LOW CARBON LIVING CRC

Monitoring and Verification of the Performance of Residential Buildings

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Australian Government
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Contents

1. Introduction

Monitoring household energy and water usage can provide valuable insights into building performance and occupant behaviour. The monitoring of building parameters such as temperature, relative humidity and carbon dioxide levels can also be used to inform building management. Additionally, when coupled with data feedback display the information can be an important tool in helping to encourage energy and water efficient behaviour (Ehrhardt-Martinez *et al*., 2010; Yew *et al*., 2012).

This report provides an introduction to the automated monitoring of residential buildings for the purpose of data collection for research purposes and end user feedback. A series of short case studies are presented describing projects from around Australia that are utilising various types performance monitoring equipment. A detailed case study of the performance monitoring activities being undertaken at the Josh's House project in Perth, Western Australia is also provided to illustrate some of the technologies and methods available.

Figure 1: Wall mounted sensor for monitoring temperature, relative humidity and carbon dioxide levels at Josh House in Perth, WA (Photo credit: Darcy Hodgkinson).

2. Monitoring System Components

Performance monitoring systems typically consist of four main components:

- Meters
- Sensors
- Data logger (or Programmable Logic Controllers (PLC))
- Management and visualisation software

Meters measuring electricity, water or gas need to be coupled to a sensor, which transmits a signal relative to the volume of water/gas or Watts used. The sensors in turn are connected to a data logger (or PLC), which is the central component of the monitoring system. The data logger or PLC is responsible for recording data from multiple sensors, storing the data and transmitting as required. In some cases, the logger (or PLC) may also be loaded with software for data management and presentation, or alternatively the data may need to be transferred to a computer (or server) for this purpose. PLCs differ from data loggers in that they can be programmed for automation and load management, such as switching appliances on or off in accordance to the peak electricity demand. Data loggers and PLCs can range in complexity depending on their design purpose.

Factors influencing the selection of a suitable data logger include the number of channels required (correlating to the number of meters/sensors to be used and whether these produce an analog and digital signal), its storage capacity, the method of data transfer (e.g. Ethernet, Wi-Fi, etc.), the data format (e.g. CSV files, web browser, etc.), the complexity of the system and the available user interface. Data logger manufacturers usually provide a compatible user interface that can be used for real-time data visualisation, data analysis, the generation of reports and load management, however the useability and presentation value of these can vary greatly. This interface is usually web-based and can be accessed remotely on any device connected to the internet.

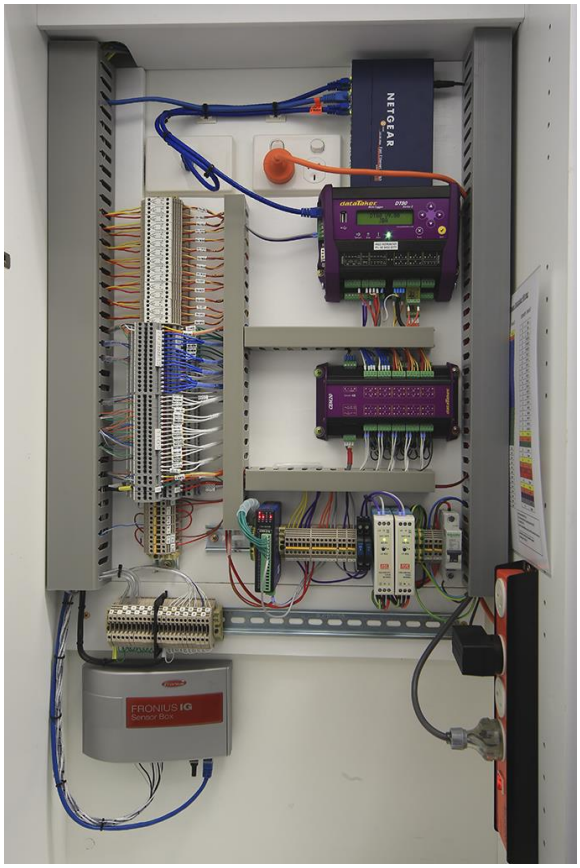

Figure 2: Data logger arrangement at Josh's House in Perth, WA (Photo credit: Morgan Gilham).

3. Monitoring System Examples

There are numerous data logger brands and models available on the market and multitude of meters and sensors. The following section describes five projects from around Australia where monitoring was deployed to assess building performance, and in some cases, provide occupants with real-time feedback.

Australian Zero Emission House

The Australian Zero Emission House (AuSZEH) is recognised as Australia's first Zero Emission House designed for the volume housing market. Developed by the CSIRO in partnership with Delfin Lend Lease and Henley Property Group, the four-bedroom, two bathroom detached house is located thirty kilometres north of Melbourne CBD, in the community of Laurimar in Victoria.

The house was completed in 2010 and after a period of being open to the public, it was occupied by a family for the purpose of intensive data collection and systems testing. Details of the equipment used in the project is provided in Table 1.

More information on the project can be found at: www.joshshouse.com.au/star-performers/zero-emission-house-melbourne

Lochiel Park

Lochiel Park is a model 'green' village located eight kilometres from the Adelaide Central Business District, alongside the River Torrens in the suburb of Campbelltown.

The 15 hectare site is a former TAFE college that was originally earmarked for a typical suburban housing development. An alternate plan was proposed and delivered by the South Australian State Government's urban renewal authority, Renewal SA, which resulted in only a third of the 15 hectare site being allocated for medium density residential development, with the remaining area set aside for public parkland, incorporating urban forest and stormwater wetlands.

Launched in 2004, there are now 106 dwellings at Lochiel Park including an innovative apartment building with 23 residences. All houses have a minimum 7.5 Star NatHERS rating and were designed and built in-line with strict energy and water efficiency guidelines that far exceeded what was the norm for residential design and construction, even today.

Lochiel Park serves as a model for other urban developments and assists to inform the public and the property development industry about sustainable housing and land development. Data is collected from all dwellings across the estate through an ongoing research collaboration with the University of South Australia, providing a unique resource for furthering our understanding of the benefits and impact of precinct-scale high performance housing. Details of the equipment used in the project is provided in Table 2.

More information on the project can be found at: www.joshshouse.com.au/star-performers/lochiel-park-adelaide

Pilbara Vernacular House

In 2012 the WA State Government Land Developer, LandCorp created the Pilbara Vernacular Handbook to promote better built form design outcomes in the region. The next step was to deliver a demonstration home that would articulate the intent behind the Handbook by contributing to the character and sense of place of the Pilbara, whilst providing functional efficiency and comfort at a reasonable market price.

Designed by Perth based architects Gresley Abbas and built by Eaton Building, the Pilbara Vernacular House is located in Madigan Estate in Karratha. The 8 Star NatHERS rated home incorporates a range of innovative design features, flexible living spaces and technologies for improved comfort, liveability and environmental performance.

It's an unconventional, yet highly practical house comprised of a protected, enclosed air-conditioned internal living area, surrounded by sheltered external living spaces. Deep eaves shield windows and walls from heat gain, and breezeways allow air flow around the house to promote air circulation and comfort. 'Wind scoops' and 'wind blades' help to capture and direct cooling breezes into the building.

Performance monitoring was undertaken to determine the effectiveness of the highly innovative design. Details of the equipment used in the project is provided in Table 3.

More information on the project can be found at: www.joshshouse.com.au/star-performers/pilbara-vernacular-house-karratha

10 House Living Lab Study

The '10 House Living Laboratory' study is being undertaken by Curtin University and the CRC for Low Carbon Living with objective of distinguishing the relative influence of design and occupant behaviour on the operational performance of a house. Ten houses located in the City of Fremantle, Western Australia, were equipped with sensors and data loggers used to record gas, electricity, water consumption and internal

temperature over a period of two years. Solar power generation and rainwater usage are also being monitored in the houses that possess photovoltaic panels and rainwater tanks.

Between December 2014 and December 2015, the houses were monitored as the participants got on with their normal lives. At the start of the second year they were given access to a 'data dashboard' which presents information about their house performance on a daily basis. They were also provided with a home efficiency audit at the start of summer and again at the beginning of winter, and given seasonally appropriate tips about energy and water savings in the house and garden. The participants were also asked to set energy and water savings goals that they felt were achievable based on the guidance that they had received. Details of the equipment used in the project is provided in Table 4.

More information on the project can be found at: www.joshshouse.com.au/living-labs

Figure 3: Weather station at Josh's House in Perth, WA (Photo credit: Josh Byrne).

Table 1: Monitoring system for the Australian Zero Emission House.

MONITORING SYSTEM APPLICATION				MONITORING SYSTEM		
Project	**Parameters monitored**	**Meters & Sensors**	**User interface**	**Data logger/ PLC**	**Features**	**Communication**
Australian Zero Emission Home (AusZEH)	Electricity (water pumps, lighting, Hot Water System, HVAC) & PV	EcoFront Pro CT sensors	EcoFront Pro Web interface: Web based user interface. Real-time monitoring data shown in tables and graphs. Possibility of load management and house automation. Integration with security systems. Data can be accessed remotely via PC browser, PDA or smartphone.	EcoFront Pro Energy Management Controller (www.ecofront.com.au)	• Inputs: 8 digital and 16 analog channels • Data storage: 2GB removable SD card • Built in LCD display	• Integrated communication interface: Ethernet, SD card and data ports (RS-422/RS-485) • Data export: CSV files sent via email and web browser
	Weather (rain, wind speed, external temperature, relative humidity)	Davis Vantage Pro				
	Temperature & humidity (internal)	Hobo UX100-003 data logger				
	Mains water	AVFI Beta-SDC DN20				

Table 2: Monitoring system for Lochiel Park.

MONITORING SYSTEM APPLICATION				MONITORING SYSTEM		
Project	**Parameters monitored**	**Meters & Sensors**	**User interface**	**Data logger/ PLC**	**Features**	**Communication**
Lochiel Park (Saman *et al.*, 2011)	Gas	Landis + Gys Model 750 & Elster In-Z61	EcoVision: Database software for data analysis and interactive touchscreen. Touchscreen interface provides real time monitoring feedback and enables load management. Historical data can be retrieved and analysed remotely over the internet.	Direct Logic 06 D0-06DR (www.automationdirect.com)	• Inputs: 20 digital channels • Analog inputs expansion module may be added • Data storage: 14.8 Kb • Optional LCD display	• Integrated data ports (RS-232/RS-422/RS-485) • Ethernet and Modbus communications module can be purchased separately • Data export: CSV file export to appropriate software via Ethernet or serial cable
	Gas for water heating	Landis + Gys Model 750 & Elster In-Z61				
	Electricity (individual appliances) & PV	Ampy EM1200				
	Temperature & relative humidity (Living area and bedrooms)	Kimo TH100				
	Mains water	Actaris TD8 & Cyble sensor 2W K=1				
	Hot water	Actaris TD8 & Cyble sensor 2W K=1				
	Greywater	Actaris TD8 & Cyble sensor 2W K=1				
	Rainwater tank level	Aquameta AN420-15				

Table 3: Monitoring system for Pilbara Vernacular House.

MONITORING SYSTEM APPLICATION				MONITORING SYSTEM		
Project	**Parameters monitored**	**Meters & Sensors**	**User interface**	**Data logger/ PLC**	**Features**	**Communication**
Pilbara Vernacular House (PVH)	Total electricity & PV	Zennio KES KNX Energy Saver ZN1IO-KES & Zennio Split Current Transformer ZN1AC-CST60	Rulergy: Mobile or web based interface. Real time monitoring and historical data accessibility. Data can be visualized in graphs, tables and dashboard. Possibility of controlling devices remotely and managing energy load. Automatic report generation and notifications.	Domatica Global Solutions iDom Collector, IDPCEB2 (www.domaticasolutions.com)	• Inputs: 16 analog channels • Expandable module	• A communication module needs to be purchased separately. The standard module is iDOM Gateway GPRS, which includes GPRS, Ethernet, data ports (RS-485/RS-232) and Modbus • PVH opted to complement the system with the following devices: IP gateway (KNX IP Interface 730), 4G Modem, Ethernet switch (TP-Link TL-SF1005D) and wifi router (D-Link DIR506RL)
	Wind speed in air chimneys	Elsner Elektronik Wind Sensor KNX W 24V				
	Temperature (Living area and bedrooms)	Zennio ZN1AC-NTC68E				
	Mains water	Actaris P40W & Cyble sensor 2W K=1				

Table 4: Monitoring system for 10 House Living Laboratory Study.

MONITORING SYSTEM APPLICATION				MONITORING SYSTEM		
Project	**Parameters monitored**	**Meters & Sensors**	**User interface**	**Data logger/ PLC**	**Features**	**Communication**
10 House Living Laboratory Study	Gas	Ampy 750 & pulse kit for 750 meter	StruxureWare Power Monitoring Expert 7.2: Web based user interface. Real-time monitoring data shown in tables, graphs and dashboards. Possibility of automation, generating reports and creating alarms. Data can be accessed remotely over the internet.	Schneider Electric COM'X 200 (www.schneider-electric.com)	• Inputs: 6 digital channels and 2 analog channels • Data storage: 128 Mb	• Integrated communication interface: USB, Ethernet, Wi-Fi, GPRS and Modbus • Data export: CSV files sent via email and web browser
	Total electricity	Schneider Electric iEM3110				
	PV	Latronics kWh				
	Temperature (Living area)	Kimo TM110				
	Mains water	20mm Elster V100 & MEB7454 'T' probe OR Actaris TD8 & Cyble sensor 2W K=1				
	Rainwater	20mm Elster V100 & MEB7454 'T' probe				

Josh's House

Background

Josh's House is a two-lot residential development in Fremantle, Western Australia which demonstrates that high performance, energy efficient housing can be built at comparable cost and timeframes to regular homes. Completed in June 2013, the detached dwellings have been designed to provide thermal comfort year-round without the need for air conditioning or additional heating. The homes are net energy exporters and they harvest and recycle water. In addition to private garden areas, a common productive garden supplies both households with fresh food.

What distinguishes this project from many others is that the building designs achieved a 10 Star energy efficiency rating, whilst intentionally using conventional building materials and construction methods so they can easily be replicated. The project also demonstrates a more sensitive approach to residential subdivision that has considered maximising effective garden area around the homes to allow for natural shading, children's play spaces and local food production opportunities.

Knowledge Sharing and Performance Results

A key objective of the Josh's House project is to showcase the benefits of high performance housing to industry and the broader community. Building plans, factsheets and other resources are made freely available as open source content. Performance verification data including internal and external temperature, energy consumption, water usage and solar energy generation is being collected and is available for use by industry and researchers (refer to Appendix 1 and 2).

There is also an on-going communications program which has documented the entire building process through to occupancy and beyond with the learnings shared via the Josh's House video series via www.joshshouse.com.au, as well as social media channels and a range of editorial media platforms.

The operational performance results have shown that the house is thermally comfortable year round. During Perth's hot summers the internal temperature remains at a comfortable average of 25°C. During the coldest months of the year, while the external temperature fluctuated between 5°C and 23°C, the internal temperature stays around 20°C (Byrne, 2014).

Early monitoring of electricity consumption showed that Josh's House imported 70% less electricity from the grid than the average Perth household, and although the 3kW solar system was generating more electricity than was being consumed, night time electricity usage still relied on the grid. The recent addition of a LiFeP04 battery system with 8kWh of storage has made the house around 90% self-reliant in electricity, with excess solar power being supplied to the grid most months of the year.

The gas consumption on Josh's House is also significantly lower than the average Perth household due to the absence of gas space heating and the use of solar hot water heating. Compared to business as usual, Josh's House saves on average $560 on annual gas bills (Byrne, 2014). Josh's House also uses 90% less scheme water than the average Perth household due to the 20kL rainwater tank, bore water and greywater system (Byrne, 2014). Again, this represents an estimated annual saving of $560 on water bills.

Monitoring also shows that Josh's House generates significantly less operational GHG's than the average local family home and that the emissions are comfortably offset by the production of excess renewable energy (Byrne, 2014). In addition, Josh's House has achieved savings of around $2,600 per year on combined bills, making this house significantly more affordable to run than a conventional home.

The project has demonstrated that it is viable to build affordable zero emission homes in Australia with the usage of conventional building materials and trades. The project also contributes further to the discussion that more ambitious energy efficiency regulations in Australia could be pursued, following the example of other OEDC countries.

More information on the project can be found at: www.joshshouse.com.au

Table 5: Monitoring system for Josh's House.

MONITORING SYSTEM APPLICATION				MONITORING SYSTEM		
Project	**Parameters monitored**	**Meters & Sensors**	**User interface**	**Data logger/ PLC**	**Features**	**Communication**
Josh's House www.joshshouse.com.au	Gas	Ampy 750 & pulse kit for 750 meter	dEX Software: Web based user interface. Real-time monitoring data shown in dynamic tables and graphs. Data can be accessed remotely over the internet. Additional custom visualization of selected data channels via a third party server based program for open use display on project website (refer Figures 5-10).	Datataker DT80 (www.datataker.com)	• Inputs: 12 digital channels and 15 analog channels • Expandable module for 300 extra analog inputs • Data storage: 128Mb (10 million data points) • Built in LCD display	• Integrated communication interface: USB, Ethernet, data ports (RS-232/ RS-422/ RS-485) and Modbus • Data export: CSV files sent via email, web browser and FTP server
	Electricity (including oven, lighting, appliance circuits and pumps) & PV	Latronics kWh				
	Weather (rain, wind speed and direction, solar radiation, external temperature, relative humidity)	Vaisala WXT520 weather station				
	Temperature (slab, wall, ceiling, roof cavity and roof surface)	TCKPP1 20AWG thermocouple wire				
	Internal relative humidity and CO2	Vaisala GMW95R Temp, Humidity, & CO2 Sensor				
	Soil moisture	Decagon 10HS capacitance soil moisture probes				
	Mains water	20mm Elster V100 & MEB7454 'T' probe				
	Rainwater	20mm Elster V100 & MEB7454 'T' probe				
	Hot water	20mm Kent S130				
	Bore water	40mm MT-EX				
	Greywater	20mm Elster V100 & MEB7454 'T' probe				
	Rainwater tank level	Mercoid Series SBLT2 submersible level transmitters				

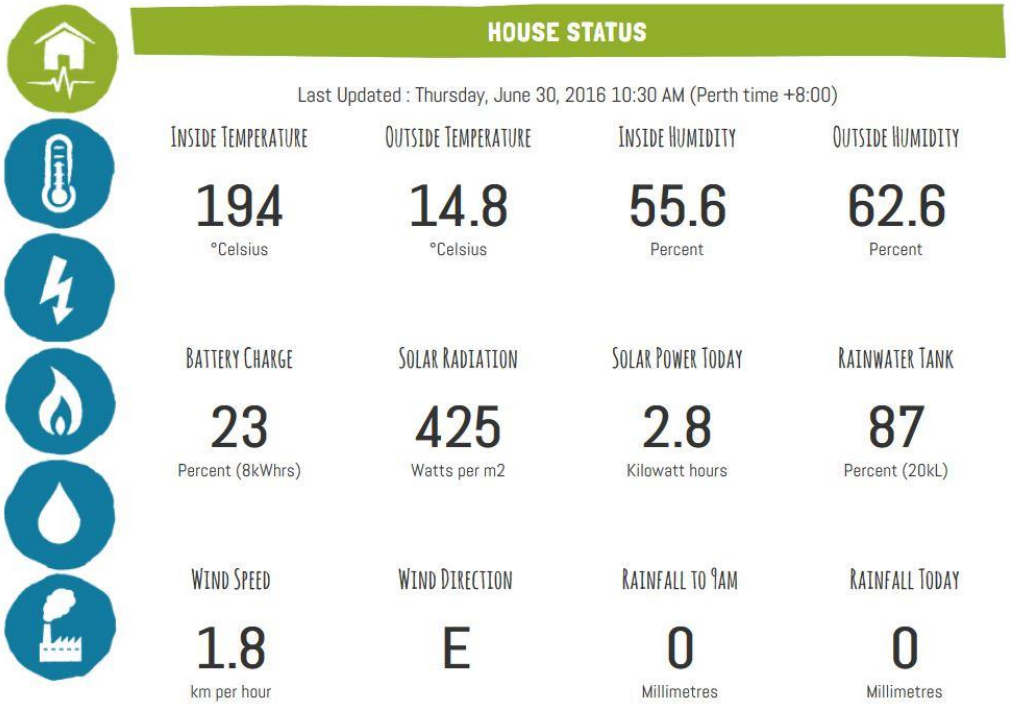

Figure 5: House status page from Josh's House data dashboard.

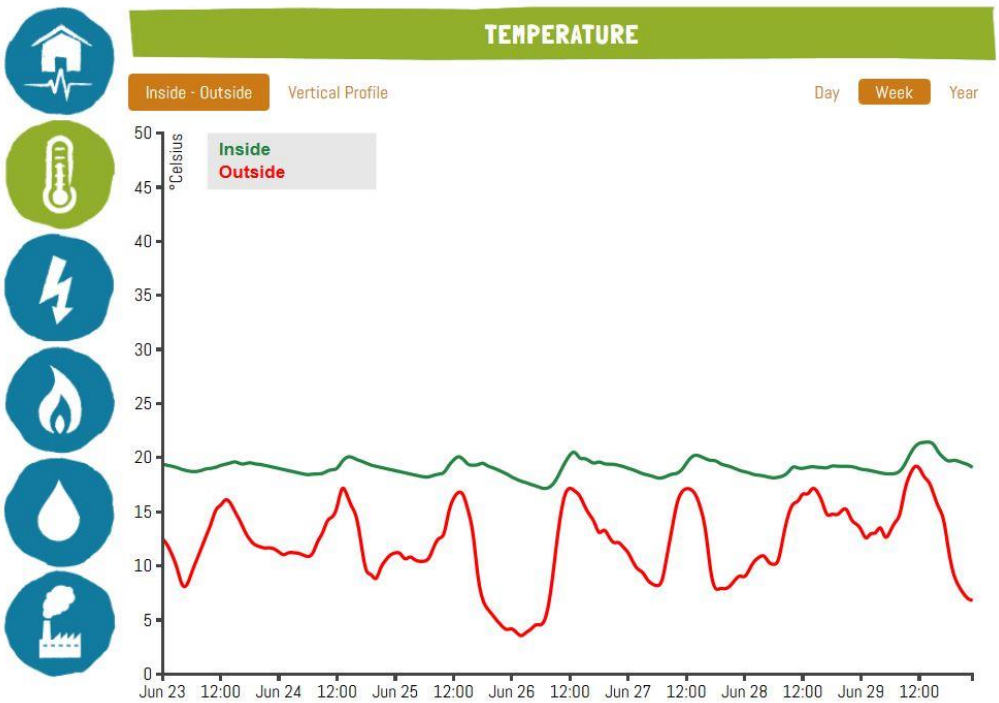

Figure 6: Temperature display (weekly) from Josh's House data dashboard.

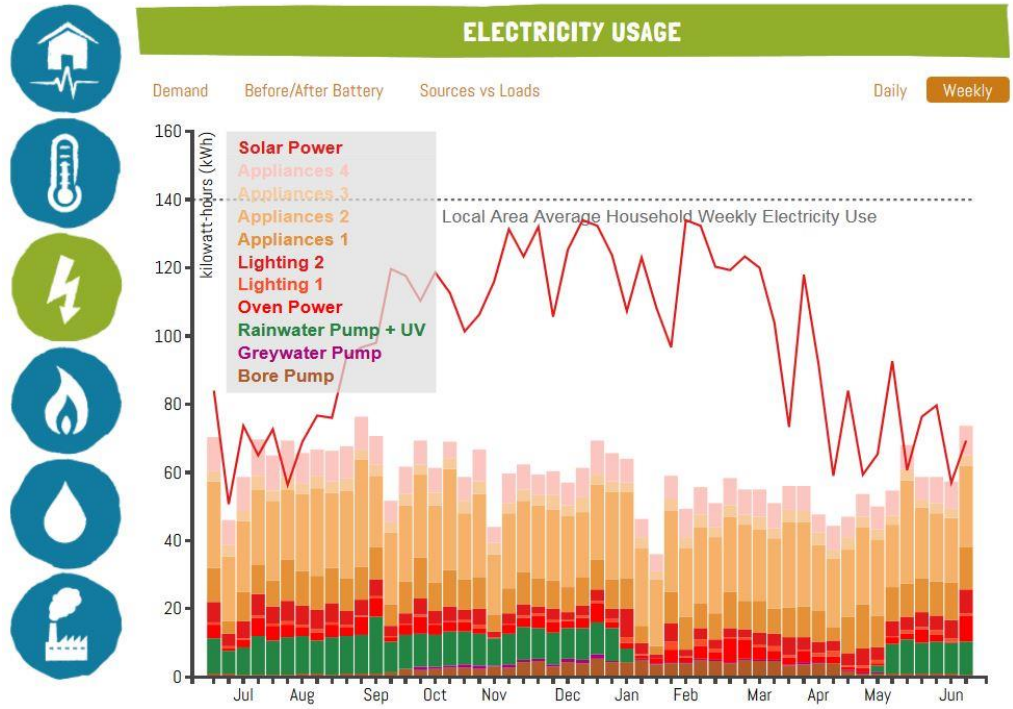

Figure 7: Electricity usage display from Josh's House data dashboard.

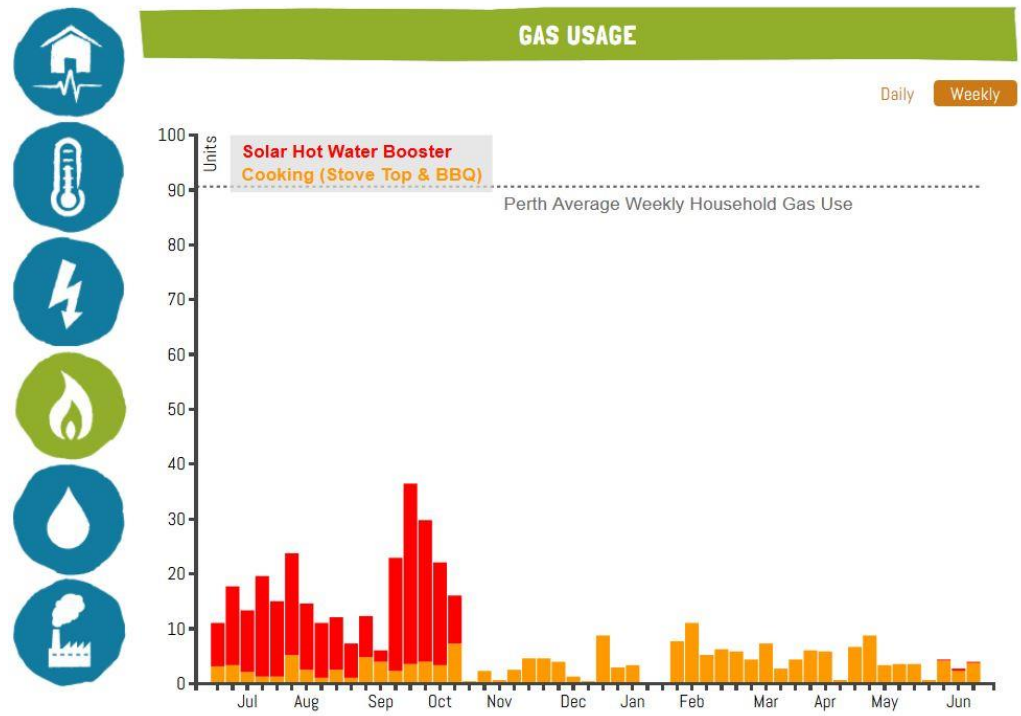

Figure 8: Gas usage display from Josh's House data dashboard.

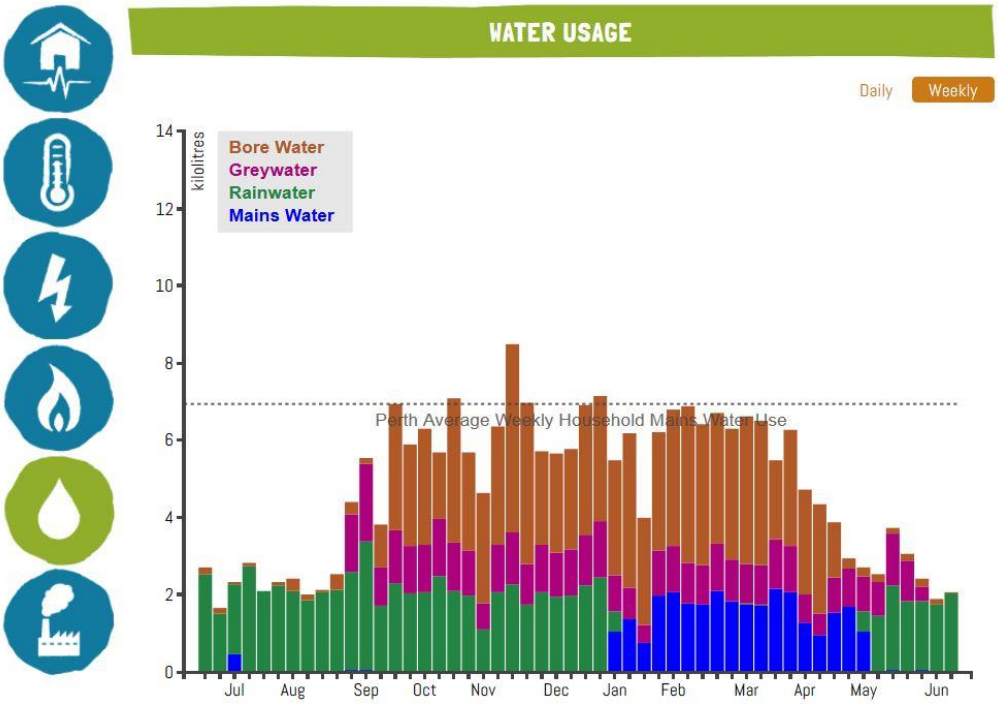

Figure 9: Water usage display from Josh's House data dashboard.

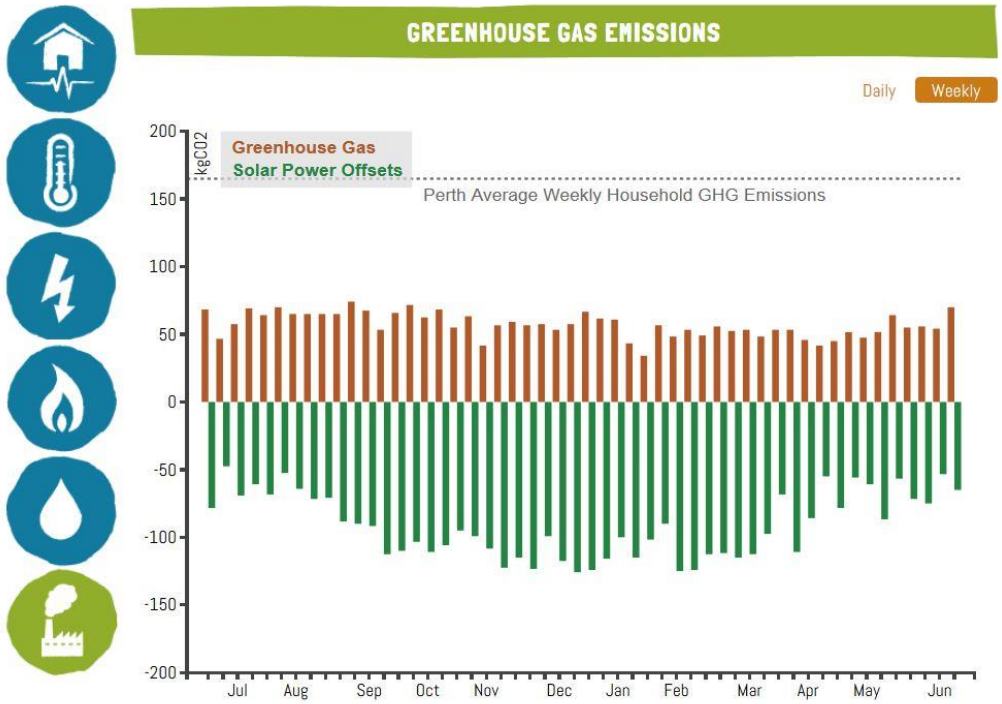

Figure 10: Greenhouse gas emission display from Josh's House data dashboard.

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Yew, M.H., A. Molla and V. Cooper (2012), *Framework for a Residential Energy Information System (REMIS) to Promote Energy Efficient Behaviour in Residential Energy End Users*, '23rd Australasian Conference on Information Systems'. Geelong, 1-11.

Appendix

1. Josh's House Monitoring Schematic and Equipment Schedule

2. Josh's House Data Base Access

JOSH'S HOUSE

MONITORING SYSTEM DESIGN

LOT 1499 GRIGG PLACE HILTON WA

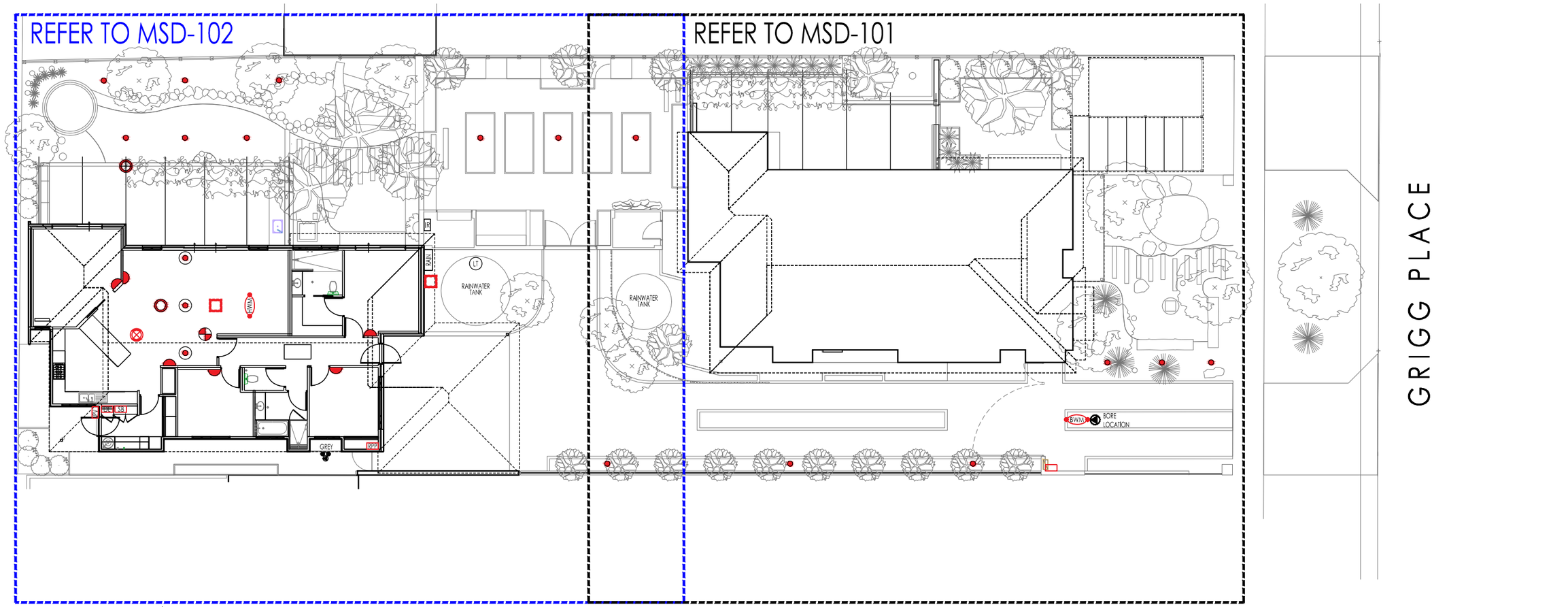
30/06/2014

SCHEMATIC DESIGN ONLY
REFER TO GENERAL NOTES, COMPLIANCE & INSTALLATION INSTRUCTIONS.

GENERAL NOTES

GENERAL
- DRAWINGS TO BE READ IN CONJUNCTION WITH ALL OTHER PROJECT, ARCHITECT, ENGINEERS & MANUFACTURERS DOCUMENTATION.
- ALL SERVICE LINEWORK & ARRANGEMENTS ARE INDICATIVE ONLY & TO BE CONFIRMED ON SITE.
- PRODUCTS TO BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.

DRAWING SHEET LIST



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02/11/2012	ISSUED FOR CONSTRUCTION	–

AS CONSTRUCTED

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Curtin University

LOW CARBON LIVING CRC

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	CAD FILE PATH --		PLOT DATE 30/06/2014	
DRAWING TITLE CONTENTS & MONITORING SYSTEM DESIGN OVERALL SITE PLAN	DRAWN AB	CHECKED JB	APPROVED JB	DWG NO. MSD-001

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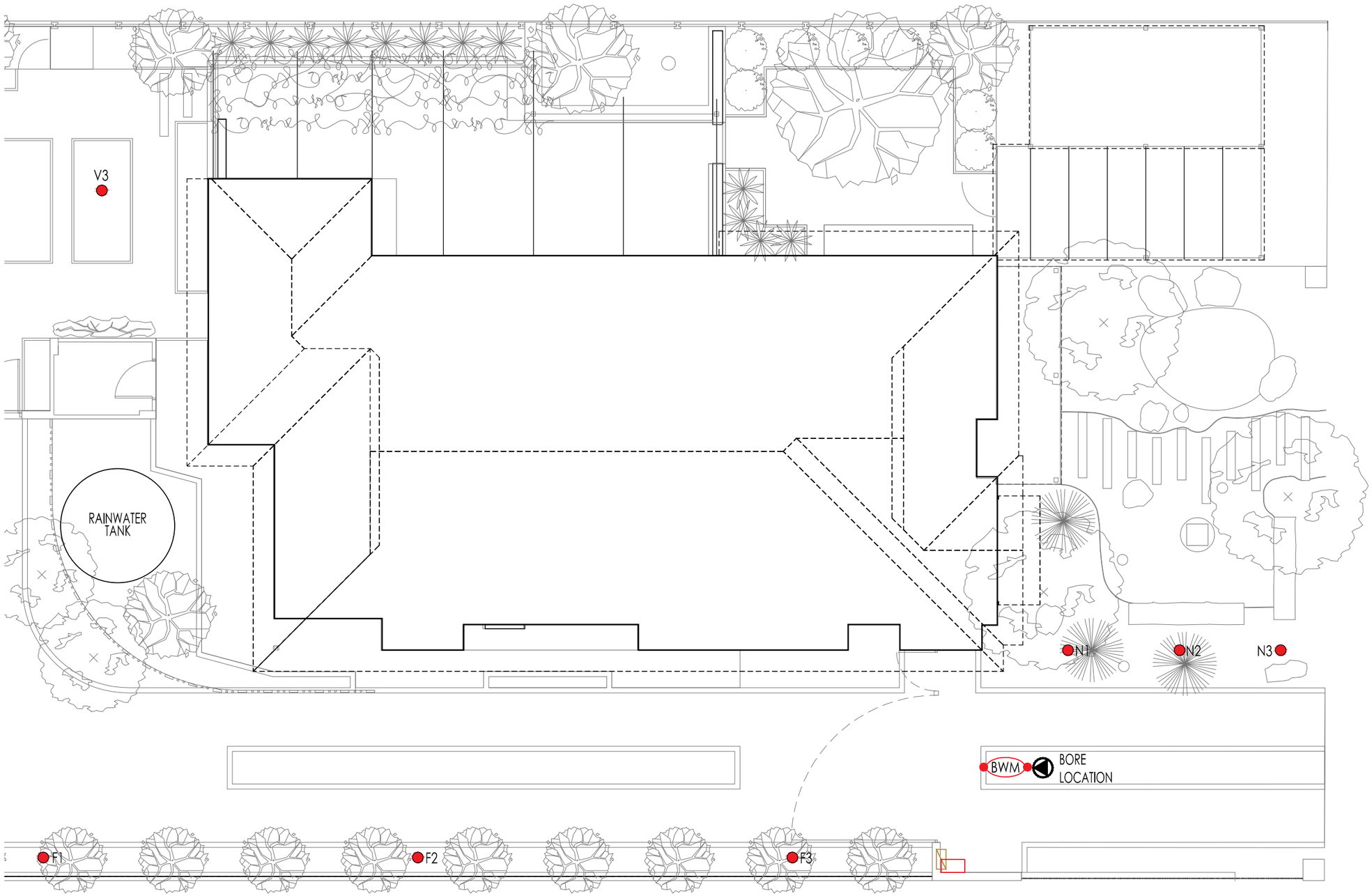

LEGEND

REFER TO EQUIPMENT & CONNECTIVITY SCHEDULE FOR MORE DETAILS

- SITE BOUNDARY
- ROOF OVERHANG
- SB — ELECTRICAL SWITCHBOARD
- DL — DATA LOGGING UNIT
- RPP — ROUTER & PATCH PANEL
- PV — SOLAR PHOTOVOLTAIC (PV) INVERTER
- EM — ELECTRICAL SUB METER (INLINE). REFER TO UNIT 2 - SCHEMATIC PLANS & EQUIPMENT SCHEDULE FOR DETAILS
- G1 — GAS METER HOUSE SUPPLY
- G2 — GAS METER SOLAR HOT WATER SYSTEM SUPPLY
- WM WM1/6 — COLD WATER SUB METERS. REFER TO SCHEMATIC PLANS & EQUIPMENT SCHEDULE FOR DETAILS
- HWM — WARM WATER SUB METER. CONNECTED TO UNIT 2 HOT WATER SYSTEM SUPPLY LINE
- BWM — BORE WATER METER
- LT — WATER LEVEL TRANSMITTER SUBMERSIBLE
- RAIN1 — WALL MOUNTED RAINWATER PUMP CABINET, WITH MAINS WATER BACKUP VALVE, PUMP, PRESSURE PUMP & RAINWATER TREATMENT UNIT. REFER TO SCHEMATIC PLAN & EQUIPMENT SCHEDULE FOR DETAILS
- GREY — GREYWATER DIVERTER UNIT. REFER TO SCHEMATIC PLAN & EQUIPMENT SCHEDULE FOR DETAILS
- IR — IRRIGATION CONTROLLER
- SL1/3 — SLAB IN-SITU TEMPERATURE SENSORS
- WA1/6 — WALL MOUNTED TEMPERATURE SENSORS
- CE — CEILING MOUNTED TEMPERATURE SENSOR
- RC — ROOF / CEILING CAVITY MOUNTED TEMPERATURE SENSOR
- RT — ROOF SURFACE MOUNTED TEMPERATURE SENSOR
- WS — ROOF MOUNTED WEATHER STATION
- GR1/3 — SOIL MOISTURE SENSORS - GREYWATER HYDROZONE
- T1/3 — SOIL MOISTURE SENSORS - TURF HYDROZONE
- V1/3 — SOIL MOISTURE SENSORS - VEGETABLES HYFROZONE
- F1/3 — SOIL MOISTURE SENSORS - FRUIT TREES HYDROZONE
- N1/3 — SOIL MOISTURE SENSORS - NATIVES HYDROZONE

SITE PLAN - UNIT 1

SCALE 1:100

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06/05/2013	REVISED FOR CONSTRUCTION	A
02/11/2012	ISSUED FOR CONSTRUCTION	–

AS CONSTRUCTED

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PROJECT TITLE
JOSH'S HOUSE
LOT 1499 GRIGG PLACE HILTON WA

DRAWING TITLE
MONITORING SYSTEM DESIGN SITE PLAN - UNIT 1

PROJECT NO.	SCALE	SHEET	REVISION
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CAD FILE PATH: --		PLOT DATE: 30/06/2014	

DRAWN	CHECKED	APPROVED	DWG NO.
AB	JB	JB	MSD-101

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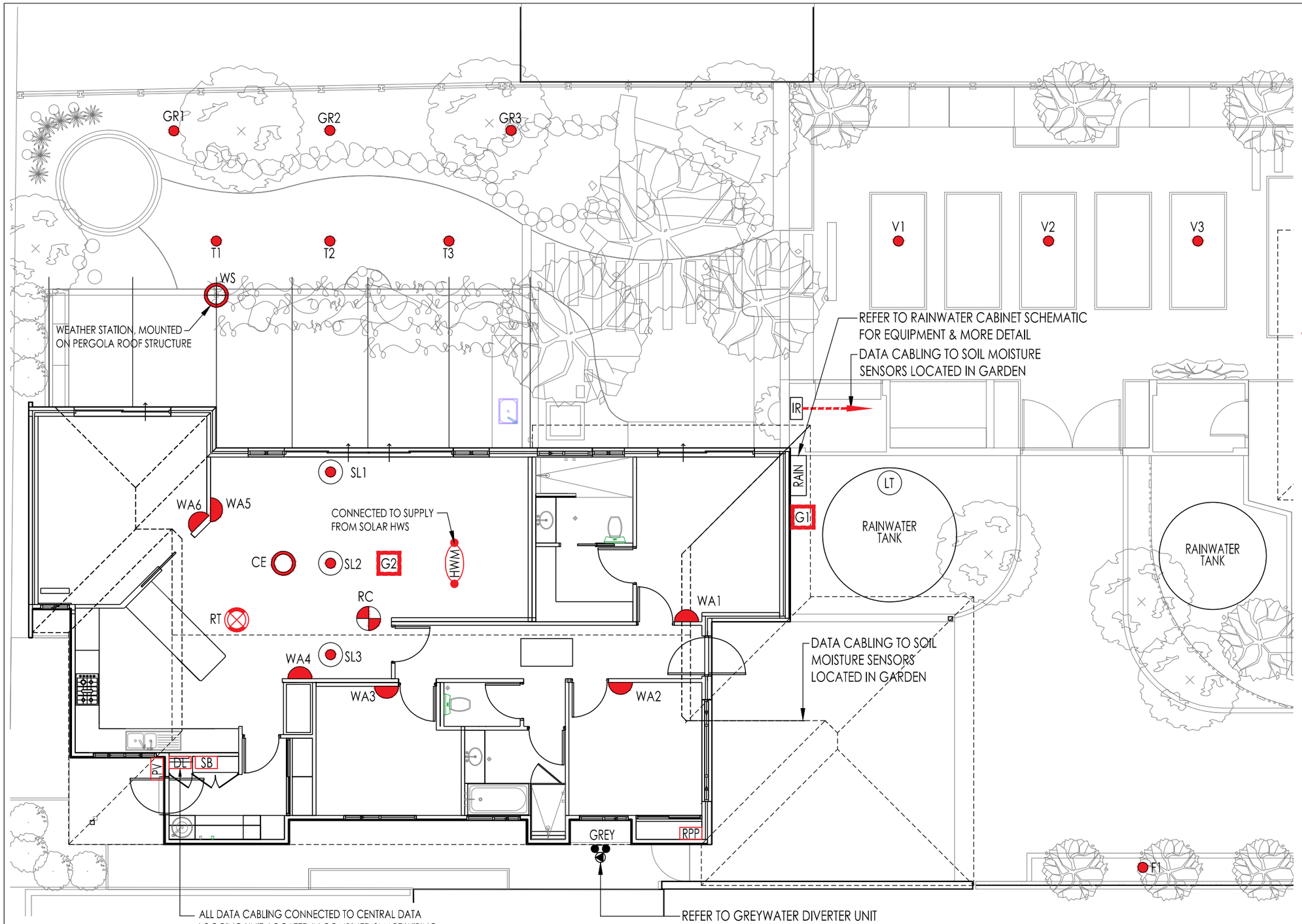

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- SL1/3 — SLAB IN-SITU TEMPERATURE SENSORS
- WA1/6 — WALL MOUNTED TEMPERATURE SENSORS
- CE — CEILING MOUNTED TEMPERATURE SENSOR
- RC — ROOF / CEILING CAVITY MOUNTED TEMPERATURE SENSOR
- RT — ROOF SURFACE MOUNTED TEMPERATURE SENSOR
- WS — ROOF MOUNTED WEATHER STATION
- GR1/3 — SOIL MOISTURE SENSORS - GREYWATER HYDROZONE
- T1/3 — SOIL MOISTURE SENSORS - TURF HYDROZONE
- V1/3 — SOIL MOISTURE SENSORS - VEGETABLES HYFROZONE
- F1/3 — SOIL MOISTURE SENSORS - FRUIT TREES HYDROZONE
- N1/3 — SOIL MOISTURE SENSORS - NATIVES HYDROZONE

SITE PLAN - UNIT 2

SCALE 1:100

DATE	DESCRIPTION	REV
30/06/2014	AS CONSTRUCTED	B
06/05/2013	REVISED FOR CONSTRUCTION	A
02/11/2012	ISSUED FOR CONSTRUCTION	–

AS CONSTRUCTED

0 1 2 3 4 5

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

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N

PROJECT TITLE
JOSH'S HOUSE
LOT 1499 GRIGG PLACE HILTON WA

DRAWING TITLE
MONITORING SYSTEM DESIGN SITE PLAN - UNIT 2

PROJECT NO.	SCALE	SHEET	REVISION
D-00-3	1:100	3 of 5	B
CAD FILE PATH: --		PLOT DATE: 30/06/2014	

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AB	JB	JB	MSD-102

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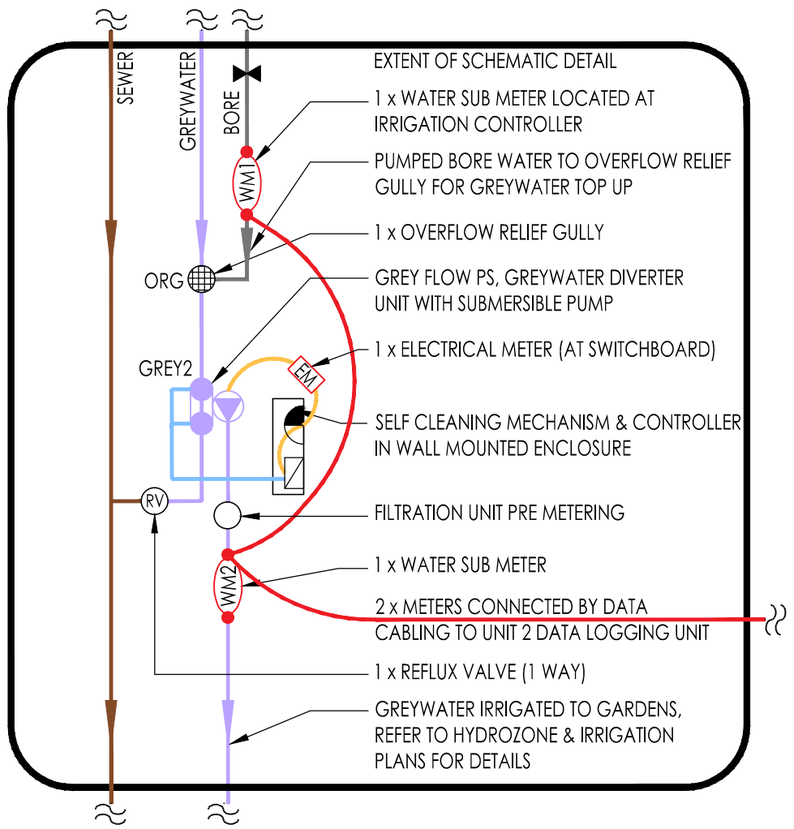
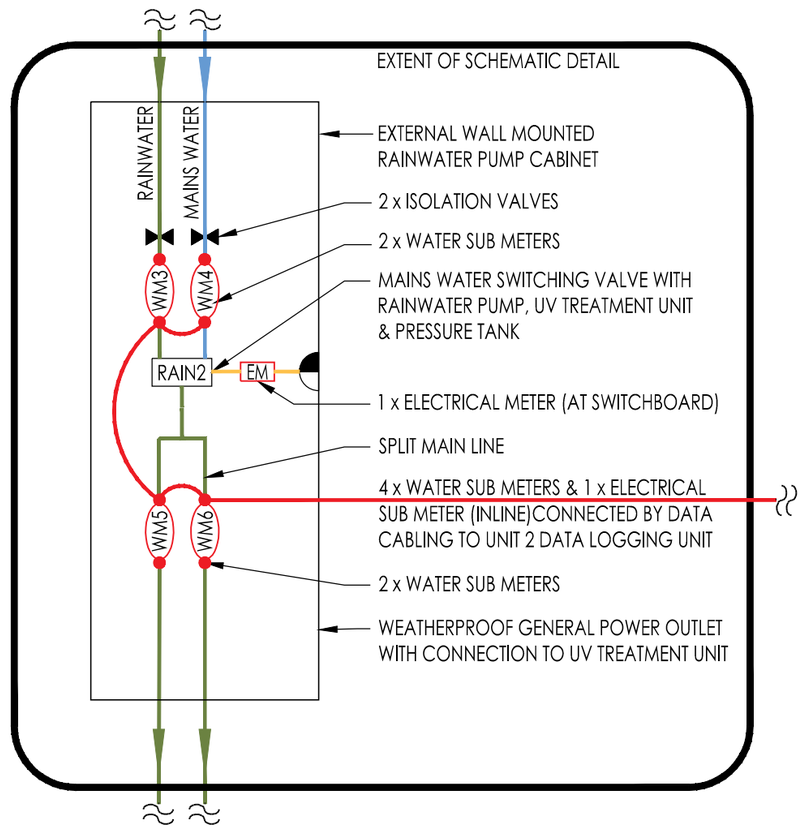


UNIT 2 - GREYWATER
DIVERTER UNIT SCHEMATIC



UNIT 2 - WALL MOUNTED
RAINWATER CABINET SCHEMATIC

DATE	DESCRIPTION	REV
30/06/2014	AS CONSTRUCTED	B
06/05/2013	REVISED FOR CONSTRUCTION	A
02/11/2012	ISSUED FOR CONSTRUCTION	–

AS CONSTRUCTED

0 1 2 3 4 5

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PROJECT TITLE
JOSH'S HOUSE
LOT 1499 GRIGG PLACE HILTON WA

DRAWING TITLE
SCHEMATIC SERVICE PLANS - UNIT 2

PROJECT NO.	SCALE	SHEET	REVISION
D-00-3	N/A	3 of 5	B
CAD FILE PATH: --		PLOT DATE: 30/06/2014	

DRAWN	CHECKED	APPROVED	DWG NO.
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EQUIPMENT SCHEDULE

QTY	LABEL	ITEM	LOCATION	DESCRIPTION
1	DL	**DATA LOGGING UNIT**	LAUNDRY SWICH BOARD CABINET	DATATAKER DT80 DATA LOGGING UNIT WITH CHANNEL EXPANSION MODULE
1	RPP	**ROUTER & PATCH PANEL**	BEDROOM 2 CABINET	ROUTER LOCATION & PATCH PANEL
1	SB	**ELECTRICAL SWITCH BOARD**	LAUNDRY SWICH BOARD CABINET	ELECTRICAL SWITCH BOARD
1	G1	**GAS METER**	EAST SIDE OF HOUSE - REFER DRAWINGS	AMPY750 VOLUMETRIC GAS METER (HOUSE SUPPLY)
1	G2	**GAS METER**	ROOF CAVITY - REFER DRAWINGS	AMPY750 VOLUMETRIC GAS METER (SOLAR HOT WATER SYSTEM SUPPLY)
11	EM1/11	**ELECTRICAL CIRCUIT METERS**	ELECTRICAL SWITCH BOARD	11 X LATRONICS KWHR METERS (4 X GPO CIRCUITS; 2 X LIGHTING / FAN CIRCUITS; 1 X OVEN CIRCUIT; 1 X GREYWATER PUMP CIRCUIT, 1 X BORE PUMP CIRCUIT; RAINWATER PUMPCIRCUIT; 1 X PV FEED CIRCUIT)
1	WSA	**RAIN GAUGE**	PERGOLA - REFER DRAWINGS	VAISALA WXT520 WEATHER STATION
1	WSB	**WIND SPEED & DIRECTION SENSOR**	PERGOLA - REFER DRAWINGS	VAISALA WXT520 WEATHER STATION
1	WSC	**SOLAR RADIATOR SENSOR**	PERGOLA - REFER DRAWINGS	VAISALA WXT520 WEATHER STATION
1	WSD	**TEMPERATURE & RELATIVE HUMIDITY SENSORS**	PERGOLA - REFER DRAWINGS	VAISALA WXT520 WEATHER STATION
3	SL1/3	**SLAB IN-SITU TEMPERATURE SENSORS**	LIVING ROOM - REFER TO DRAWINGS	TCKPP120 20AWG THERMOCOUPLE WIRE, CAST INTO SLAB
6	WA1/6	**WALL TEMPERATURE SENSORS**	INTERNAL WALLS - REFER TO DRAWINGS	TCKPP120 20AWG THERMOCOUPLE WIRE
1	CE	**CEILING TEMPERATURE SENSOR**	LIVING ROOM - REFER TO DRAWINGS	TCKPP120 20AWG THERMOCOUPLE WIRE
1	RC	**ROOF CAVITY TEMPERATURE SENSOR**	ATTIC - REFER TO DRAWINGS	TCKPP120 20AWG THERMOCOUPLE WIRE
1	RT	**ROOF MOUNTED TEMPERATURE SENSOR**	ROOF - REFER TO DRAWINGS	TCKPP120 20AWG THERMOCOUPLE WIRE, CONNECTED TO ROOF SHEETING
3	GR1/3	**SOIL MOISTURE SENSORS - GREYWATER HYDROZONE**	LANDSCAPE - REFER TO DRAWINGS	DECAGON 10HS CAPACITANCE SOIL MOISTURE PROBES
3	T1/3	**SOIL MOISTURE SENSORS - TURF HYDROZONE**	LANDSCAPE - REFER TO DRAWINGS	DECAGON 10HS CAPACITANCE SOIL MOISTURE PROBES
3	V1/3	**SOIL MOISTURE SENSORS - VEGETABLES HYDROZONE**	LANDSCAPE - REFER TO DRAWINGS	DECAGON 10HS CAPACITANCE SOIL MOISTURE PROBES
3	F1/3	**SOIL MOISTURE SENSORS - FRUIT TREES HYDROZONE**	LANDSCAPE - REFER TO DRAWINGS	DECAGON 10HS CAPACITANCE SOIL MOISTURE PROBES
6	N1/6	**SOIL MOISTURE SENSORS - NATIVE HYDROZONE**	LANDSCAPE - REFER TO DRAWINGS	DECAGON 10HS CAPACITANCE SOIL MOISTURE PROBES
6	WM1/6	**COLD WATER METERS**	VARIOUS - REFER TO DRAWINGS	20MM ELSTER V100 COLD WATER METERS
1	BWM	**BORE WATER METER**	DRIVEWAY - REFER DRAWINGS	40MM MT-EX SERIES WATER METER
1	HWM	**HOT WATER METER**	ROOF CAVITY - REFER TO DRAWING	20MM KENT S130 WARM WATER METERS
1	LT	**LEVEL TRANSMITTER (TANK)**	TANK - REFER TO DRAWINGS	MERCOID SERIES SBLT2 SUBMERSIBLE LEVEL TRANSMITTERS

DATE	DESCRIPTION	REV
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AS CONSTRUCTED

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PROJECT TITLE
JOSH'S HOUSE
LOT 1499 GRIGG PLACE HILTON WA

DRAWING TITLE
EQUIPMENT SCHEDULE

PROJECT NO.	SCALE	SHEET	REVISION
D-00-3	N/A	4 of 5	B
CAD FILE PATH: --		PLOT DATE: 30/06/2014	

DRAWN	CHECKED	APPROVED	DWG NO.
AB	JB	JB	MSD-104

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JOSH'S HOUSE
Performance Monitoring Database

VERSION DATE: 23 MAY 2016

Introduction

This document describes how to access the operational performance data made available by the Josh's House project (http://joshshouse.com.au) for the purposes of research and industry utilisation. This database forms part of a broader research program on 'high performance housing' being undertaken by Curtin University's Sustainability Institute (CUSP), through the Cooperative Centre (CRC) for Low Carbon Living in partnership with Josh Byrne & Associates.

Currently there 70+ data channels being logged at Josh's House on a continual basis and these are grouped as follows for the purpose of data organisation:

- Electricity (including individual circuits; plus battery supply status).
- Gas (including sub metering of SHWS booster).
- Soil Moisture (by landscape hydrozone).
- Solar (including PV generation; insolation (at panel angle); PV panel temp; and solar hot water temperature (pre-booster)).
- Temperature (including all habitable rooms; plus living area relative humidity and CO^2; and building vertical temperature profile).
- Water (including mains water; rain water; greywater; bore water; and rainwater tank level).
- Weather (standard meteorological parameters; plus additional landscape microclimate temperature and relative humidity by landscape zones).

NOTE:
Various data channels were added over time, so the periods of data sampled to present will vary. Blank cells indicate no available data for that time/date stamp.

Details on the specific monitoring equipment used and the general monitoring arrangement can be found at: http://joshshouse.com.au/wp-content/uploads/2014/08/Performance-Monitoring-Plan1.pdf

The information presented below describes the conventions that can be used to regularly download the data manually or via a script.

Weekly Format

This format is suitable for scripts that need to download regular data, or where small data files are preferred.

First Available:	Monday 3rd March 2014 (2014W10)
Latest Available:	Every Monday by 10am
Published Span:	Previous Monday 00:00:00 to Sunday 23:50:00 (Perth time +08:00)
Sample Rate:	Every 10 minutes
Format:	Weekly
Base URL:	http://joshsdata.buzzware.com.au/weekly
File URL:	[group]/jh-[group]-[year]W[week_number].csv **group**: currently one of solar, electricity, temperature, weather, water, soil or gas **year**: 4 digit year **week_number**: 2 digit ISO calendar week number (zero padded) 00..53
Example URL:	http://joshsdata.buzzware.com.au/weekly/temperature/jh-temperature-2014W10.csv

The week number is based on the ISO standard (https://en.wikipedia.org/wiki/ISO_week_date). Weeks start with Monday. The first week of a year is the week that contains the first Thursday of the year. 2015 begins on a Thursday, so Monday 29/12/2014 to Sunday 4/1/2015 constitute the first ISO week of 2015, or 2015W01.

It is complicated to work out whether a given year has 52 or 53 weeks. Scripts may loop through years and weeks from 01 to 53, being prepared to get a 404 (Not Found) error for W53.

All Time Format

This format is suitable for manual exploration with Excel or similar.

First Available:	Monday 3rd March 2014 (2014W10)
Refreshed:	Every Monday by 10am
Published Span:	Monday 3rd March 2014 00:00:00 to previous Sunday 23:50:00 (Perth time +08:00)
Sample Rate:	Every 10 minutes
URL:	http://joshsdata.buzzware.com.au/jh-all.zip (a “zip” file)
Contents:	One file per group named [group].csv, containing all samples recorded for that group

This document lives at:
http://joshsdata.buzzware.com.au/JoshsHouseResearchDataDocumentation.pdf

Referencing

Any use of data form the Josh's House Database should be acknowledged as follows:
Byrne. J (2013), *Josh's House Operational Performance Database* – Date Accessed – URL.

Enquiries

Technical enquiries: Gary McGhee (gary@buzzware.com.au)
All other enquiries: Josh Byrne & Associates (communications@joshbyrne.com.au)

Acknowledgement

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Curtin University

LOW CARBON LIVING CRC

JOSH BYRNE & Associates