Regional Floodplain Database:

Existing Historic and Future Floodplain Land Use

Moreton Bay Regional Council

Emergency Management EMQ Queensland

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Emergency Management Australia

Queensland Government

MBRC Regional Floodplain Database

EXISTING, HISTORIC AND FUTURE FLOODPLAIN LAND USE

- Version 1
- 27 August 2010

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1. Introduction

Sinclair Knight Merz Pty Ltd (SKM) has been commissioned by Moreton Bay Regional Council (MBRC) to carry out an investigation into the establishment of appropriate land use datasets to be adopted for use in Council's Regional Floodplain Database Project (RFD Project).

The RFD Project involves a three year (three stage) program for the development of comprehensive flood mapping across the MBRC Local Government Area (LGA). A key focus for the project is the standardisation of methods and procedures so as to ensure consistency in the flood information produced. The Burpengary 'Minor Basin', incorporating Burpengary Creek, Little Burpengary Creek and Deception Bay has been selected as the Stage 1 pilot study catchment for development of these standardised methods and procedures.

1.1. Scope

This report documents the methodologies established for the completion of two separate scopes of work under the Regional Floodplain Database project:

- Project 1H 'Floodplain Land Use Existing'; and
- Project 2J 'Floodplain Land Use Historic and Future'.

The scope of both projects covered the development of two main hydraulic and hydrologic datasets for the Regional Floodplain Database, including;

- Surface Roughness: Areas of different floodplain surface roughness are required by the hydraulic model (TUFLOW) and used to calculate hydraulic conveyance throughout the floodplain, having different surface characteristics. Each surface type within the floodplain is assigned a roughness value (Manning's n) that is interpreted by the hydraulic model during computation; and
- Impervious Cover Proportion: Estimates of imperious cover are used in the hydrologic model (WBNM) how rainfall is converted to runoff. These impervious values are applied as an attribute to the delineated minor catchment for interpretation by the model.

The scope of Project 1H was to:

- Develop a definitive 'existing catchment' land use mapping for use in hydraulic modelling, including both catchment impervious cover and surface roughness zones, within the floodplain. The coverage of this project was the entire MBRC LGA.

The scope of Project 2J was to:

- Develop a definitive historic catchment land use mapping for use in hydraulic and hydraulic modelling, including both catchment impervious cover and surface roughness zones, with the floodplain; and
- Develop a definitive future catchment land use mapping for use in hydraulic and hydraulic modelling, including both catchment impervious cover and surface roughness zones, with the floodplain.

The coverage of this project (both historic and future) was the pilot catchment of Burpengary Creek.

1.2. Objectives

The objectives of Project 1H are:

- The specification of a stable and repeatable methodology for the development of hydraulic roughness cover for the MBRC LGA which permits future upgrades as land use changes in the catchment;
- The specification of a practical data model for surface roughness (raster versus vector);
- The development of a robust and repeatable method for the calculation of impervious cover for minor catchment sub regions;
- The specification of a practical data model for surface roughness (raster versus vector); and
- Optimising the balance between data accuracy cost of data capture.

The Existing case is defined as September 2009, based on the date of imagery capture by Schlenker Mapping.

The objectives of Project 2J are:

- The establishment and implementation of a methodology to estimate floodplain surface roughness across the pilot investigation area (Burpengary Creek Catchment) for both historic and future epochs, including a data model and methodology consistent with Project 1H, and which is able to be applied regionally in a consistent manner; and
- The establishment and implementation of a methodology to estimate impervious cover across the investigation area (Burpengary Creek Catchment) for both historic and future epochs, including a data model and methodology consistent with Project 1H, and which is able to be applied regionally in a consistent manner.

The two historic cases were defined by Sub-Project 1I as February 1999 and May 2009. Given the short time between May 2009 and the currency of the base data (2009), it was decided that the 2009 data (from Project 1H) would be suitable for the 2009 representation. The Future case was defined as 2031 based on the SEQ Regional Plan horizon.

1.3. General Approach

The general approach for the development of the hydraulic roughness cover for both Project 1H and Project 2J was to create a series of vector shapefiles representing each major land use class. These can then be synthesised within the TUFLOW model based on the model topology building function within TUFLOW.

The utilisation of vector shapefiles for this data model was selected as it allows flexibility in the updating of land use class representations as land uses changes within the catchment. The utilisation of a data model which retains individual land use classes as individual shapefiles was purposely selected as it negates the need to recreate a single surface roughness raster for the catchment each time there is an amendment to an impervious feature within the catchment. This data model (individual land use vector shapefiles) leverages the inherent topology building capability within the TUFLOW package.

This topology building capability was also leveraged in the creation on the Project 2J Historic and Future Surface Roughness modifiers. Each respective dataset was compiled through use of the Existing Surface Roughness (2009) as the base land use which is then topology built within TUFLOW using the individual modifier shapefile created for either the Historic (1999) or Future (2031) case.

The major land use classes utilised to describe Surface Roughness for both Project 1H and Project 2J were;

1) Roads
2) Footpaths
3) Waterbodies
4) Buildings
5) Urban Block
6) Vegetation
    - Low grass/grazing
    - Crops
    - Medium dense vegetation
    - Swamp

- Dense vegetation

The general approach for the completion of the Impervious Cover Proportion for both Project 1H and Project 2J was to attribute the model minor catchments shapefile with impervious proportion (as a percentage) for the existing, historic and future scenarios.

It is important to note that the scope of Project 1H (Existing) covered the development of the above datasets for the entire Moreton Bay LGA, whilst the scope of Project 2J (Historic and Future) covered the development of the above datasets for only the Burpengary Creek catchment. The Burpengary Creek catchment was selected as a pilot for Project 1H, to be completed in advance of the remaining catchments. This would allow for validation of the transferability of both the Surface Roughness and Impervious Cover Proportion methodologies to Project 2J, as well as for the balance of the MBRC region.

1.4. Existing Data

Council provided a number of vector datasets that were used in Project 1H and Project 2J, including roads, footpaths, water bodies and buildings (herein called ‘Existing Council Infrastructure’). All of these datasets were last updated in approximately 2007.

A number of these datasets provided covered the spatial extent of the pre-amalgamation LGA areas of Redcliffe, Pine Rivers and Caboolture. These separate data sets required processing to combine to a Moreton Bay Regional Council LGA-wide dataset for the purposes of the project.

As part of a separate commission, SKM updated these datasets based on the 2009 aerial imagery provided for the project (herein called ‘Updated Council Infrastructure’).

Council also provided their Priority Infrastructure Plan (PIP) growth assumptions for the year 2026 (comprising assumed future dwelling numbers and gross floor area) and polygons indicating areas where additional urban density may occur.

This information was then used to approximate a future (2031) land use classification / surface roughness and impervious cover proportion as part of Project 2J. Council advised that until such time as a new planning scheme is developed, the 2026 growth assumptions data is sufficient for the purpose of defining the sensitivity of the floodplain to uncontrolled future development at an assumed future baseline of 2031. It is recommended however that this future baseline be revisited once the new planning scheme has been developed (it is understood this may be several years away).

Imagery provided and used throughout the project was the Schlenker 2009 aerials, captured between 9 to 12 September 2009.

For use in the determination of the historic land use, Council provided a series of 1999 scanned aerial photographs. These images were not geo-referenced, with an approximate capture date of December 1999 (capture scale 1:10,000).

1.5. Related Sub-projects

Projects 1H and 2J, although separate sub-projects, are directly related in both scope and methodologies and as such have been jointly reported with this document.

The RFD project also includes the following separate projects which are related to this sub-project:

- Sub-Project 1I (Rainfall and Stream Gauge Summary) is responsible for the collation of historic rainfall and stream gauging information, preparation of concise summary of historic flood events and identification of those historic flood events most suited to flood model calibration in the investigation area. This sub-project identified May 2009 and February 1999 as suitable calibration and validation events.

- Sub-Project 2N (Floodplain Parametisation) involves the development of hydraulic roughness parameters to be assigned to the land use polygons developed as part of Sub-Project 1H and 2J (i.e. this report).

2. Existing Land Use (Project 1H)

2.1. Surface Roughness

Data Inputs:

Data used in the determination of Surface Roughness for Project 1H included:

- 2009 Aerial Imagery
- Updated Council infrastructure information (roads, footpaths, buildings, water bodies)
- Digital Cadastral Database (DCDB)

Processing and Dataset compilation

Surface Roughness for the Moreton Bay LGA was developed through visual interpretation of the 2009 aerials, firstly for the Burpengary Creek catchment (as a pilot) and then for the rest of the LGA area.

Table 2-1 below lists the vegetation material classes extracted from the imagery, and shows examples of these areas. It should be noted that these areas are only shown to illustrate typical examples of classes captured, and do not necessarily represent the actual captured boundary for that area in the final dataset.

- 2-1 Vegetation Material Classes

Vegetation Material Class	Sample Area
Crops	

Vegetation Material Class	Sample Area
Medium Dense Vegetation	
Swamp	

Vegetation Material Class	Sample Area
Dense Vegetation / Riparian Vegetation	 
Low Grass / Grazing	

** Low Grass / Grazing was not digitised from the aerials, this class was interpreted as being all other vegetated area (i.e. those areas not covered by an impervious feature)

The vegetation surface roughness coverage was retained as a single ESRI shapefile with a TUFLOW Material Number, representative of a Manning's n value, assigned to each polygon. The Material Number category and assigned Manning's are listed in **Table 2-1** below.

The Updated Council Infrastructure information was retained as individual ESRI shapefiles (roads, footpaths, buildings and water bodies) for input into the hydraulic model during the topology building process. These files were updated with a Material Number (see **Table 2-1**) reflecting the Surface Roughness and ultimately the Manning's n value.

An additional hydraulic roughness class of Urban Block was also developed for input into the hydraulic model. Urban Block is used to represent areas of yards, including fences, garages and yard fixtures (e.g. barbeques).

For the purposes of this data model the Urban Block information was extracted from the Council DCDB data. A query was performed to extract all residential parcels (based on Council zoning information) that were less than 2,000 m^2. 2,000m^2 was selected as an appropriate threshold to exclude lots there were not likely to be residential, rural residential or future urban. These parcels were than dissolved based on adjoining boundaries resulting in large block polygons representing the Urban Block area. This file was then updated with a Material Number (see **Table 2-1**) reflecting the Hydraulic Roughness Class and Manning's n values documented in Sub-Project 2N.

- **Table 2-2: Project 1H Surface Roughness Material Numbers**

Material Number	Surface Roughness Class	Manning's N
1	Dense Vegetation	0.090
2	Swamp	0.080
3	Medium Dense Vegetation	0.075
4	Crops	0.040
5	Low Grass/Grazing	0.035
10	Roads and Footpaths	0.015
11	Buildings	1.000
12	Waterbodies	0.030
13	Urban Block	0.300

2.2. Impervious Cover Proportion

Data Inputs:

Data used in the determination of Impervious Cover Proportion for Project 1H included:

- Existing Council infrastructure information (roads, footpaths, buildings, water bodies)

It should be noted that only existing infrastructure was used for the calculation of the Impervious Cover Proportion for Project 1H as the separate commission to update this data was not yet complete.

Processing and Dataset Compilation

Impervious Cover Proportion for the Moreton Bay LGA was developed through the application of zonal statistics to a raster dataset compiled of the Existing Council Infrastructure layers. It should be noted that for all areas outside of Burpengary Creek, the currency of infrastructure information was 2007. Burpengary Creek was prioritised for update of the Council infrastructure to the 2009 aerials, and was included in the Impervious Cover Proportion.

The individual infrastructure datasets were converted to raster files with all impervious features (regardless of land use class) given the value '1'to represent complete imperviousness.

The individual raster datasets where then combined using the same topology hierarchy documented to be applied within the TUFLOW model (see **Section 2.2** below). The hierarchy to be applied is listed in **Table 2-3** below. This table should be read as the order of input into the topology process, i.e. the first listed file forms the base layer, followed sequentially down the list with last listed file (water bodies) forming the final layer of the topology. It should be noted that all vegetation classes (Material Numbers 1 to 5) are represented within the same ESRI shapefile referred to below as 'Vegetation'.

The result of the raster mosaic was a Pervious-Impervious raster, representing the Moreton Bay LGA with binary values of either 0 or 1. The raster cell size of each of these rasters was 1m and the snap raster functionality was used to enable raster cells to perfectly align during analysis. This raster dataset was then mosaiced with another raster representing the rest of the LGA vegetated area as the value '0', to represent pervious vegetation features.

- **Table 2-3: Topology Hierarchy**

Dataset Hierarchy	Dataset/Surface Roughness Class
1 (First File: Base of Hierarchy)	Vegetation (All Classes)
2	Urban Block
3	Buildings
4	Roads
5	Footpaths
6 (Last File: Top of Hierarchy)	Water bodies

Impervious Cover Proportion was then required to be attributed to the Minor Catchment hydrography layer. This layer broke the 14 Moreton Bay LGA catchments into a number of smaller minor catchments, each with a unique identifier (WW_ID). Due to the file size of the combined Pervious-Impervious raster, these minor catchments were split into a separate file for each of the 14 major Catchments, and the Pervious-Impervious raster clipped to each of these boundaries. This allowed for faster processing and delivery of the analysis results, on a per catchment basis. The 14 catchments processed individually include;

- Bribie Island
- Brisbane Coastal
- Burpengary Creek
- Byron Creek
- Caboolture River
- Hays Inlet
- Lower Pine River
- Mary River
- Neurum Creek
- Pumicestone Passage
- Redcliffe
- Sidling Creek
- Stanley River
- Upper Pine River

For each individual catchment, the Zonal Mean (Spatial Analyst>Zonal Statistics > Zonal Mean) was calculated on the Pervious-Impervious layer. This process used the split Minor Catchments layer as the zonal boundaries and calculated a new raster, representing the average raster value within each zone. A number of edge catchments had the anomaly where the Minor Catchment boundary was not fully covered by the Pervious-Impervious layer, due to the extent of Council infrastructure information. It was therefore important that the functionality to ignore NoData values within the tool was checked, such that any minor catchment which has NoData cells were ignored and only cells with actual values were utilised in the calculation, thereby proportioning the impervious cover based on the available data.

The result of the Zonal Mean calculation was a raster of impervious fraction, for the spatial extent of each Minor Catchment. This impervious fraction was then attributed to the split Minor Catchments layers via the Extract Values to Points function in Spatial Analyst.

3. Historic Land Use (Project 2J)

The approach of the Project 2J (Historic) was to create a hydraulic roughness modifier shapefile which represents the areas of land-use change between the existing land use (2009 Base) and the historic land use (1999). The project also required a revised minor catchment layer attributed with the historic impervious cover proportion (as a percentage) to be derived.

The two historic cases were defined by other projects as February 1999 and May 2009. Given the short time between May 2009 and the currency of the base data (September 2009), it was decided that the 2009 data (from Project 1H) would be suitable for the 2009 representation. The scope of this project covered the pilot catchment of Burpengary Creek.

3.1. Surface Roughness

Data Inputs

Data used in the determination of Surface Roughness for Project 1H included:

- 2009 Aerial Imagery
- Existing Land Use (Input from Project 1H)
- 1999 Council Historic Aerial Photographs (unreferenced)
- Digital Cadastral Database (DCDB)

Processing and Dataset Compilation

Surface Roughness for the Burpengary Creek Historic land use was developed through visual interpretation of both the 1999 and 2009 aerials to determine areas of land use change between these years.

The 1999 aerial images were provided as non-geo-referenced, scanned aerial images with an associated shapefile defining the centre point of the images. Manual geo-referencing of the images was decided against after consideration of the actual efficiency gained versus time spent completing the referencing. As such visual interpretation was made via use of the 1999 centre-points, overlaid on the 2009 imagery within ArcGIS, through inspection of the image in a Windows Picture Viewer. The images were correlated visually and inspected for any differences in land use.

Any areas of existing land use development which were present in the 2009 imagery, but not in the 1999 aerials (i.e. development had occurred in the last 10 years), were captured to represent the historic land use. Where possible, the historic land use was captured at the parcel level, using the Council supplied DCDB. Where the historic land use did not correspond with a whole cadastral parcel, the area of historic land use was then captured through inspection of the 2009 and 1999 imagery.

This process was repeated until all historic aerials had been inspected and a single shapefile was developed representing the historic land use. This shapefile contained only records of areas which had been developed (or changed land use) category in the last 10 years. Each record of historic land use was attributed with the historic Material Number of the polygon, representative of a Manning's n value, assigned to each polygon during Project 1H (see **Table 2-1** for the Material Numbers).

3.2. Impervious Cover Proportion

Data Inputs:

Data used in the determination of Impervious Cover Proportion for Project 2J (Historic) included:

- Existing Pervious-Impervious Raster (compiled during Project 1H)
- Historic Surface Roughness Modifiers

Processing and Dataset compilation

Historic Impervious Cover Proportion for the Burpengary Creek catchment was developed through the application of zonal statistics to a Historic Pervious-Impervious raster compiled dataset, based on the Existing Pervious-Impervious raster, and modified using the Historic Surface Roughness Modifiers (developed as part of Project 2J above).

In order to develop the Historic Pervious-Impervious raster, the Historic Surface Roughness Modifiers were converted to a raster dataset based on the Material Number assigned to each polygon. This was then mosaiced with the Existing Pervious-Impervious layer to replace areas in the Existing case, with any areas of change from the Historic case (i.e. the Historic case held priority during the mosaic). The result was a Historic Pervious-Impervious raster, representing the Burpengary Creek catchment with binary values of either 0 or 1. The raster cell size of each of these rasters was 1m and the snap raster functionality was used to enable raster cells to perfectly align during analysis.

Impervious Cover Proportion was then required to be attributed to the Burpengary Creek Minor Catchment hydrography layer.

The same methodology as for Project 1H (**Section 2.2**) was then applied to determine the Historic Impervious Proportion. The Zonal Mean (Spatial Analyst>Zonal Statistics > Zonal Mean) was calculated on the Historic Pervious-Impervious layer.

This process used the Burpengary Creek minor catchment layer as the zonal boundaries and calculated a new raster, representing the average raster value within each zone.

The result of the Zonal Mean calculation was a raster of Historic impervious fractions, for the spatial extent of the Burpengary Creek Catchment. This impervious fraction was then attributed to the Burpengary Creek minor catchments layers via the Extract Values to Points function in Spatial Analyst.

4. Future Land Use (Project 2J)

The approach of the Project 2J (Future) was to create a surface roughness land use modifier shapefile which represented the areas of proposed land use change between the Existing 2009 land use (Base) and the Future 2031 land use (Future). The Future land use scenario has been defined as 2031 as is currently the planning horizon of the SEQ Regional Plan. Council is currently developing a Regional Infrastructure Strategy that will be aligned to this same future baseline.

The scope of this project covered only Burpengary Creek.

4.1. Surface Roughness

Data Inputs

Data used in the determination of Surface Roughness for Project 1H included:

- Existing Land Use (Input from Project 1H)
- Council Priority Infrastructure Plan (PIP) data describing assumed future dwelling and commercial floor space density

Processing and Dataset compilation

The development of a Future Surface Roughness for the Burpengary Creek land use was created through interpolation of the Council PIP information, specifically the number of projected 2026 dwellings.

The PIP data was initially queried to extract all polygons where the number of dwellings was forecast to increase between the 2009 and 2031. Within this extracted data a calculation was performed which divided each individual lot size by the projected number of 2031 dwellings, providing an estimate of land coverage (square metres) per dwelling (m^2/dwelling). This allowed analysis of the typical land coverage expected per dwelling, per parcel. It should be noted that this calculation does not solely reflect the land coverage of the actual building footprint of the development, but includes the total land area associated with the dwelling including any associated roads or open space.

The resulting land coverage densities were then visually inspected to extract three sample test areas as follows:

- rural residential
- low density residential
- medium density residential

The test samples were used to analyse average Manning's n and impervious cover proportions that could be mathematically applied to the remaining lots having these same densities.
Within each of these three test regions, a count of the total projected houses was performed and the area of the test catchment used to determine an overall density for each catchment, represented by the land coverage (m^2) per dwelling. These test regions area shown in **Figure 4-1** below. **Table 4-1** below documents the test regions and associated dwelling counts, land coverage and land coverage densities.

It is noted that the pilot area did not contain substantial areas for determining high density residential densities. Suitable areas for the application of this density calculation and classification are recommended to be determined and assessed by Council as a future extension of this study.

- **Figure 4-1 Dwelling Density Test Areas**

Rural Residential

Low Density

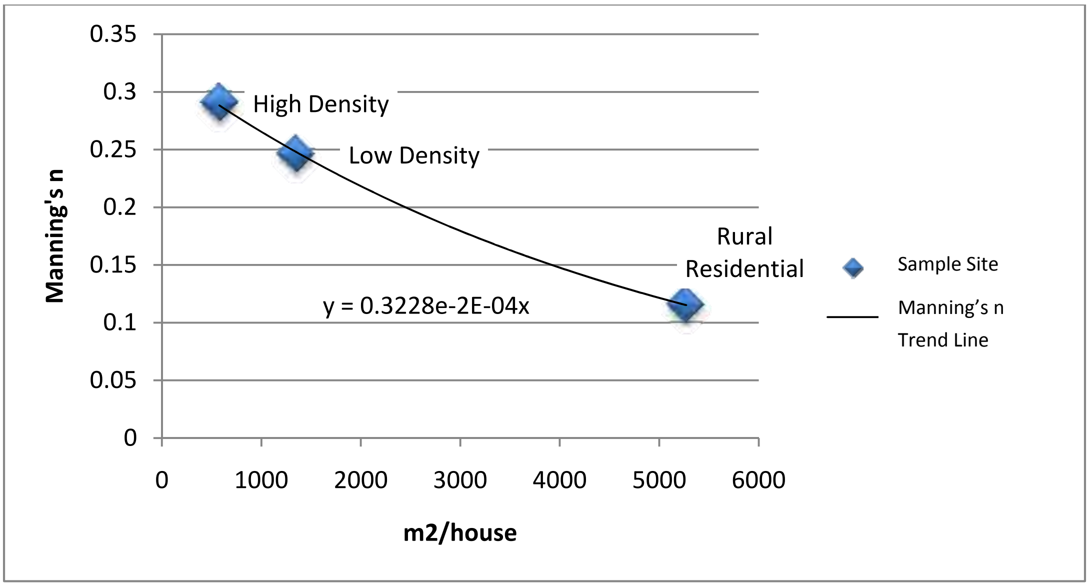
Medium Density

Each feature in the test region was then assigned a Manning's n value (based on interpretation of the Manning's Classes in **Table 2-1** above) and this data converted to a raster. A statistical average was then performed in order to determine Manning's averages for each test region. The same method was applied for the impervious cover proportion, whereby each test region was statistically analysed to determine the average impervious cover proportion. The resulting Manning's n and impervious cover proportions are provided in **Table 4-1** below.

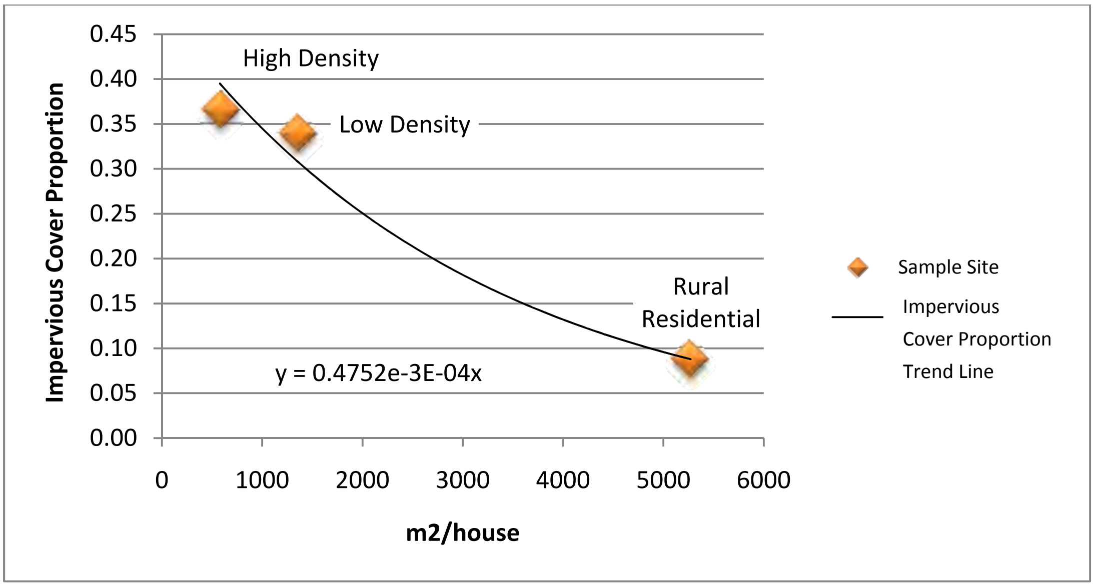
- **Table 4-1 Sample area analysis – Manning's n and impervious cover proportion**

Sample Area	No. Houses	Area (m^2)	Land Coverage/House (m^2/house)	Averaged Manning's n	Averaged Impervious Cover Proportion
Rural Residential	16	543,091	5271	0.11	0.09
Low Density	402	19,051	1350	0.24	0.34
Medium Density	33	84,350	577	0.29	0.37
High Density	*To be undertaken by Council as part of a future update to this study*				

The averaged Manning's n and Impervious Cover Proportion where then graphed in Excel to determine a line of best fit for the sample data points, in order to generate an equation that could be extrapolated for all other future development lots within Burpengary Creek catchment. The graphs and equations for the Manning's n and Impervious Cover are shown in **Figure 4-1**and **Figure 4-2** below. These equations evaluated the Land Coverage per House value with the sampled Manning's n and Impervious Cover to determine a line of best fit, utilising the exponential trend line in Excel.



▪ **Figure 4-2 Manning's n versus Land Coverage/ House (m^2/house)**



▪ **Figure 4-3 Impervious Cover Proportion versus Land Coverage/House (m^2/house)**

The equations generated within Excel were then used to update the extracted PIP cadastral parcels to determine the estimated Manning's n and Impervious Cover Proportion per lot. These calculated values were then brought back into Excel in order to validate the fit of the curve to the data values.

Due to the need to use a mathematical equation in order to graph and extrapolate Manning's n values for the future case the outputs of the Manning's calculation were individual actual Manning's n values, rather than Material Numbers (as require by TUFLOW). As such seven Material Classes, representing a range of Manning's n values, were developed and the data reclassified to determine a Material Number. These Material Numbers and associated Manning's n values are summarised in **Table** 4-2 below.

- **Table 4-2 Future Surface Roughness Material Numbers**

Material Number	Manning's n Value
41	0.00 – 0.05
42	0.05 - 0.10
43	0.10 - 0.15
44	0.15 - 0.20
45	0.20 - 0.25
46	0.25 - 0.30
47	0.30 - 0.35

The unique Impervious Cover values were utilised in the determination of the future Impervious Cover Proportions for Burpengary Creek, as described in **Section 4.2** below.

4.2. Impervious Cover Proportion

Data Inputs

- Existing Pervious-Impervious Raster (compiled during Project 1H)
- Future Surface Roughness Modifiers

Processing and Dataset compilation

Future Impervious Cover Proportion for the Burpengary Creek catchment was developed through the application of zonal statistics to a Future Pervious-Impervious raster compiled dataset, based on the Existing Previous-Impervious raster and modified using the Future Surface Roughness Modifiers (developed as part of Project 2J above).

In order to develop the Future Pervious-Impervious raster, the Future Surface Roughness Modifiers were converted to a raster dataset based on the Impervious Cover Proportion value assigned to each polygon (see **Section 4.1** above). This was then mosaiced with the Existing Pervious-Impervious layer to replace areas in the Existing case, with any areas of change from the Future case (i.e. the Future case held priority during the mosaic). The result was a Future Pervious-Impervious raster, representing the Burpengary Creek catchment with continuous float values between 0 and 1.

It should be noted this was the only case where the Pervious-Impervious raster was not a binary integer raster, this was due to the Fraction Impervious having to be interpolated as part of the Surface Roughness development in **Section 4.1** above. The raster cell size of each of these rasters was 1m and the snap raster functionality was used to enable raster cells to perfectly align during analysis.

Impervious Cover Proportion was then required to be attributed to the Burpengary Creek Minor Catchment hydrography layer.

The same methodology as for Project 1H (**Section 2.2**) was then applied to determine the Future Impervious Proportion. The Zonal Mean (Spatial Analyst>Zonal Statistics > Zonal Mean) was calculated on the Future Pervious-Impervious layer. This process used the Burpengary Creek Minor Catchment layer as the zonal boundaries and calculated a new raster, representing the average raster value within each zone.

The result of the Zonal Mean calculation was a raster of Future impervious fractions, for the spatial extent of the Burpengary Creek Catchment. This impervious fraction was then attributed to the Burpengary Creek Minor Catchments layers via the Extract Values to Points function in Spatial Analyst.

5. Recommendations for Further Work

The following tasks have been identified as necessary to update the Stage 1 works outlined in this report. These tasks are scheduled to be completed during Stage 2 of the project (following completion of the pilot project).

- Confirm the time horizon and estimated densities to be assumed for the future 2031 land use scenario (expected to replace the 2026 PIP data assumptions)
- Establish the relationship between future high density urban development and both impervious cover and manning's 'n' roughness, for application as part of the future land use scenario for the remaining MBRC region.