Sydney Zoo

Energy Efficiency & ESD Report

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Sydney Zoo
3 Wills Avenue
WAVERLEY NSW 2041

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Sydney Zoo

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610.15657-R2	Revision 0	03 November 2015	Dr Neihad Al-Khalidy	Dr Peter Georgiou	Dr Neihad Al-Khalidy

Executive Summary

SLR Consulting Australian Pty Ltd (SLR) has been engaged by Sydney Zoo to provide a qualitative Ecologically Sustainable Design (ESD) assessment, including energy efficiency, for their proposed development at Bungarribee. The assessment forms part of the Environmental Impact Statement (EIS) submission for a State Significant Development Application (SSDA) for the proposed development.

The main objectives of the current study are to:

- Reduce base and operational energy and greenhouse gas emissions;
- Facilitate energy monitoring for substantive energy uses;
- Reduce lighting energy consumption while maintaining appropriate lighting levels;
- Implement renewable energy efficiency options to reduce peak hour demand on energy supply infrastructure; and
- Reduce potable water efficiency.

The site is located approximately 33 km west of the Sydney Central Business District, and approximately 15 km east of Penrith. It falls within the Western Sydney Parklands, and is in close proximity to the Great Western Highway, M4 Western Motorway and Westlink M7, providing excellent access to both the state and regional road network and surrounding parkland areas.

Overall, positive Ecologically Sustainable Design (ESD) and energy efficiency features are currently in place in a number of design areas, incorporating the following:

- The proposed development will incorporate passive and active energy saving measures such as operable windows to enhance natural ventilation through Building 1 (Entry/Retail) and Building 2 (Restaurant).
- Ceiling fans are planned for Building 2 (Restaurant).
- A high performance double glazing system will be used including thermally broken windows aluminium framed with a minimum U Value of 2.9.
- High levels of natural light will be enabled through the maximising of north facing facades.
- Incorporation of thermal mass: concrete slab construction is proposed for all floors throughout the development - concrete has amongst the highest thermal mass capacity of a range of common building products.
- Velux fixed skylights will be sued for Building 3 (Admin Curatorial).
- An efficient VRF air conditioning system is planned for conditioned spaces.
- A “Green Roof” is planned for Building 4.
- There will be stormwater harvesting storage to achieve 81.5% water efficiency re-use via the following two open water basins
  - 1,260m^3 located in the north-west corner.
  - 840m^3 located next to the restaurant.
- Due to the high degree of stormwater re-use for the site, the design provides a high degree of stormwater treatment incorporating mechanical infiltration and UV disinfection prior to reticulation.

Executive Summary

The following recommendations have been made to improve upon the existing key sustainability elements of the proposed development:

- Line the inside of the roof and/or ceiling construction with a minimum R3.5 insulation.
- Peak Energy Demand Reduction. A preliminary feasibility study concluded that a 250.9 kW PV solar installation may reduce the peak demand for the site by approximately 11%.
  - The estimated annual energy produced by the proposed 250.9 kW system is 321,415 kWh per annum.
  - The estimated greenhouse gas CO_2 emission saving is approximately 344 tonnes/annum.
  - The estimated payback for the system is 8 years using today's electricity price of 15 ¢/kWh.

  Sydney Zoo should assess the optimal PV installation for the site once the base electricity load is established during the detail design stage.
- A self-sufficient off-grid solar street lighting system to illuminate selected locations of the proposed site would avoid the need for excavation works, cable laying and public grid connection.
- Investigation of the use of a cover to the north waste corner open water basin is recommended to significantly reduce the evaporation rate and increase water re-use efficiency.
- A minimum 4-star energy efficiency rating is recommended for dishwashers, refrigerators, and washing machines.
- Heat pump or solar boosted hot water systems should be evaluated.
- Light efficiency measures in the carparks could be enabled using motion sensors.
- LED and fluorescent lighting throughout the project would increase lighting efficiency.
- Electricity sub-metering is recommended for significant end uses that consume more than 10,000 kVA.
- Low levels of volatile organic compounds (VOC) paints and floor coverings and low formaldehyde wood products should be utilised wherever feasible.
- Dedicated carspaces should be allocated for small or low emission cars.
- Provision should be allowed for bicycle storage spaces within the proposed site.

Recommendations regarding the mechanical ventilation system, domestic hot water, other appliance and operational waste, etc., have also been made within the body of the report.

These features will help to achieve significant reductions in the energy and water required by the development both in building and operation, as well as ensuring that the site are more liveable, pleasant spaces.

It is recommended that ESD initiatives continue to be developed and implemented during the detailed design stage of the project.

A BCA Section J energy efficiency assessment of the proposed development will be carried out during the detailed design stage to reduce green gas emissions by efficiently using energy in the proposed development.

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SLR Consulting Australian Pty Ltd (SLR) has been engaged by Sydney Zoo to provide a qualitative Ecologically Sustainable Design (ESD) assessment, including energy efficiency, for their proposed development at Bungarribee. The assessment forms part of the Environmental Impact Statement (EIS) submission for a State Significant Development Application (SSDA) for the proposed development.

The following report was prepared based upon the architectural plan set DA100-400 Revision C dated 30th October 2015.

1.1 Secretary's Environmental Assessment Requirements

A Request for SEARs relating to the form and content of the EIS was submitted to the NSW Department of Planning and Environment (NSW DP&E) in August 2015. The SEARs were subsequently issued by the DP&E. **Table 1** presents the key Ecologically Sustainable Development issues to be addressed in the EIS, and identifies where each requirement is addressed in this study.

Table 1 SEARs for the proposed development

Ecologically Sustainable Development	Relevant Section
• practical opportunities to minimise energy use, • practical opportunities to minimise water use, • project water requirements on a total water cycle basis, outlining - · project water requirements and sources, and · total water balances for the project operations with the objective of minimising demands and impacts on external water resources.	Ecologically Sustainable Development

1.2 Objectives

The main objectives of the current ESD study are to:

- Reduce base and operational energy and greenhouse gas emissions;
- Facilitate energy monitoring for substantive energy uses;
- Reduce lighting energy consumption while maintaining appropriate lighting levels;
- Implement renewable energy efficiency options to reduce peak hour demand on energy supply infrastructure; and
- Reduce potable water efficiency.

2 SITE DESCRIPTION

The site is located approximately 33 km west of the Sydney Central Business District, and approximately 15 km east of Penrith. It falls within the Western Sydney Parklands, and is in close proximity to the Great Western Highway, M4 Western Motorway and Westlink M7, providing excellent access to both the state and regional road network and surrounding parkland areas.

The site is located on the north side of the Great Western Highway, in the Bungarribee Precinct of the Western Sydney Parklands. It is approximately 16.5 ha in area, and approximately 75 m setback from the main road. The site is currently open ground.

To the north of the site is the residential suburb of Bungarribee, approximately 800 m away, with separation via Bungarribee Creek which meanders through the parklands.

The Arndell Park industrial estate is to the east of the site and to the south, a mixture of industrial and warehouse type businesses. The M4 Motorway is approximately 1 km south of the site, beyond which is the Eastern Creek race track.

Westlink M7 Motorway is to the west, providing a strong border to the Parklands.

Figure 1 Site Location

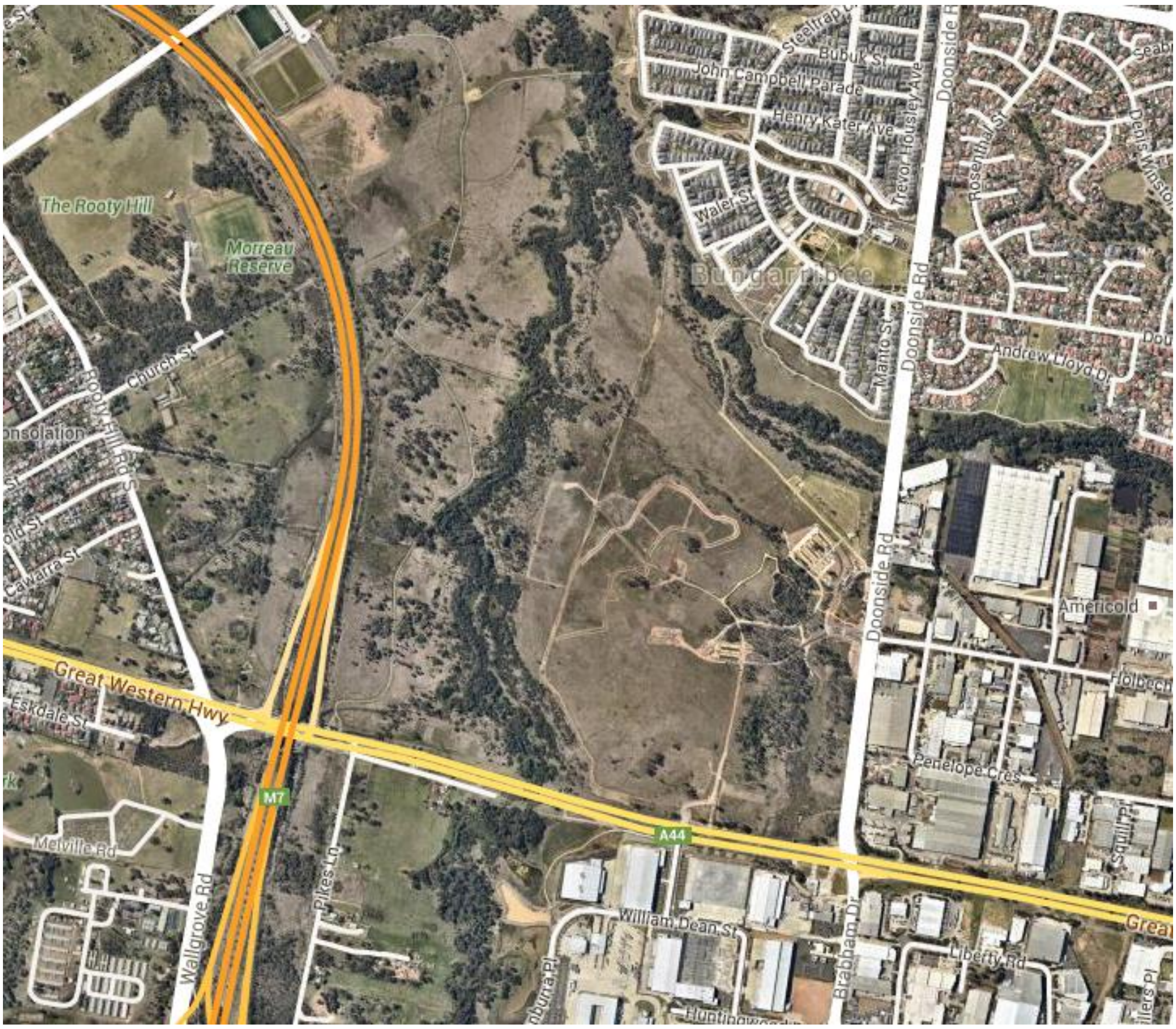


Image: NearMap on 06/10/2015

2.1 Development Description

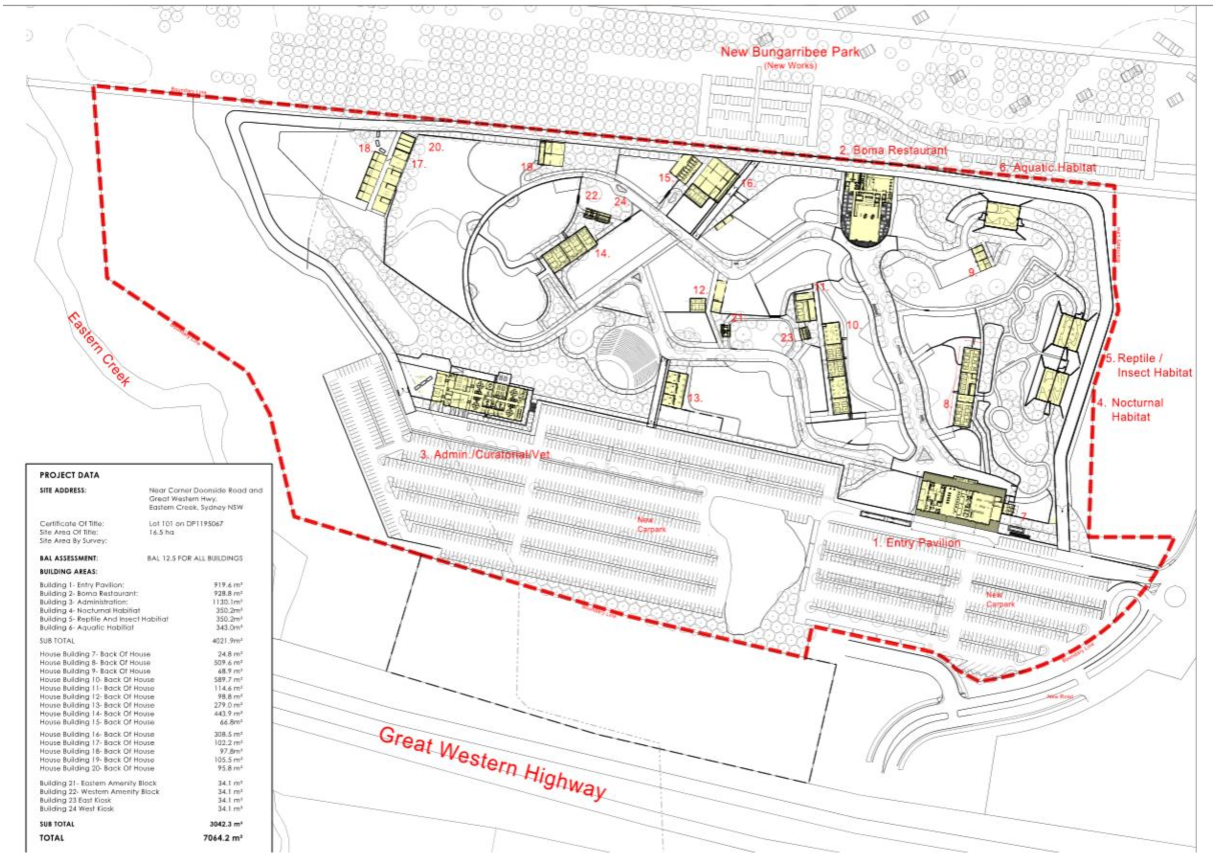
The site is currently vacant and will be developed as an open air zoological park.

The key characteristics of the site are:

- 30-35 animal exhibits across several enclosures of varying design for a range of native and exotic animals.
- Back-of-house buildings for exhibits.
- Main entrance building comprising entry/exit and gift shop.
- Restaurant and café
- 2 Kiosks with food display and associated refrigeration.
- Toilets sufficient for servicing a peak in park capacity of 5,000 people.
- Show arena.
- Picnic areas and gardens.
- Wetlands and waterways.
- An estimated 1,500 linear m of pathways, including lighting.
- An office servicing up to 60 full time staff.
- An Aquarium with up to 12 tanks and filers of an average of 10m3 water volume.
- A nocturnal house with artificial sunlight during the PM to reverse the diurnal cycle of the animals.
- A veterinary centre.
- Service yard with maintenance shelter.
- Car parking for 1,284 spaces (Main formal carpark on asphalt=387; Overflow on asphalt road=88; Overflow on Gravel = 800; and Disabled Spots = 9), access via an internal road connecting to the Great Western Highway.
- Bus parking.

The site master plan is shown in **Figure 2**.

Figure 2 Sketch of the Proposed Development – Site Master Plan



3 ECOLOGICALLY SUSTAINABLE DESIGN

3.1 Definitions of Key Concepts

3.1.1 Ecologically Sustainable Development (ESD)

The concept of Ecologically Sustainable Development (ESD) was outlined in "Our Common Future", the report of the 1987 United Nations World Commission on the Environment and Development (the Brundtland Commission). It defined Sustainable Development as

"Development that meets the needs of the present without compromising the ability of future generation to meet their own needs".

This concept was adopted within Australia in 1990 when the Council of Australian Governments endorsed a National Strategy for Ecologically Sustainable Development. The Commonwealth Government suggested the following definition for ESD in Australia:

"Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased".

Put more simply, ESD is development which aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations. To do this, it is necessary to develop ways of using those environmental resources which form the basis of our economy in a way which maintains and, where possible, improves their range, variety and quality.

The National Strategy for Ecologically Sustainable Development notes that there is no identifiable point where it can be said that ESD has been achieved. The strategy further states that there are two main features which distinguish an ecologically sustainable approach to development:

- we need to consider, in an integrated way, the wider economic, social and environmental implications of our decisions and actions for Australia, the international community and the biosphere; and
- we need to take a long-term rather than short-term view when taking those decisions and actions.

Ultimately ESD should lead to changes in our patterns of resource use, including improvements in the quality of our air, land and water, and in the development of new, environmentally friendly products and processes.

3.1.2 National Strategy for ESD Objectives and Guiding Principles

The National Strategy for ESD sets its core objectives as**:**

- To enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.
- To provide for equity within and between generations.
- To protect biological diversity and maintain essential ecological processes and life-support systems.

The Guiding Principles of the National Strategy for ESD are documented as:

- Decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations.

- Where 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.
- The global dimension of environmental impacts of actions and policies should be recognised and considered.
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised.
- The need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised.
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms.
- Decisions and actions should provide for broad community involvement on issues which affect them.

These guiding principles and core objectives need to be considered as a package. No objective or principle should predominate over the others. A balanced approach is required that takes into account all these objectives and principles to pursue the goal of ESD.

3.2 Specific Requirements for Compliance

Specifications for environmental design measures required for the proposed site are detailed in the following documents:

Mandatory ESD Measures for Consideration

- Blacktown City Council Development Control Plan (DCP), 2015.
- National Construction Code (NCC) 2015 Section J.
- State Significant Development Application Requirements.

4 ESD INITIATIVES FOR THE PROPOSED DEVELOPMENT

In order to achieve a structured integrated approach to ESD, a series of indicators and strategic goals have been identified at the outset to be communicated to the design team. SLR's role, as the project's ESD Consultant, has been to apply these principles to all aspects of the development ensuring a best possible ESD outcome.

ESD indicators identified for the proposed Concept Plan are:

- Site Layout and Building Design in terms of ESD;
- Energy Efficiency;
- Water Conservation;
- Transportation;
- Indoor Environment Quality;
- Materials;
- Land Use and Ecology; and
- Emissions.

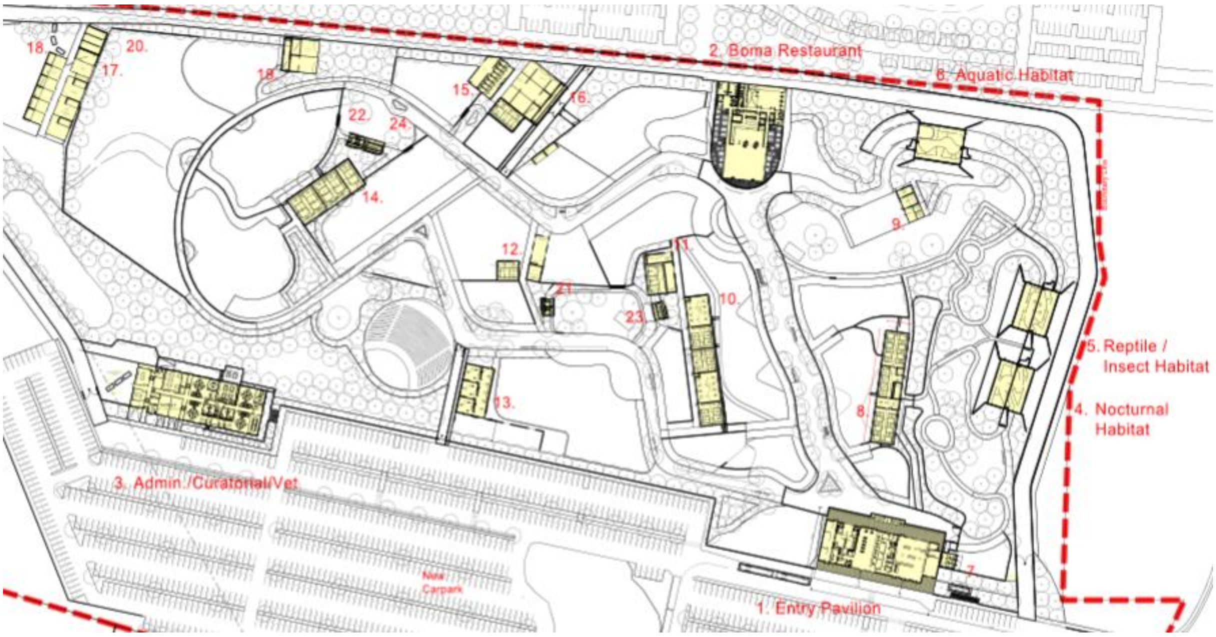
The ESD initiatives to be committed for the proposed development are outlined in the following sections.

4.1 Site Analysis and Layout

A key ESD objective should be to optimise site conditions and minimise energy consumed for cooling and heating loads through proper selection of building orientation and internal layout. The following points are noted with respect to the sitting of the proposed buildings (Refer **Figure 3**).

- Building 1 (Entry/Retail).
- Building 2 (Restaurant)
- Building 3 (Administration/Curatorial/Vet)
- Building 4 (Nocturnal Habitat)

Figure 3 Site Master Plan Showing the Proposed Buildings



4.1.1 Solar Access

One of the objectives of energy conservation is to minimise the heating and cooling requirements of buildings. Sunlight should preferably be able to penetrate the building in winter and be excluded from the building in summer.

- Building 1 (Entry/Retail) - maximised the north facing façade to have good solar access throughout the year and minimised the west and east facades (without glazing) to reduce the afternoon sun during hot summer.
- Building 2 (Restaurant) - larger glazing/open spaces are proposed to the restaurant to receive a good level of natural daylight and views.
- Building 3 (Administration/Curatorial/Vet) - maximised the north facing façade to have good solar access throughout the year and minimised the west and east facades (without glazing) to reduce the afternoon sun during hot summer. Skylights are also proposed to open plan and corridor areas.
- Building 4 (Nocturnal Habitat) – due to the nature of this building, it has to be designed without daylight penetration.

4.2 Natural Ventilation

The most important role of natural ventilation in the context of the development is to remove accumulated heat gain during periods of overheating. In this case, ventilation is intended to achieve predicted rates of volumetric air change. Also important during the summer months is the role of ventilation in directly improving the perception of thermal comfort by occupants of a space. This is achieved when moving air aids the evaporation of perspiration by passing over the skin. As long as there is some air movement, most people will tolerate somewhat higher temperatures.

Heat build-up within buildings associated with daytime summer temperatures can be quickly purged with the availability of suitable breezes at the site.

SLR encourages the use of cross ventilation to inform the building design. Building design should enable ventilation to be controlled, where comfort levels are maintained for the occupants during the summer and winter extremes. Locations of windows and openings within each room are to be suitably in line where possible with each other on opposite sides of the room. It is recommended that building openings be designed such that cross-ventilation is maximised, to minimise heat gain in summer.

Ventilation of a building is achieved by permanent openings, windows, doors or other devices which have an aggregate opening or openable size of not less than 5% of the floor area of the ventilated room. The provision of ceiling fans for use in summer months is also encouraged.

In winter it is important to close off heated areas that need warming. The opportunity to open and close doors will allow adequate control to moderate the impact of any higher than comfortable winds. It is recommended that the following initiatives also be incorporated to minimise heat leakage from the building:

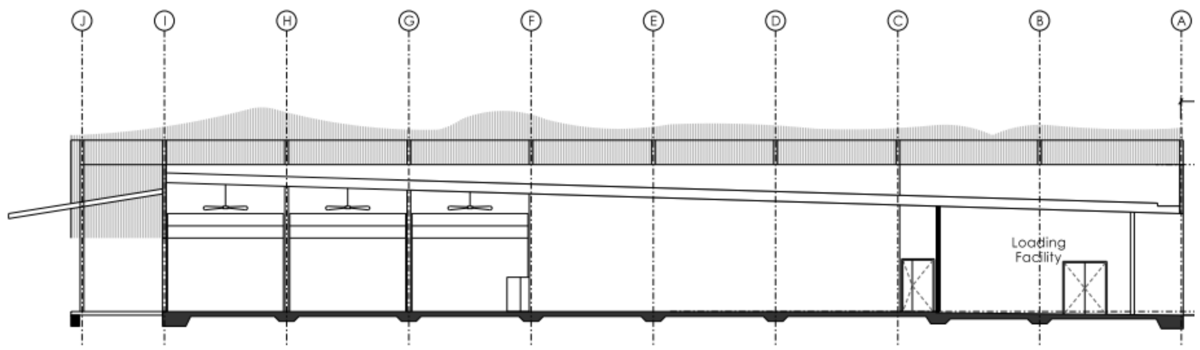
- Design detailing of the glazing interface to the window framing system and the provision of adequate sealing in accordance with the Building Code of Australia (BCA).
- Doors leading to hallways, stairwells and non-common use areas provided with draught excluders to limit heat losses during winter months.
- Doors located throughout the development in general-use areas, such as access ways to/from the building, fitted with door closers where it is deemed that their opening will have an adverse effect on heat loss during winter.

Figure 4 showing Building 1 (Entry/Retail) has been designed with good cross ventilation. This may passively cool the Entry/Pay zone area. The retail space can open windows/doors during milder seasonal periods to receive benefit from cross ventilation and close all the openings when AC units are on during hot summer season.

Figure 5 indicates Building 2 will have good cross ventilation by utilising both operable openings and ceiling fans.

Figure 4 Cross Ventilation to Building 1 (Entry/Retail)

Figure 5 Cross Ventilation to Building 2 (Restaurant) with Ceiling Fans



4.3 Building Construction

4.3.1 Building Materials

The minimum performance criteria for the building form and construction of the conditioned area will be achieved through the NCC 2015 Section J review carried out during the detailed design stage of the project. The following recommendations are made to improve upon the existing key sustainability elements of the proposed development.

Roof and Ceiling Insulation

The following roof/ceiling materials are proposed for Buildings 1 - 3:

- A new Lysaght Klip-lok 700 Hi strength roof sheeting BMT 0.60 with a layer of insulation
- A new 105 Cross Laminated Timber (CLT) panels for the ceiling

A 300 mm thick arched concrete slab with a green roof (500 mm min of soil over the top of the roof) is proposed for Building 4.

SLR recommends lining the inside of the roof and/or ceiling construction with R-value of 3.5.

Roof Lights

The design of Building 3 (Admin Curatorial) incorporates 1120 x 1180 Velux fixed skylight. The window is a high performance double glazed window (argon gas in the cavity).

The total area of roof lights serving the conditioned room or space as a percentage of the floor area of the room or space is less than 5% as per the NCC 2015 requirement.

Walls

The following internal wall design is proposed:

- 85 mm Cross Laminated Timber (CLT) panels.

The following external wall design is proposed:

- Externally new wall sheeting is to be clad in shadowclad plywood with a textured finish with timber cover trims over the vertical joints.
- The plywood is to be vertical-oriented with horizontal 40 mm top hat sections. Between the top hat sections is to be placed 30 mm foam board screw fixed to new cross laminated timber panels.
- Over the face of the foam board is to be placed an Enviroseal ProtorWrap wall membrane.
- Over the external face of the new 105 mm cross laminated timber panels (CLT) is to be placed a 40 mm top hat section at 600 mm horizontal spacing for the fixing of the external cladding.

SLR recommends a minimum Total R-Value of 2.8 for the external walls of the conditioned spaces. A detailed NCC 2015 Section J assessment will be conducted during detailed design.

Floors

Concrete slab construction is proposed for all floors throughout the development - concrete has amongst the highest thermal mass capacity of a range of common building products.

J2 External glazing

A high performance glazing system including thermally broken windows aluminium framed with a minimum U Value of 2.9 is proposed for all conditioned spaces.

Part J2 of the NCC 2015 contains the requirements of the Deemed-to-Satisfy compliance of external glazing. The purpose of this subsection is to ensure that building glazing will provide sufficient thermal insulation, and be appropriately shaded, to minimize heating and cooling loads placed on the building and the commensurate energy consumption of HVAC systems servicing internal building spaces. A detailed NCC 2015 Section J assessment will be conducted during detailed design.

4.3.2 Building Sealing

The purpose of this subsection is to ensure that additional heating and cooling loads will not be introduced through building leakage.

A seal to restrict air infiltration must be fitted to each edge of an external door, operable external window or the like when serving a conditioned space in the proposed development. The seal may be a foam or rubber compressible strip, fibrous seal or the like.

The bathroom/toilet exhaust fans in the proposed development must be fitted with a sealing device such as a self-closing damper or the like.

5 PASSIVE ENERGY EFFICIENCY

Passive energy efficiency refers to the choice of building materials, the placement of external facades and fenestration to effectively utilise solar energy for heating when required, and minimise solar gains when appropriate, thus 'passively' reducing the artificial heating and cooling requirements of the building. While high cooling and heating loads are typical in summer and winter months respectively, a good balance of heating and cooling load reduction techniques is required to produce a development with efficient passive design.

5.1 Mechanical Ventilation and Air Conditioning

At this stage the exact heating and cooling loads have not been determined for the conditioned area. Efficient VRF systems are proposed for the conditioned spaces to reduce the energy consumption for the proposed development. The use of energy efficiency measures will be fully explored during detailed design.

The proposed VRF condenser units can be mounted on rooftop or at ground level.

5.2 Domestic Hot Water

As natural gas is abundant and more energy efficient than electricity, gas is recommended for hot water in NSW. The sole use of electricity as the energy source for conventional electric water heaters is inefficient because electricity is a secondary source, deriving its energy after burning coal. As coal based systems require expensive handling equipment and specialised pollution control systems, gas water systems are more energy efficient.

However, the gas supply is not available to the site so solar hot water systems or heat pumps are recommended for the domestic hot water system. Heat pumps are used to harvest the energy in the air to create energy efficient hot water and can be installed indoors or outdoors.

5.3 Electrical Sub-Metering

Successful management of energy consumption of large uses within a building or a site allows building/site managers to fine-tune operational procedures to minimise consumption and compare historical use. Sub-metering is recommended for all substantive (greater than 100kVA) energy uses within the proposed site. These uses may include air conditioning system, lifts and common areas (lighting and power).

6 GREEN ENERGY INITIATIVES

A number of green energy initiatives have been investigated, including:

- Photovoltaic (PV) Cells including Building Integrated-Photo-Voltaic (BIPV) technology
- Stand-alone solar street or car-park lighting
- Bio-waste gas powered generator systems
- Mini/Micro Turbine Hydroelectric Generation
- Green Power Initiatives

The following comments are made with regards of the above initiatives:

6.1 PV Solar Panels

6.1.1 Introduction

The photovoltaic effect is the basic physical process through which a PV cell converts sunlight into DC electricity. When photons strike a PV cell, they will be either reflected, absorbed or pass right through. Only the absorbed photons generate electricity. When this happens, the energy of the photon is transferred to an electron in an atom of the cell (which is actually a semiconductor).

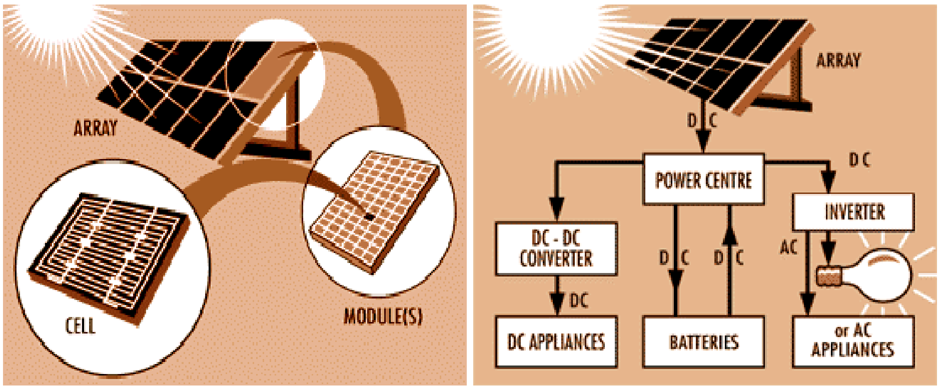
An inverter converts the DC electricity to AC electricity, the same form of electricity provided by electric utilities. The electricity from the inverter flows through an electric meter. An electrical meter can be run in reverse when generating more electricity than one can use.

The earliest PV devices converted about 1%-2% of sunlight energy into electric energy. PV panels are still relatively inefficient, converting between 14% to 20% of the sun's light into electricity. However, laboratory prototypes are now reaching 30% efficiency.

6.1.2 Where PV Cells are Suitable

Photovoltaic systems are used to generate electricity to pump water, light up the night, activate switches; charge batteries and supply power to the utility grid (refer **Figure 6**).

Figure 6 PV Cells Used to Generate Electricity



6.1.3 Orientation of PV system for the Proposed Site

Sloping north facing roofs free of shading are ideal for solar installations although they can also be installed on flat roofs. Each 1.5 kilowatt of photovoltaic panels takes up roughly 10 m^2 of roof space, so the maximum amount of solar panels that can be installed will depend on the space available.

The following features were therefore considered in order to assess the "OPTIMUM" location of the solar panels:

- Orientation and inclination angle of the solar panels to obtain highest solar radiation incident on the panels.
- Site limitation.
- The sustainability demonstration aspect of the project.

6.1.4 Sizing of PV system for the Proposed Site

6.1.4.1 Electrical Load for the Proposed Site

The estimated maximum demand for the site is approximately 2430 kVA (Refer **Table 2**). The majority of the demand is for the lighting power.

It is understood that most of the buildings loads will occur during the day including lighting; there are also exhibits like the nocturnal and aquarium which will need to be on during the evening.

A preliminary study suggests that the base load for the site may equate to roughly 45% of the peak load. The base electrical load for the proposed site will be determined during the detailed design stage of the project.

Table 2 Peak Demand for the Proposed Site

Building	Description	Area	VA/m2	Total VA	Amps/Phase	Comments
1	Retail 1	332	150	49800	69.2	Lighting Power and A/C
1	retail Store	104	150	15600	21.7	Lighting Power and A/C
1	Amentias	194.5	80	15560	21.6	Lighting Power and A/C
1	Entry Pay	201	120	24120	33.5	Lighting Power and A/C
1	Group Pay	101	120	12120	16.8	Lighting Power and A/C
1	Prayer Room	8.5	120	1020	1.4	Lighting Power and A/C
2	Kitchen/Servery	285	600	171000	237.5	Lighting Power and A/C
2	Eating and sitting	830	120	99600	138.3	Lighting Power and A/C
2	Garbage	58	100	5800	8.1	Lighting Power and A/C
2	Amentias	150	80	12000	16.7	Lighting Power and A/C
2	Loading Dock	150	70	10500	14.6	Lighting Power and A/C
2	Future Expansion	380	160	60800	84.4	Lighting Power and A/C
3	Office/Admin	370	180	66600	92.5	Lighting Power and A/C
3	Vet area	115	300	34500	47.9	Lighting Power and A/C
3	Food Prep & Storage	270	180	48600	67.5	Lighting Power and A/C
Animal enclosures						
	Aquarium	450	250	112500	156.3	Lighting Power and A/C Tank Heating pumps
	Local Reptiles	450	120	54000	75.0	Lighting Power and A/C
	Koalas	100	120	12000	16.7	Lighting
	Nocturnal Exhibit	630	120	75600	105.0	Lighting power heating
	Meerkats	260	20	5200	7.2	Lighting
	Land Gorillas	1250	30	37500	52.1	lighting
	Dingoes	450	30	13500	18.8	lighting
	Echidna	50	60	3000	4.2	lighting
	Amentias	120	110	13200	18.3	Lighting Power
	Petting Zoo	400	30	12000	16.7	Lighting
	Arboreal Monkey	800	30	24000	33.3	Lighting
	crocodiles	600	80	48000	66.7	Lighting
	Chimpanzee	2000	40	80000	111.1	Lighting
	Elephants	4800	15	72000	100.0	Lighting
	Hamadryas Baboon	1500	30	45000	62.5	Lighting
	Tigers	1500	35	52500	72.9	Lighting
	Orang-Utans	450	50	22500	31.3	Lighting
	Sun-Bear	450	70	31500	43.8	Lighting
	Hippos	3200	80	256000	355.6	Lighting
	Show Arena	1250	40	50000	69.4	Lighting
	Kiosk	120	210	25200	35.0	Lighting Power and A/C
	Avery	1150	20	23000	31.9	Lighting
	Cheetahs	1500	35	52500	72.9	Lighting
	Lions	3450	30	103500	143.8	Lighting
	African Wild Dogs	1200	20	24000	33.3	Lighting
	Leopards	450	35	15750	21.9	Lighting
	African Grassland	7500	10	75000	104.2	Lighting
	Service Yard	2500	20	50000	69.4	Lighting and power
	Carpark	20000	10	200000	277.8	Lighting & CCTV
	Overflow Carpark	10000	10	100000	138.9	Lighting & CCTV
	Pathways	13000	8	104000	144.4	Lighting & CCTV
Pumps				10000	13.9	
Total				2430570	3375.8	

6.1.4.2 Proposed PV System for the Proposed Site

Solar panels used to export surplus electricity to the state/national grid is not considered viable at this stage. SLR therefore proposes to size the PV system on the base load profile or at least 10% of the peak load. The system can then be operated on a full electricity load most of the time.

An initial feasibility study by SLR recommends installing a 250.90 kW PV system on a roof system for the large carpark facilities. The proposed system can also be installed on the roof of the buildings and/or along covered site walkways where Integrated-Photo-Voltaic (BIPV) technology can be implemented.

6.1.4.3 Preliminary Layout for the Proposed System

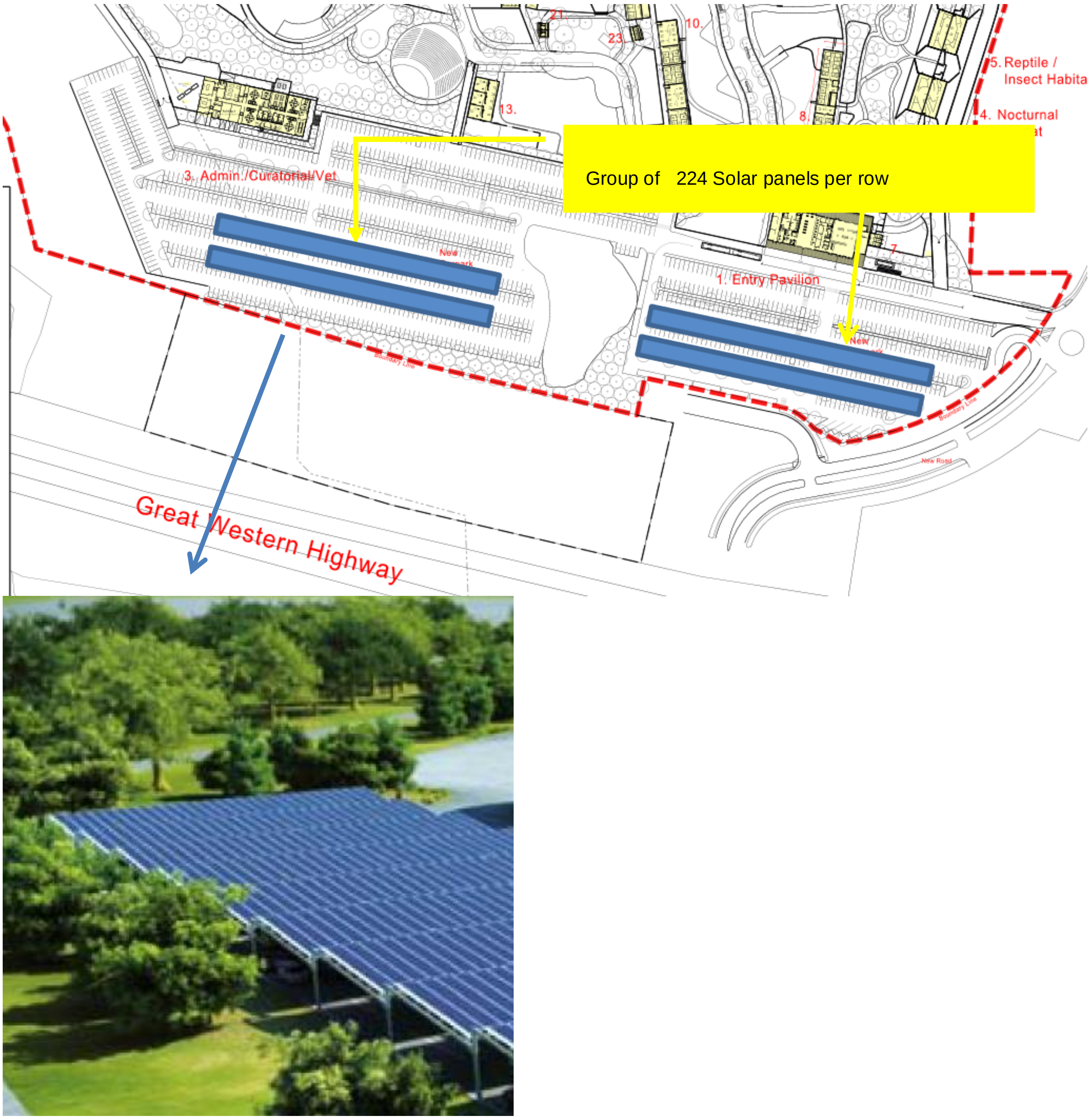
The following initial recommendations are made (Sydney Zoo should assess the optimal PV installation for the site once the base electricity load is established during the detail design stage):

- Panels are mainly located on a roof system for the large carpark facilities
  - Approximately 896 panels are located on the roof of 4 bays (or similar) - Refer **Figure 7**

The estimated power for each solar panel is in the order of 0.280 kW. The optimal proposed configuration can therefore provide ~250.9 kW in total.

- The following configurations are assumed:
  - All solar panels facing north
  - Solar panels at optimal inclination angles of 30°

Figure 7 Proposed PV Cells to Generate Electricity



6.1.4.4 Advantages of the Proposed System

- Reduce peak demand on energy supply infrastructure;
- Improved return on investment and energy yield performance;
- Weather-protected parking;
- Long-term secured investment;
- Visible expression of sustainability and the support of renewable energy solutions and
- Optional integration of charging points for electric vehicles.

6.1.4.5 Economic Aspects

When examining the cost of PV systems, the following factors must be considered:

- PV modules are technically well proven;
- The expected service time is about 30 years, and
- Flexibility is needed to meet increasing energy demands.

A preliminary cost analysis for the proposed system is summarised in **Table 3.**

Table 3 Economical Aspect for the Proposed System

System Size	250.9 kW[1]
System Description and Accessories	896 X 0.280 W Solar Panels[1,2] Aluminium and Stainless Steel Fixtures (tilted @ 30°).
Estimated Guide Price including installation as per Australian Standards after REC's	~$390,000[3]
Annual Energy Production[2]	~**321,415** kWh
Greenhouse Gas CO2 Emission saving	~344 tonnes/Annum
Estimated Payback based on 15 ¢/kWh[3]	8 years

Note 1: The sizing will be confirmed during the detailed design stage when the base load is accurately predicted.

Note 2: Panel efficiency ~ 17%; Panel dimensions = 1.67 m x 1 m and Panel weight ~19 kg.

Note 3: Preliminary cost estimate will be updated during the detailed design stage.

6.2 Standalone Solar Parking or External Lighting System

A self-sufficient off-grid solar street lighting can be used to illuminate selected locations of the proposed site without the need for excavation works, cable laying and public grid connection.

Solar panels absorb light energy converting it to electricity. This electricity is stored in a battery. A small electronic regulator controls the functions of the system. A timer is used to control the hours the light stays on and some of the commercially viable street lighting system can operate for more than 3 days without sun.

The system components are (Refer **Figure 8**):

- PV module;
- Pole (~7 m hot-dip galvanised steel);
- LED light source;
- Battery (1500 cycles of battery at 50% DOD (6-10 years);
- Component storage, solar charge regulator, photo rely and
- Configurable timer Feedstock reception and storage.

Street lighting can also be equipped with automatic dimming function and motion sensor.

This option is commercially viable and it helps to reduce run power from the grid and also reduces the cost of transformers and metering. SLR recommends conducting a detailed feasibility study for this option once the base load for the site is confirmed.

Figure 8 Solar Street Lighting

6.3 Bio-waste Gas Powered Generator Systems

A bio-waste gas powered generator system for the proposed site is considered due to its contribution to increase the overall energy efficiency for the site and improve the waste management at the same time.

SLR has investigated the practicality and feasibility of on-site processing of organic wastes generated at the zoo (ie food waste, green waste and animal manure) for increased resource recovery, potential energy recovery and a reduction of the site's carbon footprint.

A number of technologies are available to generate energy from waste (EfW) including

- Anaerobic Digestion. The Anaerobic Digestion process involves three key phases
  - Hydrolysis – the phase that breaks down the long chain carbohydrates and other feedstock"s into soluble organic compounds.
  - Acid Fermentation/Acetogenesis -Acetogenesis - Bacterial breakdown of the organic material. Hydrogen and carbon dioxide are produced as part of this process.
  - Methanogenesis – hydrogen is then bound to the carbon to produce methane

and

- Advanced Thermal Treatment (ATT) - pyrolysis or gasification.

Anaerobic digestion with biogas production has already been or is about to be implemented in some large zoos (e.g. Munich, Heidelberg, Toronto, Johannesburg).

The basic requirements for EfW system are provided below:

- Feedstock reception and storage;
- Mixing tank for slurry and maize;
- Digester;
- Gas condenser (water removal);
- Gas scrubber (H2S removal);
- Gas engine driven electricity generation plant with associated heat exchangers to recover waste heat;
- Digestate storage and dewatering if required; and
- Gas flare

The economic feasibility of the EfW will mainly depend upon the organics available for composting / energy recovery.

The available technology for sub 10,000 tonnes of input material per annum is limited (Refer Economic Viability of Farm Scale AD Biogas Production across Cheshire and Warrington, Funded by Nortwest, national Grid and British Gas and prepared for Reaseheath Enterprise Delivery Hub, 2010).

A preliminary study by SLR has estimated the following:

- Estimated food organics from café/restaurant - 55 tpa
- Animal manure – 276 tpa
- Garden organics – 15.6 tpa

Total estimated organics available for composting / energy recovery – 344 tpa (excluding minimal food waste generated from food prep for the animals).

Food waste assumes 73 peak visitation days and 292 (non-peak days).

The predicted additional food waste post feeding of carnivores are:

- Biodegradable/compostable/recyclable waste approximately 50 to 100Kgs/day (used on site) – an additional 36.5 tpa

Total maximum estimated organics available for composting / energy recovery – 384 tpa

One can see that the estimated organics available for composting / energy recovery is well below the minimum requirement of 10,000 tpa.

This option is therefore not economically viable for the site.

6.4 Mini/Micro Turbine Hydroelectric Generation

Hydropower is a renewable energy source based on the natural water cycle. Whenever water flows from a higher elevation to a lower elevation there is the potential to harness that energy to do useful work. The energy available in the water is a function of two variables: the head and the flow-rate. The relationship can be expresses as follows:

$$P_{max} = Q \cdot H \cdot \rho \cdot g$$

Where

P_{max} = Maximum power excluding losses due to turbulence and friction in the piping system
Q = volumetric flow-rate
H = gross head
ρ = density of water
G = gravitational constant

The site encompasses the peak of a hill with gradual falls away from the peak in all directions. The water is collected at a low level and in order to obtain the required water flow rate for the hydropower system, the water needs to be pumped continuously from a low level. This option is therefore considered not economically viable for the site.

6.5 Green Power Initiative

It is recommended that a certain percentage (approximately 5%) of “Greenpower” should be made available to the Zoo, providing the opportunity to contribute to a reduction in total greenhouse gas emissions produced by the proposed Development. Greenpower is produced from environmentally friendly renewable energy sources such as solar, wind, water and biomass.

When a Greenpower product is selected by the owner, the energy supplier commits to buying a certain amount of electricity from approved new renewable energy sources. The financial accounts of Greenpower suppliers are audited independently. This makes a clear distinction between the services provided by standard energy suppliers and the more sustainable service offered through Greenpower options.

6.6 Lighting

6.6.1 Natural Lighting

The proposed development maximises the north facing facades and will be implementing glazing areas to the proposed buildings to allow plentiful natural daylight access, thereby minimising the use of artificial lighting.

6.6.2 Artificial Lighting

Lighting installations require a design that properly considers the conservation of scarce energy resources. Sustainable lighting design ensures that illuminance is not excessive, that the switching arrangements are such that unnecessary illumination may be turned off and that the illumination is provided in an efficient manner.

There are additional energy losses associated with inefficient lamps and lighting losses associated with luminaries. Consequently a lighting design which uses the more efficient lamp types and the least number of luminaries for a given design illuminance will be more efficient and usually have a lower capital cost.

It is likely that the lighting to be used within the development will incorporate led lamps and compact fluorescents. It is recommended that the following lighting features be incorporated into the development to minimise energy consumption due to lighting:

- Maximise use of compact fluorescents or LED and minimise or where possible eliminate the use of halogen down lights, as compact fluorescents are much more efficient than halogen lighting.
- Light switches to be located at room exits to encourage switching lights off when leaving a room. Separate switches to be installed for special purpose lighting.
- Artificial lighting to the carpark and common hallways will be controlled by daylight sensors and time clock, to minimise unnecessary use of artificial lighting.

LED lamps are the most energy efficient form of lighting for commercial and residential developments. Fluorescent lamps are also very energy efficient form of lighting for hotels. They work by causing a phosphor coating in the inside of a glass tube to glow. Different types of phosphor give different colour light. Although more expensive to buy compared to incandescent bulbs, they are significantly cheaper to run and can last up to ten thousand hours. With careful design they can replace incandescent and halogen lights in most situations. Fluorescent lamps use only about one quarter of the energy used by incandescent bulbs to provide the same light level. Compact fluorescent lighting connected to daylight and motion sensors are recommended to the common hallways.

SLR recommends a maximum average lighting power density of 10 W/m^2 for the proposed development. A detailed NCC Section J Compliance report will be prepared during the detailed design stage of the project.

Stand-alone solar car park lighting system is proposed to the project to reduce grid electricity consumption and embodied energy from installing cabling to the lights.

6.7 Appliances

It is not yet clear what new appliances will be required, however the following measures should be adopted if required:

- Minimum 4-star energy efficient dishwashers, refrigerators, and washing machines.
- Cooking gas cylinders for the restaurant.
- The energy star feature should be enabled on all office equipment, such as computers, printers, photocopiers and fax machines.

7 WATER

In addition to increased water use efficiency, new developments can reduce potable water through the provision of an on-site alternative water supply. There are three principle forms of alternative water supply:

- Reticulation of reclaimed water to the site.
- Rainwater/storm water storage and reuse.
- Grey water storage and reuse.

The above water supply systems can be used for exhibits cleaning, toilet flushing, landscape irrigation and fire services, reducing the demand on potable water supply.

Information relating to the intended usage for the proposed development when operational has been provided by the client and has been summarised below:

Activity	Usage	Usage (L/day)
Irrigation (Tropical)	22.7 L/m^2/week	11,850
Irrigation (Turf)	22.7 L/m^2/week	17,300
Toilet Usage	100 L/day/toilet	5,300
Back of House Hose Down	5 mm/ m^2/day	5,750
Basin/Moat Evaporation	1500 mm/ year/m^2	17,150

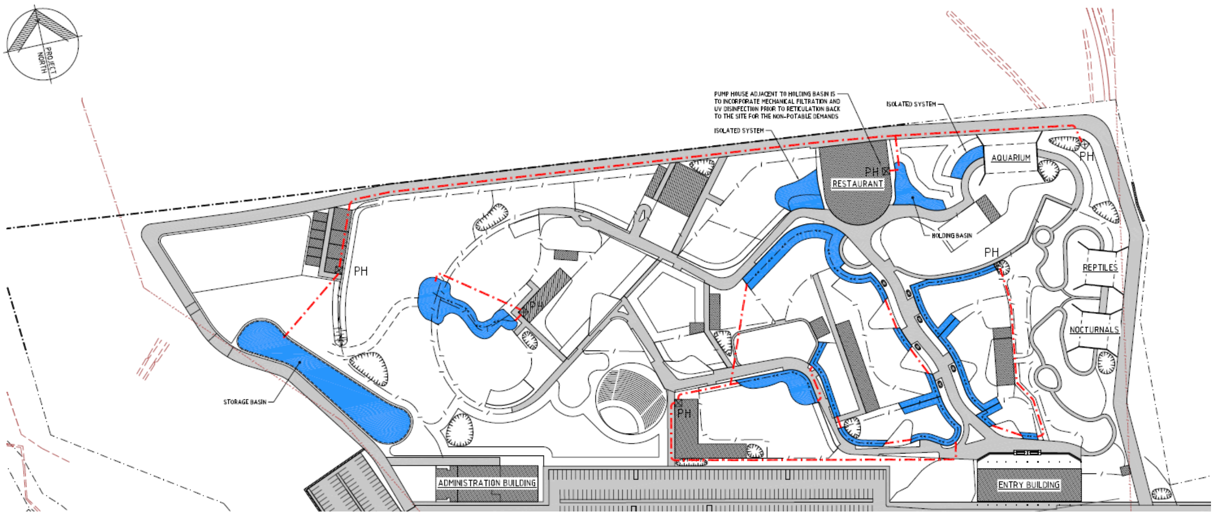
A water balance modelling of stormwater re-use has been carried out by Lindsay Dyan using the software package MUSIC. Using rainfall data obtained from over 45 years of daily rainfall from the Quakers Hill Treatment Works (6 km away from the site), the report concluded that, beyond approximately 81.5% re-use efficiency, diminishing returns would be expected with an increase in stormwater harvesting volume. It is considered that adopting a total stormwater harvesting storage volume of approximately 2,100 m^3 for the development will provide an efficient result for the project that meets the water conservation intent that has been established by Blacktown Council CC.

Storage volumes are provided via the following two open water basins (refer **Figure 10**: Lindsay Dynan drawing 12082-DA06):

- 1,260 m^3 located in the north-west corner
- 840 m^3 located next to the restaurant. Due to the high degree of stormwater re-use for the site, the design provides a high degree of stormwater treatment incorporating mechanical infiltration and UV disinfection prior to reticulation.

SLR recommends investigating the use of a cover to the northwest corner open water basin to significantly reduce the evaporation rate.

Figure 9 Hydraulic Services Plan



7.1 Water Efficiency

The minimum sustainable standard for water efficient water fixtures and fittings is 3A. To achieve greater than the standard level, the development will consider installing water efficient fixtures and fittings such as:

- 3 star showerhead with restricted flowrate in the range 6 L/min to 7.5 L/min
- 4 star toilet flushing systems
- 4 star kitchen taps
- 5 star bathroom taps
- 4 star water efficient dishwashers
- Other water efficient fixtures/fittings for Zoological park proposes

The above measures are currently considered to be good practice in sustainable design. Implementation of the above recommendations will assist in reducing the water consumption.

SLR recommends the following water metering strategies:

- Separate water meters are installed for each individual building.
- Separate meters are to be installed for the make-up lines to the Aquarium, restaurant, on the water supply to outdoor irrigation, and other major uses.

8 TRANSPORT

When designing a sustainable development, it is important to minimise the use of individual motorised transport where possible and thus enhance energy savings and environmental impact through reduced fossil fuel consumption and improved regional air quality. This can be achieved by encouraging the use of energy efficient public transport that is immediately at hand, reducing car parking facilities, and providing adequate bike storage facilities to minimise the requirement for individual motorised transport.

8.1 Provision of Car Parking

Transport emissions are one of the largest contributors of greenhouse gas emissions in Australia. The Green Building Council of Australia (GBCA) encourages the utilisation of alternative and mass transit forms of transport by limiting the availability of private vehicle spaces.

SLR recommends providing carspaces for low emission or alternative fuel vehicles such as electrical cars; as well as car-sharing scheme.

8.2 Facilitation of Pedestrian and Non-Motorised Transport

When designing a sustainable development it is important to minimise the use of individual motorised transport where possible and thus enhance energy savings and reduce environmental impact through reduced fossil fuel consumption and improved regional air quality. This can be achieved by encouraging all users of the development to make use of the energy efficient public transport that is immediately at hand.

The provision of bicycle storage spaces within the development will ensure the development become a more sustainable development in a holistic sense.

8.3 Commuting Using Public Transport

Due to the nature/size of the Sydney Zoo, the site is not suited to being close to a high urban density area. Although it is convenient to drive from the Great Western Highway and M4 Western Motorway, measures which encourage visitors to use public transportation to get to the site are recommended, thereby assisting in keeping automobiles off the road. Buses are available from both Great Western Highway and Doonside Road. It is also recommended that a frequent shuttle bus service be made available from Blacktown Station.

9 INDOOR ENVIRONMENTAL QUALITY

Achieving enhanced Indoor Environment Quality (IEQ) ensures that the building and building services are designed and managed to benefit the health and well-being of building occupants and visitors.

9.1 Internal Noise Levels

Internal noise levels are a significant factor in determining occupant and customer satisfaction and well-being. The aim of controlling internal noise levels is to encourage and recognise buildings that are designed to maintain internal noise levels at an appropriate level. SLR recommends that all future development in the proposed site meet the recommended criteria and measures provided in accordance with the relevant Building Code of Australia (BCA) requirements.

9.2 Carbon Dioxide Monitoring and Control

Elevated carbon dioxide (CO_2) levels are indicative of inadequate ventilation, affecting the quality of air within an enclosed occupied space, and the health of the occupants. CO_2 monitoring systems can detect elevated concentrations of CO_2 and automatically adjust ventilation supply rates before indoor air quality becomes problematic.

SLR recommends incorporating a CO_2 monitoring system where appropriate to satisfy BCA requirements.

9.3 Paints and Floor Coverings

SLR recommends the use of low levels of volatile organic compounds (VOC) paints and floor coverings and low formaldehyde wood products wherever feasible.

10 OPERATIONAL WASTE MANAGEMENT

An operational Waste and Recycling Management Plan is a minimum requirement to meet sustainable building design best practice. As a guideline, the Waste and Recycling Management Plan should include:

- Separate waste and recycling streams.
- Transfer of material to common storage area.
- Communal storage areas.
- Frequency of collection.
- Signage and educational initiatives for occupants.

The proposed development will implement a Waste Management Plan (WMP) that complies with the Blacktown City Council requirement (refer SLR Report 610.15657-R1 dated 3 November 2015).

It is further recommended that solar compacting smart bins are considered to enable real time monitoring and SMS alerts to report on available bin capacity/fullness, to increase waste and recycling storage capacity along public areas at the site and to reduce resources associated with visual monitoring and emptying of bins which will be of particular importance during peak visitation periods.

11 CONCLUSIONS

SLR Consulting Australian Pty Ltd (SLR) has been engaged by Sydney Zoo to provide a qualitative Ecologically Sustainable Design (ESD) assessment, including energy efficiency, for their proposed development at Bungarribee. The assessment forms part of the Environmental Impact Statement (EIS) submission for a State Significant Development Application (SSDA) for the proposed development.

Overall, positive Ecologically Sustainable Design (ESD) and energy efficiency features are currently in place in a number of design areas, incorporating the following:

- The proposed development will incorporate passive and active energy saving measures such as operable windows to enhance natural ventilation through Building 1 (Entry/Retail) and Building 2 (Restaurant).
- Ceiling fans are planned for Building 2 (Restaurant).
- A high performance double glazing system will be used including thermally broken windows aluminium framed with a minimum U Value of 2.9.
- High levels of natural light will be enabled through the maximising of north facing facades.
- Incorporation of thermal mass: concrete slab construction is proposed for all floors throughout the development - concrete has amongst the highest thermal mass capacity of a range of common building products.
- Velux fixed skylights will be sued for Building 3 (Admin Curatorial).
- An efficient VRF air conditioning system is planned for conditioned spaces.
- A “Green Roof” is planned for Building 4.
- There will be stormwater harvesting storage to achieve 81.5% water efficiency re-use via the following two open water basins
  - 1,260m^3 located in the north-west corner.
  - 840m^3 located next to the restaurant.
- Due to the high degree of stormwater re-use for the site, the design provides a high degree of stormwater treatment incorporating mechanical infiltration and UV disinfection prior to reticulation.

The following recommendations have been made to improve upon the existing key sustainability elements of the proposed development:

- Line the inside of the roof and/or ceiling construction with a minimum R3.5 insulation.
- Peak Energy Demand Reduction. A preliminary feasibility study concluded that a 250.9 kW PV solar installation may reduce the peak demand for the site by 11%.
  - The estimated annual energy produced by the proposed 250.9 kW system is 321,415 kWh per annum.
  - The estimated greenhouse gas CO_2 emission saving is approximately 344 tonnes/annum.
  - The estimated payback for the system is 8 years using today’s electricity price of 15 ¢/kWh.

  Sydney Zoo should assess the optimal PV installation for the site once the base electricity load is established during the detail design stage.
- A self-sufficient off-grid solar street lighting system to illuminate selected locations of the proposed site would avoid the need for excavation works, cable laying and public grid connection.

- Investigation of the use of a cover to the north waste corner open water basin is recommended to significantly reduce the evaporation rate and increase water re-use efficiency.
- A minimum 4-star energy efficiency rating is recommended for dishwashers, refrigerators, and washing machines.
- Heat pump or solar boosted hot water systems should be evaluated.
- Light efficiency measures in the carparks could be enabled using motion sensors.
- LED and fluorescent lighting throughout the project would increase lighting efficiency.
- Electricity sub-metering is recommended for significant end uses that consume more than 10,000 kVA.
- Low levels of volatile organic compounds (VOC) paints and floor coverings and low formaldehyde wood products should be utilised wherever feasible.
- Dedicated carspaces should be allocated for small or low emission cars,
- Provision should be allowed for bicycle storage spaces within the proposed site.

Recommendations regarding the mechanical ventilation system, domestic hot water, other appliance and operational waste, etc., have also been made within the body of the report.

These features will help to achieve significant reductions in the energy and water required by the development both in building and operation.

It is recommended that ESD initiatives continue to be developed and implemented during the detailed design stage of the project.

A BCA Section J energy efficiency assessment of the proposed development will be carried out during the detailed design stage to reduce green gas emissions by efficiently using energy in the proposed development.