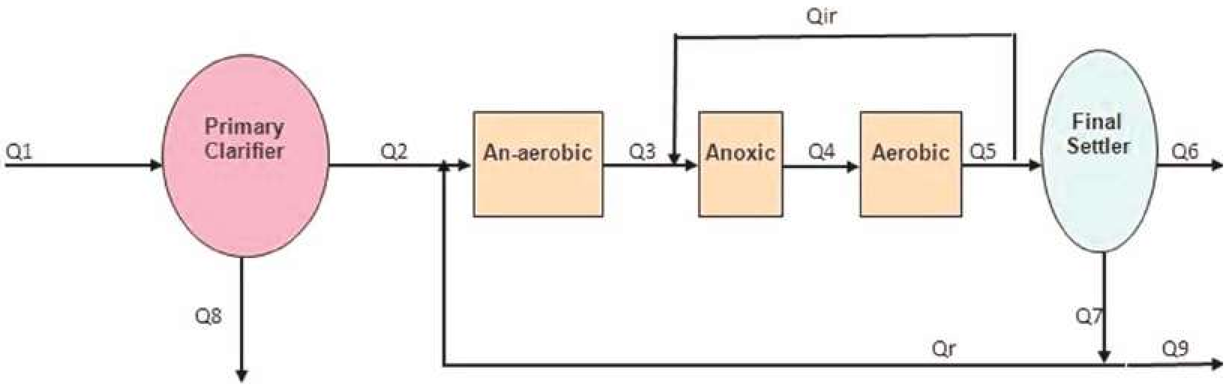


Figure 5: A_2O Process schematic. Source: (Elshorbagy et all, 2011)

A 'mixed liquor' recycle from the aeration zone to the anoxic zone occurs to enable efficient completion of the nitrogen cycle. Secondary DAF units thicken the activated sludge, and the clarified effluent is stored in a buffer tank. A portion of the activated sludge, known as return activated sludge (RAS), is recirculated through the A_2O secondary bioreactors to the anaerobic zone to maintain the necessary microbial population for the treatment process, while the remainder is designated as waste activated sludge (WAS). The 'waste' sludges resulting from the primary DAF and secondary DAF system are sent, with the initial screened solids at the start of the process, to the biogas plant for anaerobic digestion. Finally, the wastewater undergoes tertiary treatment with ultrafiltration using ceramic membranes to polish and remove the remaining solids. This is followed by double-barrier disinfection using UV and chlorination with sodium hypochlorite to achieve the desired effluent quality suitable for various reuse options, and a treated water storage tank which also serves to provide a minimum contact time for sufficient chlorination. The level of final tertiary treatment depends on state regulations, but the differences between states are typically minimal.

Further treatment with reverse osmosis can enable water to be recycled for higher quality uses, but the disposal of brine generated poses a challenge. Therefore, we do not recommend this step as standard practice unless brine disposal is feasible.

Filtrate from the biogas plant digestate dewatering contains high nutrient levels. BioWin analysis showed the designed WWTP processes for the WA and NSW facilities can treat it, but not under extreme conditions. The filtrate has the potential to significantly impact the treated wastewater quality, and should be thoroughly analysed when more details become available in further stages of the project. If higher concentrations or flow rates are expected, consider using Anammox or an alternative sidestream process for separate treatment.

Compared to domestic wastewater, red meat processing wastewater is expected, and has been anecdotally observed, to produce fewer odourous gases, including less ammonia and hydrogen sulphide. The aerated zones will be open-top tanks and do not require odour control. It is recommended to review any potential odours from the anaerobic zone during detailed design and provide treatment options if necessary.

Both the WA and NSW case study facilities were modelled using BioWin process modelling software and underwent a series of sensitivity analyses to ensure the designs were robust under various operating conditions.

For further details and specifications on the WWTP designs, BioWin modelling sensitivity analysis, equipment lists, and preferred suppliers of the WA and NSW case study facilities, refer to the Milestone 4 Report. Refer to the appendices for the WWTP design drawings.

5.6. Organic solid wastes audit and BMP tests

To identify relevant organic by-products to utilise as feedstock for the biogas plant, the selection of the organic streams considered the anticipated carbon content, volatile solids content and substrate availability at the facility, focusing on an operation independent of external substrate additions for co-digestion. Disposal costs, local demand, energy prices, and the potential financial value of by-products can influence the decision to direct specific organic streams to a biogas plant. A biogas plant design should be based on a detailed feedstock evaluation, considering the specific circumstances of each facility. For this project, design inputs were based on the WA and NSW Case Study Facilities' situation and organic stream availability, as summarised in the following figures.

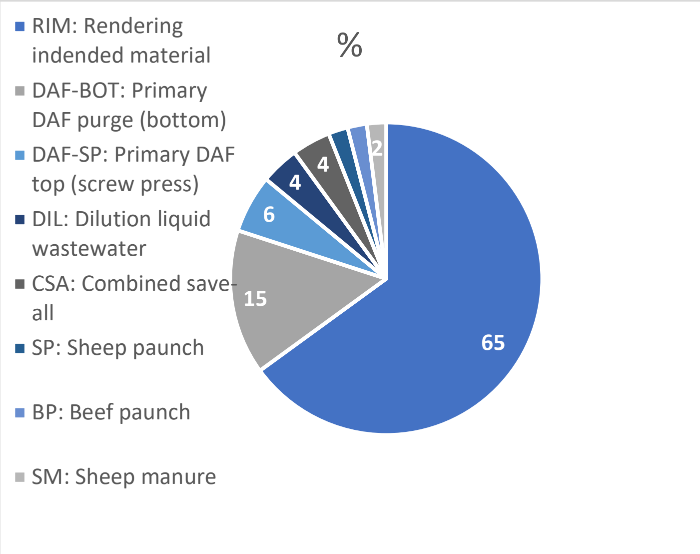


Figure 6: WA case study facility organic by-products availability, by mass percentage

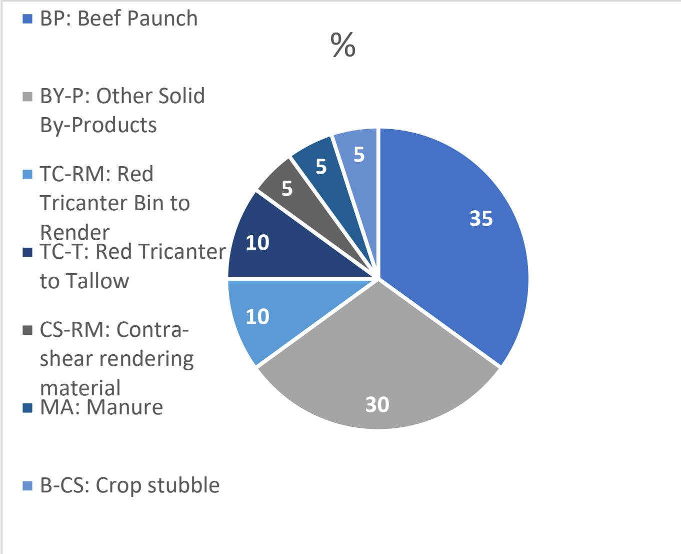


Figure 7: NSW case study facility organic by-products available for anaerobic digestion, by mass percentage

Table 8 below shows the list of selected organic by-products sent to the certified laboratory to determine Biomethane Potential (BMP), Volatile Solids (VS), and Total Solids (TS) content. The table includes sample names that are comparable between the two case study facilities.

Table 8. Selected organic by-product samples sent to EnviroMicroBio laboratory

Sample ID WA	Name WA	Sample ID NSW	Name NSW	Description
CSA	Combined save-all	CS-RM	Contra-shear rendering material	Congealed blood, meat bits and drain waste from screens.
DAF-BOT DAF-SP	Primary DAF sludge top and purge	TC-RM	Red Tricanter Bin to Render	From red stream tricanter bin to render.
-	-	TC-T	Red Tricanter to Tallow	Red tricanter to tallow. Tallow will likely continue to be sent to third grade tallow, and so in the initial biogas estimates, this was excluded.
SP BP	Sheep paunch Beef paunch	BP-1	Green Contrashear to Solids Pad – Beef Paunch	Paunch from green contrashear to solids pad.
		BP-2	Green Contrashear to Solids Pad – Beef Paunch Grits	Paunch grits from paunch sedimentation pit.
SM	Sheep manure	MA	Manure	From yards, with a mix of dirt and straw.
-	-	B-CS	Crop Stubble	Barley and oat crop stubble from the harvest.
RIM	Rendering intended material (soft offal and fat)	BY-P	Other Solid By-Products	Composite of B-grade products: tripe, runners/intestinal tracks, udders, bible (omasum), crown (mesenteric), 'wheeze ends' and spleen.
DIL	Wastewater portion	-	-	A portion of wastewater for required dilution

5.6.1. BMP for WA case study facility

Refer to the Milestone 3 Solid Waste Characterisation Report (MS3) for details on how substrates were pre-selected, characterised, and quantified. The selected substrates will provide approximately 36,500 tonnes annually to feed the WA Case Study Facility biogas plant, with a total solids content of ~12% TS. This includes the sludge from BRRC WWTP component's primary and secondary treatment. Within the characteristics presented in Table 9 after mixing, the substrates present adequate total solids content (<12%) and to be suitable for use in a wet co-digestion reactor, the addition of extra wastewater was considered for dilution purposes.

Refer to Table 9 for the quantities of substrates intended for the anaerobic digestion component of the BRRC.

Table 9. Combined organic solid stream production and future estimates for WA case study facility

ID	Name	TS (%)	VS (%)	kg/t.HSCW	Future Mass (tonnes/yr)
CSA	Combined saveall	31	95	5	340
DAF-SP	DAF (after screw press)	31	87	13	931
DAF-BOT	DAF (purge)	5	98	203	15,016
SP	Sheep paunch	25	80	14	1,057
BP	Beef paunch	16	94	39	2,868
SM	Sheep manure	56	77	10	747
RIM	Rendering Intended Material	54	99	46	3,430
DAF-SEC	WAS from secondary DAF	2	84	144	11,046
DIL	Liquid wastewater addition	1	96	N/A	N/A

*VS (%) represents the number of Volatile Solids in the Total Solids present in the sample

Refer to Table 10 for individual and combined biogas production for the solid by-products. The total yearly biogas production is ~4,015 kNm^3/yr, equivalent to 88,330 GJ per year in the form of biogas, which represent 1.2 GJ per t.HSCW of red meat processed.

Table 10 BMP and biogas production estimates for WA case study facility

ID	Name	BMP (mL$_N$ CH_4/g VS$_{Added}$)	Biogas Production @60% CH4 (kNm3/yr)
CSA	Combined saveall	563	93
DAF-SP	DAF (after screw press)	582	244
DAF-BOT	DAF (purge)	891	1,005
SP	Sheep paunch	286	100
BP	Beef paunch	262	189
SM	Sheep manure	210	114
RIM	Rendering Intended Material	651	1,978
DAF-SEC	WAS from secondary DAF	149	243
DIL	Liquid wastewater addition	800	49

5.6.2. BMP for NSW case study facility

The selected substrates for the NSW Case Study Facility will provide approximately 101,835 tonnes annually to feed the NSW case study biogas plant, with a total solids content of ~12% TS. A co-digestion sample was prepared to obtain realistic BMP, VS, and TS values for future biogas plant substrates, based on estimated practical proportions of available feedstock. Refer to Table 11 for BMP of individual solid streams and the co-digestion sample.

Table 11. Organic by-product sample results NSW case study facility

Sample ID	Name	TS (%)	VS (%)	BMP (ml_N CH_4/g VS_{Added})
CS-RM	Contra-shear rendering material	41	34	667
TC-RM	Red Tricanter Bin to Render	32	28	398
TC-T	Red Tricanter to Tallow	53	53	897
BP	Paunch	12	10	289
MA	Manure	82	5	182
B-CS	Barley crop stubble	74	64	108
BY-P	Other Solid By-Products	23	20	178
AN-P	Anaerobic Pond Crust	80	76	230
CD	Co-Digestion	29	23	602

Refer to Table 12 for the estimated quantities of substrates intended for the anaerobic digestion component of the BRRC, and the subsequent estimated biogas production. The ‘Realistic Co-Digest Compilation’ provides the most accurate biogas production estimate, which considers updated substrate availabilities, BMP results, and realistic wastewater sludges to be sent to the anaerobic digesters.

Table 12: Estimated biogas production of each organic by-product with potential for anaerobic digestion

Sample	Name	Future Substrate (tonnes/yr)	Future Biogas Production @ 60% CH4 (kNm3/yr)
CS-RM	Contra-shear rendering material	2,555	1,026
TC-RM	Red Tricanter Bin to Render	165,345	2,992
TC-T	Red Tricanter to Tallow	-	-
BP	Paunch	6,935	344
MA	Manure	1,095	19
B-CS	Crop Stubble	5,110	58
BY-P	Other Solid By-Products	5,840	356
CD	Co-digestion	33,945	7,737
N/A - estimated	Secondary DAF Sludge	47,815	563
N/A - estimated	Screened Wastewater	20,075	7
Realistic CoDigest Compilation	**CoDigest + Secondary Sludge + Wastewater**	**101,835**	**8,306**

Thus, the table below shows the estimated biogas production of the realistic samples considered for anaerobic digestion at the NSW case study facility.

Table 13. Estimated biogas production

Sample ID	Name	Future Substrate (tonnes/yr)	Future Biogas Production @ 60% CH4 (Nm3/yr)
CD	Co-digestion	33,945	7,737
DAF-S	Secondary DAF Sludge	47,815	563
SWW	Screened Wastewater	20,075	7
Realistic CoDigest Compilation	**CoDigest + Secondary Sludge + Wastewater**	**101,835**	**8,306**

5.6.3. Summary of biogas and energy potential analysis for WA and NSW case study facilities

Table 14 summarises the biogas and energy potential from anaerobic digestion of organic solid by-products at the WA and NSW case study facilities.

Table 14. Energy production of WA and NSW case study facilities based on realistic co-digestion feedstock

Item	WA Case Study Facility	NSW Case Study Facility
Biogas Production (kNm^3/year)*	4,015	8,306
Energy Production per year (GJ/year)	88,330	182,733
Energy Production per t.HSCW (GJ/t.HSCW)	1.2	1.4
Electrical Energy (MWhe)	1.05	2.37
Thermal Energy (MWht)	1.1	2.42

In summary, the pre-selected solid organic streams at red meat processors exhibit potential as substrates for anaerobic digestion, offering prospects for biogas production. The generated biogas holds the potential to offset a portion, if not the entirety, of the facility's energy consumption and contribute towards red meat processors' carbon neutrality objectives. For the WA and NSW case study facilities, the anaerobic digestion of organic by-products is expected to yield the following:

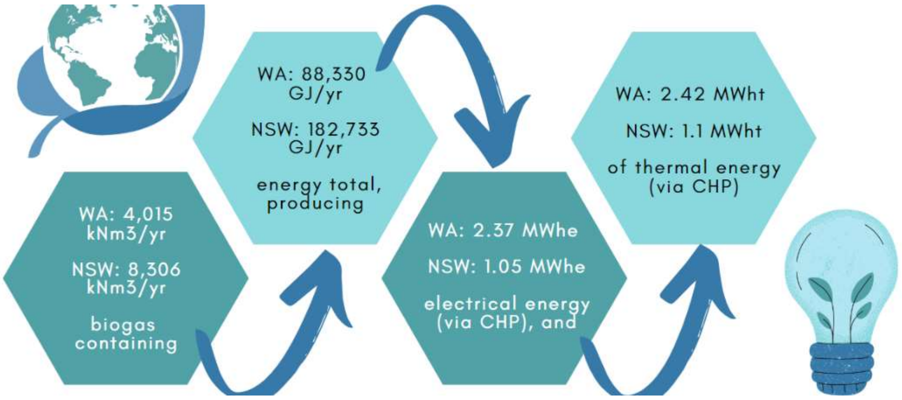


Figure 8: Forecast biogas and energy production from solids audit

This demonstrates potential as a model for red meat processors across Australia to generate energy from their own underutilised by-products via a BRRC.

5.7. Biogas Plant

This section outlines the anaerobic digestion component of the BRRC Front-End Engineering Design planned for implementation at the two case study facilities. The future biogas plant, following a waste-to-energy model, will include anaerobic digesters to process organic by-products from the facilities, generating energy in the form of electricity and heat. This setup supports bio-resource recovery, reduces carbon emissions, promotes a circular economy, and decreases reliance on fossil fuels.

The core technology comprises anaerobic digesters, along with ancillary equipment. The plant will process sludge by-product streams from the wastewater treatment plant and solid by-product from the red meat processing facility as anaerobic digestion feedstock, with the potential for co-digestion of other organic substrates, such as agro-industrial by-products like grain residues. Additionally, the biogas plant includes a CO_2 recovery component for the production of dry ice, which is utilised on-site by many red meat processors and other industries. This feature was specifically designed for the NSW Case Study Facility, as it is a priority for them. However, it can also be applied to the WA Case Study and can benefit red meat processors across Australia. The process stages of the biogas plant are illustrated in Figure 9.

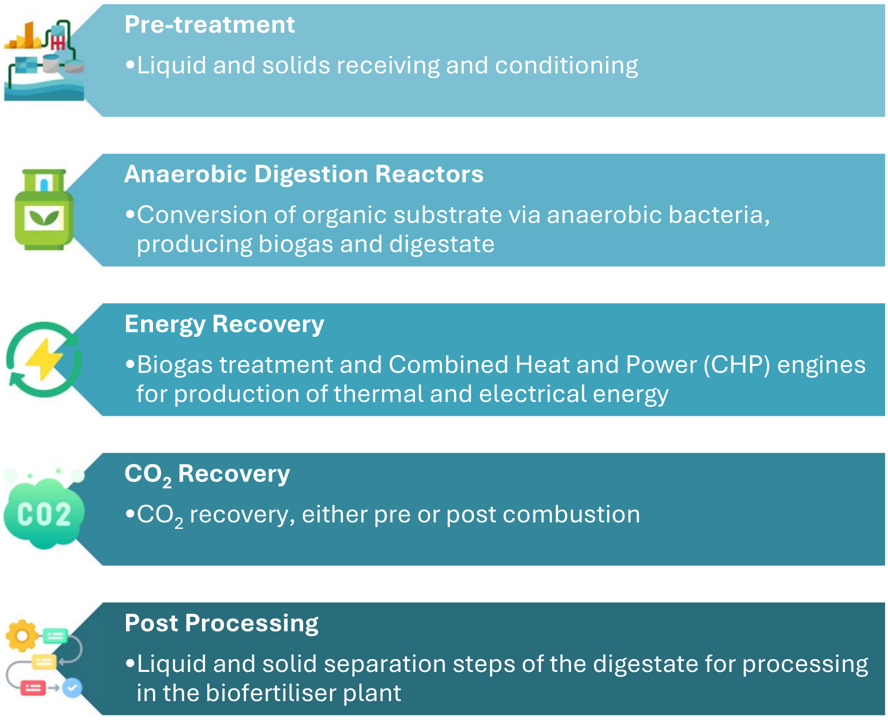


Figure 9. Summary of the process stages of the biogas production component of the BRRC

The following subsection provides a summary of the design for each stage of the biogas plant. The WA case study facility WWTP will be implemented as a two module process, and the NSW case study facility will involve the same process, sized slightly differently and in three modules. Refer to the appendices for the drawings of the biogas plants.

Table 15: Summary of biogas production component of the BRRC

Section	Equipment	Purpose	WA case study facility	NSW case study facility
Pre-conditioning of substrate	Solids receival station – hopper and grinder	Protects organic substrate from the environment; flexibility in handling materials to achieve adequate mixing ratios for feeding the AD reactors.	1 off	1 off
	Solids grinding and mixing	Mixes solid streams with liquid recirculated from the receiving	1 off	1 off

Section	Equipment	Purpose	WA case study facility	NSW case study facility
		tank; prepares substrate for next process step.		
	Liquid receival tank	Receives liquid streams from wastewater treatment plant and tanker trucks; controls mixing ratios for AD reactors.	1 off	1 off
	Substrate blending tank	Prepares substrates achieving adequate homogeneity and total solids (TS) content before feeding the AD reactor.	1 off	1 off
Anaerobic digestion	Anaerobic digestion reactors	Converts substrates into biogas and digestate; operates at Mesophilic range (37 ˚C) with HRT of 40 days and OLR of 2.7 kg/m^3.	4 off; 2x hydrolysis reactors in parallel 2x methanogenesis reactors in parallel	8 off; 4x hydrolysis reactors in parallel 4x methanogenesis reactors in parallel
	Digestate storage tank	Stores digestate produced by AD reactors; offers up to 3 days buffer capacity. Sent from here to the biofertiliser plant.	1 off	1 off
Biogas	Biogas treatment	Removes humidity and H_2S content from biogas; pre-treatment for biogas use in boilers or CHP engines.	2 off	4 off
	Biogas flare	Consumes surplus biogas in case of equipment failure or maintenance.	1 off	1 off
	Biogas purification	Biogas treatment and purification	2 off	4 off
	CHP units	Produces electricity and thermal energy from biogas; designed to run 24/7.	2 off	4 off
	CO_2 recovery	The gas scrubber purifies and cools the CHP exhaust gas, the amine scrubber utilises MEA-solution to chemically absorb the CO_2 and the stripper regenerates the rich-MEA solution with steam.	Gas scrubber 1x amine scrubber 1x amine stripper Blower for flue gas Compressor Drying Unit Purification Unit Refrigeration Unit	Gas scrubber 1x amine scrubber 1x amine stripper Blower for flue gas Compressor Drying Unit Purification Unit Refrigeration Unit
Auxiliary equipment	Progressive cavity pumps	Handles substrate and digestate with high solids content.	Several as needed	Several as needed

The biogas plant features an enclosed shed for solid substrate reception with an odour treatment system, protecting the substrates from environmental conditions while allowing flexible handling and mixing. Solid organic substrates are transported from the red meat facility to the solids receiving bay via an automatic system or manual loading. These materials are gradually moved to a feeding hopper, from where they are macerated and ground to approximately 5mm for efficient digestion, with a liquid-to-solid ratio of 10:1 maintained to prevent downstream blockages.

Liquid streams, including WWTP primary and secondary sludge from DAF units and dilution water, are continuously pumped into a receiving tank, mixed, and then pumped to the substrate blending tank. Substrates are homogenised in a blending tank before entering the anaerobic digestion (AD) reactors.

The biogas plant employs a wet co-digestion process in a continuous stirred tank reactor (CSTR) setup, operating at 37°C with a total hydraulic retention time of 40 days. The digesters, designed for a specific organic loading rate, have a total solids content of around 12%. The plant consists of multiple modules, each with two reactors in series, including hydrolysis and methanogenesis stages, each with 20 days of hydraulic retention.

Digesters are equipped with double membrane gas holder domes for biogas storage, with secondary digesters producing more biogas than primary ones. The digesters are equipped with external blowers to maintain adequate pressure in the double membrane gas holder domes. The digestate is stored in a covered tank for further processing into biofertiliser in the Biofertiliser component of the BRRC. Raw biogas, expected to contain over 2,000 ppm H_2S, undergoes pre-treatment to remove impurities before the pressure is boosted for use in boilers or CHP engines. This involves dehumidification of the ~38 – 40°C biogas via chilling to 3-5°C, integrated with a heat exchanger and knockout drum filter for condensate removal. A biogas flare is available for safe disposal during equipment failure or maintenance.

CHP units, each with the same capacity, are designed in parallel modules. It is recommended that the engines operate continuously, 24 hours a day. The biogas is converted into electricity and heat, which are used behind-the-meter to power the BRRC and for process heat, including heat for the Biofertiliser component of the BRRC and digesters. Energy produced in surplus to the needs of the BRRC can be used by the red meat processing operations.

5.7.1. CO_2 recovery component

CO_2, primarily used in the red meat industry as dry ice for preserving and transporting products, has faced supply challenges in Australia in recent years, due to global supply chain disruptions, increased demand, and production facility closures. This has caused higher costs and product assurance issues, leading some red meat processors to look into alternative dry ice supply chains. The CO_2 recovery plant concept design for the NSW Case Study Facility was conducted by using the estimated biogas production, where it is assumed that 40% of the biogas is comprised of CO_2. There are several different types of CO_2 recovery technologies, as follows:

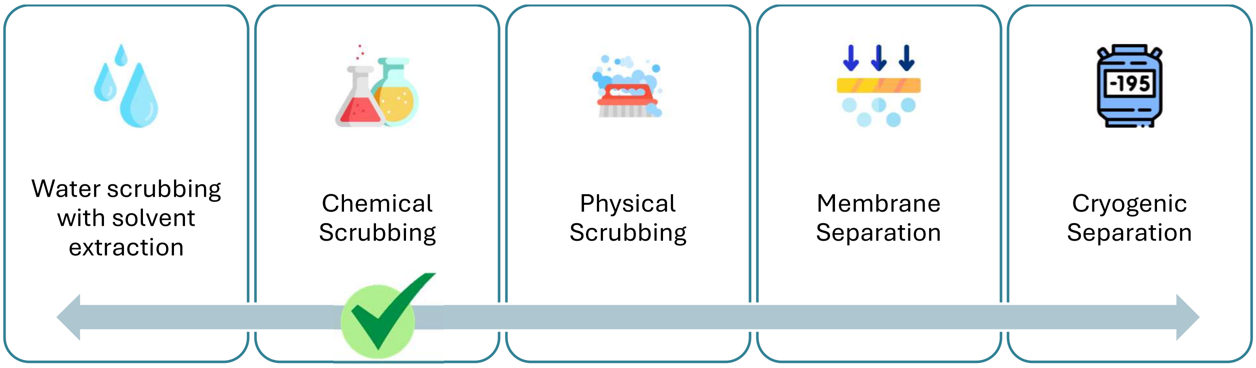


Figure 10 CO_2 recovery options

The most suitable CO_2 recovery method for the NSW Case Study facility is amine scrubbing, used for capturing CO_2 from post-CHP engine flue gas. This process effectively captures the 40% CO_2 content in biogas, along with CO_2 produced during biogas combustion in the CHP engines. The recovered CO_2 meets the facility's dry ice demand (for meat packing) without requiring additional handling for surplus CO_2. Amine scrubbing is preferred over pre-CHP membrane processes, which capture less CO_2 and may require the site to obtain supplemental dry ice to meet their on-site demand. The chosen method uses a chemical absorption process, where amine solvents capture CO_2, which is then released in a stripper unit for use as liquid, food-grade CO_2. This method offers low CAPEX, high CO_2 quantity recovered, reasonable production costs and OPEX, and a short payback period. The process ideally requires 24/7 operation, due to long start-up and shut-down times, thus requiring a baseload of power at all times. Refer to Milestone 5 for more details. It is worth noting that there is an opportunity to enhance the CO_2 recovery equipment by adding a specialised recovery unit, and/or converting the liquid food-grade CO_2 into dry ice pellets. These additions would further improve efficiency, increase capture rates, and ultimately lead to higher financial returns and savings.

5.8. Biofertiliser plant

5.8.1. Digestate characteristics

The selected substrates, including organic solid by-products from the red meat processing facility and sludges from the WWTP component of the BRRC, are processed through anaerobic digestion, becoming biogas and digestate. This digestate is a slurry containing stabilised biodegradable materials and minerals, with a total solids content of around 2-5% TS. It serves as an excellent fertiliser for crops and plants due to its rich content of micro and macro nutrients and organic matter. The stabilised digestate acts as a biofertiliser, promoting nutrient recycling and playing a crucial role in closing the circular economy loop in resource recovery facilities.

The characteristics of the digestate depend on the type of feedstock used in the biogas plant and the operational parameters of the process. Table 16 shows the estimated quantity of digestate produced at the WA and NSW Case Study Facilities following the implementation of the BRRC.

Table 16. Average characteristics of digestate produced in the red meat processing industry

Parameter	Unit	Production values
Digestate from WA biogas plant	Tonnes/yr at 5% TS	36,500
Digestate from NSW biogas plant	Tonnes/yr at 5% TS	101,835

Table 17 (Matjuda et al., 2023) presents the characteristics of digestates produced from meat processing industries.

Table 17. Physicochemical characteristics of red meat waste at the end of an anaerobic digestion process (Matjuda et al., 2023).

Parameter	Unit	Value
pH		7.9
VS	%	5
VS/TS		0.6
Moisture	%	92
TS	%	8
COD	mg/L	3,725
NH_4^+-N	% TKN	51
TKN	g/kg DM	47
EC	µS/cm	2,260
TVFA	mg/L COD	2,873
Ca	g/Kg	31
Mg	g/Kg	2
K	g/Kg	58
Na	g/Kg	15
S	mg/Kg	600
P	g/Kg	27
Fe	g/Kg	8

Parameter	Unit	Value
Mn	mg/Kg	128
B	mg/Kg	35
Mo	mg/Kg	1
Al	mg/Kg	232
N-org	%TKN	3
C-org	%	34
C/N		8
E.coli	cfu/mL	1,023
Salmonella	25g of fresh sample	Not detected
Listeria	25g of fresh sample	Not detected
Zn	mg/Kg	273
Cu	mg/Kg	49
Cd	mg/Kg	0.9
Cr	mg/Kg	44
Pb	mg/Kg	10
Ni	mg/Kg	3
Hg	mg/Kg	0.1
As	mg/Kg	5

The digestate originated from the anaerobic digestion can be used in various forms as a biofertiliser. The value of the biofertiliser is correlated with the level of technology and complexity involved in its production. Refer to the Figure 11 for an overview of the different levels of technology required for various biofertiliser forms, with increasing value and complexity descending down the chart.

Level of complexity & value

- Fertiliser irrigation: direct application of stabilised liquid digestate to soil, where regulations allow
- Dewatered digestate (15-22%): as a soil enhancement or compost base
- Dried digestate: thermal dehydration using heat exchangers
- Pellets: used as a basis for enhanced bio-based fertilisers
- Biochar: gasification or pyrolysis of dewatered and dried digestate
- Emerging technologies: unity process, struvite, vivianite (via chemical processing)

Figure 11. Digestate vs level complexity required for processing (EBA European Biogas Association, 2022)

The selection of the most viable digestate processing technology depends on several aspects, including scale of the operation, regional market for bio-fertiliser offtake, environmental regulation, weather patterns, social aspects (proximity to urban centre, potential environmental impact, etc) and the digestate characteristics at each individual facility. In the case study facilities, there are several conditions guiding the selection of the technology.

5.8.2. Bio-based fertiliser processing technology options overview and final product selection

The bio-based fertiliser processing technology options are summarised in the below schematic and are detailed in 2022-1081 Literature Review (Tessele, 2022a).

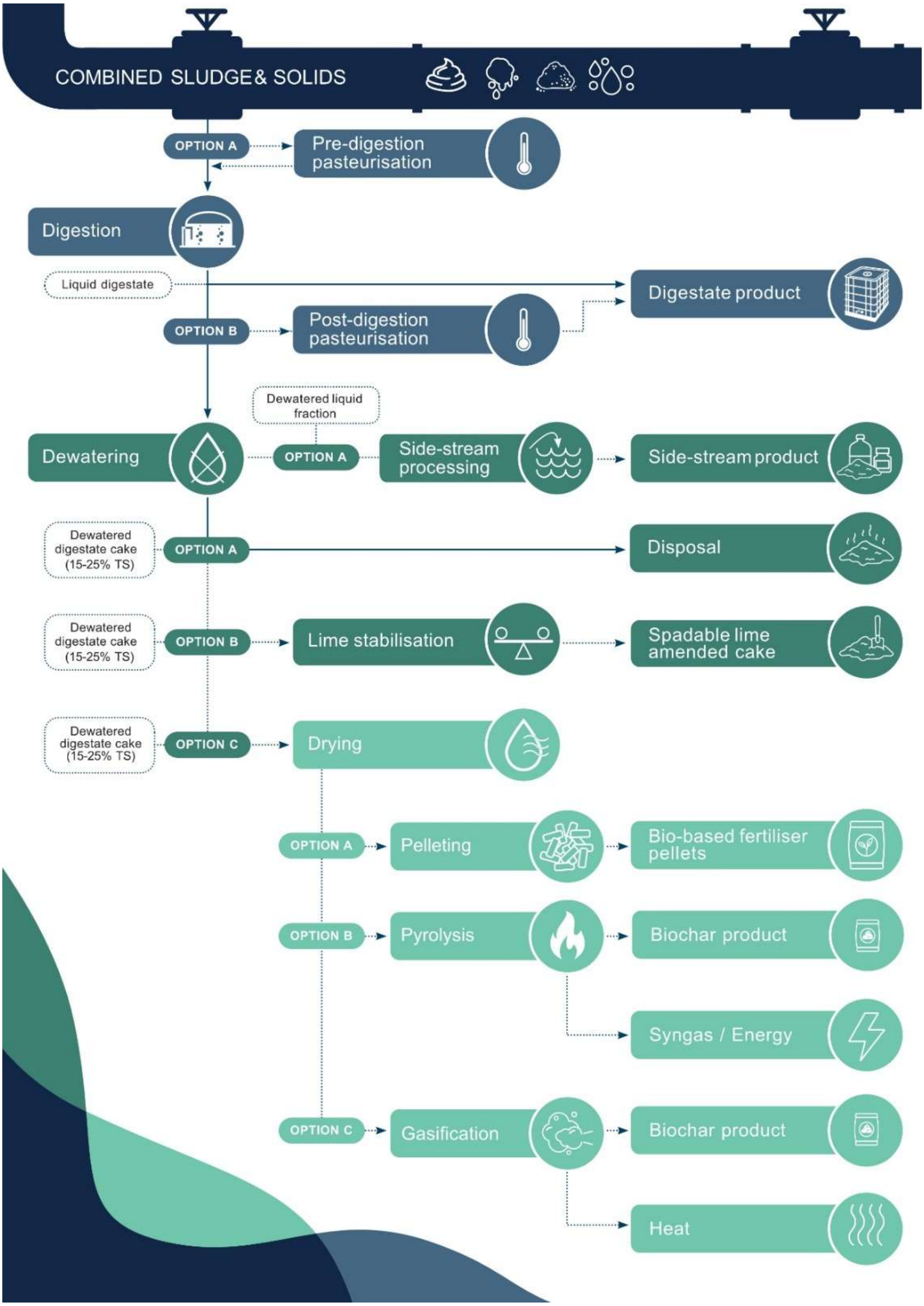


Figure 12 High-level further processing technology options to produce bio-based fertiliser from AD digestate. Source: Internal

Among the processing technologies evaluated in the feasibility study, three main options were identified to convert digestate into bio-based fertiliser at the two case study facilities:

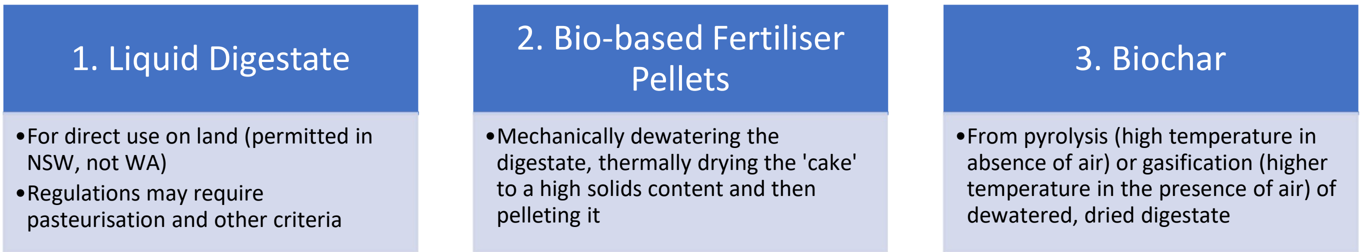


Figure 13 Main biofertiliser processing technologies

For the WA Case Study Facility, current municipal biosolids guidelines do not permit the direct use of liquid digestates, so further processing into a solid product is recommended. In NSW, while regulations permit direct land application of liquid digestate, processing it into a solid form is still advised. This approach maximises the irrigation potential nutrient-rich treated wastewater and ensures compliance with environmental licence requirements, preventing hydraulic and nutrient oversaturation of the land.

To produce a solid product from the digestate, dewatering is required. The most suitable dewatering technologies for this application, selected based on a range of criteria, include:

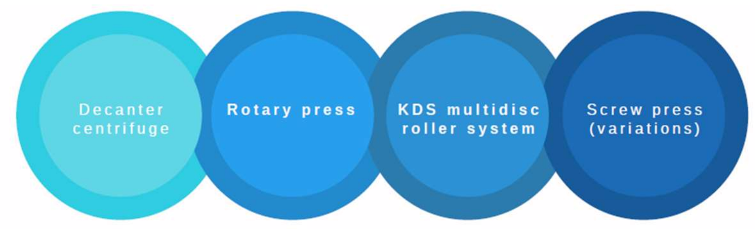


Figure 14 Main digestate dewatering technologies

It is recommended that the highly concentrated, nutrient-rich filtrate by-product from the dewatering phase be returned directly to the initial stage of the wastewater treatment plant (WWTP) for treatment, or treated in a side-stream process, pending concentration and quantity.

The solids-producing options of bio-based fertiliser pellets and biochar production have a high Technology Readiness Level, relatively high costs, energy requirements, and a medium footprint (Tessele, 2022a). Despite the higher costs, they are expected to produce high-quality products that generate more revenue and provide a good return on investment. The biochar technologies effectively destroy more pathogens and potential contaminants, likely gaining regulatory approval for a wide variety of uses. Biochar can be used for a wide range of uses such as soil amendment for moisture and nutrient retention, as a carbon feed for livestock, soil remediation, pollutant and carbon capture and various technological uses like batteries.

However, the bio-based fertiliser pellets retain more nutrients and are subsequently more valuable to some end-users, whilst still reducing pathogens enough for a wide range of reuse applications. Both the pellet and biochar processes include heat and energy recycling components to help offset operational costs.

Of the options assessed, the most favourable is the production of bio-based fertiliser pellets by:

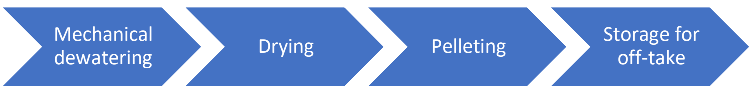


Figure 15 Selected biofertiliser processing technology

This approach results in a smaller product volume, simplifying transport and reuse.

Producing biofertiliser pellets from liquid digestate offers better storage and transportation due to reduced product volume and odours. For the WA facility, third-party offtake of biofertiliser pellets is convenient given the proximity to forestry, agricultural, and mining areas, as well as the potential retail market. This also applies to the NSW facility, located near agricultural lands that typically require fertiliser application. The pelleted product is suitable for a range of uses, is cost-effective to produce, and easier to handle.

Potential third-party offtaker stakeholders were identified and interviewed in the 2022-1081 Biofertiliser project. Fertiliser producers expressed interest in a stable, dust-free, pelletised organic-mineral fertiliser meeting global standards and noted a market interest in carbon offsetting. They suggested pricing based on nutrient content and quality, with a potential premium for sustainability. Regulations on digestate use vary across Australian states, with NSW and Queensland allowing conditional direct application of liquid digestate. A national standard for digestate quality could help overcome regulatory challenges for industry growth. For more on biofertiliser regulations, refer to project 2022-1081.

5.8.3. Biofertiliser design

This section summarises the Biofertiliser component of the BRRC Front-End Engineering Design for the WA and NSW case study facilities. This component processes the digestate by-product from anaerobic digestion, reducing disposal costs and issues while creating an additional revenue stream through the production of valuable biofertiliser, and further contributing to environmental sustainability in the larger sense. Below, the design of the Biofertiliser plants has been summarised. Refer to the appendices for Biofertiliser plant drawings.

Table 18: Summary of biofertiliser production component of the BRRC

Equipment	Purpose	WA case study facility	NSW case study facility
Dewatering	Screw press mechanically dewaters the liquid digestate to approximately 20% TS, with the assistance of flocculation and coagulation, to enable a more efficient drying process	2 off	2 off
Drying	The dryer thermally dries the dewatered ‘cake’ to achieve 85% TS	1 off	1 off
Pelleting	The pelleter takes the dried digestate and produces pellets, delivering a product at 90% TS	1 off	1 off
Storage	The bio-based fertiliser is stored in a shed to ensure it remains uncontaminated and dry. This storage acts as a buffer for sales and logistics and has capacity to store at least a month's worth of product.	1 off	1 off
Alternative option – gasification to biochar	As an alternative option to pelletisation, the 85%TS dried digestate can be put through a gasifier, where high temperatures and some oxygen produce biochar. The system is fuelled by a portion of the produced biochar.	1 off, including flue gas scrubber	1 off

For the two case study facilities, the digestate dewatering process uses a screw press to separate the 5% TS digestate into a liquid, and a solid ‘cake’ of approximately 20% TS. The screw press is chosen for its reliability, local support, lower energy demand and performance in similar applications. This process reduces the digestate volume, lowering transport and storage costs, and prepares it for further processing into biofertiliser pellets, or biochar as an alternative option. The screw press includes a polymer dosing system and handles varied sludges efficiently. The dewatered digestate ‘cake’ is then thermally dried to 85% TS, and is pelleted, or as an alternative option depending on market demand, gasified into biochar. The drying and pelleting system includes heat recovery and a three-stage odour control system enhance efficiency and environmental compliance.

Table 19 summarises the inputs and outputs from the biofertiliser plant, based on digestate characteristics and the configuration of selected technologies.

Table 19. Digestate processing: inputs and outputs in the biofertiliser plants for the WA and NSW case study facilities

Bio-based Fertiliser Plant Inputs/Outputs	Item	Total solids (TS)	WA Facility (t/yr)	NSW Facility (t/yr)
Input	Digestate from anaerobic digesters	5%	36,500	101,835
Interim output	Cake after dewatering	22%	8,295	23,137
Interim output	Thermally dried cake	85%	2,147	5,989
Final bio-based fertiliser output	Pellets Production	90%	2,028	5,656
Final bio-based fertiliser by-product output	Liquid filtrate sent to WWTP (kL)	<1%	27,375	79,465

5.9. Cost estimate of integrated system

This section summarises the cost estimates for implementing a BRRC at the WA and NSW case study facilities. According to the Association for the Advancement of Cost Engineering (AACE), the cost estimate accomplished in this report meets the Class 4 range (feasibility study), with an accuracy of +30%. Contract preliminaries, design management factors and contingency costs were considered.

The core implementation costs for the bioresource recovery facilities focused on mechanical and electrical equipment for components including the WWTP, anaerobic digestion, bio-fertiliser plant, and, in the case of NSW, an additional component for CO_2 recovery for use as a form of dry ice in meat packing.

The total CAPEX for BRRC implementation is AU$38M for the WA Case Study Facility and AU$57M for the NSW Case Study Facility.

Table 20. Summarised capital costs for BRRC implementation at the case study facilities

Description	WA Case Study Facility Total (Thousands of AUD)	NSW Case Study Facility Total (Thousands of AUD)
WWTP	$13,535	$15,592
Biogas plant	$18,602	$22,114
CO_2 recovery component	-	$11,463
Biofertiliser plant	$ 6,339	$ 8,112
Total BRRC	**$38,476**	**$57,281**

5.10. Carbon emission reduction – WA case study facility example

Red meat processing facilities traditionally emit significant greenhouse gases (GHG) primarily due to electricity consumption. Underutilised, organic by-products from these facilities can produce biogas through anaerobic digestion (AD), generating electricity and biofertiliser. The biogas is 60% methane and if it is emitted in its natural form, has a potential greenhouse effect. However, if the biogas is flared, the 40% carbon dioxide from the biomass is returned to the atmosphere in the same way it was assimilated, becoming climate neutral. This production of renewable energy has the ability to offset the red meat processors' reliance on fossil fuel-derived energy sources, such as grid electricity, natural gas and coal. Therefore, implementing an integrated Bio-resource Recovery Facility at red meat processors aligns with the Australian red meat industry's goal to be carbon neutral by 2030. This section summarises the impact on the carbon footprint with the implementation of BRRC at red meat processing facilities.

A Western Australian facility processing 4,500 sheep/lambs and 330 cattle per day was analysed to determine how much carbon emissions could be reduced by implementing a Bio-resource Recovery Centre. Wastewater and solid waste recycling were considered to produce biogas and biofertiliser through a Bio-resource Recovery Centre (BRRC). Two scenarios were examined: the current operating situation and with BRRC implementation.

5.10.1. Outcomes

Implementing the BRRC can reduce emissions by over 68%. Future production increases could lead to a 50% higher carbon footprint. The BRRC can provide 20% excess energy for facility use, potentially combined with other renewable sources to neutralise Scope 2 emissions.

Total Emissions:

- Without BRRC: High emissions from waste degradation and energy consumption.
- With BRRC: Significant reduction in emissions, especially from waste degradation. Scope 2 emissions could be neutralised with excess energy production.

In conclusion, the BRRC can substantially reduce GHG emissions in red meat processing facilities, aligning with the goal of carbon neutrality by 2030 and enabling participation in the carbon credits market.

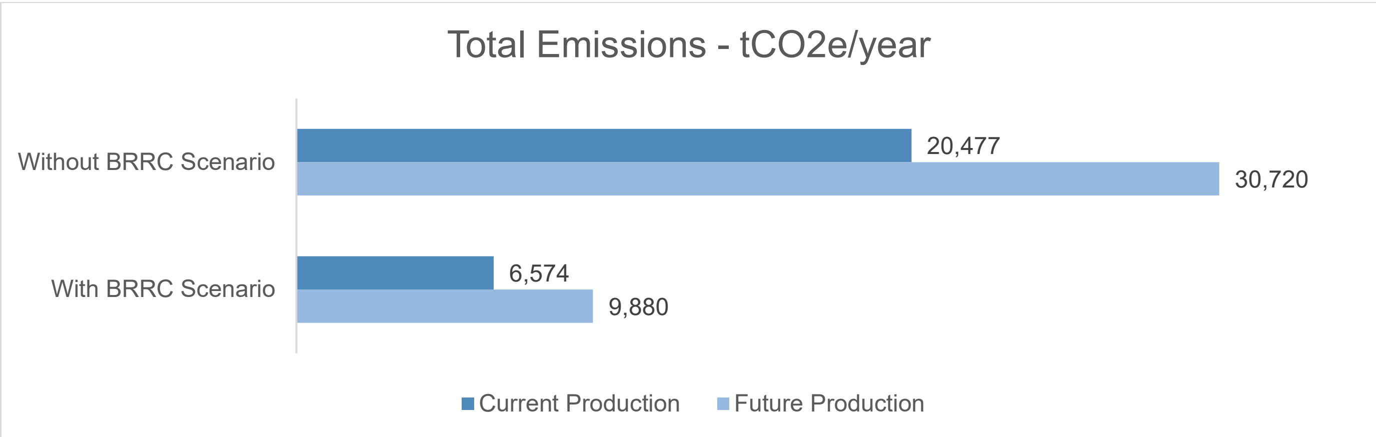


Figure 16. Total GHG emissions for each scenario

In Figure 16 shows a decrease in carbon emissions by over 68% with BRRC implementation. However, if production increases over ten years, the carbon footprint will be over 50% higher than currently. Four main groups of emissions could be categorised for calculation:

- Waste Transport: Indirect emissions from waste transported to landfills.
- Waste Degradation: Methane emissions from organic waste in landfills.
- Energy Consumption: Electricity from the grid, projected to increase from 12,020 MWh/year to 18,070 MWh/year.
- Fugitive Emissions: Methane leaks from biogas systems.

shows the total annual emissions for each activity in both scenarios (current and future production) without the BRRC.

Four main groups of emissions could be categorised for calculation:

- Waste Transport: Indirect emissions from waste transported to landfills.
- Waste Degradation: Methane emissions from organic waste in landfills.
- Energy Consumption: Electricity from the grid, projected to increase from 12,020 MWh/year to 18,070 MWh/year.
- Fugitive Emissions: Methane leaks from biogas systems.

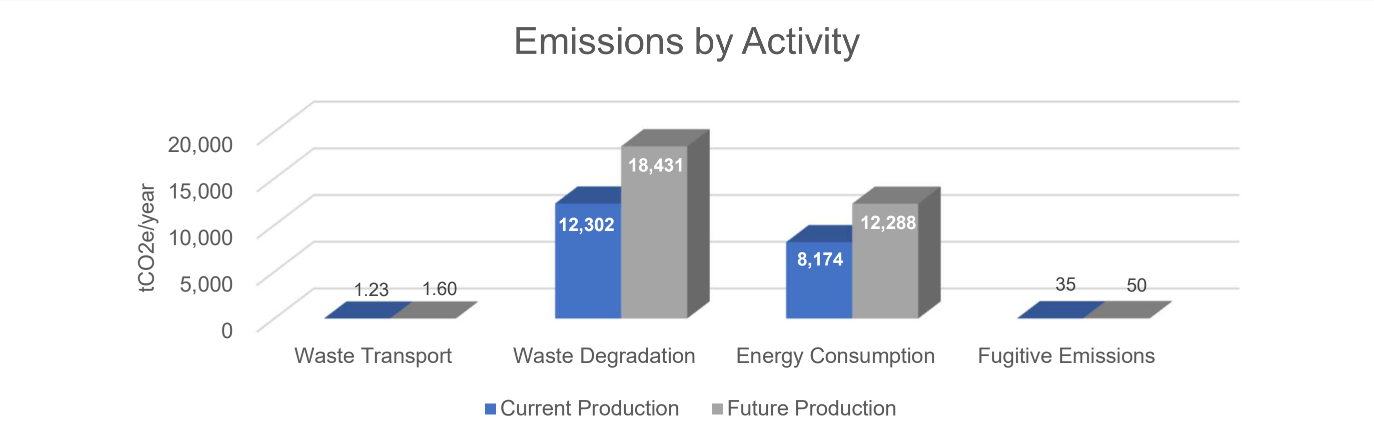


Figure 17. Total GHG emissions by waste management activities

As seen in Four main groups of emissions could be categorised for calculation:

- Waste Transport: Indirect emissions from waste transported to landfills.
- Waste Degradation: Methane emissions from organic waste in landfills.
- Energy Consumption: Electricity from the grid, projected to increase from 12,020 MWh/year to 18,070 MWh/year.
- Fugitive Emissions: Methane leaks from biogas systems.

, most emissions come from methane released during organic waste degradation, which the BRRC would eliminate. The second-largest source of carbon emissions is energy consumption. While the BRRC initially increases energy use, its biogas power plant offsets this and can provide 20% surplus electricity to use for red meat processing main operations. This percentage of surplus energy can be further increased with co-digestion, refining technology selection and energy optimisation of the plants. Combined with other renewable energy options, such as solar panels, this can neutralise Scope 2 emissions. Figure 18 shows the reduction in Scope 2 emissions as biogas power generation increases.

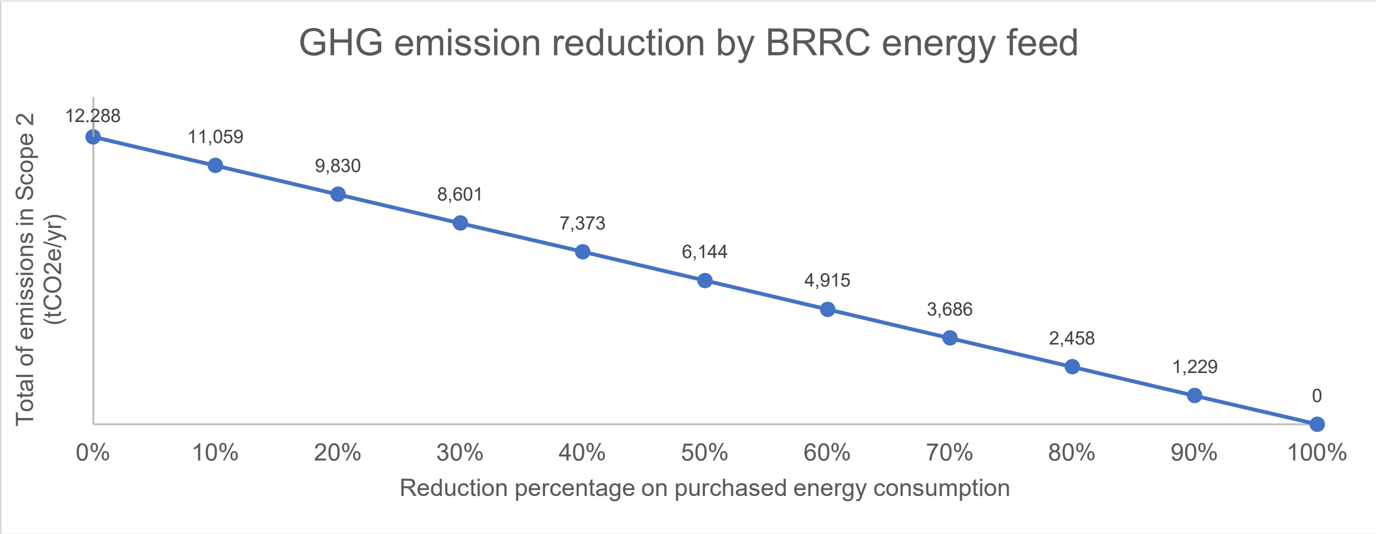


Figure 18. Potential GHG reduction by the increase of biogas power generation - baseline production of 11,000 Nm^3/yr.

Fugitive emissions rank third in potential GHG emissions. For future production, these emissions are less than 0.1% of energy generation, a negligible value. Emissions from solid waste transportation are lower due to the short distance to the landfill but increase with distance. Categorising these activities within the GHG emissions scope helps identify opportunities and impacts. Figure 19 illustrates the total emissions for each scope.

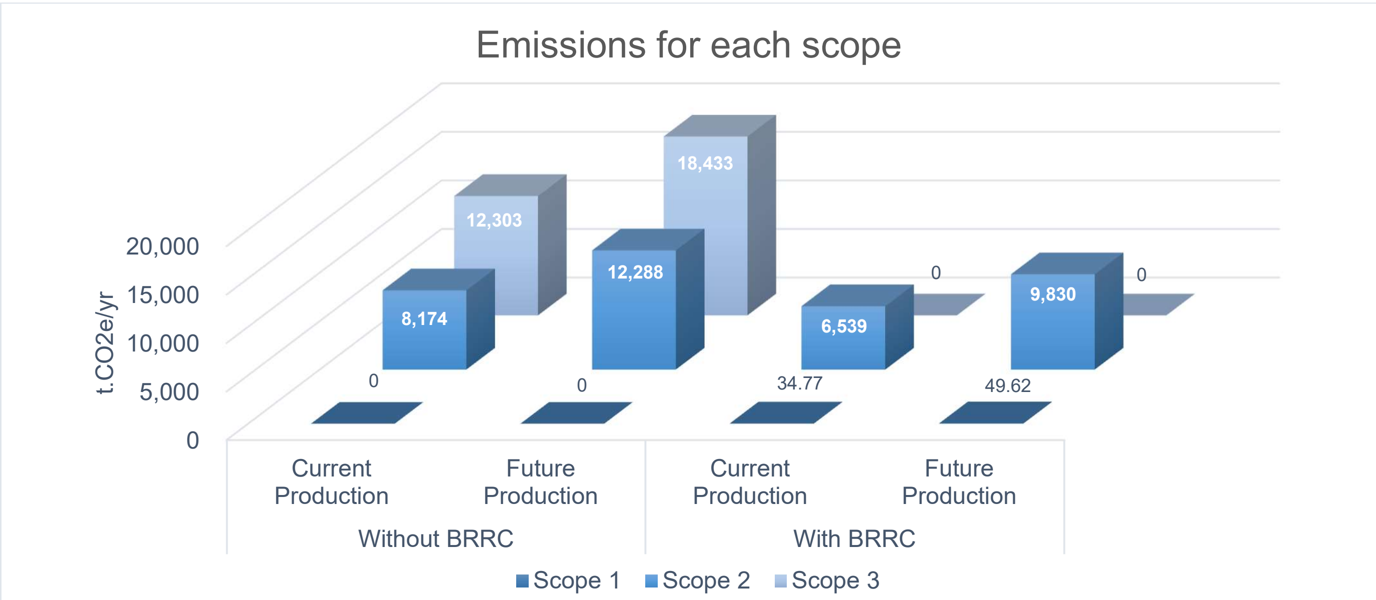


Figure 19. Total project GHG emissions by the scope

Figure 19 shows that Scopes 2 and 3 have the largest carbon footprints. In the BRRC scenario, Scope 2 represents nearly all emissions. The BRRC can produce 20% surplus energy for meat processing, potentially achieving carbon neutrality with co-digesting or other supplemental renewable energy technologies. Scope 3 represents indirect emissions beyond the organisation's control but is included for a complete analysis. More concentrated Scope 1 emissions are better managed within the company's boundaries. In the BRRC scenario, Scope 3 emissions are replaced with negligible Scope 1 emissions.

Emissions factor

Figure 5 presents the emission results in kg CO_2e per tonne of HSCW for scenarios with and without BRRC, based on the AMPC emission factor.

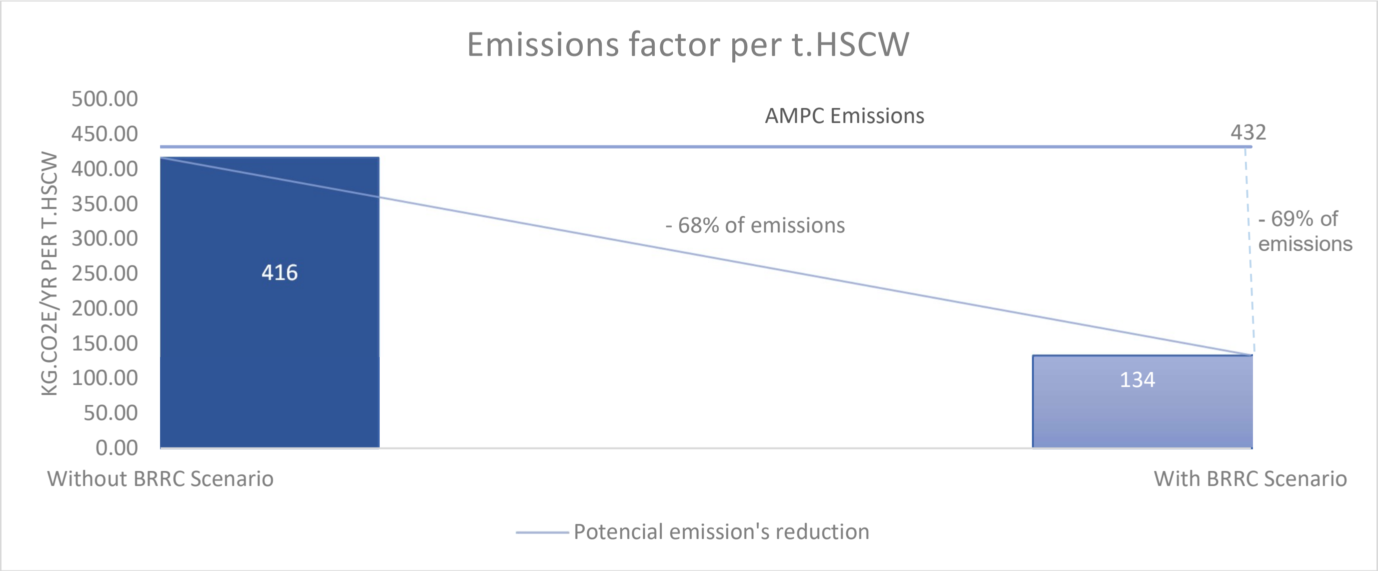


Figure 20. Comparison of total GHG emissions by HSCW between scenarios

In the scenario without the BRRC, emissions are 4% lower than the AMPC factor, indicating the case study facility is representative of the industry. The factor calculated in this report reflects that solid waste management activities are as impactful as Scope 1 and 2 activities in the AMPC factor. With BRRC, emissions are 69% lower than the AMPC factor, a 68% reduction compared to the current system. Figure 21 presents the contribution of Scope 3 in the factor of AMPC.

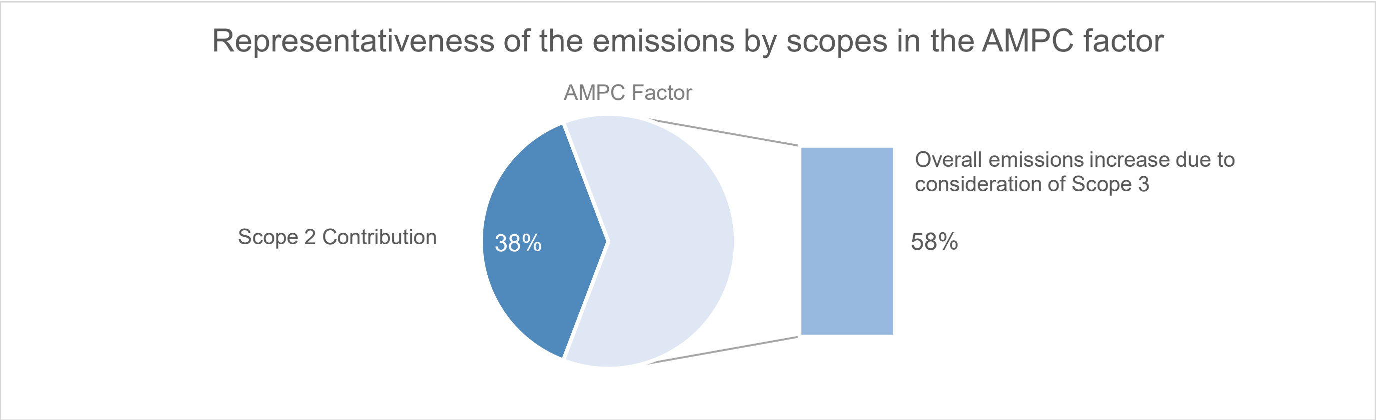


Figure 21. Contribution of GHG emissions to AMPC factor – Without BRRC scenario

Figure 21 shows that 38% of the AMPC factor is due to Scope 2 emissions from energy consumption, contributing 166 kg CO_2e/t.HSCW. Scope 1 contributes 265 kg CO_2e/t.HSCW, resulting in a total AMPC factor of 432 kg CO_2e/t.HSCW. Adding Scope 3 emissions (mainly from organic waste degradation) would increase this by 58%, or 250 kg CO_2e/t.HSCW.

Power generation from the biogas plant could reduce or neutralise Scope 2 emissions, lowering the overall GHG impact. With Scope 3 added, emissions would be 682 kg CO_2e/t.HSCW annually. With the BRRC, emissions drop to 433 kg CO_2e/t.HSCW, potentially decreasing to 300 kg CO_2e/t.HSCW with auto power generation.

5.11. Revenue estimates

Refer to Milestone 9 for details on the revenues estimate, summarised below. There are various price points across Australia for commodities such as non-potable water, electricity, natural gas, coal, fertiliser, biochar, liquid CO_2, pelleted dry ice, disposal costs and carbon credits. Of the collated prices, the conservative selected value is represented below as a large marker.

Revenue estimates

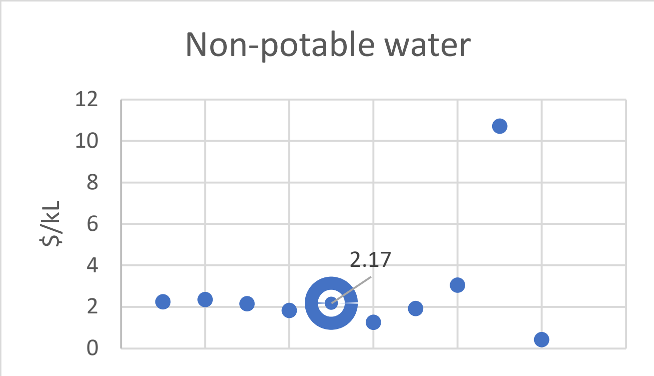


Figure 22 Non-potable water prices

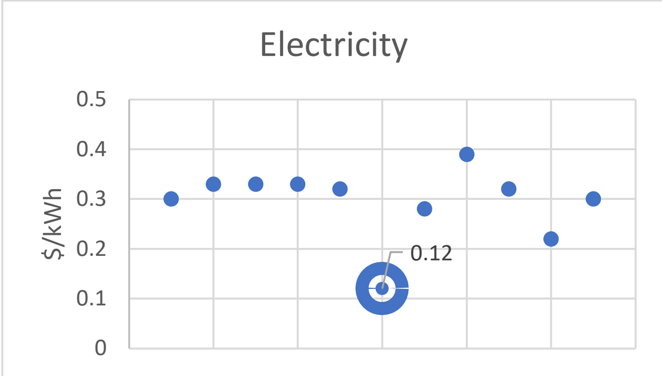


Figure 23 Electricity prices

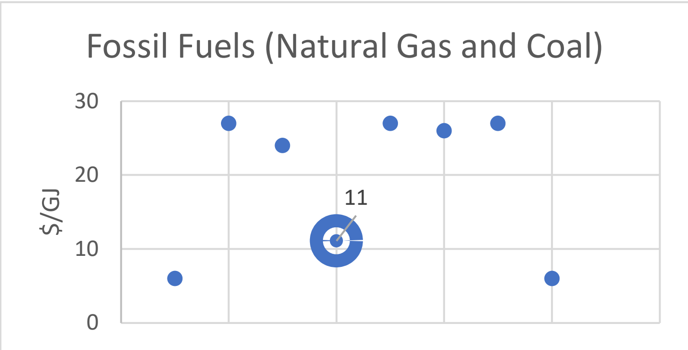


Figure 24 Energy prices

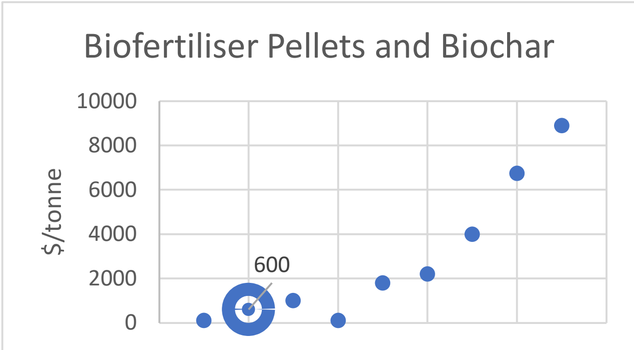


Figure 25 Biofertiliser prices

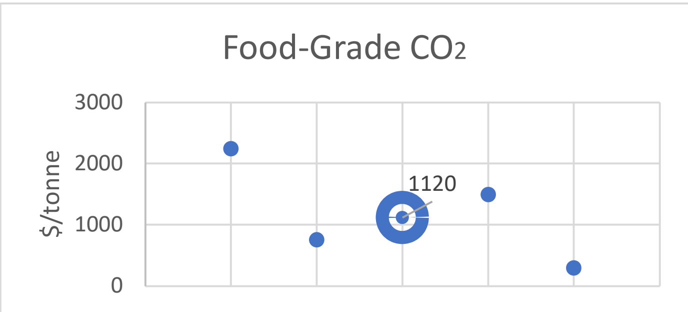


Figure 26 Food-grade CO_2 prices

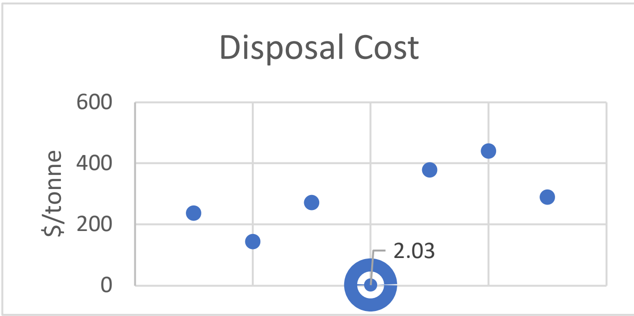


Figure 27 Disposal costs

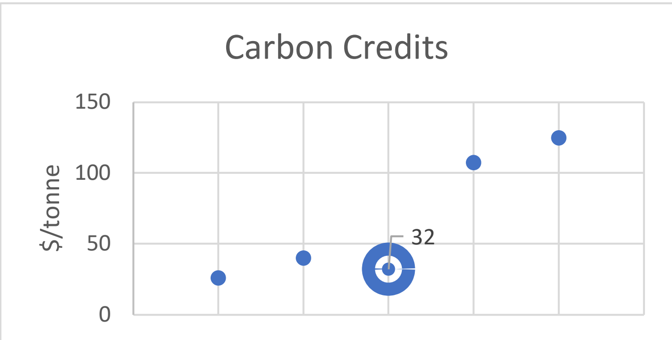


Figure 28 Carbon credit prices

While each commodity is a valuable resource, income from providing high-quality, non-potable water to third parties depends on environmental regulators' support for water reuse and recycling. There is an opportunity for regulators to develop supportive policies and incentives for red meat processors and users like non-potable water network operators and councils. Supportive policies will encourage a financial value to be attributed to the water, enabling investment in treatment infrastructure. Without this support, non-potable water might be undervalued, with some third-party off-takers expecting it for free or even charging the provider to receive it. This would prevent the realisation of the water's full value and prevent the creation of an additional revenue stream.

There is national political momentum to increase disposal costs, evident in the increases in controlled waste facility gate fees. This shift presents an opportunity for red meat processors to improve resource recovery and reduce waste. While some processors currently incur minimal or no disposal costs for their WWTP sludges and by-products through agreements with neighbouring waste facilities or by cheaply disposing of solids on their own agricultural land, increased disposal costs, supported by policy improvements, could further enhance the economic feasibility of implementing a BRRC.

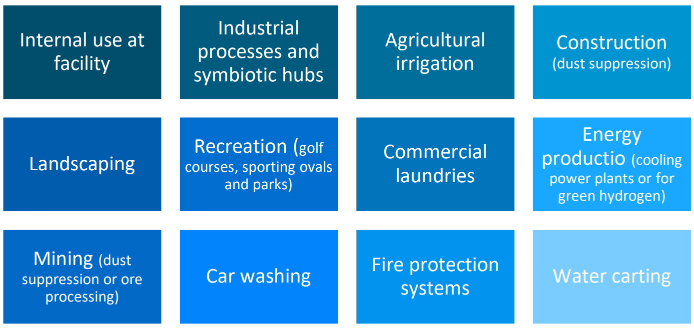
The energy market has been volatile, with Western Australia benefiting from significantly cheaper natural gas prices than the eastern states in recent years. This made feasibility studies for self-sufficient energy production in a BRRC more economically viable in the eastern states. Recently, energy prices have become more balanced across Australia, although fluctuations may still occur.

These market factors, along with future forecasts, must be considered case by case to ensure accurate economic feasibility studies and business case developments for BRRC implementation at each red meat processing facility. It is recommended to collaborate closely with regulators to promote the reuse of valuable resources and to attribute financial value to these recovered products. Regulator support unlocks the full potential and enables investment in resource recovery infrastructure, reducing payback times for projects like the BRRC.

5.11.1. Commercial opportunities for the use of new commodities

Outlined below are high-level commercial opportunities for revenue-generating resources recovered from the BRRCs.

Non-potable water



Selling non-potable water to businesses like carting companies (generating a high revenue) or to other off-takers such as non-potable water network operators, generates revenue. Alternatively, using it for onsite needs (e.g., livestock non-final wash, toilet flushing, irrigation, and process water for the BRRC) decreases reliance on potable water, ensuring reliable water supply, reducing costs, and enabling expansion where potable water supply is limited.

Figure 29 Non-potable water reuse opportunities

Biofertiliser

The following outlines key opportunities for biofertiliser use and potential third-party offtakers.

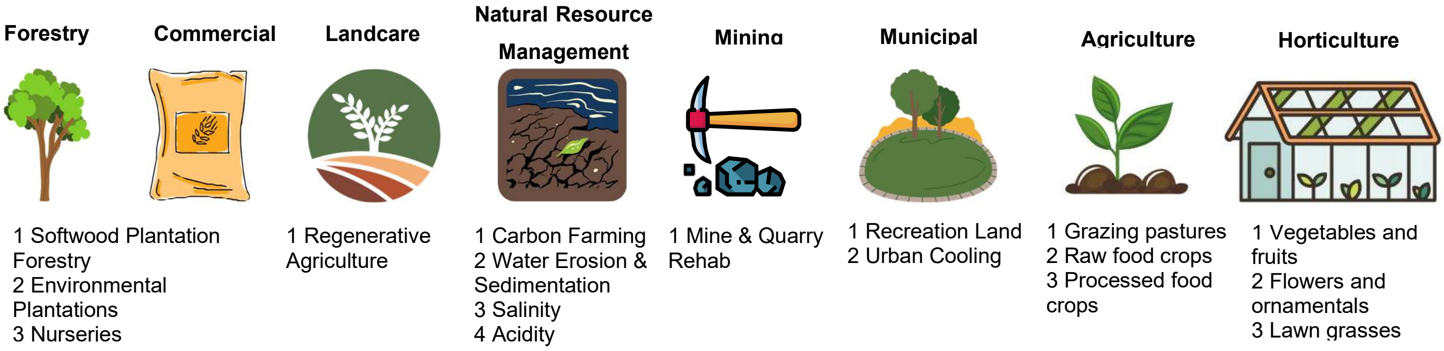


Figure 30 Biofertiliser reuse opportunities

Biochar

In some cases, biochar production may be considered more beneficial than biofertiliser pellets. The following identifies the high-level markets which the biochar could be used, with the potential for lucrative additional revenue.

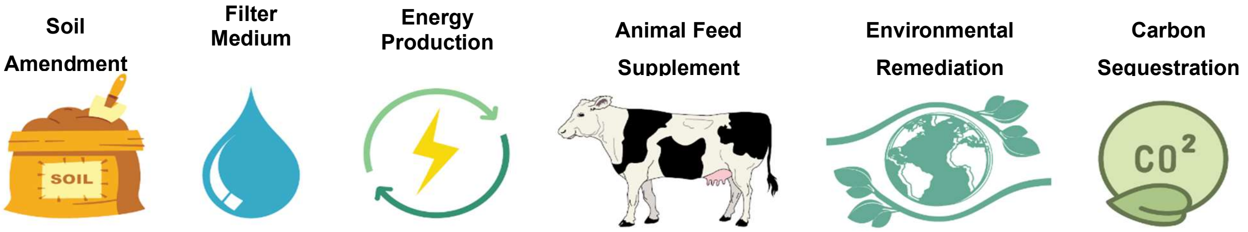


Figure 31 Biochar reuse opportunities

Biogas

The following outlines the opportunities for biogas use.

Power generation in CHP engines - onsite	Replacement of natural gas or coal onsite	Injecting into natural gas network	Biogas upgrading to biomethane
Diesel replacement - remote power generation	Biogas as a form of RNG	Biogas for industrial processes	Fuel for vehicles

Figure 32 Biogas use opportunities

CO_2

Separating CO_2 from biogas for use at the red meat processing facility as food-grade CO_2 for meat packing, or for sale to other industries, presents a revenue generating opportunity. Given Australia's high prices and limited production of dry ice, this provides a cheaper, reliable supply for meat chilling. If not used on-site, it can be sold to nearby companies who require dry ice. Additionally, it may improve biogas engine efficiency or count towards additional carbon credits, pending approved carbon accounting policies. CO_2 recovery for onsite use was considered for the NSW case study facility and could also be considered for the WA facility, and other facilities, for third-party offtake.

Electricity

The biogas used in CHP engines can generate electricity valued at market prices, creating an additional revenue stream. The CHP can make the BRRC self-sufficient with approximately 20 - 30% energy surplus for the red meat processing facility's core electrical needs. With co-digestion, enough electricity can be produced to power both the facility and the BRRC, with potential surplus for neighbouring businesses.

Thermal energy recovery

Opportunities to use the produced heat are outlined below.

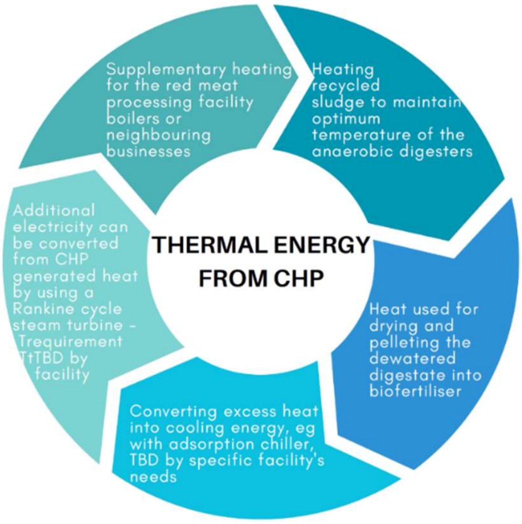


Figure 33 Heat use options

Disposal costs

Implementing the BRRC will reduce disposal costs by redirecting solids, currently sent to controlled waste facilities or underutilised at the facility, into anaerobic digesters. This will result in savings. Below are examples of underutilised products at red meat processors that could be redirected to reduce disposal costs.

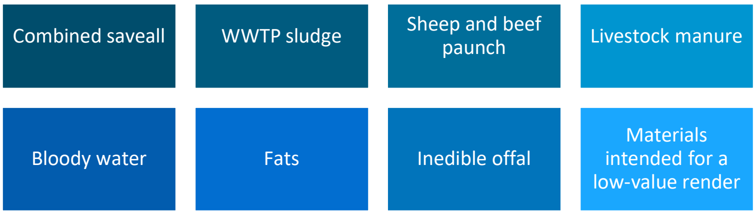


Figure 34 By-products diverted from disposal

Carbon credits

There is potential to reduce scope 1, 2 and 3 greenhouse gas emissions at red meat processing facilities by implementing a BRRC, as follows:

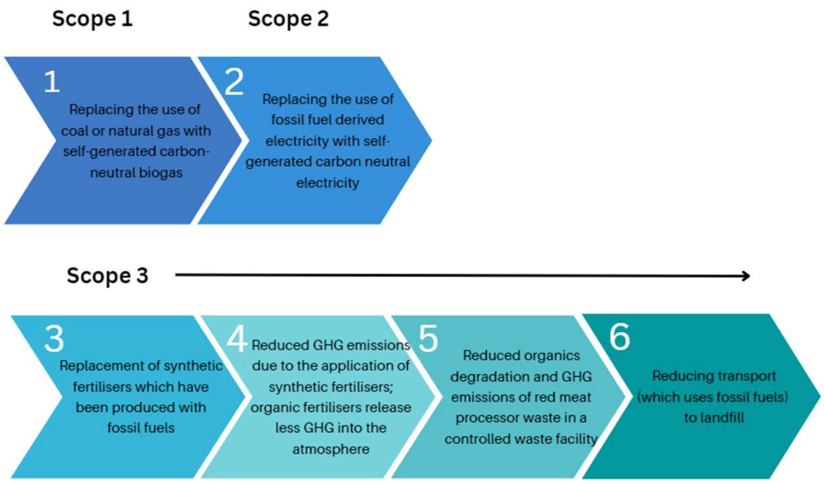


Figure 35 Carbon credits

Carbon credits from the use of biofertiliser benefit the fertiliser end-user, not the red meat processor, but sharing these benefits through a mutual agreement is possible. Biochar use can generate effective carbon credits by permanently sequestering carbon in the soil. Selling the CO_2 component of biogas, which is already carbon neutral, could potentially provide additional carbon credits and has high resale value in Australia for various industries. If enough carbon credits are generated, surplus credits can be sold on the voluntary market. Additionally, future carbon credits can be sold internationally via a global exchange platform to help fund project capital costs.

Other opportunities for revenue

Additional revenue generating prospects have been outlined below:

- Growing energy dense crops (such as corn) on the red meat processing facility site for co-digestion
- Co-digestion of two facilities within close vicinity to each other to increase critical mass and return on investment
- Converting the biogas into biomethane, or hydrogen, if demand and cost/benefit are worthwhile
- Government grants
    - Potential financial incentives for implementing sustainable farming practices, animal welfare, environmental conservation and carbon neutral initiatives

Revenue estimates summary

Maximising revenue streams is crucial for the feasibility and ROI of BRRCs at red meat processors. Expanding their red meat processing operations can boost revenue, but can be challenging. Challenges include increased demand for potable water from potentially limited sources (as in NSW's case) and constraints on wastewater treatment plants due to environmental regulations and infrastructure capacity limitations (as in WA's case).

The BRRC can address limitations in treated wastewater quality and internal processing water availability. Additionally, the BRRC enables energy self-sufficiency, reducing costs and protecting against volatile energy prices. Revenue opportunities from recycled water, biofertiliser (or biochar), biogas, electricity, heat, carbon credits, CO_2 recovery, and co-digestion are summarised in the figure below.

Commodity	WA Case Study Facility	NSW Case Study Facility
Driving Forces: Expansion – Water	Environmental compliance of treated wastewater	Internal water reuse creates an increase in processing water availability
Driving Forces: Expansion – Power	Reliable power and reduced Opex associated with power outages	Off-grid power, impervious to expensive prices in volatile market conditions
Recycled Water	• Local water utility non-potable water network • Non-potable water source for nearby water carting companies	• Non-potable water production stream for internal use at the red meat processing facility enables expansion • Non-potable water production for other site processing needs and for energy crop irrigation on their own land • Non-potable water production for supplementing nearby raw water networks, particularly for drought aid
Biofertiliser	• Local forestry companies expressed interest in offtaking biofertiliser pellets for nearby forests • Potential retail markets for high retail value	• Liquid digestate can be applied on land • Use on energy crops on their own land • Use on nearby agricultural land • Third-party off-take of biofertiliser pellets
Biogas	Offset natural gas use in onsite boilers	Replace the use of coal and electricity for boilers and rendering
Electricity	Reliable self-sufficient power and protection from market volatility	
Thermal Recovery	Heat recovered for anaerobic digester heating, onsite rendering processes, dewatered digestate drying and pelleting	Heat recovered for anaerobic digester heating, onsite rendering processes, dewatered digestate drying and pelleting (if required)
Biochar	Similar NPV but better local reliable market with the biofertiliser pellets	Strong potential in NSW for the use of less processed digestate, so the liquid digestate or pelleted biofertiliser options are a lower risk option to achieve return on investment
Carbon Credits	• Scope 1: • Replacing fossil-fuel derived natural gas for rendering process • Scope 2: • Replacing fossil fuel-derived electricity with carbon neutral electricity • Scope 3: • Replacing synthetic fertiliser which were produced using fossil fuels • Reduced GHG emissions from offgas due to synthetic fertiliser application • Reduced organics degradation and GHG emissions in controlled waste facilities • Reduced transport of 'wastes' to landfill (which uses fossil fuels)	
CO2 Production	Potential production of CO2 for sale in a high demand, low supply industry with a high sale price	Production of CO2 for internal use to cool meat for transport
Other Relevant Opportunities	• Co-digestion with grain dust and local waste feedstock such as brewery waste • Grants	• Co-digestion with corn (grow energy crops) and other local waste feedstock • Grants

Figure 36 Summary of revenue estimates

5.12. Stakeholder engagement meetings

The BRRCs concept has received positive feedback and insights from a diverse range of stakeholders, including owner-operators, investors, feedstock suppliers, researchers, contractors, agricultural industry stakeholders, government entities, off-takers, environmental groups, local businesses, the community, traditional landowners, training organisations, tourism stakeholders, and media representatives. They emphasised equitable ownership, financial viability, collaboration, technological advancements, transparent communication, environmental impact mitigation, community engagement, and integrating Indigenous knowledge. This feedback highlights the BRRC's potential for sustainable development, economic growth, job creation, environmental stewardship, and community well-being. The below schematic shows the key stakeholders that were contacted.

Figure 37 Stakeholders

All stakeholders responded positively, providing encouraging feedback and expressing interest in the project's implementation.

Effective stakeholder engagement is crucial for the success of the Bio-resource Recovery Centres project. Engaging a diverse range of stakeholders—such as BRRC owners-operators, investors, feedstock suppliers, researchers, contractors, agricultural stakeholders, various levels of government, product off-takers, environmental entities, local businesses, the community, traditional landowners, training partners, tourism operators, and the media—is vital to ensure a comprehensive and inclusive approach. Stakeholder feedback is summarised below.

Figure 38 Summary of stakeholder engagement feedback

5.13. Funding and financial modelling

5.13.1. Financial model

The primary objective of the financial model is to offer a detailed analysis of cost structures based on real-time, updated data, and adaptable to any production capacity measured in t.HSCW/yr. It examines a comprehensive bio-resource recovery centre (BRRC) designed for long-term expansion, with capital expenditure delivered in a single stage. This includes wastewater treatment, biogas production, CO_2 recovery for dry ice, and biofertiliser plants. The financial model was based on a BRRC designed for a hypothetical annual red meat processing throughput of 40,000 t.HSCW/year, serving as the primary source for key parameters in the proposed financial analysis. The development of this model leveraged financial and design engineering techniques.

5.13.2. CAPEX and OPEX

CAPEX was obtained using the six-tenths rule of design engineering, providing an order of magnitude estimate classified as Class 5 (±30-50%). This estimate is well-suited for the current preliminary stage of the project. As the project advances and more detailed studies are conducted, the accuracy of cost estimates will improve significantly, potentially reaching ±5-10%.

Table 21 Reference CAPEX for each plant to be built considering a capacity of 40,000 t.HSCW/yr based on the 2024-1019 MS6 Economic Analysis report

Plant	CAPEX ($AUD)
WWTP	7,508,476
Biogas Plant with CO_2 recovery and pelletised dry ice production	16,860,142
Biogas Plant with CO_2 recovery and snow dry ice production	16,169,256
Biogas Plant without CO_2 recovery	10,649,221
Biofertiliser Plant	3,906,652

To determine the Operating Expenditure (OPEX) for the proposed bioresource recovery facility in the red meat sector, 6% of the Capital Expenditure (CAPEX) was deemed a fair estimate based on several industry-specific factors.

Firstly, the red meat sector typically incurs lower OPEX relative to CAPEX compared to more energy-intensive industries. Primary operational costs, including water treatment, biogas production, and biofertiliser management, are kept manageable through efficient modern technologies. Secondly, the adoption of advanced anaerobic digestion and CO_2 recovery systems in the facility reduces maintenance and energy costs, enhancing operational efficiency and justifying the 6% OPEX estimate.

Additionally, integrating bioresource recovery with wastewater treatment optimises resource use, generates renewable energy from biogas, and lowers external energy expenses, supporting sustainability goals. This holistic approach can lead to cost savings and potential incentives, making the lower OPEX percentage feasible.

5.13.3. Intensity values and average costs

The “intensity” values encompass metrics such as the amount of biogas produced, the volume of water treated, and the quantity of biosolids converted into energy and biofertiliser. These values are derived from real-life operations and are benchmarked against industry averages. It shows the potential of recovering resources related to the facility.

Table 22 Intensity values sourced from 2024-1019 MS6 Economic Analysis report adjusted to 40,000 t.HSCW/yr

Item	Value	Intensity (Item/1000*t.HSCW)
Wastewater (kL/yr)	335,799	8,395
Biogas (Nm^3/yr)	2,457,416	61,435
Electricity (kWhe/yr)	6,130,762	153,269
Heat (kWht/yr)	6,282,139	157,053
Food-grade liquid CO_2 available (tonnes/yr)	2,720	68
Food-grade dry ice pellets available (tonnes/yr)	2,092	52
Food-grade dry ice Snow Horn available (tonnes/yr)	604	15
Biofertiser (tonnes/yr)	1,673	42
Disposal avoided (tonnes/yr)	7,419	185
CO_2 Credit (tCO_2/yr)	3,244	81
Recycled water (kL/yr)	20,148	504

The values utilised are summarised in the Revenues Estimate section of the report, and are critical cost parameters for the financial model of the proposed bioresource recovery facility. These values provide a realistic and up-to-date basis for the financial analysis and ensure accurate projections.

Additionally, the value for pelletised food-grade dry ice is an estimate based on current prices in Australia. There is no consensus on a standardised price for dry ice, as it varies significantly depending on the state of the facility, the distance from the supplier, and the current market supply and demand (July 2024). As liquid food-grade CO_2 is more accessible in price, its solid form is estimated to be slightly more expensive due to added value and extra processing.

5.13.4. Financial model comprehensiveness

For the financial model to be practical, feasibility must be achieved for the majority of the possible stakeholders. This way, the study can be relevant and serve as a guide for the industry. Table 23 provides a detailed breakdown of the production capacities of red meat facilities, segmented by plant size for both beef and sheep processors.

Table 23 Distribution of AMPC's processing facilities and estimated annual production normalised to 2024's total red meat Australian production (Source: AMPC Annual Report 2021 and Australian Bureau of Statistics)

Plant Size	Plants	Annual throughput (%)	Produced (t.HSCW/2024)	Average (t.HSCW/ plant)
Beef				
Small	25	15%	342,260	13,690
Medium	33	51%	1,163,684	35,263
Large	13	34%	775,790	59,676
Total	**71**	**100%**	**2,281,734**	**32,137**
Sheep				
Small	27	12%	107,016	3,964
Medium	12	22%	196,196	16,350
Large	10	66%	588,588	58,859
Total	**49**	**100%**	**891,800**	**18,200**

Large and medium-sized beef plants, representing 85% of total annual throughput (65% of total plants), significantly contribute to the beef processing industry, making them a reliable benchmark for average production capabilities. Similarly, large and medium sheep processors, accounting for 88% of total annual throughput (45% of total plants), play a critical role in the industry, representing the primary drivers of production.

On average, large and medium-sized beef plants produce 47,470 t.HSCW per year, and large and medium-sized sheep plants produce 37,605 t.HSCW per year. Combining both sectors, the average annual production is 42,537 t.HSCW, justifying the chosen baseline of 40,000 t.HSCW for the financial model. This focus on the most impactful categories ensures the model reflects the true scale of red meat processors and establishes a baseline for achieving positive financial returns based on annual production.

5.13.5. Study case: BRRC with CO_2 recovery and pelletised dry ice revenue

To evaluate the financial attractiveness of constructing a bio-resource recovery centre based on the annual output of a red meat processing facility, several case studies were simulated using the financial model. The simulations explored a range of annual outputs, with 100,000 t.HSCW/yr as the upper limit (a few facilities are achieving this production ballpark) and the annual output resulting in a payback of 25 years as the lower limit. For each case study, the intensity values and the CAPEX and OPEX parameters aforementioned were maintained. This approach allowed for a thorough analysis of how varying production capacities impact the financial viability of the BRRC.

In this scenario, a full implementation of a bio-resource recovery facility was considered, including specific equipment for CO_2 recovery and pelletising. Table 24 below summarises the financial insights and outcomes of each case study, providing a clear comparison of potential investment returns and cost implications.

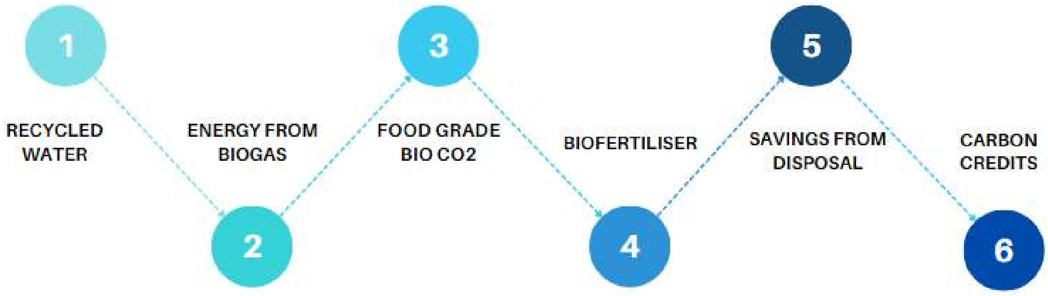


Figure 39 Income streams considered in the financial model

Table 24 Key financial parameters obtained from the simulation of 7 case studies varying the annual output of hscw

Case study	t.HSCW/yr	NPV ($)	Water CAPEX ($/ML)	Energy CAPEX ($/GJ)	Biofertiliser CAPEX ($/tonne)	CO_2 CAPEX ($/tonne)	ROI	Annualised ROI (25 years)	Payback time (yr)
1	100,000	$232,168,158	$66,852	$6	$187	$60	565%	8%	6
2	80,000	$175,945,665	$73,093	$7	$204	$66	503%	7%	7
3	60,000	$121,473,798	$82,007	$7	$229	$74	431%	7%	8
4	40,000	$69,659,081	$96,447	$9	$269	$87	342%	6%	9
5	15,000	$12,496,171	$142,783	$13	$399	$129	178%	4%	16
6	10,000	$3,401,962	$167,924	$15	$469	$151	127%	3%	21
7	7,821	$868	$185,271	$17	$517	$167	100%	3%	25

Dry ice in pellet form is known to hold its form for longer periods, as the rate of sublimation is lower and it is denser when compared to its powder form. In fact, the conversion rate of liquid CO_2 to dry ice pelletised is 1.35:1 (w/w), a significant difference from the powder option at 4.5:1 (w/w). Making CO_2 in the powder form is a common practice in the red meat industry and utilising it in this form is often referred to as a "snow horn". However, pelletising and recovering the CO_2 vapour from the process requires certain investment, which was considered in this case.

These results highlight that larger processing capacities are significantly more financially attractive, with lower unit costs and higher returns, whereas smaller capacities may not be economically feasible without additional efficiencies or cost reductions. Further insights can be obtained by analysing Figure 40.

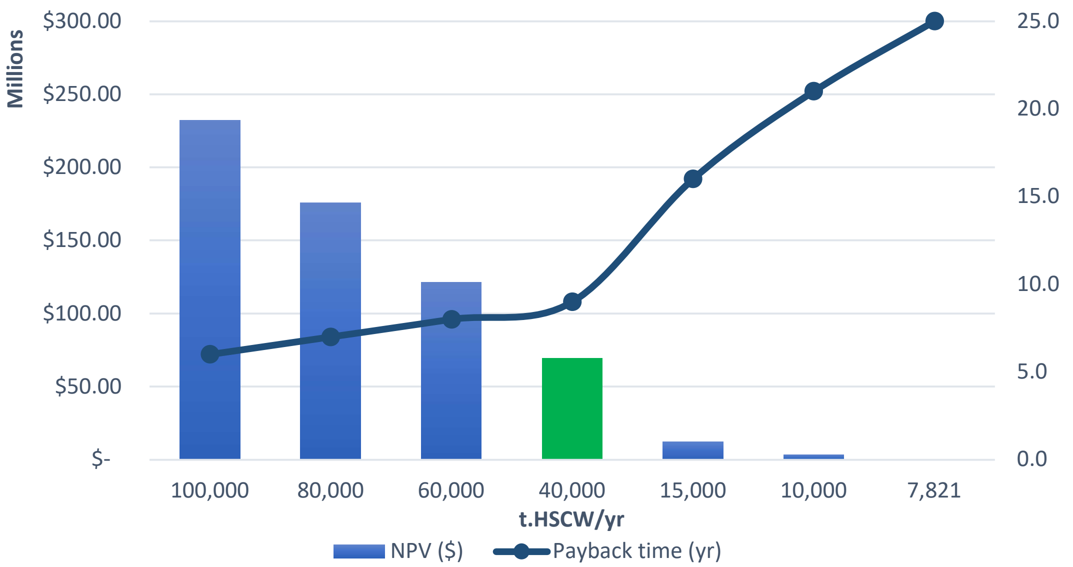


Figure 40 NPV and payback time graphs comparing all case studies

As per Figure 41, the highest income stream is derived from food-grade bio- CO_2, which can either offset the cost of outsourcing dry ice by producing it on-site or generate revenue by selling it to local off-takers (in pellet form).

The second highest income stream comes from the energy generated by the biogas at the CHP engines, reducing electricity and heat costs. The third most significant income is from the sale of biofertiliser, followed by smaller income streams such as carbon credits (ACCUs), disposal savings, and recycled water usage.

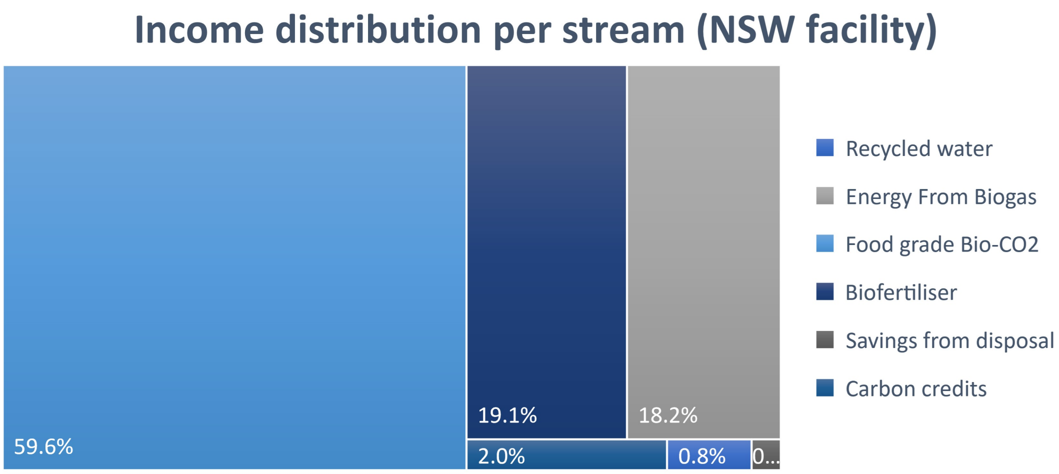


Figure 41 Income distribution per stream resulting from the financial model

This distribution underscores the significance and impact of each stream within the overall financial model. Despite diversified income sources, the model is sensitive to fluctuations in the prices of dry ice, electricity, coal, and biofertiliser, as detailed in the sensitivity analysis section. However, the financial outlook is promising, as facilities producing up to 7,821 t.HSCW/yr could break even within 25 years. While this payback period is not typically considered attractive, it is attainable for most red meat processors due to the low annual production requirement.

The heavy dependence on food-grade CO_2 presents a considerable risk if market conditions for this product change unfavourably. The forthcoming sensitivity analysis will provide additional insights into the optimal strategy for maximising profitability while mitigating risk in the dynamic market landscape.

Considering the current capabilities among AMPC members, Table 25 shows that, with a 25-year payback period and a positive NPV, most representative beef and sheep processing facilities (in terms of total t.HSCW production) could potentially invest in such a development. This suggests that despite the extended payback time, the scale and productivity of these key facilities are sufficient to make the financial investment worthwhile. However, this does not imply that every facility should invest in a BRRC under these terms, as the financial attractiveness varies by company.

Table 25 Average beef and sheep annual production per facility in Australia (large and medium-sized plants) and the minimum required to achieve a positive NPV in 25-year period

Beef Average production (t.HSCW/yr)	Sheep Average production (t.HSCW/yr)	Beef and Sheep Average production (t.HSCW/yr)	Minimum production to reach positive NPV (t.HSCW/yr)
47,470	37,605	42,537	7,821

5.13.6. Sensitivity analysis

The sensitivity analysis is crucial for understanding the robustness and resilience of the financial model. It evaluates how changes in the prices of key commodities affect the overall financial performance. By analysing these fluctuations, it is possible to identify which income streams have the most significant influence on the model's outcomes. This information is vital for decision-making, allowing stakeholders to anticipate potential risks and develop strategies to mitigate them. Furthermore, sensitivity analysis helps in stress-testing the financial model, ensuring it remains viable under various market conditions. This analysis provides a clearer picture of the model’s dependencies and aids in optimising the financial planning and resource allocation, ultimately contributing to more informed and strategic decisions.

Table 26 Sensitivity analysis for +/-50% changes in key cost parameters at 40,000 t.HSCW/yr

Scenarios	Parameter varied	Variation	Parameter new value	NPV (mil $)	ROI	Annualised ROI (25 years)	Payback time (yr)
O	None (Original)	None	None	69.66	342%	6%	9
A1	Pelletised dry ice	+50%	2250 $/tonne	112.96	492%	7%	7
A2		-50%	750 $/tonne	26.35	191%	4%	15
A3		-80%	300 $/tonne	0.37	101%	3%	25
B1	Thermal Energy price - Coal	+50%	0.06 $/$kWh_t$	73.13	354%	6%	9
B2		-50%	0.02 $/$kWh_t$	66.19	330%	6%	9
C1	Electricity cost	+50%	0.18 $/$kWh_e$	80.55	380%	6%	8
C2		-50%	0.06 $/$kWh_e$	60.25	309%	6%	10
D1	Biofertiliser price	+50%	900 $/tonne	83.51	390%	7%	8
D2		-50%	300 $/tonne	55.80	294%	6%	10

Scenarios	Parameter varied	Variation	Parameter new value	NPV (mil $)	ROI	Annualised ROI (25 years)	Payback time (yr)
E1	Average Water price Australia	+50%	1.09	69.06	340%	6%	9
E2		-50%	3.25	70.26	344%	6%	9

The sensitivity analysis reveals the financial robustness of the model against key cost parameter variations. The model is highly sensitive to changes in the price of pelletised dry ice. A 50% price increase significantly improves NPV and ROI, shortening the payback period, while an 80% price reduction still maintains a positive ROI of 101%, demonstrating resilience.

The model is moderately sensitive to biofertiliser prices. A 50% price increase improves NPV and ROI, reducing the payback period to 8 years, while a 50% price decrease extends the payback period to 10 years. This indicates that, while biofertiliser prices influence financial metrics, it does not pose a significant risk to the model's overall financial health.

Also, variations in coal, water, and electricity prices have minimal impact on financial performance. A 50% change in coal or water prices only slightly affects NPV, ROI, and payback time, showcasing the model's strong resiliance to fluctuations in these resources and ensuring stability in financial outcomes.

5.13.7. Financial model conclusions

Based on the findings of the financial model, the current scenario for implementing a bio-resource recovery facility is highly promising. The model demonstrates a positive Net Present Value (NPV) and a relatively short payback period for the prevailing costs in the Australian food industry, specifically within red meat processing. Facilities producing at least 40,000 t.HSCW/yr, including large and medium-sized beef and sheep facilities that represent over 85% of Australia's annual red meat production, would see a payback time of 9 years when a full BRRC and CO2 recovery to dry ice pellets is commissioned.

This financial model considers a "blue sky" scenario, assuming all proposed installations are completed on time and within budget, generating reliable income for the design life of 25 years. While optimistic, this scenario reflects the current market sentiment and the commitment of the Australian government and AMPC to support innovative projects and improve environmental practices. However, it is not implied that all red meat facilities should invest in such projects, as each facility may have its own ideal payback time and governance strategy for long-term investments.

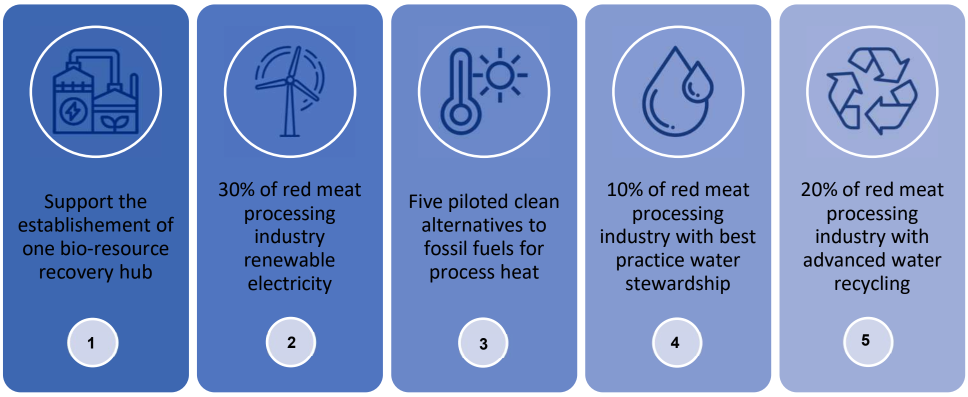
The model serves as a robust guide for future projects and financial assessments, demonstrating the viability of enhancing red meat processing facilities with advanced technologies in water treatment, biogas harvesting, CO2 recovery, and biofertiliser production. Stakeholders and interested parties are encouraged to explore further potential scenarios using the provided spreadsheet (2023-1013 Bio-resource Recovery Centres MS14 Economic Analysis). This tool allows for testing different intensity values, cost parameters, and other relevant factors, providing a comprehensive understanding of various financial outcomes and ensuring informed decision-making.

5.14. Business case

AMPC aims for Australian red meat processors to attain a prestigious global status by 2030, recognised as leaders in environmental stewardship and responsible business practices. This includes being acknowledged for exceptional efforts in environmental protection, ethical conduct, transparency, and accountability. The goal is to generate positive economic and social impacts, contributing to local economic growth by creating jobs, supporting suppliers, and fostering development. Socially, they aim to enhance community quality of life through initiatives like education, health and community engagement projects.

This vision positions Australian processors as model corporate citizens excelling in environmental responsibility while promoting economic prosperity and social well-being. As part of this strategy, one of AMPC's key performance indicators for 2025 is to support the establishment of a bio-resource recovery hub. This Business Case lays the foundation for investing in sustainable resource recovery hubs, highlighting the value of by-products currently considered waste.

One of AMPC KPI’s for 2025 is to support the establishment of one bio-resource recovery hub. The Business Case set up the foundations for enabling investment in truly sustainable resource recovery hubs, showing the value that can be recovered from by-products that are currently being treated as wastes. The implementation of this BRRC will support the achievement of the following 2025 AMPC sustainability KPIs:



The establishment of a network of Bio-Resource Recovery Centres (BRRC) in the red meat industry represents a strategic initiative aimed at addressing critical environmental and economic challenges. The BRRC will serve as hubs of innovation and efficiency, dedicated to advancing sustainable practices and achieving carbon neutrality within the industry.

The primary purpose of the BRRC is to create a robust framework for resource recovery within the red meat sector. This will involve the development and implementation of cutting-edge technologies and processes designed to maximise resource utilisation, minimise waste, and move the industry toward carbon neutrality. By focusing on resource recovery, the BRRC aims to transform the red meat industry into a model of sustainability and efficiency.

The key benefits include:

- Environmental Impact Reduction: By reducing waste, promoting sustainable practices, and striving for carbon neutrality, the BRRC will contribute to a significant decrease in the environmental impact of the red meat industry.
- Cost Savings: Improved waste management and resource recovery processes will result in substantial cost savings, enhancing the economic viability of industry operations.
- Improved Regulatory Compliance: The BRRC will help the red meat industry meet and exceed regulatory requirements, ensuring compliance with environmental standards and reducing the risk of penalties.
- Market Leadership in Sustainable Practices: Through the establishment of the BRRC, the red meat industry can position itself as a leader in sustainability and carbon neutrality, setting benchmarks for other industries to follow.

The Resource Recovery Centres will play a pivotal role in transforming the red meat industry. By focusing on sustainability, waste reduction, profitability, innovation, and carbon neutrality, the BRRC will deliver significant environmental and economic benefits, positioning the industry as a leader in sustainable practices, regulatory compliance, and climate action. Figure 42 summarises the BRRC initiative five main goals: Enhance Sustainability, Reduce Waste, Increase Profitability, Promote Innovative Technologies and Achieve Carbon Neutrality.

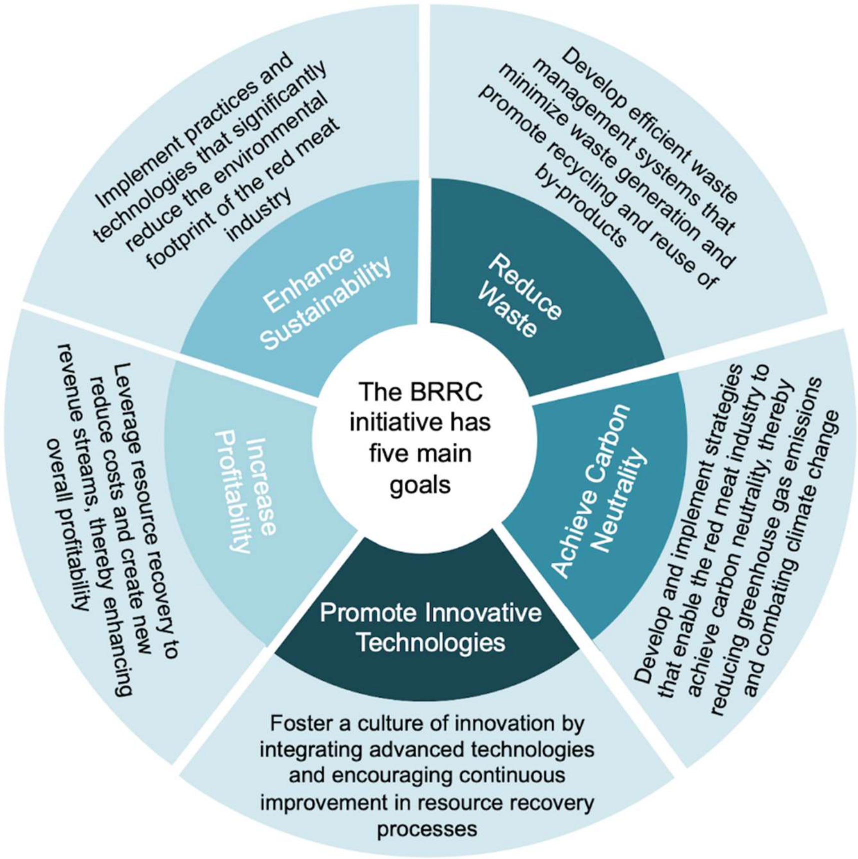


Figure 42. The BRRC initiative five main goals: Enhance Sustainability, Reduce Waste, Increase Profitability, Promote Innovative Technologies and Achieve Carbon Neutrality

The Resource Recovery Centres (BRRC) were designed to meet specific business objectives that align with the overarching goals of sustainability, economic viability, regulatory compliance, and innovation within the red meat industry. These objectives are critical for transforming the industry into a leader in sustainable practices and resource efficiency. Table 27 presents the Resource Recovery Centres (BRRC) main drivers and strategy: Sustainability, Economics, Compliance, and Innovation.

Table 27. Bio-resource Recovery Centres (BRRC) main drivers and strategy: Sustainability, Economic, Compliance, Innovation

Sustainability: Reduce the environmental footprint of the red meat industry by maximising resource recovery and minimising waste.
- Implement advanced waste management systems to ensure minimal waste generation.
- Develop processes to recycle and reuse by-products effectively.
- Adopt sustainable practices across all operations to lower greenhouse gas emissions and energy consumption.
- Promote the use of renewable energy sources and improve energy efficiency in all stages of production.
Economics: Increase profitability through cost savings in waste management and generate new revenue streams from recovered resources.
- Identify and implement cost-effective waste management solutions to reduce disposal costs.
- Develop new products and revenue streams from by-products and waste materials.
- Optimise resource use and improve operational efficiencies to reduce overall costs.
- Engage in partnerships and collaborations to explore innovative business models and market opportunities for recovered resources.
Compliance: Ensure compliance with increasingly stringent environmental regulations and standards.
- Stay updated with current and upcoming environmental regulations affecting the red meat industry.

- Implement comprehensive compliance programs to meet and exceed regulatory requirements.
- Conduct regular environmental audits and assessments to identify and address potential compliance issues.
- Train employees and stakeholders on compliance best practices and the importance of adhering to environmental standards.
Innovation: Foster innovation and technological advancements in resource recovery processes.
- Invest in research and development to explore new technologies and methods for resource recovery.
- Collaborate with academic institutions, technology providers, and industry experts to drive innovation.
- Pilot and scale up promising technologies that enhance resource recovery and sustainability.
- Encourage a culture of continuous improvement and creativity within the organisation to develop innovative solutions for resource management.

By focusing on these business objectives, the BRRC will play a crucial role in advancing the sustainability, economic performance, compliance, and innovation of the red meat industry. This comprehensive approach will ensure that the industry not only meets its current challenges but also sets a benchmark for future developments in resource recovery and environmental stewardship.

Project Definition: *The Bio-Resource Recovery Centres (BBRRC) initiative is a strategic project aimed at transforming the red meat industry by achieving key business objectives of sustainability, economic viability, regulatory compliance, and innovation. The BBRRC will implement advanced waste management systems, develop processes for recycling and reusing by-products, and adopt sustainable practices to reduce the industry's environmental footprint. Economically, the project will increase profitability through cost savings in waste management and generate new revenue streams from recovered bio-resources. Compliance will be ensured by adhering to stringent environmental regulations while fostering innovation through research, development, and collaboration with academic institutions and industry experts. The project plan includes detailed phases for technology implementation, infrastructure development, stakeholder engagement, and continuous improvement, ensuring a comprehensive approach to transforming the red meat industry into a model of sustainability and efficiency.*

5.14.1. Market analysis

Industry Trends: The red meat industry is evolving due to rising consumer demand for sustainable and ethically produced products. Key trends include sustainable farming practices, greenhouse gas emissions reduction, and waste minimisation. Technological advancements in resource recovery, such as anaerobic digestion and bioenergy production, are also gaining momentum, with an emphasis on circular economy principles.

Competitive Landscape: The resource recovery sector within the red meat industry features established companies and emerging start-ups focused on sustainability and innovation. Major meat processors are investing in technologies to enhance environmental performance and meet regulations. Competitors are converting waste into bioenergy, producing organic fertilisers, and creating high-value products from by-products, though there is still room for greater adoption of advanced solutions across the industry.

Market Needs: There is a demand for scalable, cost-effective resource recovery technologies that integrate seamlessly with existing operations. The market also needs better infrastructure and logistical support for collection, processing, and distribution of recovered resources. Companies seek solutions that comply with environmental regulations, enhance brand reputation, and meet consumer expectations for sustainability. Bio-Resource Recovery Centres (BRRC) aim to address these needs by offering state-of-the-art facilities and expertise to advance resource recovery and reduce environmental impact, driving economic benefits for the industry.

5.14.2. Vision and mission statements

Vision: To transform the red meat industry into a global leader in sustainability and resource efficiency by establishing cutting-edge Bio-Resource Recovery Centres (BBRRC) that maximise resource utilisation, minimise waste, and achieve carbon neutrality.

Mission: To develop and implement innovative bio-resource recovery technologies and practices that enhance environmental sustainability, economic viability, regulatory compliance, and industry-wide adoption of sustainable practices within the red meat sector.

5.14.3. Overarching operational plan

Table 28 BRRC operational plan

Location selection	Infrastructure Requirements
- Near major red meat processing facilities - Reliable access to utilities (water, electricity, waste management) - Supportive regulatory frameworks - Consideration of social and economic community impacts - Potential for future expansion	- State-of-the-art waste processing and bioenergy technology - Adequate storage and laboratory facilities - Renewable energy systems (e.g., solar panels, biogas generators) - Efficient transportation networks
Technology and Processes	**Partnerships and Collaborations**
- Anaerobic digestion for biogas and fertiliser - Advanced recovery (hydrolysis, pyrolysis) - Water treatment systems for reusing water for process - Bioenergy production from biomass, reducing fossil-fuel reliance and lowering GHG	- Technology providers for innovation - Research institutions for cutting-edge research - Industry stakeholders (producers, processors, retailers) - Government agencies for funding and regulations - NGOs for community engagement and public relations - Financial institutions for funding
Financial Plan	**Potential Funding Sources**
- Detailed projections of CAPEX and OPEX - Revenue streams from recovered resources - Cost savings from waste reduction - Evaluation of economic viability and sustainability	- 20% to 50% CAPEX from Government Grants: CEFC, ARENA - 30% to 40% CAPEX from Industry Investments and partnerships - 30% to 50% CAPEX from Public-Private Partnerships: Financial institutions and private investors - Research Grants and Subsidies: ARC, CRC for R&D activities

5.14.4. Risk management plan

The implementation of the Bio-Resource Recovery Centres (BRRC) involves several potential risks and challenges, which can be categorised into operational, financial, regulatory, technological, and market-related risks. These risks are summarised in Figure 43 including the mitigation strategy.

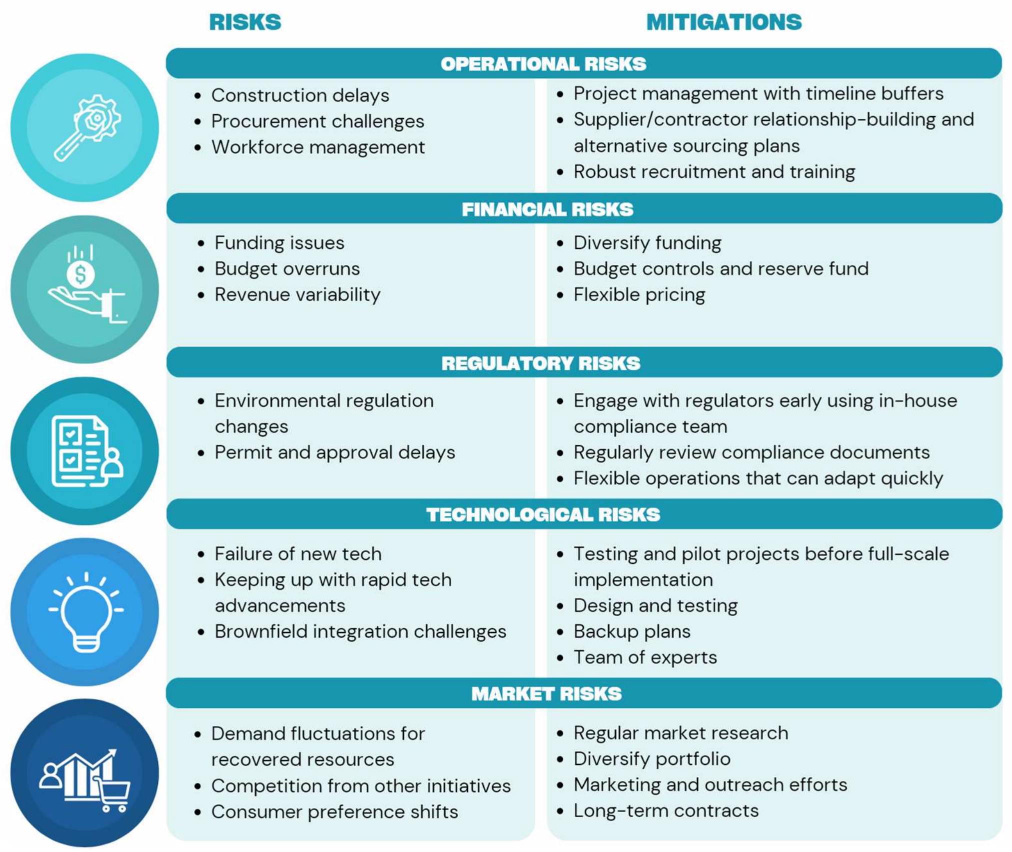


Figure 43 Summary of potential risks, challenges and mitigations

6.0 Discussion

The objective of the Bio-resource Recovery Centres project is to design an integrated facility encompassing advanced technologies for water treatment, organic waste management, and energy production, aimed at optimising resource recovery and sustainability. The facility reduces disposal issues, resulting in environmental, social and economic benefits, by producing high quality non-potable water, biogas converted into electricity and heat, bio-CO2 recovery and biofertiliser production. The project's methodology is comprehensive, encompassing technology refreshers, analyses of water and solid wastes, engineering designs, carbon abatement assessments, revenue estimates, cost estimations, funding and financial modelling, and the development of a business case, all summarised in this report.

Technology Refresher Trip: A key component of the methodology involved targeted technical visits to Europe. These visits included participation in IFAT trade fairs, renowned for showcasing cutting-edge solutions in water and waste management, and tours of facilities specialising in biogas production. These activities provided critical insights into the latest technologies and operational practices, informing the design and equipment selection for the project.

Water Sampling Campaign and Updated Flows Estimate: A water sampling campaign was conducted at both case study facilities to update flow and concentration data, which are essential for accurate design calculations.

Organic Solid Wastes Audit and BMP Tests: The project included an audit of organic solid wastes at two facilities, where samples underwent physicochemical analysis to determine Biomethane Potential (BMP) and other key metrics. These analyses, alongside data on organic by-product volumes, allowed for estimations of biogas production potential. This data is vital for designing the biogas plant and assessing its feasibility.

Wastewater Treatment Plant Design: For the WA and NSW facilities, the wastewater treatment plant design was refined using updated flow and chemical data, with BioWin modelling employed for process and hydraulic calculations. Initial assumptions were revised and a sensitivity analysis conducted, to ensure the wastewater treatment designs could accommodate variations in flow rates and concentrations.

Biogas Plant Design: The anaerobic digestion plant design, for the production of biogas, was optimised to enhance efficiency and reduce capital costs, including modular implementation for scalability. Additionally, the NSW facility explored innovative CO2 recovery to produce dry ice, expanding the scope of resource recovery and contributing to plant reliability and economic feasibility.

Biofertiliser Plant Design: The biofertiliser plant designs were refined using a technology selection deemed appropriate for both case study facilities and expected to be suitable for a variety of red meat processors across Australia. This design was informed by analysis of anaerobic digester substrates. The designs involved estimating the anticipated digestate quantity and developing processes for converting it into marketable biofertiliser, with detailed FEED drawings and equipment specifications supporting the design.

Cost Estimates: Cost estimates for the integrated Bio-resource Recovery Centres were updated, considering inputs from preferred suppliers.

Carbon Emission Assessment: A detailed carbon emission assessment was performed to evaluate the environmental benefits of the project, including potential reductions achieved through the bio-resource recovery centre.

Revenues Estimate: Several new revenue streams were considered in the analysis, including recycled non-potable water, energy (from biogas), biofertiliser, carbon credits and savings on waste disposal. Furthermore, revenue generated from CO2 recovery for the use as dry ice was also considered, which addresses concerns about supply reliability and high commodity costs, which are significant issues for some red meat processors.

Peer Review and Relevant Updates: A reputable external consultant was engaged to conduct a third-party peer review of the design and cost estimate. The peer review endorsed the overall concepts and methodology, and resulted in minor improvements made to the design details based on the consultant's recommendations.

Stakeholder Engagement: The project also involved extensive stakeholder engagement, mapping potential stakeholders and seeking their feedback on the project.

Financial Modelling: An economic assessment was undertaken, using capital and operational costs, in conjunction with revenues from the recovered resources. Various funding and financial models were explored, including private investment and government grants, to ensure the project's financial viability.

The methodology employed in this project ensures a thorough evaluation of the technologies and processes involved, aiming for a holistic and sustainable approach to resource recovery and environmental management. The findings and design optimisations provide a solid foundation for moving forward with the implementation of integrated Bio-resource Recovery Centres at red meat processors across Australia.

7.0 Conclusions / Recommendations

In conclusion, this comprehensive final report summarises the findings of the Bio-resource Recovery Centres project, detailing the design and feasibility of implementing integrated Bio-resource Recovery Centres at red meat processing facilities across Australia. The report utilises two case study facilities—one in WA and one in NSW—to illustrate the integration of a wastewater treatment plant, biogas plant, biofertiliser plant, and CO_2 recovery plant. The CO_2 recovery plant, highlighted in the NSW case, represents an additional, and currently lucrative, opportunity that could be extended to facilities in WA and other states. The below figures summarise the findings of the Bio-resource Recovery Centres project.

Metric	WA Case Study Facility	NSW Case Study Facility
Red Meat Processing Throughput for BRRC Design (t.HSCW/yr)	73,921	135,200
Design Wastewater Throughput (kL/yr)	480,340	919,800
Solid By-products to Anaerobic Digestion (tonnes/yr)	36,500	101,835
Biogas Production (Nm3/yr)	4,015,000	8,305,940
Total Energy Production from Biogas (GJ/yr)	88,330	182,733
Relative Energy Production from Biogas (GJ/tHSCW)	1.2	1.4
Electrical Energy from CHP (MWhe)	1.05	2.37
Thermal Energy from CHP (MWht)	1.1	2.42
Liquid CO2 recovered (tonnes/yr)	-	9,194
Biofertiliser Pellets Production at 90% TS (tonnes/yr)	2,028	5,656
BRRC CAPEX	$38M	$57M (includes CO2 plant)

Figure 44: Summary of Bio-resource Recovery Centres outcomes

Financial Metrics	Example 40,000 tHSCW/yr Facility
NPV	$69,659,081
ROI	342%
Annualised ROI	6%
Payback Time	9 yrs

Figure 45: Summary of economic assessment for Bio-resource Recovery Centres implementation

With reference to Figure 46, the payback time decreases, with NPW and ROI increasing with scale for the larger red meat processing facilities.

The wastewater treatment plants are designed for estimated future flow rates but have the flexibility to handle different flowrates and concentrations, within reason. The design enables the treated effluent to be recycled for uses for livestock washdown, onsite irrigation and off-take by third parties, reducing the red meat processors' reliance on potable water and addressing potential supply concerns. The higher-quality treated effluent will also improve red meat processors' ability to meet environmental license requirements for irrigation.

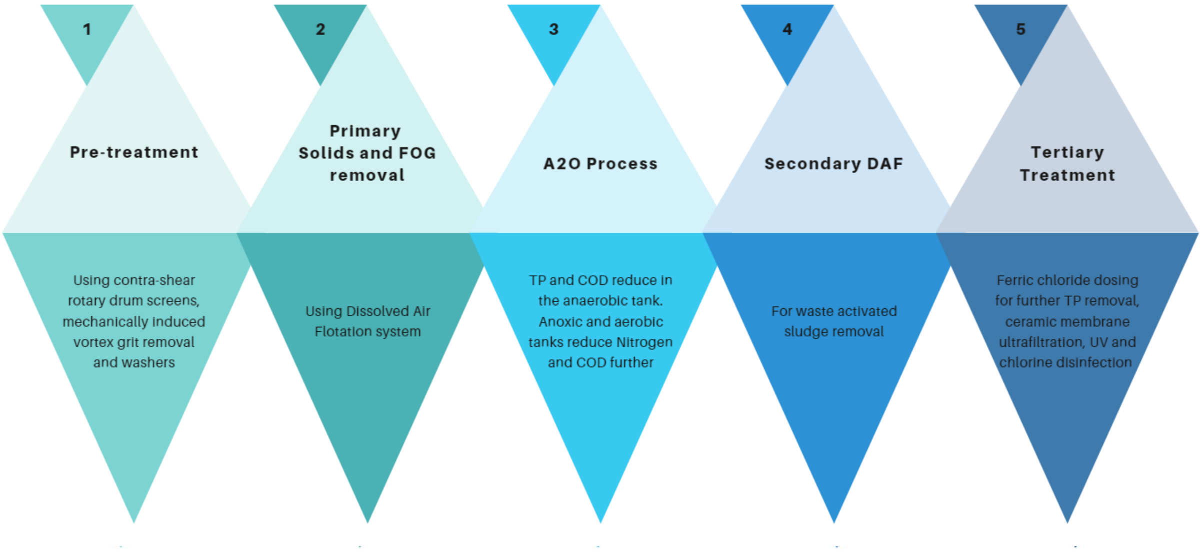


Figure 46: Wastewater treatment plant design summary

The solid streams audit and BMP tests used to validate the biogas plant design identified several organic by-products that could be redirected from waste or underutilised uses to more valuable applications as feedstock for anaerobic digestion. This includes solids from various sources such as screens, render bins, paunch, manure, B-grade products, inedible offal, wastewater treatment plant (WWTP) sludges, and other organic solids present on the land, like crop stubble.

The biogas plant design, validated by information obtained in the solids streams audit and BMP testing, incorporates modular units to enhance redundancy and supports future expansion, with an energy production capacity of 1.2 to 1.4 GJ per t.HSCW. The generated energy of reduces onsite gas and electricity consumption, contributing to environmental stewardship and financial efficiency

The CO_2 recovery plant design, detailed for the NSW facility as per their needs, aims to enable the production of the site's own dry ice, enhancing supply reliability and significantly reducing the high costs associated with externally supplied dry ice. The recommended CO_2 recovery option, that is both cost-effective and produces CO_2 beyond the typical site demand, is post-CHP combustion CO_2 recovery using the chemical absorption method with amine. The concept design for CO_2 recovery using chemical absorption via amine is included in the report, and outcomes summarised below.

The bio-based fertiliser plant design characterises and quantifies processed biomass, proposing technologies for digestate processing with an overall energy demand lower than the biogas plant's output. This facility not only reduces controlled waste disposal costs but also generates additional revenue and completes a circular economy loop.

Recommended Biofertiliser Technology

The recommended biofertiliser recovery technology for implementation is mechanical dewatering to ~22% TS, thermally drying and pelletising the digestate into bio-based fertiliser pellets ready for third-party off-take.

Implementing the full integrated Bio-resource Recovery Centre (BRRC), including wastewater, biogas, CO_2, and biofertiliser plants, offers the highest return on investment, helping offset energy consumption and support carbon neutrality.

It is recommended to conduct Front-End Engineering Designs (FEED) and economic analyses, including sensitivity analyses on both the engineering and economic aspects, for each red meat processor planning to implement an integrated Bio-resource Recovery Centre. For the two case study facilities, it is advised to proceed with the subsequent stages of project implementation. This includes optimising resource recovery pricing and refining assumptions used in the design, such as wastewater flow rates and concentrations. Additionally, precise measurement, analysis, and projection of the quantities and quality of solid organic by-products should be undertaken.

Overall, implementing a Bio-resource Recovery Facility at red meat processors in Australia transforms necessary wastewater treatment plant upgrades—otherwise a financial burden needed for regulatory compliance—into a profitable venture. The BRRC initiative provides a positive return on investment by integrating bio-resource recovery components that recycle high-quality non-potable water, generate renewable energy from biogas, recover food-grade CO_2 for use as dry ice, and produce valuable biofertiliser.

By recovering food-grade CO_2 for use as dry ice, the facility enhances supply reliability, reduces the amount of lost production revenue associated with potential supply issues, and mitigates reliance on expensive liquid CO_2 or dry ice prices. Additionally, the Bio-resource Recovery Centres (BRRC) initiative generates carbon offsets, supporting red meat processors in their goals to achieve net zero targets. It promotes environmental stewardship, eases pressure on potable water supplies in a drying climate, improves regulatory compliance, and supports a circular economy.

The comprehensive design of the BRRC offers social, economic, and environmental benefits, strongly supporting the rationale for advancing to the next phases of the project at the case study facilities, and at other red meat processors across Australia.

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10.0 Appendices

10.1. Appendix 1: WWTP drawings

NOTES:

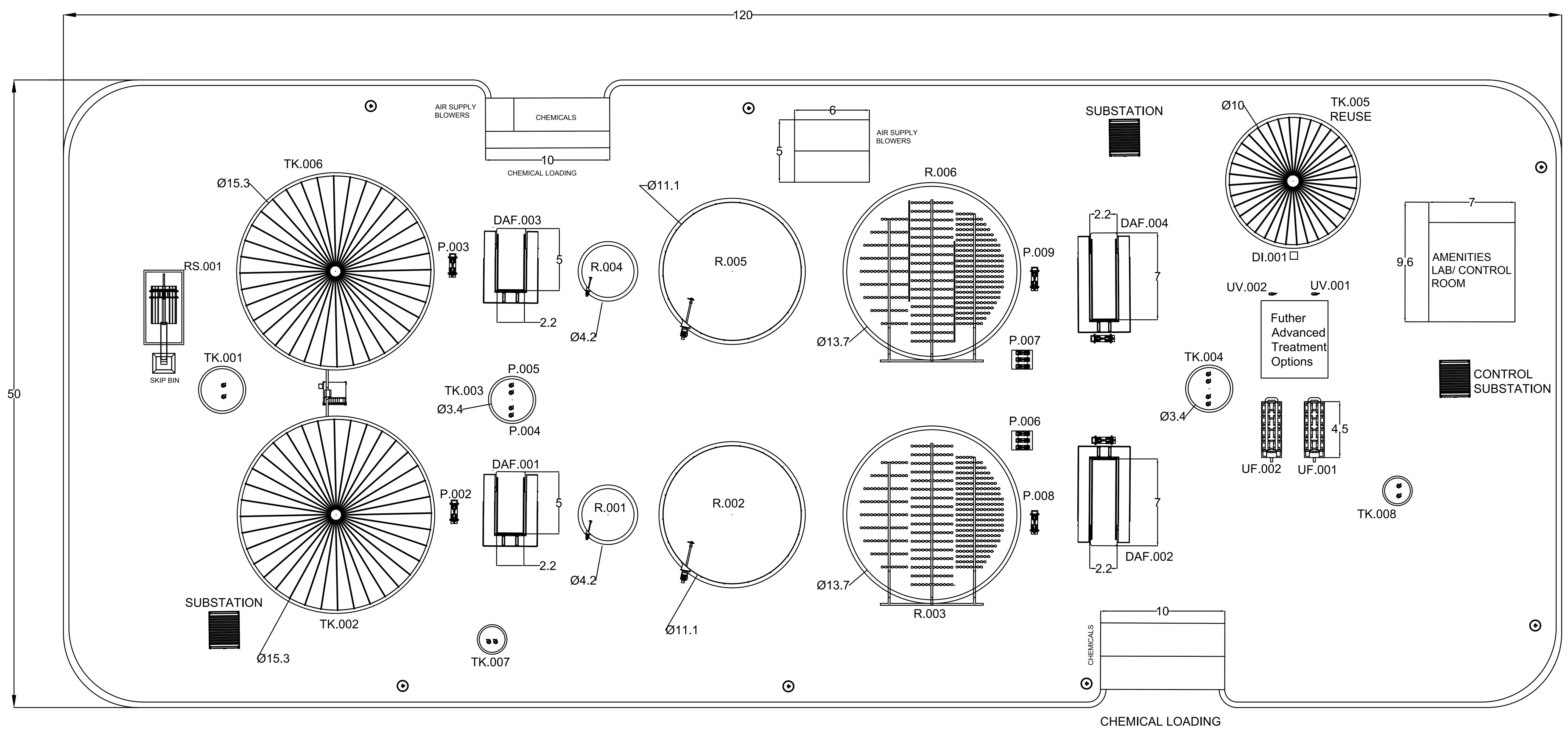
1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. SITE AREA ~6,000 M^2

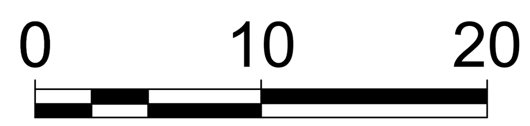
WWTP COMPONENTS:

RS.001	Rotary Screen
TK.001	Transfer Tank
TK.002	Equalisation Tank
TK.003	Pumping Station
TK.004	Pumping Station
TK.005	Treated Water Storage Tank
TK.006	Equalisation Tank
TK.007	Thickened Raw Primary Sludge Tank
TK.017	Thickened Excess Activated Sludge Tank
R.001	Reactor - Anaerobic Stage
R.002	Reactor - Anoxic Stage
R.003	Reactor - Aerobic Stage
R.004	Reactor - Anaerobic Stage
R.005	Reactor - Anoxic Stage
R.006	Reactor - Aerobic Stage
DAF.001	Dissolved Air Floatation
DAF.002	Dissolved Air Floatation
DAF.003	Dissolved Air Floatation
DAF.004	Dissolved Air Floatation
UF.001	Ultrafiltration System
UF.002	Ultrafiltration System
UV.001	Ultraviolet Disinfection
UV.002	Ultraviolet Disinfection
DI.001	Hypochlorite Disinfection

LEGEND:

⊙ Hydrants





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10.04.23	ISSUED FOR MS11 REPORT	B
10.10.22	ISSUED FOR MS4 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	DRAWING TITLE:
1:250		2023-1013	WASTEWATER TREATMENT PLANT GENERAL ARRANGEMENT

DRAWN:	CHECKED:	APPROVED:	SHEET:	DRAWING NUMBER:	REVISION:
O.K	G.T	F.T	1 OF 7	2023-1013- AMPC-CP-DW-001	A

NOTES:

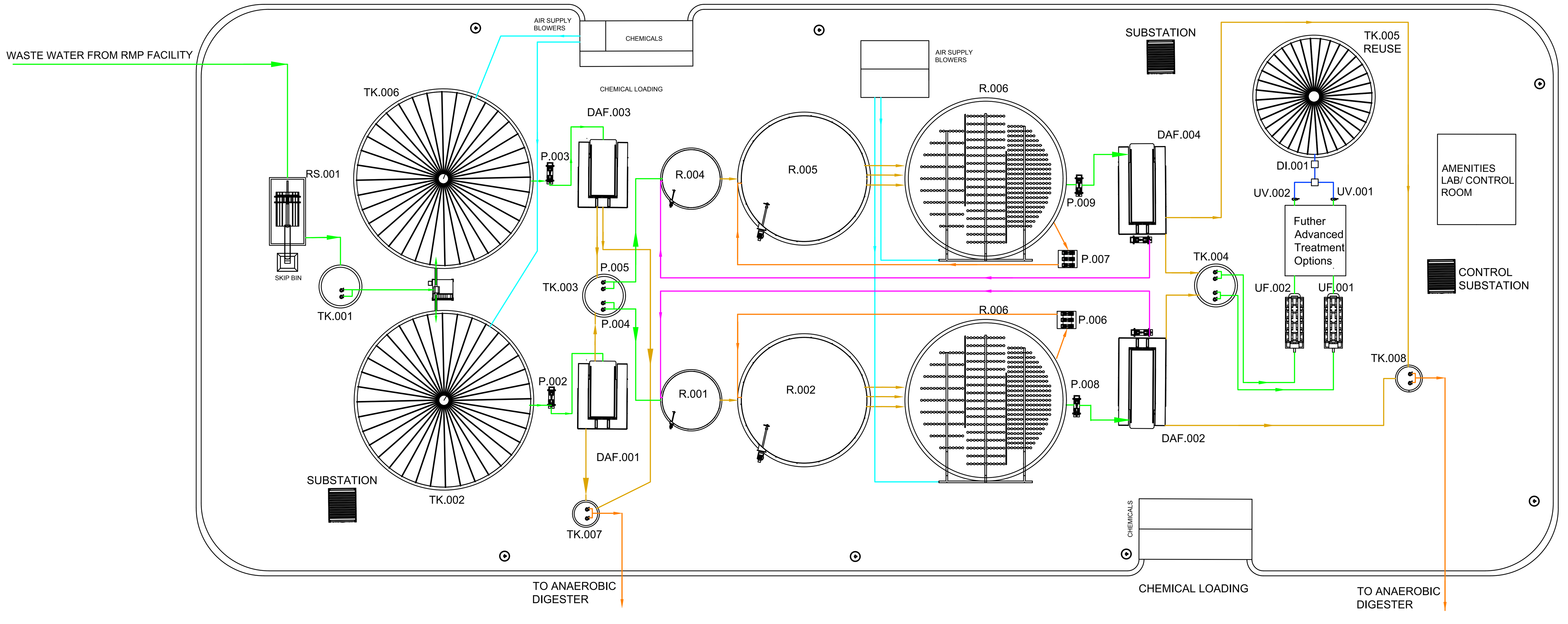
1. PIPELINE LAYOUT FOR INTEGRATED LIQUID AND SOLID STREAMS MANAGEMENT NO DIMENSIONS NOTED

WWTP COMPONENTS:

RS.001	Rotary Screen
TK.001	Transfer Tank
TK.002	Equalisation Tank
TK.003	Pumping Station
TK.004	Pumping Station
TK.005	Treated Water Storage Tank
TK.006	Equalisation Tank
TK.007	Thickened Raw Primary Sludge Tank
TK.017	Thickened Excess Activated Sludge Tank
R.001	Reactor - Anaerobic Stage
R.002	Reactor - Anoxic Stage
R.003	Reactor - Aerobic Stage
R.004	Reactor - Anaerobic Stage
R.005	Reactor - Anoxic Stage
R.006	Reactor - Aerobic Stage
DAF.001	Dissolved Air Floatation
DAF.002	Dissolved Air Floatation
DAF.003	Dissolved Air Floatation
DAF.004	Dissolved Air Floatation
UF.001	Ultrafiltration System
UF.002	Ultrafiltration System
UV.001	Ultraviolet Disinfection
UV.002	Ultraviolet Disinfection
DI.001	Hypochlorite Disinfection

LEGEND:

- Hydrants
- Gravity Effluent Pipeline
- Pressurized Effluent Pipeline
- Sludge Recirculation Pipeline
- Air Pipeline (Aerobic Reactor)
- Treated Effluent/ DAF Recirculation
- Treated Water for Disinfection and Storage



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SCALE@A1:	PLOT DATE:	PROJECT NO:
1:250		2023-1013

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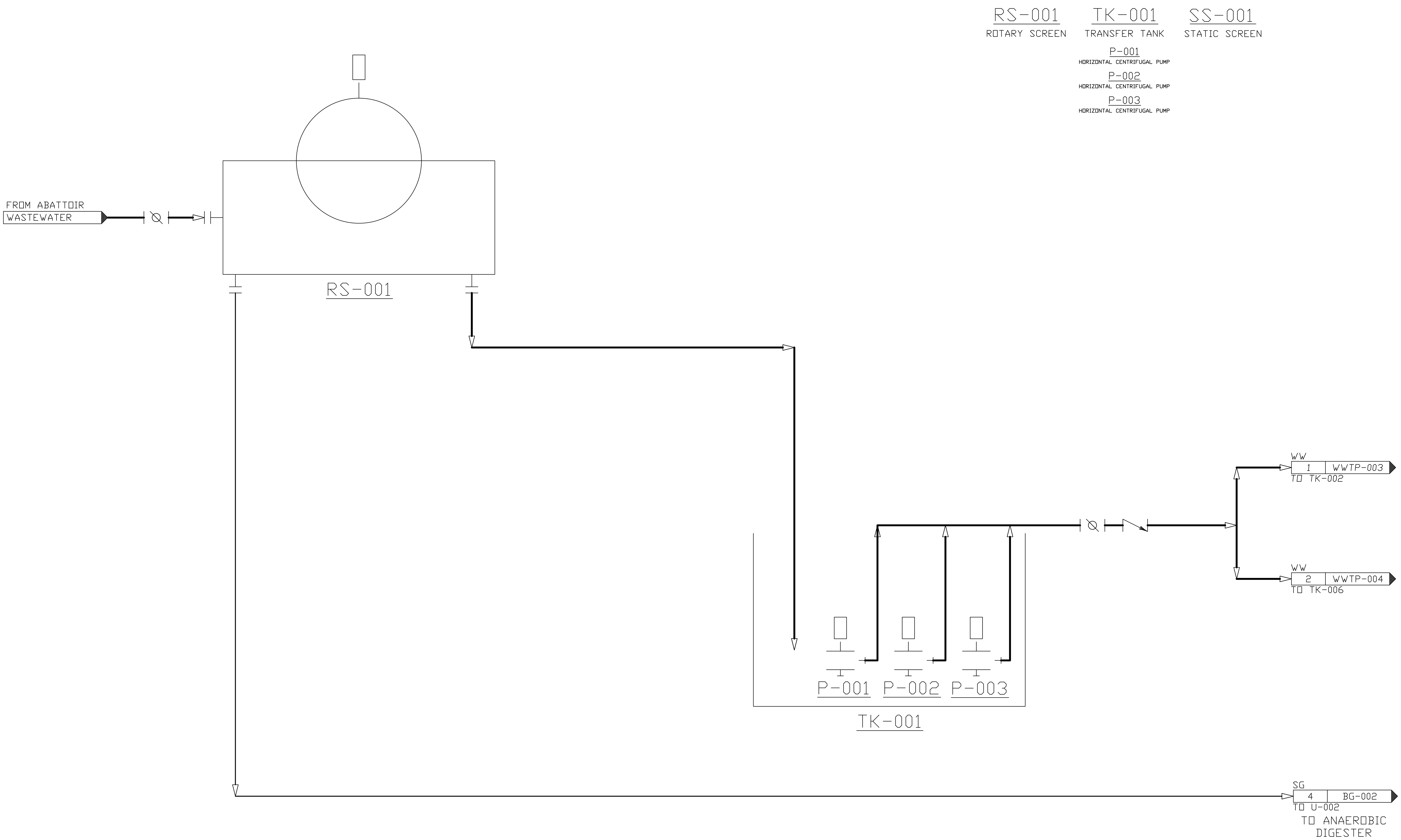
WASTEWATER TREATMENT PLANT PIPING AND INTERCONNECTIONS

DRAWING NUMBER: 2023-1013- AMPC-CP-DW-007

REVISION: A



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SCALE@A1:	PLOT DATE:	PROJECT NO:	
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O.K.	G.T.	F.T	2 OF 7

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DRAWING NUMBER:	REVISION:
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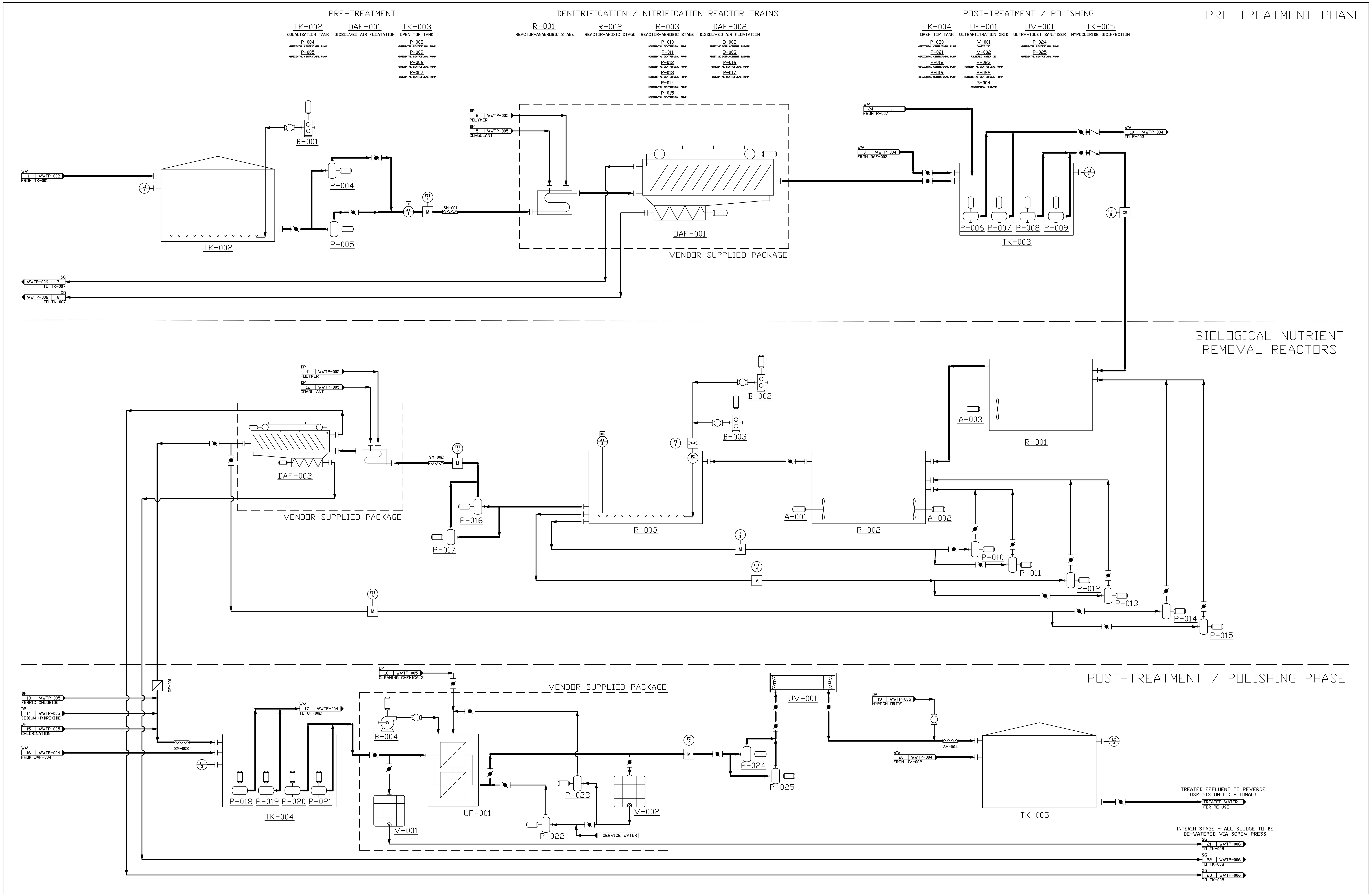

10.10.22	ISSUED FOR MS4 REPORT	A
DATE	DESCRIPTION	REV

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

TESSELE CONSULTANTS
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BICTON, WA
www.tessele.com
TESSELE

NORTH:

PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	DRAWING TITLE:
NTS		2023-1013	WASTEWATER TREATMENT PLANT PROCESS FLOW DIAGRAM - PFD

DRAWN:	CHECKED:	APPROVED:	SHEET:	DRAWING NUMBER:	REVISION:
O.K	G.T	F.T	3 OF 7	2023-1013-AMPC-CP-DW-003	A

10.10.22	ISSUED FOR MS4 REPORT	A
DATE	DESCRIPTION	REV

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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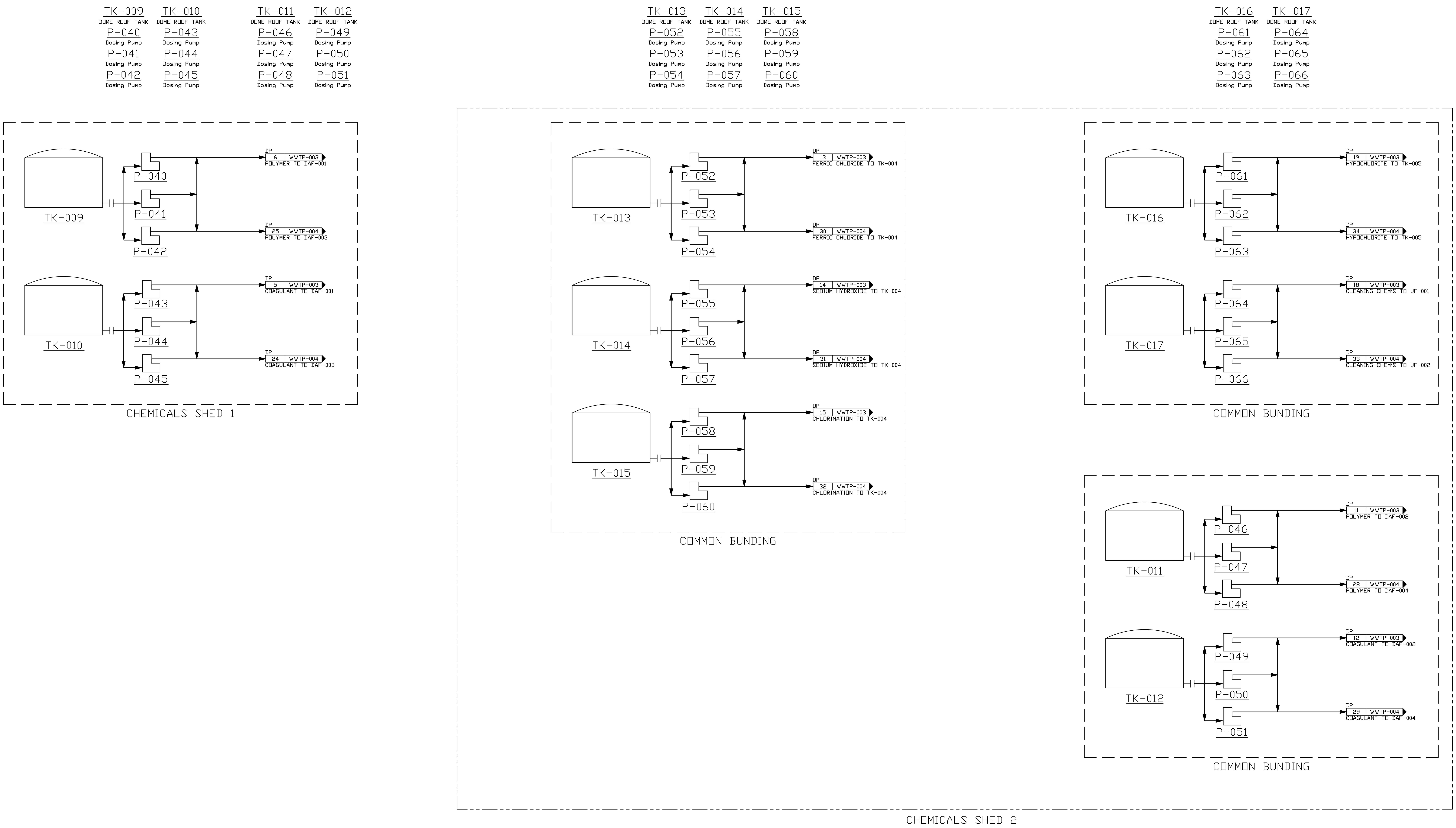
PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:		PROJECT NO:
NTS			2023-1013
DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	4 OF 7

DRAWING TITLE:
WASTEWATER TREATMENT PLANT
PROCESS FLOW DIAGRAM - PFD

DRAWING NUMBER:	REVISION:
2023-1013-AMPC-CP-DW-004	A



DATE	DESCRIPTION	REV
10.10.22	ISSUED FOR MS4 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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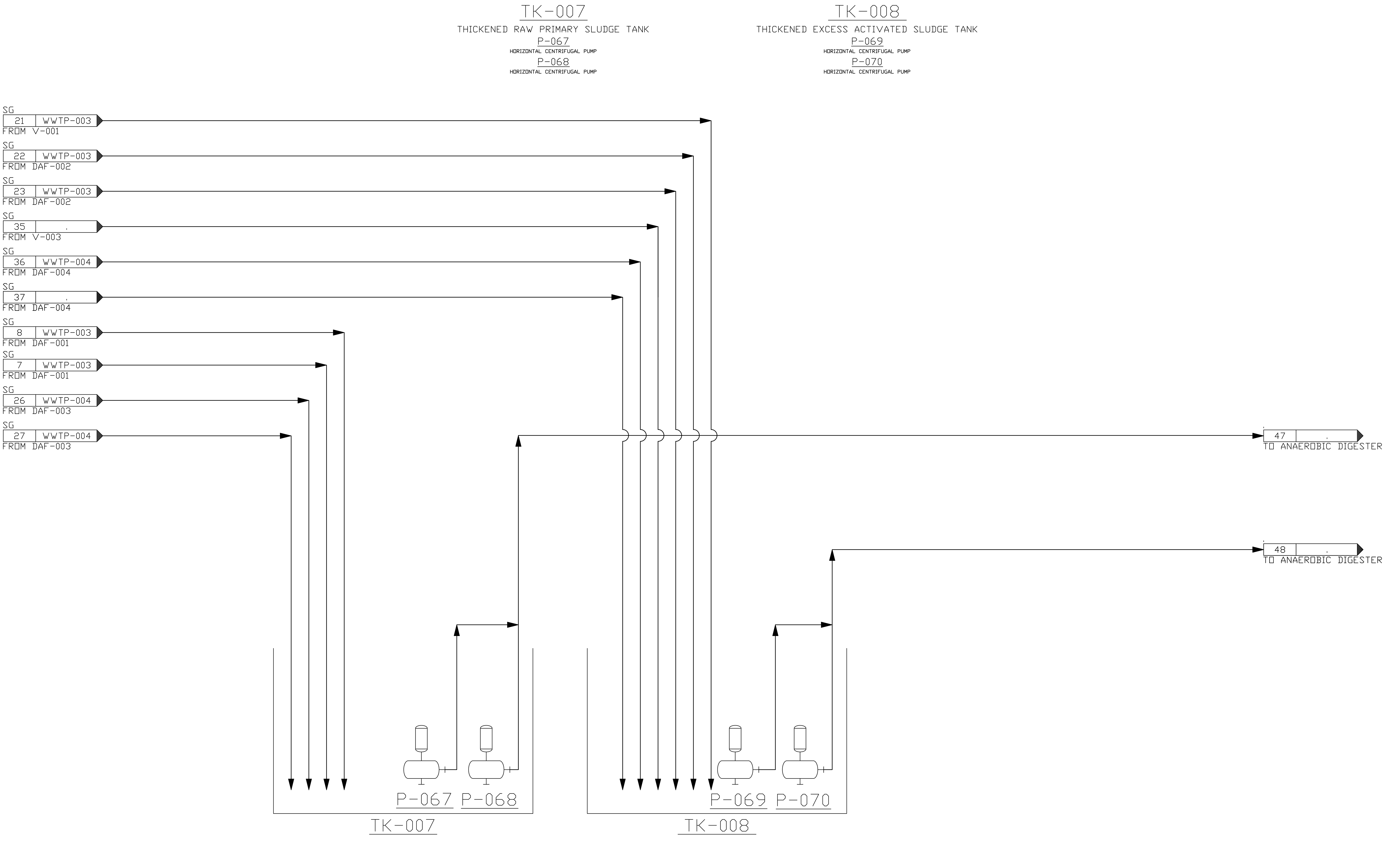
NORTH:

PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NTS		2023-1013	
DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	5 OF 7

DRAWING TITLE:
WASTEWATER TREATMENT PLANT
PROCESS FLOW DIAGRAM - PFD

DRAWING NUMBER: 2023-1013-AMPC-CP-DW-005
REVISION: A



DATE	DESCRIPTION	REV
10.10.22	ISSUED FOR MS4 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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NORTH:

PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NTS		2023-1013	
DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	6 OF 7

DRAWING TITLE:
WASTEWATER TREATMENT PLANT
PROCESS FLOW DIAGRAM - PFD

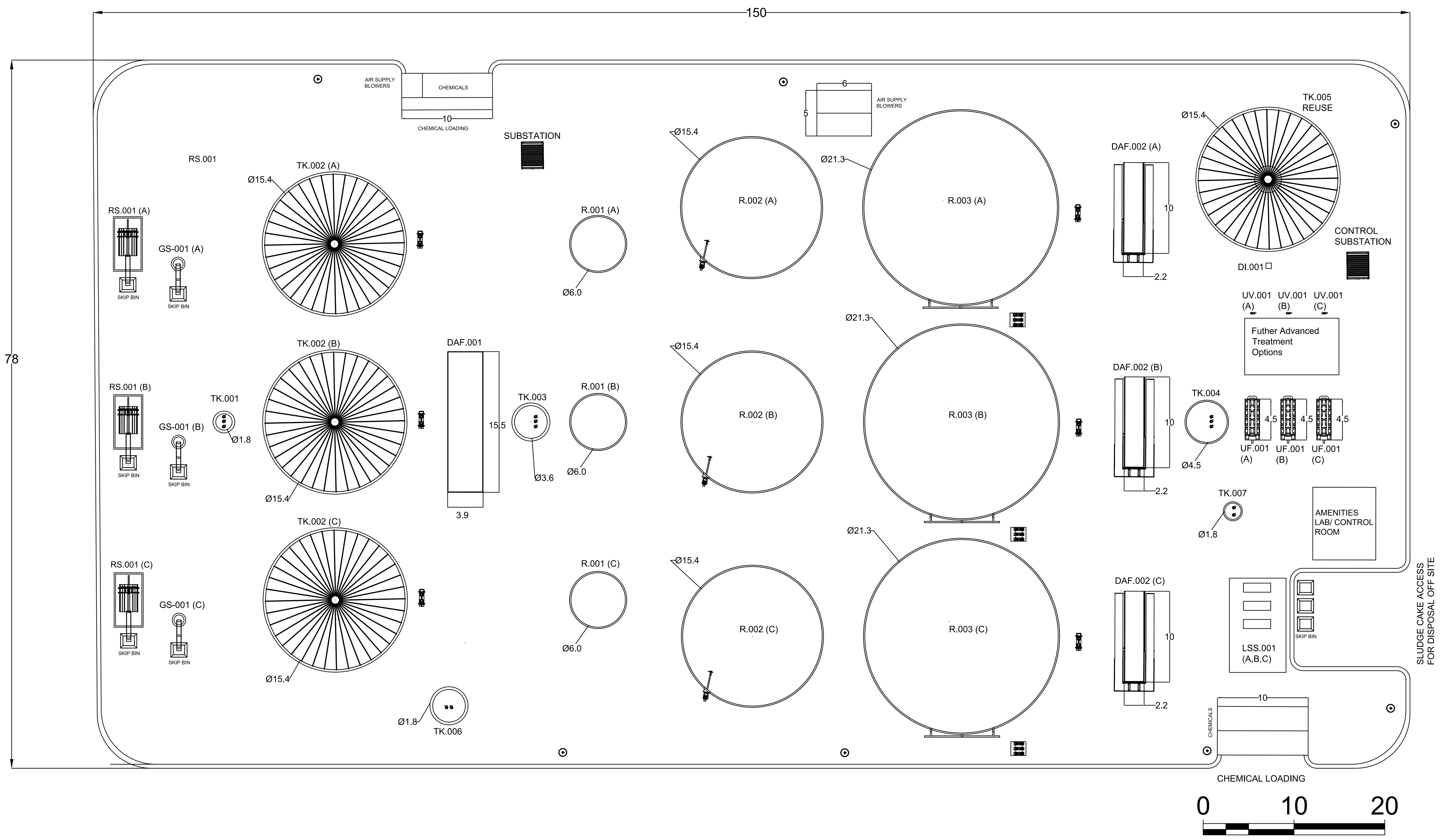
DRAWING NUMBER: 2023-1013-AMPC-CP-DW-006
REVISION: A

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. SITE AREA ~12,000 M^2

WWTP COMPONENTS:

RS.001	Rotary Screen
GS.001	Grit Separation
TK.001	Pumping Station
TK.002	Equalisation Tank
TK.003	Pumping Station
TK.004	Pumping Station
TK.005	Treated Water Storage Tank
TK.006	Thickened Primary Sludge Tank
TK.007	Thickened Excess Activated Sludge Tank
R.001	Reactor - Anaerobic Stage
R.002	Reactor - Anoxic Stage
R.003	Reactor - Aerobic Stage
DAF.001	Dissolved Air Flotation
DAF.002	Dissolved Air Flotation
UF.001	Ultrafiltration System
UV.001	Ultraviolet Disinfection
DI.001	Hypochlorite Disinfection
LSS.001	Liquid Solid Separator



LEGEND:

⊙ Hydrants

DATE	DESCRIPTION	REV
18.04.23	ISSUED FOR MS3 REPORT	B
04.04.23	ISSUED FOR MS3 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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NORTH:

PROJECT TITLE:
FRONT END ENGINEERING DESIGN
INTEGRATED BIO-RESOURCE RECOVERY FACILITY
STAGE - 1

SCALE@A1:	PLOT DATE:	PROJECT NO: 2023-1028	
DRAWN: L.M	CHECKED: K.F	APPROVED: F.T	SHEET: 2 OF 4

DRAWING TITLE:
WASTEWATER TREATMENT SYSTEM
GENERAL ARRANGEMENT

DRAWING NUMBER: 2023-1028-AMPC-CP-DW-002

REVISION: B

DATE	DESCRIPTION	REV
18.04.23	ISSUED FOR MS3 REPORT	B
04.04.23	ISSUED FOR MS3 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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NORTH:

PROJECT TITLE:
FRONT END ENGINEERING DESIGN
INTEGRATED BIO-RESOURCE RECOVERY FACILITY
STAGE - 1
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:
NTS		2023-1028

DRAWN:	CHECKED:	APPROVED:	SHEET:
L.M	K.F	F.T	3 OF 4

DRAWING TITLE:
WASTEWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM - PFD

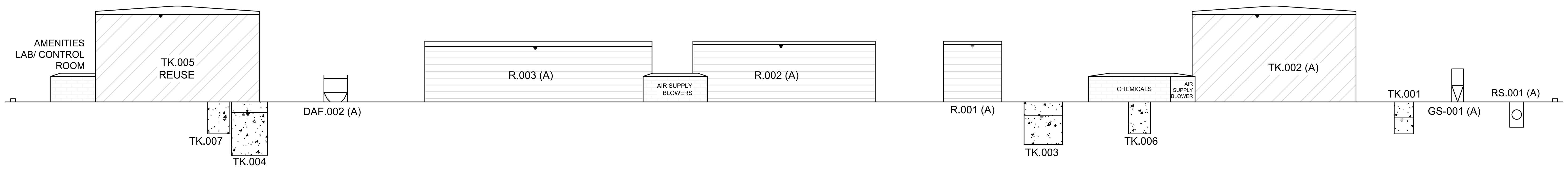
DRAWING NUMBER:	REVISION:
2023-1028-AMPC-CP-DW-003	B

NOTES:

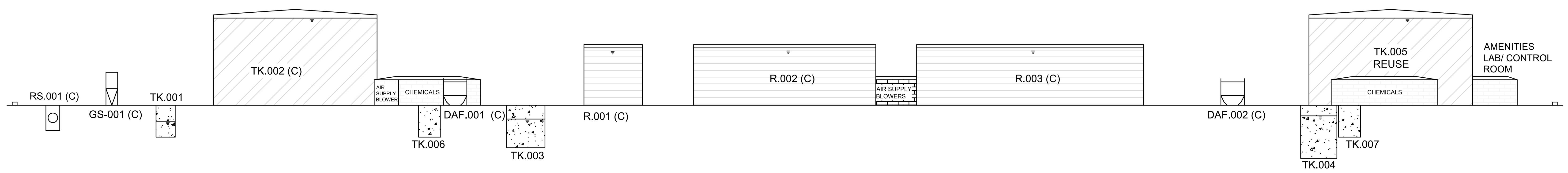
1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. SITE AREA ~12,000 M^2

WWTP COMPONENTS:

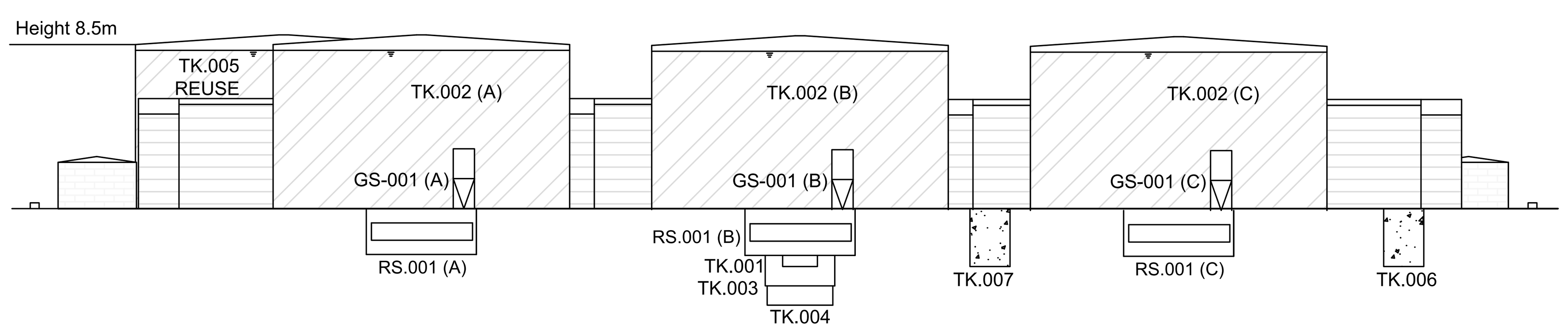
RS.001	Rotary Screen
GS.001	Grit Separation
TK.001	Pumping Station
TK.002	Equalisation Tank
TK.003	Pumping Station
TK.004	Pumping Station
TK.005	Treated Water Storage Tank
TK.006	Thickened Primary Sludge Tank
TK.007	Thickened Excess Activated Sludge Tank
R.001	Reactor - Anaerobic Stage
R.002	Reactor - Anoxic Stage
R.003	Reactor - Aerobic Stage
DAF.001	Dissolved Air Flotation
DAF.002	Dissolved Air Flotation
UF.001	Ultrafiltration System
UV.001	Ultraviolet Disinfection
DI.001	Hypochlorite Disinfection
LSS.001	Liquid Solid Separator



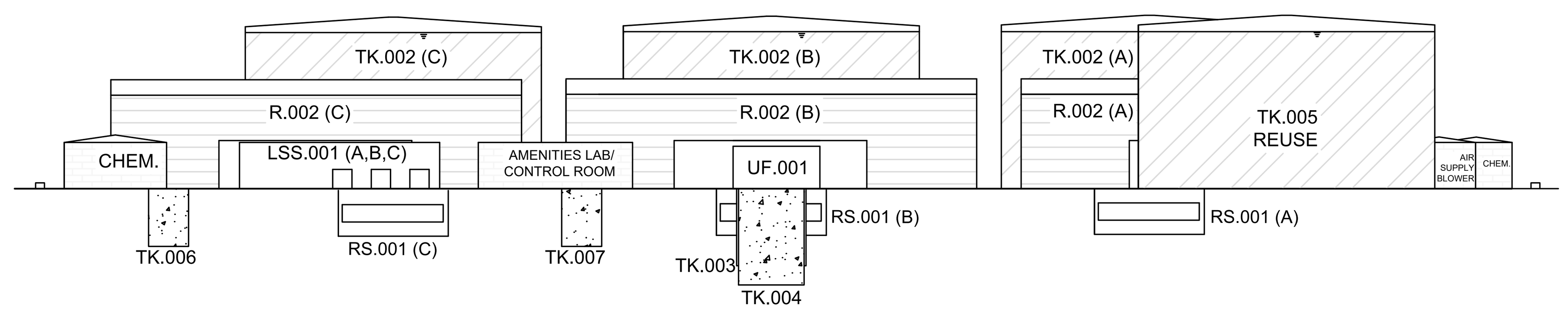
EAST VIEW



WEST VIEW



SOUTH VIEW



NORTH VIEW

DATE	DESCRIPTION	REV
18.04.23	ISSUED FOR MS3 REPORT	B
04.04.23	ISSUED FOR MS3 REPORT	A

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NORTH:

PROJECT TITLE:
FRONT END ENGINEERING DESIGN
INTEGRATED BIO-RESOURCE RECOVERY FACILITY
STAGE - 1

SCALE@A1:	PLOT DATE:	PROJECT NO: 2023-1028	
DRAWN: L.M	CHECKED: K.F	APPROVED: F.T	SHEET: 4 OF 4

DRAWING TITLE:
WASTEWATER TREATMENT SYSTEM
ELEVATIONS

DRAWING NUMBER: 2023-1028-AMPC-CP-DW-004

REVISION: B

10.2. Appendix 2: Biogas plant drawings

NOTES:

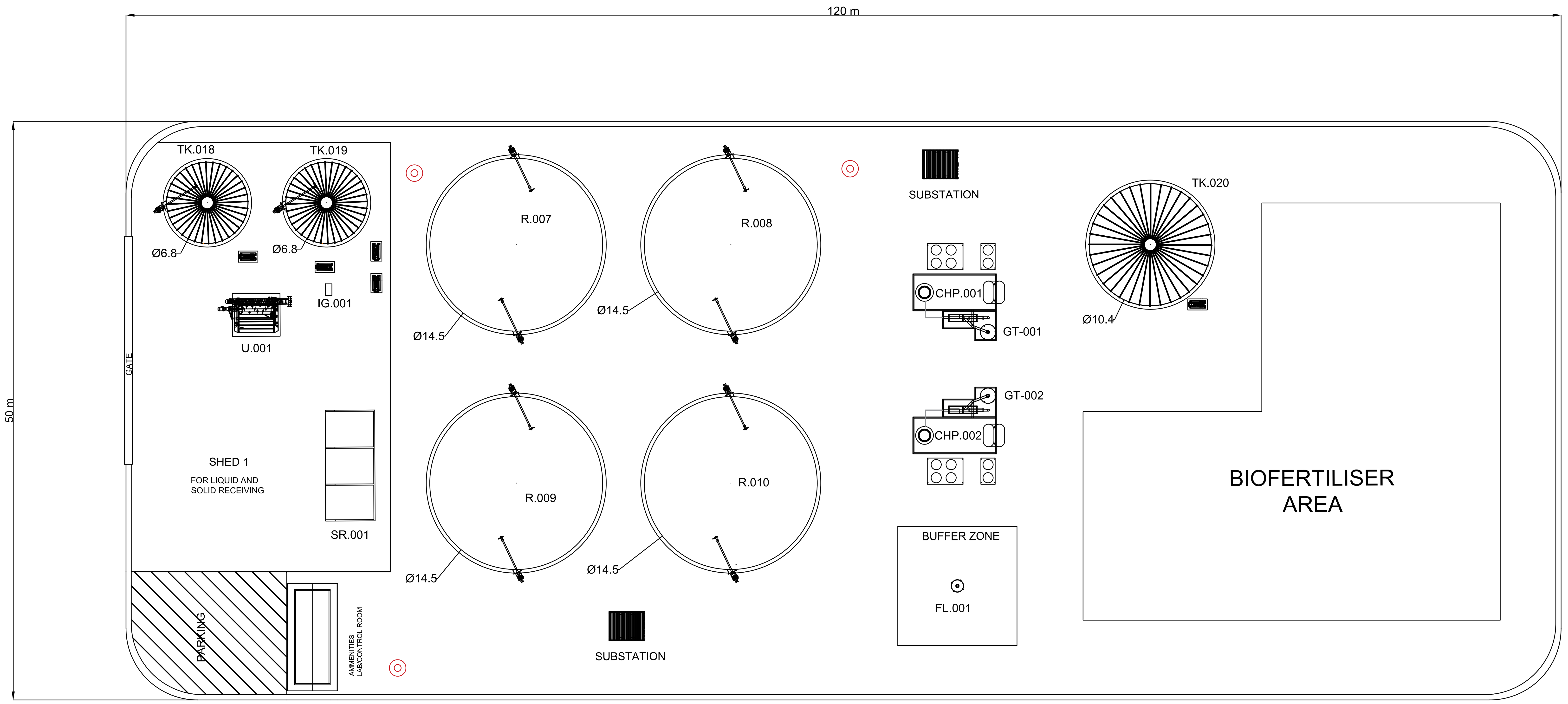
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. SITE AREA ~6,000 M^2

BIOGAS COMPONENTS:

TK.018	Liquid Receiving Tank
TK.019	Blending Tank
R.007	Anerobic Digester & Biogas Storage
R.008	Anerobic Digester & Biogas Storage
R.009	Anerobic Digester & Biogas Storage
R.010	Anerobic Digester & Biogas Storage
TK.020	Post Digester Storage
SR.001	Solids Receiving Station
U.001	Receiving Hopper
A.006	Solids/Liquid Mixer
CHP.001	Solids Receiving Station
CHP.002	Solids Receiving Station
FL.001	Emergency Flare
IG.001	In-line Shaft Grinder
GT.001	Gas Treatment
GT.002	Gas Treatment

LEGEND:

Hydrants



0 10 20

DATE	DESCRIPTION	REV
24.10.22	ISSUED FOR MS5 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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NORTH:

PROJECT TITLE: BIO-RESOURCE RECOVERY CENTRES OF EXCELLENCE AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:
NA		2023-1013

DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	1 OF 3

DRAWING TITLE: BIOGAS PLANT GENERAL ARRANGEMENT

DRAWING NUMBER: 2023-1013- AMPC-CP-DW-008

REVISION: A

NOTES:

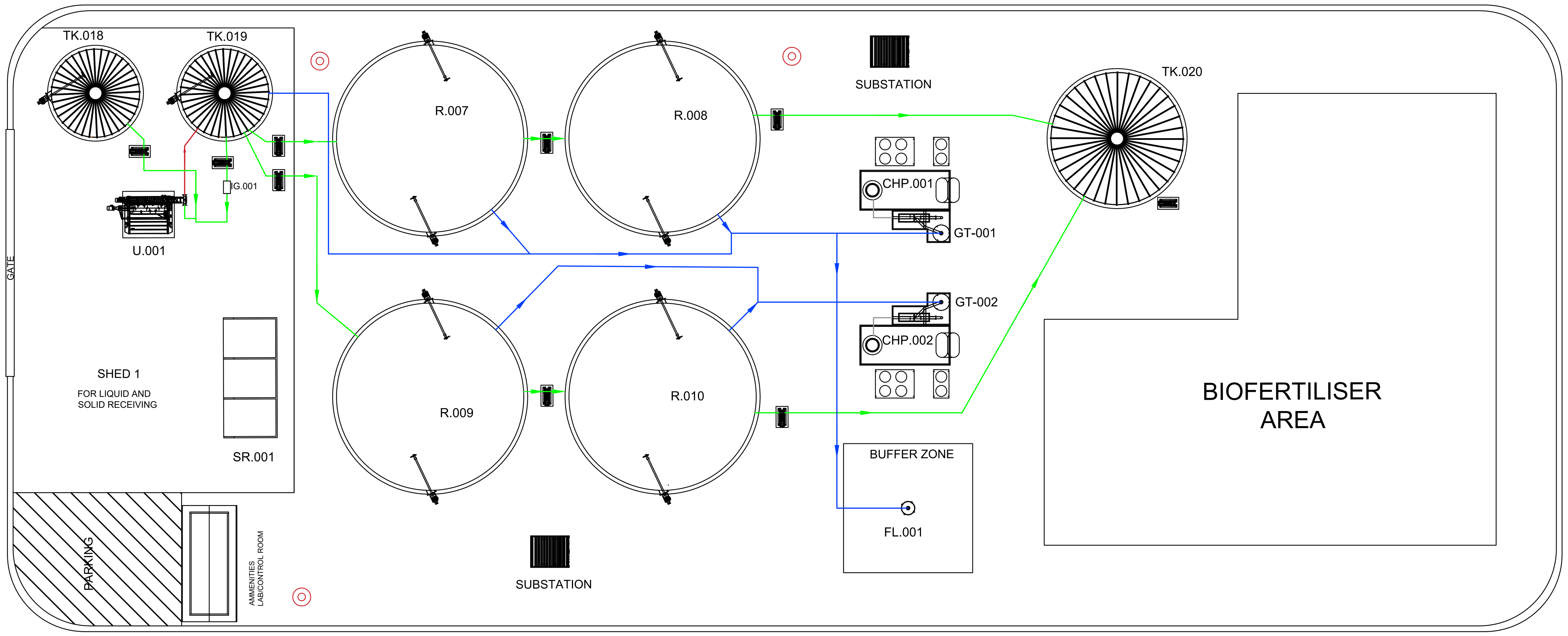
1. GENERIC LAYOUT FOR INTEGRATED LIQUID AND SOLID STREAMS MANAGEMENT-NO DIMENSIONS NOTED

BIOGAS COMPONENTS:

TK.018	Liquid Receiving Tank
TK.019	Blending Tank
R.007	Anerobic Digester & Biogas Storage
R.008	Anerobic Digester & Biogas Storage
R.009	Anerobic Digester & Biogas Storage
R.010	Anerobic Digester & Biogas Storage
TK.020	Post Digester Storage
SR.001	Solids Receiving Station
U.001	Receiving Hopper
A.006	Solids/Liquid Mixer
CHP.001	Solids Receiving Station
CHP.002	Solids Receiving Station
FL.001	Emergency Flare
IG.001	In-line Shaft Grinder
GT.001	Gas Treatment
GT.002	Gas Treatment

LEGEND:

- Pressurized Pipeline
- Gas Line



0 10 20

DATE	DESCRIPTION	REV
24.10.22	ISSUED FOR MS5 REPORT	A

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NORTH:

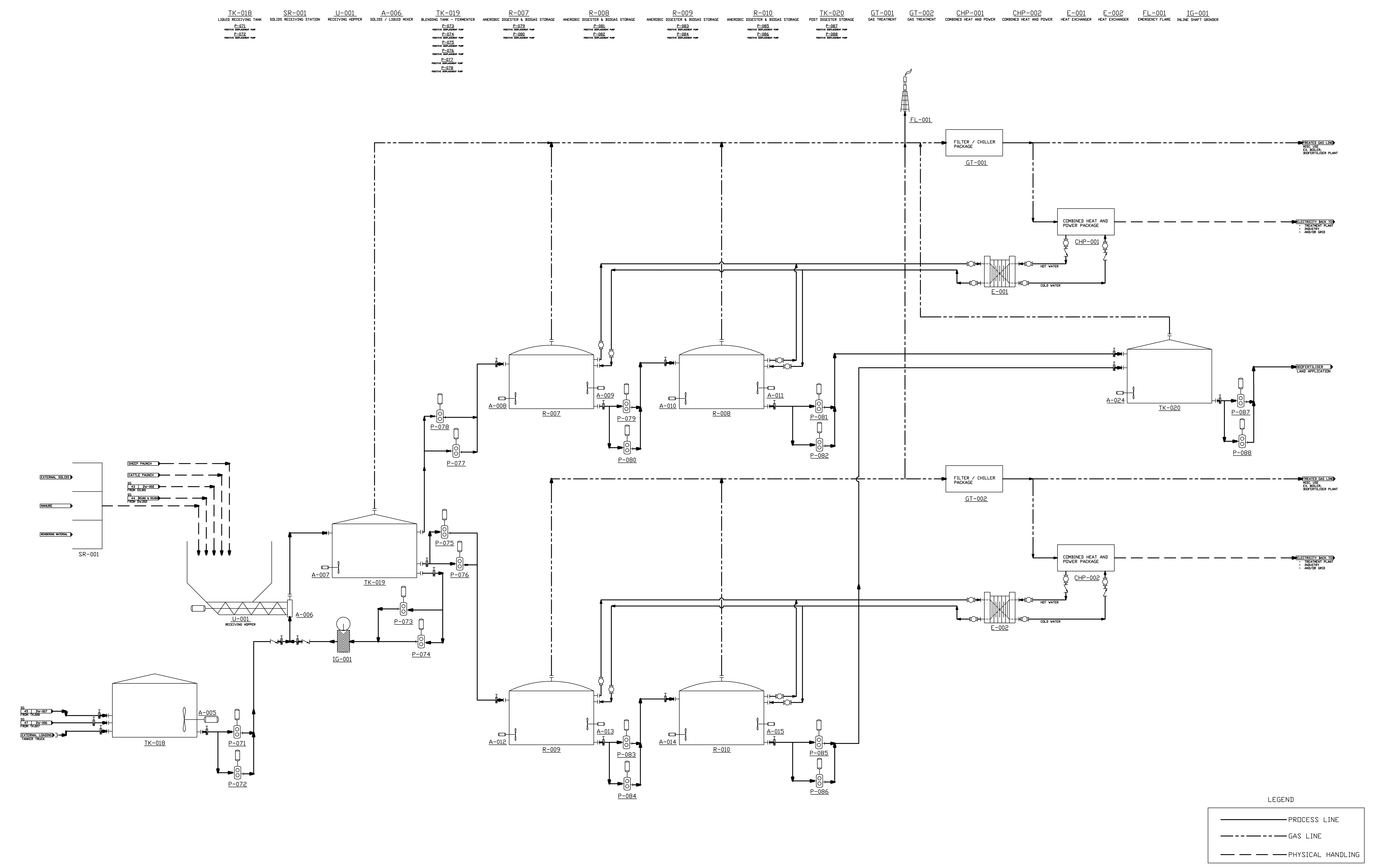
PROJECT TITLE:
BIO-RESOURCE RECOVERY CENTRES OF EXCELLENCE AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NA		2023-1013	
DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	3 OF 3

DRAWING TITLE:
BIOGAS PLANT PIPING AND INTERCONNECTIONS

DRAWING NUMBER: 2023-1013- AMPC-CP-DW-010

REVISION: A



28.10.22	ISSUED FOR MS5 REPORT	A
DATE	DESCRIPTION	REV

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NORTH:

PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NTS		2023-1013	
DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	2 OF 3

DRAWING TITLE:
BIOGAS PLANT
PROCESS FLOW DIAGRAM - PFD

DRAWING NUMBER: 2023-1013-AMPC-CP-DW-009

REVISION: A

NOTES:

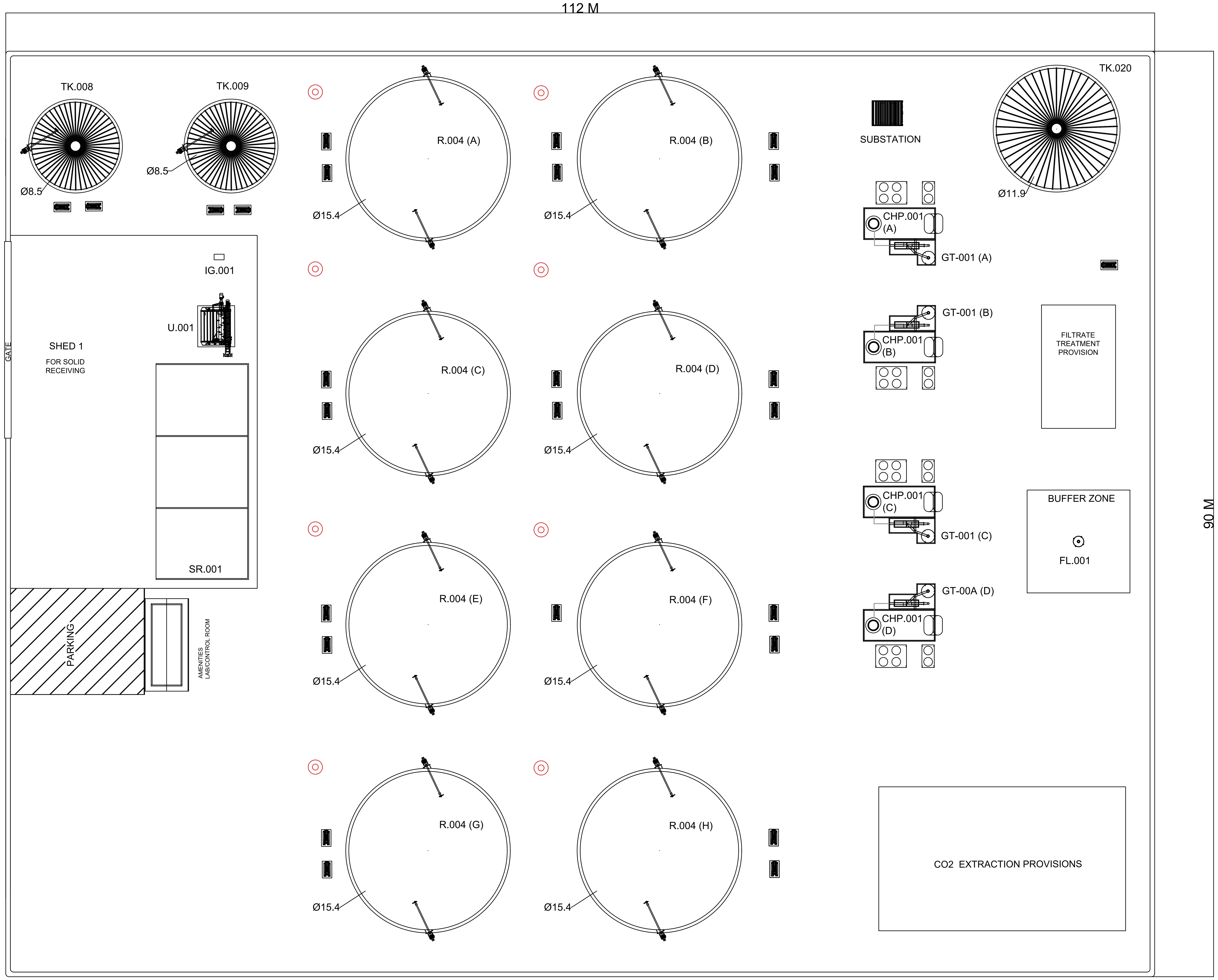
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. SITE AREA ~10,000 M^2

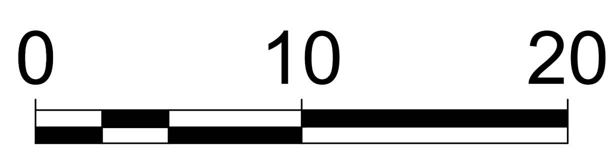
BIOGAS COMPONENTS:

TK.008	Liquid Receiving Tank
TK.009	Blending Tank
R.004(A)	Anaerobic Digester & Biogas Storage
R.004(B)	Anaerobic Digester & Biogas Storage
R.004(C)	Anaerobic Digester & Biogas Storage
R.004(D)	Anaerobic Digester & Biogas Storage
R.004(E)	Anaerobic Digester & Biogas Storage
R.004(F)	Anaerobic Digester & Biogas Storage
R.004(G)	Anaerobic Digester & Biogas Storage
R.004(H)	Anaerobic Digester & Biogas Storage
TK.010	Post Digester Storage
SR.001	Solids Receiving Station
U.001	Receiving Hopper
A.003	Solids/Liquid Mixer
CHP.001(A)	Combined Heat & Power Package
CHP.001(B)	Combined Heat & Power Package
CHP.001(C)	Combined Heat & Power Package
CHP.001(D)	Combined Heat & Power Package
FL.001	Emergency Flare
IG.001	In-Line Shaft Grinder
GT.001(A)	Gas Treatment
GT.001(B)	Gas Treatment
GT.001(C)	Gas Treatment
GT.001(D)	Gas Treatment

LEGEND:

Hydrants





DATE	DESCRIPTION	REV
18.12.2023	ISSUED FOR MS2 REPORT	A

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NORTH:

PROJECT TITLE:
INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:
1:250		2024-1019

DRAWN:	CHECKED:	APPROVED:	SHEET:
L.L	K.F	F.T	1 OF 1

DRAWING TITLE:
BIOGAS PLANT GENERAL ARRANGEMENT

DRAWING NUMBER: 2024-1019-NSW-005

REVISION: A

CO-001-(A) CARBON DIOXIDE EXTRACTION & PURIFICATION VENDOR PACKAGE

CO-001-(B) CARBON DIOXIDE EXTRACTION & PURIFICATION VENDOR PACKAGE

TK-008 LIQUID RECEIVING TANK
- P-001 POSITIVE DISPLACEMENT PUMP
- P-002 POSITIVE DISPLACEMENT PUMP

SR-001 SOLIDS RECEIVING STATION

U-001 RECEIVING HOPPER

A-003 SOLIDS / LIQUID MIXER

TK-009 BLENDING TANK - FERMENTER
- P-003 POSITIVE DISPLACEMENT PUMP
- P-004 POSITIVE DISPLACEMENT PUMP
- P-005 POSITIVE DISPLACEMENT PUMP
- P-006 POSITIVE DISPLACEMENT PUMP
- P-007 POSITIVE DISPLACEMENT PUMP
- P-008 POSITIVE DISPLACEMENT PUMP
- P-009 POSITIVE DISPLACEMENT PUMP
- P-010 POSITIVE DISPLACEMENT PUMP
- P-011 POSITIVE DISPLACEMENT PUMP
- P-012 POSITIVE DISPLACEMENT PUMP

R-004 (A) ANAEROBIC DIGESTER & BIOGAS STORAGE
- P-013 POSITIVE DISPLACEMENT PUMP
- P-014 POSITIVE DISPLACEMENT PUMP

R-004 (B) ANAEROBIC DIGESTER & BIOGAS STORAGE
- P-015 POSITIVE DISPLACEMENT PUMP
- P-016 POSITIVE DISPLACEMENT PUMP

R-004 (C) ANAEROBIC DIGESTER & BIOGAS STORAGE
- P-017 POSITIVE DISPLACEMENT PUMP
- P-018 POSITIVE DISPLACEMENT PUMP

R-004 (D) ANAEROBIC DIGESTER & BIOGAS STORAGE
- P-019 POSITIVE DISPLACEMENT PUMP
- P-020 POSITIVE DISPLACEMENT PUMP

TK-010 POST DIGESTER STORAGE
- P-029 POSITIVE DISPLACEMENT PUMP
- P-030 POSITIVE DISPLACEMENT PUMP

GT-001 (A) GAS TREATMENT

GT-001 (B) GAS TREATMENT

CHP-001 (A) COMBINED HEAT AND POWER

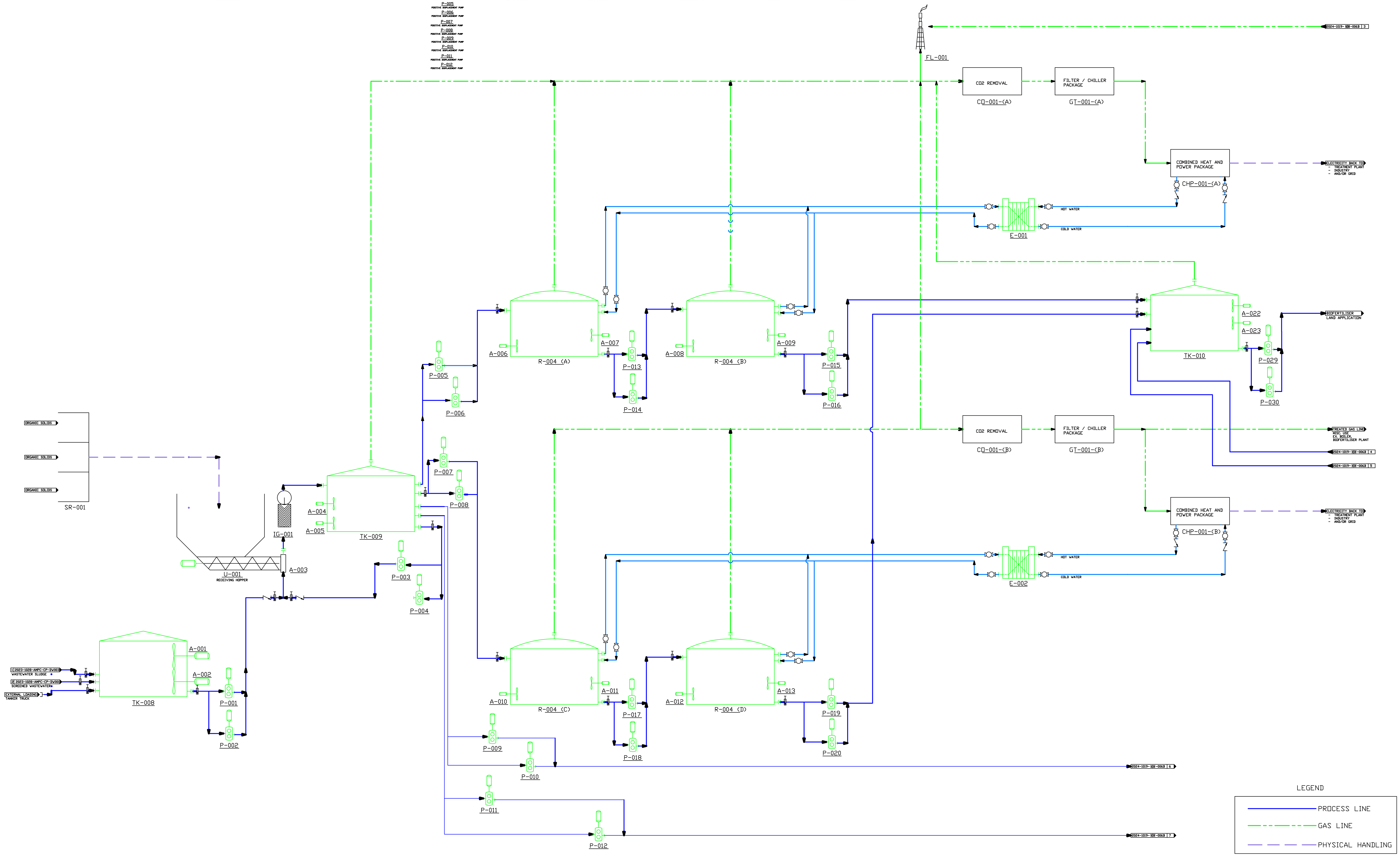
CHP-00A (B) COMBINED HEAT AND POWER

E-001 HEAT EXCHANGER

E-002 HEAT EXCHANGER

FL-001 EMERGENCY FLARE

IG-001 INLINE SHAFT GRINDER



18.12.2023	ISSUED FOR MS2 REPORT	A
DATE	DESCRIPTION	REV

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www.tessele.com

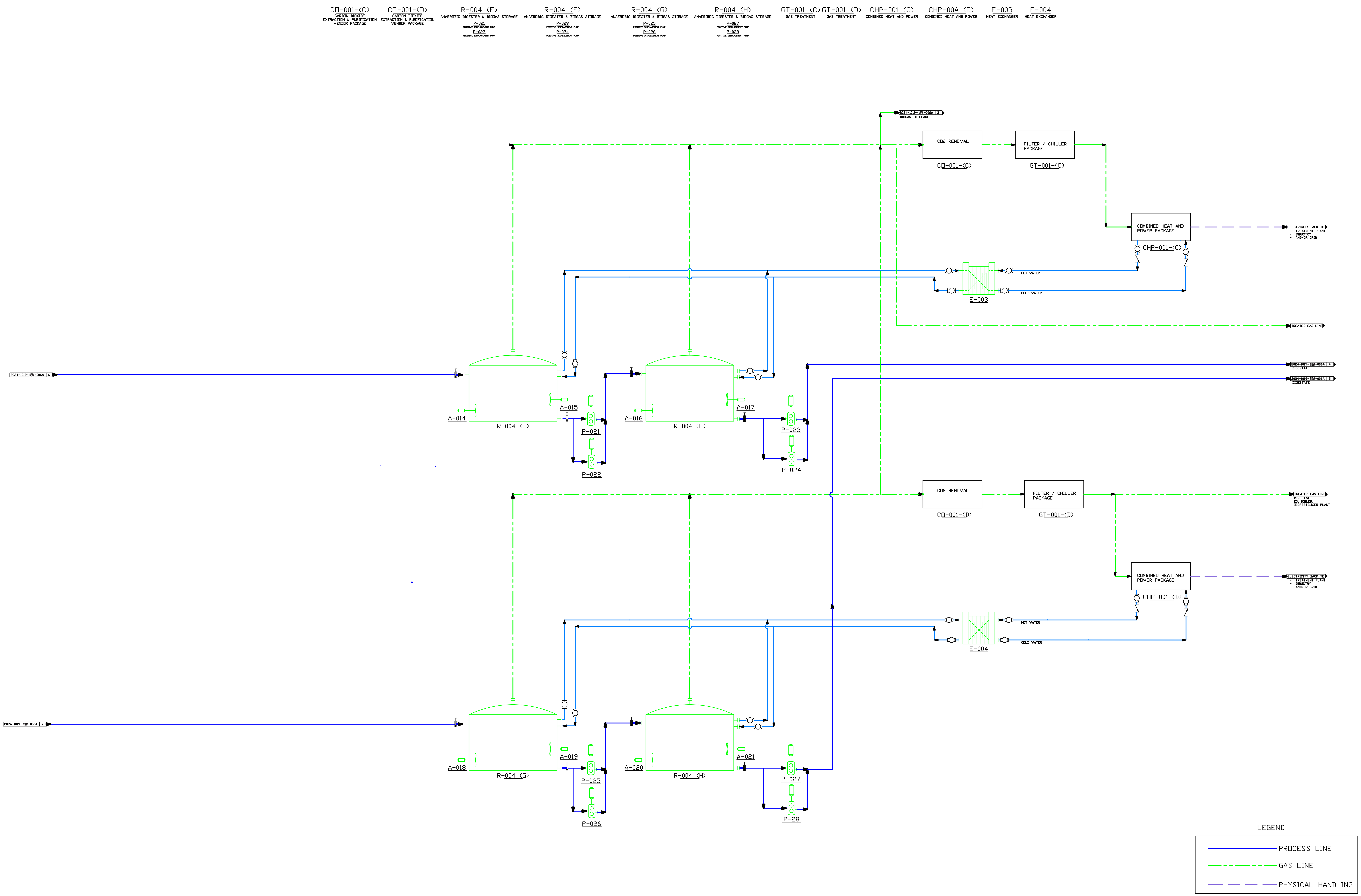
NORTH:

PROJECT TITLE:
INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NTS		2024-1019	
DRAWN:	CHECKED:	APPROVED:	SHEET:
L.L	K.F	F.T	1 OF 2

DRAWING TITLE:
BIOGAS PLANT
PROCESS FLOW DIAGRAM - PFD

DRAWING NUMBER:	REVISION:
2024-1019-NSW-006A	A



18.12.2023	ISSUED FOR MS2 REPORT	A
DATE	DESCRIPTION	REV

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NORTH:

PROJECT TITLE:
INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:	
NTS		2024-1019	
DRAWN:	CHECKED:	APPROVED:	SHEET:
L.L	K.F	F.T	2 OF 2

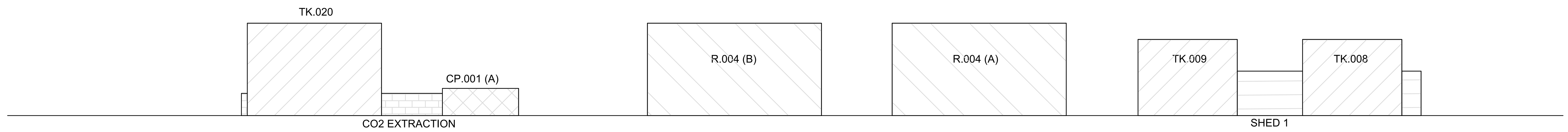
DRAWING TITLE:
BIOGAS PLANT
PROCESS FLOW DIAGRAM - PFD

DRAWING NUMBER: 2024-1019-NSW-006B

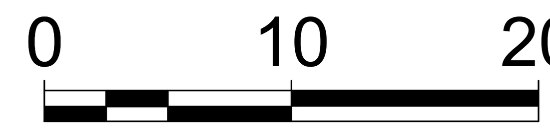
REVISION: A

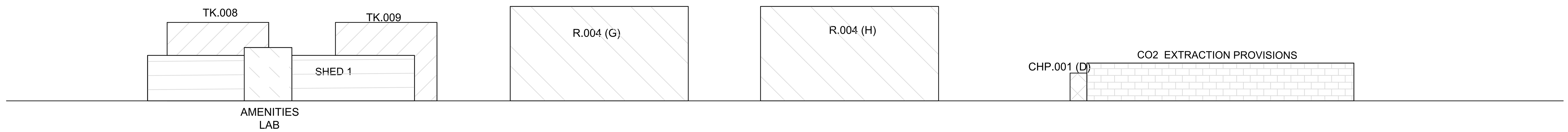
BIOGAS COMPONENTS:

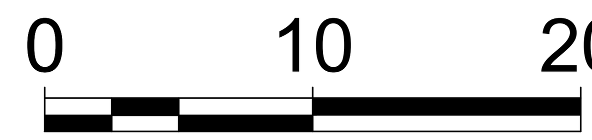
TK.008	Liquid Receiving Tank
TK.009	Blending Tank
R.004(A)	Anaerobic Digester & Biogas Storage
R.004(B)	Anaerobic Digester & Biogas Storage
R.004(C)	Anaerobic Digester & Biogas Storage
R.004(D)	Anaerobic Digester & Biogas Storage
R.004(E)	Anaerobic Digester & Biogas Storage
R.004(F)	Anaerobic Digester & Biogas Storage
R.004(G)	Anaerobic Digester & Biogas Storage
R.004(H)	Anaerobic Digester & Biogas Storage
TK.020	Post Digester Storage
SR.001	Solids Receiving Station
U.001	Receiving Hopper
A.003	Solids/Liquid Mixer
CHP.001(A)	Combined Heat & Power Package
CHP.001(B)	Combined Heat & Power Package
CHP.001(C)	Combined Heat & Power Package
CHP.001(D)	Combined Heat & Power Package
FL.001	Emergency Flare
IG.001	In-Line Shaft Grinder
GT.001(A)	Gas Treatment
GT.001(B)	Gas Treatment
GT.001(C)	Gas Treatment
GT.001(D)	Gas Treatment



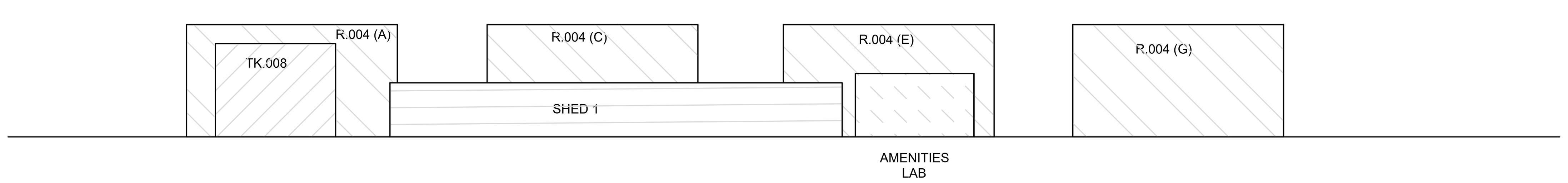
NORTH VIEW

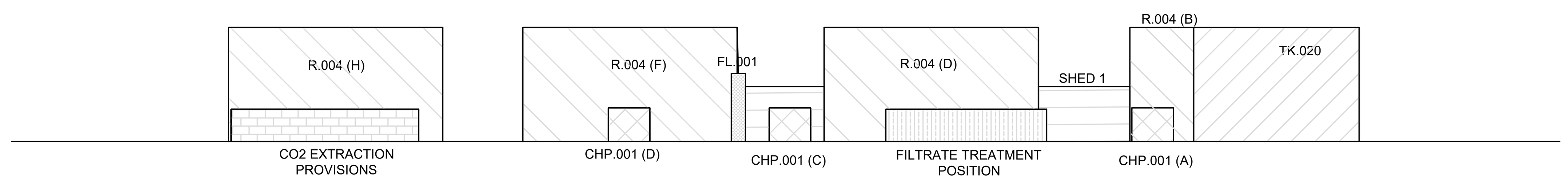


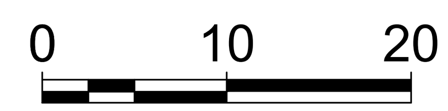




SOUTH VIEW







WEST VIEW

EAST VIEW

DATE	DESCRIPTION	REV
18.12.24	ISSUED FOR MS2 REPORT	A

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PROJECT TITLE:
INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO: 2024-1019	DRAWING TITLE: BIOGAS PLANT ELEVATIONS
DRAWN: L.L	CHECKED: K.F	APPROVED: F.T	SHEET: 1 OF 1

DRAWING NUMBER: 2024-1019-NSW-007

REVISION: A

10.3. Appendix 3: Biofertiliser plant drawings

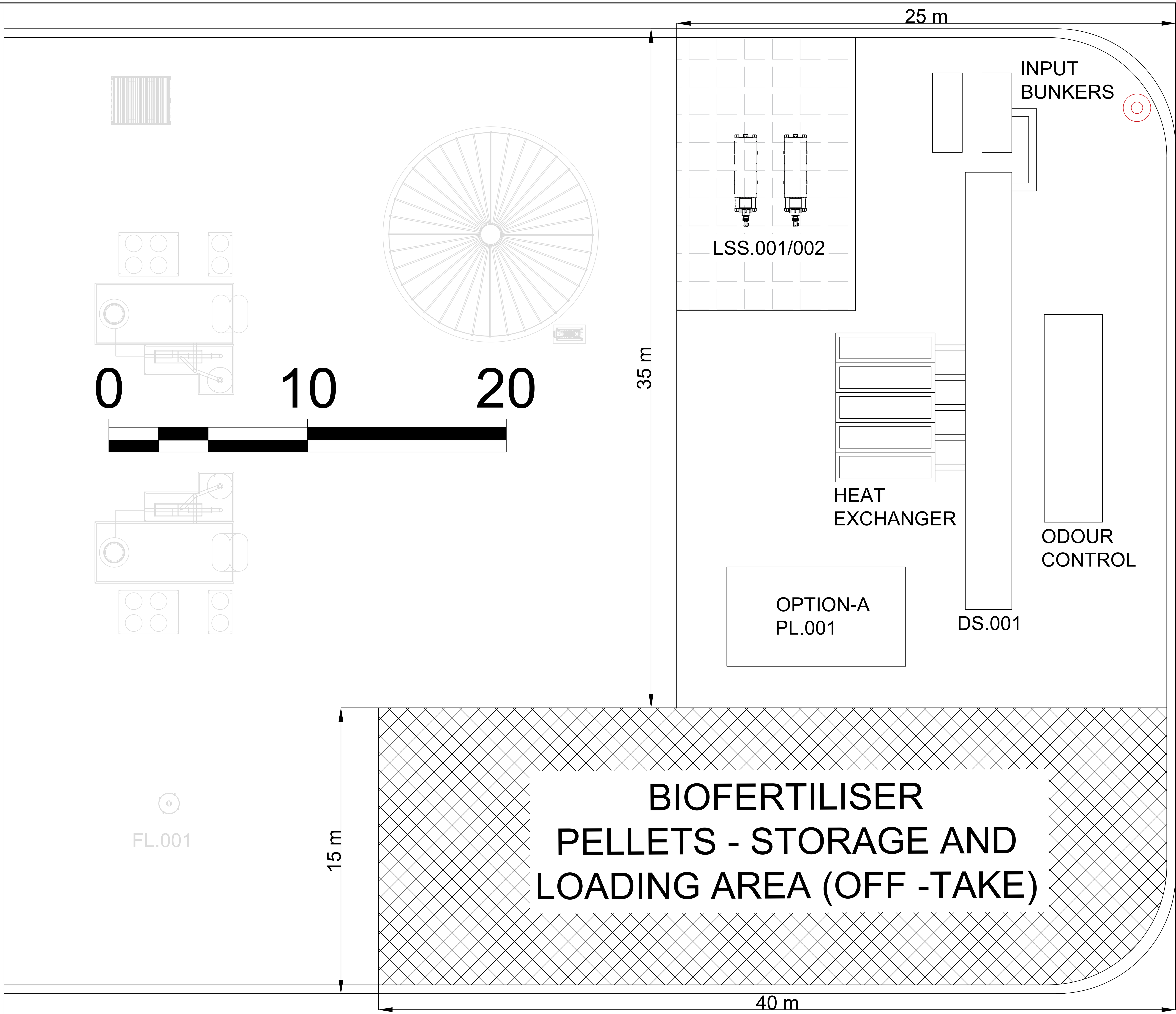
NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. BIOFERTILISER PROCESSING AREA AREA ~840 M^2
3. BIOFERTILISER LOADING AREA AREA ~590 M^2

LSS.001	Liquid Solids Separation
DS.001	Drying System
PL.001	Pelleting System (Op. A)

LEGEND:

Hydrants



DATE	DESCRIPTION	REV
15.10.22	ISSUED FOR MS6 REPORT	A

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NORTH:

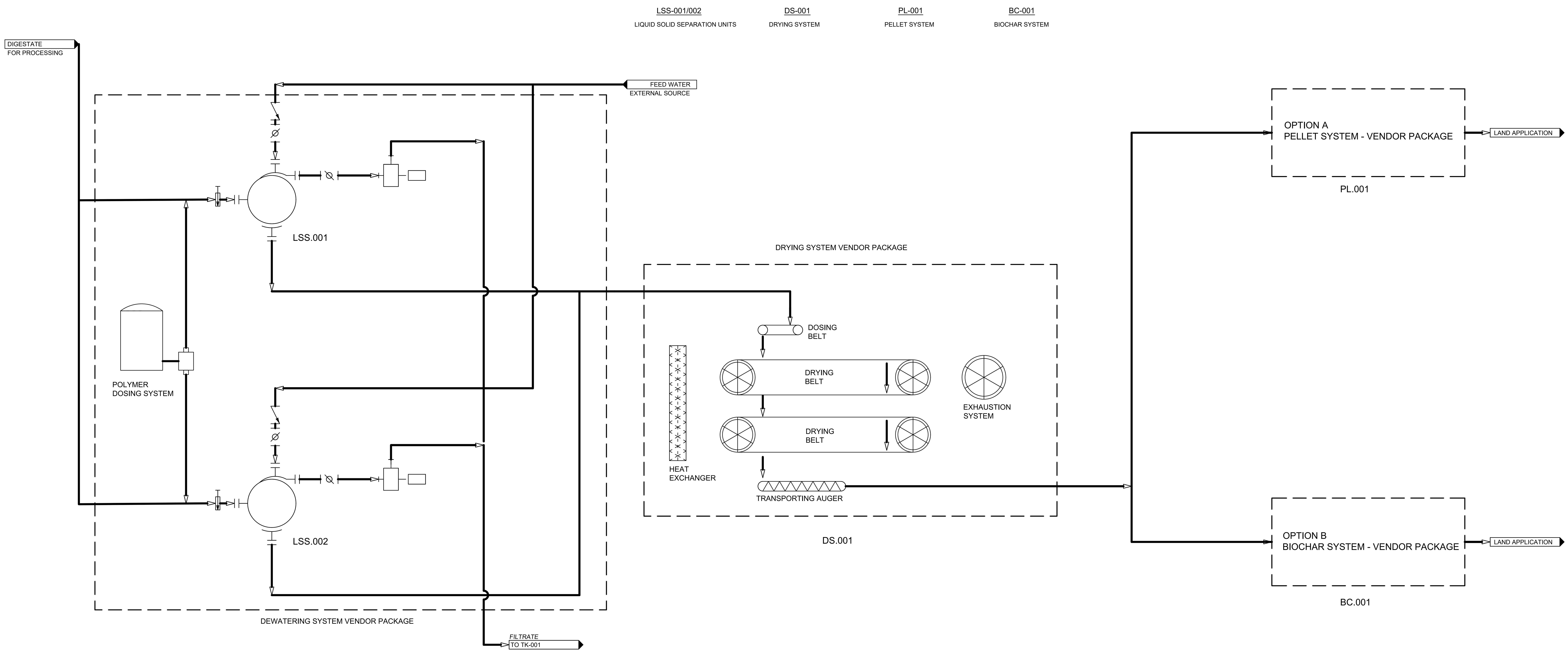
PROJECT TITLE: BIO-RESOURCE RECOVERY CENTRES OF EXCELLENCE AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:
NA		2023-1013

DRAWN:	CHECKED:	APPROVED:	SHEET:
O.K	G.T	F.T	1 OF 3

DRAWING TITLE: BIOFERTILISER PLANT GENERAL ARRANGEMENT (OPTION A)

DRAWING NUMBER:	REVISION:
2023-1013- AMPC-CP-DW-011	A



DATE	DESCRIPTION	REV
15.11.22	ISSUED FOR MS6 REPORT	A

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PROJECT TITLE:
BIO-RESOURCE RECOVERY
CENTRES OF EXCELLENCE
AMPC

SCALE@A1:	PLOT DATE:	PROJECT NO:
NTS		2023-1013

DRAWN:	CHECKED:	APPROVED:	SHEET:
G.T	K.F	F.T	3 OF 3

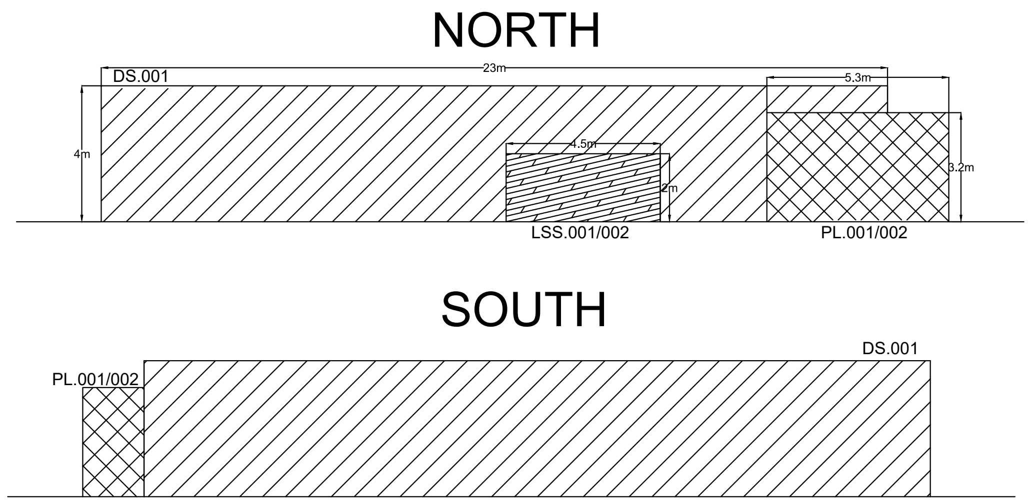
DRAWING TITLE:
BIOFERTILISER PLANT
PROCESS FLOW DIAGRAM

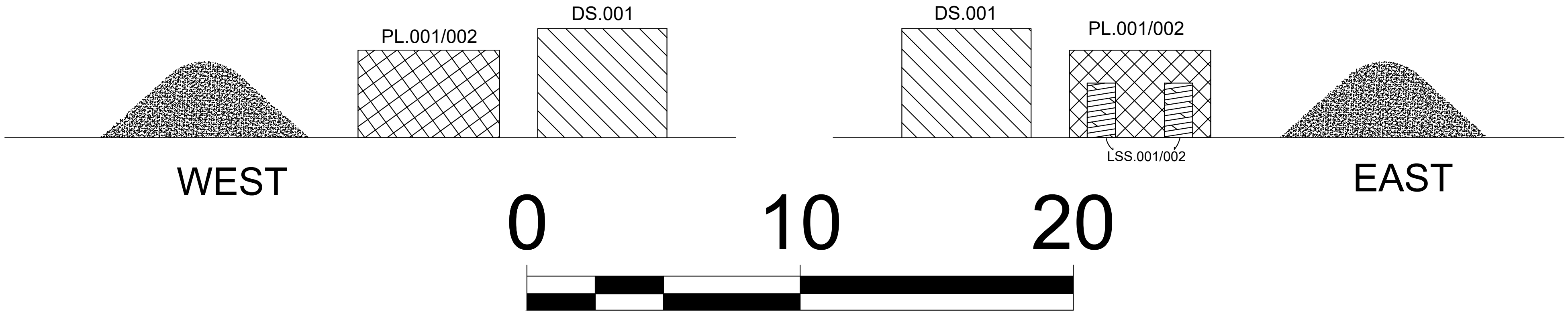
DRAWING NUMBER: 2023-1013-AMPC-CP-DW-013

REVISION: A

BIOFERTILISER COMPONENTS:

LSS.001/002	Liquid Solids Separation
DS.001	Drying System
PL.001/002	Pelleting System
ST.001	Storage Area





DATE	DESCRIPTION	REV
20-2-24	ISSUED FOR MS4 REPORT	A

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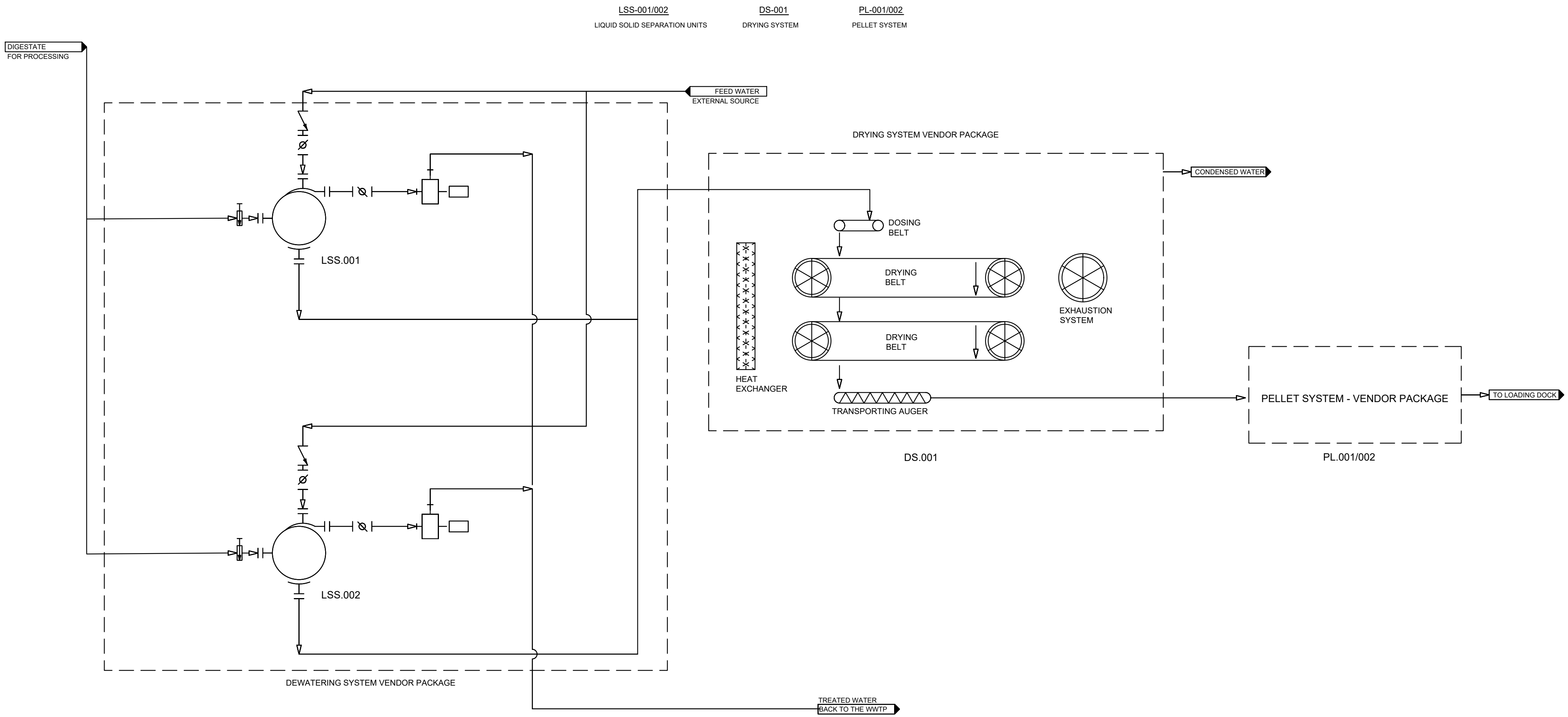
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:	
1:1000		2024-1019	
DRAWN:	CHECKED:	APPROVED:	SHEET:
L.M	K.F	F.T	1 OF 1

DRAWING TITLE:
BIOFERTILISER PLANT ELEVATIONS

DRAWING NUMBER:	REVISION:
2024-1019-NSW-011	A



DATE	DESCRIPTION	REV
20-2-24	ISSUED FOR MS4 REPORT	A

NOTE: CHECK ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE. ALL DRAWINGS TO BE READ IN CONJUNCTION WITH MANUFACTURERS AND CONSULTANTS DOCUMENTATION AND SPECIFICATION. REPORT ANY DISCREPANCIES TO DESIGNER BEFORE PROCEEDING WITH WORK.

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INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:
1:1000		2024-1019

DRAWN:	CHECKED:	APPROVED:	SHEET:
L.M	K.F	F.T	1 OF 1

DRAWING TITLE:
BIOFERTILISER PLANT ELEVATIONS

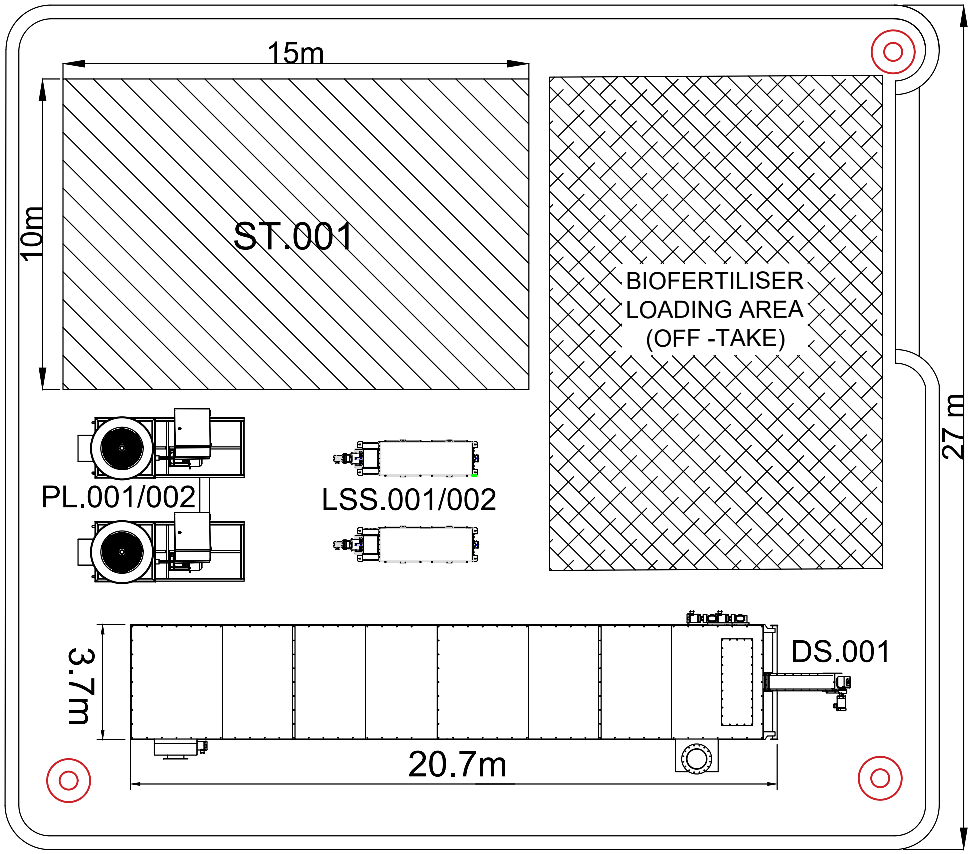
DRAWING NUMBER:	REVISION:
2024-1019-NSW-010	A

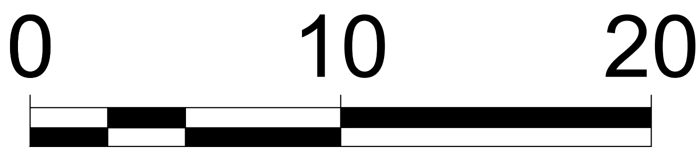
NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. BIOFERTILISER PROCESSING AREA
3. ~810 M^2
4. BIOFERTILISER LOADING AREA
5. ~170 M^2

BIOFERTILISER COMPONENTS:

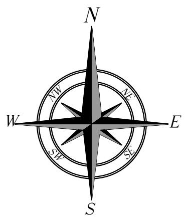
LSS.001/002	Liquid Solids Separation
DS.001	Drying System
PL.001/002	Pelleting System
ST.001	Storage Area





LEGEND:

Hydrants



20-2-24	ISSUED FOR MS4 REPORT	A
DATE	DESCRIPTION	REV

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PROJECT TITLE:
INTEGRATED BIORESOURCE RECOVERY FACILITY
NOVEL FEED STUDY - STAGE 2
NSW CASE STUDY FACILITY

SCALE@A1:	PLOT DATE:	PROJECT NO:	
1:1000		2024-1019	
DRAWN:	CHECKED:	APPROVED:	SHEET:
L.M	K.F	F.T	1 OF 1

DRAWING TITLE:
BIOFERTILISER PLANT ELEVATIONS

DRAWING NUMBER:	REVISION:
2024-1019-NSW-BF-008	A