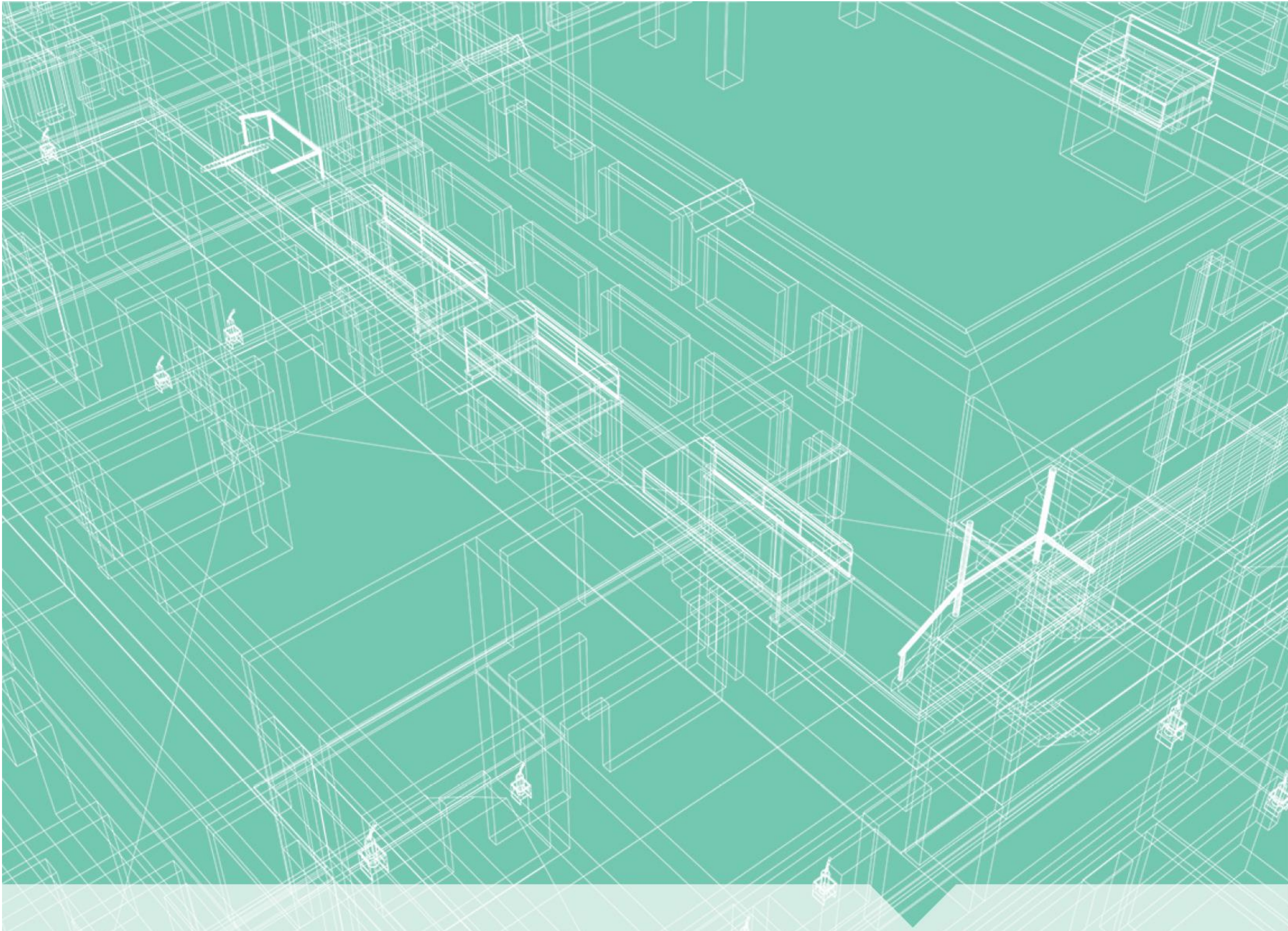

ESD SSDA REPORT

ST PATRICK’S COLLEGE, STRATHFIELD

NEW SCIENCE & LEARNING CENTRE

ESD SERVICES

JHA

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EXECUTIVE SUMMARY

This report has been prepared by JHA to identify and summarise the Ecologically Sustainable Design (ESD) initiatives which have been considered in the design of the proposed new science & learning centre for St Patrick’s College, Strathfield located at Francis St, Strathfield NSW 2135.

The report demonstrates compliance with the Secretary’s Environmental Assessment Requirements (SEARs) which apply to the project and has been prepared to accompany a State Significant Development (SSD) application to the NSW Department of Planning and Environment. This report should be read in conjunction with the Architectural design drawings and other consultant design reports submitted as part of the application.

The aim of the ESD objectives is to encourage a balanced approach to designing new facilities for the project; to be resource-efficient, cost-effective in construction and operation; and to deliver enhanced sustainability benefits with respect to impacts on the environment and on the health and well-being of students, staff and visitors whilst providing the best possible facilities for a constructive student learning experience.

Some of the proposed key ESD initiatives to be committed for the proposed development are listed below:

- Sufficient exposure to daylight
- Well-designed openings to promote cross-ventilation (night purge)
- Appropriate construction and glazing selection
- Energy-efficient air-conditioning systems with control strategy and thermal comfort tuning
- External horizontal shading devices
- On-site renewable energy
- Efficient water fixtures
- Sustainable materials

The report also documents how the principles of Ecologically Sustainable Design (as defined in clause 7(4) of Schedule 2 of the Environmental Planning and Assessment Regulation 2000) will be incorporated in the design and on-going operation phases of the development.

1. INTRODUCTION

1.1 PROJECT DESCRIPTION

The proposed development is a major upgrade of St Patrick's College which will result in the construction of a new four-storey educational building and a basement carpark, removal of existing sports court and fencing. The new science and learning centre building will be a landmark development for the St Patrick's College campus that can be seen from both Fraser Street and Francis Street.

1.2 SITE LOCATION

The subject site is located at Francis St, within the suburbs of Strathfield NSW 2135 and surrounded by residential developments.

Figure 1 – Aerial photo of site

1.3 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS (SEARS)

This report acknowledges the SEARs prepared by the Secretary which notes the followings in Section 8 of the document:

8. Ecologically Sustainable Development (ESD)

- *Detail how the ESD principles (as defined in clause 7(4) of Schedule 2 of the Environmental Planning and Assessment Regulation 2000) will be incorporated in the design and ongoing operation phases of the development.*
- *Include a framework for how the development will be designed to consider and reflect national best practice sustainable building principles to improve environmental performance and reduce ecological impact. This should be based on a materiality assessment and include waste reduction design measures, future proofing, use of sustainable and low carbon materials, energy and water efficient design (including water sensitive urban design) and technology and use of renewable energy.*
- *Demonstrate how environmental design will be achieved in accordance with the GANSW Environmental Design in Schools Manual.*
- *Include preliminary consideration of building performance and mitigation of climate change, including consideration of Green Star Performance.*
- *Include an assessment against an accredited ESD rating system or an equivalent program of ESD performance. This should include a minimum rating scheme target level.*
- *Provide a statement regarding how the works are responsive to the CSIRO projected impacts of climate change. Specifically:*
  - *hotter days and more frequent heatwave events;*
  - *extended drought periods;*
  - *more extreme rainfall events;*
  - *gustier wind conditions; and*
  - *how these will inform material selection and social equity aspects (respite/shelter areas)."*

In accordance with the above SEARS requirements, the development will implement a holistic and integrated approach to Ecologically Sustainable Design (ESD), maximising passive opportunities with the selective application of modern technology where appropriate. Initiatives will be chosen with due regard to whole of lifecycle cost benefits to the school.

The items listed above of the SEARS requirements are addressed in sections 2, 3, 4, 5, and 6 of this report.

2. PRINCIPLES OF ECOLOGICALLY SUSTAINABLE DEVELOPMENT

The principles of Ecologically Sustainable Development as defined in clause 7(4) of Schedule 2 of the Environmental Planning and Assessment Regulation 2000 have been incorporated into the design and on-going operation phases of the development as follows:

2.1 THE PRECAUTIONARY PRINCIPLE

Namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

(i) Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and;
(ii) An assessment of the risk-weighted consequences of various options.

PROJECT RESPONSE:

This development is being designed in accordance with a wide range of ESD goals that pertain to the design, construction and operational stages. The development team will ensure that the building minimises the impact on the environment in the areas of energy, water and materials. The design will incorporate with external high performance shading device and energy efficiency favoured passive design features to minimise severe or irreversible environmental damages.

2.2 INTER-GENERATIONAL EQUITY

Namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

PROJECT RESPONSE:

This development will not cause any significant impact on the health, diversity and productivity of the environment and will provide a community benefit in the form of increased student capacity, upgraded teaching and learning facilities. The project will contribute to a lively community environment and add architectural interest to the surrounding area.

2.3 CONSERVATION OF BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY

Namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration

PROJECT RESPONSE:

Biodiversity Constraints Assessment Report will be prepared in accordance with the Biodiversity Conservation Act to ensure any future development will not have a significant effect on any threatened species, endangered communities, or their habitat. Ecological integrity has been considered for development. The design will include practical strategies to increase the ecological value of the site.

2.4 IMPROVED VALUATION, PRICING AND INCENTIVE MECHANISMS

Namely, that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

PROJECT RESPONSE:

The development is aiming to achieve the same level as a 4 star Green Star rated building (self-assessment). The construction material will be selected based on the outcomes of life cycle assessment (LCA) and relative cost-benefit analysis with decisions being made based on the whole of life costs rather than capital expenditure only. Certified recycled and reused materials, as well as the materials with low embodied energy, will be preferred over others.

3. SUSTAINABLE DESIGN FRAMEWORK

3.1 FRAMEWORK

The sustainable design framework for this development aims to incorporate the best practice design initiatives and Ecologically Sustainable Development principles in new school buildings to the development. The ESD initiatives and targets outlined within this framework have been compiled based on the following:

- National Construction Code (NCC) Section J
- Green Star Design and As-Built Submission Guidelines v1.3;
- GANSW Environmental Design in Schools Manual.

3.2 BUILDING ENVELOPE

Intelligent design and material selection ensure that thermal comfort is not entirely achieved by a mechanical means. Passive design initiatives such as performance glazing, shading and use of insulation will reduce demand on the mechanical air conditioning systems resulting in a reduction of energy consumption and greenhouse gas emissions.

3.2.1 Building Envelope Performance

The building fabric will be designed to meet or exceed the NCC 2019 Section J requirements for building envelope. Thermal breaks will be incorporated into walls, floors and roofs where appropriate to ensure a continuous thermal barrier on the building envelope, reducing the flow of thermal energy between conductive materials.

A preliminary assessment under the Performance Pathway (JV3) to show compliance has been carried out during the schematic design stage of the project. The indicative results on insulation material quantity and glazing specifications demonstrating compliance with NCC 2019 Section J are provided below.

3.2.1.1 Building Fabric

The preliminary minimum performance requirements obtained under Performance Pathway (JV3) for the development (Class 9b) at the proposed location (Climate Zone 5) as per the NCC 2019 Section J - Energy Efficiency are:

Building Elements	Indicative NCC 2019 Requirements
Roof/Exposed Ceiling Envelope	Total R-Value of 3.7 (Solar absorptance of the upper surface of a roof must be not more than 0.45)
External Envelope Walls	Total R-Value of 1.4
Internal Envelope Walls	Nil
Envelope Floors	Nil

Note: NCC 2019 total R-value of 1.4 for walls is anticipated to be equivalent to the NCC 2016 total R-value of 2.8 once the impacts of the thermal bridge have been taken into consideration.

This will necessitate the use of insulation in the walls, floor and roof for both the new building fabrics and extensions or alterations to new fabric constructions. Insulation reduces heat flow and consequent heat loss in winter and heat gain in summer. This minimises the heating and cooling load demand on the air conditioning systems. Light coloured roof material with a low solar absorptance (SA) is recommended to be used to isolate more sunlight and reduce summer heat gain. It also has an effect of reducing elevated localised temperatures (the heat island effect) and potentially can improve the efficiency of solar PV panels (if any) as they perform more efficiently in reduced temperatures.

3.2.1.2 Glazing

Glazing is a major source of unwanted heat gain in the summer and can cause significant heat loss in the winter due to its low insulation performance. It is thus recommended that windows will be high performance glazing systems. Performance glazing substantially reduces heat transmission. This particularly reduces heat loss in winter; therefore, internal heat gain from equipment, lighting and people are better contained. Also, performance glazing absorbs the infrared portion of sunlight and reduces the amount of heat transferred into the conditioned space. This will correspond to a reduction of both heating and cooling loads.

The building will comply with NCC 2019 Section J Energy Efficiency by means of Performance Pathway (JV3). A preliminary assessment to show compliance has been carried out during the schematic design stage of the project as demonstrated below:

Building & Level	Orientation	PROPOSED (Indicative Specifications)	
		Total Systems U-Value	Total Systems SHGC
St Patrick's College, New Science and Learning Centre	N	High Performance Double Glazing Total Systems U-value = 3.6 Total Systems SHGC = 0.45 (Subject to detailed design)	
	E		
	S		
	W		

3.3 SHADING AND DAYLIGHTING

Solar access can enhance indoor environmental quality through access to daylighting and reduce lighting energy consumption. However, excessive solar access and hence, direct solar radiation heat can increase HVAC energy demand and can also cause thermal discomfort. Passive solar heating principle which aims to prevent solar heat gain in the summer and harvest it in the winter for free source of heating, and Passive cooling principle which prevents heat from entering the building during the summer months, are strategies which can conveniently take advantage of the site specific solar access for optimised indoor environmental quality and reduction of HVAC energy demand through use of tailored shadings.

The proposed buildings have been designed to make the best use of the sun by using external high performance horizontal shading screen devices to prevent the high summer sun from entering the building whilst allowing the low winter sun to enter the building for passive heating. The large portion of windows are also shaded by roof eaves and balconies/access paths to the floor above that will reduce the amount of incident summer solar radiation.

These passive design features allow for enriched daylighting and greater access to external views for occupants. Additional daylighting reduces the reliance on artificial light and benefits alertness, mood and productivity. External views provide a connection to nature and the school setting and also help to create an environment encouraging constructive learning.

3.4 NATURAL VENTILATION

Adequate natural air movement makes an important contribution in creating a comfortable indoor environment and reducing the need for mechanical ventilation by carrying accumulated heat out and replacing it with cooler external air. This is important during the summer months where heat build-up within spaces can be quickly removed with the availability of suitable breeze at the site.

Night purge is a high efficient pre-cooling method to a building during the night or before it is occupied on the next day. The design team proposed to utilise night purge through automatic controlled openable windows. The spaces are designed to allow night purge to pre-cool the building before a fresh day started. Night purge can also provide energy savings from a reduction in both operating hours and load of HVAC plant. A computational analysis has been carried out to investigate the most preferable cross-ventilation options and optimise the effect of night purge.

3.5 ENERGY EFFICIENCY

Each climate zone under the Building Code has different design and conditioning requirements to minimise energy use for heating and cooling. Good balance of heating and cooling reduction techniques are required to create an energy efficient development.

3.5.1 HEATING, COOLING AND VENTILATION SYSTEMS

The air-conditioning and ventilation systems shall be designed to comply or exceed the minimum requirements of NCC 2016 Section J5.

The proposed underground car park will be provided with a mechanical exhaust system that will discharge through the roof. The car park mechanical ventilation system will be controlled via carbon monoxide (CO) monitoring system, the car park exhaust fan will also be provided with a variable speed drive (VSD) to opitmise energy efficiency. The basement storage room will be provided with an outside air ventilation system comprising of an inline fan ducted from a louvre located under the seating area.

The air conditioning system to general learning areas will be VRV/VRF (variable refrigerant volume/flow) Heat Recovery System, which can provide simultaneous operation of cooling and heating to each individual space. Each system will comprise of indoor fan coil units (wall-mounted, ceiling cassette or ceiling ducted). The control of air conditioning system shall be designed to minimise energy consumption with a system such as an after hour push button for adjustable timer controller and/or motion detector controls. Further, high efficiency equipment for the HVAC system will be selected to further assist with energy conservation of the building.

All bathroom, storage, and general exhaust are to be naturally ventilated where possible, with mechanical ventilation required where necessary and provided with time controls (time switches or run-on timers as appropriate).

Ductwork systems will be designed to reduce system pressure losses to reduce fan motor power. This includes the selection of equipment for reduced coil and fittings drops and being generous with ductwork sizes to reduce friction losses.

Further, a centralised control system will also be provided to monitor and control all mechanical services with the building. The system will allow building management to interrogate system usage, allow for programming of AC systems (for example time scheduling, and temperature settings), notification on maintenance requirements and system diagnostics. It is proposed to provide remote access to the centralised controller via the internet.

These initiatives will provide significant savings in energy use.

3.5.2 LIGHTING

Lighting will be designed to comply with or exceed the minimum requirements of NCC 2019 Section J6.

Fittings incorporating the latest lamp technologies will be installed to minimise energy use and provide efficient artificial lighting systems.

The proposed development shall be illuminated using LED fittings and be controlled via automatic control system with timer controls, PIR occupancy sensors and microwave occupancy sensors.

Lighting in each learning area shall be provided with a daylight sensor to reduce light output or turn off lights when sufficient daylight is provided within the space. For large spaces, perimeter lightings shall be designated on a separate zone to make maximum use of the daylight.

3.5.3 CONTROLS

All lighting and HVAC installed shall be controlled by time switch or motion sensor for energy conservation. Closed spaces such as storage rooms and cleaner's cupboards are to also have a wall switch. Voltage control (dimming) should be provided where appropriate.

3.5.4 ELECTRICITY METERING

Electricity metering and sub-metering shall be specified in accordance with the Section J requirement to monitor and manage electricity consumption in the building.

3.5.5 ENERGY EFFICIENT APPLIANCES AND EQUIPMENT

Energy consumption shall be reduced by installing energy efficient appliances. Appliances with higher energy stars will provide a return in saving energy and decrease greenhouse gas emission. Appliances shall be selected within 1 star of the highest energy efficiency rating available on the market.

3.5.6 VERTICAL TRANSPORT

The use of lifts within the development will be discouraged by providing visually prominent staircases for all floors.

3.5.7 PHOTOVOLTAICS

Collecting solar energy has been chosen as a key ESD strategy for the project, with an aspirational goal of reducing the building's energy consumption and greenhouse gas emissions from a renewable source via the provision of a roof-mounted photovoltaic system. The project is actively seeking on-site alternative energy source opportunities with less environmental impact. The initial proposal includes fitting up to $80m^2$ of the roof space with an optimal PV system to allow on-site renewable energy and reduce electricity consumption from the grid. The proposed on-site PV system will be orientated to maximise its exposure to direct solar radiation.

3.6 INDOOR AIR QUALITY (IAQ)

The quality of indoor air has a significant impact on our health and environment. Poor indoor air quality resulting in adverse health effect such as allergy, asthma, etc. The outdoor air ventilation rates shall be in accordance with AS 1668.2 for mechanically ventilated spaces. Mechanical ventilation systems shall be linked to CO_2 sensors and designed to not exceed 1,500ppm for more than 20 consecutive minutes in each day. The ventilation system shall be designed to minimise the entry of outdoor pollutants.

3.7 WATER CONSERVATION

The following initiatives are proposed to ensure that significant water saving is achieved.

3.7.1 Fittings and Fixtures

Water consumption shall be reduced by incorporating water efficient fixtures and fittings in accordance with the Australian Government's Water Efficiency Labelling Scheme (WELS). The fixtures and fittings are to have the following minimum WELS Rating. In addition, flow restrictors or taps with timed flows can be used to minimise water usage.

Water Fittings / fixtures	Minimum WELS Rating	Highest Available Rating (AS/NZS 6400-2016)
Showerhead rating	3	4
Sink tap rating	5	6
Toilet cistern rating	4	6
Urinals rating	4	6

3.8 SUSTAINABLE MATERIALS

3.8.1 LOW VOC / LOW FORMALDEHYDE MATERIALS

Adhesives, sealants, flooring and paint products will be selected to contain low or no Volatile Organic Compounds (VOCs) and all engineered timber products used in exposed or concealed applications are specified to contain low or no formaldehyde to avoid harmful emissions that can cause illness and discomfort for occupants.

3.8.2 RECYCLED CONTENT

Loose furnishings within the building shall be selected based on their recycled content, end-of-life recyclability and product stewardship agreements. By selecting loose furnishings which comply with independent environmental certification, for example, Ecospecifier or Good Environmental Choice Australia, the project will confidently reduce environmental impacts and waste from furnishings over the life of the building.

Steel and concrete to comply with Green Star requirements, pending feasibility.

- For steel frame buildings at least 60% of the fabricated structural steelwork shall be supplied by a steel fabricator/ contractor accredited to the Environmental Sustainability Charter of the Australian Steel Institute (ASI).
- For concrete framed buildings at least 60% (by mass) of all reinforcing bar and mesh is produced using energy-reducing processed in its manufacture.

3.9 ECOLOGICAL CONSERVATION

The current design have been designed to bring nature and the buildings together by optimising the use of outdoor space with provision of sensible separation of uses, such as active play, quiet learning and gathering space, and flexible spaces of varying form and function for outdoor environmental learning, whilst ensuring connectivity throughout the site between main school area and oval.

3.10 WASTE

Waste collection and disposal plays an important role in the protection of the environment and the health of the population in the modern world. A waste management plan will be prepared to assess and monitor the waste management process during construction and demolition, as well as waste produced during occupation within the development. The waste management plan shall incorporate how to minimise the amount of waste generated, maximise the reuse, recycling and reprocessing construction waste materials and minimise the volume to materials disposed to landfill.

3.11 WATER SENSITIVE URBAN DESIGN

External area design will implement best practices of water sensitive urban design, including indigenous low water usage plants to increase stormwater retention, decrease total suspended solids and mitigate the urban heat island effect. The carbon sequestration of the plants will also combat climate change contributions.

4. GANSW ENVIRONMENTAL DESIGN IN SCHOOLS MANUAL

The GANSW Environmental Design in Schools Manual provides the guidance on new school developments and major upgrades in NSW and incorporates the scopes of State Environmental Planning Policy (Educational Establishments and Child Care Facilities) 2017 (the Education SEPP).

With the assistance of the GANSW Design Guide, the project is to demonstrate the adoption of the following seven design quality principles outlining under Education SEPP and how school developments can apply design considerations and strategies to improve their learning spaces, education building, and school campus.

- Context, built form and landscape
- Sustainable, efficient and durable
- Accessible and inclusive
- Health and safety
- Amenity
- Whole of life, flexible and adaptive
- Aesthetics

The Design Verification Statement (DVS) addressing the development has been coupled with the above Education SEPP design quality principles is to be completed by the architect.

5. GREEN STAR RATING SCHEME COMPARISON

The project is not pursuing a formal Green Star rating through the certification procedures of the Green Building Council Australia (GBCA). However, the project team has benchmarked it against the Green Star Design & As Built v1.3 Rating System, with a goal of a four (4) Star Green Star rating.

For the purposes of comparison, the Green Star Scorecard has been prepared in *Appendix A Green Star Scorecard* which outlines the sustainability initiatives targeted for the project. The Scorecard demonstrated a pathway for the project to achieve the required 45 possible points for the Four Star Rating. Below table summarises the findings of the Green Star gap assessment. Weighting is calculated as per the official Green Star Design and As-Built V1.3 Scorecard.

Category	Total Points Targeted
Management	13
Indoor Environment Quality	13
Energy	4.4
Transport	0
Water	3
Materials	5
Land Use & Ecology	2
Emissions	5
Innovation	1
Total	46.4

6. IMPACTS OF CLIMATE CHANGE

6.1 NEEDS ANALYSIS

Considering climate risk during the needs analysis stage of the project can help with the early identification of the challenges and opportunities that are likely to have an impact on the project across the lifecycle of the asset.

The first step is to consider whether any of the extreme events are likely to have an impact on the project by considering the project's exposure to climate impacts. Past climatic events that have impacted and potential hazards that may affect the site are summarised below:

- Heat waves – Over the period 1911–2013, heatwaves in parts of NSW have become longer, hotter and occur more often. Infants and young children are considered one of the groups most at risks to impact of heat related illness. [Source: AdaptNSW Heatwaves Climate Change Impact Snapshot]
- Storm – Low rainfall intensity for 60minute 1:100yr Storm. Predicted to receive 136 mm, or up to 426 mm over 3 days. [Source: Bureau of Meteorology]
- Flood – No known exposure to riverine flood events. [Source: Predicted Coastal Flooding Resulting from Climate Change, Coastal Risk Australia website]. See also *Appendix B: Inundation Map*.
- Bushfire – The parcel of land selected is not identified as bush fire prone however it could still be affected by a bush fire. [Source: NSW RFS Bushfire Prone Land 2017].

Studies have shown that learning performance can be impacted by higher temperatures. Warm classrooms may decrease interest and alertness, distracting students. In hotter classrooms, headaches and heat exhaustion symptoms may develop that can hinder academic performance. High temperatures may be accompanied by higher levels of humidity. Increased humidity can cause drowsiness in students. Studies have shown concentration tests scores are lower in humid, hot environments.

6.2 CLIMATE VARIABLES OF INTEREST

Based on the above, the climate variables of interest for this site are maximum daily temperature and rainfall (rainfall correlates to humidity), particularly for the summer months of December to February.

6.3 IDENTIFIED TIME SERIES

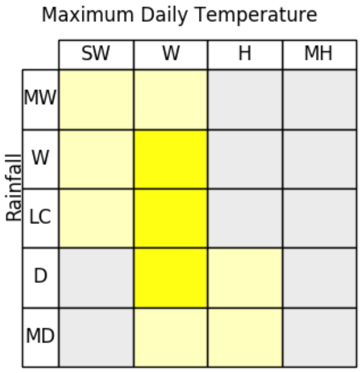
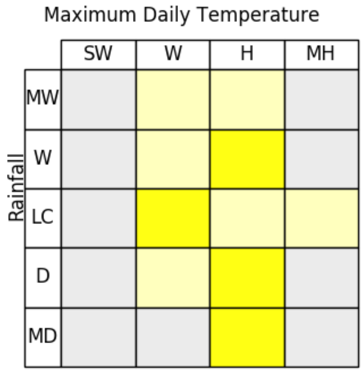
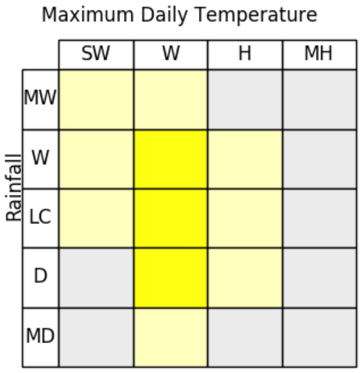
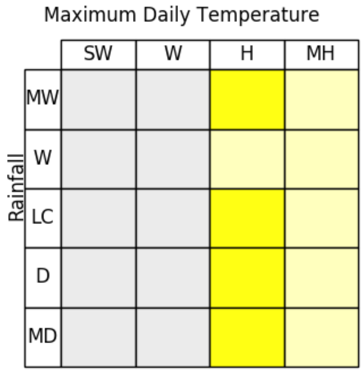
The lifespan of the project components was considered to determine the time series. Based on components design life, the time series that is selected to understand the future climate impacts across the project's life are 2030 and 2070.

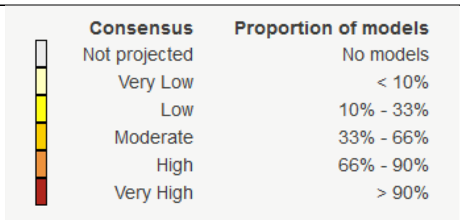
6.4 IDENTIFIED GREENHOUSE GAS SCENARIOS

In order to source relevant climate projection, a representative concentration pathway (RCPs) based on the latest IPCC report (AR5) is chosen. The RCPs provide plausible climate futures that may eventuate over the coming years. RCP 8.5 scenario has been selected as one future climate projection for this assessment as it's the most conservative pathway and because current emissions are tracking close to RCP 8.5. RCP 8.5 reflects a future with less curbing of emissions, coal fired power generation, increased carbon dioxide concentration reaching 940 ppm by 2100. The RCP 4.5 is chosen to represent a stabilisation pathway in which lower emissions is achieved by the application of some mitigation strategies and technologies. RCP 4.5 reflects a future where emissions peak around 2040, and the CO_2 concentration reaches 540 ppm by 2100.

6.5 CLIMATE FUTURE PROJECTIONS

The series of climate futures matrices representing the combination of time periods and greenhouse gas scenarios and classified by the combined changes of the climate variables identified above are provided in the table below:

<table>
<tr><td colspan="2" rowspan="2">East Coast
Climate Futures</td><td colspan="2">Year</td></tr>
<tr><td>Summer 2030</td><td>Summer 2070</td></tr>
<tr><td rowspan="2">Emissions Scenarios</td><td>RCP 4.5</td><td>
</td><td>
</td></tr>
<tr><td>RCP 8.5</td><td>
</td><td>
</td></tr>
<tr><td colspan="2">Keys</td><td>Maximum Daily Temperature
SW Slightly Warmer < 0.50
W Warmer 0.50 to 1.50
H Hotter 1.50 to 3.00
MH Much Hotter > 3.00

Rainfall (December to February)
MW Much Wetter > 15.00
W Wetter 5.00 to 15.00
LC Little Change -5.00 to 5.00
D Drier -15.00 to -5.00
MD Much Drier < -15.00</td><td>
</td></tr>
</table>

Source: CSIRO and Bureau of Meteorology, Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au/), cited 28/01/2020).

6.6 KEY CASES

For thermal comfort:

"Best Case": Climate Future with the least increase in maximum daily temperature and the largest decrease (or least increase) in rainfall (shorthand: "coolest and driest")

"Worst Case": Climate Future with the greatest increase in maximum daily temperature and the greatest increase (or least decrease) in rainfall (shorthand: "hottest and wettest")

6.7 RESULTS

For thermal comfort:

Case	2030 Climate Future		2070 Climate Future	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
"Best"	Slightly warmer and no change (Consensus: Very low)	Slightly warmer and little change (Consensus: Very low)	Warmer and drier (Consensus: Very low)	Hotter and much drier (Consensus: Low)
"Worst"	Warmer and much wetter or Hotter and drier (Consensus: Very low)	Hotter and wetter (Consensus: Very low)	Much hotter and little change (Consensus: Very low)	Much hotter and much wetter (Consensus: Very low)
"Maximum consensus"	Warmer and little change to drier (Consensus: Moderate)	Warmer and little change to wetter (Consensus: Moderate)	Warmer to hotter and little change to drier (Consensus: Moderate)	Hotter and little change to drier (Consensus: Moderate)

6.8 DISCUSSIONS

In the "best case" scenarios, the summer maximum daily temperature is projected to be slightly warmer by 2030 and warmer to hotter by 2070. Therefore, this project should be designed with warmer temperature being taken into considerations. The direction of rainfall change (increasing or decreasing) is highly uncertain at this stage; as such, this project may consider a wait and see approach until a clearer pattern emerges to avoid potential maladaptation.

High level of passive thermal features should be considered, especially features that will assist in reducing solar heat gains in summer. Air-conditioning should be considered throughout, budget permitting. However, overreliance on air-conditioning should be avoided, especially during extreme temperature and heatwave events; air-conditioning should be accompanied by appropriate occupant behaviours and responses to ensure fitting and efficient use of the system. As the climate becomes warmer, energy consumption associated with cooling will increase. This additional electricity demand and associated greenhouse gas emission could be offset with additional photovoltaics panels to provide renewable electricity.

Dedicated "Cool outdoor areas" where students and teachers can take shelter during extreme hot days when the power fails and there is no air conditioning should be explored by the design team. This cool area should utilise passive design principals to moderate temperature during extreme days. Secondly, this cool area should consider ways to harness the cooling power of water to provide additional cooling.

APPENDIX A: GREEN STAR SCORECARD

Green Star - Design & As Built Scorecard v1.3

Project:	190326 St Patrick's College, Strathfield
Targeted Rating:	4 Star - Best Practice

	Total Score	Points Available	Points Targeted
	46.4	100	46.4

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Management			14	13
Green Star Accredited Professional	1.0	Accredited Professional	1	1
	2.0	Environmental Performance Targets	Complies (Mandatory)	
	2.1	Services and Maintainability Review	1	1
Commissioning and Tuning	2.2	Building Commissioning	1	1
	2.3	Building Systems Tuning	1	1
	2.4	Independent Commissioning Agent	1	-
Adaptation and Resilience	3.0	Implementation of a Climate Adaptation Plan	2	2
Building Information	4.1	Building Information	1	1
Commitment to Performance	5.1	Environmental Building Performance	1	1
	5.2	End of Life Waste Performance	1	1
Metering and Monitoring	6.0	Metering	Complies (Mandatory)	
	6.1	Monitoring Systems	1	1
Responsible Building Practices	7.0	Enviromental Management Plan	Complies (Mandatory)	
	7.1	Formalised Enviromental Management System	1	1
	7.2	High Quality Staff Support	1	1
Operational Waste	8A	Performance Pathway		
	8B	Prescriptive Pathway	1	1

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Indoor Environment Quality			17	13
Indoor Air Quality	9.1	Ventilation System Attributes	1	1
	9.2	Provision of Outdoor Air	2	1
	9.3	Exhaust or Elimination of Pollutants	1	1
Acoustic Comfort	10.1	Internal Noise Levels	1	1
	10.2	Reverberation	1	1
	10.3	Acoustic Separation	1	1
	11.0	Minimum Lighting Comfort	Complies (Mandatory)	

Lighting Comfort	11.1	General Illuminance and Glare Reduction	1	1
	11.2	Surface Illuminance	1	1
	11.3	Localised Lighting Control	1	-
	12.0	Glare Reduction	Complies (Mandatory)	
Visual Comfort	12.1	Daylight	2	1
	12.2	Views	1	
Indoor Pollutants	13.1	Paints, Adhesives, Sealants and Carpets	1	1
	13.2	Engineered Wood Products	1	1
Thermal Comfort	14.1	Thermal Comfort	1	1
	14.2	Advanced Thermal Comfort	1	1
Category/Credit	**Code**	**Credit Criteria**	**Points Available**	**Points Targeted**
Energy			22	4.4
Greenhouse Gas Emissions	15E.0	Conditional Requirement: Reference Building Pathway	Complies (Mandatory)	
	15E.1	Comparison to a Reference Bulding Pathway	20	3.4
Peak Electricity Demand Reduction	16A	Prescriptive Pathway - On-site Energy Generation	2	1
	16B	Modelled Performance Pathway - Reference Building		
Category/Credit	**Code**	**Credit Criteria**	**Points Available**	**Points Targeted**
Transport			10	0
Sustainable Transport	17A.1	Performance Pathway	-	-
	17B.1	Access by Public Transport	3	-
	17B.2	Reduced Car Parking Provision	1	-
	17B.3	Low Emission Vehicle Infrastructure	1	-
	17B.4	Active Transport Facilities	1	-
	17B.5	Walkable Neighbourhoods	1	-
Category/Credit	**Code**	**Credit Criteria**	**Points Available**	**Points Targeted**
Water			12	3
Potable Water	18A.1	Performance Pathway	-	-
	18B.1	Sanitary Fixture Efficiency	1	1
	18B.2	Rainwater Reuse	1	-
	18B.3	Heat Rejection	2	2
	18B.4	Landscape Irrigation	1	-
	18B.5	Fire System Test Water	1	-
Category/Credit	**Code**	**Credit Criteria**	**Points Available**	**Points Targeted**
Materials			14	5
Life Cycle Assessment (LCA)	19A.1	Comparative Life Cycle Assessment	6	-
	19A.2	Additional Life Cycle Impact Reporting	4	-
Life Cycle Impacts	19B.1	Concrete	3	-
	19B.2	Steel	1	-
	19B.3	Building Reuse	4	-
	19B.4	Structural Timber	4	-
Responsible Building Materials	20.1	Structural and Reinforcing Steel	1	1
	20.2	Timber Products	1	1
	20.3	Permanent Formwork, Pipes, Flooring, Blinds and Cables	1	1
Sustainable Products	21.1	Product Transparency and Sustainability	3	1

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Construction and Demolition Waste	22.0	Reporting Accuracy	Complies (Mandatory)	
	22A	Fixed Benchmark	1	1
	22B	Percentage Benchmark		

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Land Use & Ecology			6	2
Ecological Value	23.0	Endangered, Threatened or Vulnerable Species	Complies (Mandatory)	
	23.1	Ecological Value	3	1
Sustainable Sites	24.0	Conditional Requirement	Complies (Mandatory)	
	24.1	Reuse of Land	1	-
	24.2	Contamination and Hazardous Materials	1	-
Heat Island Effect	25.0	Heat Island Effect Reduction	1	1

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Emissions			5	5
Stormwater	26.1	Stormwater Peak Discharge	1	1
	26.2	Stormwater Pollution Targets	1	1
Light Pollution	27.0	Light Pollution to Neighbouring Bodies	Complies (Mandatory)	
	27.1	Light Pollution to Night Sky	1	1
Microbial Control	28.0	Legionella Impacts from Cooling Systems	1	1
Refrigerant Impacts	29.0	Refrigerant Impacts	1	1

Category/Credit	Code	Credit Criteria	Points Available	Points Targeted
Innovation			10	1
Innovative Technology or Process	30A	Thermal Comfort	1	-
		Greenhouse Gas Emissions	2	1
			1	-
		Potable Water	1	-
Market Transformation	30B	Potable Water	1	-
		Microbial Control	1	-
		Commissioning and Tuning	1	-
		Greenhouse Gas Emissions	1	-
		Life Cycle Impacts - Concrete	1	-
Improving on Green Star Benchmarks	30C	Commissioning and Tuning	1	-
			2	-
		Indoor Pollutants	1	-
			1	-
		Greenhouse Gas Emissions	2	-
		Sustainable Transport	1	-

		Potable Water	1	-
		Life Cycle Impacts	1	-
		Sustainable Products	1	-
		Construction and Demolition Waste	1	-
		Stormwater	1	-
Innovation Challenge	30D	Indoor Pollutants	1	-
Global Sustainability	30E	Global Sustainability	1	-

APPENDIX B: INUNDATION MAP

The Map below shows the site is not subjected to risk of inundation.

Source: Predicted Coastal Flooding Resulting from Climate Change, Coastal Risk Australia website (http://coastalrisk.com.au, cited 28/01/2020).