City of Wanneroo

DISTRICT PLANNING SCHEME No. 2

Amendment No. 119

FORM 1C

PLANNING AND DEVELOPMENT ACT 2005

RESOLUTION DECIDING TO AMEND A LOCAL PLANNING SCHEME

CITY OF WANNEROO

DISTRICT PLANNING SCHEME NO. 2 - AMENDMENT NO. 119

RESOLVED that the Council, in pursuance of Section 75 of the Planning and Development Act 2005, amend the above local planning scheme by:

(i) Inserting a new clause 4.5.4 and 4.5.5 as follows:

"4.5.4 Split Density Code – Development

Where a split residential density code is depicted on the Scheme Maps, any development shall conform to the lower density code applicable to the lot, unless the Council determines that development up to the higher density code would comply with the following requirements:

a) Sufficient capacity exists in all necessary public utility services to adequately meet the needs of the development;

b) The development has one consolidated vehicular access point with reciprocal access rights to serve all dwellings, and restricted vehicular access to other areas of road frontage;

c) All dwellings located adjacent to the street frontage present to the streetscape and provide passive surveillance of the public realm; and

4.5.5 Split Density Code – Subdivision

Council will base its recommendations in respect to applications for subdivision of land depicted on the Scheme Maps with a split residential density code in accordance with the development requirements set out in clause 4.5.4."

(ii) Amending the scheme maps as depicted in Attachment 1.

Dated this day of 20

.....
CHIEF EXECUTIVE OFFICER

PLANNING AND DEVELOPMENT ACT 2005

CITY OF WANNEROO

DISTRICT PLANNING SCHEME NO. 2 - AMENDMENT NO. 119

The City of Wanneroo under and by virtue of the powers conferred upon it in that behalf by the Planning and Development Act 2005 hereby amends the above local planning scheme by:

(iii) Inserting a new clause 4.5.4 and 4.5.5 as follows:

"4.5.4 Split Density Code – Development

Where a split residential density code is depicted on the Scheme Maps, any development shall conform to the lower density code applicable to the lot, unless the Council determines that development up to the higher density code would comply with the following requirements:

a) Sufficient capacity exists in all necessary public utility services to adequately meet the needs of the development;

b) The development has one consolidated vehicular access point with reciprocal access rights to serve all dwellings, and restricted vehicular access to other areas of road frontage;

c) All dwellings located adjacent to the street frontage present to the streetscape and provide passive surveillance of the public realm; and

4.5.5 Split Density Code – Subdivision

Council will base its recommendations in respect to applications for subdivision of land depicted on the Scheme Maps with a split residential density code in accordance with the development requirements set out in clause 4.5.4."

(iv) Amending the scheme maps as depicted in Attachment 1.

PLANNING AND DEVELOPMENT ACT 2005

CITY OF WANNEROO

DISTRICT PLANNING SCHEME NO 2 - AMENDMENT NO. 119

SCHEME AMENDMENT REPORT

Strategic Context

The City of Wanneroo has a rapidly growing population that is projected to almost double to approximately 354,000 by 2036. To house this population and make efficient use of existing infrastructure, public transport, activity centres and community facilities Directions 2031 and Beyond sets a 'connected city' infill target of 47% for the Perth metropolitan area. This equates to approximately 33,000 dwellings being provided through infill development outside of the central sub region by 2031. The 2013 Delivering Directions 2031 Report Card sets an infill dwelling target of 16,360 for the City of Wanneroo by 2031. According to the 2014 Urban Growth Monitor the City of Wanneroo has only provided 194 dwellings towards reaching this target. The proposed amendment may enable the development of up to 18,500 additional infill dwellings, significantly contributing to the delivery of the regional infill dwelling targets from Directions 2031 and Beyond.

The City of Wanneroo Local Housing Strategy, which was adopted in 2005, aims to guide the future form and type of housing within the City of Wanneroo to ensure it is appropriate and affordable for future communities. Key objectives of the strategy are to:

- Promote appropriate forms of housing close to existing and proposed community facilities and services to enable more efficient and effective use of those facilities and services; and
- Ensure an overall residential density which will improve the viability and range of transport alternatives.

Increased residential density allows the development of a wider range of housing types to meet the needs of the population in the City of Wanneroo. It will help to reduce the rate of urban sprawl and the impacts of development on the environment by planning a more compact city.

The Local Housing Strategy analyses the existing residential development within the City of Wanneroo and identifies several areas that may be suitable for residential redevelopment due to the age of the existing housing stock, lot sizes and proximity to existing services and infrastructure.

In 2010 Council adopted Local Planning Policy 3.1: Local Housing Strategy Implementation (LPP 3.1) which introduced housing precincts in the suburbs of Wanneroo, Girrawheen-Koondoola, Quinns, Yanchep and Two Rocks. LPP 3.1 defined the boundaries of these housing precincts, identify the extent of potential density increases in these areas and provide guidance on the process for implementing the residential density increases in an orderly way. A subsequent amendment to LPP 3.1 was adopted in 2011, which expanded the areas to be recoded.

This scheme amendment will implement the recommendations of Directions 2031 and Beyond and the City of Wanneroo Local Housing Strategy and LPP 3.1 for the Wanneroo and Girrawheen-Koondoola housing precincts. It is intended to progress the recoding of the Quinns, Yanchep and Two Rocks housing precincts through a future scheme amendment.

Background

LPP 3.1 prioritises the Wanneroo and Girrawheen-Koondoola housing precincts as priority one and two for implementation, and requires the following three key issues to be addressed prior to, or as part of, a scheme amendment to increase the R-Coding in these areas:

1. *Assess the existing infrastructure provision and identify infrastructure upgrades needed to facilitate redevelopment at a higher density;*

   Following the adoption of the amended LPP 3.1, Administration engaged consultants to assess the capacity of the road, water and sewer networks and their ability to accommodate the higher densities proposed for the housing precincts. A copy of these studies is included as **Attachment 2** and **Attachment 3**. These desktop studies concluded that the following infrastructure upgrades may be required to achieve full development in the housing precincts:

   - Nine upgrades to Wanneroo Road to be funded by Main Roads WA;
   - Nine road upgrades to local and neighbourhood roads;
   - A main sewer in Girrawheen to be funded by the Water Corporation; and
   - Numerous upgrades to local water and sewer infrastructure.

   Further consultation with the Water Corporation following the completion of these studies has indicated that there may be more capacity within existing water and sewer infrastructure than what has been indicated in the consultant studies. A copy of this correspondence is included as **Attachment 4**. The Water Corporation has advised that this capacity may be sufficient to accommodate the proposed infill development without completing any infrastructure upgrades.

2. *Establishment of a development contribution arrangement for funding of infrastructure upgrades; and*

   The establishment of a development contribution arrangement to fund infrastructure upgrades was considered as a part of the City's preparation of this Amendment. However, it is not considered that a development contribution arrangement could be implemented equitably in accordance with State Planning Policy 3.6 – Development Contributions across such a large area. The Department of Planning has advised that they do not support the establishment of a development contribution arrangement to fund any necessary infrastructure upgrades in the housing precincts as they could not support an arrangement that would run for an uncertain amount of time.

   Based on the advice of the Water Corporation and Department of Planning the City has not proceeded with the preparation of a development contributions arrangement. Instead, the upgrading of local and neighbourhood roads is intended to be met by the City through existing road upgrade programs as and when required. Any upgrades to the local water and sewer network that may be required in the future are proposed to be met by private developers as and when the need arises. It is considered more rational to allow redevelopment to occur using existing capacity and only complete upgrades if and when that capacity has been reached.

3. *Introduction of provisions for the application of Design Guidelines to address the specific aspects and context of each housing precinct to facilitate appropriate future residential development and subdivision.*

   It is necessary to ensure that development within the housing precincts contributes to the streetscape and public realm of the local area. There is a risk that development allowed to proceed without design guidance or control could result in inactive street frontages characterised by a dominance of carports and garages, a proliferation of crossovers, and a reduced capacity for street trees and verge landscaping.

   Rather than prepare a specific design guideline, the provisions of the scheme amendment have been designed to address subdivision and development design issues. Further policy guidance may be prepared in the future to support the application of the proposed scheme provisions.

To address the infrastructure, funding and design issues identified above, the City is proposing to initiate an amendment to DPS 2 to implement a split density code for the Wanneroo and Girrawheen-Koondoola housing precincts.

Detail

The proposed amendment to DPS 2 comprises the following components:

Amending the Scheme R-Code Maps to recode lots in the Wanneroo and Girrawheen-Koondoola housing precincts to R20/R40 and R20/R60.

It is proposed to implement a split density code over the Girrawheen-Koondoola and Wanneroo housing precincts in accordance with the Scheme Amendment Maps included as **Attachment 1**.

In this case the base code reflects the existing R-Code, and the higher code reflects the R-Codes identified, and previously adopted by Council, in LPP 3.1.

The application of a split density code gives the City greater control and influence over subdivision and development than a conventional recoding by only allowing development at the higher R-Code where the proposed development can be adequately serviced and meets the necessary design requirements.

Where the servicing and design requirements cannot be met then the existing base code of R20 will apply and redevelopment at the higher R-Code cannot be approved.

Introducing new provisions that apply to split code areas.

To support the proposed split density code, it is proposed to introduce two new sub-clauses under clause 4.5 of DPS 2 – Special Application of the Residential Design Codes, which deal with the application of the split density code. These provisions provide guidance on development and subdivision applications.

The first clause applies to development proposals under the split density coding and sets out the criteria that must be met for the higher R-Code to apply. These criteria would be applied by the City in determining applications for planning approval. They aim to ensure that proposed development is capable of being adequately serviced, that it does not contribute to a proliferation of driveways and crossovers at the expense of usable, attractive

streetscapes and that passive surveillance of the public realm is maintained as infill development occurs.

The second clause acknowledges that subdivision applications may also be made under the split density coding and that the City is not the determining authority for subdivision applications. It states that Council will base its recommendations on subdivision applications referred to it by the Western Australian Planning Commission on the same requirements for development applications.

Comment

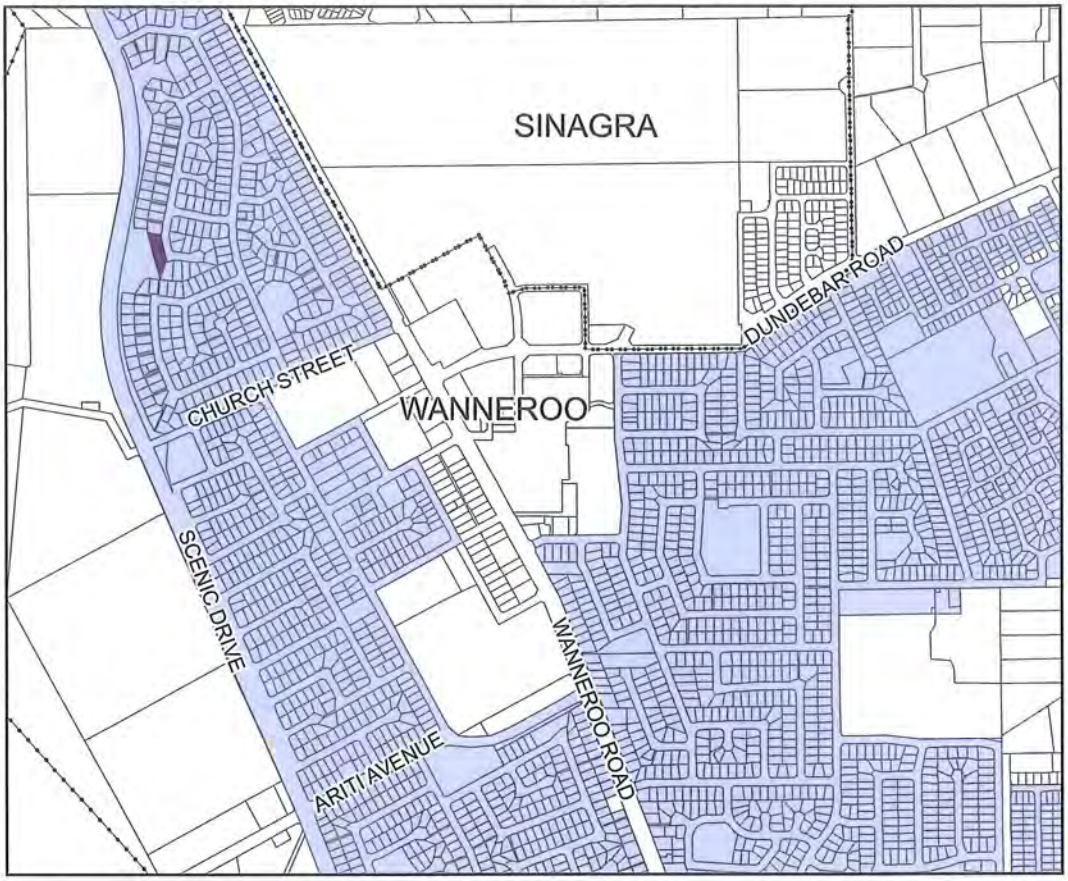
The implementation of a split density code over the Girrawheen-Koondoola and Wanneroo housing precincts is seen as the optimum solution to complex infrastructure and urban design issues. The split density code approach directly links any required infrastructure upgrades with actual development uptake rather than basing infrastructure upgrades on assumptions about when and where development might occur. It will also provide a safeguard against poor urban design outcomes and negative impacts on streetscapes and the public realm that could potentially result from infill redevelopment.

It is acknowledged that the split density code does not provide absolute certainty of the timing or location of future infrastructure upgrades, or unrestricted development opportunities for landowners within the housing precincts. It is possible that some land owners may not be able to proceed with development at the higher R Coding until infrastructure capacity is addressed and there may be a perceived inequality associated with this.

There may be a risk that the community expects the City to provide necessary infrastructure upgrades when capacity is reached. To mitigate this risk the City intends to closely monitor the uptake of development in the housing precincts and will continue to liaise with the Water Corporation to monitor infrastructure capacity. If and when infrastructure capacity is reached, Council has the ability, but is not required, to consider funding infrastructure upgrades to allow this development to proceed. Notwithstanding that potential infrastructure upgrades may be required; some infrastructure capacities may never be reached. The split code approach is therefore considered the most appropriate option given the uncertainty in relation to infrastructure capacity.

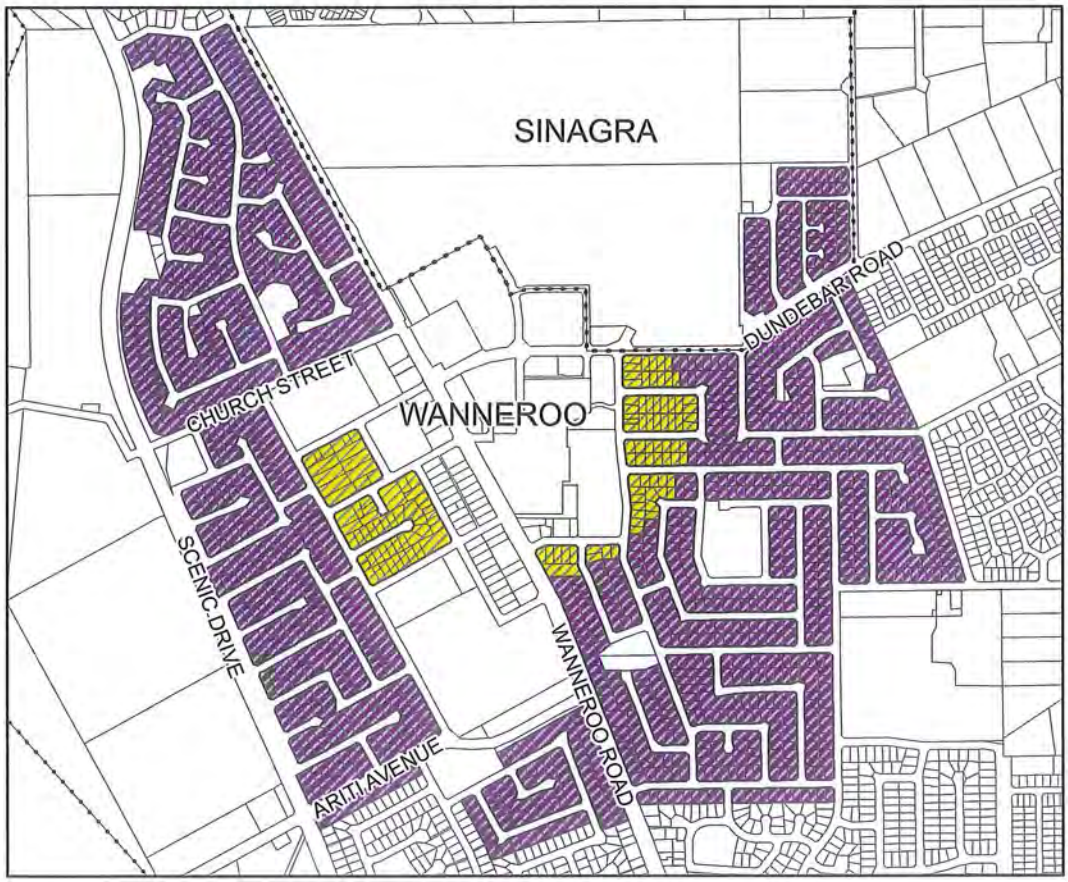
ATTACHMENT 1 – SCHEME AMENDMENT MAPS

CITY OF WANNEROO
DISTRICT PLANNING SCHEME No. 2
AMENDMENT No. 119



EXISTING R-CODE

Metres
0 200 400 800 1,200 1,600



N

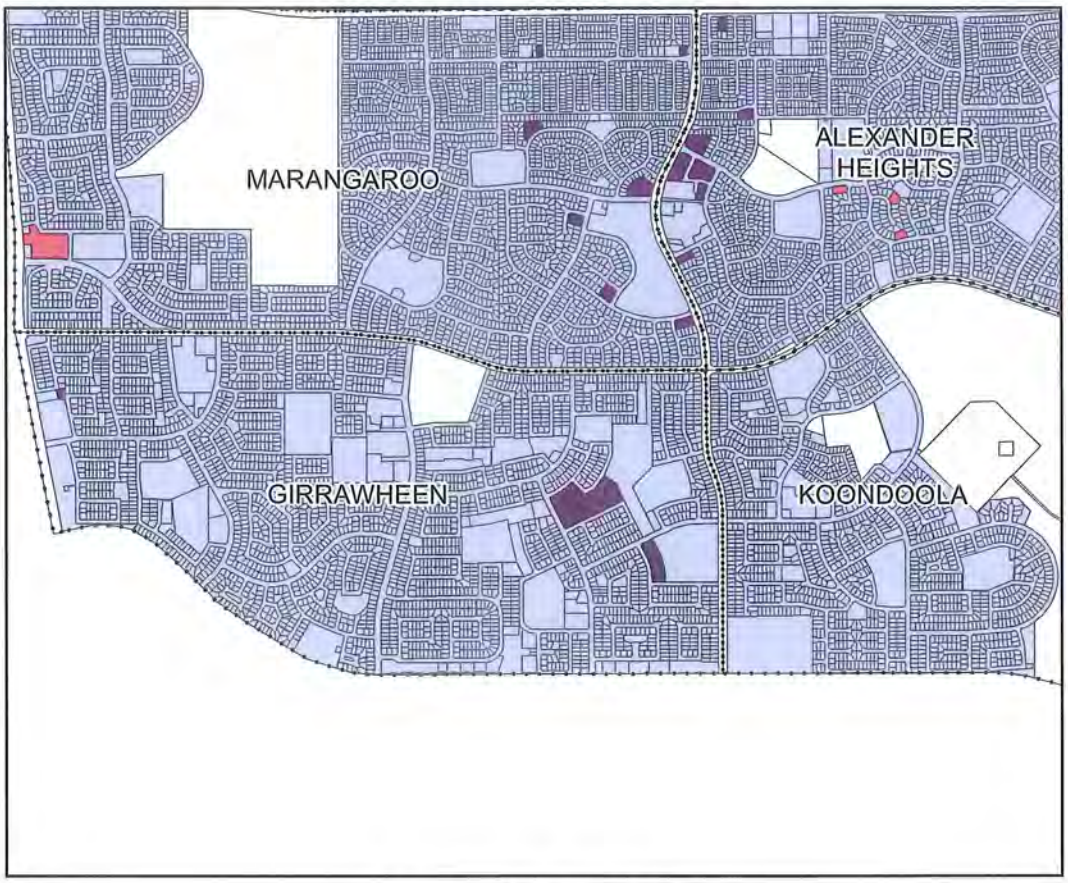
GDA

City of Wanneroo

Produced by Planning & Sustainability
7 January 2015

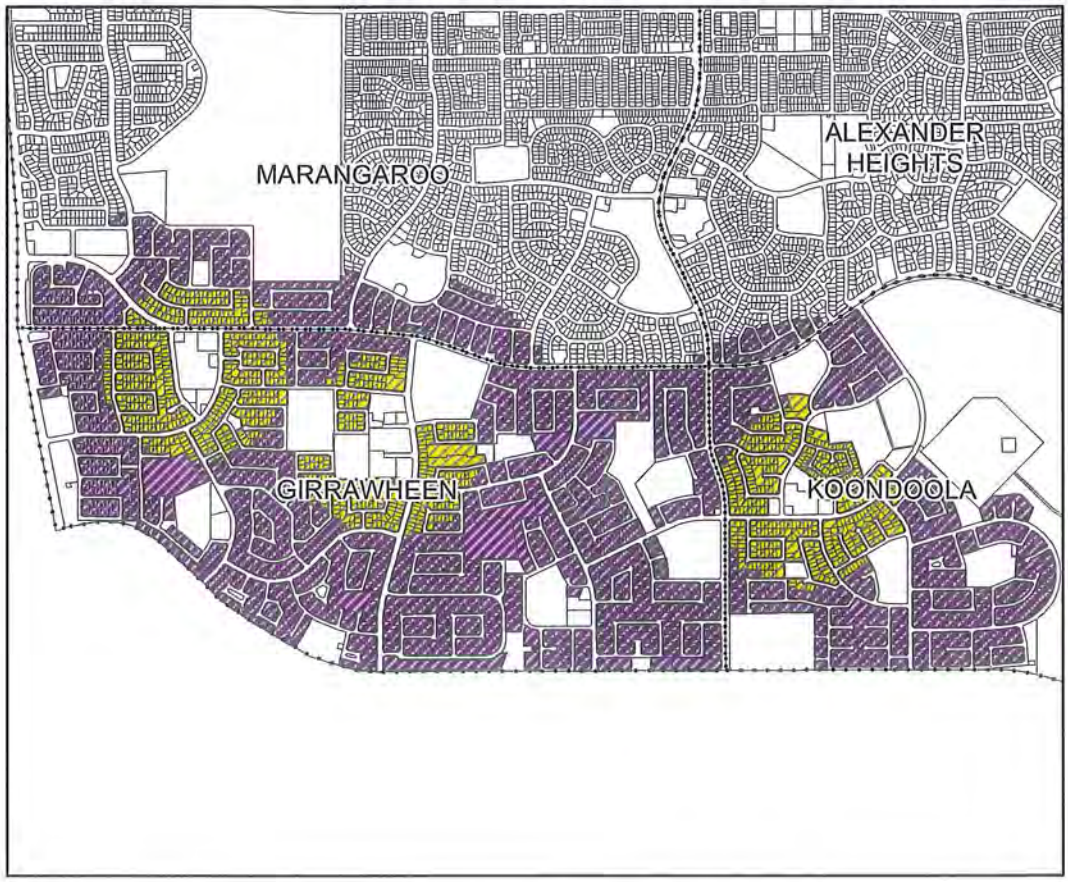
R-CODE (AMENDMENT) MAP

CITY OF WANNEROO
DISTRICT PLANNING SCHEME No. 2
AMENDMENT No. 119



EXISTING R-CODE

Kilometres
0 0.5 1 2 3 4



R-CODE (AMENDMENT) MAP

City of Wanneroo
Produced by Planning & Sustainability
7 January 2015

ATTACHMENT 2 – WATER AND SEWER CAPACITY STUDY

Sewer & Water Capacity Assessment

Wanneroo & Girrawheen-Koondoola Precincts

E11042

Prepared for
City of Wanneroo

January 2013

Cardno
Shaping the Future

Document Information

Prepared for	City of Wanneroo
Project Name	Wanneroo & Girrawheen-Koondoola Precincts
File Reference	E11042-001 City of Wanneroo-Sewer & Water Assessment-JT.docx
Job Reference	E11042
Date	January 2013

Contact Information

Cardno WA Pty Ltd
Trading as Cardno
ABN 77 009 119 000

11 Harvest Terrace, West Perth WA 6005

Telephone: 08 9273 3888
Facsimile: 08 9486 8664
International: +61 8 9273 3888

wa@cardno.com
www.cardno.com

Document Control

Version	Date	Author	Author Initials	Reviewer	Reviewer Initials
1	29/10/12	Jarryd Treacy	JT	Paul Broadhurst	PAB
2	25/01/13	Jarryd Treacy	JT	Paul Broadhurst	PAB

Executive Summary

Cardno was engaged by the City of Wanneroo (the City) to undertake a sewer and water review for services within the Wanneroo and Girrawheen-Koondoola housing precincts (the Precincts).

The work scope for the study required Cardno to:

- Assess the capacity of the existing infrastructure within the Precincts.
- Determine the future maximum number of dwellings as a result of the new planning scheme.
- Determine what upgrades are required to the existing infrastructure so that the increased demand due to the Town Planning Scheme Amendment can be supported.
- Assess the cost of the required upgrades and determine approximate trigger dates.

In carrying out the study, the following information was collected and reviewed:

- Local Housing Strategy Plans
- Report titled 'Estimated Rates of Development of New Dwellings in Wanneroo' by the City of Wanneroo
- The Water Corporations review of sewer reticulation capacity within the Precincts
- Notes from the Water Corporation explaining methodology for calculating water reticulation capacities
- Digital data showing alignments and sizes of existing water & sewer reticulation

The Water Corporations review of the existing water headworks infrastructure found that no immediate upgrades were required to support redevelopment in the short term future. Their review of the sewer headworks infrastructure found a significant section of sewer that would require upgrading prior to redevelopment being permitted within a major catchment area in the Girrawheen-Koondoola Precinct. The Water Corporation advised that they would monitor capacity over the long term and make additional headworks upgrades when required.

Cardno's assessment of water and sewer reticulation found that several areas within the precincts required significant immediate upgrades before any redevelopment would be approved by the Water Corporation. However, it was found that the majority of catchments within the precincts had no immediate capacity restrictions and would be approved for redevelopment if the amended planning scheme was rolled out to these areas in advance of the capacity restricted catchments.

It was estimated that the cost of upgrading water reticulation infrastructure within the critical catchments (catchments flagged for upgrades within 2 years) would be in the order of $3,990,000 (excl GST). From 2014 onwards, upgrades will cost approximately $2.2 million per decade on average until the expected maximum build out date (2081). The total extent of recommended water main upgrades is 22,418m at an estimated cost of $19.5 million over 68 years.

The total extent of recommended sewer main upgrades is 629m at an estimated cost of $720,000 over 26 years. The first upgrade required is predicted to be in 2016 at an estimated cost of $210,000.

Table of Contents

Appendices

Tables

1 Background

The project covers two areas within the City of Wanneroo, the Wanneroo precinct and the Girrawheen-Koondoola precinct. The City of Wanneroo (the City) has chosen these two precincts for re-zoning as a part of the recommendations put forward in the Local Housing Strategy (2005) and Local Planning Policy 3.1. The locality and re-zoning is shown by the City's Local Housing Strategy Implementation plans (Appendix A).

The City of Wanneroo engaged Cardno to undertake a sewer and water capacity assessment in order to review the adequacy of the existing services within the Precincts and to determine any necessary upgrades which would be required to support future demand as a result of the amendment to the town planning scheme.

Prior to Cardno commencing the project, the Water Corporation were requested by the City to complete the headworks review for the Precincts. This review included the assessment of sewer pressure mains, pumping stations and treatment plants, and all water reticulation pipes 300mm in diameter and larger to determine if the capacity of these assets would be sufficient to cope with future demand. The Water Corporation advised that no water or sewer headworks assets would require immediate upgrading to increase capacity. During their review, the Water Corporation also reviewed the sewer reticulation network and their findings were provided to Cardno to assist with their assessment.

2 Servicing Investigations

2.1 Water Reticulation

2.1.1 Capacity Assessment

Cardno requested the Water Corporation to provide all required information necessary to undertake the water reticulation capacity assessments in both the Girrawheen-Koondoola and Wanneroo precincts. This included all existing reprographics covering both precincts as well as capacities of all existing pipe types and methods for calculating the capacities of complex networks. The Water Corporation provided all required information, noting that the data for existing pipe capacities was now considered conservative as water consumption has reduced in recent years. The Water Corporation was in the process of reviewing the data but the revised data would not be available for this review. The Water Corporation requested that this data not be published.

Cardno liaised with The City in order to determine a method for estimating the future maximum dwelling numbers based on the proposed planning codes of R40 and R60 within each precinct. It was agreed that for R40 coded areas, the predicted maximum dwelling number for a given area would be the developable area divided by 240m^2(the predicted average area per dwelling), for R60 coded areas the developable area would be divided by 210m^2. The difference between the predicted maximum dwellings and the current number of dwellings was then reduced by 25% to allow for factors such as lot owners not wanting to subdivide and lots that couldn't be subdivided for any reason (the method for this calculation is further explained in the report under Appendix B). The resulting figure is described as the estimated number of dwellings (75% build out) on the concept design drawings.

In order to assess the capacity of the network within the precincts, they were divided into smaller catchment areas as per the methods advised by the Water Corporation for assessing water reticulation networks. The catchment areas were assessed by comparing the capacity of existing pipes versus the estimated future number of dwellings to determine if any upgrades would be required within the catchment. If future demand was higher than existing capacity, the minimum possible upgrade was applied in order to exceed future demand whilst complying with Water Corporation design standards.

After the initial assessment process by Cardno, drawings showing recommended upgrades were issued to the City and the Water Corporation for review and comment. The Water Corporation performed a technical review of the assessment and recommended minor changes to the otherwise approved drawings which have been incorporated into the final drawings and cost estimates.

2.1.2 Cost Estimates

As the Water Corporation manages the construction of all upgrades to their existing assets, Cardno requested their advice for estimating the cost of upgrades for each catchment. The Water Corporation were not willing to provide any figures for upgrading pipes citing many variables which would make it very difficult to estimate a cost to some degree of accuracy without an extensive review of each catchment. The variables which will cause significant variation of rates between catchment areas include:

- Locations of existing services that need to be protected
- Number/size of trees that need protection/removal.
- Extent of traffic management required.

- Number/complexity of bore shots under driveways/intersections.
- Location of valves - trenches need to be kept open until lot connections are switched from old to new water mains which will incur traffic & safety management costs.
- Reinstatement costs - brick paving/turf/concrete/asphalt etc.

Taking these points into consideration, it should be emphasized that the cost estimates provided in this report are concept level estimates and any decisions based on these estimates should reflect this.

In order to determine realistic rates for calculating the cost estimates, Cardno assessed costs from several recent jobs where similar works were undertaken. Rates were then determined for three aspects of the works to be undertaken: Preliminaries ($25,000 per catchment), installation of water main ($380-$550/m depending on pipe size), and reinstatement ($195/m). An allowance was also made for engineering fees and contingency which has been estimated at 20% of construction costs.

2.1.3 Trigger Date Estimates

Trigger dates were determined in order to estimate when upgrades for each catchment would be required to be constructed such that supply can meet demand at all times. Based on the advice from The City that full build out (to 75%) is expected to occur by 2081, a linear rate of development was determined by dividing the additional number of dwellings estimated for each catchment by the time (69 years) it will take to reach this number. The trigger dates were then determined by adding the rate of development to the number of existing dwellings and finding the year when demand (estimated number of dwellings) overtook supply (existing capacity). The formula used is as follows:

$$\text{Trigger Date (year)} = 2013 + \frac{(C-E)}{(F-E)/(2081-2013)}$$

Where: C = Capacity of existing water reticulation (No. dwellings)

E = Number of existing dwellings

F = Estimated number of dwellings as at 2081

As development rates are rarely linear, it should be noted that the City will be required to monitor development and liaise with the Water Corporation on a yearly basis to determine actual trigger dates for each catchment.

2.2 Sewer Reticulation

2.2.1 Capacity Assessment

Cardno obtained all required information for the sewer capacity assessment from the Water Corporation. This included the reprographics which included all existing sewer alignments and pipe sizes as well as existing flows entering the precincts from adjacent catchments. Water Corporation also provided their own sewer reticulation review which identified the headworks upgrades required to cope with the increased demand. The headworks review included existing pipes over 300mm in diameter as well as pipes currently less than 300mm in diameter that would need to be upgraded to 300mm. Cardno completed an independent review to determine upgrades required for reticulation

which included all pipes with an upgraded size of less than 300mm in diameter. The Water Corporation also reviewed Cardno's assessment using their own method for determining critical pipes which identified several more pipes that will require upgrading.

In completing Cardno's assessment, the precincts were broken up into catchments and areas were calculated for both R40 and R60 developable land within each catchment. These areas could then be used to calculate flow rates for the sewer network based on future maximum population density as per the Water Corporation design manual for gravity sewers (DS 50). DS 50 was then used to determine which existing pipes would be unable to cope with the increased flow that would be created and suitable upgraded pipe sizes were chosen.

2.2.2 Cost Estimates

As per the water reticulation cost estimates, the Water Corporation were not willing to provide advice for estimating the cost to upgrade the sewer reticulation. The variables described in section 2.1.2 also apply to estimating the cost of the sewer reticulation, as well as the following significant factors:

- Alignment of sewer – Significant portions of the existing sewer are currently located within private property (generally at the back of lots). The Water Corporation require that the sewer reticulation be relocated to the road reserve where possible and significant design work will be required to determine a suitable alignment.
- Trench or trenchless – Most, if not all of the sewer installation may be done by trenchless technique. The decision to use trench or trenchless will depend on several factors including depth of sewer, final alignment, duplication or replacement of sewer, and existing assets (above & below ground).
- Duplication or replacement of sewer – In some sections, it may be more practical to duplicate the sewer rather than replace it resulting in smaller pipes being used. Further investigations will be needed to determine the locations where this method may be viable.

Taking these points into consideration, it should be emphasized that the cost estimates provided in this report are concept level estimates and any decisions based on these estimates should reflect this.

2.3 Assessment Outcomes

2.3.1 Water

The assessment of the water reticulation network within the two precincts found that significant upgrades will be required as a result of the amendment to the town planning scheme. Concept design drawings have been produced to show the proposed upgrades for each catchment (Appendix C). Several catchments have been identified as critical which means the demand is currently higher than the theoretical supply capacity.

A brief summary of cost estimates sorted by trigger dates is shown below. A more comprehensive breakdown of costs estimates, trigger dates and quantities is shown under Appendix D.

Table 2-1 Summary of estimated costs for water reticulation upgrades

Trigger Date	Total Cost (Excl GST)	Catchments
Critical	$3,990,000	W4, GK3, GK7, GK10, GK18, GK22, GK28, GK31, GK8, GK13, GK36
2015	$876,000	GK16
2017	$1,029,000	GK21
2020-2029	$2,467,000	GK30, GK25, GK12, GK17, GK14, GK15, GK19
2030-2039	$2,143,000	GK1, W5, GK23, GK37, GK4, W3
2040-2049	$2,460,000	W1, GK5, GK11, GK34, GK33
2050-2059	$2,316,000	GK9, GK32, GK26, W10, W7, W8
2060-2069	$2,055,000	GK35, W6, W2, GK29, GK24, GK6
2070-2081	$2,106,000	GK38, GK2, W9, GK20, GK27

The following comments and assumptions can be made regarding the cost estimate for the upgrading of water reticulation within the Precincts:

- Cost estimates are intended to be all inclusive allowing for items such as engineering & surveying fees, mobilisation, traffic management, protection of existing assets and reinstatement.
- No allowance has been made for inflation of construction and material costs as it is not certain when construction will commence. An allowance of 3% inflation per year should be made when predicting future construction costs.
- Rates for scheduled items are based on rates for similar activities from recent projects that have been managed by Cardno.
- Cost estimates are concept level only. Costing advice should be updated regularly as the design process progresses.
- Trigger dates are estimates only. Development rates should be monitored closely with trigger dates updated accordingly.
- It is assumed that horizontal drilling techniques will be used to install water mains under intersections in order to reduce traffic management requirements and prevent unnecessary road closures.
- It is assumed that reinstatement will be required for a 2.5m width over the alignment of the proposed water mains.
- It is assumed that the new water mains will be installed adjacent to existing water mains with the redundant water mains remaining in the ground.

As shown in table 1, a number of catchments have already reached capacity or are expected to reach capacity within the next 2 years. It is recommended that these catchments be upgraded prior to amending the planning scheme for these areas. If possible, it may be beneficial to roll out the planning scheme such that other areas within the Precincts may be redeveloped without being restricted by the need for upgrades within the critical catchments.

It is recommended that a developer's contribution scheme be considered by the City in order to recoup the costs associated with upgrading the water reticulation. Although catchment boundaries on the drawings show lots which directly affect the required upgrades for each given catchment, all lots within the Precincts indirectly contribute to requirement for increased capacity. As such, it is recommended that all lots with the Precincts be subject to contributions for upgrades.

2.3.2 Sewer

The assessment of the sewer reticulation network within the two precincts found that a significant section of the existing 230mm diameter sewer main within the Girrawheen-Koondoola precinct requires upgrading to 300mm diameter. The main in question services the majority of the catchments within the precinct and runs from the connection to the trunk main near the intersection of Wanneroo Rd & Shortland Way, down to Beach Rd, then up and along Nanovich Ave. The extent of the proposed upgrade is shown on the concept design under Appendix E (GSU4). As this section of sewer is being upgraded to 300mm diameter, it is considered a headworks upgrade which falls under the responsibility of the Water Corporation. The Water Corporation advised that upgrade of this sewer main would be a condition of redevelopment, as such, the trigger date for the proposed works is considered critical at present.

It was found that 4 minor sections of 150mm diameter sewer reticulation would require upgrading to 225mm diameter mains as shown under Appendix E (WSU1 & GSU1-3) totaling a length of 629m. These upgrades will not be funded by the Water Corporation and come to an estimated cost of $720,000 as per the summary below.

Table 2-2 Summary of estimated costs for sewer reticulation upgrades

Trigger Date	Total Cost (Excl GST)	Catchment
2016	$210,000	GSU2
2027	$127,000	GSU3
2036	$257,000	GSU1
2039	$125,000	WSU1

The following comments and assumptions can be made regarding the cost estimate for the upgrading of sewer reticulation within the Precincts:

- Cost estimates are intended to be all inclusive allowing for items such as engineering & surveying fees, mobilisation, traffic management, protection of existing assets and reinstatement.
- No allowance has been made for inflation of construction and material costs as it is not certain when construction will commence. An allowance of 3% inflation per year should be made when predicting future construction costs.
- Rates for scheduled items are based on rates for similar activities from recent projects that have been managed by Cardno.

- Cost estimates are concept level only. Costing advice should be updated regularly as the design process progresses.

- Trigger dates are estimates only. Development rates should be monitored closely with trigger dates updated accordingly.

- It is assumed that horizontal drilling techniques will be used to install all sewer mains.

- Reinstatement costs relate to the disturbed areas due to bore pits and relocated sewer pits.

- It is assumed that the new sewer mains will be installed adjacent to existing sewer mains with the redundant sewer mains remaining in the ground. Allowance has been made for relocation/reconstruction of sewer pits for this reason.

It is recommended that a developer's contribution scheme be considered by the City in order to recoup the costs associated with upgrading the sewer reticulation. Catchment boundaries shown on the drawings identify all lots which contribute to the increased flow in the section of sewer that requires upgrading. The City is to determine whether to collect contributions from only lots within these catchments or to apply a flat contribution amount for all lots within the Precincts in addition to the contribution for water reticulation upgrades.

3 Recommendations and Conclusions

It is recommended that:

- Upgrades to water reticulation within catchments identified as critical are completed prior to allowing any redevelopment within these areas.
- The amended planning scheme is rolled out gradually such that areas not restricted by water & sewer capacities may be redeveloped prior to critical upgrades being completed.
- The City considers the introduction of a developer's contribution scheme such that the City is not responsible for the full cost of the upgrades for both water and sewer reticulation.
    - For water reticulation upgrades, contributions to be collected from all lots within both Precincts.
    - For sewer reticulation upgrades, the City to decide whether contributions be collected from all lots or lots within catchment boundaries only.
- The City continually monitors development rates and adjust trigger dates as required.

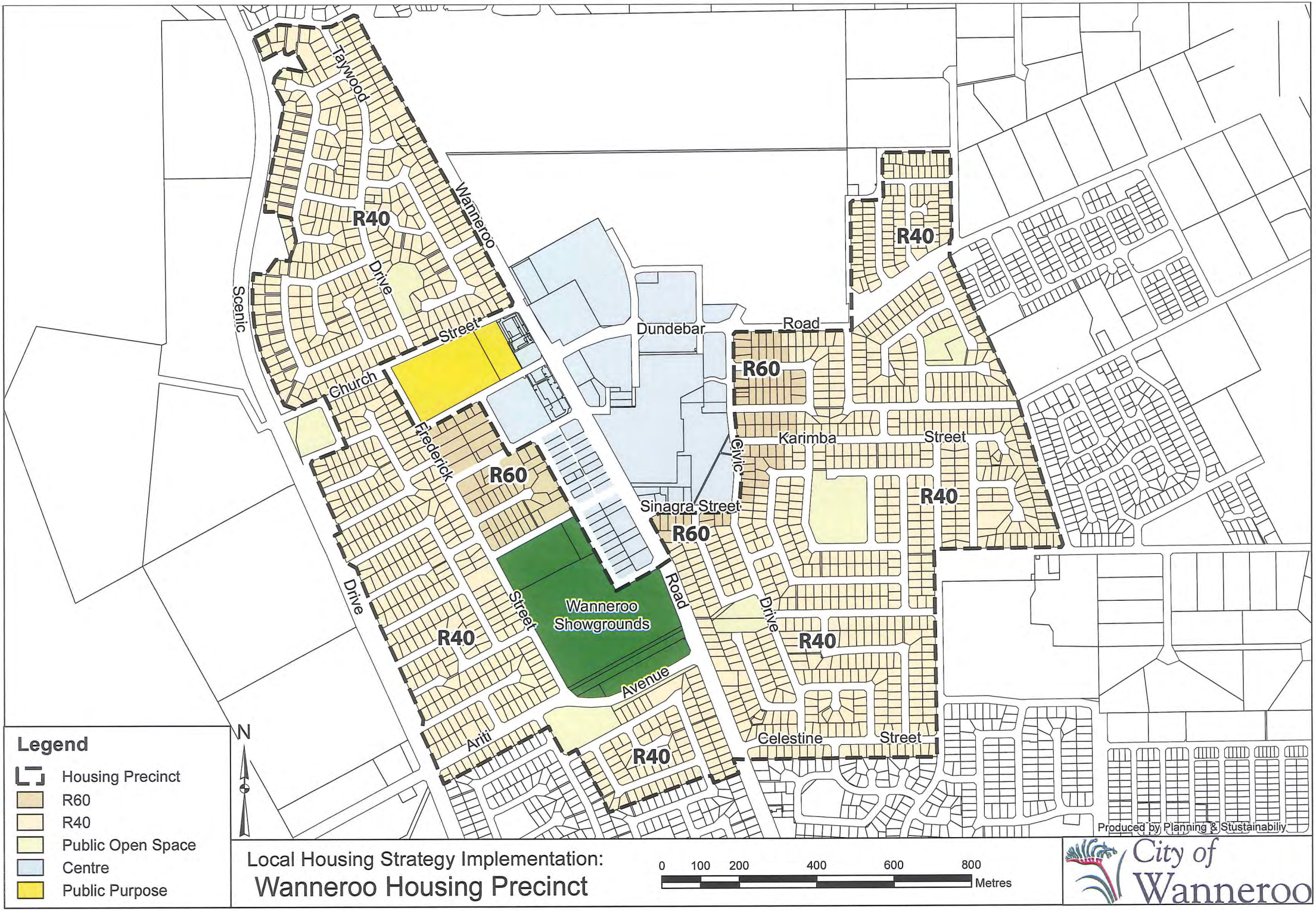
It is concluded that:

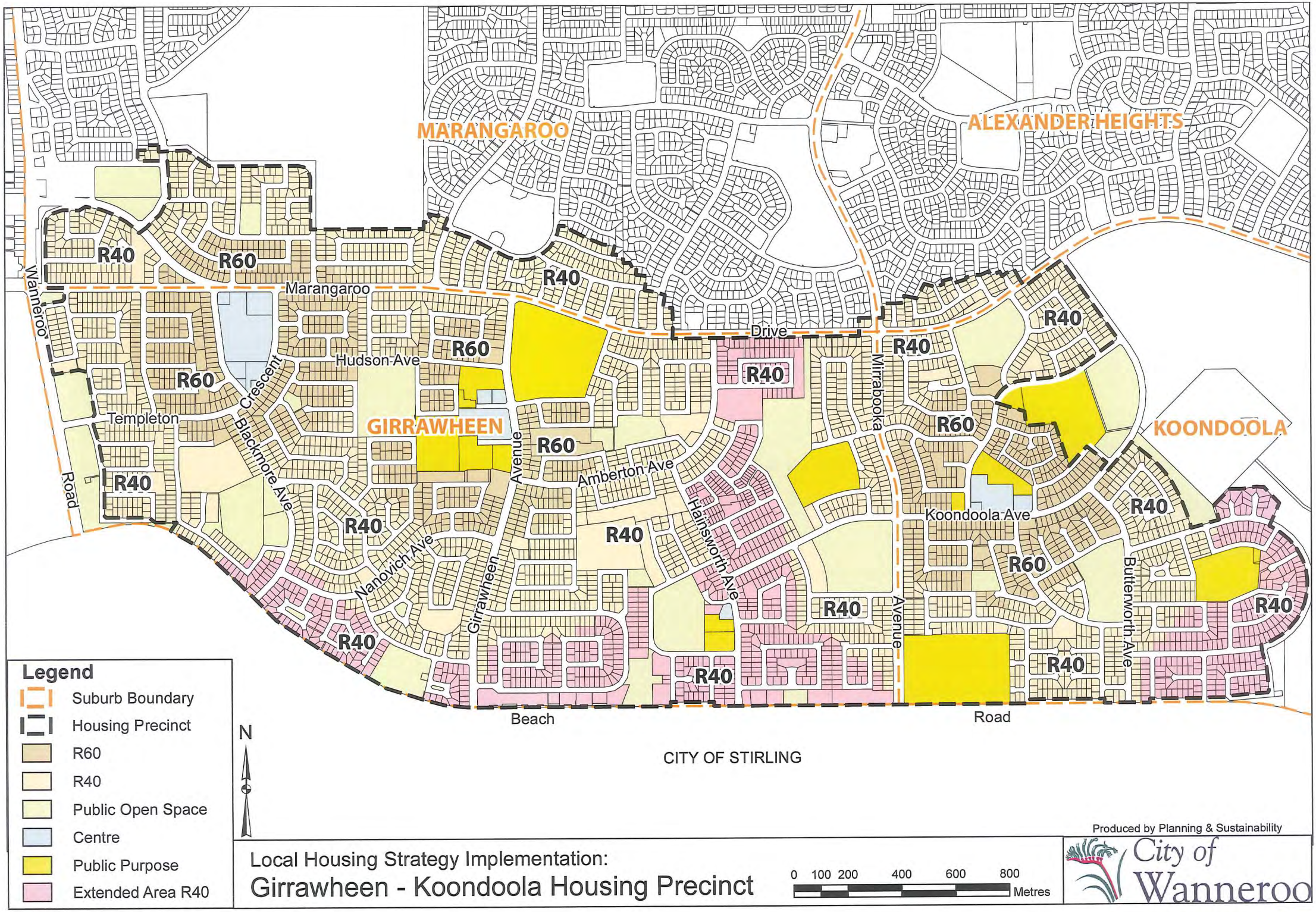
- Significant upgrades are required to both the existing sewer and water infrastructure to ensure they can cope with future demand.
- The estimated total cost to upgrade water reticulation infrastructure within the Precinct for critical catchments within the next two years is $3,990,000 (excl GST).
- Excluding works recommended within the next two years, upgrades will cost approximately $2.2 million per decade on average until the expected maximum build out date (2081).
- The estimated total cost for upgrades to sewer reticulation infrastructure is $720,000 (excl GST).
- A major sewer headworks upgrade is to be undertaken by the Water Corporation before a significant area within the Girrawheen-Koondoola Precinct is approved for redevelopment.

Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX A
LOCAL HOUSING STRATEGY PLANS

Cardno
Shaping the Future


Taywood
Wanneroo
Scenic
Drive
R40
Street
Church
Frederick
R60
Dundebar
Road
R60
R40
Karimba
Street
Civic
R40
Sinagra Street
R60
Drive
Street
Wanneroo
Showgrounds
Road
Drive
R40
R40
Avenue
Ariti
R40
Celestine
Street
N
Legend
Housing Precinct
R60
R40
Public Open Space
Centre
Public Purpose
Produced by Planning & Stustainabiliy
Local Housing Strategy Implementation:
Wanneroo Housing Precinct
0 100 200 400 600 800
Metres
City of
Wanneroo


MARANGAROO
ALEXANDER HEIGHTS
GIRRAWHEEN
KOONDOOLA
R40
R60
Wanneroo Road
Marangaroo Drive
Templeton Crescent
Hudson Ave
Blackmore Ave
Girrawheen Avenue
Amberton Ave
Nanovich Ave
Hainsworth Ave
Mirrabooka Avenue
Koondoola Ave
Butterworth Ave
Beach Road
CITY OF STIRLING
N
Legend
Suburb Boundary
Housing Precinct
R60
R40
Public Open Space
Centre
Public Purpose
Extended Area R40
Local Housing Strategy Implementation:
Girrawheen - Koondoola Housing Precinct
0 100 200 400 600 800
Metres
Produced by Planning & Sustainability
City of Wanneroo

Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX B

ESTIMATED RATES OF DEVELOPMENT OF NEW DWELLINGS IN WANNEROO

Cardno
Shaping the Future

City of Wanneroo

City of Wanneroo Local Housing Strategy

Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts

January 2011

Table of Contents

Estimated Rates of Development of New Dwellings in Wanneroo, Koondoola and Girrawheen Precincts

Background

This document supports the City of Wanneroo's Draft Amendment to Local Planning Policy 3.1: Local Housing Strategy Implementation (LHS).

The LHS identifies six 'Housing Precincts' divided across the suburbs of Wanneroo, Koondoola, Girrawheen, Yanchep, Two Rocks and Quinns Rocks. The Housing Precinct boundaries identified in the LHS are generally based on close proximity/easy access to existing retail and employment centres, public transport nodes, high amenity public open space, recreational facilities, major arterial routes and community facilities/education institutions.

These Housing Precincts are targeted for an increase in density coding from R20 to R40 or R60 as identified on LHS maps below.

The recommended density increases will require amendments to the City of Wanneroo District Planning Scheme No. 2 (DPS 2). In addition, other planning issues may also need to be addressed prior to or in support of amendment proposals. This includes assessment of the existing infrastructure provision and identification of possible infrastructure upgrades needed to facilitate redevelopment at a higher density, possible establishment of development contribution arrangements for funding of infrastructure upgrades, and preparation of design guidelines

Introduction

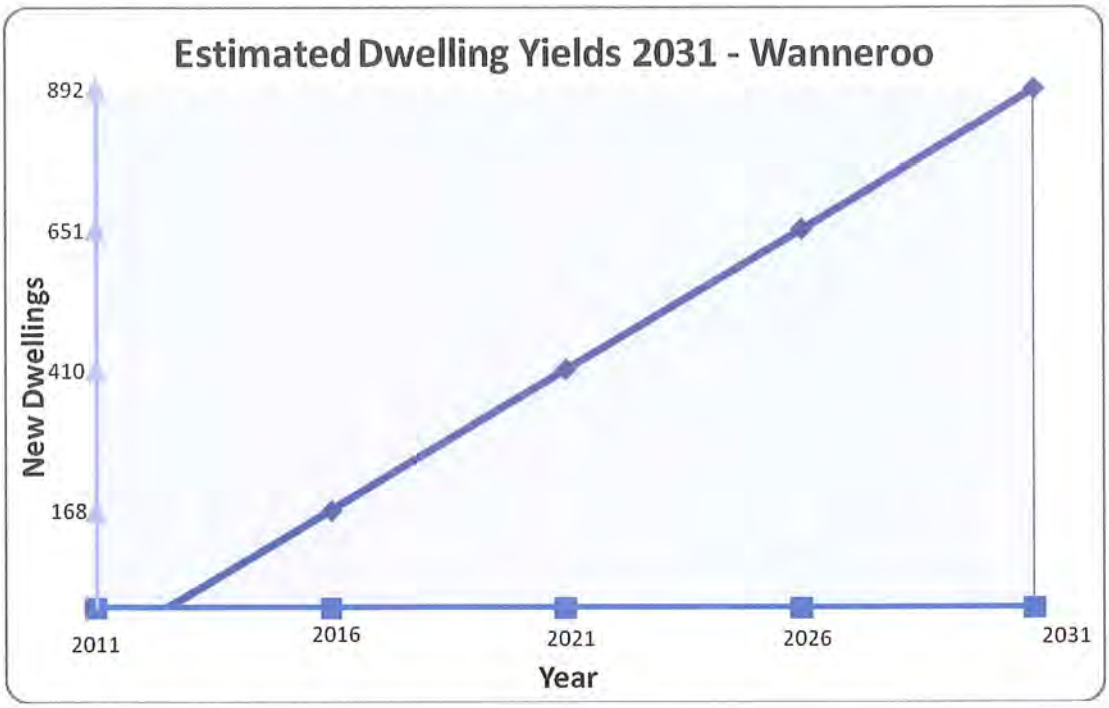
Discussion in this document will focus on the estimated rates of development of new dwellings in the precincts of Wanneroo and Girrawheen-Koondoola, as identified by the LHS. The methodology of how the City of Wanneroo calculated these rates of development will also be discussed.

The main purpose of this document is to enable service agencies to accurately assess both their relevant existing infrastructure and to identify any infrastructure upgrades that may be required by 2031 in the Housing Precincts of Wanneroo and Girrawheen-Koondoola using the following models created by the City of Wanneroo.

Wanneroo Housing Precinct

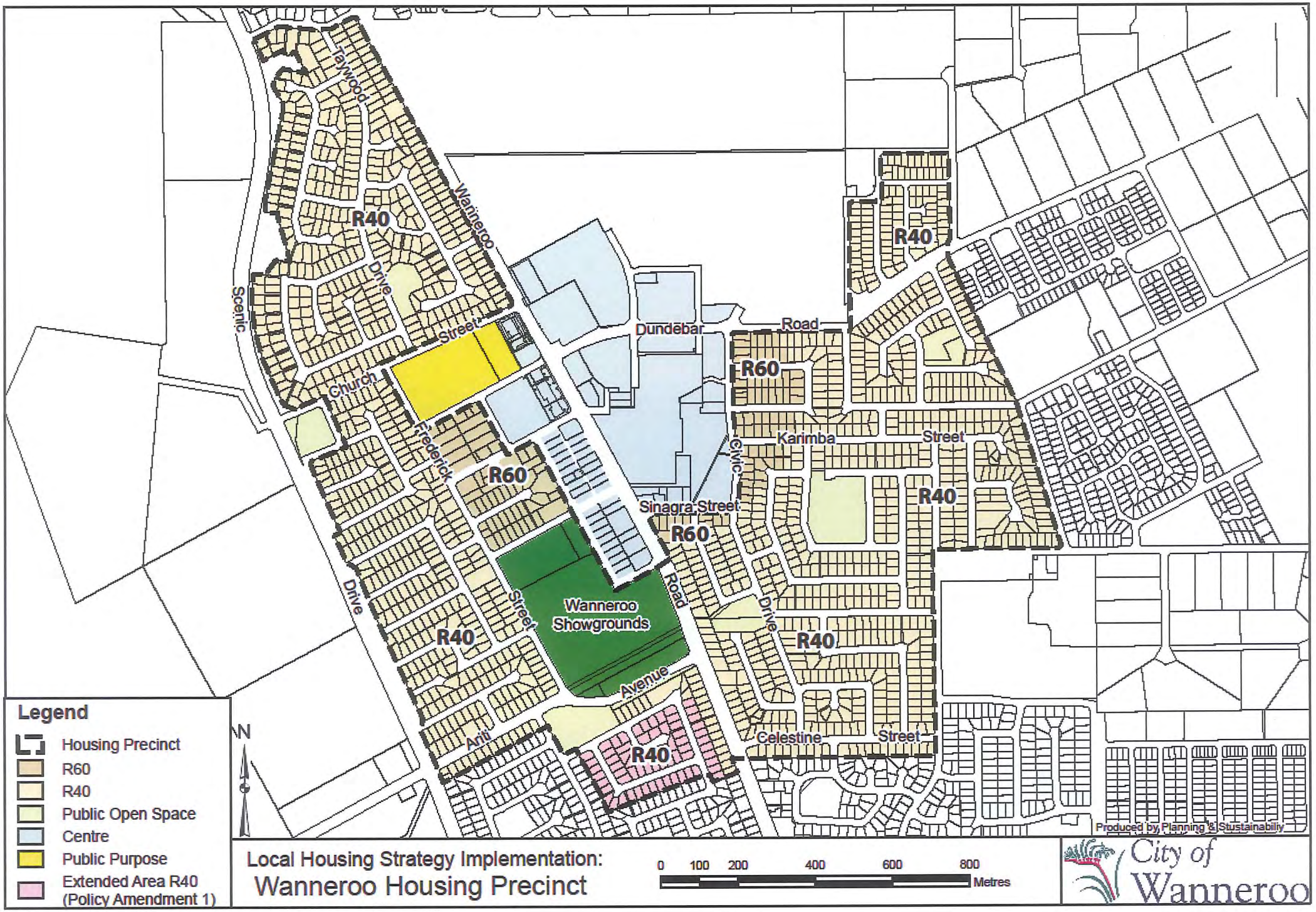
The following graph shows the estimated dwelling yields for the Wanneroo Housing Precinct.

Graph 1



As shown by Graph 1 above, it is estimated that by 2031, there shall be a total of 892 new dwellings in the Wanneroo Housing Precinct. This equates to roughly 45 new dwellings per year.

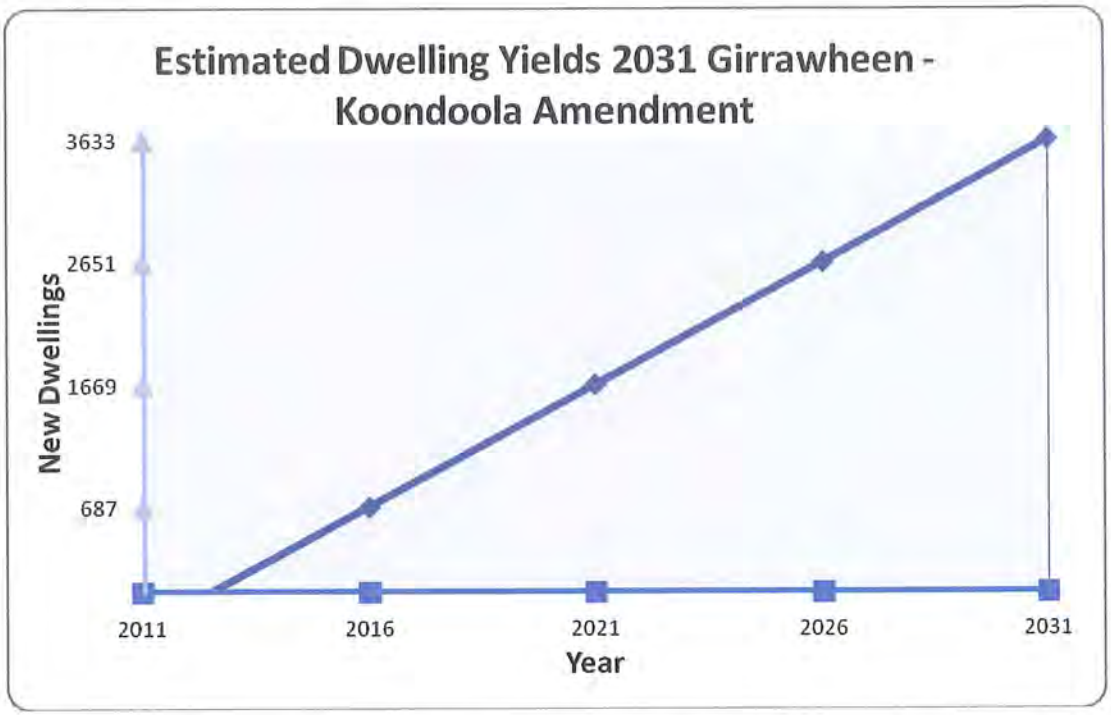
As explained below in 'Methodology', this figure is approximated using a number of techniques that reflect a realistic development scenario. If, however, every landowner was to subdivide his/her land to its maximum potential then the theoretical number of new dwellings that could be constructed would be 3678. Having said this, it is estimated that in over 80 years time at final build out, due to constraints in land layout, existing dwelling layout, personal reasons or location, this number will be closer to 2758 (75% of 3678).


Teywood
Wanneroo
Drive
Scenic
Street
Church
Frederick
Dundebar
Road
Karimba
Street
Civic
Sinagra Street
Drive
Street
Wanneroo
Showgrounds
Road
Drive
Avenue
Anti
Celestine
Street
R40
R60
R40
R60
R40
R60
R40
R40
R40
Produced by Planning & Stustainabiliy
Legend
Housing Precinct
R60
R40
Public Open Space
Centre
Public Purpose
Extended Area R40
(Policy Amendment 1)
N
Local Housing Strategy Implementation:
Wanneroo Housing Precinct
0 100 200 400 600 800
Metres
City of
Wanneroo

Girrawheen-Koondoola Housing Precinct

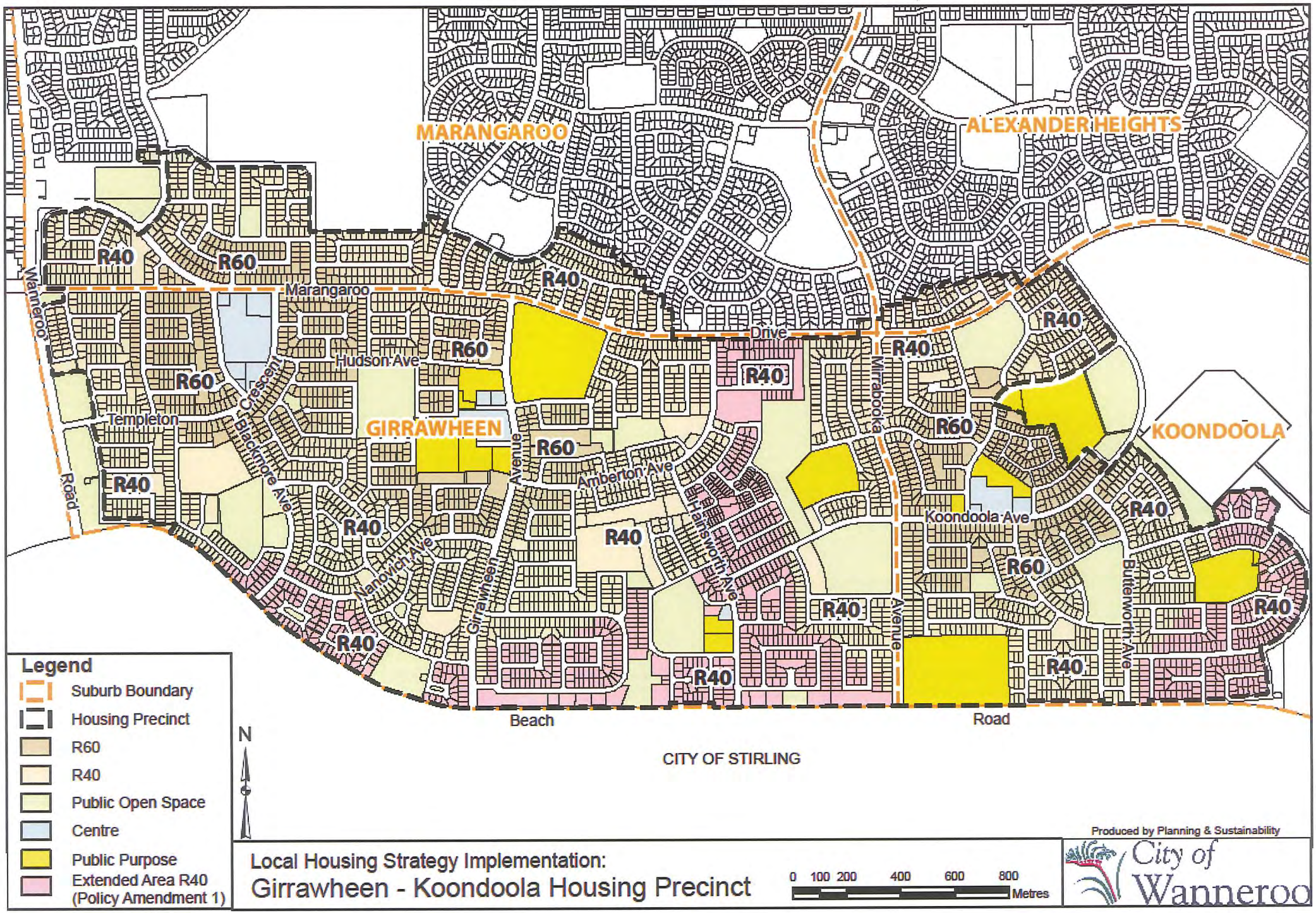
The following graph shows the estimated dwelling yields for the Girrawheen-Koondoola Housing Precinct.

Graph 2



As shown by Graph 2 above, it is estimated that by 2031, there shall be a total of 3,633 new dwellings in the Girrawheen-Koondoola Housing Precinct. This equates to roughly 181 new dwellings per year.

As explained below in 'Methodology', this figure is approximated using a number of techniques that reflect a realistic development scenario. If, however, every landowner was to subdivide his/her land to its maximum potential then the theoretical number of new dwellings that could be constructed would be 14,964. Having said this, it is estimated that in over 80 years time at final build out, due to constraints in land layout, existing dwelling layout, personal reasons or location, this number will be closer to 11,223. (75% of 14,964).


MARANGAROO
ALEXANDER HEIGHTS
KOONDOOLA
GIRRAWHEEN
Wanneroo Road
Marangaroo Drive
Hudson Ave
Templeton Crescent
Blackmore Ave
Girrawheen Avenue
Amberton Ave
Nanovich Ave
Transworth Ave
Mirrabooka Avenue
Koondoola Ave
Butterworth Ave
Beach Road
R40
R60
Legend
Suburb Boundary
Housing Precinct
R60
R40
Public Open Space
Centre
Public Purpose
Extended Area R40
(Policy Amendment 1)
N
CITY OF STIRLING
Local Housing Strategy Implementation:
Girrawheen - Koondoola Housing Precinct
0 100 200 400 600 800
Metres
Produced by Planning & Sustainability
City of Wanneroo

Summary

The large increase in dwellings per year of Girrawheen-Koondoola over Wanneroo is due to its larger number of lots and, as outlined in the LHS, three major centres have been identified in Girrawheen-Koondoola to increase to R60 coding instead of one centre as per all other Housing Precincts.

The following table shows the two precincts' predicted future growth.

	Wanneroo	Girrawheen-Koondoola
2011	0	0
2016	168	687
2021	410	1 669
2026	651	2 651
2031	892	3 633

The table below shows the effect of the additional areas, as per the LHS.

Precinct	Current Policy			Additional Area		
	2031	*Estimated Full Build Out (75%)*	*Theoretical Full Build Out (100%)*	*2031*	*Estimated Full Build Out (75%)*	*Theoretical Full Build Out (100%)*
Wanneroo	866	2 676	3 568	26	82	110
Girrawheen-Koondoola	2 894	8 942	11 922	739	2 281	3042

Precinct	Total Future Dwellings		
	2031	*Estimated Full Build Out (75%)*	*Theoretical Full Build Out (100%)*
Wanneroo	892	2 758	3 678
Girrawheen-Koondoola	3 633	11 223	14964

Methodology

In order to calculate dwelling yields for 2031, a number of variables were involved. These variables included lot sizes, number of lots, existing dwellings, and theoretical dwellings per lot.

Mean lot size in proposed R40 area	a
Mean lot size in proposed R60 area	b
Number of lots in proposed R40 area	c
Number of lots in proposed R60 area	d
Rounded down maximum dwellings per lot after recoding in R40 area	e
Rounded down maximum dwellings per lot after recoding in R60 area	f
Existing single dwellings	x
Existing multiple/grouped dwellings	y
Total dwellings (theoretical maximum)	t
Additional dwellings (theoretical maximum)	g
Additional dwellings (less 25%)	u
Estimated additional dwellings 2031	v

Step 1.

The maximum numbers of dwellings per lot (with proposed coding changes) are equated as follows:

$$e \text{ (unrounded)} = \frac{a}{220} \qquad f \text{ (unrounded)} = \frac{b}{160}$$

The values of 220 and 160 above are taken from the Residential Design Codes and are minimum average site area per dwelling requirements for R40 and R60 coded areas respectively. The above formula has therefore

calculated, on average, how many dwellings may be constructed on each lot, subsequent to recoding.

The above dwelling figures were then rounded down to 0 decimal places to recognise that a portion of a dwelling cannot be built. For example, in an area coded R40, a 650 m^2 lot can have a maximum of 2 dwellings built on it, the same as a 440 m^2 lot.

Step 2.
To calculate the total theoretical maximum amount of dwellings, the rounded-down maximum dwellings per lot is multiplied by the number of lots in the two separate coding areas.

$$t = e.c + f.d$$

Step 3.
Subtract the existing dwellings from the total (t) to achieve a value for the number of additional dwellings that will be created (g)

$$g = t - (x + y)$$

Step 4.
To allow for lots that may never be developed due to varying reasons such as landform, personal reasons, location, and existing dwelling layout, it has been assumed that 75% of the theoretical maximum number of new dwellings will actually ever eventuate:

$$u = 0.75g$$

Step 5.
To translate the above total figures into a rate of development, it is assumed that 35% of the estimated total additional dwellings will be achieved over a 20 year period. This is the rate that the Department of Planning has previously used to estimate rates of development in similar situations.

The 2031 additional dwelling estimate is therefore:

$$v = 0.35u$$

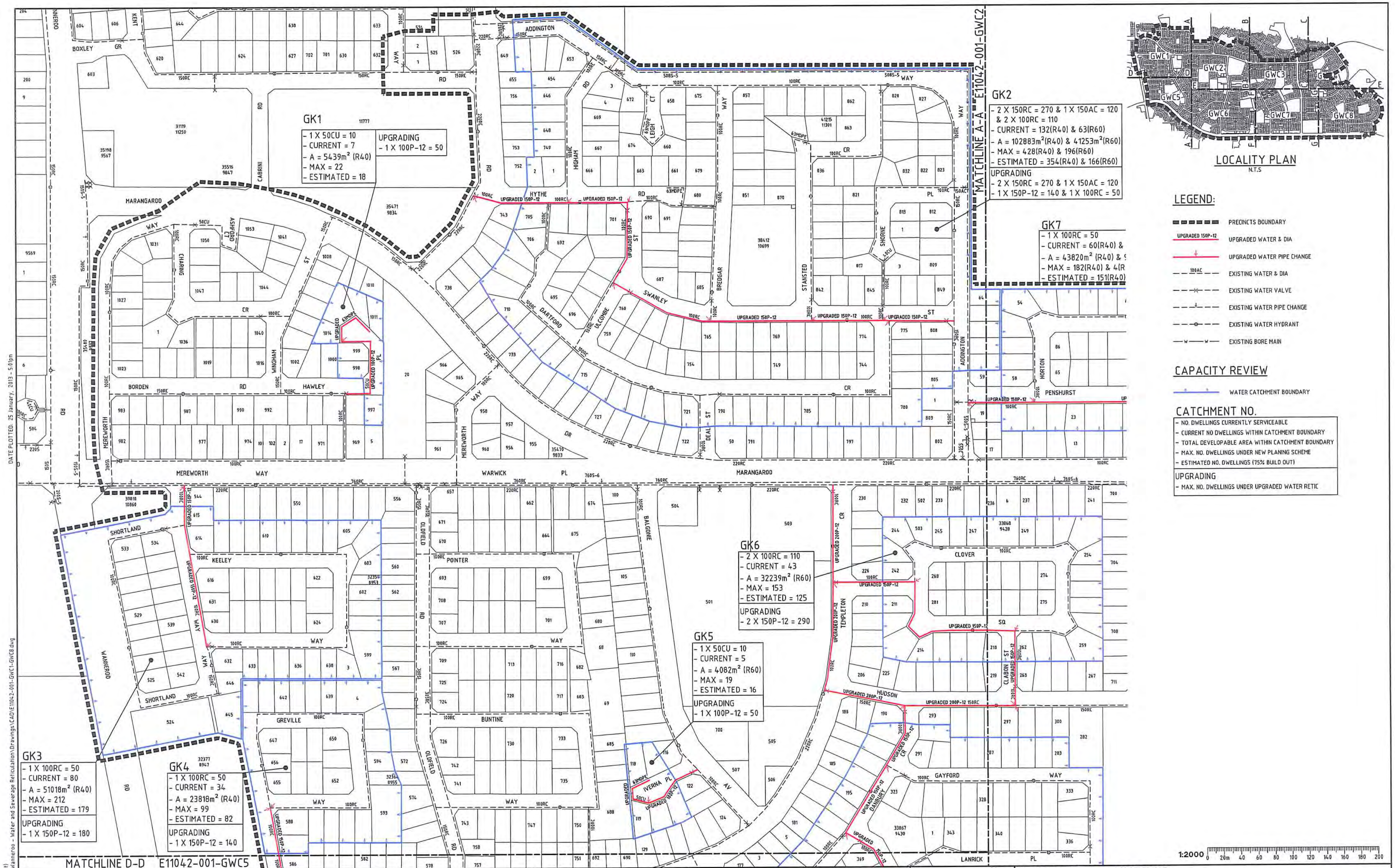
Finally, due to normal planning practices and any delays that may arise, development applications are estimated to take place in approximately 18 months time. This has been represented on the final graphs as a +1.5 year shift on the x axis.

Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX C

WATER RETICULATION – CONCEPT DESIGNS

Cardno
Shaping the Future



DATE PLOTTED: 25 January, 2013 - 5:01pm

XREF's: Xref_ OA(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn: JYY Date: 16.12.2011
Designed: Date:
Checked: Date:
Reviewed: Date:
Approved: Date:

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

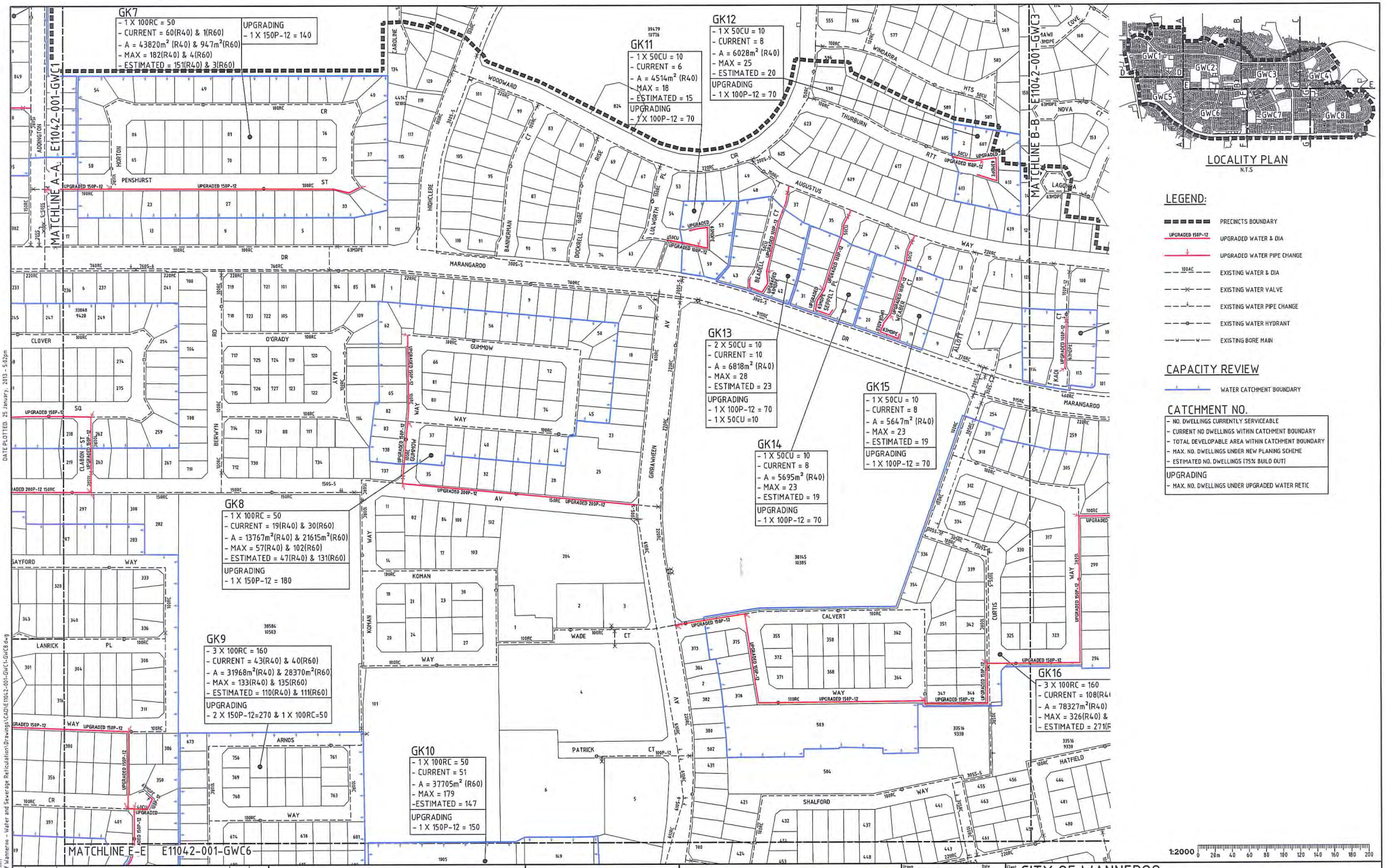
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 1 OF 8

Status: PRELIMINARY ISSUE

Date: 16.12.2011 | Datum: A.H.D | Scale: 1:2000 | Size: A1

Drawing Number: E11042-001-GWC1 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100RC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3031
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

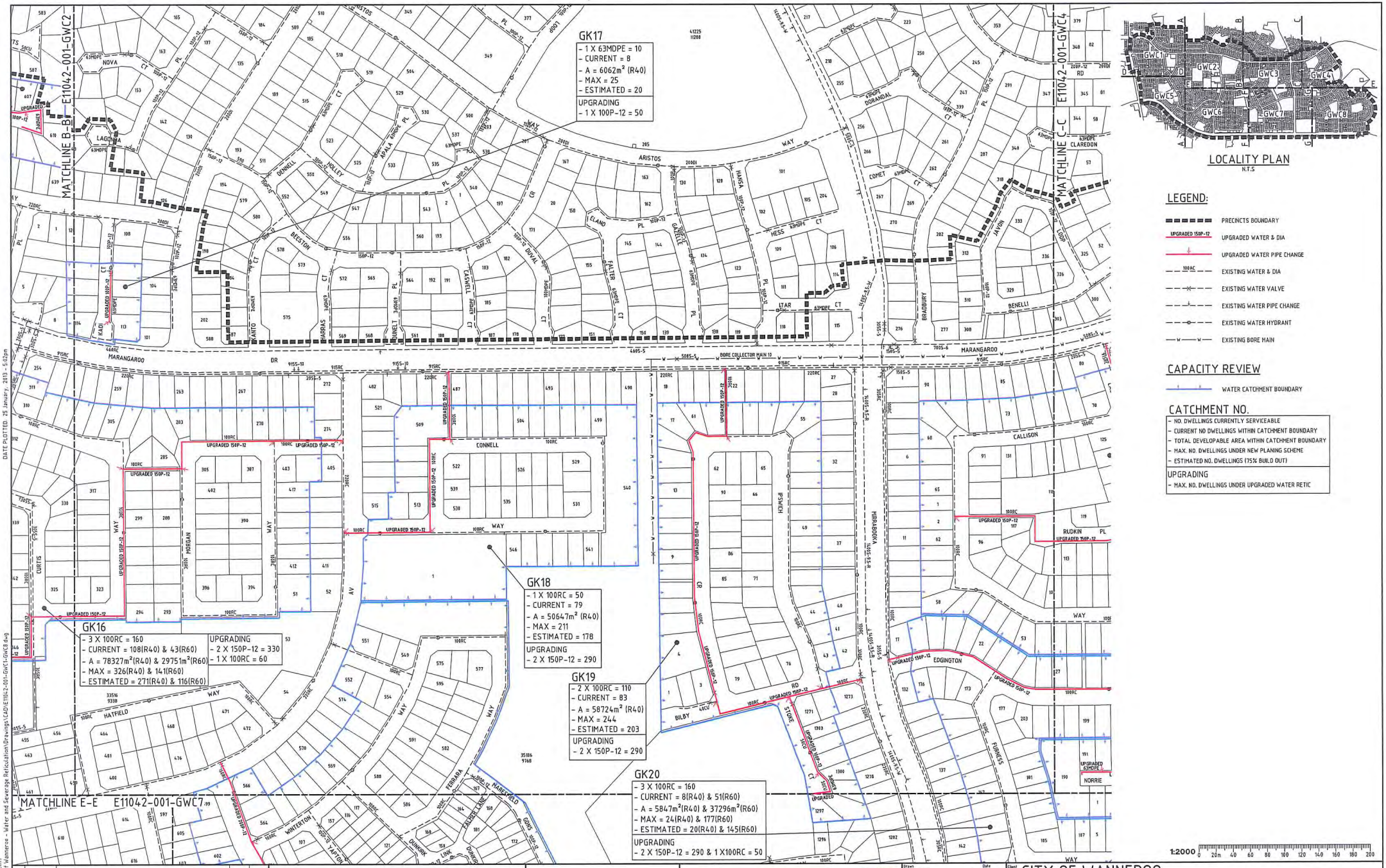
Drawn	JYY	Date	16.12.2011
Designed		Date	
Checked		Date	
Reviewed		Date	
Approved		Date	

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 2 OF 8

Status: PRELIMINARY ISSUE
Date: 16.12.2011 | Status: A.H.D | Scale: 1:2000 | Size: A1
Drawing Number: E11042-001-GWC2 | Revision: D

XREFs: x:\ref_Q&N\wanneroo Precinct
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg
DATE PLOTTED: 25 January, 2013 - 5:02pm



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

DATE PLOTTED: 25 January, 2013 - 5:02pm

XREFs: Xref: ...\Wanneroo Precinct\CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CATCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date 16.12.2011
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

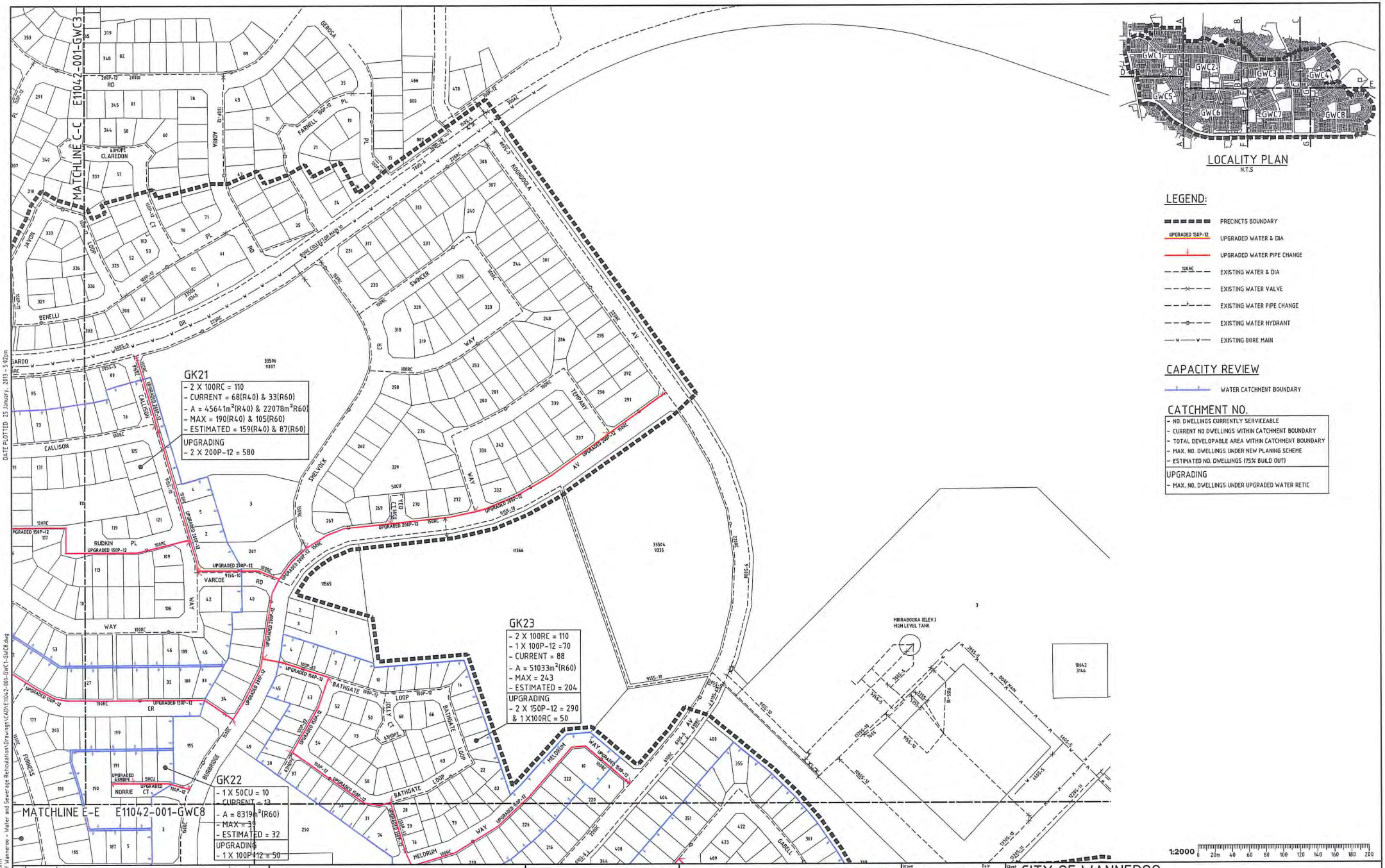
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
WATER CATCHMENT PLAN
SHT 3 OF 8

Status: PRELIMINARY ISSUE

Date	Datum	Scale	Size
16.12.2011	A.H.D	1:2000	A1

Drawing Number: E11042-001-GWC3
Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000
0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BOY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

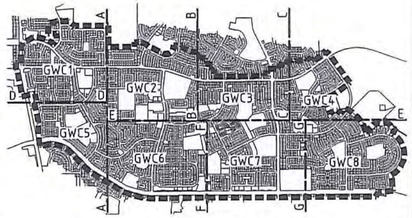
Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3931
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 710, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date	16.12.2011
Designed		Date	
Checked		Date	
Reviewed		Date	
Approved		Date	

Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 4 OF 8
Status: PRELIMINARY ISSUE
Date: 16.12.2011 | Datum: A.H.D | Scale: 1:2000 | Size: A1
Drawing Number: E11042-001-GWC4 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:42pm
XREFs: Xref - QA(Wanneroo Precinct)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn JYY Date 16.12.2011
Designed
Checked
Reviewed
Approved

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 5 OF 8

Status: PRELIMINARY ISSUE

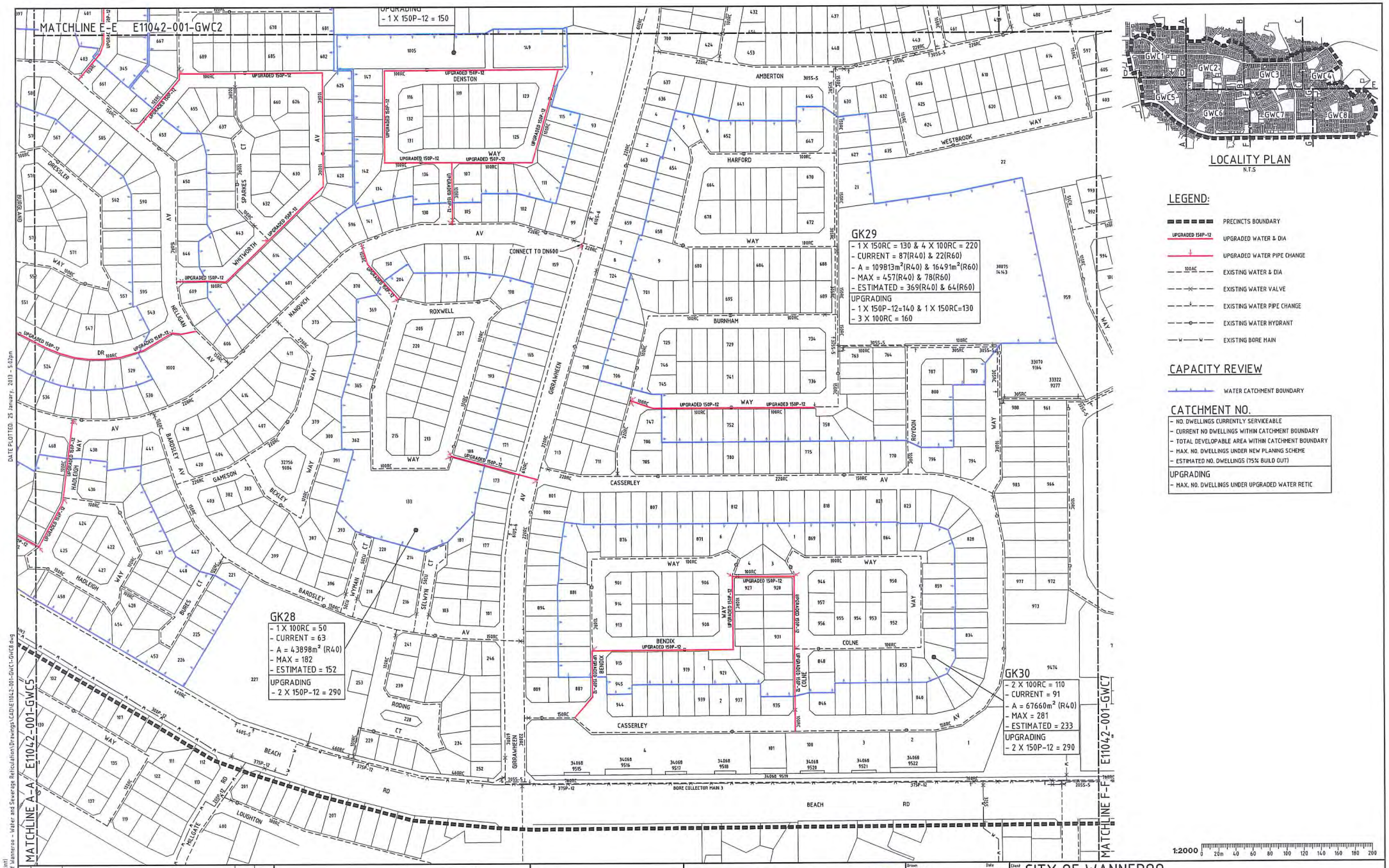
Date 16.12.2011 | Datum A.H.D | Scale 1:2000 | Size A1

Drawing Number E11042-001-GWC5 | Revision D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

DATE PLOTTED: 25 January, 2013 - 5:02pm

XREF's: Xref_0A(Wanneroo Precint)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Severage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

DATE PLOTTED: 25 January, 2013 - 5:42pm

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING EAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

		Date
Drawn	JYY	16.12.2011
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

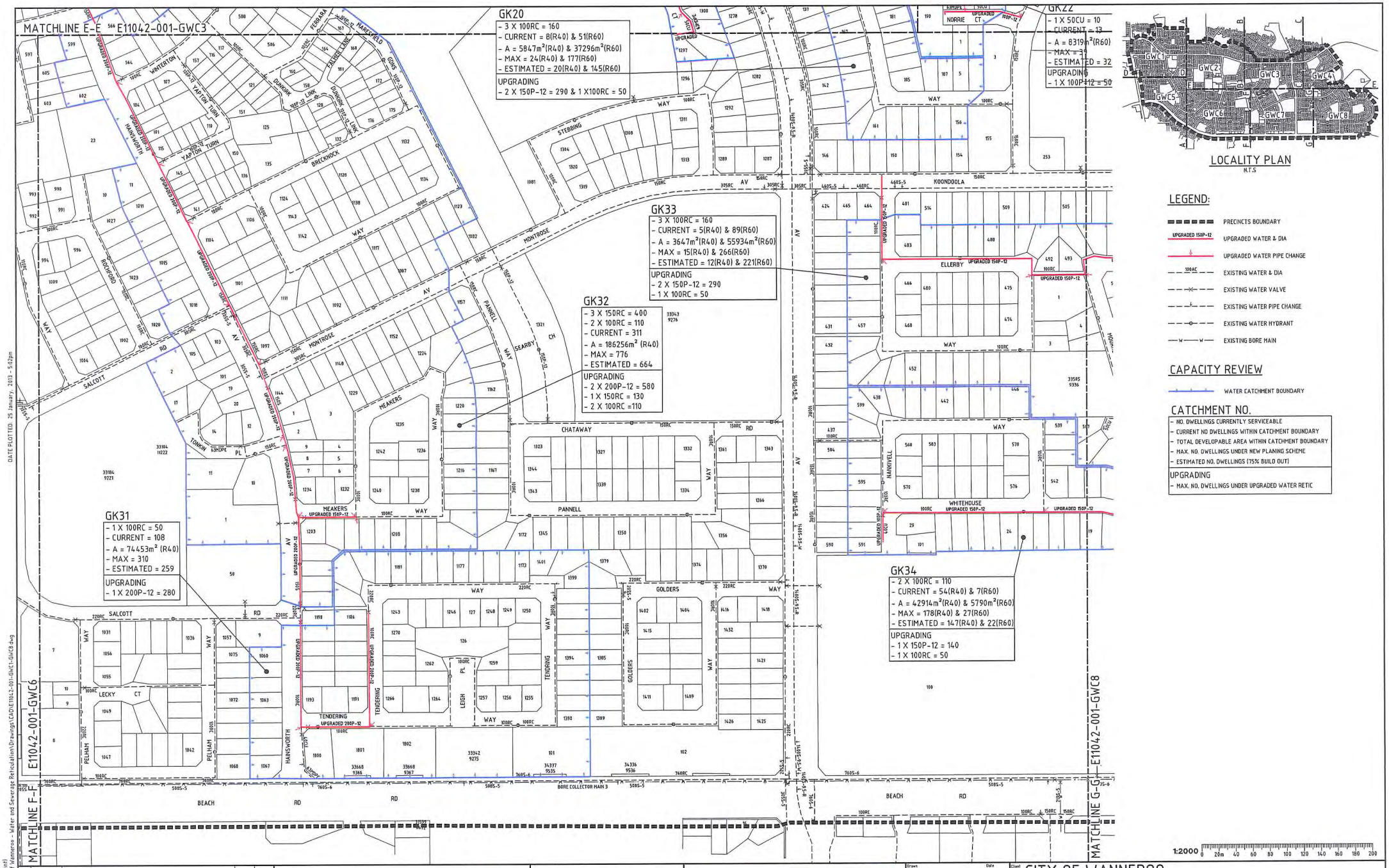
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
WATER CATCHMENT PLAN
SHT 6 OF 8

Status: PRELIMINARY ISSUE

Date	Datum	Scale	Size
16.12.2011	A.H.D	1:2000	A1

Drawing Number: E11042-001-GWC6
Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

DATE PLOTTED: 25 January, 2013 - 5:42pm

XREF's: Xref Q:\Wanneroo Precinct\CAD FILE\...\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 115, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date	16.12.2011
Designed		Date	
Checked		Date	
Reviewed		Date	
Approved		Date	

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

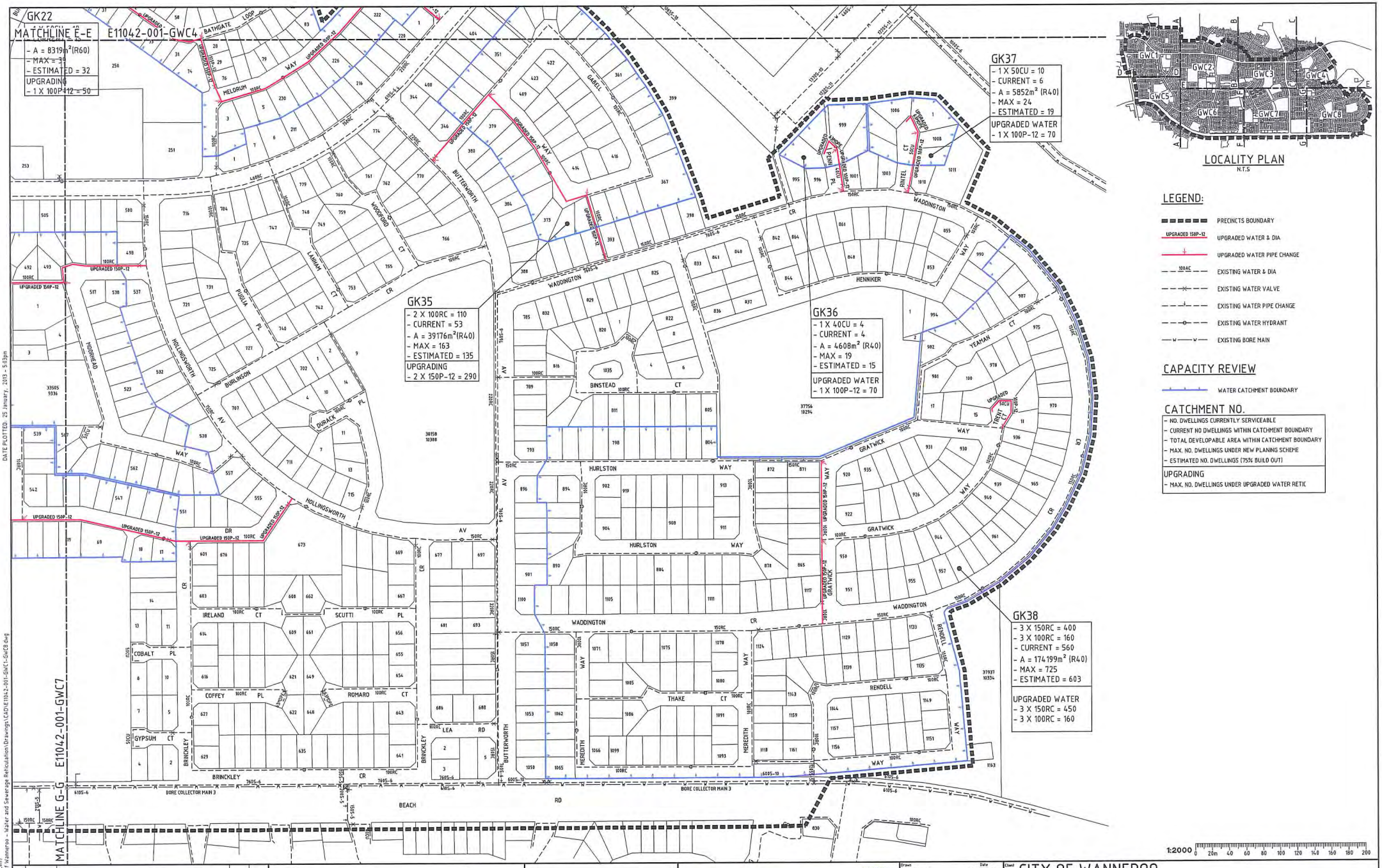
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 7 OF 8

Status: PRELIMINARY ISSUE

Date	Datum	Scale	Size
16.12.2011	A.H.D	1:2000	A1

Drawing Number: E11042-001-GWC7 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



DATE PLOTTED: 25 January, 2013 - 5:03pm

XREFs: Xref GA(Wanneroo Precinct)
CAD FILE: L:\JOY\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GWC1-GWC8.dwg

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3000 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY
Date	16.12.2011
Designed	
Date	
Checked	
Date	
Reviewed	
Date	
Approved	
Date	

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS WATER CATCHMENT PLAN SHT 8 OF 8

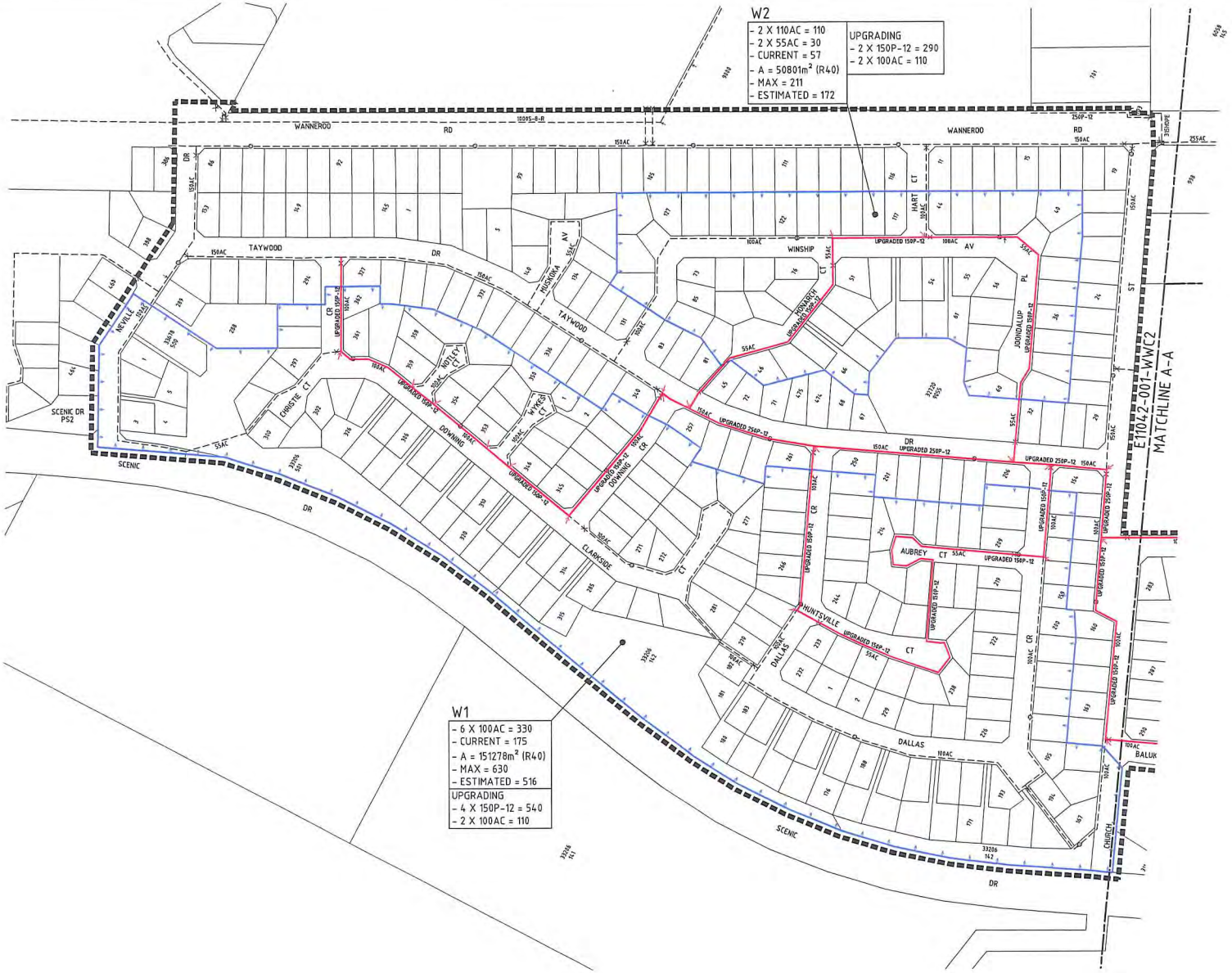
Status: PRELIMINARY ISSUE

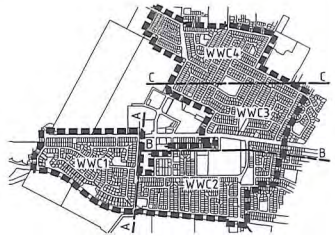
Date	Datum	Scale	Size
16.12.2011	A.H.D	1:2000	A1

Drawing Number: E11042-001-GWC8

Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL





LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000 0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.11.2011	PRELIMINARY ISSUE	JYY	JT

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3031
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date	16.12.2011
Designed		Date	
Checked		Date	
Reviewed		Date	
Approved		Date	

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

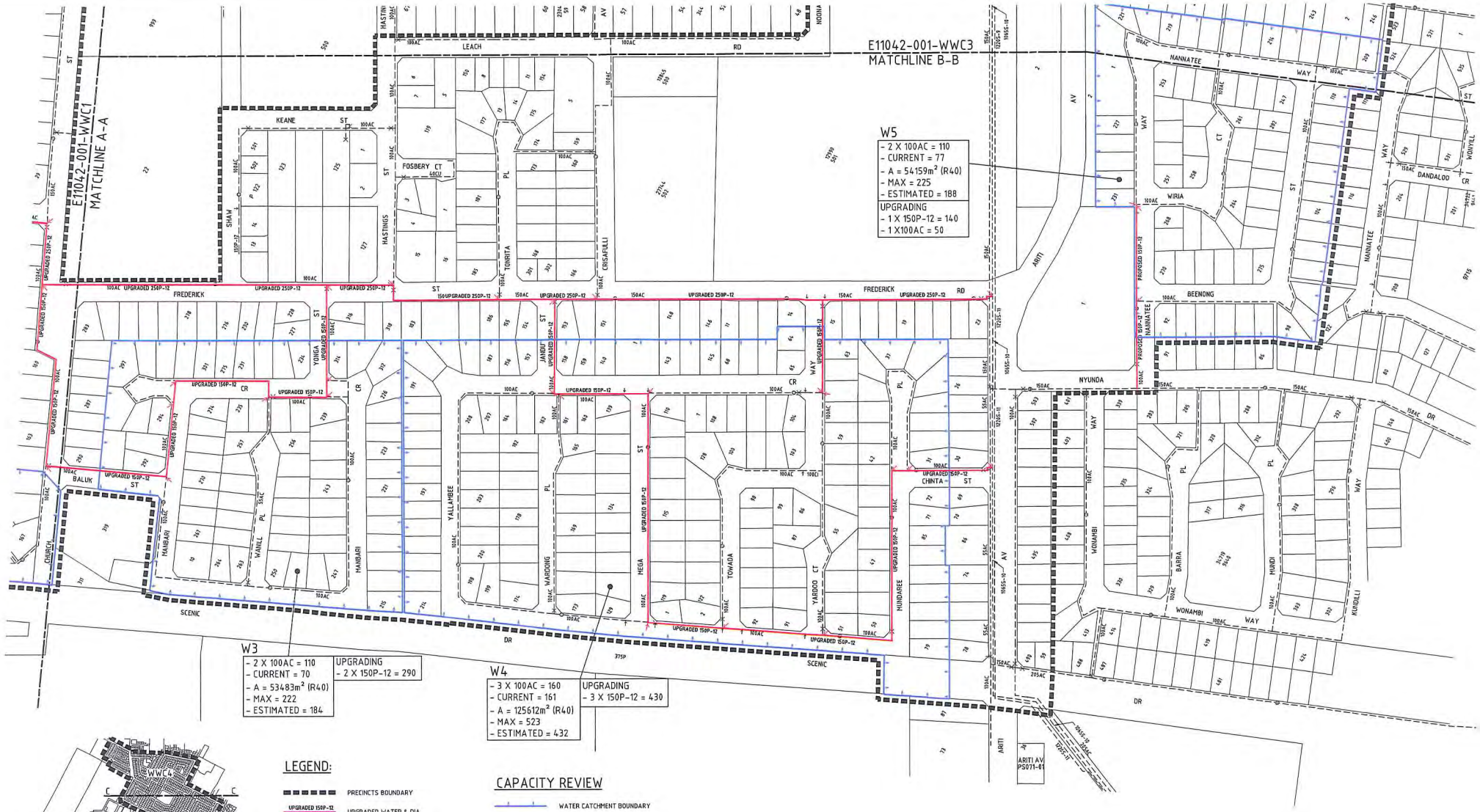
Title: WANNEROO HOUSING PRECINCT
WATER CATCHMENT PLAN
SHT 1 OF 4

Status: PRELIMINARY ISSUE

Date	Datum	Scale	Size
16.12.2011	A.H.D	1:2000	A1

Drawing Number: E11042-001-WWC1 Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC

1:2000
0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3031
South West Regional Office, Units 2-4, 69 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

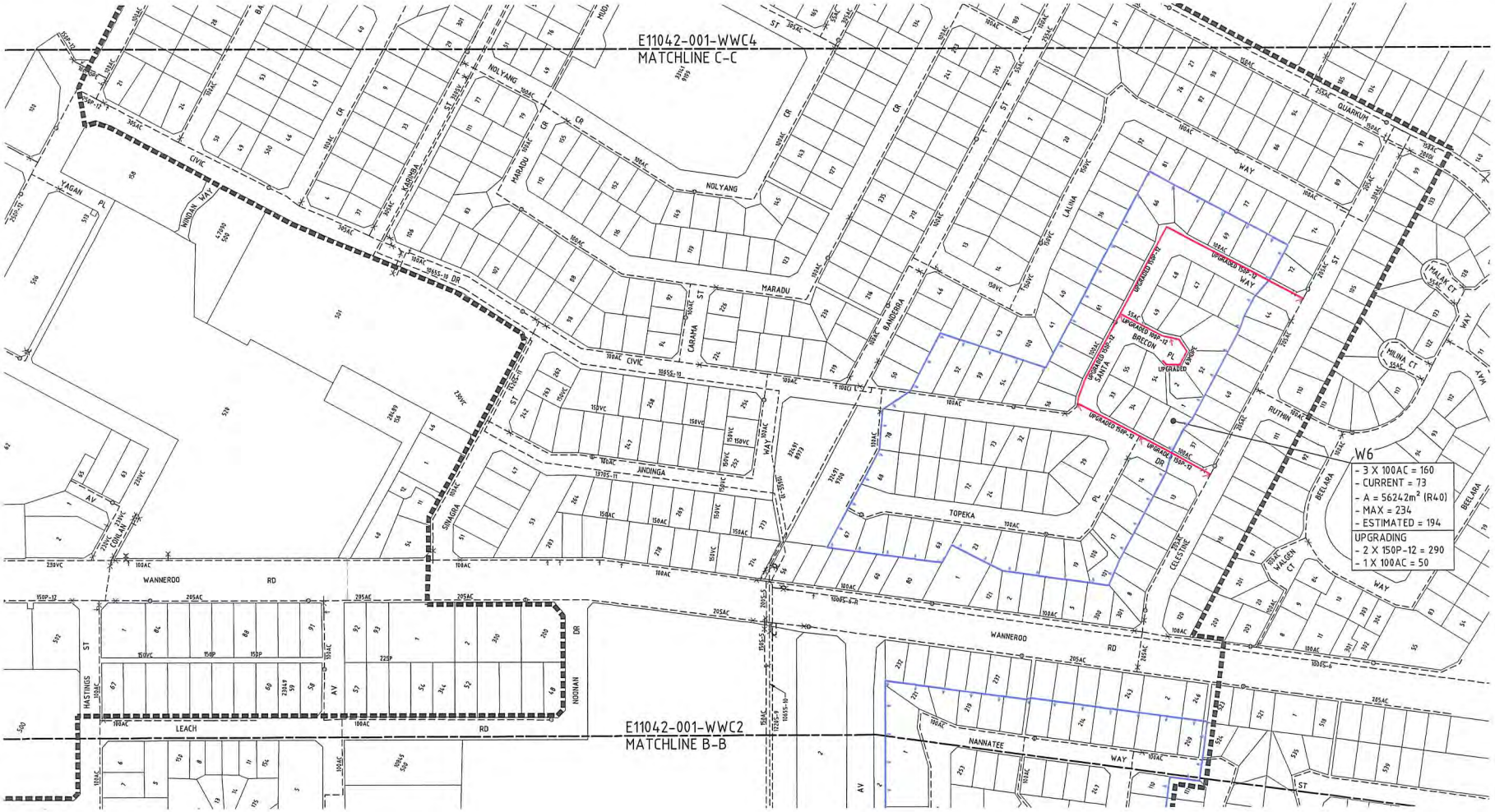
Drawn JYY Date 16.12.2011
Designed Date
Checked Date
Reviewed Date
Approved Date

Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 2 OF 4

Status: PRELIMINARY ISSUE
Date 16.12.2011 | Datum A.H.D | Scale 1:2000 | Size A1
Drawing Number: E11042-001-WWC2 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

XREFs: Xref DA(Wanneroo Precinct)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg
DATE PLOTTED: 25 January, 2013 - 5.07pm



LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

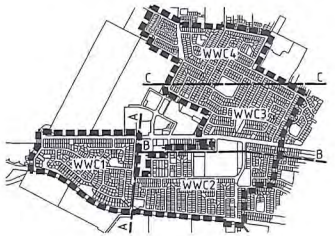
CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC



LOCALITY PLAN
N.T.S

1:2000 0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

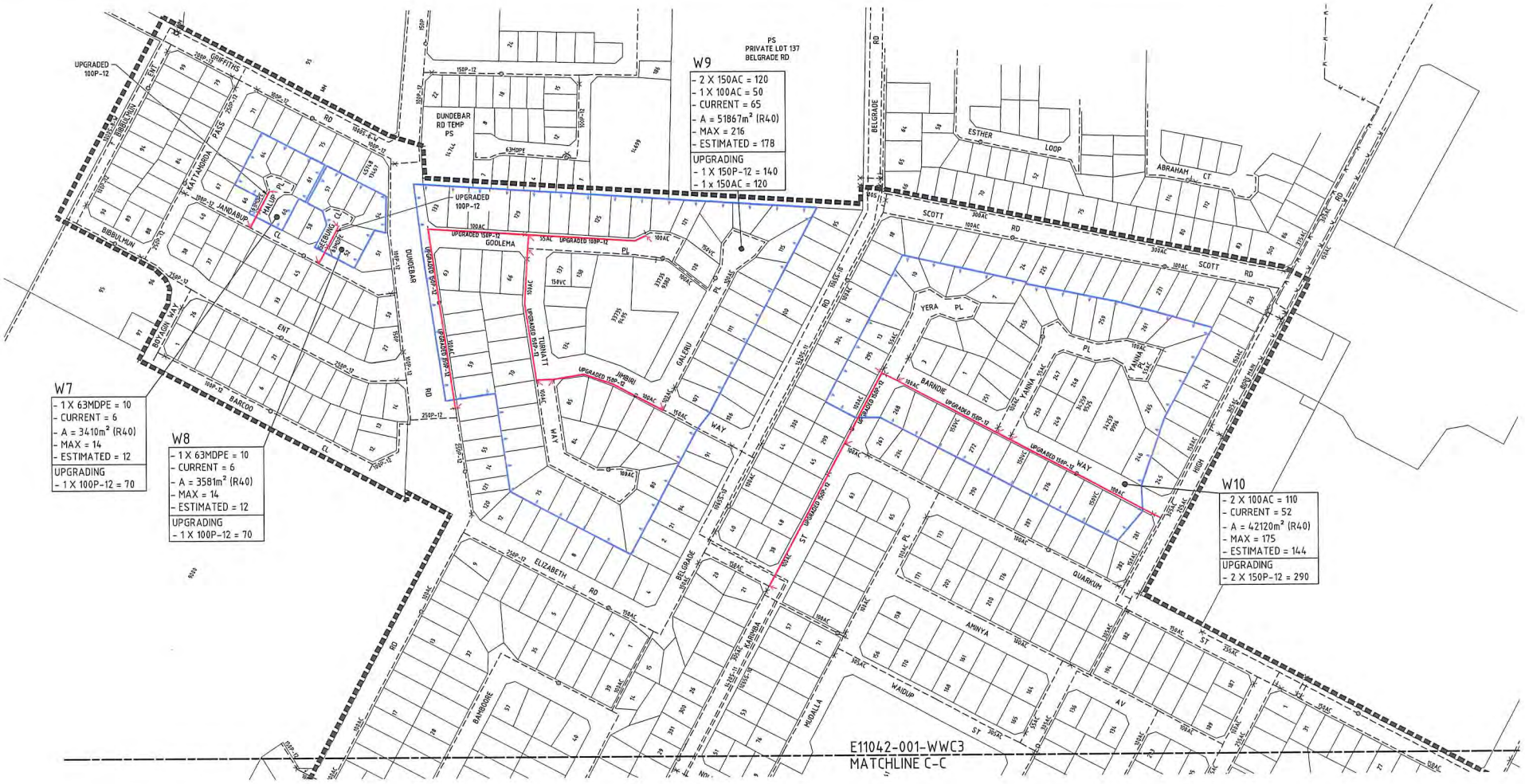
Drawn	JYY	Date 16.12.2011
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 3 OF 4

Status: PRELIMINARY ISSUE
Date: 16.12.2011 | Datum: A.H.D | Scale: 1:2000 | Size: A1
Drawing Number: E11042-001-WWC3 | Revision: D

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

XREFs: Xref_DA(Wanneroo Precinct)
CAD FILE L:\20NE\11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg
DATE PLOTTED: 25 January, 2013 - 5:07pm



LEGEND:

- PRECINCTS BOUNDARY
- UPGRADED 150P-12 — UPGRADED WATER & DIA
- UPGRADED WATER PIPE CHANGE
- 100AC — EXISTING WATER & DIA
- EXISTING WATER VALVE
- EXISTING WATER PIPE CHANGE
- EXISTING WATER HYDRANT
- W — W — EXISTING BORE MAIN

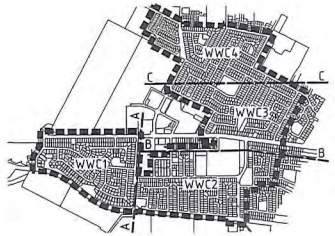
CAPACITY REVIEW

- WATER CATCHMENT BOUNDARY

CATCHMENT NO.

- NO. DWELLINGS CURRENTLY SERVICEABLE
- CURRENT NO DWELLINGS WITHIN CATCHMENT BOUNDARY
- TOTAL DEVELOPABLE AREA WITHIN CATCHMENT BOUNDARY
- MAX. NO. DWELLINGS UNDER NEW PLANING SCHEME
- ESTIMATED NO. DWELLINGS (75% BUILD OUT)

UPGRADING
- MAX. NO. DWELLINGS UNDER UPGRADED WATER RETIC



LOCALITY PLAN
N.T.S

1:2000 0 20m 40 60 80 100 120 140 160 180 200

Rev	Date	Description	Drawn	Appr.
D	12.12.2012	AMENDED CHTCHMENT BDY TYPE	JYY	
C	14.9.2012	AMENDED AS PER WC COMMENTS	JYY	
B	28.6.2012	AMENDED UPDATING CAL	JYY	
A	16.12.2011	PRELIMINARY ISSUE	JYY	JT

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date	16.12.2011
Designed		Date	
Checked		Date	
Reviewed		Date	
Approved		Date	

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

Client: CITY OF WANNEROO
Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Title: WANNEROO HOUSING PRECINCT WATER CATCHMENT PLAN SHT 4 OF 4
Status: PRELIMINARY ISSUE
Date: 16.12.2011 | Datum: A.H.D | Scale: 1:2000 | Size: A1
Drawing Number: E11042-001-WWC4 | Revision: D

XREFs: Xref: (DA\Wanneroo Precinct)
CAD FILE: L:\Z011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WWC1-WWC4.dwg
DATE PLOTTED: 25 January, 2013 - 5:07pm

Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX D

WATER RETICULATION – COST ESTIMATES & TRIGGER DATES

Cardno
Shaping the Future

PROJECT BUDGET - PRELIMINARY ONLY

Project:	City of Wanneroo - Water Reticulation
Reference:	E11042
Subject:	Project Budget 29-10-2012
Client:	City of Wanneroo

Trigger Date	*Total Cost*	*Precinct*
Critical	$ 1,389,000.00	W4
Critical	$ 181,000.00	GK3
Critical	$ 321,000.00	GK7
Critical	$ 563,000.00	GK10
Critical	$ 277,000.00	GK18
Critical	$ 99,000.00	GK22
Critical	$ 177,000.00	GK28
Critical	$ 338,000.00	GK31
Critical	$ 414,000.00	GK8
Critical	$ 143,000.00	GK13
Critical	$ 88,000.00	GK36
2015	$ 876,000.00	GK16
2017	$ 1,029,000.00	GK21
2022	$ 498,000.00	GK30
2023	$ 889,000.00	GK25
2024	$ 103,000.00	GK12
2024	$ 74,000.00	GK17
2025	$ 139,000.00	GK14
2025	$ 139,000.00	GK15
2028	$ 625,000.00	GK19
2031	$ 163,000.00	GK1
2033	$ 178,000.00	W5
2033	$ 679,000.00	GK23
2033	$ 103,000.00	GK37
2035	$ 99,000.00	GK4
2036	$ 921,000.00	W3
2043	$ 1,402,000.00	W1
2043	$ 84,000.00	GK5
2043	$ 96,000.00	GK11
2043	$ 476,000.00	GK34
2045	$ 402,000.00	GK33
2050	$ 506,000.00	GK9
2051	$ 768,000.00	GK32
2052	$ 479,000.00	GK26
2055	$ 443,000.00	W10
2058	$ 60,000.00	W7
2058	$ 60,000.00	W8
2060	$ 315,000.00	GK35
2061	$ 462,000.00	W6
2062	$ 512,000.00	W2
2063	$ 202,000.00	GK29
2066	$ 107,000.00	GK24
2068	$ 457,000.00	GK6
2072	$ 230,000.00	GK38
2074	$ 571,000.00	GK2
2076	$ 531,000.00	W9
2077	$ 407,000.00	GK20
2078	$ 367,000.00	GK27

WANNEROO HOUSE PRECINCT - WATER

	Quantities (m)				Trigger Dates			
Catchment	DN63	DN100	DN150	DN250	Exist lots	Estimated lots	Exist Capacity	Trigger date
W1			1198	481	175	516	330	2043
W2			613		57	172	140	2062
W3			706	375	70	184	110	2036
W4			1054	593	161	432	160	Critical
W5			188		77	188	110	2033
W6	52	46	460		73	194	160	2061
W7		40			6	12	10	2058
W8		40			6	12	10	2058
W9		112	532		65	178	170	2076
W10			525		52	144	110	2055
Sub-Total	52	238	5276	1449				
			Total	**7015**				

GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS - WATER

	Quantities (m)				Trigger Dates			
Catchment	DN63	DN100	DN150	DN200	Exist lots	Estimated lots	Exist Capacity	Trigger date
GK1	60	123			7	18	10	2031
GK2			688		195	530	500	2074
GK3			191		80	179	50	Critical
GK4			87		34	82	50	2035
GK5		72			5	16	10	2043
GK6			396	129	43	125	110	2068
GK7			370		61	154	50	Critical
GK8			175	275	49	178	50	Critical
GK9			605		83	221	160	2050
GK10			677		51	147	50	Critical
GK11	57	36			6	15	10	2043
GK12	69	34			8	20	10	2024
GK13	52	104			10	23	10	Critical
GK14	51	99			8	19	10	2025
GK15	53	97			8	19	10	2025
GK16			1076		151	387	160	2015
GK17		59			8	20	10	2024
GK18			314		79	178	50	Critical
GK19	47	96	625		83	203	110	2028
GK20			387	81	59	165	160	2077
GK21			271	879	101	246	110	2017
GK22	27	67			13	32	10	Critical
GK23			716	96	70	204	110	2033
GK24			97		77	208	180	2066
GK25		33	678	337	127	338	160	2023
GK26			571		58	148	110	2052
GK27			428		62	163	160	2078
GK28			186		63	152	50	Critical
GK29			218		109	433	350	2063
GK30			595		91	233	110	2022
GK31				344	108	259	50	Critical
GK32			68	765	311	664	510	2051
GK33			473		94	233	160	2045
GK34		35	534		61	169	110	2043
GK35			362		53	135	110	2060
GK36	29	51			4	15	4	Critical
GK37	28	72			6	19	10	2033
GK38		65	193		238	603	560	2072
Sub-Total	473	1043	10981	2906				
			Total	**15403**				

WANNEROO HOUSE PRECINCT - WATER

Catchment	Cost Estimate Prelims	Water Main	Reinstatement	Fees/Contingency	Total
W1	$ 25,000.00	$ 815,630.00	$ 327,405.00	$233,607.00	$ 1,401,642.00
W2	$ 25,000.00	$ 281,980.00	$ 119,535.00	$85,303.00	$ 511,818.00
W3	$ 25,000.00	$ 531,010.00	$ 210,795.00	$153,361.00	$ 920,166.00
W4	$ 25,000.00	$ 810,990.00	$ 321,165.00	$231,431.00	$ 1,388,586.00
W5	$ 25,000.00	$ 86,480.00	$ 36,660.00	$29,628.00	$ 177,768.00
W6	$ 25,000.00	$ 250,680.00	$ 108,810.00	$76,898.00	$ 461,388.00
W7	$ 25,000.00	$ 16,800.00	$ 7,800.00	$9,920.00	$ 59,520.00
W8	$ 25,000.00	$ 16,800.00	$ 7,800.00	$9,920.00	$ 59,520.00
W9	$ 25,000.00	$ 291,760.00	$ 125,580.00	$88,468.00	$ 530,808.00
W10	$ 25,000.00	$ 241,500.00	$ 102,375.00	$73,775.00	$ 442,650.00
				Sub-Total	$ 5,953,866.00

GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS - WATER

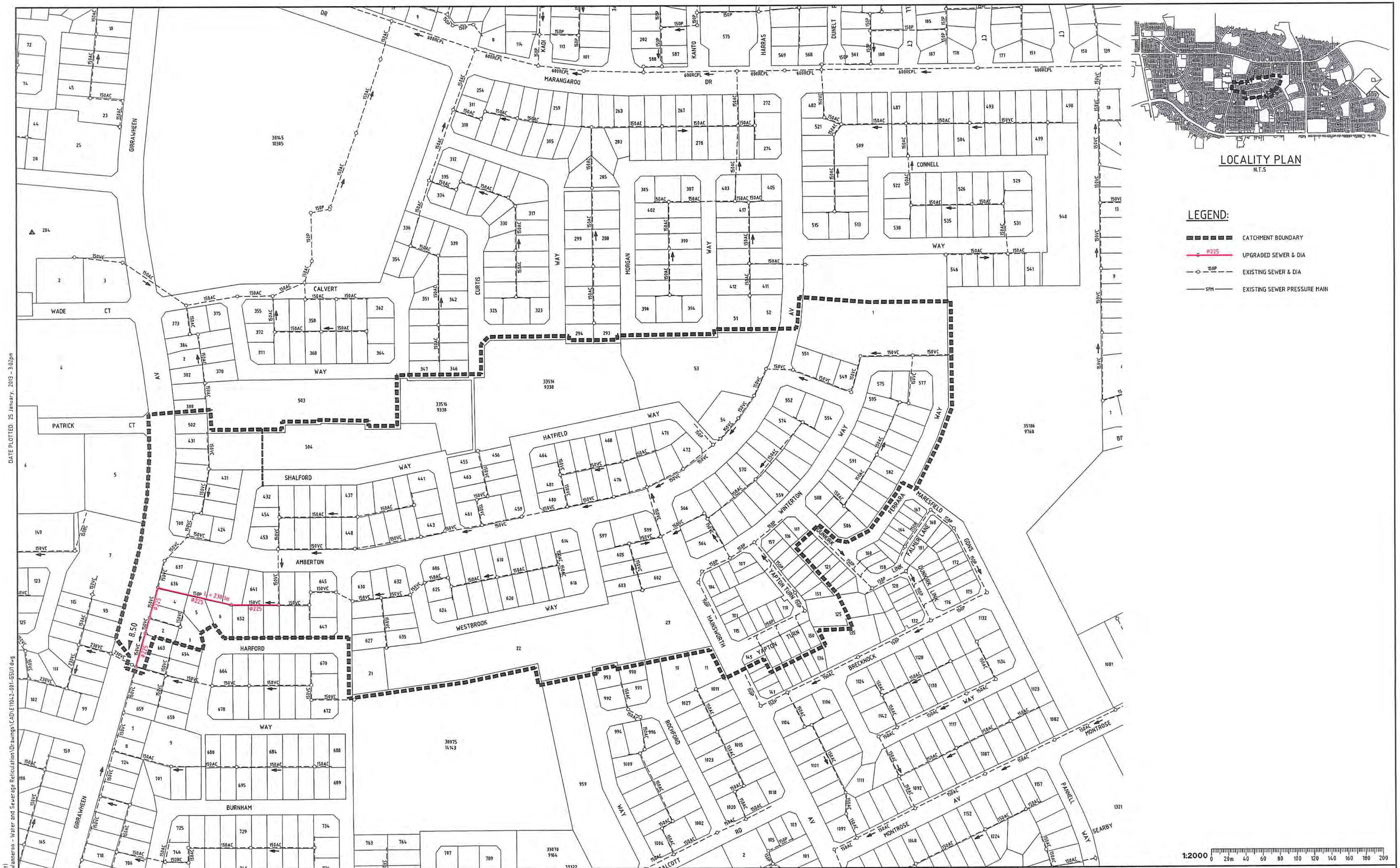
Catchment	Cost Estimate Prelims	Water Main	Reinstatement	Fees/Contingency	Total
GK1	$ 25,000.00	$ 74,460.00	$ 35,685.00	$27,029.00	$ 162,174.00
GK2	$ 25,000.00	$ 316,480.00	$ 134,160.00	$95,128.00	$ 570,768.00
GK3	$ 25,000.00	$ 87,860.00	$ 37,245.00	$30,021.00	$ 180,126.00
GK4	$ 25,000.00	$ 40,020.00	$ 16,965.00	$16,397.00	$ 98,382.00
GK5	$ 25,000.00	$ 30,240.00	$ 14,040.00	$13,856.00	$ 83,136.00
GK6	$ 25,000.00	$ 253,110.00	$ 102,375.00	$76,097.00	$ 456,582.00
GK7	$ 25,000.00	$ 170,200.00	$ 72,150.00	$53,470.00	$ 320,820.00
GK8	$ 25,000.00	$ 231,750.00	$ 87,750.00	$68,900.00	$ 413,400.00
GK9	$ 25,000.00	$ 278,300.00	$ 117,975.00	$84,255.00	$ 505,530.00
GK10	$ 25,000.00	$ 311,420.00	$ 132,015.00	$93,687.00	$ 562,122.00
GK11	$ 25,000.00	$ 36,780.00	$ 18,135.00	$15,983.00	$ 95,898.00
GK12	$ 25,000.00	$ 40,500.00	$ 20,085.00	$17,117.00	$ 102,702.00
GK13	$ 25,000.00	$ 63,440.00	$ 30,420.00	$23,772.00	$ 142,632.00
GK14	$ 25,000.00	$ 60,960.00	$ 29,250.00	$23,042.00	$ 138,252.00
GK15	$ 25,000.00	$ 60,880.00	$ 29,250.00	$23,026.00	$ 138,156.00
GK16	$ 25,000.00	$ 494,960.00	$ 209,820.00	$145,956.00	$ 875,736.00
GK17	$ 25,000.00	$ 24,780.00	$ 11,505.00	$12,257.00	$ 73,542.00
GK18	$ 25,000.00	$ 144,440.00	$ 61,230.00	$46,134.00	$ 276,804.00
GK19	$ 25,000.00	$ 345,680.00	$ 149,760.00	$104,088.00	$ 624,528.00
GK20	$ 25,000.00	$ 222,570.00	$ 91,260.00	$67,766.00	$ 406,596.00
GK21	$ 25,000.00	$ 608,110.00	$ 224,250.00	$171,472.00	$ 1,028,832.00
GK22	$ 25,000.00	$ 38,400.00	$ 18,330.00	$16,346.00	$ 98,076.00
GK23	$ 25,000.00	$ 382,160.00	$ 158,340.00	$113,100.00	$ 678,600.00
GK24	$ 25,000.00	$ 44,620.00	$ 18,915.00	$17,707.00	$ 106,242.00
GK25	$ 25,000.00	$ 511,090.00	$ 204,360.00	$148,090.00	$ 888,540.00
GK26	$ 25,000.00	$ 262,660.00	$ 111,345.00	$79,801.00	$ 478,806.00
GK27	$ 25,000.00	$ 196,880.00	$ 83,460.00	$61,068.00	$ 366,408.00
GK28	$ 25,000.00	$ 85,560.00	$ 36,270.00	$29,366.00	$ 176,196.00
GK29	$ 25,000.00	$ 100,280.00	$ 42,510.00	$33,558.00	$ 201,348.00
GK30	$ 25,000.00	$ 273,700.00	$ 116,025.00	$82,945.00	$ 497,670.00
GK31	$ 25,000.00	$ 189,200.00	$ 67,080.00	$56,256.00	$ 337,536.00
GK32	$ 25,000.00	$ 452,030.00	$ 162,435.00	$127,893.00	$ 767,358.00
GK33	$ 25,000.00	$ 217,580.00	$ 92,235.00	$66,963.00	$ 401,778.00
GK34	$ 25,000.00	$ 260,340.00	$ 110,955.00	$79,259.00	$ 475,554.00
GK35	$ 25,000.00	$ 166,520.00	$ 70,590.00	$52,422.00	$ 314,532.00
GK36	$ 25,000.00	$ 32,440.00	$ 15,600.00	$14,608.00	$ 87,648.00
GK37	$ 25,000.00	$ 40,880.00	$ 19,500.00	$17,076.00	$ 102,456.00
GK38	$ 25,000.00	$ 116,080.00	$ 50,310.00	$38,278.00	$ 229,668.00
				Sub-Total	$ 13,465,134.00
				Total	**$ 19,419,000.00**

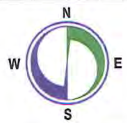
Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX E

SEWER RETICULATION – CONCEPT DESIGN

Cardno
Shaping the Future





Rev	Date	Description	Drawn	Appr.
A	22.01.2012	PRELIMINARY ISSUE	JYY	

Cardno

Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date 22.01.2012
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS SEWER RETIC UPGRADE PLAN SHT 1 OF 3

Status: PRELIMINARY

Date	Datum	Scale	Size
22.01.2012	A.H.D	1:2000	A1

Drawing Number: E11042-001-GSU1

Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

LOCALITY PLAN
N.T.S

LEGEND:

- CATCHMENT BOUNDARY
- Ø225 UPGRADED SEWER & DIA
- 150P EXISTING SEWER & DIA
- SPM EXISTING SEWER PRESSURE MAIN

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 29 January, 2013 - 12:21pm

XREFs: XYef: Oh(Wanneroo Precinct)
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU2.dwg

Rev	Date	Description	Drawn	Appr.
A	22.01.2012	PRELIMINARY ISSUE	JYY	

N W E S

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3631
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date 22.01.2012
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
SEWER RETIC UPGRADE PLAN
SHT 2 OF 3

Status: PRELIMINARY

Date	Datum	Scale	Size
22.01.2012	A.H.D	1:2000	A1

Drawing Number: E11042-001-GSU2
Revision: A

DATE PLOTTED: 25 January, 2013 - 3:43pm

XREFs: y:\Ref_Dir\Wanneroo Precinct\
CAD FILE: L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU3.dwg

Rev	Date	Description	Drawn	Appr.
A	22.01.2012	PRELIMINARY ISSUE	JYY	

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 69 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date 22.01.2012
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

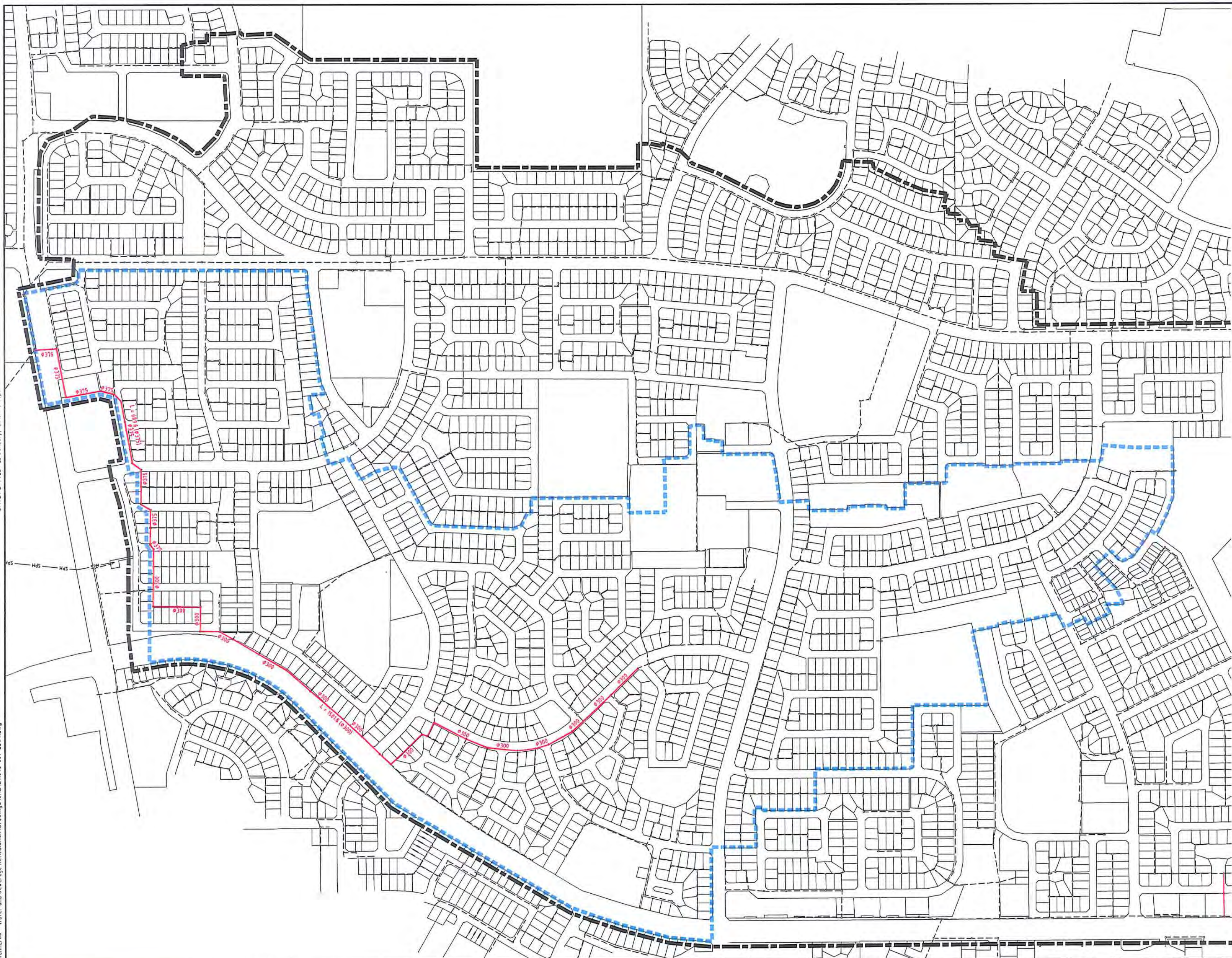
Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
SEWER RETIC UPGRADE PLAN
SHT 3 OF 3

Status: PRELIMINARY

Date	Datum	Scale	Size
22.01.2012	A.H.D	1:2000	A1

Drawing Number: E11042-001-GSU3
Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

PRECINCT BOUNDARY

CATCHMENT BOUNDARY

Ø225 UPGRADED SEWER & DIA

EXISTING SEWER

SPN EXISTING SEWER PRESSURE MAIN

1:4500 0 100m 200 300 400

XREF's Xref_GA(Wanneroo Precint)
CAD FILE L:\2011\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-GSU4.dwg
DATE PLOTTED: 25 January, 2013 - 5:07pm

Rev	Date	Description	Drawn	Appr
A	22.01.2012	PRELIMINARY ISSUE	JYY	

N
W E
S

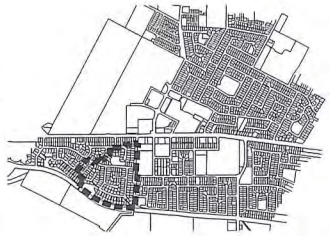
Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn: JYY	Date: 22.01.2012	Client: CITY OF WANNEROO
Designed	Date	Project: WATER AND SEWER RETICULATION SERVICES WANNEROO AND GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS
Checked	Date	
Reviewed	Date	Title: GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS SEWER HEADWORKS UPGRADE PLAN
Approved	Date	

Status			
PRELIMINARY			
Date: 22.01.2012	Datum: A.H.D	Scale: 1:4500	Size: A1
Drawing Number: E11042-001-GSU4			Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL



LOCALITY PLAN
N.T.S

LEGEND:

- CATCHMENT BOUNDARY
- Φ225 UPGRADED SEWER & DIA
- 150P EXISTING SEWER & DIA
- SPM EXISTING SEWER PRESSURE MAIN

1:2000 0 20m 40 60 80 100 120 140 160 180 200

DATE PLOTTED: 25 January, 2013 - 3:43pm

XREFs: Xref_GWI(Wanneroo Precnt); Xref_GWI(Wanneroo Precnt)
CAD FILE: L:\20\E11042 - City of Wanneroo - Water and Sewerage Reticulation\Drawings\CAD\E11042-001-WSU1.dwg

Rev	Date	Description	Drawn	Appr.
A	22.01.2012	PRELIMINARY ISSUE	JYY	

Cardno
Cardno (WA) Pty Ltd
Cardno Centre, 2 Bagot Road, P.O. Box 155
Subiaco Western Australia 6904
Phone (08) 9273 3888 Fax (08) 9388 3831
South West Regional Office, Units 2-4, 89 Duchess Street,
P.O. Box 713, Busselton Western Australia 6280
Phone (08) 9781 1444 Fax (08) 9752 2471

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

Drawn	JYY	Date 22.01.2012
Designed		Date
Checked		Date
Reviewed		Date
Approved		Date

Client: CITY OF WANNEROO

Project: WATER AND SEWER RETICULATION SERVICES
WANNEROO AND
GIRRAWHEEN-KOONDOOLA HOUSING PRECINCTS

Title: WANNEROO HOUSING PRECINCT
SEWER RETIC UPGRADE PLAN

Status: PRELIMINARY

Date	Datum	Scale	Size
22.01.2012	A.H.D	1:2000	A1

Drawing Number: E11042-001-WSU1
Revision: A

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150mm ON A1 ORIGINAL

Wanneroo & Girrawheen-
Koondoola Precincts

APPENDIX F

SEWER RETICULATION – COST ESTIMATES & TRIGGER DATES

Cardno
Shaping the Future

GIRRAWHEEN-KOONDOOLA/WANNEROO HOUSING PRECINCTS - SEWER

	Quantities (m)				Flow (L/s)			
Catchment	DN150	DN225			Exist flow	Estimated flow	Exist Capacity	Trigger date
WSU1		100			3.79	6.9	5	2039
GSU1		238			4.67	8.5	6	2036
GSU2		189			5.77	10.5	6	2016
GSU3		102			5.11	9.3	6	2027
Total		**629**						

GIRRAWHEEN-KOONDOOLA/WANNEROO HOUSING PRECINCTS - SEWER

	Cost Estimate				
Catchment	Prelims	Sewer Main	Reinstatement	Fees/Contingency	Total
WSU1	$ 25,000.00	$ 60,000.00	$ 19,500.00	$20,900.00	$ 125,400.00
GSU1	$ 25,000.00	$ 142,800.00	$ 46,410.00	$42,842.00	$ 257,052.00
GSU2	$ 25,000.00	$ 113,400.00	$ 36,855.00	$35,051.00	$ 210,306.00
GSU3	$ 25,000.00	$ 61,200.00	$ 19,890.00	$21,218.00	$ 127,308.00
				Total	**$ 720,066.00**

ATTACHMENT 3 – ROAD NETWORK CAPACITY STUDY

City of Wanneroo

Girrawheen - Koondoola Housing Strategy

Traffic Impact Assessment

January 2013

Table of contents

Table index

Figure index

Appendices

1. Introduction

The City of Wanneroo is proposing increases to R Coding in the Girrawheen-Koondoola Housing Precinct. This will result in a significant increase in the number of dwellings and population in this area, which will impact on the number of trips generated.

A plan showing the location of the Girrawheen - Koondoola Housing Precinct is shown overleaf in Figure 1-1 and Figure 1-2.

As a result, a traffic impact assessment (TIA) is required for the road network to satisfy MRWA and Department of Planning and for the local road network which is the City's responsibility. The broad requirements of the TIA are identified as follows:

- Assess impacts of this additional traffic on the immediate regional road network as well as the local road network
- Recommend improvements which may be required to those road networks to address the impacts
- Estimate for each of these improvements, the proportion of that improvement which can be considered attributable to the density increases in the Girrawheen-Koondoola Precinct, as distinct from population and traffic increases occurring in the wider region.
- Estimate costs for the undertaking of each of the recommended road network improvements and then applying the proportions estimated to each cost estimate.

1.1 Scope of work

The following scope of work has been undertaken:

- Land use input to Main Roads Regional Operations Model (ROM) to allow Main Roads to model the increased densities.
- Undertake localised modelling.
- Undertake Sidra intersection analysis for the following scenarios:
  - Existing layout to 2031, no local housing strategy (LHS) forecast traffic volumes.
  - Proposed layout using future traffic volumes 2031 with LHS.
- Make recommendations for road network improvements.
- Prepare concept designs for improvements.
- Prepare cost estimates.
- Apportion costs based on ROM modelling.
- Prepare final report.

Figure 1-1 Study area

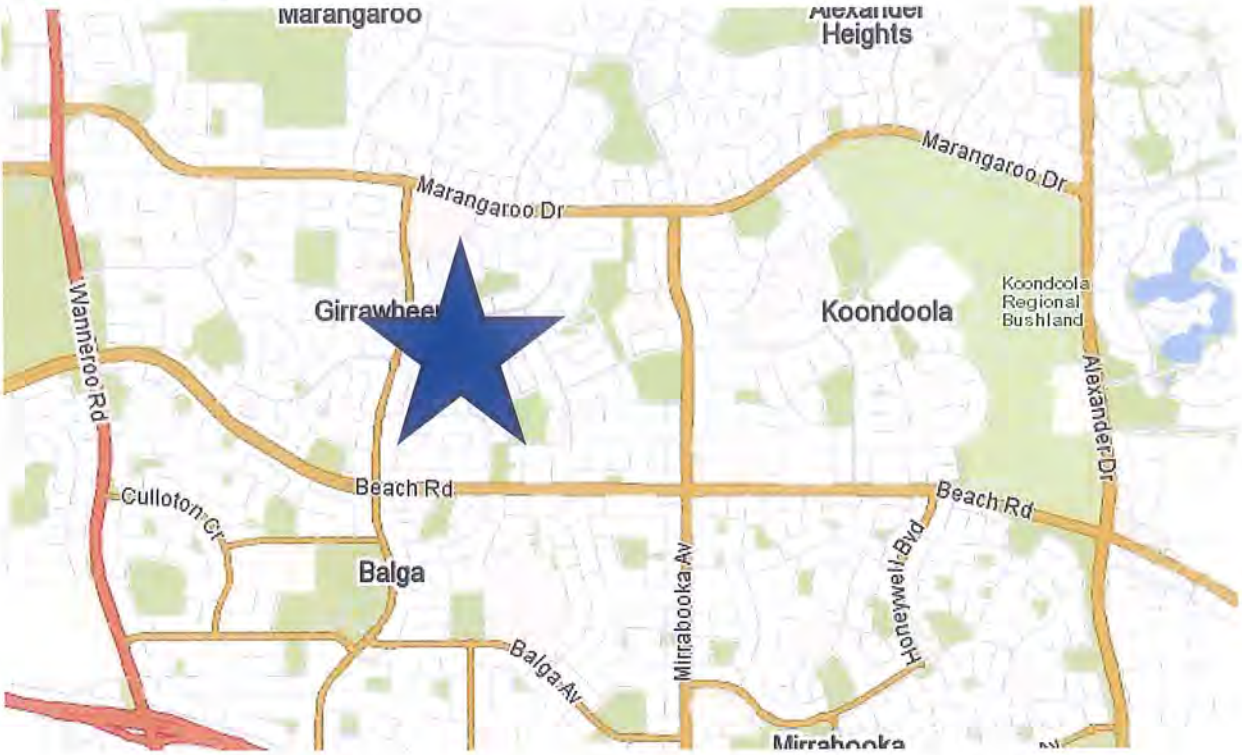
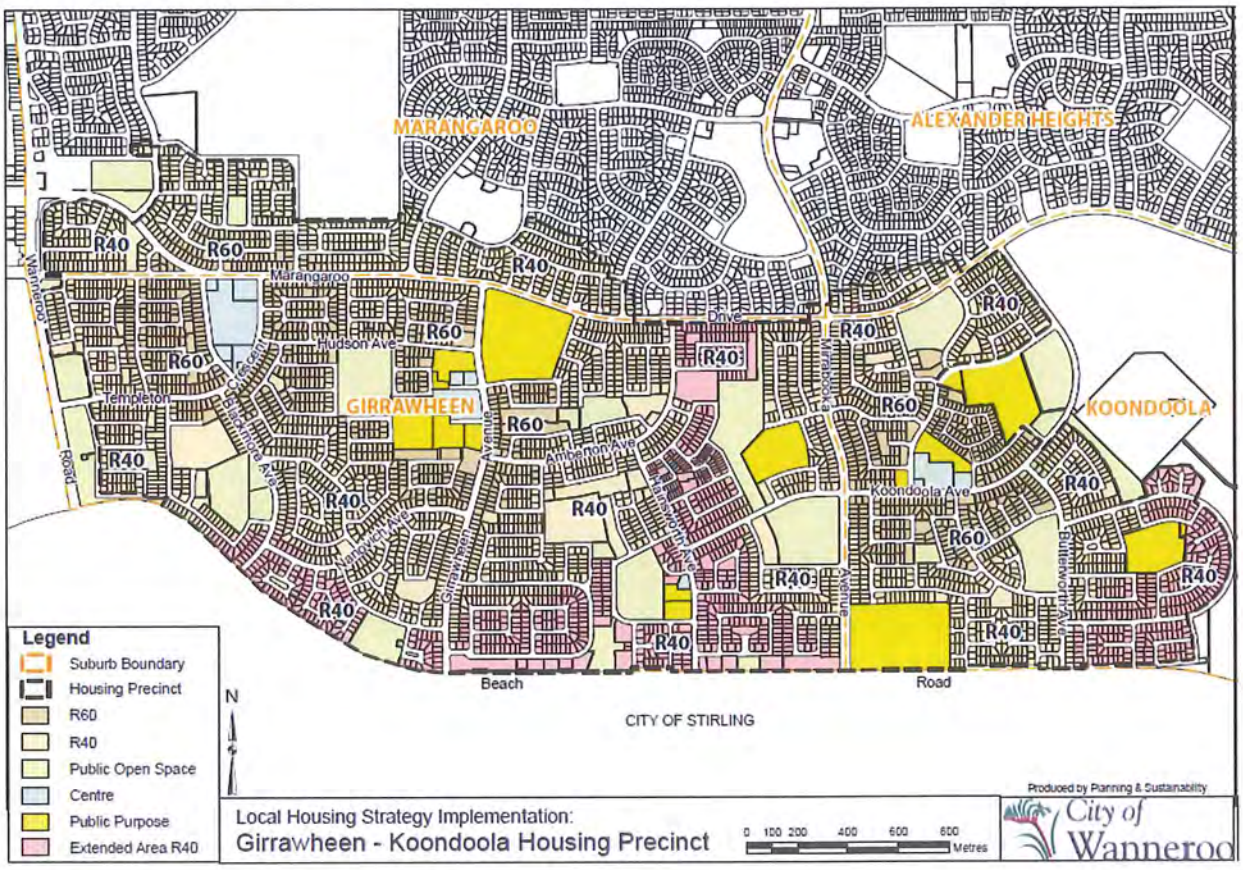


Figure 1-2 Housing strategy area



2. Stakeholder liaison

2.1 City of Wanneroo

The following summarises the consultation with the City of Wanneroo.

- An inception meeting was held with Planning Officers at the City of Wanneroo. The following was discussed.
  - Base aerial photo, high resolution - Council will arrange.
  - Traffic data - Planners were liaising with Council's engineers and will provide any available information.
  - Intersection Counts – Main Roads have been asked for SCATS info at all relevant signals. GHD will need to arrange others up to the PS value.
  - Council were asked for their construction rates for our subsequent costing of measures.
  - Council can provide suitable base for any conceptual design.
  - Shawmac report for Wanneroo TC has been provided.
  - GHD's Planning staff to follow up with Council regarding Structure Plans.
  - Council were advised GHD can provide estimate of costs for land acquisition (based on Council advice regarding land costs), design costs and survey costs. However we cannot provide costs for services implications only flag issues. Council were advised that costing for relocation, protection etc is impossible at this stage. GHD will flag issues based on One Call Info and allow a contingency based on experience elsewhere (subject to exclusions and qualifications).
  - Council advised that the contact for liaison with DoT is Mohsin Mutaqui.
  - Council advised that the contacts at Main Roads are John Van Luen, David van Den Dries, Wes Soet (modelling)

Council advised recent road upgrades include:

- Pinjar Rd/Wanneroo Rd signals
- Dundebar Rd/Wanneroo Rd, double right turn from Dundebar Road is underway.
- There are plans for Wanneroo Rd north of Dundebar Rd (need to speak to Main Roads)
- Wanneroo Rd (Ashby to Tapping recently upgraded)
- Grade separation of Ocean Reef Rd/Wanneroo Rd long term plan (discuss timing with Main Roads)
- Ocean Reef Road now connects with Gnangara Road.

Council confirmed:

- Important to look specifically at traffic volume increase within the precincts of Wanneroo and Girrawheen - Koondoola and their impacts.
- Keep client advised of progress and any issues.
- Council were advised of likely delays in ROM modelling turnaround in view of Main Roads commitments in this area.

- The City were consulted regarding the content of the land use input to the ROM model and asked for acceptance of the results prior to asking Main Roads to run the ROM model.

2.2 Main Roads Western Australia (MRWA)

Contact was made with Main Roads as follows:

- Main Roads WA were contacted for base traffic data including:
  - SCATS information
  - ROM model traffic zones for land use input
  - Traffic signal information
- Main Roads were also consulted regarding confirmation of the extent of Paramics modelling and ROM areas to be modelled.
- Main Roads were asked to advise of any road upgrades planned in the future and GHD were advised that no works were planned that would impact on this study.
- Regular contact was made with Main Roads modelling section (Dr Wes Soet) to confirm the modelling requirements and inputs for the study in May July and August 2012. Discussion was also held with David Van Den Dries at Main Roads on 19 June 2012 regarding the extent of the modelling and confirmation of the area of influence.
- Responses to comments made by Main Roads on the draft report are shown in Appendix G.

2.3 Department of Transport (DoT)

Contact was made with the DoT regarding the East Wanneroo North-South Road (EWNSR) and the following provides a summary of the current status:

- Department of Planning has completed a route alignment study for the East Wanneroo N-S Road between East Wanneroo and Tonkin Highway. There is more work to be done.
- The route will be a freight route and Primary Regional Road.
- The route is justified within the study.
- This has now been handed over to Main Roads. (Lindsay Broadhurst/Justin McKirdy)
- The N-S route will connect with Tonkin Highway along the new section of Hepburn Avenue.
- There will be no connection to Marshall Road; this will be a fly over.
- EWNSR joins Perth Darwin National Highway north of Reid Highway. There will be an interchange at Hepburn Ave.
- There will be an interchange at N-S Road/Reid Highway/Tonkin Highway
- The treatment and intersections of Beechboro Road is uncertain at this stage.
- The N-S road is likely within 20 years and may or may not include grade separation in the first stage.
- The will be no connection to Hepburn Avenue (new N-S Route) permitted.
- Main Roads will probably commence their Planning Study in 2012 and anticipate this will take 12-18 months to complete.

3. Literature review

3.1 Planning documents

GHD have reviewed planning documents as follows:

- Mirrabooka Local Area Plan.
- City of Wanneroo Local Housing Strategy, Estimated Rates of Development of New Dwellings in Wanneroo and Girrawheen-Koondoola Precincts.
- Wanneroo Local Area Strategy Plan, Planning and Sustainability, Local Planning Policy Framework, Local Planning Policy 3.1: Local Housing Strategy Implementation.

4. Land use update

4.1 Planning investigation

Main Roads WA has provided GHD with details of the traffic zones within the ROM model for the study area including a 1km buffer around the Girawheen – Koondoola Housing Precinct.

GHD's Planners have updated the landuse for each of the traffic zones following a review of local structure plans, relevant planning documents, liaison with the City of Wanneroo and Main Roads WA. The City of Wanneroo have reviewed and agreed the planned landuse inputs and assumptions.

A spreadsheet showing the content of the ROM traffic zones for 2031 with and without the R Code Increases is shown in Appendix A.

Main Roads WA has subsequently run the ROM model incorporating the increased R Code for use in the transport assessment for the Girawheen – Koondoola Housing Precinct.

The land use inputs include:

- Population
- Occupied dwellings
- Households
- Manufacturing, commercial and retail employment numbers
- School attendee numbers

The Paramics model also includes the increased R codes and ROM output and is discussed further in Section 5.

5. Network modelling

A localised network model of the precinct was required in order to assess the impacts of forecast traffic volumes. The development of models simulating both 'with density increase' (with LHS) and 'without density increase' (without LHS) scenarios was undertaken to allow a clear comparison to be drawn that isolates the traffic impacts attributable to the changes in R-coding in each area.

Paramics microsimulation traffic modelling software has been used in conjunction with Azalient Ceejazz plugins.

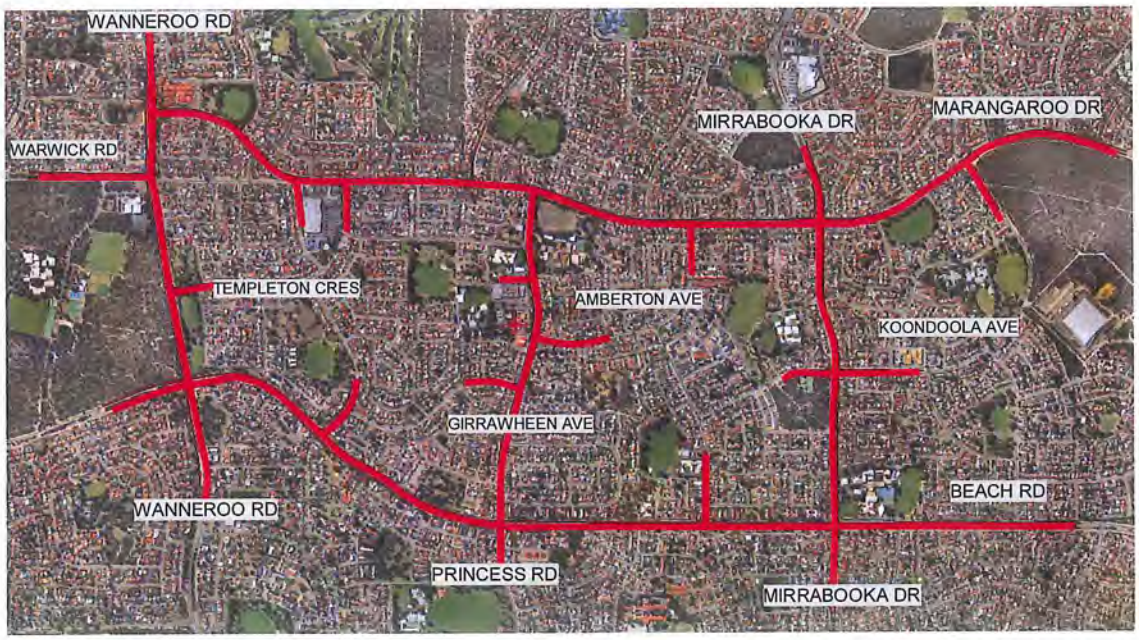
5.1 Localised network modelling study area

GHD have developed models that include the key network extents and intersections for the Girrawheen-Koondoola precinct as follows:

- Marangaroo Road;
- Wanneroo Road;
- Beach Road;
- Mirrabooka Avenue; and
- Girrawheen Avenue.

The modelled network is displayed in Figure 5-1.

Figure 5-1 Simulation model network



5.2 Base models

Base models were initially developed to represent the current on-site conditions through the study area. These AM and PM peak models were calibrated to traffic volume data and validated against recorded on-site sectional travel times to ensure they provided a comprehensive representation of the existing conditions.

A detailed model validation report has been prepared which documents the inputs, methodology, and results of the Base model development and calibration. This validation report is attached as Appendix B. The key elements of the validation process are summarised below.

5.2.1 Data inputs

The key data sources and inputs into the Base model included the following:

- Traffic volume data: Data included manual turning movement surveys, SCATS detector loop counts and historical tube counts;
- Traffic signal information: SCATS data was sourced from Main Roads (including Intersection Diagnostic Monitor files, Traffic Control Signal graphics and intersection timing charts);

- Travel time data: Sectional travel times were recorded for the key routes through the study area network; and
- ROM outputs: Main Roads provided strategic model sub-area trip matrices from the ROM.

Public transport data i.e. bus routes, were not coded into the model network as operationally they were not considered critical to the traffic modelling component.

5.2.2 Base trip matrices

Trip matrices for both the AM and PM periods were developed by combining the known turning movement volumes (from recent surveys) with the routing patterns and trip distributions obtained from the ROM sub-area cordon outputs. These trip matrices were refined and entered into the simulation model as demand inputs. (Further information regarding the trip matrix developed is provided in Appendix B).

5.2.3 Calibration/validation results

Each recorded turning movement count was compared against the equivalent model output to assess whether the model was representing on-site conditions. The statistical GEH measure was used as the primary acceptance criteria (the GEH statistic is explained in detail in Appendix B), whereby comparisons should produce a GEH value less than 5 to be considered a reasonable fit. The following tables summarises the AM and PM Base model calibration results. Modelled results are the average of five seed runs.

Table 5-1 Base model turning volume calibration results survey

Time Period	Number of Observations	Observations with GEH < 5	Average GEH	R2 and Slope	Exceeds Criteria?
AM Peak	92	92 (100%)	1.56	0.99, 1.009	Yes
PM Peak	92	92 (100%)	1.66	0.99, 0.978	Yes

Travel time recordings were also compared against the modelled equivalent as a validation check following the traffic volume calibration process. Modelled travel times within 15% or 1 minute of the recorded time were considered to represent a reasonable fit. This validation criteria is adopted from the Design Manual for Roads and Bridges (DMRB) (and is also stated within the latest RMS NSW Traffic Modelling Guidelines, to be release shortly). Table 5-2 summarises the AM and PM base model travel time validation results.

Table 5-2 Base model travel time validation results summary

Time Period	Number of recorded travel time sections	Observations within 15% or 1-minute	Exceeds Criteria?
AM Peak	14	14 (100%)	Yes
PM Peak	14	14 (100%)	Yes

Both the AM and PM base models were found to present observed on-site conditions closely, and were hence considered a robust platform against which to assess the future year scenarios.

Shared model space: Wanneroo and Girrawheen

It should be noted that this Girrawheen-Koondoola model network has been developed at the same time as a Wanneroo study area model has been developed also for City of Wanneroo. Given the close proximity of these two areas, the two models have been developed within the

same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

5.3 Forecast traffic volumes

5.3.1 Trip matrix

The calibrated base model trip matrices were taken as the starting point for determining the forecast 2031 demand matrices. AM and PM peak hour periods were analysed separately. The methodology implemented was as follows:

- The base model (2012) demand matrices were factored based upon the updated ROM outputs;
- Trip attractions and productions for individual zones based upon the existing, and proposed, land uses were assessed and applied to the corresponding zones within the simulation model network;
- The movements to/from zones within the Paramics model (which represent roads connecting into the study area) were consequently scaled based upon the revised land uses of the areas feeding these road connections.
- The escalation of trip attractions and trip productions were applied separately and the resulting demand matrix balanced to ensure any changes to distributions were incorporated into the 2031 matrices.

The above process was applied for the AM and PM peak hour matrices for the 'with LHS' and 'without LHS' scenarios.

ROM outputs

Main Roads' Regional Operations Model (ROM) data was provided as a sub-area cordon trip matrix for the alternate scenarios. The coarseness of the zone structure as well as the 24-hour time period which ROM operates meant that the outputs were not used as a direct input into the simulation model. Instead the ROM outputs were used to evaluate the magnitude of forecast trip volume escalations as well as providing an initial distribution of trips across the study area.

Main Roads incorporated the revised and updated lane use figures (discussed in Section 4) for the alternate scenarios into ROM, and subsequently provided the corresponding 2031 trip matrices for the with and without LHS options. These outputs were then used as described above.

5.3.2 Turning movement volumes

Following the determination of trip matrices, the corresponding forecast turning movement volumes were then analysed. The 2031 turning movement volumes were determined by applying the demand files (trip matrices) to the simulation network and recording the resulting turning movements. It is noted that there are a number of alternate route choices within the network, as such, not all forecast turning volumes could be determined directly from inspection of the trip matrix alone.

The resulting 2031 forecast turning movement volumes for key intersections within the study network are presented in Appendix C. These display the forecast AM and PM volumes for both the 'with LHS' and 'without LHS' scenarios.

5.4 Scenario testing

A sequential and staged approach was implemented for the various scenario tests to assess the impact to the road network with, and without, the increased R-coding ratings i.e. with/without the local housing strategy (LHS) in place. Consequently the following scenarios were assessed within the simulation model (note, all scenarios consisted of a 2031 horizon year):

- Existing network 'without LHS' volumes;
- Existing network 'with LHS' volumes;
- Suggested network upgrades to facilitate 'without LHS' volumes;
- Suggested network upgrades for 'without LHS' with 'with LHS' volumes; and
- Suggested network upgrades to facilitate 'with LHS' volumes.

Known and committed network upgrades

GHD liased with council and Main Roads to ascertain whether any known network upgrades are to occur within the study area. Both council and Main Roads indicated no upgrades or capacity enhancements are currently planned. Had any upgrades been planned to occur, these would have been included into the base network for the purposes of testing the 2031 status quo scenario.

5.4.1 Methodology for capacity enhancements

The process adopted to determine the network upgrades necessary to provide an acceptable level of service under the various scenarios, was as follows:

- Forecast traffic volumes were initially applied to the existing network model without any upgrades or capacity enhancements;
- The models were visually observed in operation to assess performance;
- Key areas of deficiencies within the network were identified, i.e. areas exhibiting substantial congestion or oversaturated conditions;
- Signal operation adjustments or refinements were implemented to improve the efficiency of the network. That is, congested conditions within the network were initially attempted to be resolved through the refinement of signal operations in the first instance. The dynamic nature of the SCATS signalling functionality on-site would attempt to optimise signal operations in a similar manner. Furthermore, adjustments to signal operations were preferable over capacity increases requiring infrastructure works;
- The performance of the network was evaluated through quantitative model outputs and qualitative model observations to determine where network capacity increases were required;
- Network upgrades were implemented into model network and then the assessment process repeated. That is, visual observations of the simulation model combined with quantitative outputs were used to evaluate the proposed intersection and mid-block modifications. Throughout the iterative process of determining required intersection upgrades, a level of service (LOS) D was targeted as the junction performance measure.

During this process, a number of Sidra models were developed to assist with determining suggested upgrades. These Sidra models were used to determine board capacity requirements and suggested signal operations, which were then taken into the Paramics microsimulation model and assessed as part of an integrated and connected road network.

The process described above was undertaken in an iterative manner to account for the fact that deficiencies within the network were not always initially identifiable. Due to the integrated network of intersections within the simulation model, congestion at neighbouring intersections can obscure or mask the actual performance of a given site. As such, the process above was conducted iteratively do address the most critical areas of concern first.

Following the simulation model scenario testing, and identification of broad network upgrade requirements, comprehensive Sidra models were run and analysed for the key sites throughout the network. These are discussed and presented in detail in Section 6.

The modelling process outlined above was undertaken to determine the following;

- The upgrades likely to be required by 2031 assuming no change to current R-code ratings or density levels i.e. without implementation of the local housing strategy; and
- The further upgrades likely to be required if the local housing strategy is implemented and R-coding designations are increased to allow higher density developments.

The resulting suggested upgrade requirements from the modelling assessment were as follows for the scenario ***without LHS***:

- Wanneroo Road: Additional lane in each direction i.e. three lanes northbound and southbound;
- Wanneroo Road /Warwick Road: Double right turn and double departure lanes for north-to-west movement;
- Wanneroo Road/Beach Road: Double right turns east-to-north, west-to-south, and north-to-west;
- Beach Road /Girrawheen Road: two lane approach from Princess Street with two through lanes and a flared right turn lane onto Beach Road (i.e. south-to-east), two lane departure on north leg (Girrawheen Avenue);
- Signal adjustments as required, i.e. phase times and some cycle times, to cater for changed traffic volumes/movements. Note, no infrastructure changes.

Additional upgrades required to facilitate the 2031 ***with LHS***:

- Girrawheen Avenue: additional lane in each direction, i.e. two lanes northbound and southbound, between Beach Road and Marangaroo Drive;
- Beach Road /Girrawheen Road: double right turn from Princess Street to Beach Road (i.e.south-to-east), left turn lane from Beach Road to Princess Street (east-to-south), right turn lane from Girrawheen Avenue to Beach Road (north-to-west);
- Signalisation of Beach Road /Hainsworth Avenue, Wanneroo Road /Templeton Crescent, Mirrabooka Avenue /Koondoola Avenue, and Mirrabooka Avenue /Girrawheen Avenue; (Main Roads response to these suggestions is discussed in Section 6);.
- Beach Road/Mirrabooka Avenue: Double right turns east-to-north, west-to-south, and north-to-west;
- Marangaroo Avenue /Mirrabooka Avenue: Flared northbound/southbound (Mirrabooka Avenue) approaches and departures to 3-lanes, double right turns east-to-north and west-to-south, left turn lanes east-to-south and west-to-north;
- Girrawheen Avenue /Amberton Avenue: Amberton Avenue two lane approach to Girrawheen Avenue;
- Signal adjustments as required i.e. signal operation changes without any infrastructure changes.

It should be noted that the suggested upgrades above did not consider the available land on-site at these locations. The proposed configurations represent the ultimate junction layouts which would provide an acceptable level of service based upon the forecast traffic volumes. Consideration has been given to site constraints during the detailed intersection assessments discussed in Section 6.

The modelled intersection configurations of the three scenarios (i.e. base, upgrades without LHS and upgrades with LHS) are presented in Appendix D.

5.5 Model results

Each scenario model was run five times with different seed values and the results extracted from each model. Statistical outputs were then averaged across the five seed value runs.

Results are presented in the sections below and show comparisons across the different scenarios for the following statistical outputs and performance measures:

- Intersection levels of service (LOS);
- Blocked (unreleased) vehicle summary for each zone; and
- Modelled travel time recordings for key routes through the network.

In addition to the quantitative results listed above, video files of the simulation models in operation have also been produced.

The result summary tables in the sections below display the following abbreviated scenario names:

- **BASE**: Existing conditions as per the calibrated base model (current 2012 volumes);
- **DN w/o LHS**: Existing network i.e. Do-Nothing (DN), 'without LHS' volumes;
- **DN w/ LHS**: Existing network i.e. Do-Nothing (DN), 'with LHS' volumes;
- **NU w/o LHS**: Suggested network upgrades (NU) necessary to facilitate 'without LHS' volumes;
- **NU w/o LHS, w/ LHS vols**: Suggested network upgrades (NU) for 'without LHS', but modelled with 'with LHS' volumes;
- **NU w/ LHS**: Suggested network upgrades (NU) to facilitate 'with LHS' volumes.

5.5.1 Level of service

The key statistical performance measure which has been used to evaluate the network and individual junctions is delay, which has subsequently been converted into a level of service (LOS). The intersections which have been analysed using the simulation model include a mixture of signalised sites, priority control, and roundabouts. The average approach delay thresholds and corresponding LOS categories which have been utilised are as shown in Table 5-3.

Table 5-3 Level of service/delay categories

Level of Service	Signals	Roundabout	Priority Control
A	0s – 10s	0s – 10s	0s – 10s
B	10s – 20s	10s – 20s	10s – 15s
C	20s – 35s	20s – 35s	15s – 25s
D	35s – 55s	35s – 50s	25s – 35s
E	55s – 80s	50s – 70s	35s – 50s
F	80s+	70s+	50s+

Table 5-4 outlines the recorded LOS for the AM peak scenario tests.

Table 5-4 Intersection level of service results: AM peak

	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Rd / Beach Rd	E	F	F	D	E	E
Wanneroo Rd / Marangaroo Dr	B	E	F	C	C	D
Wanneroo Rd / Warwick Rd	C	E	E	C	C	C
Beach Rd / Princess Rd / Girrawheen Ave	C	E	F	D	F	D
Beach Rd / Mirrabooka Ave	C	D	F	D	F	D
Marangaroo Dr / Mirrabooka Ave	D	E	E	D	E	D
Marangaroo Dr / Highclere Blvd	B	B	C	B	B	B
Marangaroo Dr / Templeton Cres	B	B	F	B	B	B
Girrawheen Ave / Amberton Ave	A	A	C	A	D	B
Girrawheen Ave / Wade Ct	A	A	D	A	E	A
Mirrabooka Ave / Koondoola Ave	A	A	D	A	E	D
Girrawheen Ave / Marangaroo Dr	A	A	D	A	F	B
Beach Rd / Hainsworth Ave	A	A	D	A	E	B
Wanneroo Rd / Templeton Cres	E	F	F	B	F	D

Table 5-5 outlines the recorded LOS for the PM peak scenario tests.

Table 5-5 Intersection level of service results: PM peak

	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Rd / Beach Rd	E	F	F	D	E	E
Wanneroo Rd / Marangaroo Dr	B	B	C	B	C	C
Wanneroo Rd / Warwick Rd	C	F	E	C	D	D
Beach Rd / Princess Rd / Girrawheen Ave	C	E	F	D	F	C
Beach Rd / Mirrabooka Ave	C	D	F	D	E	D
Marangaroo Dr / Mirrabooka Ave	D	E	E	D	E	C
Marangaroo Dr / Highclere Blvd	A	B	B	B	B	B
Marangaroo Dr / Templeton Cres	B	B	C	B	C	C
Girrawheen Ave / Amberton Ave	A	A	A	A	D	A
Girrawheen Ave / Wade Ct	A	A	A	A	C	A
Mirrabooka Ave / Koondoola	A	A	B	A	B	D

	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Ave						
Girrawheen Ave / Marangaroo Dr	A	A	C	A	D	B
Beach Rd / Hainsworth Ave	A	A	A	A	A	B
Wanneroo Rd / Templeton Cres	A	D	F	A	C	C

It can be seen from Table 5-4 and Table 5-5 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with numerous sites exhibiting LOS E and F. Similarly, if the suggested network upgrades to facilitate the 2031 traffic volumes 'without LHS' are adopted, and then the LHS is implemented then many sites would be expected to operate at LOS E and F. Applying the recommended network upgrades results in acceptable levels of service for both the with/without LHS scenarios.

It is noted that the intersection of Wanneroo Road and Beach Road is shown in Table 5-4 and Table 5-5 to operate at LOS E under both the current conditions as well as the upgraded scenarios. This result is partially attributable to the 190 second cycle time which is currently in operation at this site (and has been maintained for the scenario testing).

5.5.2 Blocked vehicle summary

Blocked (or 'unreleased') vehicles occur within the simulation when the full extent of the traffic demand cannot be loaded onto the model network. These blocked vehicles occur due to downstream network congestion or insufficient capacity on the link which connects the zone onto the model network. Blocked vehicles essentially represent the length of queue (in terms of number of vehicles) extending off the study area network.

Table 5-6 displays the modelled blocked vehicle summary for each zone across the various scenarios for the AM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-6.

Table 5-6 Blocked vehicle summary: AM peak

Model Entry Zone	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Warwick Rd	0	16	49	0	0	0
Beach Rd west	0	30	26	0	0	0
Princess Rd	0	0	361	0	0	0
Mirrabooka Ave north	0	68	50	0	0	0
Highclere Blvd	0	0	50	0	0	0
Giralt Rd	0	63	195	0	0	0
Wanneroo Rd north	0	0	29	0	0	0
Hainsworth Ave	0	0	8	0	33	0
Koondoola Ave (@ Mirrabooka)	0	0	188	0	224	0
Amberton Ave (@ Marangaroo)	0	0	0	0	68	0
Amberton Ave (@ Girrawheen)	0	0	88	0	75	0
Nanovich Ave	0	0	0	0	11	0
Balgonie Ave	0	0	73	0	0	0

Model Entry Zone	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Templeton Cres (@ Wanneroo Rd)	0	120	427	0	26	0
Wade Ct (or Hudson Ave)	0	0	7	0	15	0
Total	0	297	1549	0	451	0

Table 5-7 displays the blocked vehicle summaries for the various scenarios for the PM period. Note; only zones which exhibited blocked vehicles in at least one scenario have been included in Table 5-7.

Table 5-7 Blocked vehicle summary: PM peak

Model Entry Zone	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
Wanneroo Rd south	0	118	711	0	0	0
Princess Rd	0	231	1038	0	263	0
Amberton Ave (@ Girrawheen Ave)	0	0	0	0	99	0
Templeton Cres (@ Wanneroo Rd)	0	0	123	0	0	0
Wade Ct (or Hudson Ave)	0	0	0	0	78	0
Total	0	349	1872	0	440	0

It can be seen from Table 5-6 and Table 5-7 that the anticipated performance of the network without any intersection upgrades (i.e. the Do-Nothing scenarios) is expected to be poor with substantial numbers of trips unable to be access the network due to congestion. Similarly, if the suggested network upgrades to facilitate the 2031 traffic volumes 'without LHS' are adopted, and then the LHS is implemented then the network would still be unable to service the full extent of the forecast trips. These results are consistent with the LOS results presented in Table 5-4 and Table 5-5.

5.5.3 Travel times

Modelled travel times for key sections of the network have been extracted from each of the scenarios. The recorded sections are consistent with the sections recorded (and validated against) during the base model development. The recorded sections are highlighted in Table 5-2.

Figure 5-2 Recorded travel time sections

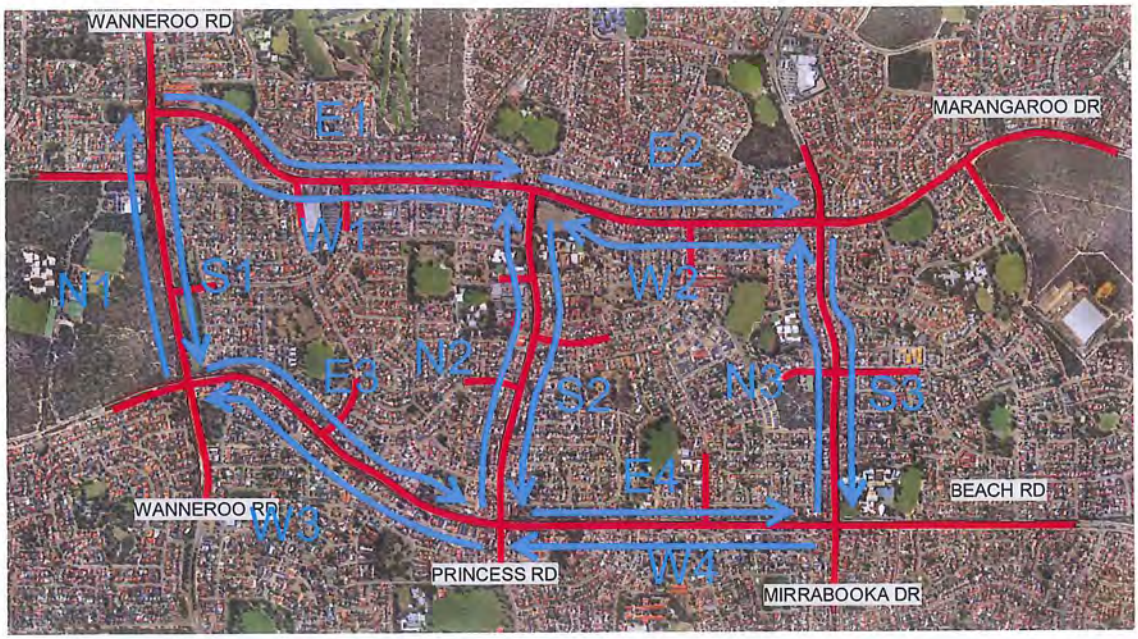


Table 5-9 shows the modelled travel time comparisons between each scenario for the AM period.

Table 5-8 Modelled travel time result (seconds): AM peak

Location	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
N1	231	257	266	249	254	263
N2	161	171	244	168	410	194
N3	128	133	131	115	140	186
S1	195	333	348	143	173	215
S2	189	331	274	242	289	184
S3	138	175	238	130	229	212
E1	137	126	143	133	155	153
E2	109	117	128	119	147	118
E3	117	120	128	125	281	141
E4	111	126	282	142	234	145
W1	195	509	612	187	198	223
W2	68	68	169	68	343	101
W3	151	163	167	147	146	150
W4	112	126	264	132	465	121

Table 5-9 shows the modelled travel time comparisons between each scenario for the PM period.

Table 5-9 Modelled travel time results (seconds): PM peak

Location	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
N1	177	269	221	181	203	199
N2	151	153	199	161	242	159
N3	137	204	168	144	197	166
S1	87	100	169	120	118	181

Location	BASE	DN w/o LHS	DN w/ LHS	NU w/o LHS	NU w/o LHS, w/ LHS vols	NU w/ LHS
S2	174	181	205	229	512	166
S3	129	134	139	135	158	173
E1	126	128	146	132	151	175
E2	111	113	224	116	127	107
E3	115	128	126	138	132	126
E4	107	115	114	112	116	121
W1	119	124	153	198	222	247
W2	68	68	68	68	77	99
W3	184	340	361	161	163	176
W4	113	222	414	129	324	122

Observations of the travel time results presented in Table 5-8 and Table 5-9 generally reveal the following trends:

- All sections are expected to experience increased vehicle journey times if no network modifications are applied, particularly if the LHS is introduced; and
- Adoption of the suggested network upgrades would provide the least variation from current travel times through the study area.

5.6 Trigger Points

A number of horizon year sensitivity tests were undertaken to determine the required staging of the suggested upgrades. Five and ten year horizons were adopted to determine the intersections requiring treatment within the short/medium term. The trigger/threshold assessments were undertaken separately for the scenarios with and without the proposed LHS. The following methodology was employed for this assessment:

- The escalation of traffic between the current (2012 Base) scenario and 2031 forecast year (i.e. 20 year horizon) was determined for without and with LHS scenarios;
- A linear escalation of the forecast traffic volume increases was assumed, such that 25% of the increase would occur over the next 5 years, and similarly 50% of the forecast increase would occur over ten years;
- The traffic demands corresponding to 5 and 10 year horizons were calculated separately for AM and PM peak periods.
- The calculated interim year traffic volumes were applied to the simulation model with the current road configuration to assess the anticipated network performance.

Table 5-10 and Table 5-11 present the modelled intersection performance results of the scenario testing without LHS and with LHS respectively.

The recommended staging of intersection treatments is discussed in Section 7.

Table 5-10 Intersection performance – without LHS

	5 year		10 year	
	AM peak	PM peak	AM peak	PM peak
Wanneroo Rd / Beach Rd	E	E	E	F
Wanneroo Rd / Warwick Rd	C	C	C	D
Beach Rd / Princess Rd / Girrawheen Ave	C	C	D	D

	5 year		10 year	
Beach Rd / Mirrabooka Ave	C	C	D	D
Marangaroo Dr / Mirrabooka Ave	D	D	D	D
Girrawheen Ave / Amberton Ave	A	A	A	A
Mirrabooka Ave / Koondoola Ave	A	A	A	A
Girrawheen Ave / Marangaroo Dr	A	A	A	A
Beach Rd / Hainsworth Ave	A	A	A	A
Wanneroo Rd / Templeton Cres	E	A	F	A

Table 5-11 Intersection performance – with LHS

	5 year		10 year	
	AM peak	PM peak	AM peak	PM peak
Wanneroo Rd / Beach Rd	E	E	F	F
Wanneroo Rd / Warwick Rd	C	C	C	D
Beach Rd / Princess Rd / Girrawheen Ave	D	D	E	F
Beach Rd / Mirrabooka Ave	E	C	E	D
Marangaroo Dr / Mirrabooka Ave	D	D	E	D
Girrawheen Ave / Amberton Ave	A	A	A	A
Mirrabooka Ave / Koondoola Ave	A	A	B	A
Girrawheen Ave / Marangaroo Dr	A	A	A	A
Beach Rd / Hainsworth Ave	A	A	A	A
Wanneroo Rd / Templeton Cres	F	A	F	B

6. Intersection analysis and road network improvements

The following section considers the intersection requirements based on the forecast traffic volumes from both the Paramics modelling and ROM modelling and subsequent Sidra modelling.

The following Sidra analysis has been undertaken

- Undertake Sidra intersection analysis for two scenarios:
  - Existing layout to 2031, no LHS forecast traffic volumes
  - Proposed layout using future traffic volumes 2031 with increased R Code

A summary of all Sidra analysis for scenarios with and without LHS to 2031 is shown in Appendix D and Appendix E.

The following intersections have been analysed:

- Mirrabooka/Koondoola Intersection 2031.
- Beach Road/Mirrabooka Road Intersection 2031.
- Girrawheen/Beach Road Intersection 2031.
- Mirabooka/Marangaroo Ave Intersection 2031.
- Marangaroo Drive/Girawheen Ave Intersection 2031.
- Beach Road/Wanneroo Road Intersection 2031.

- Wanneroo Road/Templeton Road Intersection 2031.
- Marangaroo Dr/Templeton Crescent Intersection 2031.

6.1 Wanneroo Road Cross Section

Main Roads have provided the following comment regarding the cross section of Wanneroo Road.

"It is acknowledged that future predicted volumes, especially on Wanneroo Rd, suggest the need to consider upgrading this road to six lanes, however current ultimate planning is for four lanes. Current thinking would suggest, if any additional lanes are introduced then they would be for public transport purposes, such as bus lanes. Additionally, the extra demand predicted may actually result in peak spreading with the demand being forced to utilise the infrastructure available. Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"

Modelling for this project confirms these findings in relation to capacity and operation.

6.2 Intersection analysis 2031 (existing layout with no LHS)

This section summarises the analysis of the current geometry at key intersections to 2031 with No LHS. It indicates whether the existing geometry needs to be upgraded. Full analysis and intersection layouts are shown in Appendix D. Intersection layouts are not repeated here.

It should be noted that most intersections considered are forecast to require upgrade based on the surrounding traffic growth ***without*** *the increased traffic generation due to the planned increased housing density.*

6.2.1 Mirrabooka/Koondoola intersection 2031

The analysis with NO LHS indicates that the existing roundabout will accommodate forecast traffic volumes to 2031. A LoS of A/B is forecast.

6.2.2 Beach Road/Mirrabooka Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of D/E to 2031 for the current geometry. Stop rates for some movements are greater than 1 and the degree of saturation is 1. The analysis indicates that upgrade is required to improve the performance.

6.2.3 Girrawheen/Beach Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of E/F to 2031 for the current geometry. Stop rates for most movements are greater than 1 and the degree of saturation is greater than 1 in the pm peak hour 1. The analysis indicates that upgrade is required to improve the performance.

6.2.4 Mirabooka/Marangaroo Avenue intersection 2031

The analysis with NO LHS indicates an intersection LoS of E to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 0.9. Queues in excess of 400m are forecast in Mirrabooka Drive. The analysis indicates that upgrade is required to improve the performance.

6.2.5 Marangaroo Drive/Girawheen Avenue intersection 2031

The analysis with NO LHS indicates an intersection LoS of F for the right turn from Girrawheen Ave to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Girrawheen Ave. The analysis indicates that upgrade is required to improve the performance

6.2.6 Beach Road/Wanneroo Road intersection 2031

The analysis with NO LHS indicates an intersection LoS of F to 2031 for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 1km are forecast in Wanneroo Road. The analysis indicates that upgrade is required to improve the performance.

6.2.7 Wanneroo Road/Templeton Road intersection 2031

The analysis with NO LHS indicates a LoS of F for right turn movements to 2031 with no LHS, for the current geometry. Stop rates for a number of movements are greater than 1 and the degree of saturation is greater than 1. Queues in excess of 400m are forecast in Templeton Crescent. The analysis indicates that upgrade is required to improve the performance.

6.2.8 Marangaroo Dr/Templeton Crescent intersection 2031

The analysis with NO LHS indicates a LoS of A to D for most movements to 2031 for the current geometry. Stop rates for all movements are less than 1 and the degree of saturation is 0.395 and 0.573. Queues in excess of 60m are forecast in Templeton Crescent during the pm peak hour indicating this short two lane approach should be extended. The analysis indicates that minor upgrade is required to improve the performance.

6.2.9 Wanneroo Road/Marangaroo Drive intersection 2031

The analysis with no LHS indicates a LoS of E and F for some movements to 2031, for the current geometry. Stop rates for all movements during the pm peak hour are less than 1 however some are greater than 1 during the am peak hour. The degree of saturation is 1 and 0.896. Queues in excess of 700m are forecast on Wanneroo Road north during the am peak hour. The analysis indicates upgrade is required to improve the performance.

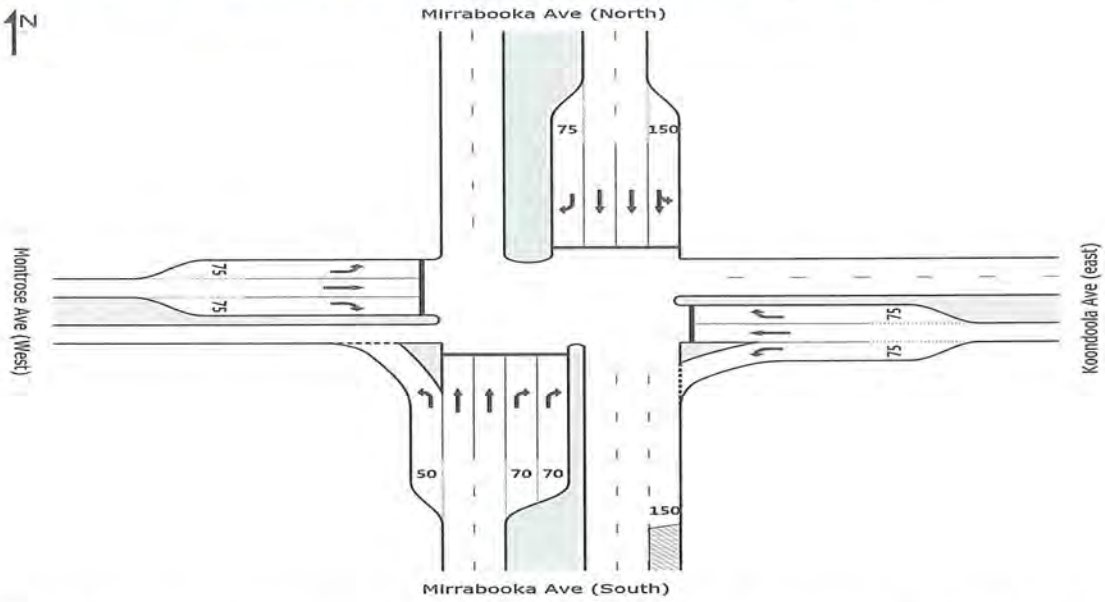
6.3 Intersection analysis 2031 (proposed layout with LHS)

Analysis has been undertaken of a modified intersection to determine the ultimate requirement to achieve a good level of service, however in view of the fact that some sites are constrained a compromise layout is provided to avoid land acquisition. All layouts are shown in Appendix E and are not repeated here, only the recommended layouts.

6.3.1 Mirrabooka Ave/Koondoola Ave intersection 2031

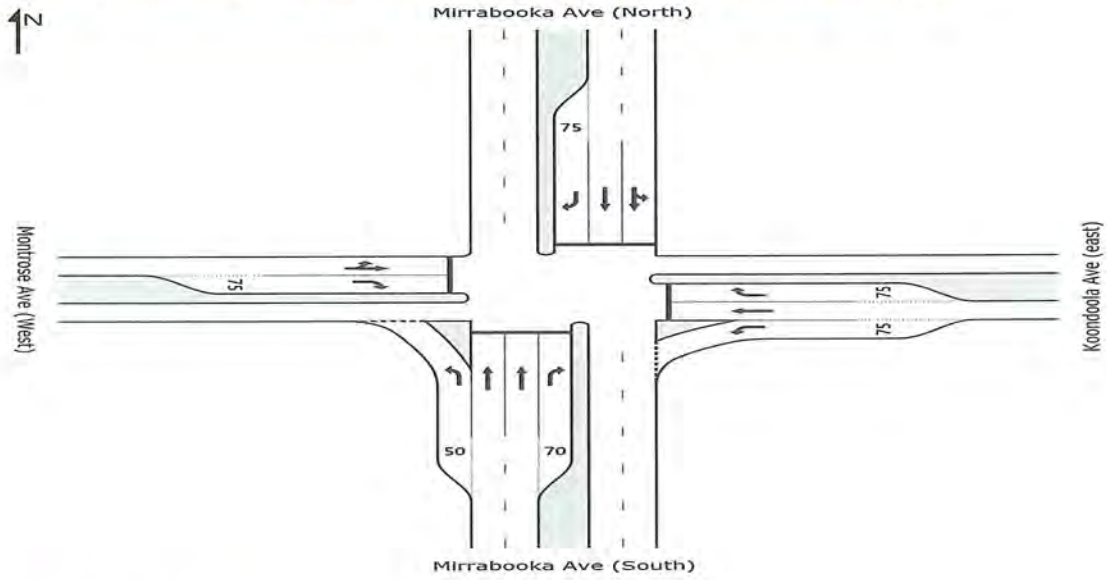
The analysis with LHS indicates that an upgraded intersection which includes replacing the roundabout with a signalised intersection as shown in Appendix F is likely to accommodate forecast traffic volumes to 2031. Degree of saturation is 0.883 to 0.887, LoS is C/D, queue length on Mirrabooka Ave North is 214m and the stop rate is 0.9. It is noted that the road reserve is not wide enough to accommodate the requirements and significant land acquisition would likely be required. Figure 6-1 refers.

Figure 6-1 Mirrabooka Ave/Koondoola Ave – Ultimate Design



A compromise design is therefore indicated as follows. The performance is not as good as the optimal upgrade however the site is constrained. The intersection LoS is C/D. The degree of saturation is 0.882/0.887 and queue length on Mirrabooka Ave North is 407m. The average stop rate is 0.86/0.92. Figure 6-2 refers.

Figure 6-2 Mirrabooka Ave/Koondoola Ave - Compromise Design



Recommendation

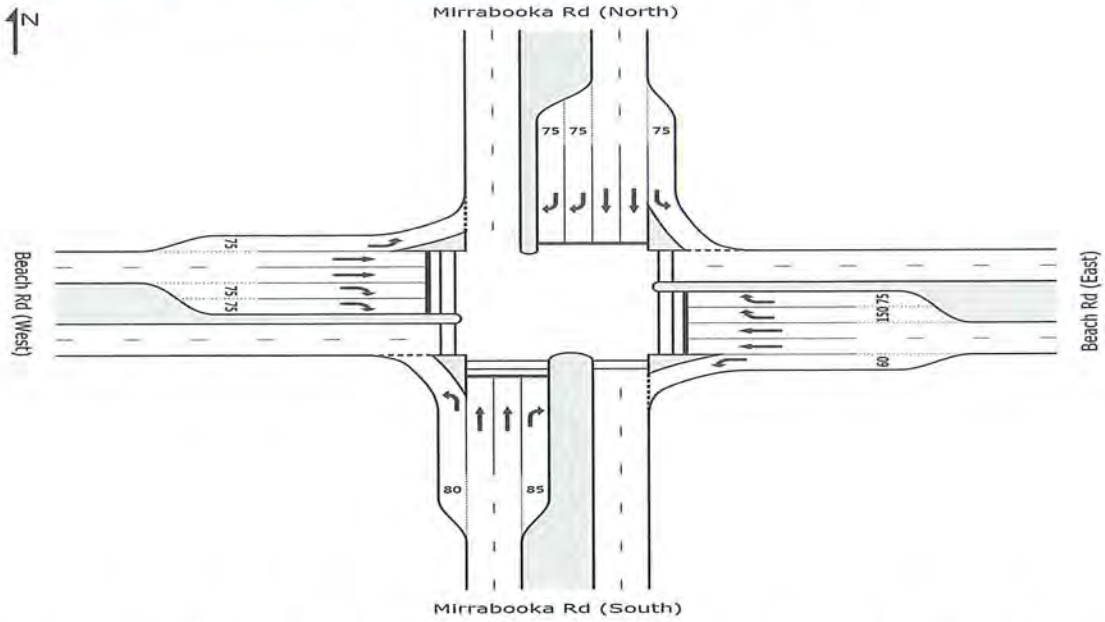
In order to accommodate increased traffic volumes due to the LHS an option is to replace the existing roundabout with a signalised intersection as indicated in Figure 6-2. However following Main Roads review of the proposed measures, indicate they are not supportive of signals at this location, a preferred option is therefore to convert the Koondoola Ave and Montrose Ave approaches to left in/out at a future date when the intersection is at capacity and promote distribution of traffic to the existing east west regional roads.

6.3.2 Beach Road/Mirrabooka Road Intersection 2031

The analysis with LHS indicates that an upgraded signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on

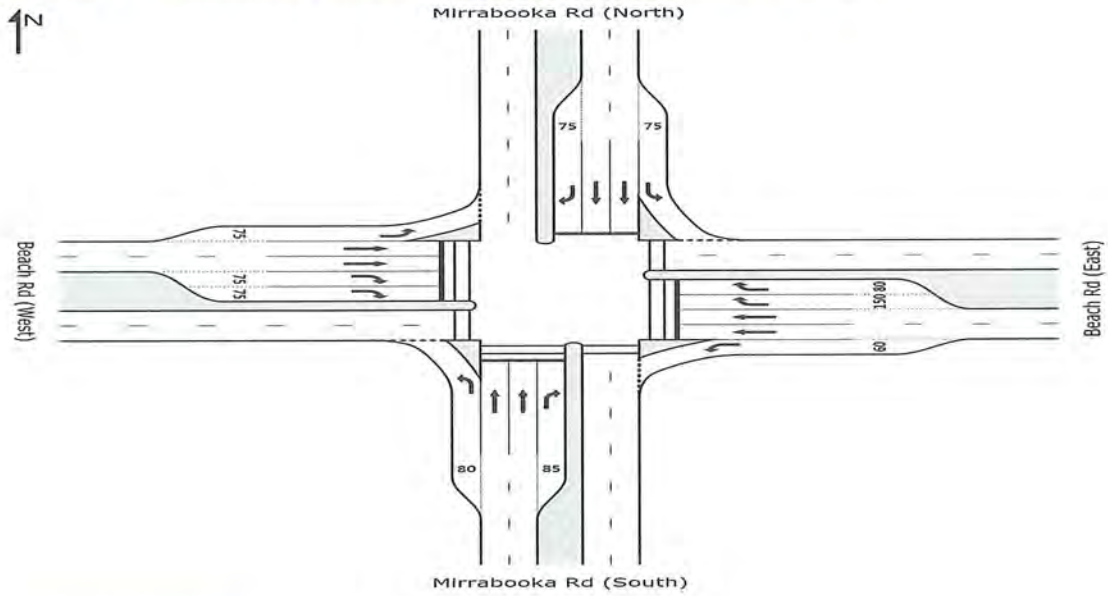
the eastern, western and northern approaches. Degree of saturation is 0.889, LoS is D, queue length on Mirrabooka Ave North is 230m and the stop rate is 0.88- 0.9. It is noted that the reserve on Mirrabooka Road north would not appear to be wide enough to accommodate a double right turn and significant land acquisition would likely be required. Figure 6-3 refers.

Figure 6-3 Mirrabooka Ave/Beach Road – Ultimate Design



A compromise design with a reduced performance is therefore considered as follows. The intersection LoS is E/F. The degree of saturation is 1-1.022. The average stop rate is 0.92/1.05. Figure 6-4 refers.

Figure 6-4 Mirabooka Ave/Beach Road – Compromise Design



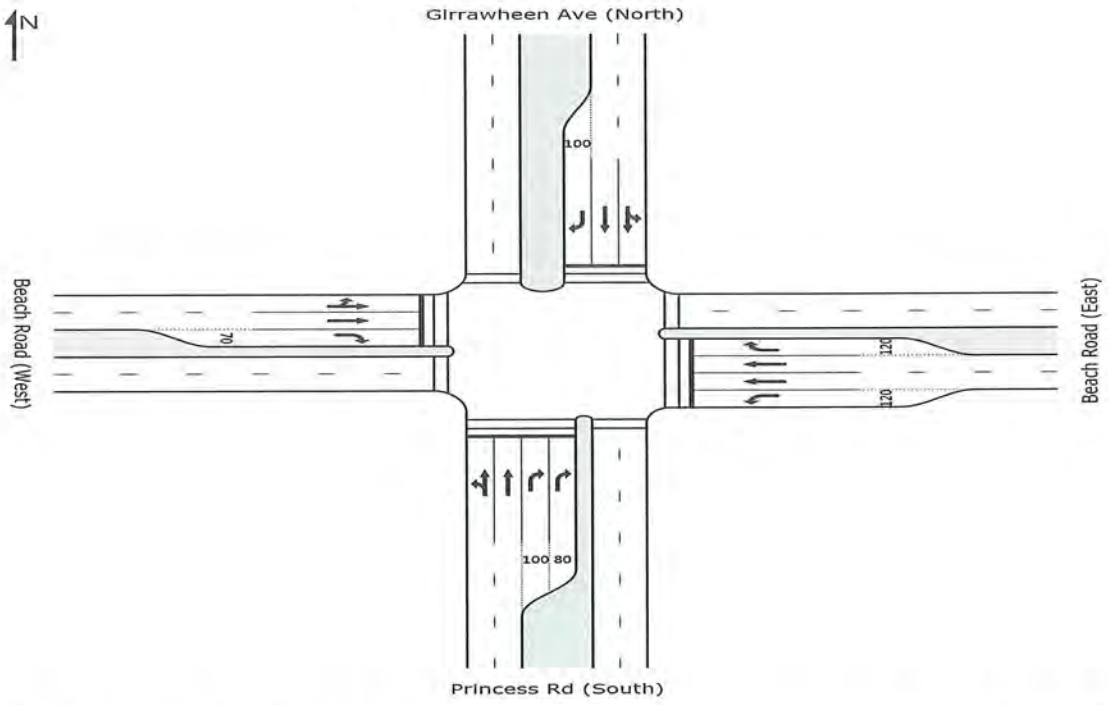
Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6.3 however if land resumption is not possible the layout in Figure 6-4 could be considered.

6.3.3 Girrawheen Ave/Beach Road Intersection 2031

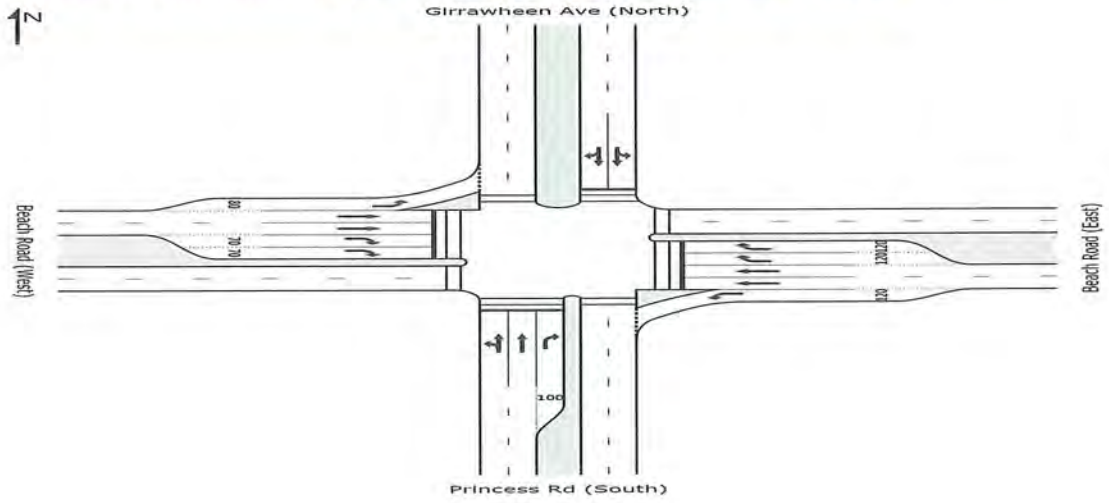
The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on the southern approach and additional through and turn lanes. Degree of saturation is 0.909 to 0.925, LoS is D/E, queue length on Princess Rd South is 269m and the stop rate is 0.94 - 0.95. It is noted that the reserve on Girrawheen Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required. Figure 6-5 refers.

Figure 6-5 Girrawheen Ave/Beach Road – Ultimate Design



A compromise is therefore considered as follows, the performance is poor in comparison but the site is constrained. The intersection LoS is D/E. The degree of saturation is 0.9-1, the queue on Princess Road south is 326m. The average stop rate is 0.94/1.1. Figure 6-6 refers.

Figure 6-6 Girrawheen Ave/Beach Road – Compromise Design



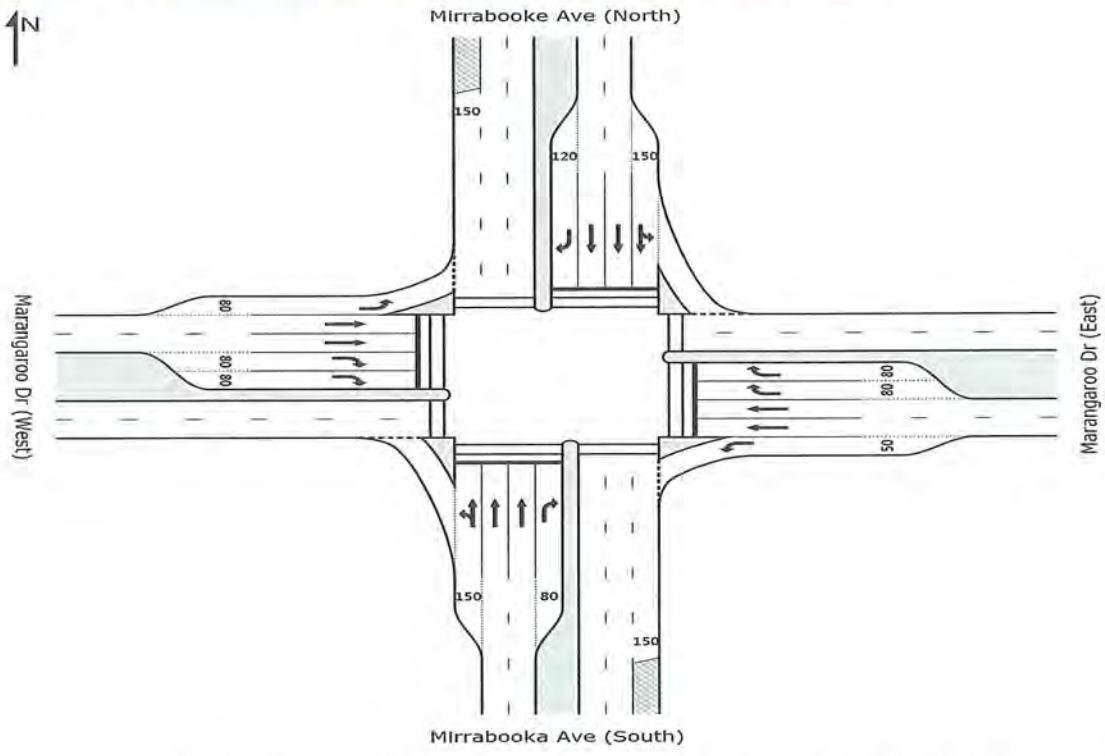
Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6-5 however if land resumption is not possible the layout in Figure 6-6 could be considered.

6.3.4 Mirabooka Ave/Marangaroo Ave intersection 2031

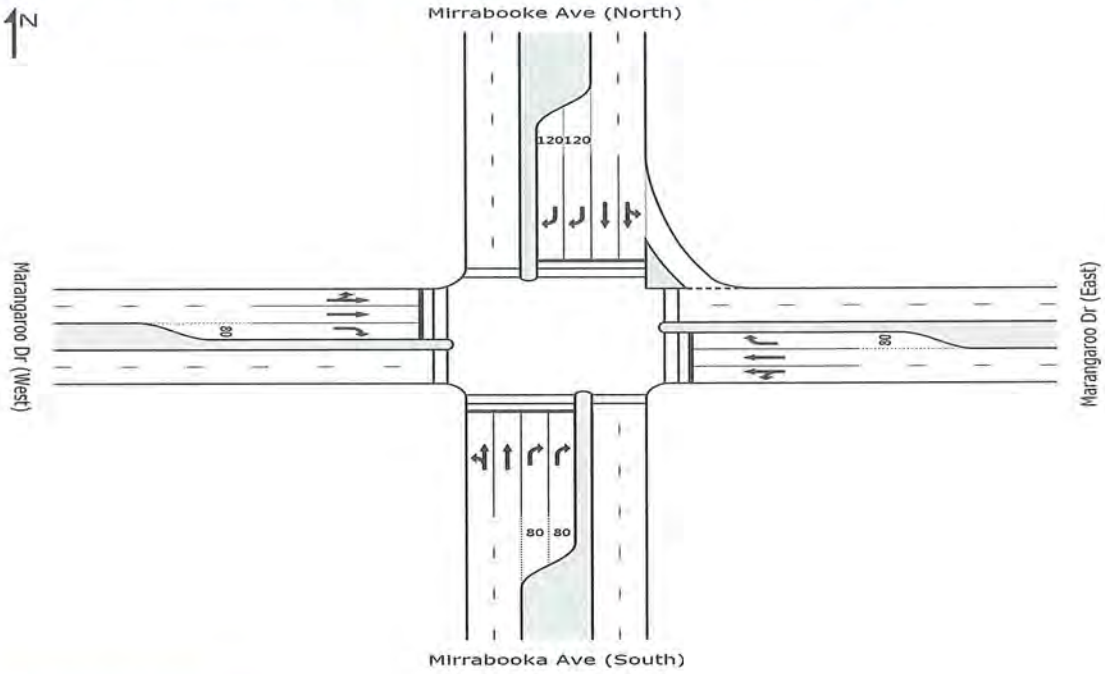
The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include double turn lanes on Marangaroo Drive and additional left turn lanes on each approach. Degree of saturation is 0.902 to 0.903, LoS is D, queue length on Mirrabooka Ave south is 307m and the stop rate is 0.88. It is noted that the reserve on Marangaroo Drive and Mirabooka Ave north would not appear to be wide enough to accommodate the proposed modifications and significant land acquisition would likely be required. Figure 6-7 refers.

Figure 6-7 Mirabooka Ave/Marrangaroo Dr – Ultimate Design



A compromise is therefore considered as follows, the performance is poor in comparison but the site is constrained. The intersection LoS is E/F. The degree of saturation is 1-1.037. The average stop rate is 0.95/1.05. Queues of up to 650m are forecast on Mirabooka Ave South. It is clear that this design does not provide a good solution and ultimately land acquisition may be required to accommodate further modification. Figure 6-8 refers.

Figure 6-8 Mirabooka Ave/Marrangaroo Dr – Compromise Design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated in Figure 6-7. However if land resumption is not possible the layout in Figure 6-8 could be considered.

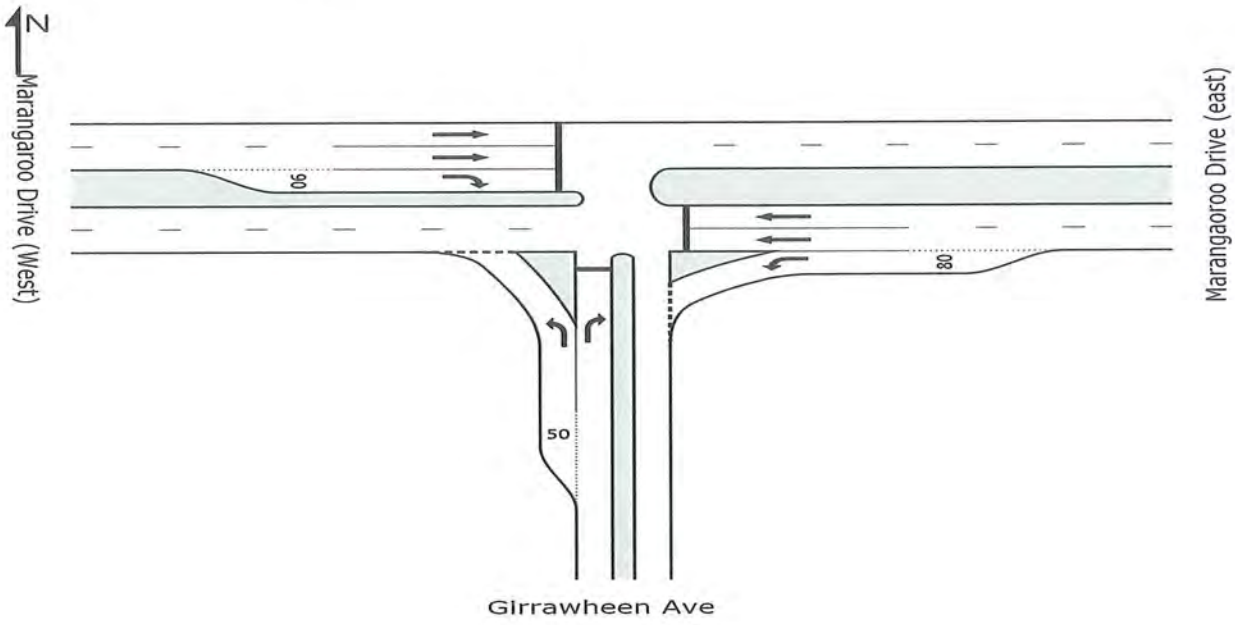
6.3.5 Marangaroo Drive/Girawheen Avenue intersection 2031

The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS. Upgrade will include signalising the intersection and providing double right turn lanes on Girrawheen Avenue. Degree of saturation is 0.87 to 0.906, LoS is C, queue length on Marrangaroo Dr east is 185m and the stop rate is 0.71-0.76. It is noted that the reserve on Girawheen Ave would not appear to be wide enough to accommodate the proposed double right turn and significant land acquisition would be likely. Figure 6-9 refers.

Figure 6-9 Marrangaroo Drive/Girrawheen Ave – Ultimate Design

The following geometry is therefore considered. The intersection LoS is C. The degree of saturation is 0.766-0.915. The average stop rate is 0.69/0.76. Figure 6-10 refers.

Figure 6-10 Marangaroo Drive/Girrawheen Ave – Compromise Design

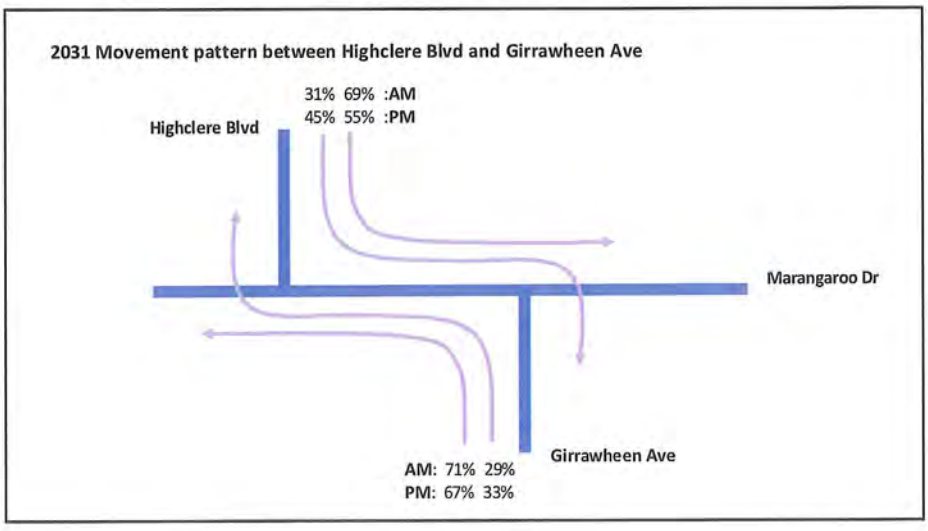


Main Roads have raised the following issue with this proposal.

" If Girrawheen Ave is signalised at Marangaroo Dr, how does this proposal impact Highclere Bvd (currently signalised)? What is the relationship between these intersections in terms of movement patterns? The separation between these intersections is only approximately 280m."

Main Roads Western Australia

Paramics modelling has tested the operation of the two intersections and the movement pattern between these two roads is indicated on the figure below. Observation of the modelled 2031 upgraded configurations shows queuing is not expected to extend from one junction to the upstream junction. Nor were any weaving issues identified.



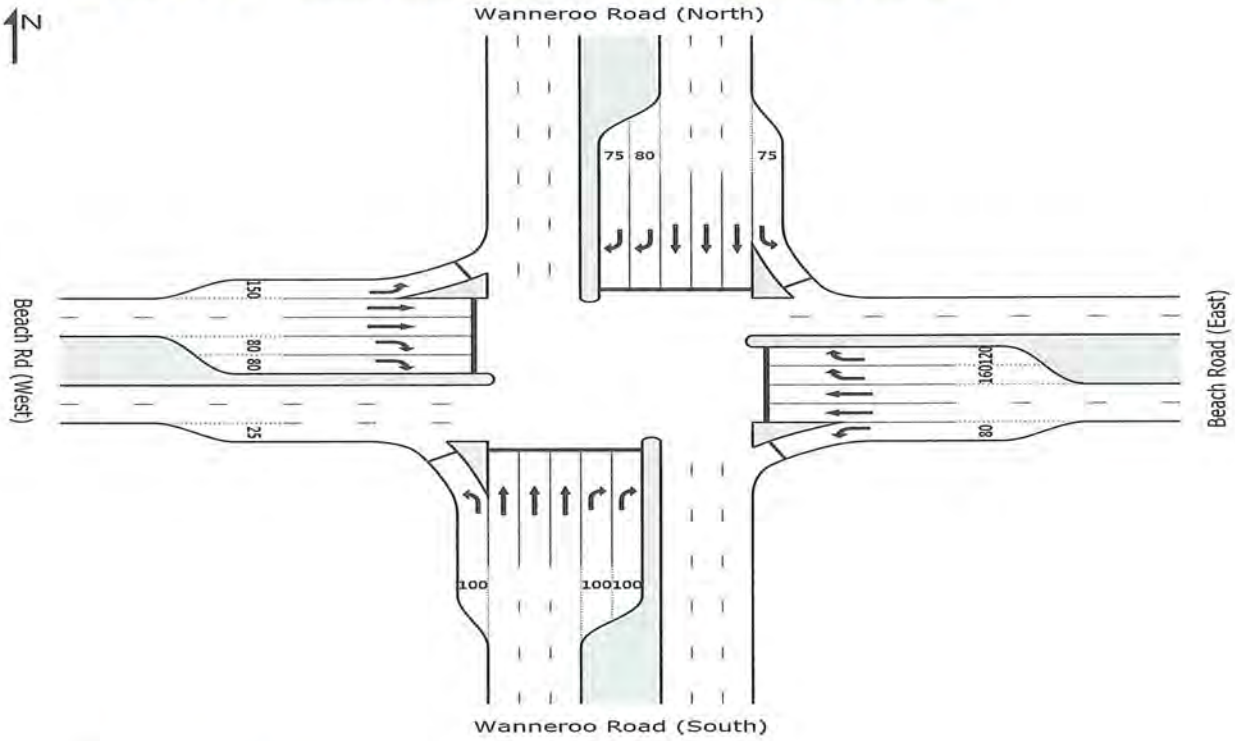
Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include a signalised intersection as indicated in Figure 6-9.

6.3.6 Beach Road/Wanneroo Road intersection 2031

The analysis indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031 with LHS to a reasonable LoS. Most traffic will clear the intersection in a single cycle. Upgrade will include additional through lanes on Wanneroo Road and the provision of double right turns on the north, south, east and west approaches. No land acquisition would appear to be required. (To be confirmed as part of a concept design). The intersection LoS is D. The degree of saturation is 0.892-0.917. The average stop rate is 0.88/0.93 Queues on Wanneroo South are forecast to be 380m during the am peak hour. Figure 6-11 refers.

Figure 6-11 Beach Road/Wanneroo Road – Ultimate Design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above. It is noted that PTA are currently progressing a study to provide bus propriety measures at this intersection which may constrain future plans to provide double right turns.

Main Roads comment is acknowledged

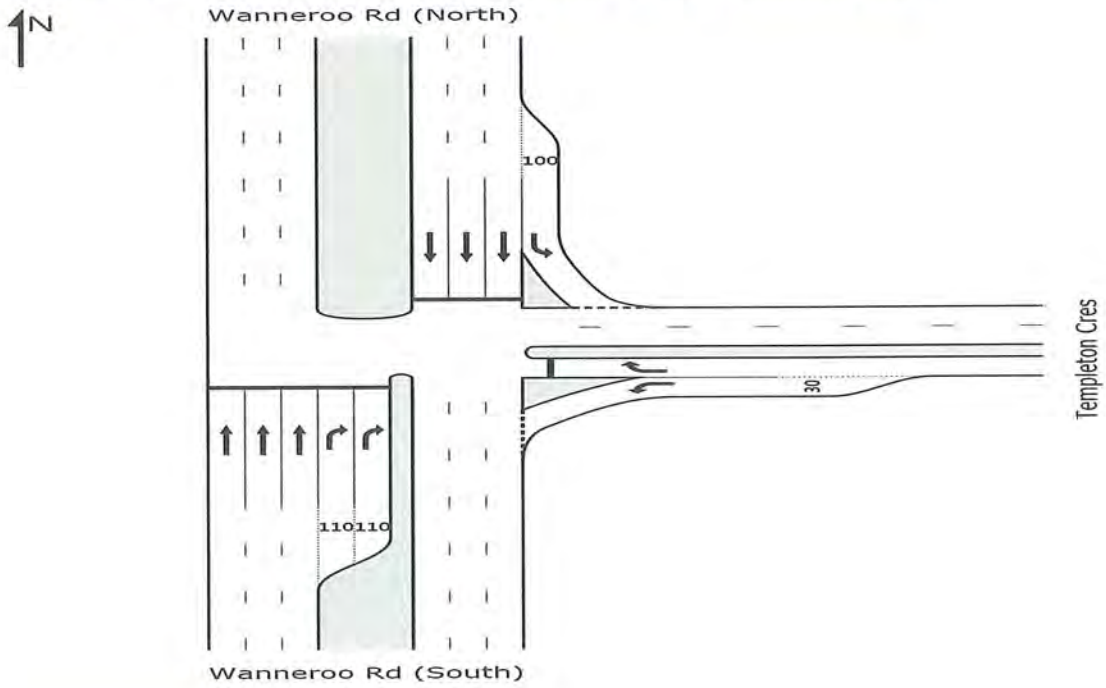
"Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"

Main Roads Western Australia

6.3.7 Wanneroo Road/Templeton Road Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include signalisation, additional through lanes on Wanneroo Road and the provision of a double right turns on the south approach and a left turn lane in Wanneroo Road north. Degree of saturation is 0.629 to 1, LoS is B, queue length on Wanneroo Road north is 250m and the stop rate is 0.54 - 0.61. No land acquisition would appear to be required. Figure 6-12 refers.

Figure 6-12 Wanneroo Road/Templeton Cresc – Ultimate Design



Recommendation

In order to accommodate increased traffic volumes due to the LHS an option is to signalise the existing unsignalised intersection as indicated above. However Main Roads does not support this proposal and suggest converting Templeton Crescent to left in/out only and promote the use of Blackmore Ave and Templeton Crescent connection to the existing east west regional roads to access Girrawheen. The aim of this is to retain the integrity of Wanneroo Road as a Primary regional road.

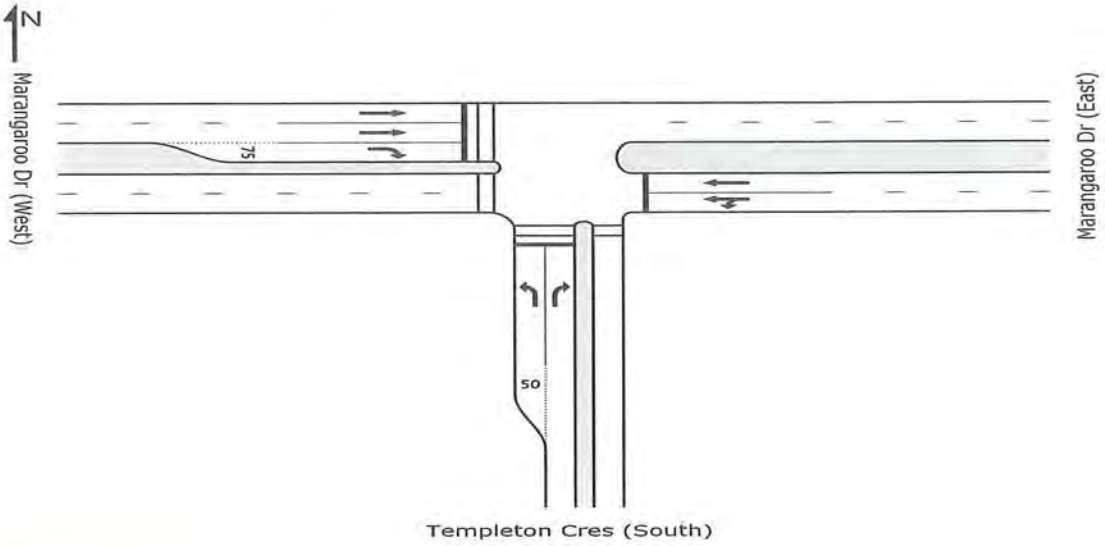
It is recommended therefore that the Main Roads proposal is considered as a future strategy.

6.3.8 Marangaroo Dr/Templeton Crescent Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include a 50m widening along the Templeton Crescent approach to accommodate two lanes of traffic. Degree of saturation is 0.575 to 0.781,

LoS is B/C, queue length on Templeton Crescent south is 168m and the stop rate is 0.62 - 0.83. No land acquisition would appear to be required. Figure 6-13 refers.

Figure 6-13 Marrangaroo Drive/Templeton Crescent – Ultimate Design



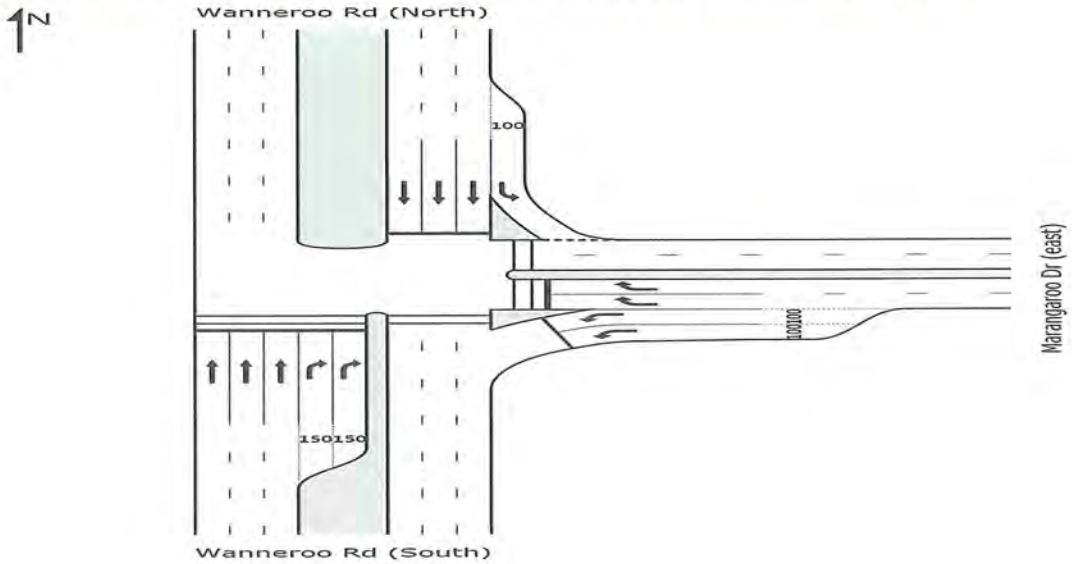
Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above.

6.3.9 Wanneroo Road/Marangaroo Drive Intersection 2031

The analysis with LHS indicates that the modified intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include an additional lane in Wanneroo Road and a signalised double left turn lane in Marrangaroo Drive. Intersection C/D is achieved and Stop rates generally below 1. The degree of saturation is 0.904 for the am peak hour. No land acquisition would appear to be required. Figure 6-14 refers.

Figure 6-14 Wanneroo Road/Marrangaroo Dr – Ultimate Design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing signalised intersection is upgraded as indicated above.

Main Roads comment is acknowledged

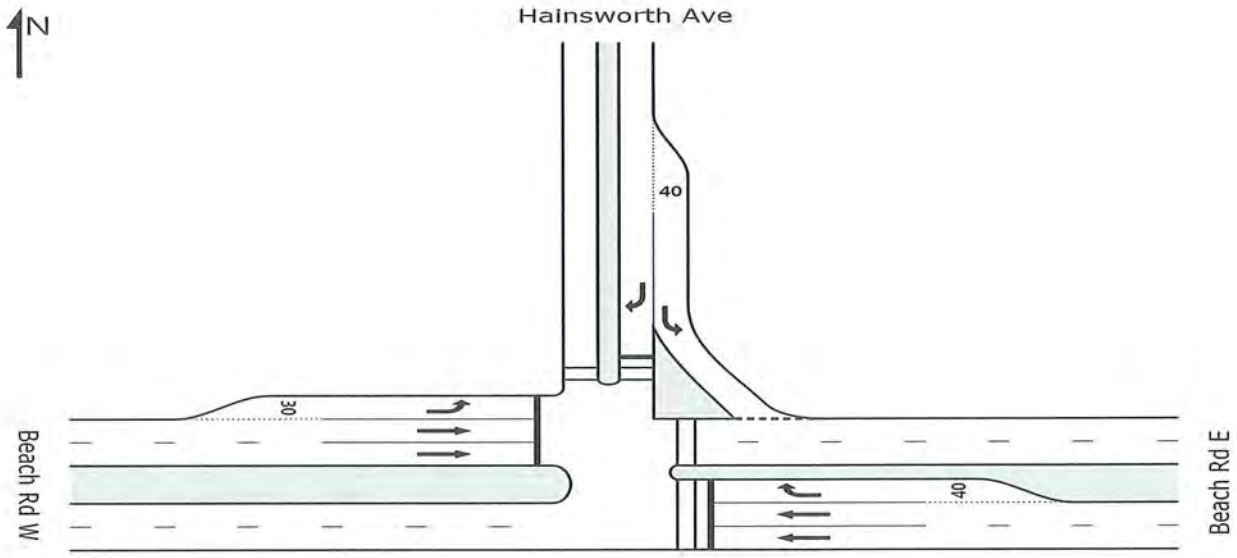
"Reference to ARRB's North West Corridor Structure Plan Review – Strategic Assessment of Regional Transport Requirements – October 2009 concluded /recommended that four lanes for Wanneroo Rd through the Girrawheen area will be required by 2031 but accepting it will be operating at a level of service F during peak periods"

Main Roads Western Australia

6.3.10 Beach Road/Hainsworth Ave Intersection 2031

The analysis with LHS indicates that the modified signalised intersection is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include installation of traffic signals. Intersection LoS C is achieved and Stop rates generally below 1. However the degree of saturation is 1 for the am and pm peak hour and queues in excess of 200m are forecast on Beach Road. No land acquisition would appear to be required. Figure 6-14 refers.

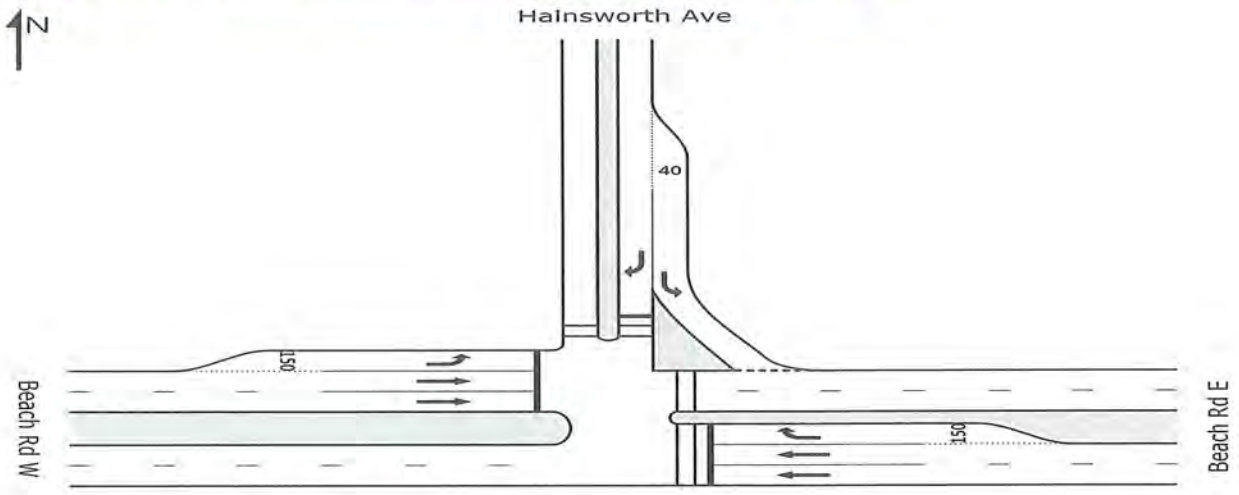
Figure 6-15 Beach Road/Hainsworth Ave – Existing Design



Further analysis has been undertaken with the turn lanes on Beach Road extended to 150m.

The analysis with LHS indicates that the modified signalised intersection improves performance and is likely to accommodate the forecast traffic volumes to 2031. Upgrade will include installation of traffic signals and extended turn lanes (to 150m) on Beach Road. Intersection LoS C is achieved and Stop rates are below 1. The degree of saturation is 0.581-0.747 for the am and pm peak hour. Queues in below 200m are forecast on Beach Road. No land acquisition would appear to be required. Figure 6-14 refers.

Figure 6-16 Beach Road/Hainsworth Ave – Ultimate Design



Recommendation

In order to accommodate increased traffic volumes due to the LHS it is recommended that the existing unsignalised intersection is upgraded to include signals and extended turn lanes in Beach Road.

6.3.11 Internal Roads

The above analysis considers road requirements to the key road network, i.e Local Distributor classification and above, there are however a number of Access Streets within the internal road network and commentary on these roads is provided as follows.

The WAPC document 'Liveable Neighbourhoods' indicates the anticipated traffic volumes for residential streets:

- Access Street Type C (single carriageway 7.2m to 7.5m wide): 3,000vpd
- Access Street Type D (single carriageway, 5.5m to 6m wide): 1,000vpd

The physical capacity of a single carriageway road is 8,000-12,000vpd at a good level of service C, based on the assessment of the precinct it is clear considerable capacity is available within the lower order roads in the study area and the planned increased residential density is unlikely to adversely impact these roads requiring the need to upgrade.

The following intersection thresholds are indicated by Austroads, below which capacity analysis is unnecessary.

Major Road Flow	Minor Road Flow
400vph	250vph
500vph	200vph
650vph	100vph

Based on the above thresholds, minor road intersections within the precinct are not expected to exceed these volumes on full development and therefore not anticipated to require significant upgrade for capacity reasons.

6.4 Stakeholder liaison

Following completion of the technical analysis the outcomes were forwarded to the City of Wanneroo who has also consulted with Main Roads. Their coordinated response is shown in Appendix F together with GHD response. Amendments have been incorporated into this report.

7. Cost estimates

7.1 Apportionment of cost estimates

The following calculation has been used to estimate the proportion of each of the cost estimates which are directly attributable to the increase in traffic in the Girrawheen-Koondoola Housing Precinct.

The following points (b and C) are the forecast total traffic volumes consisting of the current volumes plus additional volumes.

a. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct to 2031 based on current planning: 46,605vpd.

b. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct to 2031 based on increased R Codes: 120,155pd.

c. Forecast traffic generation from the Girrawheen-Koondoola Housing Precinct and Area of Influence to 2031 based on increased R Codes: 756,060pd.

Therefore the apportionment of cost is calculated by (b-a)/b and represents 61.20**%** of road upgrade cost.

Area of influence: 1km surrounding precinct.

7.2 Cost estimates for road network improvements

Cost estimates have been prepared for the recommended measures based on the City of Wanneroo construction rates.

Table 7-1 Cost Estimate for Road Network Improvements

Location	Measure	Estimated Cost	Apportionment %	Apportioned Cost
Girrawheen Ave (Beach Road to Marrangaroo Drive).	Additional lane in each direction	$840,000	61.2%	$514,080
Amberton Ave approach to Girrawheen Ave	Additional approach lane (60m)	$55,000	61.2%	$33,660
Beach Road/Girrawheen Ave	Double right turn from Princess Street to Beach Road (i.e.south-to-east), left turn lane from Beach Road to Princess Street (east-to-south), right turn lane from Girrawheen Avenue to Beach Road	$495,000	61.2%	$302,940
Mirrabooka Ave/Koondoola Ave	Left in/out for Koondoola and Montrose.	$255,000	61.2%	$156,060

Location	Measure	Estimated Cost	Apportionment %	Apportioned Cost
Marrabooka Ave/Marrangaroo Drive	Flared northbound/southbound (Mirrabooka Avenue) approaches and departures to 3-lanes, double right turns east-to-north and west-to-south, left turn lanes east-to-south and west-to-north	$681,000	61.2%	$416,772
Marrangaroo Drive/Girrawheen Ave	Upgrade will include signalising the intersection and providing double right turn lanes on Girrawheen Avenue.	$97,000	61.2%	$59,364

GHD has prepared the preliminary cost estimate set out in Table 7-1 using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD (eg indicative geometric on requirements from conceptual drawings, no survey base was provided).

The Cost Estimate has been prepared for the purpose of indicative budgets and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

No allowance is made for services protection/relocation.

No allowance is made for design costs or escalating land costs.

7.2.1 Services

'One Call' information is embedded into the dwg files and it should be noted that there would appear to be significant underground services at all locations. No allowance is made within the cost estimates for any relocation or protection of services. Further study should be undertaken as part of the design process to conform actual impacts and likely costs for services.

7.3 Staging of Works

Based on observations of the models in operation as well as the performance results presented in Table 5-10 and Table 5-11, the following table outlines the anticipated staging requirements of intersection treatments.

Table 7-2 Intersection treatment and roadworks staging

	Without LHS			With LHS		
	0-5 years	5-10 years	10-20 years	0-5 years	5-10 years	10-20 years
Wanneroo Rd / Beach Rd	x			x		
Wanneroo Rd / Warwick Rd			x			x
Beach Rd / Princess			x		x	

Rd / Girrawheen Ave						
Beach Rd / Mirrabooka Ave					x	
Marangaroo Dr / Mirrabooka Ave					x	
Girrawheen Ave / Amberton Ave						x
Mirrabooka Ave / Koondoola Ave						x
Girrawheen Ave / Marangaroo Dr						x
Beach Rd / Hainsworth Ave						x
Wanneroo Rd / Templeton Cres (Signals not supported by Main Roads, left in/out preferred)					x	
Girrawheen Avenue					x	
Amberton Avenue						x

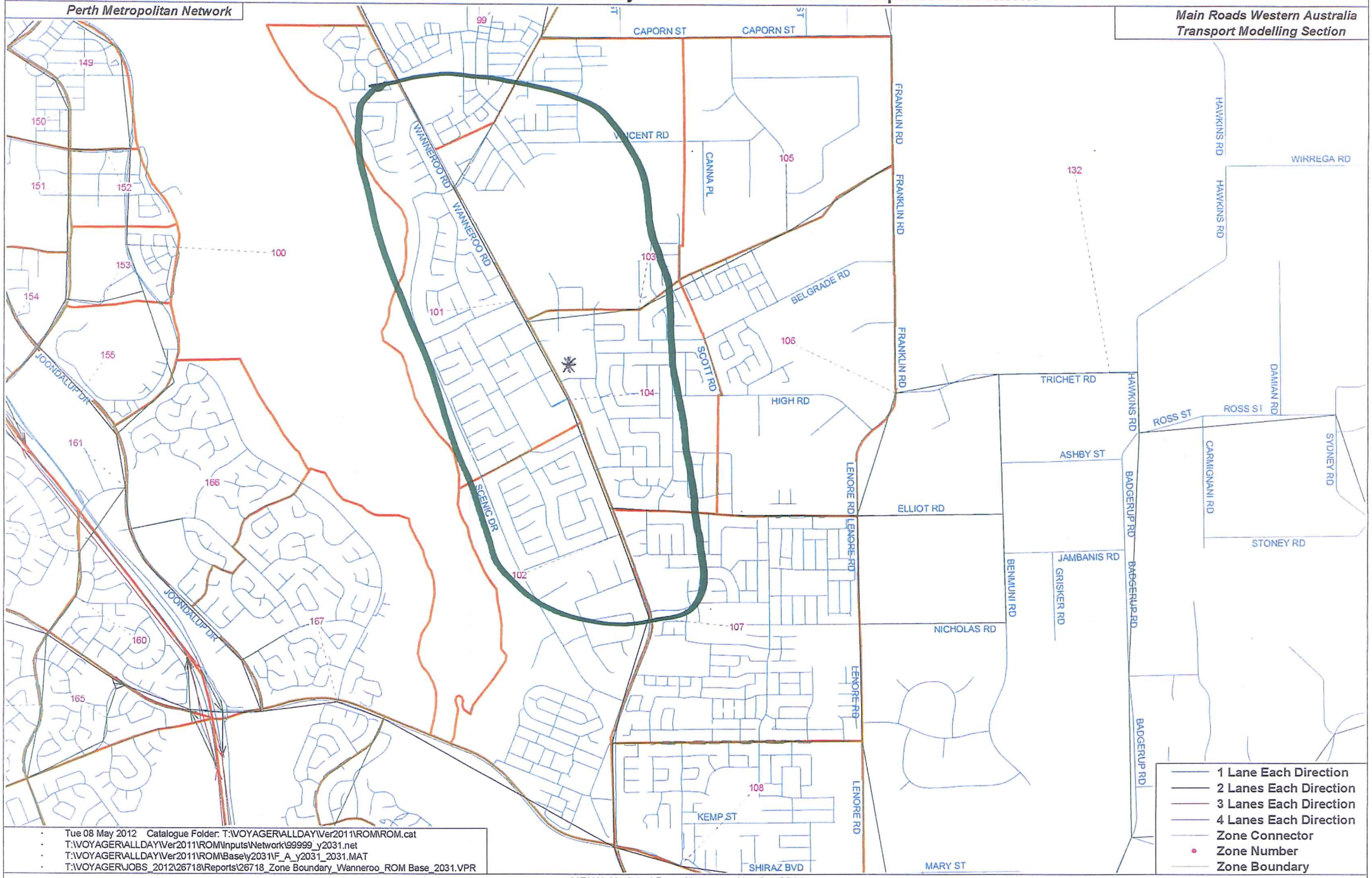
Appendices

Appendix A - Landuse input

2031 Base Model - Zone Boundary Plot for Wanneroo Traffic Impact Assessment

Perth Metropolitan Network

Main Roads Western Australia
Transport Modelling Section

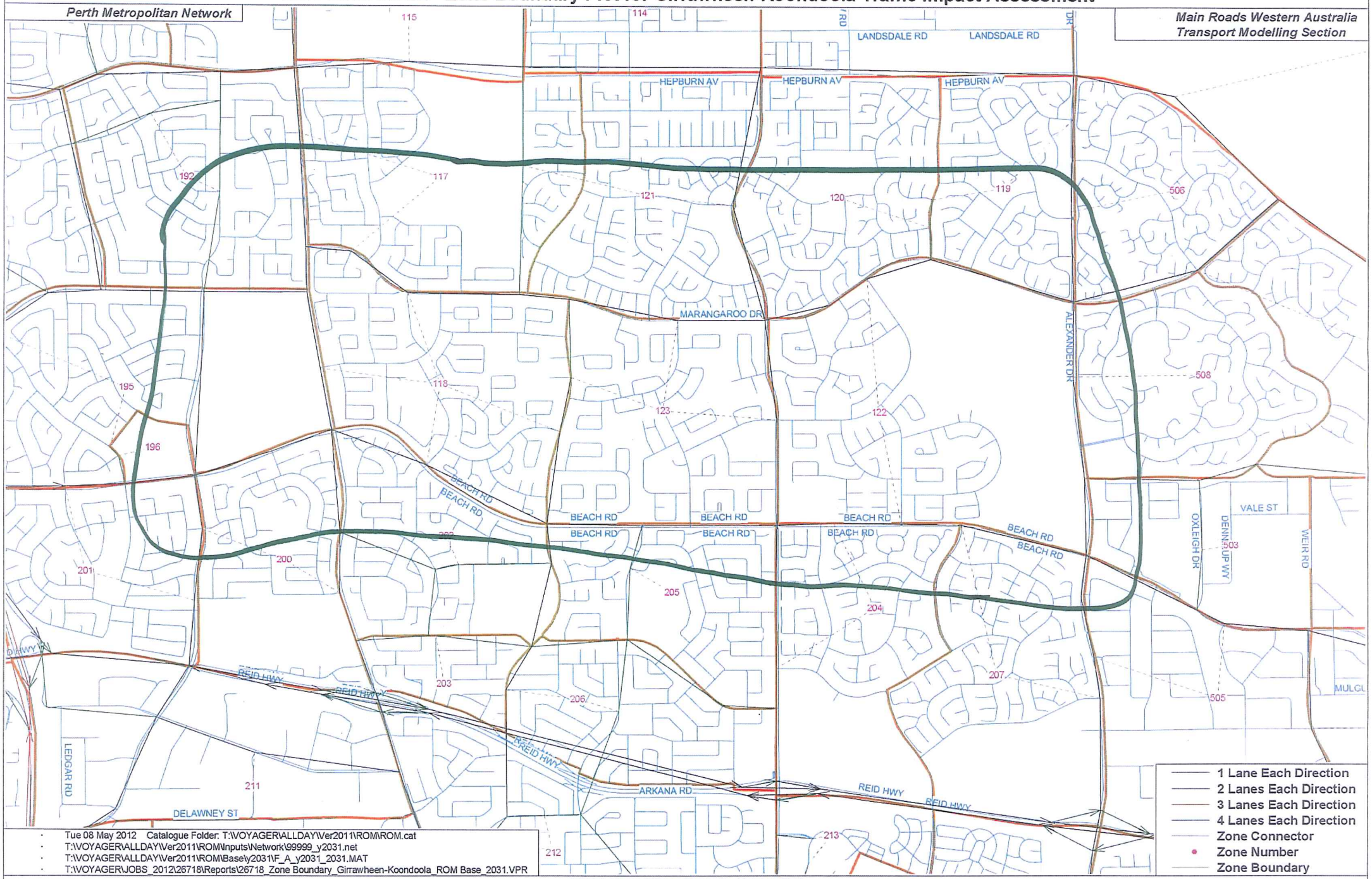


- Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
- T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Wanneroo_ROM Base_2031.VPR

MRWA Updated Base Network - Version 2011

cube

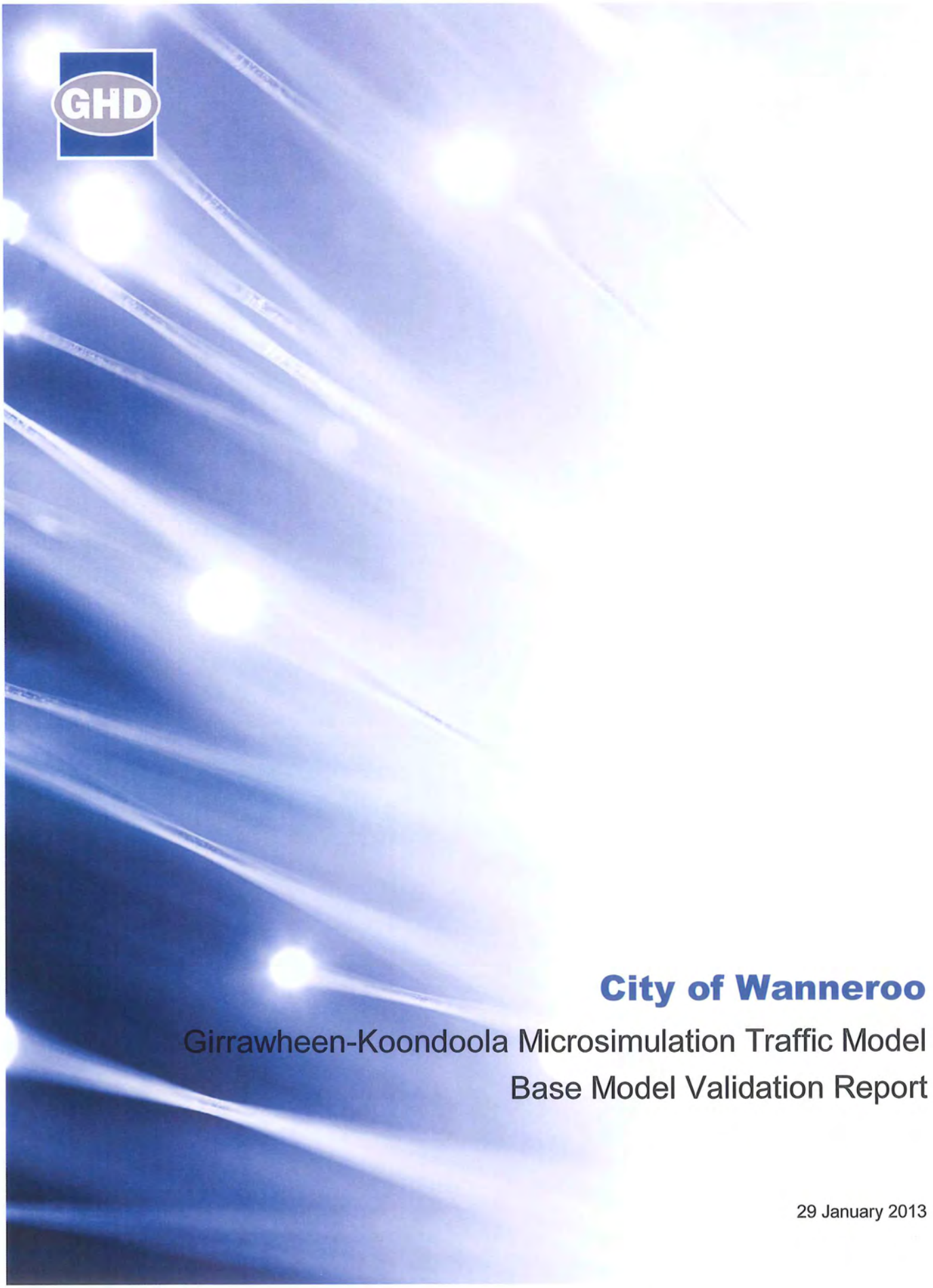
2031 Base Model - Zone Boundary Plot for Girrawheen-Koondoola Traffic Impact Assessment



- Tue 08 May 2012 Catalogue Folder: T:\VOYAGER\ALLDAY\Ver2011\ROM\ROM.cat
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Inputs\Network\99999_y2031.net
- T:\VOYAGER\ALLDAY\Ver2011\ROM\Base\y2031\F_A_y2031_2031.MAT
- T:\VOYAGER\JOBS_2012\26718\Reports\26718_Zone Boundary_Girrawheen-Koondoola_ROM Base_2031.VPR

MRWA Updated Base Network - Version 2011

Appendix B - Paramics base model validation report



City of Wanneroo

Girrawheen-Koondoola Microsimulation Traffic Model
Base Model Validation Report

29 January 2013

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Table of contents

Table index

Figure index

Appendices

This report has been prepared by GHD for City of Wanneroo and *may only be used and relied on by City of Wanneroo for the purpose agreed between GHD and the City of Wanneroo as set out in Section 1 of this report.*

GHD otherwise disclaims responsibility to any person other than City of Wanneroo arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by City of Wanneroo, Main Roads, Excel Traffic Data and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1. Introduction

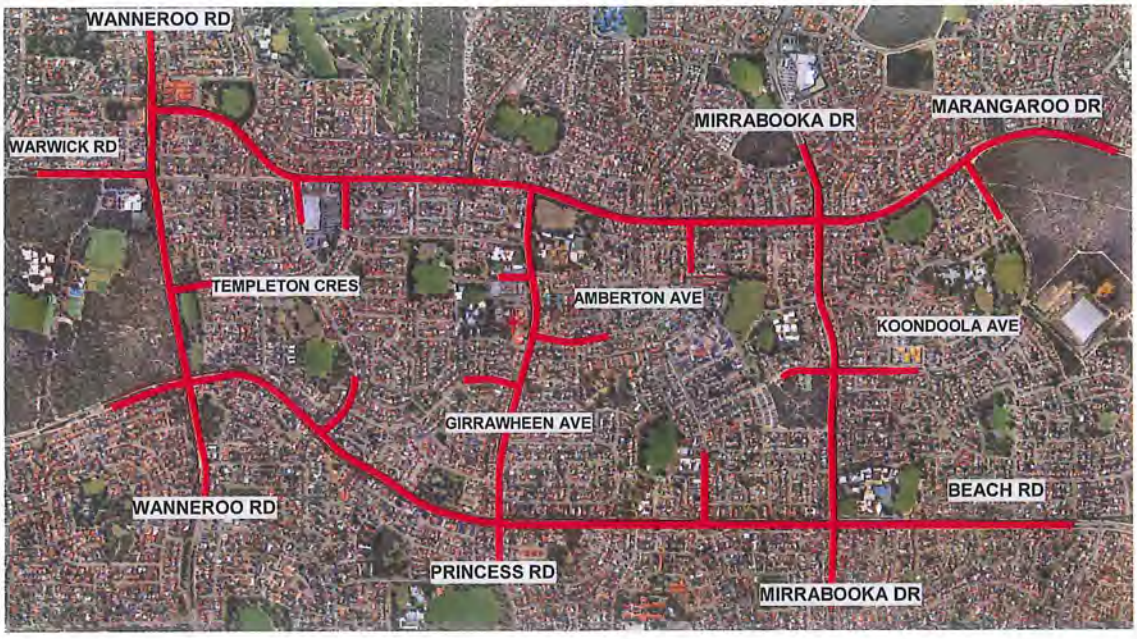
City of Wanneroo has engaged GHD to undertake a Traffic Impact Assessment (TIA) to evaluate the potential effect of the proposed increases to R Coding within the Girrawheen and Koondoola housing precincts. As part of this study, GHD is undertaking local area microsimulation traffic modelling to assist in the traffic assessment. This report discusses the development of the initial 'Base' models which provide a representation of the current on-site conditions on the Girrawheen and Koondoola road networks, and outlines the calibration and validation methodologies that have been employed.

The purpose of this report is to demonstrate and provide confidence that the Girrawheen Base models are a robust representation of the on-street conditions and as such provide a suitable foundation for the subsequent testing of future year scenario. The report therefore provides information relating to the following topics:

- Data sources used for the modelling;
- Model network development;
- Trip matrix development;
- Model calibration; and
- Model validation.

Figure 1 outlines the adopted study area for the traffic modelling assessment.

Figure 1 Extents of Model Study Area



2. Data Collection

2.1 Introduction

Microsimulation models typically require large volumes of data in order to accurately represent traffic networks at a microscopic level and to ensure the model is a good representation of current on-site conditions. This section of the report details each dataset that has been collected for the study. It provides information relating to the type of data, the source of the data and the date and time periods that the data was collected for.

2.2 Traffic Volume Data

Traffic volume count data was obtained from a number of sources including the following:

- SCATS loop counts;
- Manual turning movement surveys; and
- Historical tube count data.

2.2.1 SCATS Loop Counts

Signalised intersection detector counts were requested from Main Roads for the sites within the Girrawheen-Koondoola study area. These signalised intersections consisted of the following:

- Wanneroo Road / Marangaroo Drive (TCS 592);
- Wanneroo Road / Warwick Road (TCS 268);
- Marangaroo Drive / Templeton Crescent (TCS 683);
- Marangaroo Drive / Mirrabooka Avenue (TCS 618);
- Marangaroo Drive / Highclere Boulevard (TCS 767);
- Beach Road / Girrawheen Avenue (TCS 290);
- Beach Road / Mirrabooka Avenue (TCS 382); and
- Beach Road / Wanneroo Road (TCS 271).

Detector counts were provided in hourly intervals for each intersection loop for the week beginning 19 March 2012.

These types of traffic counts have a number of limitations which need to be considered when assessing the suitability of such data to use an input traffic models. These constraints include:

- Some intersection movements are not captured due to some lanes not being covered by an in-pavement detector, e.g. often left turn slip lanes are not detected:
- Some lanes have multiple designations e.g. a shared left turn and through movement lane. In these instances it is unclear from the detector count what proportion of vehicles conduct each movement;

- Detectors are not always reliable e.g. detectors can be faulty and hence not record all vehicles accurately; and
- Detector counts do not differentiate between vehicle classifications.

2.2.2 Manual Turning Movement Count Surveys

To supplement the SCATS detector count data (and to overcome some of the shortcomings of that data set) a number of manual turning movement surveys were collected. These were undertaken by Excel Traffic Data at the following sites:

- Amberton Avenue / Girrawheen Avenue;
- Beach Road / Girrawheen Avenue / Princess Road;
- Beach Road / Hansworth Avenue;
- Girrawheen Avenue / Marangaroo Drive;
- Koondoola Avenue / Marangaroo Drive;
- Marangaroo Drive / Mirrabooka Avenue; and
- Tempelton Crescent / Wanneroo Road.

Surveys were undertaken for the following time periods:

- AM Peak: 7.30 – 9.30; and
- PM Peak: 15.30 – 17.30.

Traffic count data was provided in the form of turning counts in 15 minute intervals and was disaggregated into car and truck vehicle types. These traffic surveys provided a high level of data resolution for input into the model.

2.2.3 Historical Tube Count Data

City of Wanneroo provided a number of tube count surveys which had previously been undertaken throughout the study area. These surveys were used by GHD to inform the project of indicative volumes on lower order roads and to assess the validity of recently collected data. These data sets typically provided only mid-block two-way traffic volumes, and as such they were not used to determine directional or turning movement data inputs. The provided tube counts ranged in currency from 2009 and 2012.

2.3 Signal Data

In additional to the SCATS detector counts (discussed in Section 2.2.1), traffic signal operation data was sourced from Main Roads for each signalised intersection in the study area to ensure signal operations could be represented accurately. The signalised sites included:

- Wanneroo Road / Marangaroo Drive (TCS 592);
- Wanneroo Road / Warwick Road (TCS 268);
- Marangaroo Drive / Templeton Crescent (TCS 683);

- Marangaroo Drive / Mirrabooka Avenue (TCS 618);
- Marangaroo Drive / Highclere Boulevard (TCS 767);
- Beach Road / Girrawheen Avenue (TCS 290);
- Beach Road / Mirrabooka Avenue (TCS 382); and
- Beach Road / Wanneroo Road (TCS 271)

The specific signal data which was requested and subsequently provided by Main Roads consisted of the following:

- SCATS TCS graphics;
- IDM (intersection diagnostic monitor) data files (for two consecutive days, June 2012); and
- Intersection timing charts.

2.4 Travel Time Data

Vehicular journey times through the study area were recorded on-site for the key movements. This information would provide the key source of model validation data (discussed in detail in Section 5). GHD collected travel time survey data, as well as in-car video footage for the AM and PM peak periods on Wednesday 6 June 2012. GHD staff undertook these travel time surveys which allowed observations of queuing and congestion levels on-site to be considered during the calibration and validation stages of the modelling process.

The key routes through the Girrawheen road network were identified as Wanneroo Road, Marangaroo Drive, Beach Road, Girrawheen Avenue and Mirrabooka Avenue. These routes were surveyed in both directions and journey times disaggregated into the intervals identified in Figure 2 and Table 1.

Figure 2 Surveyed Travel Time Routes

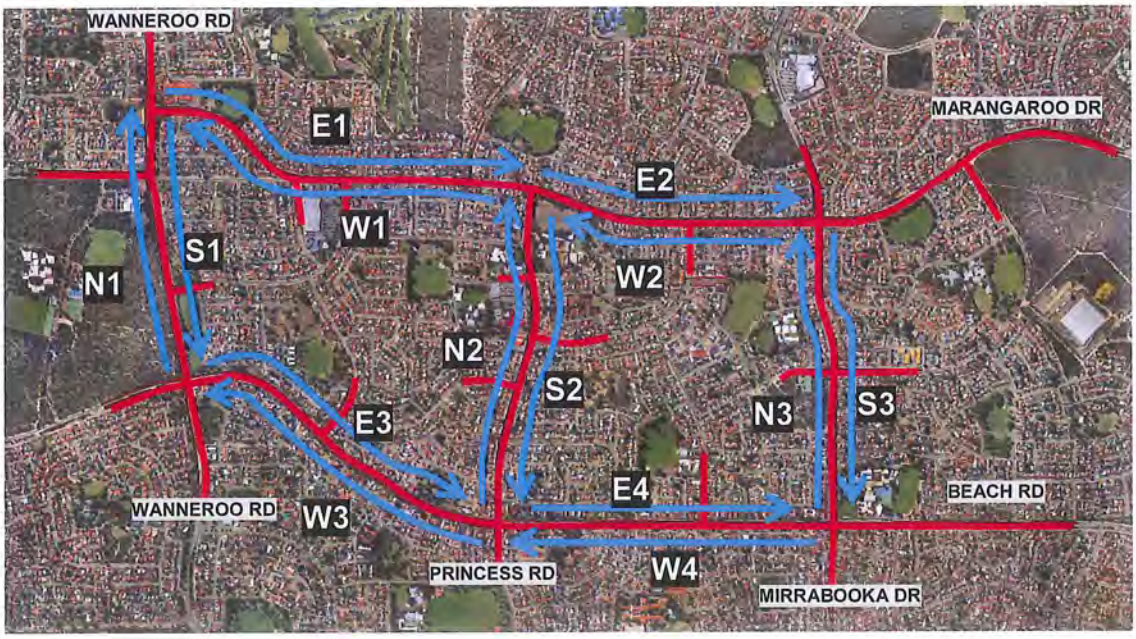


Table 1 Travel Time Section Descriptions

Movement	Description
Northbound movements	
N1	Wanneroo Rd: Beach Rd to Marangaroo Dr
N2	Girrawheen Ave: Beach Rd to Marangaroo Dr
N3	Mirrabooka Ave: Beach Rd to Marangaroo Dr
Southbound movements	
S1	Wanneroo Rd: Marangaroo Dr to Beach Rd
S2	Girrawheen Ave: Marangaroo Dr to Beach Rd
S3	Mirrabooka Ave: Marangaroo Dr to Beach Rd
Eastbound movements	
E1	Marangaroo Dr: Wanneroo Rd to Girrawheen Ave
E2	Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave
E3	Beach Rd: Wanneroo Rd to Girrawheen Ave
E4	Beach Rd: Girrawheen Ave to Mirrabooka Ave
Westbound movements	
W1	Marangaroo Dr: Girrawheen Ave to Wanneroo Rd
W2	Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave
W3	Beach Rd: Girrawheen Ave to Wanneroo Rd
W4	Beach Rd: Mirrabooka Ave to Girrawheen Ave

2.5 ROM Strategic Model Outputs

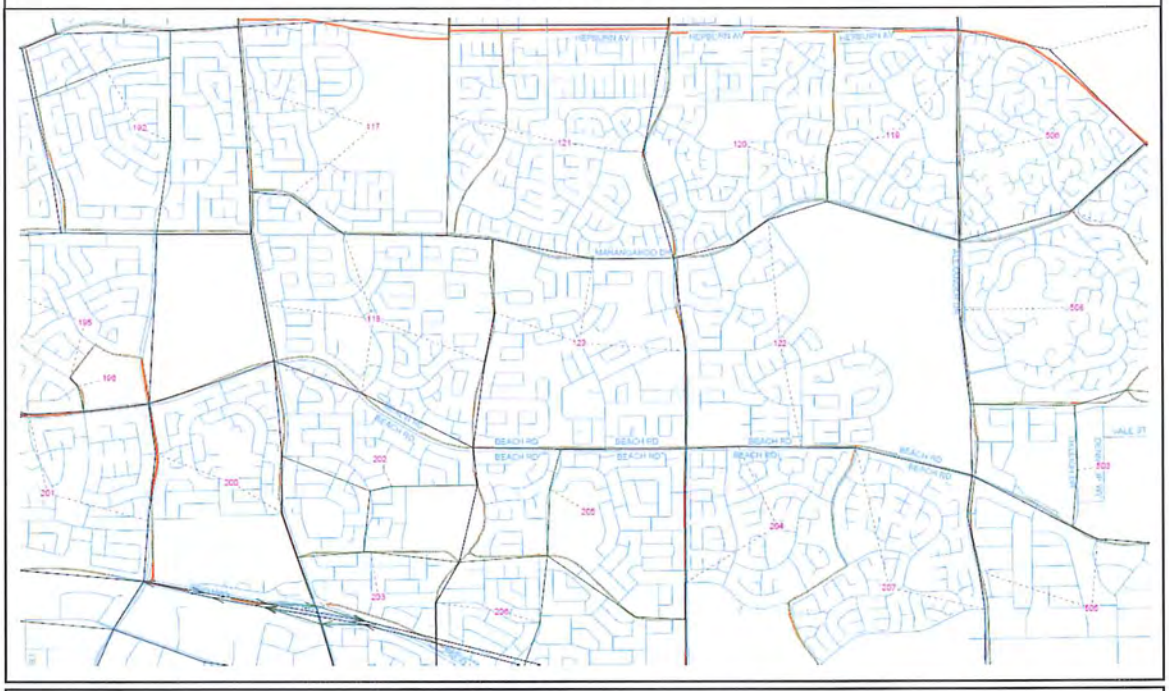
Main Roads provided outputs from the Regional Operations Model (ROM) to assist with the study. The outputs requested by GHD and provided by Main Roads consisted of the following:

- ROM network layout and zoning structure around the Girrawheen study area; and
- Sub-area cordon trip matrices from ROM for the 2011 Base scenario (as well as the 2031 scenario matrices) for the Girrawheen microsimulation model study area.

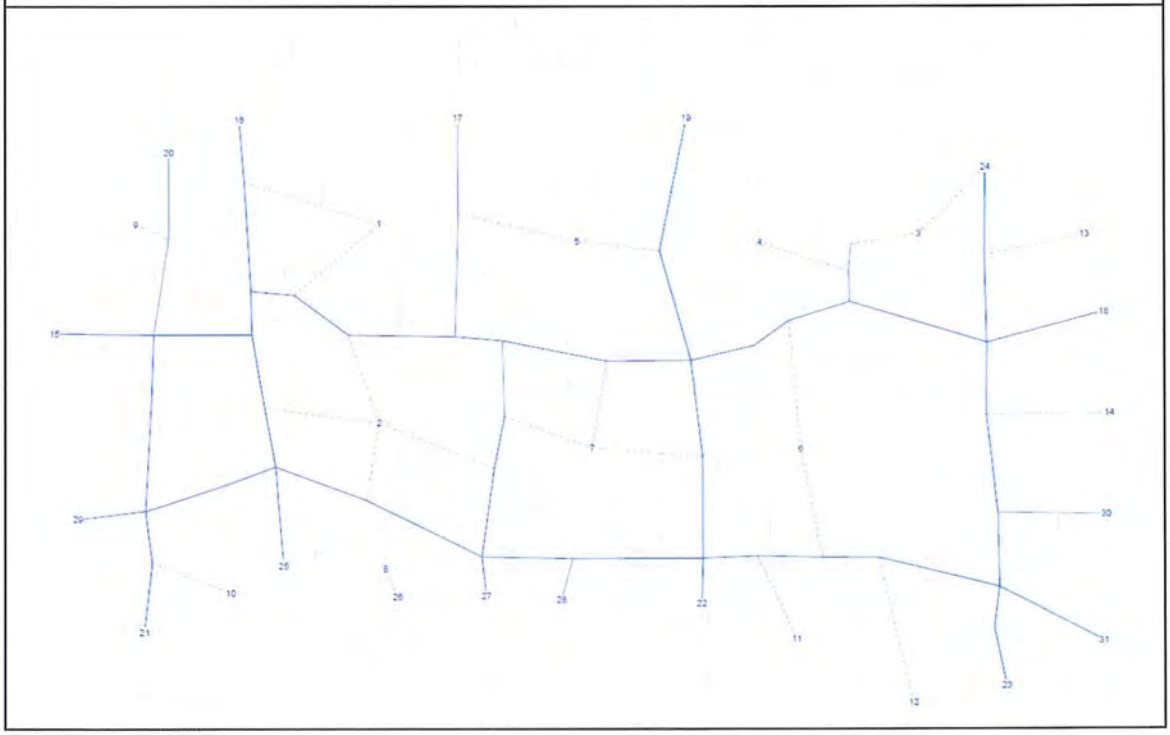
The ROM network and the requested sub-area network is shown in Figure 3.

Figure 3 ROM Network and Sub-area

ROM Network



Girrawheen-Koondoola sub-area



3. Model Development

3.1 Introduction

The microsimulation modelling for this study has been developed using Quadstone Paramics software (version 6). Paramics is a traffic simulation software package that can be used to analyse a connected network of road links and signal controlled intersections, roundabouts, priority junctions in a single model network and to a high level of detail. The simulated driver behaviour is based on lane changing and vehicle following models and can provide an accurate reflection of on-site driver and vehicle behaviour.

3.2 Model Definition

The model runs for two discreet one-hour time periods as per the following:

- AM Peak Model: 8.00-9.00 with preceding warm-up period between 7.00 and 8.00; and
- PM Peak Model: 16.00-17.00 with preceding warm-up period between 15.00 and 16.00.

The time periods above were found to be the critical peak periods with regards to the highest traffic volumes following a review of the available traffic data for the study area. The warm-up periods are in place to ensure vehicles are upon the network at the commencement of the evaluation period.

The Base model is simulated using five variable 'seed values' with the resultant outputs analysed for discrepancies and ultimately averaged for output purposes. The seed value affects the generation of the random numbers that influence the model operation and variability. Therefore each time the model is run with a different seed value a slightly different set of outputs is generated. It would generally be expected that these outputs would be very similar (but not identical), and can loosely be thought of as day-to-day on-site fluctuations. The use of multiple seed values therefore provides confidence that the model results are not based upon a single outlying model run, but the result of a larger sample of model runs.

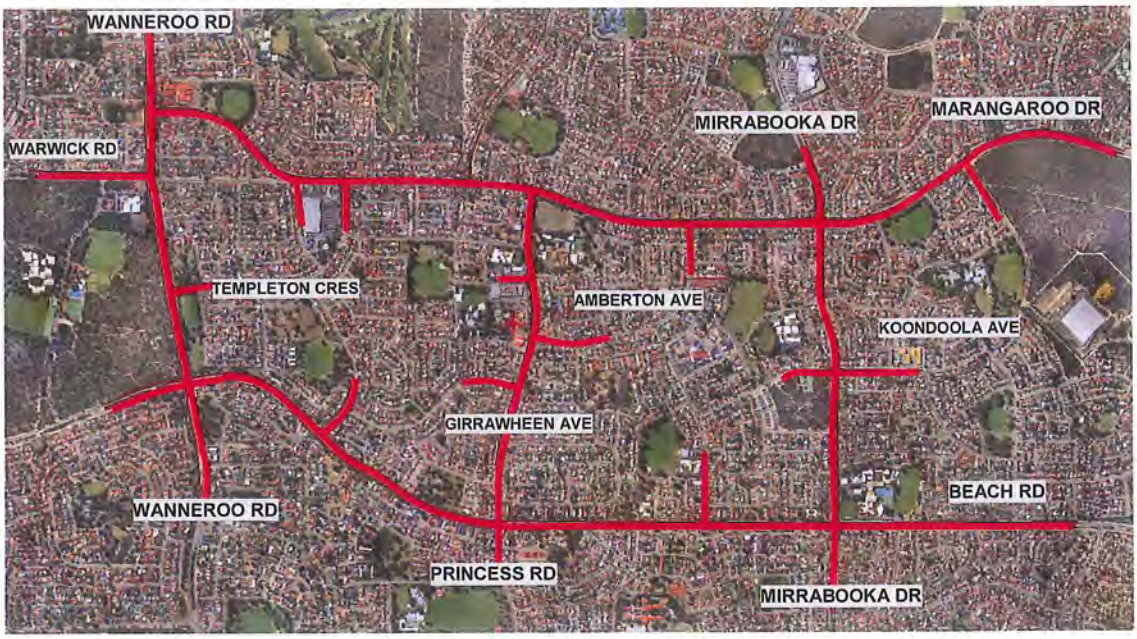
3.3 Model Network

The core model network was coded through the assistance of aerial photography and on-site observations to ensure the following attributes were included into the network:

- Intersection configurations;
- Number of lanes and lane allocations;
- Roadway widths, kerb locations and stopline positions;
- Road speed limits;
- Unsignalised intersection priority controls; and
- Turning lane storage lengths.

The model network is shown in Figure 4.

Figure 4 Girrawheen-Koondoola Model Network



Shared Model Space: Wanneroo and Girrawheen-Koondoola

It should be noted that this Girrawheen model network has been developed at the same time as a Wanneroo study area model has been developed also for City of Wanneroo. Given the close proximity of these two area, the two models have been developed within the same Paramics model space. The models can be run together (although the two networks do not interact with each other) or separately (by specifying demands for an individual network).

3.4 Signalised Intersections

Signalised junctions have been coded into the model to function under fixed time operation consisted with the phasing structure and times recorded in the IDM files. A review of the signal information provided by Main Roads revealed that phase and cycle times remained broadly consistent between consecutive days, as such these timing were coded into the model for the AM and PM peak periods.

3.5 Trip Matrices

Microsimulation models require accurate trip matrices in order to produce an indicative simulation of existing traffic movements. To develop a detailed set of trip matrices the following data sources were used:

- Turning movement volumes from recent surveys (outlined in Section 2.2); and
- An understanding of routing patterns and trip distributions through the study area network (outlined in Section 2.5).

The information above was combined to generate the trip matrices from the traffic assessment as per the following methodology:

A sub-area cordon was cut in ROM by Main Roads to represent only traffic movements within the study area. This produced a daily trips matrix for the study area network, albeit at a coarse zone and network level. A number of the ROM zones were split in order to match the more detailed definition of the zones within the microsimulation network. Following this, the proportional distribution matrix was determined from the ROM daily trip volume matrix. This distribution pattern was then utilised as the initial estimate of trip distributions for the peak period models.

An iterative process of furnessing was undertaken to factor the row and column totals of the microsimulation demand matrices to match the turning count data for entry and exit points to the Paramics model. This factored the overall matrix size to the observed traffic levels whilst retaining the broad original-destination pattern of the original matrices. This process was undertaken separately from both the AM and PM periods. The resulting matrices then underwent a manual matrix-estimation refinement process based on comparisons against known turning movement volumes. These refined trip sets were then applied as the input demand matrices for the Base models.

3.6 Vehicle Release Profiling

Demand release profiles were developed for each of the key model entry locations (where the necessary data was available). These profiles are used to specify the staged release of vehicles into the models across the hourly periods i.e. vehicles do not necessarily arrive at a constant rate across a one hour peak period. Profiles were developed for 15-minute intervals from observed turning movement counts. Individual profiles were applied to external zones which connect directly to an intersection where a turning movement survey was undertaken (and hence 15-minute data was available). For entry zones where data was not available in 15-minute intervals, the 'average' profile was applied to these releases.

3.7 Model Assignment

The modelled network has a number of different route choices between origins and destinations which drivers could potentially elect to use. However, for the vast majority of trips through the network the most logical, or attractive, path is clearly identifiable. The Paramics assignment method that has been employed in this instance is 'all-or-nothing plus perturbation (AON+P)'. This assignment method produces a spread of paths for trips which have comparable alternate route choices. As such, not all vehicles will necessarily choose the same path for a specific trip through the network.

3.8 Vehicle Classification

Traffic survey data was interrogated to determine the average recorded proportion of light and heavy vehicles on the network during the AM and PM peak periods. The resulting truck proportions are shown in Table 2 and have been incorporated in the respective model periods.

Table 2 Heavy Vehicle Proportions

Peak Period	Heavy Vehicle Proportion
AM Peak	4.2 %
PM Peak	2.3 %

3.9 Model Plugins

Azalient Ceejazz model plugins have been utilised within the model. These third party plugins operate in conjunction with the core Paramics software and enhance its functionality. The specific plugin modules which have been used on the Girrawheen model network consist of the following:

- Validator: Used to extract results relating to modelled traffic volumes and travel times;
- Lane Choice: Used to ensure sensible and accurate lane discipline of vehicles on approach to junctions; and
- Route Choice: Used only to ensure sensible vehicle movements through roundabouts (i.e. to prevent vehicle undertaking multiple circulations of a roundabout due to perturbation of route costs).

4. Model Calibration

4.1 Introduction

Model calibration is the process whereby data that has been used in the model building process is checked against the model output to ensure that the model has been accurately coded and is representing the measured on-site conditions. Turning movement traffic volumes have been used as the calibration measure in this instance. As such, the calibration process involved ensuring traffic volumes output by the model were sufficiently accurate when compared against traffic volumes observed on site.

4.2 Turning Count Calibration

A turning count calibration was undertaken for each of the major intersections within the model study area. The purpose of this calibration was to check that traffic volumes collected from the model were representative of traffic volumes measured on site for each traffic movement at each intersection. The GEH statistic was used to compare observed and modelled traffic volumes.

The GEH statistic is a self scaling indicator developed to sensibly compare observed and modelled flows. Rather than directly comparing flows by measure of either absolute or relative differences, the GEH statistic considers both of these measures within thresholds that are appropriate for traffic flow. For instance, the GEH statistic reflects that while an absolute difference of 100 vehicles/hr can be important in the context of a flow of 200 vehicles/hr, it is much less relevant in a flow of several thousand vehicles/hr.

GEH compares the differences between hourly observed flows and hourly modelled flows by using the following formula:

$$GEH = \sqrt{(V_O - V_A)^2 / (0.5 \times (V_O + V_A))}$$

Where:

V_O = Observed traffic flow (vehicles/hour)

V_A = Assigned (or modelled) hourly traffic flow (vehicles/hour)

The following criteria were used during the turning count calibration process:

- 85% of GEH statistics for individual junction turning-movement total volumes should be less than 5;
- R^2 statistic between 0.9 and 1.0 and slope factors between 0.9 and 1.1, of modelled vs. observed flow plots.

Table 3 provides a summary of the turning movement GEH criteria results. It can be seen that a total of 92 individual movements were assessed within each time period. The turning movements included as part of the calibration assessment include only movements which were directly known from recent survey information i.e. manual counts and selected SCATS detector recordings.

Table 3 demonstrates that during both peak periods, the model provides a close match of modelled and observed traffic flows.

Table 3 Summary of GEH Criteria Results

Time Period	Number of Observations	Observations with GEH < 5	Average GEH	R^2 and Slope	Exceeds Criteria?
AM Peak	92	92 (*100%*)	1.56	0.99, 1.009	Yes
PM Peak	92	92 (*100%*)	1.66	0.99, 0.978	Yes

Figure 5 and Figure 6 show plots of modelled traffic volumes compared with observed traffic volumes for each turning movement. It can be seen from theses charts that there is close fit between observed and modelled traffic volumes across each of the time periods surveyed.

It should be noted that the raw surveyed traffic volumes have been adopted directly for this assessment. That is, there has not been any manual smoothing or manipulation of the surveyed data, as such there exist some minor discrepancies between adjacent sites due to inherent survey errors. Consequently, under this approach it is not possible to match each and every count precisely.

Appendix A provides fully tabulated results of the turning count calibration assessment for each individual turning movement.

Figure 5 AM Peak Traffic Volume Comparison

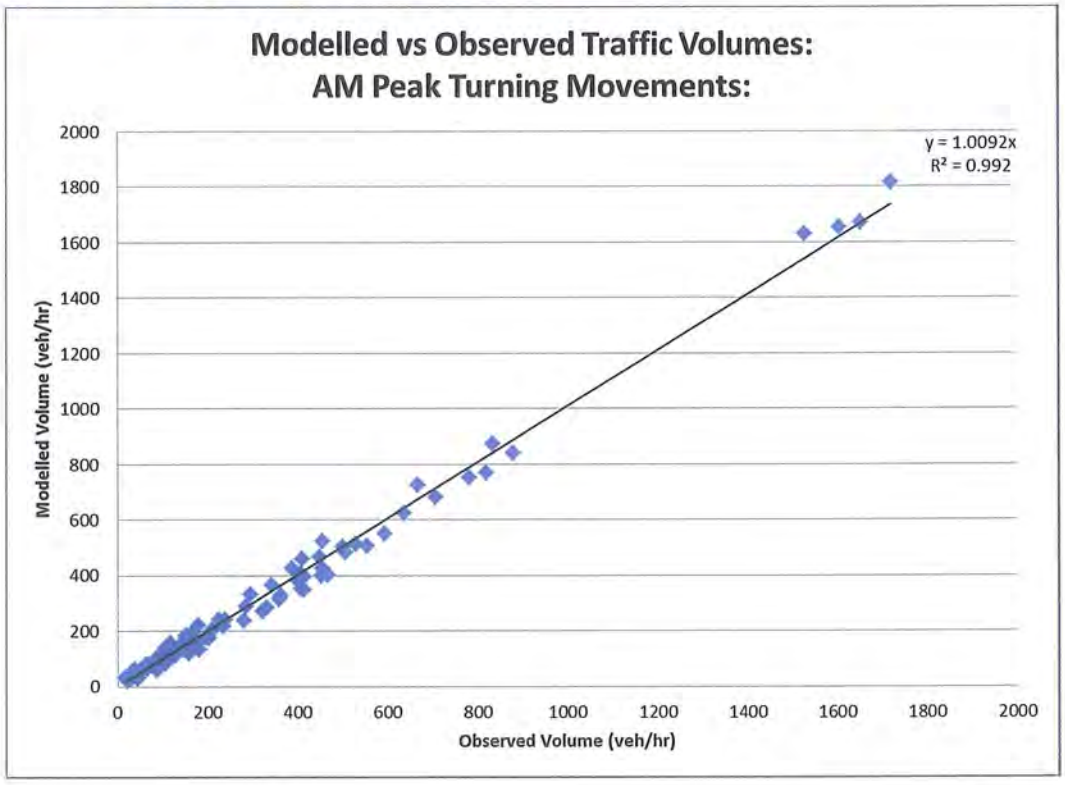
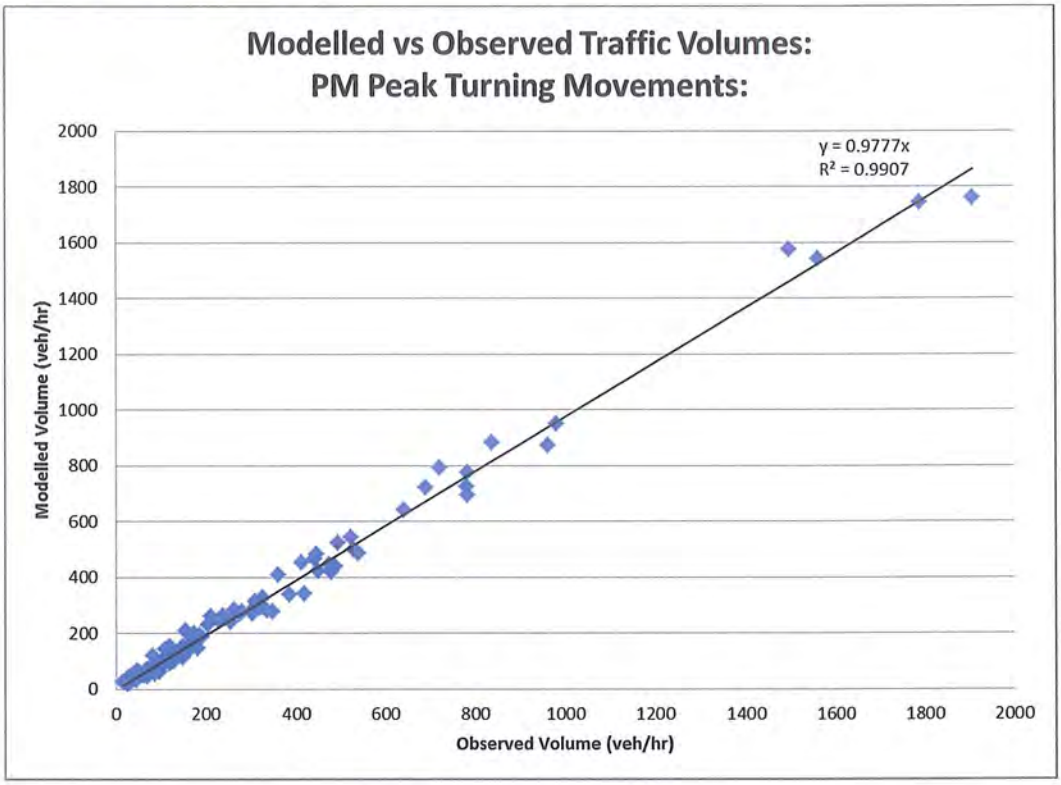


Figure 6 PM Peak Traffic Volume Comparison



5. Model Validation

5.1 Introduction

This section details the results from the validation of the base model. The purpose of model validation is to ensure that statistical results in the model accurately reflect data collected during the survey period, but have not been explicitly used as model inputs during the development stages. The validation measure used in this instance was travel time data.

In addition to the travel time validation, an assessment of model stability has also been presented which shows model output variations across multiple seed value runs.

5.2 Travel Time Validation

As part of the validation process GHD undertook an analysis of journey times for vehicles in the model along Wanneroo Road, Marangaroo Drive, Beach Road, Girrawheen Avenue and Mirrabooka Avenue and compared these against journey time observations recorded on site. Average journey times across five seed runs were collected from the model outputs and analysed. The following criteria was used to assess whether the modelled journey times were representative of conditions on site:

- Percentage difference between total observed and total modelled journey times for each route should be less than 15% or 1-minute (whichever is greater).

Figure 7 displays the travel time routes surveyed and compared with modelled outputs.

Table 4 and Table 5 shows a summary of the travel time validation results for the various sections of the network for the AM and PM periods respectively. It is clear that the model closely replicates the recorded travel times along the critical corridors for both the AM and PM periods.

Figure 7 Surveyed Travel Time Sections

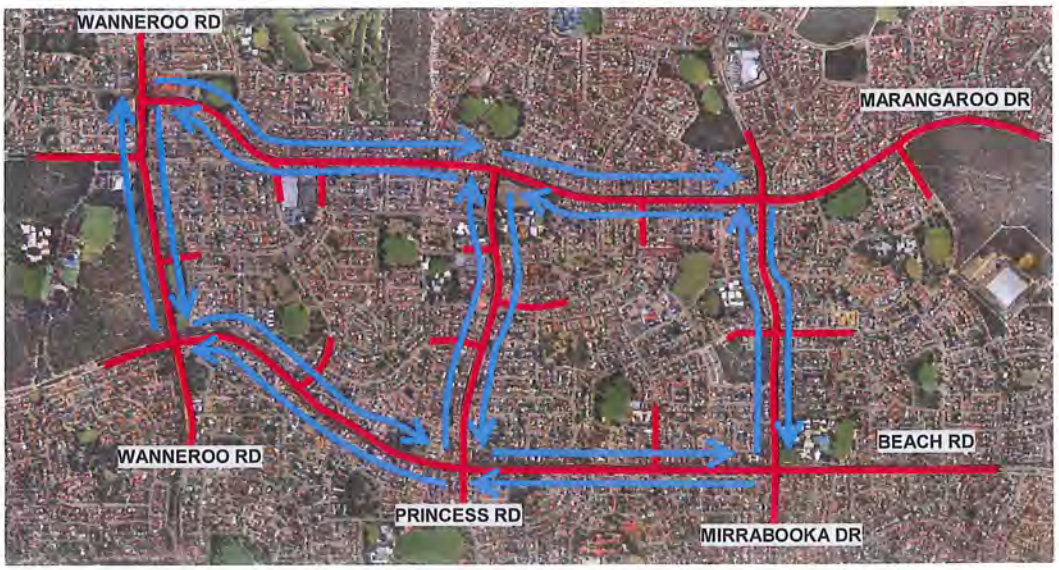


Table 4 AM Peak Travel Time Comparison

Location	Observed (seconds)	Modelled (seconds)	Difference (seconds)	Meets Criteria?
Northbound movements				
Wanneroo Rd: Beach Rd to Marangaroo Dr	226	231	5	*Yes*
Girrawheen Ave: Beach Rd to Marangaroo Dr	180	161	-19	*Yes*
Mirrabooka Ave: Beach Rd to Marangaroo Dr	126	128	2	*Yes*
Southbound movements				
Wanneroo Rd: Marangaroo Dr to Beach Rd	217	195	-22	*Yes*
Girrawheen Ave: Marangaroo Dr to Beach Rd	205	189	-16	*Yes*
Mirrabooka Ave: Marangaroo Dr to Beach Rd	147	138	-9	*Yes*
Eastbound movements				
Marangaroo Dr: Wanneroo Rd to Girrawheen Ave	164	137	-27	*Yes*
Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave	112	109	-3	*Yes*
Beach Rd: Wanneroo Rd to Girrawheen Ave	138	117	-21	*Yes*
Beach Rd: Girrawheen Ave to Mirrabooka Ave	109	111	2	*Yes*
Westbound movements				
Marangaroo Dr: Girrawheen Ave to Wanneroo Rd	184	195	11	*Yes*
Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave	76	68	-8	*Yes*
Beach Rd: Girrawheen Ave to Wanneroo Rd	153	151	-1	*Yes*
Beach Rd: Mirrabooka Ave to Girrawheen Ave	138	112	-26	*Yes*

Table 5 PM Peak Travel Time Comparison

Location	Observed (seconds)	Modelled (seconds)	Difference (seconds)	Meets Criteria?
Northbound movements				
Wanneroo Rd: Beach Rd to Marangaroo Dr	202	177	-24	Yes
Girrawheen Ave: Beach Rd to Marangaroo Dr	143	151	8	Yes
Mirrabooka Ave: Beach Rd to Marangaroo Dr	152	137	-15	Yes
Southbound movements				
Wanneroo Rd: Marangaroo Dr to Beach Rd	82	87	5	Yes
Girrawheen Ave: Marangaroo Dr to Beach Rd	143	174	31	Yes
Mirrabooka Ave: Marangaroo Dr to Beach Rd	143	129	-14	Yes
Eastbound movements				
Marangaroo Dr: Wanneroo Rd to Girrawheen Ave	148	126	-22	Yes
Marangaroo Dr: Girrawheen Ave to Mirrabooka Ave	112	111	-1	Yes
Beach Rd: Wanneroo Rd to Girrawheen Ave	117	115	-2	Yes
Beach Rd: Girrawheen Ave to Mirrabooka Ave	117	107	-10	Yes
Westbound movements				
Marangaroo Dr: Girrawheen Ave to Wanneroo Rd	118	119	1	Yes
Marangaroo Dr: Mirrabooka Ave to Girrawheen Ave	73	68	-5	Yes
Beach Rd: Girrawheen Ave to Wanneroo Rd	194	184	-9	Yes
Beach Rd: Mirrabooka Ave to Girrawheen Ave	123	113	-9	Yes

It can be seen from Table 4 and Table 5 that the difference between the observed and modelled journey times is significantly less than the 1-minute threshold for all comparisons.

5.3 Model Stability

The base model has been run with five 'seed' values (as discussed in Section 3.2 of this report) and the results of these model runs have been averaged for the calibration and validation outputs. However, it is important to ensure that the model runs are providing a stable and consistent model platform to take forward to the option testing stage. This requires the assessment of output

statistics from each seed run to ensure that the variability of the outputs appears to be within reasonable limits.

In order to assess model stability for this study, two network wide statistics have been extracted and presented comparing each of the five individual seed value runs. The two assessment statistics are as follows:

- Average vehicle speed (veh/hr) of all vehicles currently in the model network; and
- Current number of vehicles being serviced by the network.

Figure 8 and Figure 9 show the stability test outputs for the AM and PM models respectively. These figures display variations between seed vales (as expected), but do not highlight any substantial outlying or rogue results.

Figure 8 AM Peak Model Stability Test Results

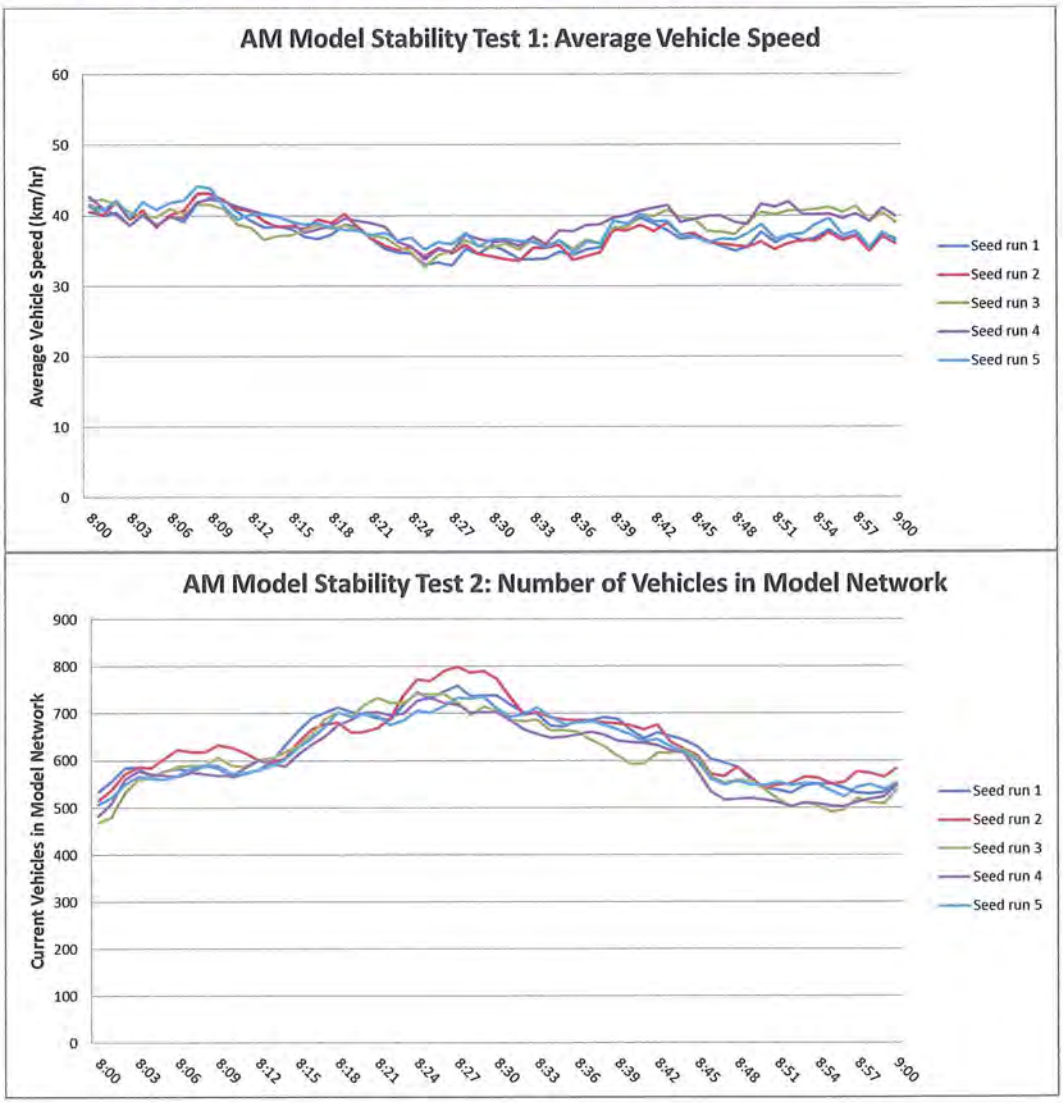
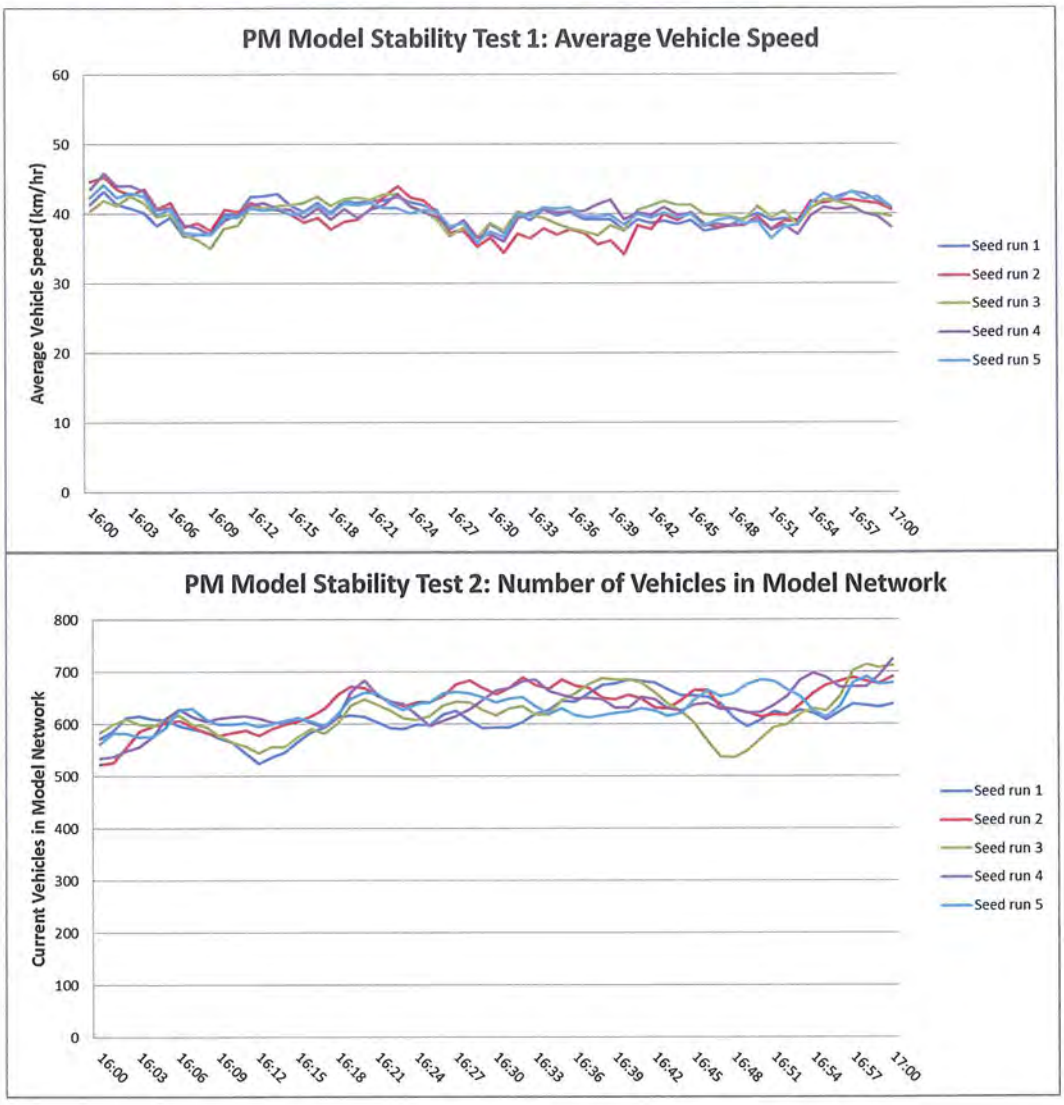


Figure 9 PM Peak Model Stability Test Results



6. Conclusion

6.1 Summary

This document has outlined the development of the microsimulation Base model for the central area of Girrawheen-Koondoola. Paramics (version 6) in conjunction with Azalient plugins has been used to simulate the movement vehicles for the critical AM and PM peak periods of an average weekday.

The report has detailed the calibration process used to ensure that the model is representative of observed on-site turning movement traffic volumes. These have been shown to meet and significantly exceed industry standard guidelines.

In addition, the validation process for travel times has been outlined. All modelled travel time data has been shown to meet the target criteria. Furthermore, both the AM and PM models have been found to exhibit stable results across different seed value runs.

Given the results of the calibration and validation process, the model is now considered a robust representation of the study area during the AM and PM peak time periods. As such, these models are considered suitable to be used as the foundation for future year scenario testing.

6.2 Next Steps

The next step with regards to the traffic modelling assessment consists of using the AM and PM models as detailed in this report to assess the Girrawheen-Koondoola network performance with increased traffic volumes aligning with the following scenarios:

- 2031 horizon with no change to R-coding; and
- 2031 horizon with increased R-coding designations.

The volumes and trip distributions corresponding to the above scenarios will be determined through analysis of the provided ROM trip matrices for the two scenarios. The relative change in volumes between the two scenarios, and the base volumes, will be considered when interpreting these forecast volumes.

Appendices

Appendix A Turning Count Calibration Statistics

AM Peak Turning Movement Comparison

Intersection	Movement	Observed	Modelled	GEH
Wanneroo Road / Marangaroo Drive	N to S	1604	1655	1.26
Wanneroo Road / Marangaroo Drive	N to E	200	175	1.86
Wanneroo Road / Marangaroo Drive	E to N	167	199	2.38
Wanneroo Road / Marangaroo Drive	E to S	410	461	2.43
Wanneroo Road / Marangaroo Drive	S to E	239	243	0.26
Wanneroo Road / Marangaroo Drive	S to N	880	841	1.34
Wanneroo Road / Warwick Road	N to W	506	482	1.09
Wanneroo Road / Warwick Road	N to S	1527	1629	2.57
Wanneroo Road / Warwick Road	S to N	669	724	2.10
Wanneroo Road / Warwick Road	W to S	224	240	1.05
Wanneroo Road / Templeton Cres	N to S	1720	1814	2.23
Wanneroo Road / Templeton Cres	N to E	46	53	0.97
Wanneroo Road / Templeton Cres	E to N	29	28	0.15
Wanneroo Road / Templeton Cres	E to S	169	151	1.44
Wanneroo Road / Templeton Cres	S to E	87	61	3.02
Wanneroo Road / Templeton Cres	S to N	834	873	1.33
Wanneroo Road / Beach Road	N to W	158	140	1.47
Wanneroo Road / Beach Road	N to S	1652	1672	0.48
Wanneroo Road / Beach Road	N to E	147	135	0.99
Wanneroo Road / Beach Road	E to N	154	177	1.77
Wanneroo Road / Beach Road	E to W	358	316	2.31
Wanneroo Road / Beach Road	E to S	106	83	2.37
Wanneroo Road / Beach Road	S to E	32	38	1.01
Wanneroo Road / Beach Road	S to N	638	624	0.57
Wanneroo Road / Beach Road	S to W	109	111	0.19
Wanneroo Road / Beach Road	W to S	209	206	0.24
Wanneroo Road / Beach Road	W to E	449	465	0.77
Wanneroo Road / Beach Road	W to N	106	136	2.76
Beach Road / Girrawheen Avenue	N to W	38	63	3.49
Beach Road / Girrawheen Avenue	N to S	363	328	1.91
Beach Road / Girrawheen Avenue	N to E	160	148	0.98
Beach Road / Girrawheen Avenue	E to N	121	140	1.70
Beach Road / Girrawheen Avenue	E to W	407	354	2.72
Beach Road / Girrawheen Avenue	E to S	152	184	2.44
Beach Road / Girrawheen Avenue	S to E	112	101	1.11
Beach Road / Girrawheen Avenue	S to N	170	176	0.44
Beach Road / Girrawheen Avenue	S to W	104	98	0.64

AM Peak Turning Movement Comparison (*Continued*)

Intersection	Movement	Observed	Modelled	GEH
Beach Road / Girrawheen Avenue	W to S	92	91	0.10
Beach Road / Girrawheen Avenue	W to E	555	508	2.04
Beach Road / Girrawheen Avenue	W to N	18	33	2.90
Beach Road / Hainsworth Avenue	N to W	158	120	3.24
Beach Road / Hainsworth Avenue	N to E	162	141	1.67
Beach Road / Hainsworth Avenue	E to N	117	157	3.42
Beach Road / Hainsworth Avenue	E to W	594	552	1.75
Beach Road / Hainsworth Avenue	W to E	708	683	0.96
Beach Road / Hainsworth Avenue	W to N	90	73	1.84
Beach Road / Mirrabooka Avenue	N to W	153	176	1.76
Beach Road / Mirrabooka Avenue	N to S	782	754	1.01
Beach Road / Mirrabooka Avenue	E to N	234	217	1.16
Beach Road / Mirrabooka Avenue	E to W	453	399	2.60
Beach Road / Mirrabooka Avenue	S to E	141	145	0.30
Beach Road / Mirrabooka Avenue	S to N	342	364	1.18
Beach Road / Mirrabooka Avenue	W to S	206	197	0.61
Beach Road / Mirrabooka Avenue	W to E	529	514	0.66
Marangaroo Drive / Koondoola Avenue	E to W	455	524	3.10
Marangaroo Drive / Koondoola Avenue	E to S	119	126	0.65
Marangaroo Drive / Koondoola Avenue	S to E	67	68	0.07
Marangaroo Drive / Koondoola Avenue	S to W	21	22	0.13
Marangaroo Drive / Koondoola Avenue	W to S	28	27	0.19
Marangaroo Drive / Koondoola Avenue	W to E	388	427	1.92
Marangaroo Drive / Mirrabooka Avenue	N to W	128	130	0.19
Marangaroo Drive / Mirrabooka Avenue	N to S	820	770	1.77
Marangaroo Drive / Mirrabooka Avenue	N to E	103	113	0.94
Marangaroo Drive / Mirrabooka Avenue	E to N	103	96	0.66
Marangaroo Drive / Mirrabooka Avenue	E to W	321	271	2.88
Marangaroo Drive / Mirrabooka Avenue	E to S	201	176	1.82
Marangaroo Drive / Mirrabooka Avenue	S to E	50	53	0.47
Marangaroo Drive / Mirrabooka Avenue	S to N	400	382	0.92
Marangaroo Drive / Mirrabooka Avenue	S to W	105	140	3.20
Marangaroo Drive / Mirrabooka Avenue	W to S	165	135	2.45
Marangaroo Drive / Mirrabooka Avenue	W to E	284	289	0.30
Marangaroo Drive / Mirrabooka Avenue	W to N	54	62	1.08
Marangaroo Drive / Girrawheen Avenue	E to W	456	426	1.44
Marangaroo Drive / Girrawheen Avenue	E to S	177	155	1.68

AM Peak Turning Movement Comparison (*Continued*)

Intersection	Movement	Observed	Modelled	GEH
Marangaroo Drive / Girrawheen Avenue	S to E	63	80	2.01
Marangaroo Drive / Girrawheen Avenue	S to W	178	222	3.10
Marangaroo Drive / Girrawheen Avenue	W to S	293	332	2.22
Marangaroo Drive / Girrawheen Avenue	W to E	414	395	0.93
Girrawheen Avenue / Amberton Avenue	N to S	407	405	0.12
Girrawheen Avenue / Amberton Avenue	N to E	129	114	1.34
Girrawheen Avenue / Amberton Avenue	E to N	180	135	3.60
Girrawheen Avenue / Amberton Avenue	E to S	87	103	1.62
Girrawheen Avenue / Amberton Avenue	S to E	66	79	1.50
Girrawheen Avenue / Amberton Avenue	S to N	331	285	2.61
Marangaroo Drive / Highclere Boulevard	N to W	279	238	2.58
Marangaroo Drive / Highclere Boulevard	E to N	134	144	0.83
Marangaroo Drive / Highclere Boulevard	E to W	501	503	0.11
Marangaroo Drive / Highclere Boulevard	W to E	467	401	3.15
Marangaroo Drive / Templeton Cres	S to E	118	106	1.11
Marangaroo Drive / Templeton Cres	S to W	46	33	2.07
Marangaroo Drive / Templeton Cres	W to S	44	31	2.09
Marangaroo Drive / Templeton Cres	W to E	413	350	3.24

PM Peak Turning Movement Comparison

Intersection	Movement	Observed	Modelled	GEH
Wanneroo Road / Marangaroo Drive	N to S	961	872	2.93
Wanneroo Road / Marangaroo Drive	N to E	177	191	1.05
Wanneroo Road / Marangaroo Drive	E to N	237	263	1.67
Wanneroo Road / Marangaroo Drive	E to S	263	286	1.38
Wanneroo Road / Marangaroo Drive	S to E	359	409	2.54
Wanneroo Road / Marangaroo Drive	S to N	1907	1762	3.39
Wanneroo Road / Warwick Road	N to W	335	283	2.98
Wanneroo Road / Warwick Road	N to S	836	882	1.57
Wanneroo Road / Warwick Road	S to N	1494	1576	2.08
Wanneroo Road / Warwick Road	W to S	135	125	0.88
Wanneroo Road / Templeton Cres	N to S	979	952	0.87
Wanneroo Road / Templeton Cres	N to E	85	55	3.59
Wanneroo Road / Templeton Cres	E to N	37	39	0.29
Wanneroo Road / Templeton Cres	E to S	119	93	2.53
Wanneroo Road / Templeton Cres	S to E	309	295	0.83
Wanneroo Road / Templeton Cres	S to N	1787	1743	1.05
Wanneroo Road / Beach Road	N to W	185	194	0.67
Wanneroo Road / Beach Road	N to S	780	725	2.02
Wanneroo Road / Beach Road	N to E	115	123	0.72
Wanneroo Road / Beach Road	E to N	210	263	3.43
Wanneroo Road / Beach Road	E to W	446	485	1.81
Wanneroo Road / Beach Road	E to S	61	50	1.53
Wanneroo Road / Beach Road	S to E	52	51	0.11
Wanneroo Road / Beach Road	S to N	1558	1544	0.37
Wanneroo Road / Beach Road	S to W	162	158	0.28
Wanneroo Road / Beach Road	W to S	149	152	0.28
Wanneroo Road / Beach Road	W to E	307	315	0.48
Wanneroo Road / Beach Road	W to N	204	232	1.87
Beach Road / Girrawheen Avenue	N to W	29	47	2.92
Beach Road / Girrawheen Avenue	N to S	230	244	0.91
Beach Road / Girrawheen Avenue	N to E	97	87	1.09
Beach Road / Girrawheen Avenue	E to N	148	113	3.10
Beach Road / Girrawheen Avenue	E to W	641	641	0.00
Beach Road / Girrawheen Avenue	E to S	127	99	2.61
Beach Road / Girrawheen Avenue	S to E	154	212	4.30
Beach Road / Girrawheen Avenue	S to N	418	342	3.91
Beach Road / Girrawheen Avenue	S to W	118	155	3.20

PM Peak Turning Movement Comparison (*Continued*)

Intersection	Movement	Observed	Modelled	GEH
Beach Road / Girrawheen Avenue	W to S	95	63	3.60
Beach Road / Girrawheen Avenue	W to E	324	328	0.22
Beach Road / Girrawheen Avenue	W to N	38	54	2.39
Beach Road / Hainsworth Avenue	N to W	68	45	3.03
Beach Road / Hainsworth Avenue	N to E	65	66	0.15
Beach Road / Hainsworth Avenue	E to N	166	154	0.98
Beach Road / Hainsworth Avenue	E to W	720	792	2.63
Beach Road / Hainsworth Avenue	W to E	492	525	1.46
Beach Road / Hainsworth Avenue	W to N	119	106	1.25
Beach Road / Mirrabooka Avenue	N to W	69	75	0.68
Beach Road / Mirrabooka Avenue	N to S	450	422	1.35
Beach Road / Mirrabooka Avenue	E to N	275	271	0.27
Beach Road / Mirrabooka Avenue	E to W	688	722	1.27
Beach Road / Mirrabooka Avenue	S to E	137	132	0.45
Beach Road / Mirrabooka Avenue	S to N	781	694	3.21
Beach Road / Mirrabooka Avenue	W to S	100	96	0.38
Beach Road / Mirrabooka Avenue	W to E	347	277	3.94
Marangaroo Drive / Koondoola Avenue	E to W	411	455	2.10
Marangaroo Drive / Koondoola Avenue	E to S	30	24	1.15
Marangaroo Drive / Koondoola Avenue	S to E	65	63	0.22
Marangaroo Drive / Koondoola Avenue	S to W	26	19	1.39
Marangaroo Drive / Koondoola Avenue	W to S	15	25	2.16
Marangaroo Drive / Koondoola Avenue	W to E	440	466	1.20
Marangaroo Drive / Mirrabooka Avenue	N to W	124	120	0.40
Marangaroo Drive / Mirrabooka Avenue	N to S	487	439	2.24
Marangaroo Drive / Mirrabooka Avenue	N to E	83	71	1.41
Marangaroo Drive / Mirrabooka Avenue	E to N	133	121	1.06
Marangaroo Drive / Mirrabooka Avenue	E to W	318	290	1.59
Marangaroo Drive / Mirrabooka Avenue	E to S	51	62	1.46
Marangaroo Drive / Mirrabooka Avenue	S to E	109	144	3.14
Marangaroo Drive / Mirrabooka Avenue	S to N	782	775	0.24
Marangaroo Drive / Mirrabooka Avenue	S to W	161	137	1.97
Marangaroo Drive / Mirrabooka Avenue	W to S	113	102	1.04
Marangaroo Drive / Mirrabooka Avenue	W to E	278	278	0.00
Marangaroo Drive / Mirrabooka Avenue	W to N	189	187	0.13
Marangaroo Drive / Girrawheen Avenue	E to W	475	445	1.39
Marangaroo Drive / Girrawheen Avenue	E to S	87	95	0.88

PM Peak Turning Movement Comparison (*Continued*)

Intersection	Movement	Observed	Modelled	GEH
Marangaroo Drive / Girrawheen Avenue	S to E	148	128	1.70
Marangaroo Drive / Girrawheen Avenue	S to W	254	241	0.83
Marangaroo Drive / Girrawheen Avenue	W to S	156	206	3.70
Marangaroo Drive / Girrawheen Avenue	W to E	529	502	1.20
Girrawheen Avenue / Amberton Avenue	N to S	301	273	1.64
Girrawheen Avenue / Amberton Avenue	N to E	111	99	1.15
Girrawheen Avenue / Amberton Avenue	E to N	102	87	1.54
Girrawheen Avenue / Amberton Avenue	E to S	46	68	2.89
Girrawheen Avenue / Amberton Avenue	S to E	82	120	3.82
Girrawheen Avenue / Amberton Avenue	S to N	384	339	2.38
Marangaroo Drive / Highclere Boulevard	N to W	181	149	2.52
Marangaroo Drive / Highclere Boulevard	E to N	173	201	2.08
Marangaroo Drive / Highclere Boulevard	E to W	538	485	2.33
Marangaroo Drive / Highclere Boulevard	W to E	523	545	0.93
Marangaroo Drive / Templeton Cres	S to E	324	295	1.67
Marangaroo Drive / Templeton Cres	S to W	66	70	0.44
Marangaroo Drive / Templeton Cres	W to S	45	34	1.72
Marangaroo Drive / Templeton Cres	W to E	479	419	2.82

GHD

180 Lonsdale Street
Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

G:\31\29005\WP\213867.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S. Bennett	S. Smedley		S. Smedley		

www.ghd.com

Appendix C - 2031 forecast traffic volumes

Turning movement volumes - veh/hr

Intersection	Movement	2031 AM without LHS	2031 AM with LHS	2031 PM without LHS	2031 PM with LHS
Wanneroo Road / Marangaroo Drive	N to S	2224	2337	1144	1206
Wanneroo Road / Marangaroo Drive	N to E	182	351	193	316
Wanneroo Road / Marangaroo Drive	E to N	278	380	318	443
Wanneroo Road / Marangaroo Drive	E to S	550	722	356	531
Wanneroo Road / Marangaroo Drive	S to E	254	407	463	694
Wanneroo Road / Marangaroo Drive	S to N	1156	1158	2452	2460
Wanneroo Road / Warwick Road	N to W	637	665	339	368
Wanneroo Road / Warwick Road	N to S	2145	2392	1156	1364
Wanneroo Road / Warwick Road	S to N	947	1076	2174	2375
Wanneroo Road / Warwick Road	S to W	192	200	256	233
Wanneroo Road / Warwick Road	W to S	302	319	139	159
Wanneroo Road / Warwick Road	W to N	468	497	752	799
Wanneroo Road / Templeton Cres	N to S	2404	2607	1242	1395
Wanneroo Road / Templeton Cres	N to E	44	107	52	129
Wanneroo Road / Templeton Cres	E to N	26	56	31	88
Wanneroo Road / Templeton Cres	E to S	139	368	87	190
Wanneroo Road / Templeton Cres	S to E	53	153	249	622
Wanneroo Road / Templeton Cres	S to N	1112	1223	2401	2520
Wanneroo Road / Beach Road	N to W	156	197	220	271
Wanneroo Road / Beach Road	N to S	2218	2490	911	1066
Wanneroo Road / Beach Road	N to E	155	283	196	244
Wanneroo Road / Beach Road	E to N	201	291	356	508
Wanneroo Road / Beach Road	E to W	384	408	578	572
Wanneroo Road / Beach Road	E to S	88	216	47	98
Wanneroo Road / Beach Road	S to E	26	71	48	111
Wanneroo Road / Beach Road	S to N	794	874	1980	2244
Wanneroo Road / Beach Road	S to W	125	108	232	166
Wanneroo Road / Beach Road	W to S	306	283	226	175
Wanneroo Road / Beach Road	W to E	570	574	370	374
Wanneroo Road / Beach Road	W to N	172	210	298	362
Beach Road / Girrawheen Avenue	N to W	47	153	28	107
Beach Road / Girrawheen Avenue	N to S	541	695	347	539
Beach Road / Girrawheen Avenue	N to E	98	285	56	197
Beach Road / Girrawheen Avenue	E to N	91	244	68	220
Beach Road / Girrawheen Avenue	E to W	359	474	665	799
Beach Road / Girrawheen Avenue	E to S	422	416	256	206
Beach Road / Girrawheen Avenue	S to E	210	188	483	451
Beach Road / Girrawheen Avenue	S to N	296	396	568	736
Beach Road / Girrawheen Avenue	S to W	199	170	312	317
Beach Road / Girrawheen Avenue	W to S	197	189	176	127
Beach Road / Girrawheen Avenue	W to E	528	672	358	410
Beach Road / Girrawheen Avenue	W to N	30	82	41	106
Beach Road / Hainsworth Avenue	N to W	128	339	48	142
Beach Road / Hainsworth Avenue	N to E	100	288	52	132
Beach Road / Hainsworth Avenue	E to N	127	343	126	336
Beach Road / Hainsworth Avenue	E to W	751	798	947	1098
Beach Road / Hainsworth Avenue	W to E	780	941	775	778
Beach Road / Hainsworth Avenue	W to N	56	205	119	280
Beach Road / Mirrabooka Avenue	N to W	325	410	121	243
Beach Road / Mirrabooka Avenue	N to S	1014	1116	555	644
Beach Road / Mirrabooka Avenue	N to E	369	464	270	388
Beach Road / Mirrabooka Avenue	E to N	241	322	324	384
Beach Road / Mirrabooka Avenue	E to W	450	506	809	899
Beach Road / Mirrabooka Avenue	E to S	133	114	126	118
Beach Road / Mirrabooka Avenue	S to E	117	122	114	116
Beach Road / Mirrabooka Avenue	S to N	550	593	925	1061
Beach Road / Mirrabooka Avenue	S to W	111	227	144	293
Beach Road / Mirrabooka Avenue	W to S	146	338	76	154
Beach Road / Mirrabooka Avenue	W to E	584	606	312	279
Beach Road / Mirrabooka Avenue	W to N	167	286	439	482

Intersection	Movement	2031 AM without LHS	2031 AM with LHS	2031 PM without LHS	2031 PM with LHS
Marangaroo Drive / Koondoola Avenue	E to W	706	650	662	635
Marangaroo Drive / Koondoola Avenue	E to S	101	263	31	73
Marangaroo Drive / Koondoola Avenue	S to E	72	158	63	137
Marangaroo Drive / Koondoola Avenue	S to W	21	78	20	83
Marangaroo Drive / Koondoola Avenue	W to S	32	108	19	80
Marangaroo Drive / Koondoola Avenue	W to E	491	499	591	544
Marangaroo Drive / Mirrabooka Avenue	N to W	243	323	178	248
Marangaroo Drive / Mirrabooka Avenue	N to S	1272	1285	724	735
Marangaroo Drive / Mirrabooka Avenue	N to E	198	179	146	98
Marangaroo Drive / Mirrabooka Avenue	E to N	189	134	268	173
Marangaroo Drive / Mirrabooka Avenue	E to W	306	360	332	443
Marangaroo Drive / Mirrabooka Avenue	E to S	241	241	77	98
Marangaroo Drive / Mirrabooka Avenue	S to E	68	77	171	174
Marangaroo Drive / Mirrabooka Avenue	S to N	677	694	1300	1334
Marangaroo Drive / Mirrabooka Avenue	S to W	114	262	126	269
Marangaroo Drive / Mirrabooka Avenue	W to S	108	262	82	267
Marangaroo Drive / Mirrabooka Avenue	W to E	260	350	292	353
Marangaroo Drive / Mirrabooka Avenue	W to N	96	116	290	377
Marangaroo Drive / Girrawheen Avenue	E to W	554	686	549	731
Marangaroo Drive / Girrawheen Avenue	E to S	160	383	74	201
Marangaroo Drive / Girrawheen Avenue	S to E	61	140	115	273
Marangaroo Drive / Girrawheen Avenue	S to W	280	492	374	454
Marangaroo Drive / Girrawheen Avenue	W to S	449	600	217	430
Marangaroo Drive / Girrawheen Avenue	W to E	398	565	607	878
Girrawheen Avenue / Amberton Avenue	N to S	556	768	318	577
Girrawheen Avenue / Amberton Avenue	N to E	82	278	62	232
Girrawheen Avenue / Amberton Avenue	E to N	120	351	62	215
Girrawheen Avenue / Amberton Avenue	E to S	92	256	72	178
Girrawheen Avenue / Amberton Avenue	S to E	79	200	139	280
Girrawheen Avenue / Amberton Avenue	S to N	326	521	477	656
Marangaroo Drive / Highclere Boulevard	N to W	242	311	160	181
Marangaroo Drive / Highclere Boulevard	N to E	470	409	242	222
Marangaroo Drive / Highclere Boulevard	E to N	218	212	358	280
Marangaroo Drive / Highclere Boulevard	E to W	610	964	566	912
Marangaroo Drive / Highclere Boulevard	W to E	371	760	589	1089
Marangaroo Drive / Highclere Boulevard	W to N	69	78	157	250
Marangaroo Drive / Templeton Cres	E to W	776	1085	648	934
Marangaroo Drive / Templeton Cres	E to S	74	189	78	156
Marangaroo Drive / Templeton Cres	S to E	83	221	265	670
Marangaroo Drive / Templeton Cres	S to W	35	78	74	181
Marangaroo Drive / Templeton Cres	W to S	34	60	32	89
Marangaroo Drive / Templeton Cres	W to E	358	618	482	664
Mirrabooka Ave / Koondoola Ave	N to E	56	130	47	141
Mirrabooka Ave / Koondoola Ave	N to S	1563	1536	799	773
Mirrabooka Ave / Koondoola Ave	N to W	52	104	44	132
Mirrabooka Ave / Koondoola Ave	E to S	140	283	94	227
Mirrabooka Ave / Koondoola Ave	E to W	74	301	17	78
Mirrabooka Ave / Koondoola Ave	E to N	75	155	95	232
Mirrabooka Ave / Koondoola Ave	S to W	68	153	116	272
Mirrabooka Ave / Koondoola Ave	S to N	764	798	1448	1305
Mirrabooka Ave / Koondoola Ave	S to E	109	253	99	249
Mirrabooka Ave / Koondoola Ave	W to N	40	100	65	197
Mirrabooka Ave / Koondoola Ave	W to E	32	143	29	80
Mirrabooka Ave / Koondoola Ave	W to S	75	156	83	224

Appendix D - Modelled intersection configurations – Paramics

Beach Road – Wanneroo Raod

Existing layout	'without LHS'	'with LHS' *(no change from 'without LHS')*
		

Beach Road – Girrawheen Avenue

Existing layout	'without LHS'	'with LHS'
		

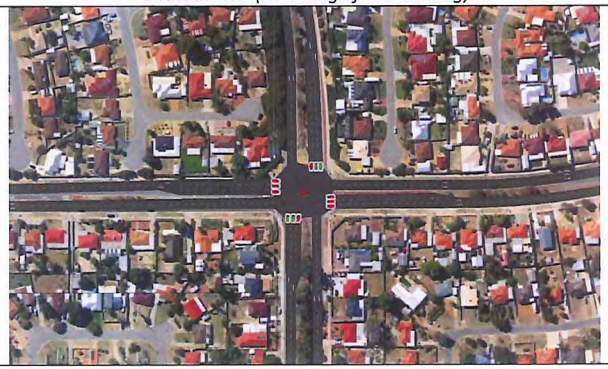
Beach Road – Mirrabooka Avenue

Existing layout	'without LHS' *(no change from existing)*	'with LHS'
		

Mirrabooka Avenue - Koondoola Avenue

Existing layout	'without LHS' *(no change from existing)*	'with LHS'
		

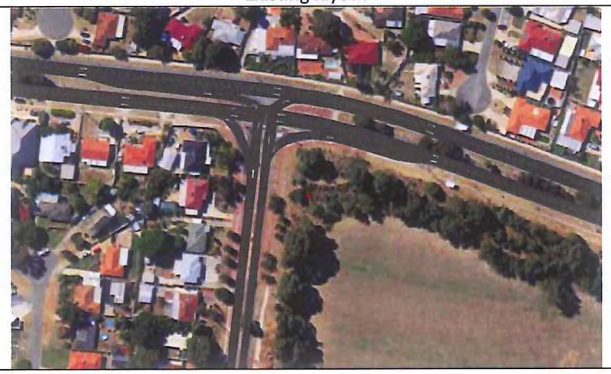
Marangaroo Drive – Mirrabooka Avenue

Existing layout	'without LHS' *(no change from existing)*	'with LHS'
		

Wanneroo Road – Warwick Road

Existing layout	'without LHS'	'with LHS' *(no change from 'without LHS')*
		

Marangaroo Drive – Girrawheen Avenue

Existing layout	'without LHS' *(no change from existing)*	'with LHS'
		

Wanneroo Road – Templeton Crescent

Existing layout	'without LHS'	'with LHS'