Superlot D, Exmouth Marina

URBAN WATER MANAGEMENT PLAN

Stage 1

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1 EXECUTIVE SUMMARY

This Urban Water Management Plan (UWMP) has been developed to support the Subdivision of Lot 9510 Murat Road, Exmouth (Superlot D), within the Exmouth Marina. This area is referred to as the subject land. It specifically deals with the detailed design of Stage 1, however it also covers the balance of the original Superlot D, where it relates the development of the Stage 1 area, as well as to provide guidance on the future development of Stage 2. The proposed development is for a range of residential lots in Stage 1, while Stage 2 includes residential lots along with commercial and industrial lots. Stage 1 is approximately 10.4ha while the entire Superlot D is approximately 17.8829ha in area. The subject land is bounded by Murat Road to the west, Mortiss Street to the south, Cobia Close and its associated residential lots to the north, while the north eastern and eastern boundary are located predominately on the marina channel. The southern portion of the eastern boundary adjoins undeveloped marina land classified under the Strategic Infrastructure scheme reserve. The site is currently composed of low scrub and areas cleared for a go-kart track and previous developmental works associated with the creation of the marina. The entire subject land can be seen in Figure 1 -4, with the location shown in Figure 1. The Stage 1 area can be seen in Figure 2 -4.

The subject land is relatively flat, with localised depressions, with a general fall towards the east into the marina's canals. The surface is generally sandy clay or a fill material of gravelly sand. The existing site features are shown on Figures 3 to 9.

The objective of this UWMP is to detail the best management practices approach to water management that will be undertaken for the development. This will include managing, protecting and conserving the total water cycle of the local environment and the greater catchment. The practices will involve:

- Stormwater management that incorporates the water sensitive urban design practices;
- Flood protection from localised stormwater and the regional flood flows;
- Protection from ocean flooding
- Groundwater resource management;
- Protection of surrounding ecosystems; and
- Sustainable water servicing

The effectiveness, efficiency and benefits provided by the best management practices require a collaborative effort between local governments, developers and relevant regulatory authorities. The developers are committed to the concepts and outcomes outlined within the approved UWMP for the subject land. This includes the implementation, monitoring and maintenance of the best management practices for stormwater designed specifically for this site.

1.1 PLANNING SUMMARY

This UWMP has been prepared to satisfy the WAPC Reference: 201804 and specifically Condition 2, which states;

2. Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water and Environmental Regulation, consistent with any approved Local Water Management Strategy. (Shire of Exmouth)

The development is proposed to be undertaken as 2 Stages. Stage 1 is for 112 residential lots, sized between 246m^2 and 2276m^2. It also includes 3 POS areas of 971m^2, 3209m^2 and 5605m^2 as well as the associated road network.

Stage 2 includes 46 residential lots, sized from 450m^2 to 869m^2. It also includes 9 mixed use lots (1000m^2 – 1271m^2), a single commercial lot (4315m^2) and 5 light industrial lots, (1281m^2 – 4395m^2). There is also a linear POS area (1502m^2) and associated road network. The lot sizing can be seen in Figure 3, with the Land Use outlined in Figure 2.

This UWMP follows on from the Local Water Management Strategy (LWMS). The LWMS was undertaken for the subject land as part of the Scheme Amendment to support of rezoning of Lot 9510 Murat Road, Exmouth, from the 'Special Use 7' zone ('SU7') to the 'Urban Development' zone under the Shire of Exmouth Local Planning Scheme No. 4 (LPS 4). This rezoning was achieved on the 10th October 2025.The LWMS has been supported by the Department of Water and Environmental Regulation (DWER). The Shire of Exmouth has agreed that Stage 1 subdivisional works can be undertaken while the LWMS finalisation and agreement is completed.

A District Water Management Strategy (DWMS) (Cardno 2012) for the entirety of the Exmouth townsite was prepared and provides guidance on the water management planning for the subject land. A new DWMS is currently being prepared for the townsite, with preliminary discussions with the DWMS consulting team noting that there is likely to be little change in relation to matters that affect the subject land.

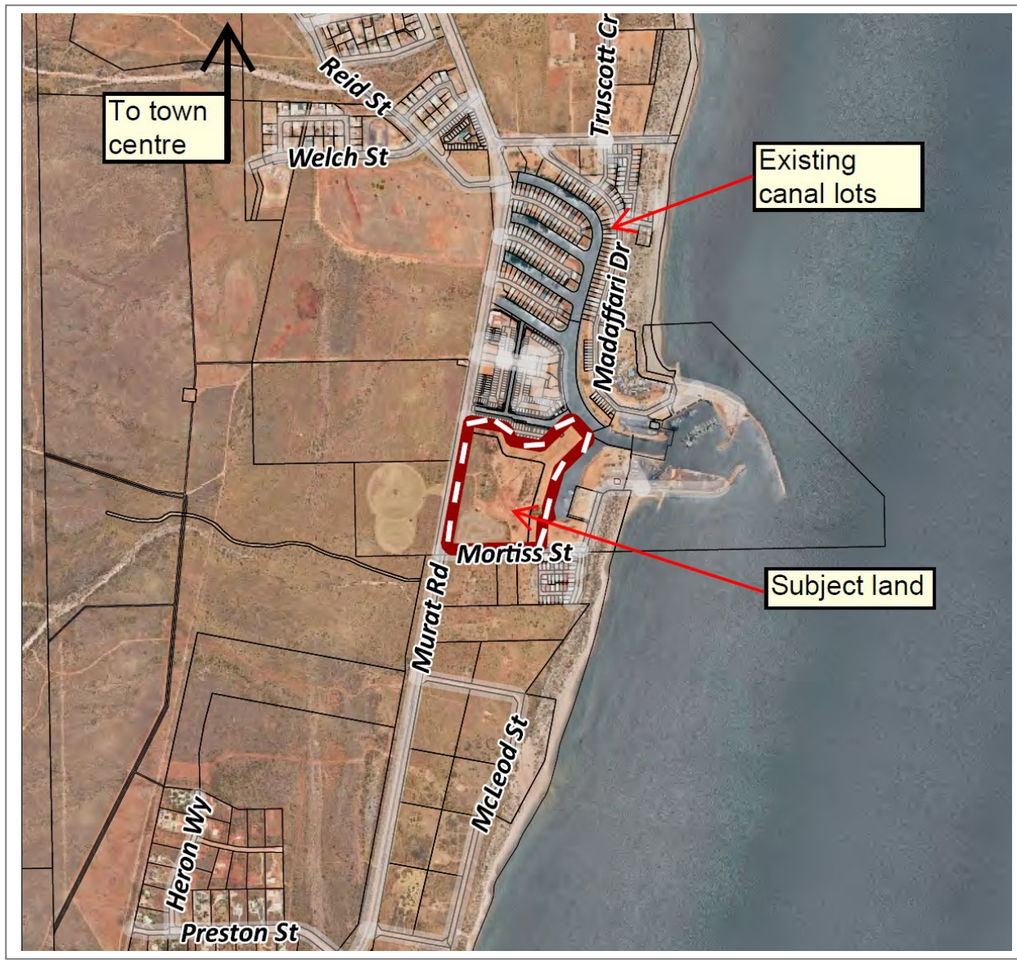


Figure 1 Location Plan

This UWMP will guide the implementation of the subdivision, to ensure that the land is developed in a sustainable manner, fulfils the objectives of the WAPC as described in Liveable Neighbourhoods (WAPC, 2009) and in accordance with the objectives of the Department of Water and Environmental Regulation (DWER) and the Shire of Exmouth (Shire). It also outlines the necessary water management strategies to guide the Local Development Plan (LDP) and subsequent building applications.

1.2 SUPPORTING DOCUMENTATION

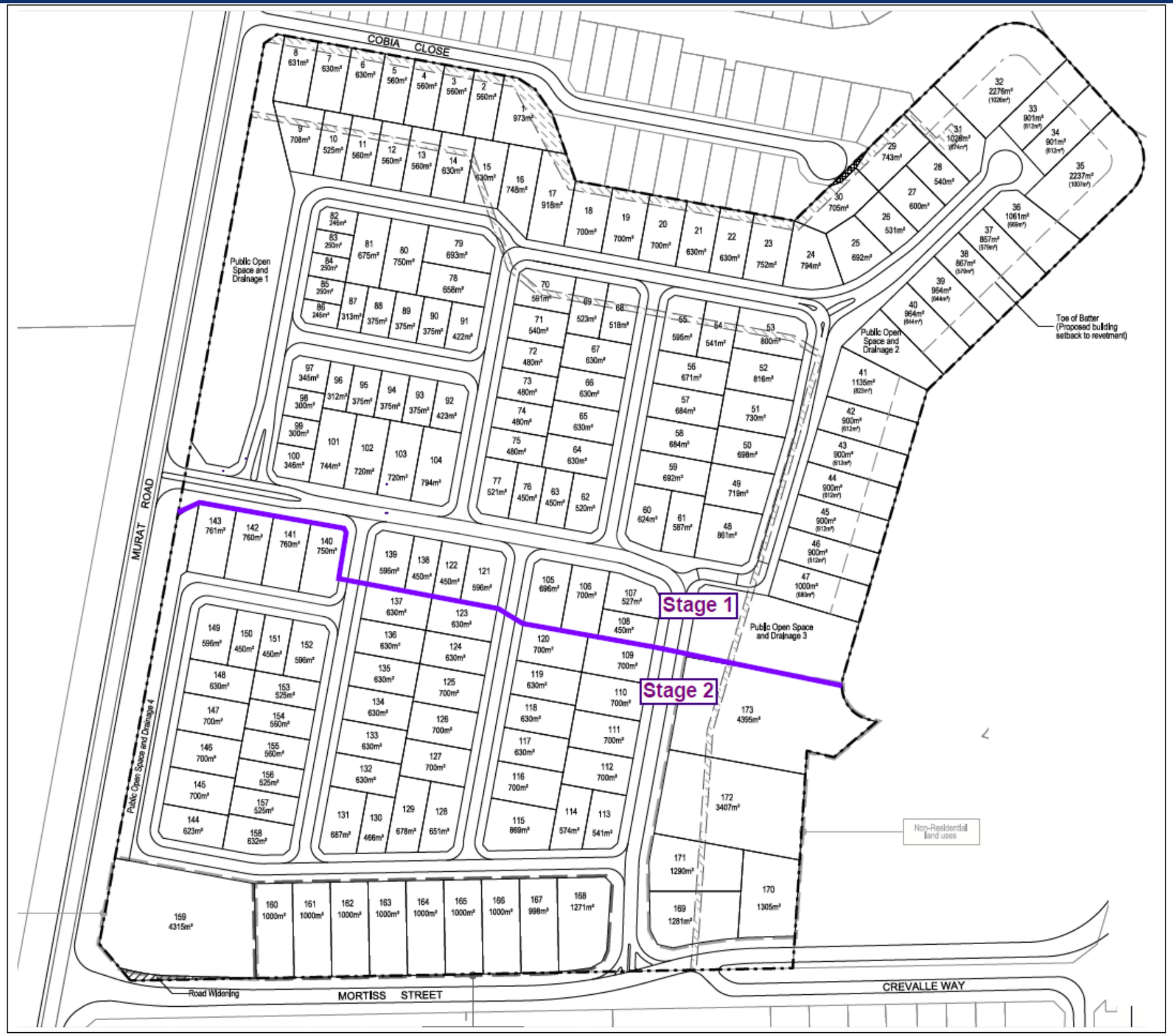
This UWMP has been compiled using information contained within the detailed assessments and reports undertaken for the subject land and surrounds. For further information relating to the water management on the subject land please refer to these supporting documents:

- *Environmental Assessment Report Scheme Amendment: Superlot D, Lot 9510 Murat Road, Exmouth (Western Environmental, 2024)*
- *Geotechnical Study Proposed Subdivision Precinct D, Exmouth Marina Exmouth, Western Australia (Galt Geotechnics, 2025)*
- *Geotechnical Studies Exmouth Marina Village Superlot D Exmouth (Golder Associates, 2006)*
- *Lot 9510 Murat Road (Superlot D), Exmouth, Assessment of Flood risk Mitigation Options (JDA, 2023)*
- *Market Street Levee, Exmouth – Flood Mitigation Works Detailed Design Report (Worley Parsons, 2012)*
- *Lot 9510 Murat Road, Exmouth Inundation Level Assessment (MP Rogers & Associates, 2023)*
- *District Water Management Strategy, Shire of Exmouth (Cardno, 2012)*
- *Lot 9510 Murat Road, Exmouth – Proposed Subdivision Development Servicing Review (Porters, 2025)*
- *Superlot D Exmouth Local Water Management Strategy (Oversby Consulting, 2025)*
- *Lot 9510 Murat Road Exmouth – Stage 1 Civil Design Plan (Porter Consulting, 2025)*
- *Sundrift Estate Local Development Plan (TBB Planning, 2025)*



Figure 2 Land use plan and Stage 1 boundary

Figure 3 Subdivision Plan



2 KEY ELEMENTS PLAN

Water management strategies for the subject land are based on best practice water sensitive urban designs that integrate sustainability and the provision of attractive communities. The strategies will be achieved through the synthesis of planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's residential development, surrounding environment, former and future stages and local drainage characteristics.

A summary of the WSUD elements that will be implemented within the development to achieve best management practices are outlined below. The general strategies can also be seen in Figure 4.

Water Conservation and Servicing

- The site is to be serviced with potable water from the Water Corporation's network.
- Sewer is to be connected to the Water Corporation's sewer main.
- Landscaping is designed to be waterwise to reduce irrigation requirements.
- The Landscaping water is to be sourced from groundwater.

Stormwater Management

- For lots over 350m^2, on lot detention systems are to be installed to capture the first 15mm of rainfall, in line with the DWMS guidelines.
- For lots under 350m^2, the first 15mm of rainfall is to be directed to the street pipe network and detained in the POS basins.
- In line with the DWMS, the road runoff is to be collected in a pit and pipe network and transferred to the bioretention basin systems, which are sized for capture of the first 15mm of rainfall from the road network (and lots under 350m^2).
- 1EY stormwater treatment is achieved through on lot detention and infiltration in conjunction with road runoff treatment through the bioretention basins.
- Flows are predominately discharged to the canal network with minor flows to Cobia Close, Mortiss Street and Murat Road.

Flood Protection

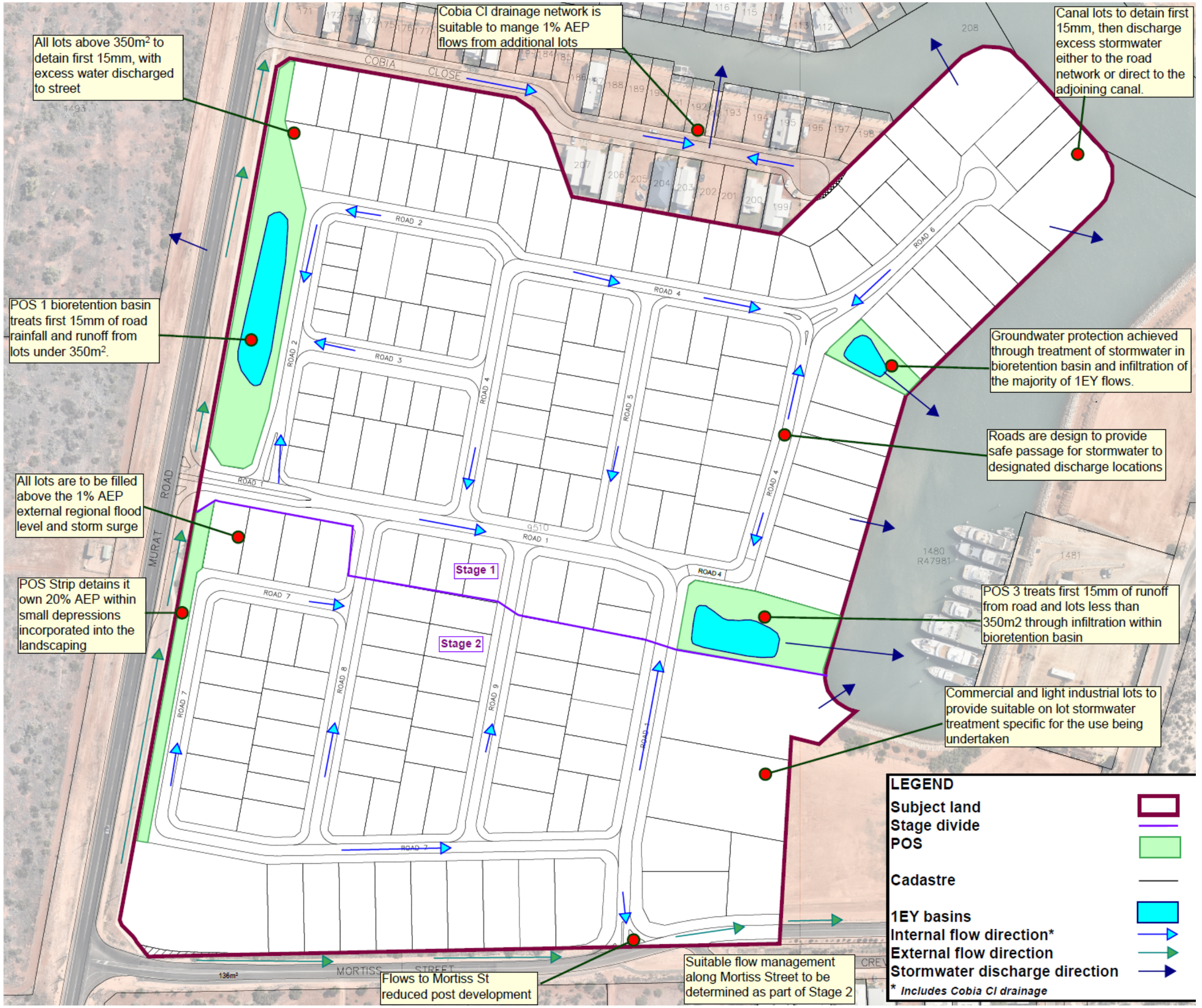
- All finished floor levels will be designed to be a minimum 300mm above the adjoining road gutter flows.
- All finished floor levels are to be a minimum of 5.95mAHD to provide separation to the modelled ocean storm surge.
- All lots are to be a minimum of 300mm above the 1% AEP modelled regional surface water flood from the Market Street Creek.
- Flows across the site in events up to and including the 1%AEP will be managed to protect infrastructure and human safety, with discharge to the canal network.
- Stage 2 Works along Mortiss Street are to take into account the overall flood management associated with the downstream areas.

Ecosystem Protection

- New ephemeral riparian habitat will be created within the basin as a result of using native riparian species plantings suited to the Exmouth climate.
- Future landscaping within the POS will utilise native species that complement the nearby bushland and coastal environment.
- The WSUD elements used on-site will treat stormwater, improving the water quality prior to it entering the Exmouth Gulf.
- The landscaping will utilise nutrient and waterwise practices to minimise contamination of the groundwater and surface runoff to the Exmouth Gulf and any groundwater dependent ecosystems.
- All commercial and light industrial lots in Stage 2 are to implement best practice water management to minimise leaching of contaminants into the groundwater or surface water system.

Groundwater Management

- Groundwater quality is managed via infiltration of stormwater through the POS bioretention basins and best practice within commercial lots.
- The natural separation to groundwater in combination with the filling of the site provides suitable post development separation to groundwater.


All lots above 350m² to detain first 15mm, with excess water discharged to street
Cobia Cl drainage network is suitable to mange 1% AEP flows from additional lots
Canal lots to detain first 15mm, then discharge excess stormwater either to the road network or direct to the adjoining canal.
POS 1 bioretention basin treats first 15mm of road rainfall and runoff from lots under 350m².
Groundwater protection achieved through treatment of stormwater in bioretention basin and infiltration of the majority of 1EY flows.
Roads are design to provide safe passage for stormwater to designated discharge locations
All lots are to be filled above the 1% AEP external regional flood level and storm surge
POS Strip detains it own 20% AEP within small depressions incorporated into the landscaping
POS 3 treats first 15mm of runoff from road and lots less than 350m2 through infiltration within bioretention basin
Commercial and light industrial lots to provide suitable on lot stormwater treatment specific for the use being undertaken
Flows to Mortiss St reduced post development
Suitable flow management along Mortiss Street to be determined as part of Stage 2
Stage 1
Stage 2
COBIA CLOSE
MURAT ROAD
MORTISS STREET
ROAD 1
ROAD 2
ROAD 3
ROAD 4
ROAD 5
ROAD 6
ROAD 7
ROAD 8
ROAD 9
LEGEND
Subject land
Stage divide
POS
Cadastre
1EY basins
Internal flow direction*
External flow direction
Stormwater discharge direction
* Includes Cobia Cl drainage

3 LANDFORM

The subject land is mildly undulating with its current levels heavily influenced by previous earthworks and land uses. There is a general fall from the southwest corner approximately 6.4mAHD to the north and east, with levels plateauing to around 5.0mAHD. There are some lower trapped areas through the center that drop to approximately 3.9mAHD. The two major systems can be seen in Figure 3. Throughout the site there are isolated stockpiles that reach to between approximately 6.0mAHD and 7.6mAHD.

There is a shallow channel that traverses the site from the southern boundary with Mortiss Street northward. This channel begins on the southern boundary with an invert of approximately 4.4m AHD down to 4.08mAHD in line with the northern most point of the canal. At this point the channel turns eastward, dropping down an area of rock armoring to approximately 2.2mAHD. From here the eastern channel continues to drop in an easterly direction, before flowing over further rock armoring and into the canal. It is noted that there may possibly be other erosional side channels that bypass the rock armoring within this system. The majority of the site's surface water exits via this eastern channel system. This is due to a general grading within the plateau area to direct water away from the canal edges, the general slope of the site and bunding across the northern boundary. Around the very edge of the canals, there is generally a steep drop down from approximately 5.2mAHD to the canal water line (average of 0mAHD – tidal). The general site characteristics can be seen in Figure 3.

A survey of the site and a heat map can be seen in Appendix A.

4 GROUNDWATER

The following is a summary of the current groundwater characteristics of the site. This information is based on groundwater investigations undertaken as part of the Geotechnical assessments and DWMS.

4.1 REGIONAL GROUNDWATER LEVELS

The DWMS highlights that there is no long term groundwater level and quality monitoring data available for the subject land or nearby areas. It is likely that any superficial aquifer flow would be eastward from the ranges to the gulf, with the flow following preferential pathways through the mixed subsurface formations.

4.2 SUBJECT LAND GROUNDWATER LEVELS

There has been no recent groundwater level monitoring specifically for the subject land. The geotechnical investigations found no groundwater in January and after recent cyclonic rainfall. In 1999, groundwater levels were recorded as part of the Exmouth Marina Village Stygofauna Assessment (Bowan Bishaw Gorham 1999). This investigation found that the marina area had groundwater levels approximately 0.5mAHD and likely strongly influenced by the ocean levels as noted by the salinity profiles (see 4.3 below).

There is the possibility of some short term shallow mounding of fresher groundwater over the fluctuating saline layer, after extended heavy rainfall, with this likely to be less than 0.3m. A similar short term and thin groundwater layer may appear on top of any limestone confining layers. Limestone/cemented soils were noted in some of the Geotech test pits (between 1.2 – 2.5m down) but there was no groundwater found on top of these. Any perching of groundwater on these confining layers is therefore unlikely to be present for the majority of the time or for any extended period. The excavation of the canals, also provides an avenue for any perched groundwater to migrate out horizontally into the ocean. The maximum groundwater level for the site is therefore likely to be more than 3 -3.5m below the current surface.

4.3 GROUNDWATER QUALITY

Groundwater quality monitoring has not been undertaken recently for the site. In 1999, groundwater salinity levels were recorded as part of the Exmouth Marina Village Stygofauna Assessment. This investigation noted that the overall marina area and surrounds generally has a saline layer overlaid by a fresh to brackish layer of vary depths but generally 1-2m thick. The samples were collected over the top 5.5m portion of the aquifer. The salinity profile indicates that there is a strong ocean influence for approximately 250 - 500m inland from the ocean water edge. Based on this the superficial groundwater layer under the site is likely to be highly correlated with the ocean and saline, with the potential for a thin layer of fresher water on top, especially in the west.

4.4 GROUNDWATER AVAILABILITY

There are 2 aquifers noted as being under the subject land that are subject to licensing. These are both within the Gascoyne Area and Exmouth Central Subarea. The Aquifers are the Carnarvon - Cape Range Limestone aquifer and the Saline Resource aquifer. As of February 2025, both have allocation available.

5 ENVIRONMENTAL CONDITIONS AND HERITAGE

5.1 ENVIRONMENTAL

The following is a summary of the environmental characteristics of the subject land, with relevant references to the surrounding areas. This information has been summarised from the Environmental Assessment Report – Scheme Amendment: Superlot D, Lot 9510 Murat Road, Exmouth (Western Environmental 2024).

5.1.1 VEGETATION

The site has been largely cleared, except for approximately 3.11ha of remnant native vegetation within the western portions of the subject land. None of this vegetation has characteristics associated with being a wetland or waterway community. There is also no mangrove vegetation within the canal system adjoining the subject land. Generally, the vegetation is in a degraded state, with a high presence of weeds.

5.1.2 FAUNA

Given the degraded nature of the vegetation within the subject land, it is not likely that fauna reliant on wetlands or waterways will generally be present. A site walk over found no significant fauna. No threatened or priority fauna species have been recorded within the subject land according to the Department of Biodiversity, Conservation and Attractions' mapping information. The nearest known threatened or priority fauna is a fish and has a buffered area which is more than 500 m away from the subject land. Given this distance and as there is no open water within the Project Area, this record is considered irrelevant to the subject land.

The 1999 Exmouth Marina Village Stygofauna Assessment sampled for stygofauna throughout the greater Exmouth Marina area and surrounds. While some species were found throughout this area, it was concluded that recorded species are widespread and not threatened. It also noted that the majority of the area had unsuitable habitat for most species, as the majority of the voids within the limestone rock was filled with clay material.

5.1.3 WETLANDS AND WATERWAYS

One wetland was found to intersect the Project Area as per the Department of Biodiversity, Conservation and Attractions (DBCA) Directory of Important Wetlands in Australia - Western Australia (DBCA-045). The Cape Range Subterranean Waterways mapping overlaps with the southwestern corner of the Project Area. The mapped area can be seen in Figure 4, noting that there is limited evidence on-site for the system being present.

There are no natural waterways within the subject land. The shallow drain has no appreciable riparian environmental values. There is a minor tributary approximately 150m to the south of the subject land that forms part of the Market Creek system.

5.1.4 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

A threatened ecological community (TEC) identified as DBCA – 038) has been identified approximately 1 km southwest of the Subject land. The buffer for this TEC overlaps with the southwestern corner of the subject land. The degraded nature of the vegetation within this portion of the subject land suggests that it is unlikely that this TEC is present within the subject land. This mapped area can be seen in Figure 5.

5.2 HERITAGE SITES

A search on the Aboriginal Heritage Inquiry System on the Department of Indigenous Affairs (DIA) website, indicated no Aboriginal Cultural Heritage places recorded within the subject land

A search on the Heritage Council of Western Australia (2011) database reveals no European heritage exists within the subject area.



Figure 5 Landform Characteristics

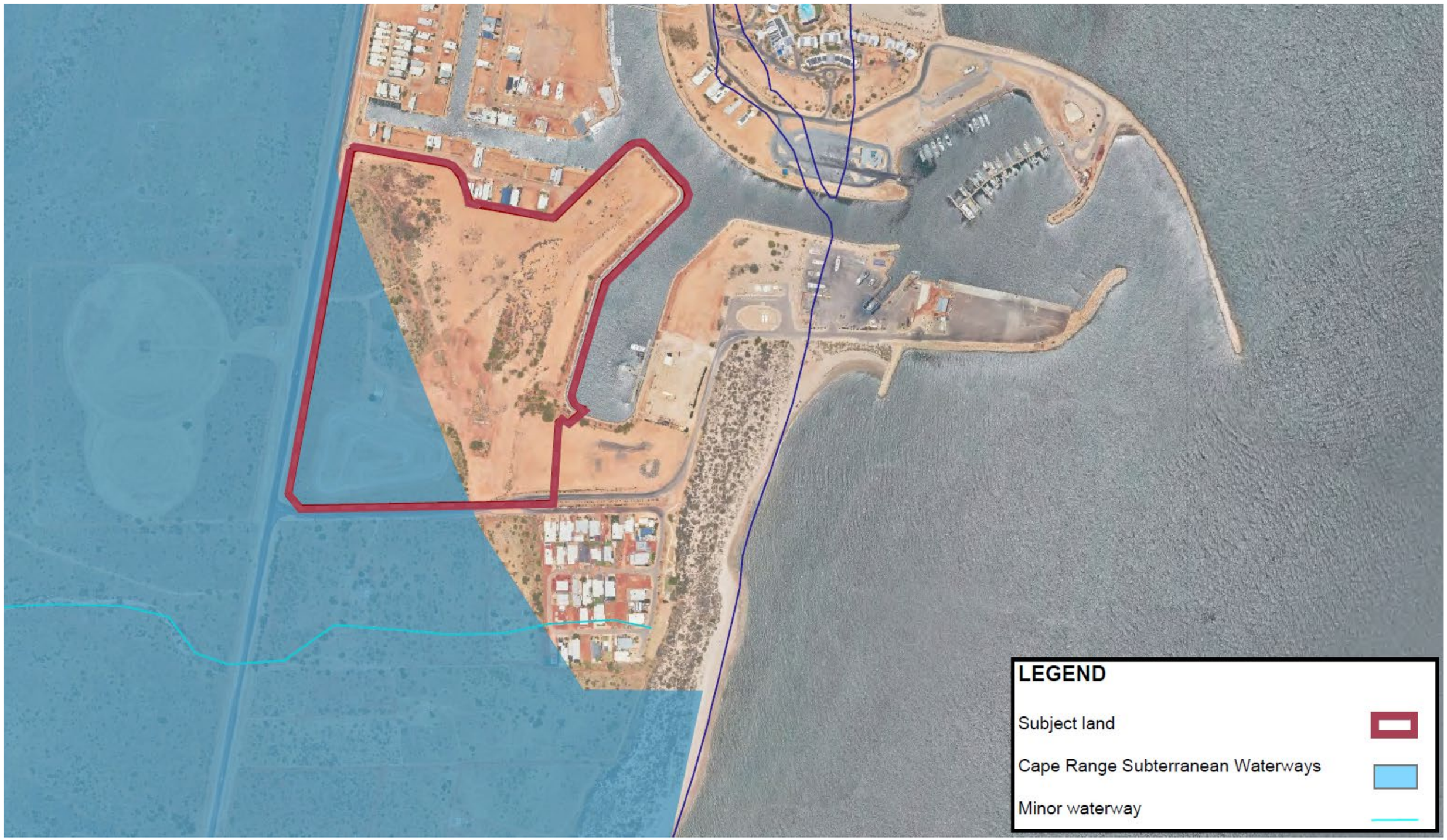


Figure 6 Wetlands and waterways

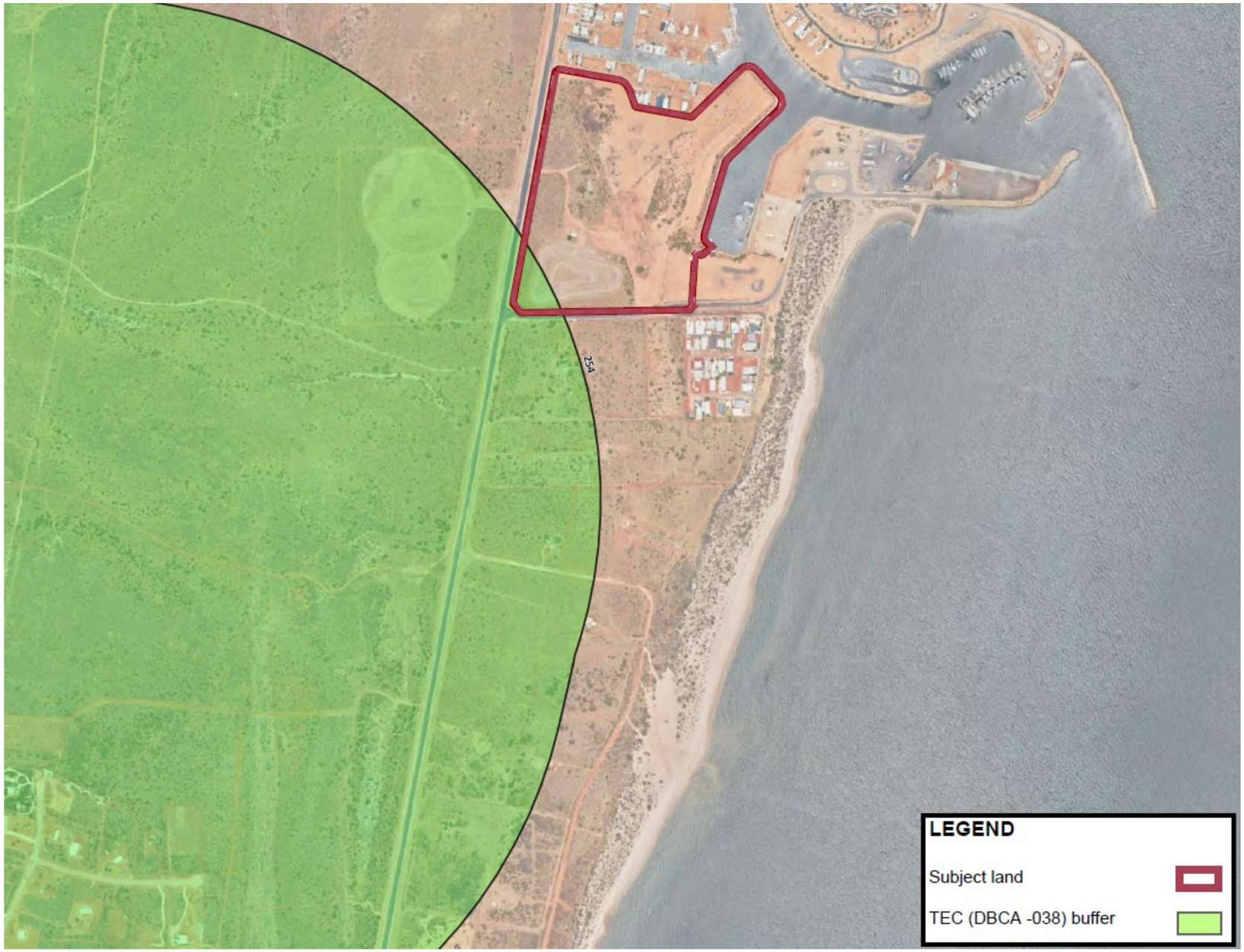


Figure 7 Threatened Ecological community

6 GEOTECHNICAL

The following information is taken from the following reports:

- Geotechnical Studies Exmouth Marina Village Superlot D Exmouth (Golder Associates, 2006)
- Geotechnical Study Proposed Subdivision Precinct D, Exmouth Marina Exmouth, Western Australia (Galt, 2025)

6.1 GENERAL GEOLOGY AND GEOMORPHOLOGY

The site is mapped as being underlaid by coastal dunes along the eastern boundary, with clay, silt, gravel and cobbles over the remainder. Trealla Limestone over Tulki Limestone is mapped as occurring subsurface..

6.2 GEOTECHNICAL SITE INVESTIGATION

The more detailed Galt 2025 study was undertaken in January 2025. It noted that the subsurface profile is comprised of a thin surficial topsoil over 2 main soil types. These are

- Southwest area (not previously earthworked): Sandy CLAY about 0.25 m to 2.0 m thick, over Gravelly Sandy CLAY / Clayey Sandy GRAVEL extending to depths of 0.8 m to 2.0 m; over Inferred Calcarenite ROCK / Cemented soil;
- Northeast area (previously earthworked): FILL: Gravelly Sandy CLAY / FILL: Clayey Sandy GRAVEL, typically up to about 1.5 m thick but becomes over 3 m thick adjacent to the marina, over a natural soil profile similar to that described above.

6.3 PERMEABILITY

In-situ permeability tests were undertaken for the site. The measured permeability rate varies from 0.1m/day to 2.1m/day, with the variability reflecting the range of soil types. The results can be seen in Table 1. The test locations can be seen in Figure 6.

Table 1 Table 4: Infiltration Test Results

Test Location	Soil Description	Depth (m)	Minimum Unsaturated Hydraulic Conductivity, k_{unsat} (m/day)
TP04 / IT01	FILL: Clayey GRAVEL	0.50	0.1
TP07 / IT02	Clayey SAND	0.62	1.4
TP15 / IT03	Clayey SAND	0.49	0.6
TP17 / IT04	FILL: Clayey GRAVEL	0.52	2.1

6.4 GROUNDWATER – FROM GEOTECHNICAL INVESTIGATION

Groundwater was not encountered in any of the test pits. Water can pond / perch on or near the ground surface following rain events. Groundwater will also be influenced by nearby sea levels, approximately 3.5 – 5m below the current site.

6.5 PHOSPHORUS RETENTION INDEX

Testing for Phosphorous Retention Index (PRI) has not been undertaken. The in situ soils with their likely high iron content means that the soil is likely to have a high capacity for phosphorus retention.

6.6 CONTAMINATED SITES

The Department of Water and Environmental Regulation (DWER) contaminated sites database was searched for known contaminated sites (sites classified as Contaminated-restricted use, remediated for restricted use or Contaminated-remediation required) in proximity to the site. The adjoining Lot 3004 on the eastern boundary, (including a portion of the canal) is registered as a contaminated site that has been remediated for restricted use. It is understood that there may be remaining hydrocarbons in the soil and groundwater.

There are no other registered sites with 100m of the subject land.



Figure 8 Geotechnical testing locations

7 PRE DEVELOPMENT SURFACE WATER SITUATION

7.1 REGIONAL AND EXTERNAL FLOODING

SURFACE WATER FLOODING

There has been a range of regional flood modelling and reviews undertaken for the area that includes the subject land. A summary of the potential impacts of these floods was reported in the technical note titled *Lot 9510 Murat Road (Superlot D), Exmouth Assessment of flood risk mitigation options* (JDA 2023). The following provides the key items from this analysis. Further detail can be found in Appendix B.

Flood mapping presented in the Exmouth Floodplain Management Study (SKM, 2007b) for the Exmouth townsite shows Superlot D inundated during the 1 in 10, 25 and 100 year (10%, 4% and 1% AEP) flood events in the pre development state. Aerial laser scanning survey data was collected by Fugro pre-2007 and provided as irregularly spaced elevation data points from which a 5 m resolution digital elevation model [DEM] was developed for input into the MIKE-21 hydraulic model (SKM, 2007a). The coarser resolution resulted in the DEM not adequately accounting for some infrastructure smaller than the grid size, such as the higher elevation of Murat Road compared to the surrounding topography and therefore stormwater flow was assumed to flow unimpeded locally east to west across Murat Road.

This modelling was conducted using the rainfall intensity frequency duration (IFD) data from the now superseded 1987 version of Australian Rainfall and Runoff (IEAust, 1987). This IFD has been replaced by new IFDs from the Bureau of Meteorology (BoM, 2016) which have been incorporated into the current version of Australian Rainfall and Runoff (Ball et al., 2019) and account for over 30 years of additional rainfall data. The revised design rainfalls in Exmouth for the 100 year ARI (1% AEP) event have reduced approximately 30% across durations of 1 and 3 hours; which were deemed critical for the Exmouth townsite catchments in the SKM (2007b) modelling.

Due to these aspects and some other assumptions within the SKM2007b model, JDA have reassessed the flooding within the Market Street Creek catchment area in 2022, which includes Superlot D. (*Note; Market St has now been renamed Mortiss St. For consistency with the original flood mitigation report, the waterway will be called the Market Street Creek for this LWMS*). The refinement included use of updated rainfall IFD data, Australian Rainfall & Runoff 2019 revised flood modelling methodology and a finer hydraulic model DEM resolution grid from 5 m to 2 m of the original SKM DEM.

JDA revised modelling indicated maximum flood water levels across Superlot D were substantially lower than those shown in SKM (2007). This was due to the combined effect of lower IFD design rainfall depths, more accurate representation of the elevation profile of the Market Street Creek flood protection bund, Murat Rd and the catchment as defined by the Fugro (2006) and De Nada (2015) LiDAR survey dataset.

The flood modelling also showed the Market Street Creek flood protection bund (in 2007 survey condition) withstands the 1 in 100 AEP event, and in particular, there was no discharge of floodwater across Murat Road and into Superlot D between Cobia Close to the north and Mortiss Street to the south, in both the 20% AEP and 1% AEP flood events. The results of this revised modelling can be seen in Figure 7. There is a drop from 6.5mAHD in the south west corner to approximately 5.4mAHD in the northwest corner, while the level in the south east corner is 5.3mAHD.

These modelling refinements were presented to DWER, to review the requirement for importation of fill to raise lot level to achieve DWER's, floodplain management guideline for minimum habitable floor levels to be 500 mm above the 1 in 100 AEP.

DWER advised JDA on 27 January 2023 that whilst the modelling demonstrates the Market Street Creek flood protection bund withstands the 1 in 100 AEP event, additional flow from a break-out should the bund fail, and due to other aspects of its design and maintenance, they are unable to comment on whether the bund is suitable to provide 1 in 100 AEP flood protection.

Notwithstanding the above, DWER recommend minimum habitable floor levels along the western and southern boundary of the lot should be above the adjacent 1 in 100 AEP flood levels, however a lower freeboard (say 250 mm to 300 mm) than their recommended 500 mm may be considered. Therefore, the minimum floor level recommended by DWER for Superlot D adopts the 1 in 100 AEP flood levels provided by DWER from SKM (2007) plus 300 mm freeboard. This produces a finished floor level in relation to surface flood flows from 5.3 to 6.8mAHD. Figure 8 shows the minimum floor levels to be adopted.

It is also noted that there is a potential flood risk associated with the residential development to the south east of the site. This includes flood risks from Mortiss Street and the Market Street Creek flows. There has been recorded flooding within Mortiss Street due to there not being a designated overland flow path out for water within this locality. There is the potential for flood waters along Mortiss Street to flow through the subject land once water levels in the Mortiss Street swale rise to approximately 4.4mAHD. The flood analysis undertaken by JDA(2023) and supported by DWER was on the assumption that the entire subject land and the nearby development to the south east were filled to at least 5.2mAHD. At this height, flood water no longer enters the subject land.

It is noted that the Shire is currently exploring alternative options to assist with the localised flood management in the area. This includes upgrading the existing inlet pits as well as potentially modification of the Mortiss St swale network to transfer flows to the existing 600mm outlet pipe.

OCEAN FLOODING

An analysis of the inundation risk from the ocean due to extreme storms was undertaken for the subject land. The findings were detailed in the report titled *Lot 9510 Murat Road Exmouth Inundation Level Assessment* (MP Rogers 2023).The report outlined the current 500year ARI current inundation flood level as well as the likely impact of a 0.98m sea level rise due to Climate change over the 100 year timeframe. Based on the combination of these 2 aspects, the relevant flood level is determined to be 5.95mAHD, which is also to be set as the minimum floor level.

7.2 INTERNAL SURFACE WATER CHARACTERISTICS AND CATCHMENTS

There are no natural waterways within the actual subject land. There is a constructed channel that runs from the southern boundary northward for approximately 130m. The channels invert drops from approximately 4.4m AHD at the southern boundary down to 4.08mAHD in line with the northern most point of the canal. At this point the channel turns eastward, dropping down an area of rock armoring and continuing eastward before flowing over further rock armoring and into the canal. It is noted that there may possibly be other erosional side channels that bypass the rock armoring within this system. The internal catchment (Catchment Pre B) that feeds this eastern discharge point is 5.1871ha. It contains a localised depression that holds water to approximately 4.4mAHD (see Figure 3). Catchment Pre E (0.4253ha) also flows into this system, entering via the southern channel.

Catchment Pre A is located in the northwest of the subject land. This is the largest catchment at 6.3788ha. It is effectively a trapped catchment, with water ponding up to 5.1mAHD over an area of approximately 3.12ha. Should water reach this level, it will flow out to Murat Rd. This discharge point also allows flows from Murat to come into the subject land during large regional flood events. In this situation the water ponds temporarily before flowing back out until the level drops to 5.1m AHD. The remaining water then infiltrates or evaporates from the ponded area. Flows from Murat Road continue northward and flow under the Cobia Close intersection via a 525mm pipe bubble up system. In larger events, this overtops at approximately 5.22mAHD. Flows then continue northward within the Murat Rd swale and in larger events top over and flow into the canal network.

Catchment Pre C (1.8757ha) is composed of a strip of land around the eastern and northeastern boundary. Water here falls directly to the canal itself or exits via the ramp in the northeast corner.

Catchment Pre D (3.1105ha) covers the southwest corner of the site. Due to fill being placed within the eastern portion of the subject land, water tends to pond in a very shallow layer along the eastern edge of this catchment, then flow southward into the Mortiss Street verge, while noting that Mortiss Street is also likely to contribute flows into Catchment D, when the capacity of the road swale is exceeded. Flows leaving the south east corner of this catchment continue eastward along the Mortiss Street swale. At the point where the Mortiss street swale meets the southern channel, water will preferentially continue along the Mortiss St swale, until the level in the swale rises to approximately 4.4mAHD. At this height, flows are then split between the Mortiss Street swale and the southern channel.

There is a 0.3898ha catchment in the south east corner (Catchment Pre G) that sheets flow predominately eastward onto the adjoining lot. This water is then directed southward to Mortiss St, down gradient of the southern swale/ Mortiss Street confluence point.

Catchment Pre F is a 0.0283ha catchment that also flows eastward onto the adjoining lot, with this water likely to flow through to the canal network.

There is currently no appreciable flow from the subject land to Cobia Close, due to a constructed bund along the northern boundary.

As a portion of the subject land will discharge to Cobia Close in the post development situation, the predevelopment catchment associated with Cobia Close is considered (Catchment CC). This catchment is assumed to be 1.6552ha and is composed of a piped street drainage network that discharges to the northern canal. Overland flows that exceed the pipe network flow in the same direction and exits out through a dedicated access way to the northern canal. This accessway has a lip level at 4.63mAHD. At 4.63mAHD, there is approximately 55m3 of storage within the road reserve, with the maximum depth of water in the road being 0.23m (at the lip of the drainage pits) and the majority being less than 0.1m deep. Above 4.63mAHD there is a clear flow path through the accessway along the 2.0m wide concrete footpath plus the rocked edges sloping up at approximately 1 in 8 on both sides, giving a total reserve width of 5m. The surrounding lot levels start at a minimum of 5.3mAHD. This wide accessway provides a safe flow path out for stormwater, with any flooding likely to be more than 400mm below the current lot levels, in the unlikely event that the pipe network becomes completely blocked.

To be conservative, this assessment has also assumed that all lots along Cobia Close discharge their water onto the street, rather than the canal fronting lots discharging water out to the northern canal. The configuration of the entrance intersection off Murat Road means that it is unlikely that water from Murat Road will flow into Cobia Close.

A summary of the catchments can be seen in Table 2. Figure 9 shows the predevelopment characteristics and general surface water characteristics.

7.3 PRE DEVELOPMENT DRAINAGE MODELLING

A predevelopment model was constructed in DRAINS. This was to determine likely flow rates generated from the internal catchments and adjoining portions of Murat Road and Mortiss Street as well as the development associated with Cobia Close. The model included the following assumptions:

- Horton/ ILSAX drainage modelling method used.
- ARR 2019 methodology and rainfall figures used.
- A soil factor of 3 was applied (slow infiltration restricted by lower hydraulic conductivity subsoils) to reflect the sandy clay soil with heavier soils and rock at depth.
- Antecedent Moisture Condition 2 used (0-12mm of rainfall in preceding 5 days)
- Catchments were as per Figure 9 and Table 2 and assumed no flow from other external areas into the subject land.
- A retardance coefficient of 0.12 was used to reflect the rough grass and tree vegetated unfilled areas.
- A retardance coefficient of 0.03 was used to reflect the bare filled areas.
- A retardance coefficient of 0.01 was used to reflect the impervious surfaces of the sheds and racetrack, while the gravel tracks were assumed to have a retardance coefficient of 0.013.

The storms modelled were the 5min,10min,15min, 20min, 25min, 30min, 45, 1 hr, 1.5hr, 2hr, 3hr, 4.5hr, 6 h, 9hr, 12hr, and 24hr. Longer events were not modelled as the events peaked at 12hr or less. These were modelled for the 20% AEP and 1%AEP.

The results from this modelling are outlined in Table 3. While there is not a need to match pre and post development flows, this analysis provides an understanding of how the subject land currently functions, which assist with determining suitable post development discharge management.

Table 2 Pre development minor catchment summary

Minor catchments	Area (ha)	Characteristics/ Comments	Discharge location
Subject land			
A Pre	6.3788	3.12ha central depression holds water. Tips at RL5.1	Murat Rd swale, but doesn't flow out in 1% AEP
B Pre	5.1871	0.6511ha central depression holds water. Tips at RL4.4 the flows to eastern channel	Eastern canal (channel flow)
C Pre	1.8757	Relatively flat filled area with short run sheet flow.	Northern and Eastern canal (Sheet flow)
D Pre	3.1105	Contains hardstand. Flows accumulate against filled portion then flow south.	Mortiss St swale
E Pre	0.4253	Relatively flat filled area with short run to southern channel.	Southern Channel, then into eastern channel
F Pre	0.0283	Relatively flat filled area with short run to adjoining eastern lot, then likely flows north east.	Eastern canal (channel flow)
G Pre	0.3898	Relatively flat filled area with short run to adjoining eastern lot, then flows south.	Mortiss St swale
Surrounding			
CC	1.6552	Partially developed. Lot portion assumed to drain to street drainage network.	Northern canal via constructed pipe and overflow PAW.
CC - direct	0.1641	Existing lots assumed to drain direct to canal	Northern canal
MUR	0.9143	Crown of road to existing road side swale	Existing pipe under Cobia Cl, then continues north in swale, larger events tip into Northern Canal
MOR	0.2922	Crown of road to existing road side swale	Continues eastward on Mortiss St, with discharge into southern swale during larger events

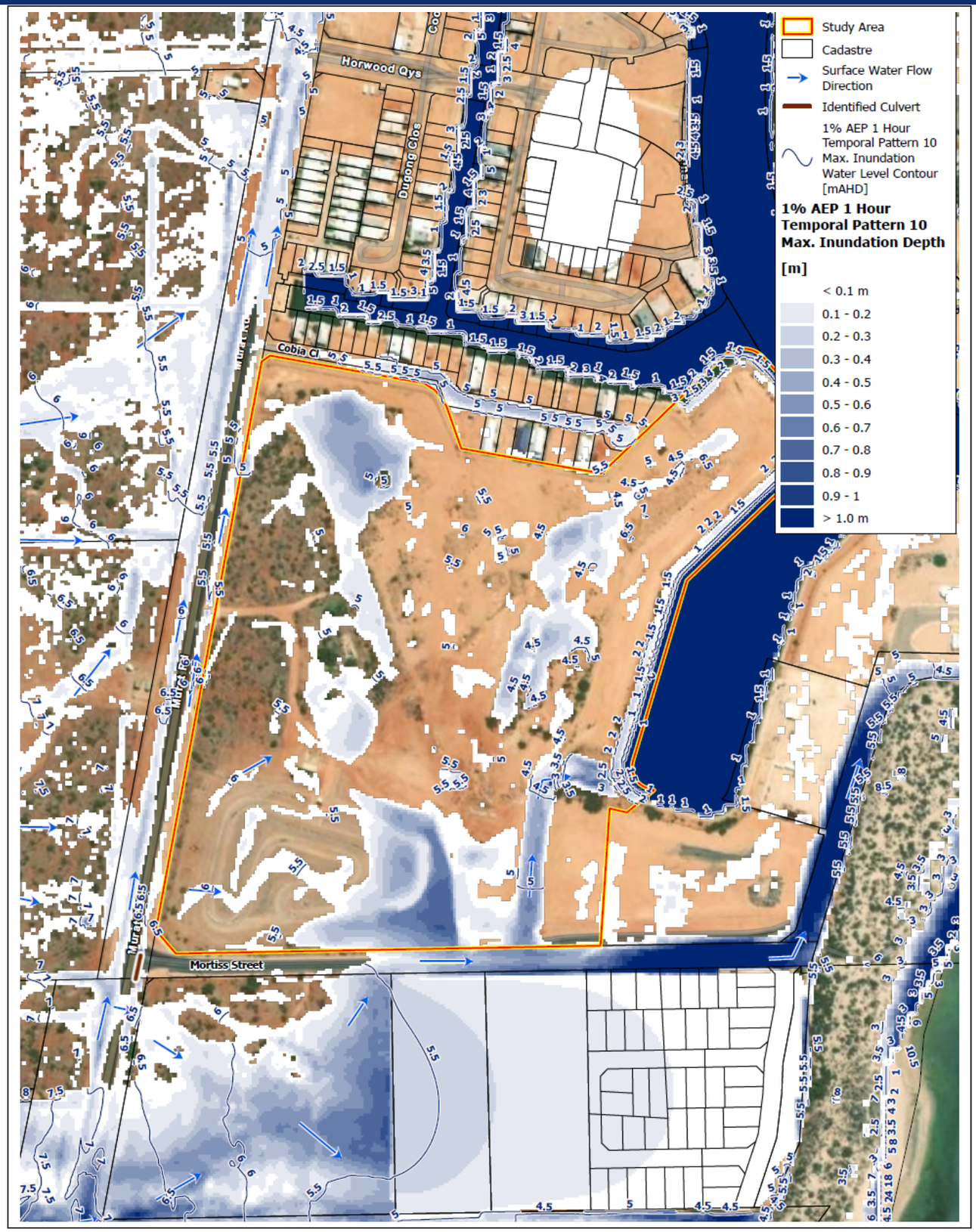
Table 3 Pre development drainage modelling results

Major Catchment	Contributing Minor Catchment	1EY		20% AEP		1%AEP		Comments
		Peak flow (m^3/sec)	Critical Storm	Peak flow (m^3/sec)	Critical Storm	Peak flow (m^3/sec)	Critical Storm	
East Canal	B,E, F	0	NA	0.108	12hr	0.896	15min direct/ 12hour for channel	Also takes some flow from Catchment D via Mortiss St during large events
A	A	0	NA	0	NA	0	NA	Catchment A, all water held within trapped low.
Murat Rd combined	MUR and A	0.039	25min	0.067	15min	0.117	30min	Flow rate through pipe and overland flow at Cobia Cl intersection
Mortiss Street	D, G, MOR	0.006	12hr	0.072	12hr	0.359	45min	Flow at eastern end of subject land. Some flow lost to Southern Channel in large events.
Cobia Close – Canal via RD	CC	0.037	15min	0.132	1hr	0.384	25min	Includes exiting lots and road, with existing lots assumed to discharge into Cobia Cl drainage network.
Cobia Close – direct	CC direct	0.017	15min	0.014	0.036	0.08	10min	
Total		0.099		0.393		1.836		

7.4 SURFACE WATER QUALITY

No predevelopment surface water quality samples have been taken, as there are no surface wetlands or natural waterways within the subject land.

Figure 9 Revised 1% AEP 1 Hour Market Street Creek flood mapping



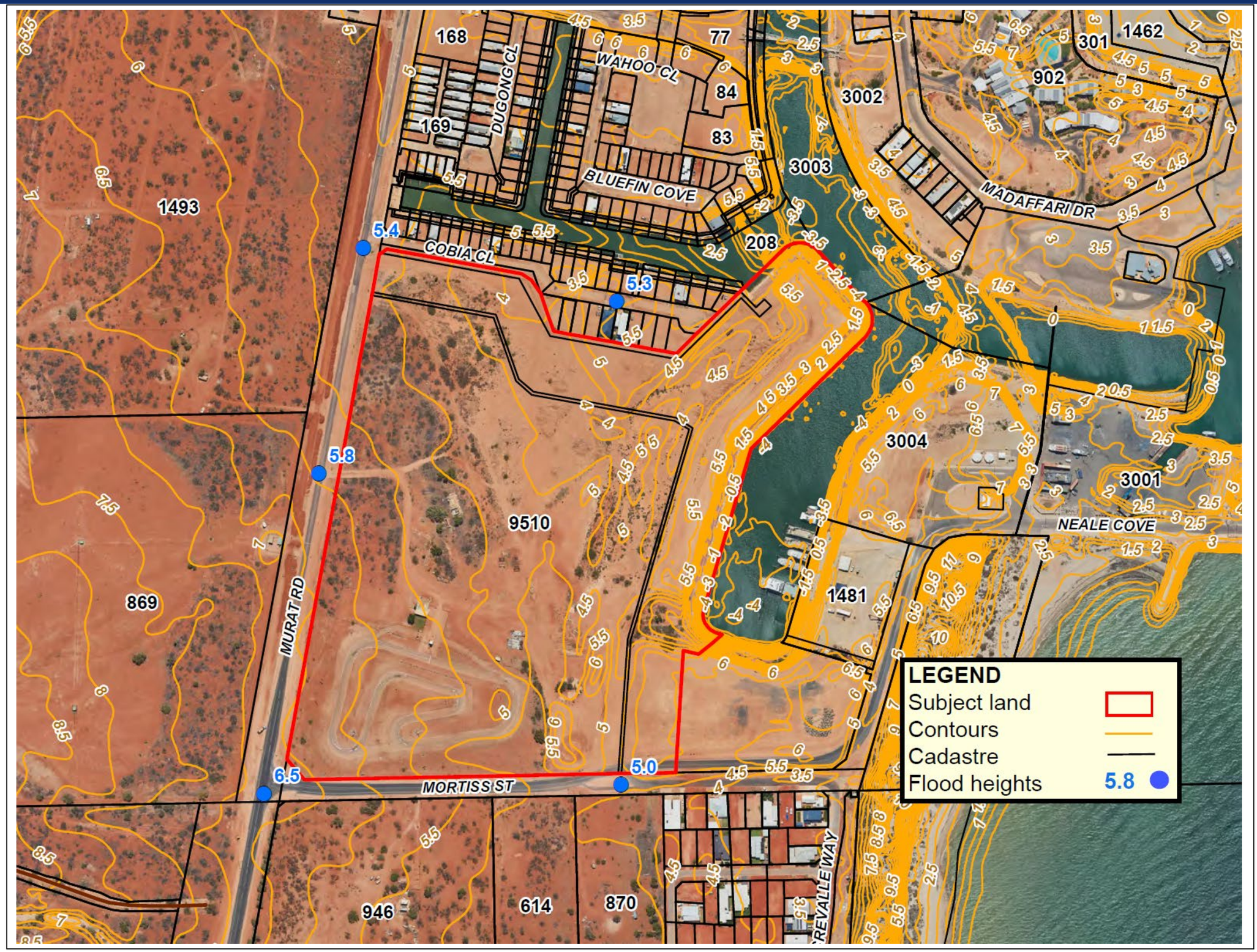


Figure 10 Determined flood heights on Superlot D boundaries



Figure 11 Internal predevelopment catchments

8 DRAINAGE MANAGEMENT STRATEGY OVERVIEW

The aim of Drainage Management for the subject land is to generally manage the water flows so that water treatment is achieved and that the major storms are managed through the subject land.

The majority of the 1EY is to be treated to reduce nutrients, sediments and other contaminant prior to discharge offsite. Above the 1EY, the main function is to control the flow of drainage water throughout the subject land and its release from the subdivision in a controlled manner.

The following sections show in more detail how water is treated and conveyed in the different AEP scenarios,

8.2 – 1EY

8.3 – 20%AEP

8.4 – 1%AEP

The drainage network, including indicative basin locations can be seen in Figure 10.

8.1 MODELLING AND GENERAL SUMMARY

The subject land, adjoining roads and Cobia Close locality have been assessed as part of the post development drainage modelling. 5 main subject land catchments that were modelled to represent the water flowing to the different discharge locations. The catchments were also divided into lot and road catchments, to represent the different land uses and their individual drainage characteristics. A summary of these catchments can be seen in Table 5.

In line with the recommendation of the DWMS, all lots and roads are to detain and infiltrate the first 15mm of rainfall. A guidance note for Lot owners on options for storage within their lot is outlined In Appendix F.

For events above this, there is no extra detention, with the focus on allowing water to safely move through to the discharge point. The flow predominately discharges to the canal network, meaning there is minimal impact on downstream flooding. The exception to this is the portion of the site that drains to Murat Rd. Due to the existing constraints associated with the pipe network under the Cobia Cl entrance road, the flow has been managed so that there is no effective overtopping of the Cobia Cl entrance road in the 20% AEP. This has been achieved through increasing the storage volume in the POS 1 basin and directing a portion of the pipe flow from this POS 1 feeding catchment, through to POS 3. The POS 1 catchment can be seen in Figure 12, with the area where the pipe network drains water to POS 3 also identified. The pipe network can also be seen in Figure 13, with further details in the Civil drawings (Appendix

The flow along Murat Road is to remain as a swale system, with culverts to be placed under the new entrance road to the subject land.

Options for minimising impacts on the downstream Mortiss Street system are to be further explored as part of detailed design of Stage 2. To assist the current preliminary design for Stage 2 has resulted in a reduced flow to Mortiss St from the subject land in events above the 1EY. Further details can be found in Section 8.6

Cobia Close has achieved a stormwater management outcome that works with the current pipe network discharging to the canals. Details on Cobia Close flood management are also outlined in Section 8.5. This includes a minor stormwater flow and subsoil discharge from Basin 1.

The key modelling assumptions and characteristics are as follows:

- Horton/ ILSAX drainage modelling method used.
- ARR 2016 methodology and rainfall figures used.
- Catchments were designed to be logical areas of stormwater capture with the discharge node for the roads being the stormwater pits. Lot areas were divided out into separate catchments, with associated storage (where relevant). Catchments are as per Table 5 and Figure 12.
- All roads were assumed to conservatively be 80% impervious, with 10% of this indirectly connected.
- POS areas were assumed to be 20% impervious (10% directly connected) to account for footpaths, basins and other hard landscaping.
- All lots were assumed to conservatively be 70% impervious, with 10% of this indirectly connected.
- New lots above 350m^2 have been modelled with water flowing to on lot storage sized to capture an equivalent value to 15mm of rainfall over the entire lot. Infiltration for on lot infiltration was assumed to be 0.5m/day.
- Lots below 350m^2 have been modelled with stormwater discharging to the road drainage network. The additional 15mm of rainfall detention is provided in the POS 1 basin.
- Existing lots along Cobia Close were assumed to have storage sized to capture an equivalent value to 15mm of rainfall over the entire lot. To be conservative, it was assumed that all Cobia Close lots drain to the road once the on-lot storage is exceeded. The back portion of the lots as identified in Figure 12 are assumed to drain direct to the canals due to the level of these areas.
- For new canal lots (Catchment E1, E2 and E3), it is assumed that the majority of the lot area discharges to the road network after the 15mm required lot storage is exceeded. The exception is the portion of each lot that slopes directly down to the canal. The catchment divide can be seen in Figure 12. Canal lots may discharge all water directly to the canal, however for conservative assessments this was not assumed in the detailed modelling.
- The catchment flowing to Mortiss Street Catchment is to achieve storage in shallow soakwells or similar underground storage, sized to detain the first 15mm of rainfall. An assumed volume of 15.1m^3 of storage has been use for current drainage modelling. The final amount will be determined as part of the detailed design of Stage 2. The soakwells are assumed to have an infiltration rate of 0.5m/day.
- Basin 1 is to have a 225mm pipe connection to the Cobia Close drainage network (see Figure 13) for the management of the 20% AEP.
- Directly connect impervious areas (eg roads, basins during floods and rooves) had an assumed retardance coefficient of 0.01, while supplementary impervious areas eg footpaths and on lot paving had an assumed retardance coefficient of 0.013.
- Road at pervious surfaces (eg areas of verge or landscaping) were assumed to have a retardance coefficient of 0.1.
- Lot pervious surfaces (eg lot landscaping) were assumed to have a retardance coefficient of 0.15.
- POS pervious surfaces (eg areas of grass or stone landscaping) were assumed to have a retardance coefficient of 0.2.
- The bioretention garden was assumed to have bioretention media and suitable planting throughout. To be conservative and to account for potential clogging, the basin infiltration rate was assumed to be 0.5m/day for the base and sides. It is likely that the bioretention base will have a higher infiltration rate, which will assist with infiltrating the longer duration events.
- A portion of the site has the pipe network draining to POS 3, while the road flow (when pipe capacity is exceeded) going to POS 1. This has been done to reduce flows out to Murat Rd. The location of this area can be seen on Figure 12.
- The basin designs within each POS are as per Table 4.
- The final storms modelled were the 5min,10min,15min, 20min, 25min, 30min, 45, 1 hr, 1.5hr, 2hr, 3hr, 4.5hr, 6 h, 9hr,12hr, 18hr, 24hr, 36hr, 48hr. Longer events were not modelled as the peak events were generally 18 hours or less for flows leaving the site. These were modelled for the 1EY, 20%AEP and 1%AEP.

Table 4 POS basin summary

POS	Basin base (RL	Base area (m^2)	Basin top (RL)	Top area (m^2)	Total volume to top over (m^3)	Outlet pit height from base (m)	Weir height from base (m)	Total depth (m)	Side slopes
1	4.1	372	5.3	1720	1169	1.05	1.15	1.2	1 in 6
2	3.7	55	4.7	350	151	0.9	0.95	1	1 in 6
3	3.05	190	4.25	869	480	0.9	0.95	1.2	1 in 6

Table 5 Post Development Catchment summary

Catchment	Catchment areas (Ha)				Initial Discharge point	Comments
	Lots	POS	Road	Total		
1	1.4139	0.5604	0.6624	2.6367	Lot soakwells & POS 1 basin	Includes 11 lots below 350m^2, which discharge direct to road drainage with no detention. Portion of Road catchment has pipe flow to POS 3 basin. POS 1 Basin discharges to Murat Road Drainage swale.
Murat other	0	0.1502	0.03	0.1802	Murat Rd swale	POS 4 landscaped to detain 15mm through localised depressions.
Murat Rd Existing	0	0	0.9143	0.9143	Culvert under Cobia Cl entrance	Existing road and verge. Catchment effectively the same as pre development
2	2.5397	0.1125	0.7813	3.4335	Lot soakwells & POS 2 basin	All lots detain first 15mm. POS 2 Basin discharges to Canal
3	7.1964	0.3937	2.2977	9.8878	Lot soakwells & POS 3 basin	All lots detain first 15mm. POS 3 Basin discharges to Canal. Includes some pipe flow from Catchment 1. Includes commercial lots.
Canal new– back portion	0.7149	0	0	0.7149	Canal waters	Portion of new canal fronting lots where the level is too low to drain back to new road drainage network.
Canal existing – back portion	0.1641	0	0	0.1641	Canal waters	Portion of existing canal fronting lots where the level is too low to drain back to Cobia Cl drainage network.
Mortiss	0.2854	0	0.0837	0.3691	Lot soakwell	All Lots detain first 15mm, then overflow direct to Mortiss St
Mortiss St Existing	0	0	0.2922	0.2922	East along Mortiss St.	Existing road and verge. Catchment effectively the same as pre development.
Cobia Cl	1.9289	0	0.4986	2.4275	Lot soakwell and direct pipe to canal	Discharges through to canal via drainage pipe and footpath accessway.

8.2 1EY STORM EVENT AND WATER QUALITY

Key points of the minor drainage system strategy are as follows:

- All new lots over 350m^2 will use on lot storage to infiltrate first 15 mm of rainfall. When the storages is exceeded by other 1EY events, they will flow out to the road network. On lot storage options may include surface bioretention gardens, dedicated landscaped storage depressions, shallow soakwells or other shallow below ground storage systems, above ground tank for roof water with small trickle out pipe to garden areas or a combination of the above. The exact configuration is to be determined as part of each lots building design and licence.
- All new lots under 350m^2 will discharge their first 15mm of stormwater to the road drainage network via lot connection pits. This water is detained with the POS basins.
- Treatment of road stormwater is to be in the vegetated bioretention basins located in the POS areas. The basins are able to hold the entire 15mm generated from the roads and relevant lots.
- The POS 2 and 3 basins will be fitted with subsoil drainage to ensure that the basin infiltrate rain between storm events and that they remain free from localised groundwater mounding. The subsoil is to discharge to the outlet pipe network that drains to the canals. POS 1 will be over excavated by 1m and back filled with clean free draining bioretention media. This will assist with infiltrating any held stormwater into the surrounding soil profile between storm events.

8.3 DRAINAGE MANAGEMENT PLAN – 20%AEP

The pit and pipe network is designed to transport the flow from the internal road network and from relevant lot runoff to the POS basins. Key points for the 20% AEP event are:

- The flows are contained within the pipe network to the relevant POS basin. The 20% AEP basin discharge is predominantly via the outlet pit and pipe from the basin to either the canals or external drainage network.
- There is a safe overflow route via a rocked weir in the case of the outlet pipe being blocked.
- Any discharge from canal lots directly to the canal will be via a dedicated discharge structure to the canal at their lot boundary. Each structure is to be approved by the Shire as part of the building licence.
- Overflow from Catchment D will discharge to the Mortiss Street swale. This swale and culverts under the new southern entrance Road are to convey the 20% AEP as a minimum. The exact configuration is to be determined as part of the Stage 2 detailed design.
- Flows under the Cobia Cl intersection with Murat Road are kept within the existing culvert, with no effective overtopping in the 20% AEP.
- Flows to Mortiss St are reduced compared to the pre development flow rate as per Table 7.

8.4 DRAINAGE MANAGEMENT PLAN – 1%AEP

The Subject area has been designed to safely manage the 1%AEP flood event so that impacts on the subject land and downstream infrastructure, the environment and people's safety are minimised.

Key points of the major drainage system strategy are as follows:

- The roads are graded to direct flow overland to the basin POS areas. The final road low point for each catchment is adjacent to the relevant POS, with overflow into the POS basin. Any trapped points within the road network are designed to overtop downstream towards the relevant POS.
- Outflows from the POS basins will occur through both the outlet pipe and weir, with the total peak flows being as per Table 6.
- The flow from the POS basin systems and Cobia Close will all discharge to the canal network.
- 1% AEP flows along Mortiss Street are reduced post development, assisting with minimising downstream flood issues.

In relation to flood protection the key points are:

- All lot finished levels have a minimum 0.3 m clearance above the 1% AEP flood level in the road and POS flood level.
- All lot finished levels have a minimum 0.3m clearance above the relevant modelled 1% AEP flood level of the Market Street Creek break out flow.
- All building floor levels are set at a minimum of 5.95mAHD to account for the 500year ARI ocean inundation level that includes future sea level rise.
- The finished floor levels for Stage 1 to achieve these outcomes can be seen in Figure 14. Indicative levels for Stage 2 can be seen in Figure 15, with these to be finalised as part of the Stage 2 detailed design.
- The filling of the land to achieve flood separation has been taken into account as part of the overall flood analysis of the Market Street Creek and supported by DWER. This includes the high level flow channel across the subject land being removed.

Table 6 Post development flow summary from subject land and Mortiss St.

Catchment	Minor Catchment	1EY - all storms		1EY - 1hr (approx. 15mm)	20% AEP		1%AEP	
		Peak flow (m^3/s)	Critical Storm	Peak flow (m^3/s)	Peak flow (m^3/s)	Critical Storm	Peak flow (m^3/s)	Critical Storm
East Canal : POS 2	2A – 2F	0.105	6hr	0	0.322	1.5hr	0.697	25min
POS 3	3A - 3P + 1E - 1G pipe flow	0.280	12hr	0	0.669	1.5hr	1.703	45min
Direct lot discharge	Canal E + Canal NE	0.017	15min	0.048	0.134	15min	0.327	5min
Murat Road: POS 1	1A - 1D + 1E - 1G surface flow + POS 1	0.004*	4.5hr	0	0.012*	36hr	0.317**	4.5hr
Other	POS 4 & MUR Entrance	0.002	5min	0	0.042	30min	0.154	20min
Mortiss Street - Subject land	MS	0.006	12hr	0	0.025	1hr	0.088	25min
Mortis St - Existing verge and Road	MOR	0.018	20min	0.014	0.039	15min	0.108	15min
Cobia Close - Via Road	CCA-CCD	0.042	12hr	0.032	0.185	1hr	0.484	30min
Cobia Close - direct	CC - Direct	0.017	15min	0.014	0.036	10min	0.08	5min
Total		0.481		0.094	1.425		3.844	

Notes: ** Pipe flow to Cobia Close*
*** 0.050m^3/s via pipe flow to Cobia Close, and 0.267m^3/s to Murat Rd.*

Table 7 Pre vs Post development flow summary

Discharge location	1EY flow rate (m^3/s)		20% AEP flow rate (m^3/s)		1% AEP flow rate (m^3/s)	
	Pre	Post	Pre	Post	Pre	Post
East Canal	0	0.402	0.108	1.125	0.896	2.727
Murat Road Combined	0.039	0.014	0.067	0.054	0.117	0.421
Mortiss Street (including Rd reserve)	0.006	0.022	0.072	0.064	0.359	0.196
Cobia Close - Canal	0.054	0.059	0.168	0.221	0.464	0.564
Total	0.099	0.497	0.393	1.464	1.836	3.952

8.5 COBIA CLOSE DRAINAGE

An analysis was undertaken along Cobia Close to review the existing stormwater outlet network and the potential for flooding due to the addition of new lots. DRAINS modelling was used to review:

- the entire feeding catchment excluding flows from POS 1 - Basin 1.
- he entire feeding catchment including flows from POS 1 -Basin 1.
- the pipe and overland flow routes (down footpath) to the canals, as provided by the Shire and available survey
- the trapped low volume until top over to the overland flow path is achieved (taken from site survey).
- height of lots relative to the maximum flood level (lowest existing undeveloped lot level at 5.30AHD), with all future finished floor levels to be a minimum of 5.95mAHD

From this analysis it was determined that the addition of new lots from the Cobai Cl catchment (excluding the Basin 1 flow) does not significantly increase the flood level, with the final flood level post development being RL4.60 and a discharge rate of 0.484m^3/s. There is also a peak flow rate within the internal street rather than the pipe of 0.189m^3/s. This flood level is 0.7m below the lowest undeveloped existing lot level. As there is a 5m+ wide clear overland flow path available at RL 4.63, even with full pipe blockage there is no appreciable risk to lots from localised flooding, as water will safely discharge through this pathway to the canals.

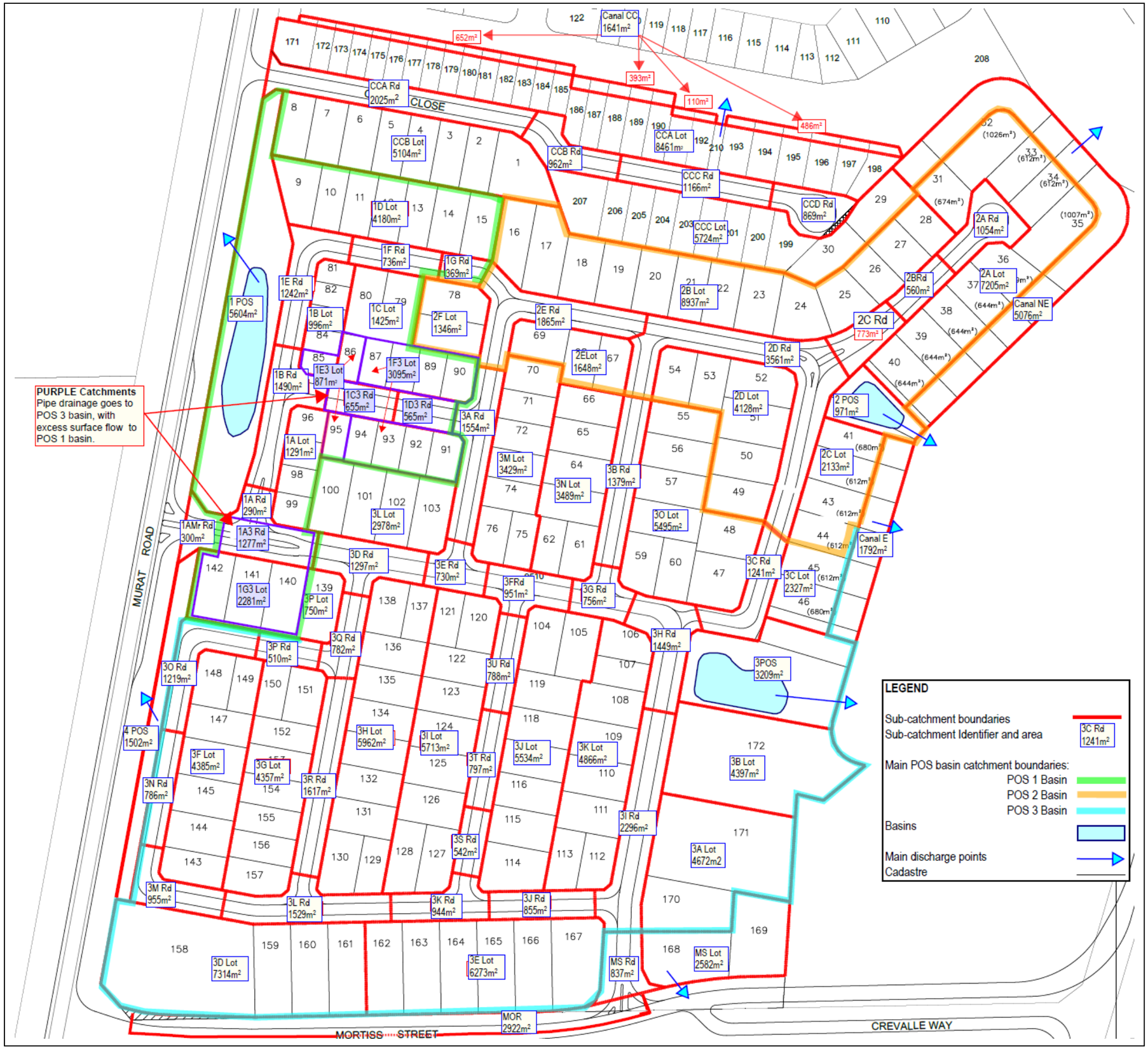
When the flow from a 225mm pipe from Basin 1 was included, the flood level remained unchanged at 4.6mAHD, with the ultimate pipe discharge rate remaining the same. There is an increase of 0.008m^3/s to 0.197m^3/s for flows within the street.

There is no appreciable difference in the 1 EY and 20% AEP flow rates at the discharge point of Cobia Cl.

8.6 MORTISS STREET DRAINAGE

It is noted that there is an existing flood management issue on Mortiss St, down gradient of the subject land. This flood issue is currently being reviewed by the Shire to determine the most suitable option for managing stormwater within this location. Stage 1 will not impact the current flow regime of Mortiss St and the overland flow path through the subject land is to be retained throughout the Stage 1 works. Prior to or as part of Stage 2 detailed design, it is noted that an overall solution is to be determined to assist with managing this existing flood issue. This includes both pit/pipe and or open swale options to transfer flows away from the current flood prone areas along Market St/Mortiss St. Further details on managing Mortiss Street flood flows, including options for downstream works, can be seen in Appendix E.

Figure 12 Post Development Catchments



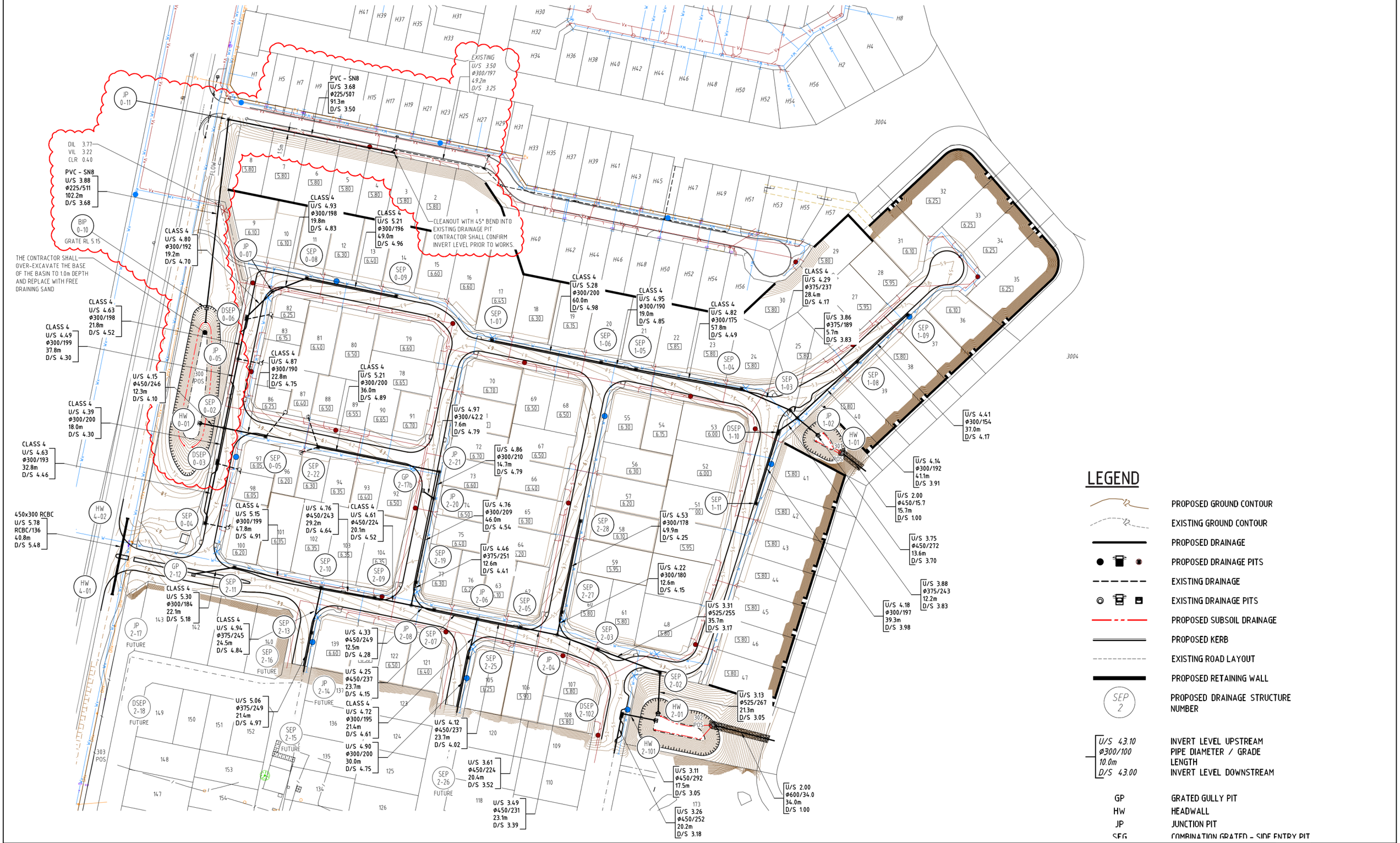


Figure 13 Stage 1 Drainage Network

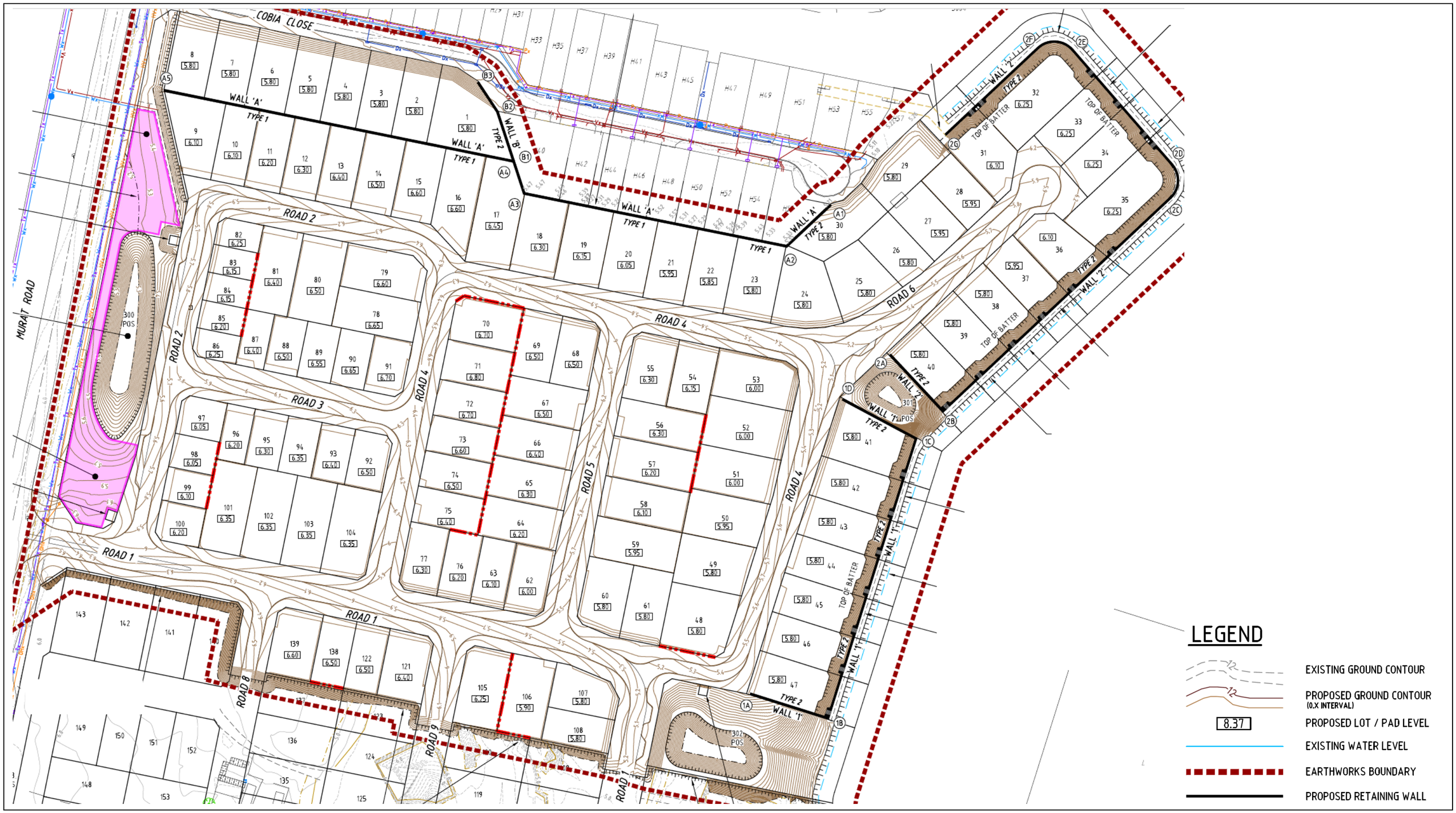
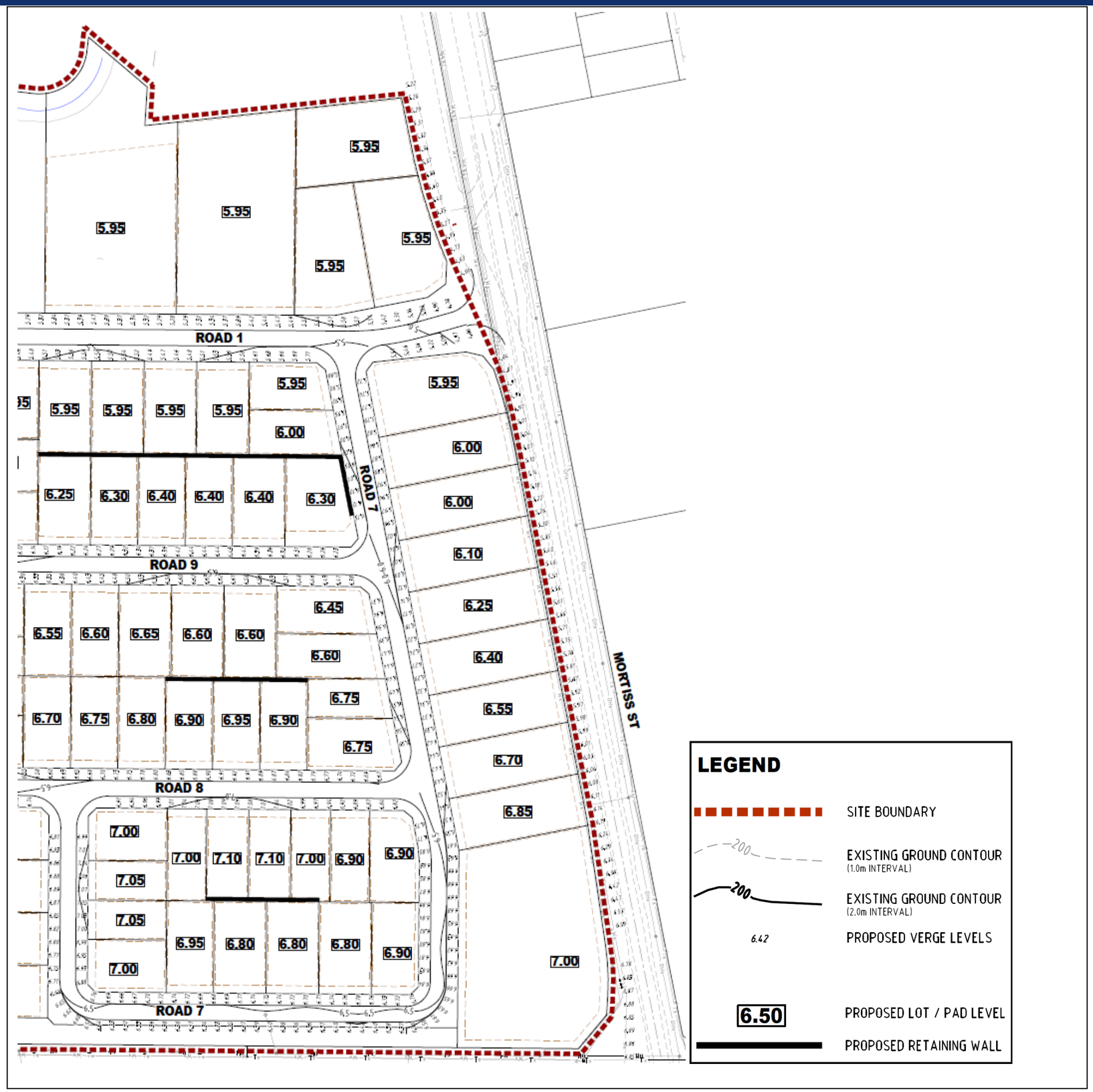


Figure 14 Stage 1 Lot levels

Figure 15 Indicative Stage 2 Lot levels



9 GROUNDWATER MANAGEMENT STRATEGY

The focus of groundwater management for the subject land is to maintain groundwater as close as possible to existing levels, while maintaining adequate separation from infrastructure. Furthermore, groundwater will be managed to improve water quality before it leaves the subject land. By maintaining the groundwater at a level similar to the current level, the development will have minimal impact on any groundwater dependent ecosystems that exist down gradient of the subject land or the water quality within the canals. Groundwater will still be fed from the soil profile and canals at similar rates to the current situation. There are two primary objectives for groundwater protection and management for the proposed development, these include:

- Protection of infrastructure and assets form high groundwater levels.
- Protection of groundwater dependent ecosystems/canal water quality from modified groundwater hydrology following development.

9.1 INFRASTRUCTURE SEPARATION

A vertical separation between significant infrastructure and the onsite groundwater is to be implemented. This is to be achieved primarily through the current separation to groundwater already present. As the site is to be filled to achieve flood separation, this will further increase the separation to 5m or more from the likely ocean induced groundwater level of approximately 0.5mAHD. The fill is to be clean, and with a hydraulic conductivity of at least as high as the in situ soil (assumed average of 0.5m/day). Fill materials, placement and compaction methods and quality control will apply according to standard industry practice and as outlined in the geotechnical report.

All soakwells and basins will have a clear separation of at least 3m over the likely groundwater level. The clayey subsurface material is also to be graded so that any minor perching will flow towards the edge of the development.

To assist with infiltration of stormwater into the ground profile, the bioretention gardens will include a free draining media on their base. A subsoil network will also be installed under the basins, which will negate any potential mounding within the basin locations. Basins 2 and 3 subsoil networks discharge out to the canals via the POS stormwater network, while Basin 1's subsoil is connected to a 225mm pipe into the existing Cobia CI drainage network.

The finished lot levels can be seen in Figure 14 and 15, which highlights the significant separation to the groundwater level.

9.2 QUALITY MANAGEMENT

The groundwater quality is managed by road stormwater being treated within the bioretention basin. The infiltrating stormwater will receive treatment as it infiltrates through the bioretention media and plant root zone, prior to entering the groundwater system. This will minimise nutrients and other contaminants from entering the superficial groundwater system.

Fertiliser use for landscaping areas in the POS is recommended to be minimal and utilise slow-release products, as necessary. This will reduce the total load of nutrients applied to the development area and minimise the risk for nutrient movement into the groundwater.

All commercial and light industrial enterprises are to incorporate industry best practice so that any potential contaminants are captured and treated before they enter the soil profile (and potentially the groundwater system). This is to be achieved through compliance with industry and Shire requirements as part of the Building License for each lot. All prescribed premises are also to comply with the license requirements as determined by DWER and associated guidelines and legislation. Further details related to the implementation of necessary mechanisms to manage potential contaminants are to be outlined in the UWMP for Stage 2.

9.3 PROTECTION OF GROUNDWATER DEPENDENT ECOSYSTEMS

Potential threats to groundwater dependent ecosystems will be managed by:

- POS to have waterwise landscaping and irrigated through water efficient system
- Infiltrate water close to source to minimise hydrological changes (eg all lots infiltrate first 15mm and road stormwater infiltrated over 3 diverse locations
- The bioretention garden subsoil system is to connect to the outlet stormwater pipe system and discharged the treated excess groundwater offsite.

9.4 DEWATERING

It is unlikely that any dewatering will be required for the construction of services due to the depth to groundwater. There may be a requirement for dewatering associated with the construction of the canal retaining wall toe footings. This is to be assessed as part of the construction program and tidal movements. Should the works be likely to trigger the requirement for a dewatering licence, then a licence will be acquired prior to the relevant works beginning.

Should it be required, a dewatering management plan is to be produced as part of this process, noting that the dewatering will be removing infiltrating seawater back into the ocean, with minimal impact.

10 WATER SERVICING AND SUSTAINABLE USAGE STRATEGY

10.1 POTABLE WATER

There are existing 150mm water mains in Mortiss Street and Cobia Close to the south and north of the site respectively. The Water Corporation (WCWA) had previously advised (October 2020) that they did not believe there would be any capacity issues with servicing the development. This advice was re-confirmed in Sept 2023 and again in November 2024.

The internal water reticulation has been designed and constructed in accordance with standard Water Corporation requirements. This service is to be managed by Water Corporation. The potable water layout for Stage 1 layout can be seen in Appendix D.

10.2 WASTEWATER MANAGEMENT

There is an existing sewer vacuum system in the immediate area that will be able to be connected to for wastewater disposal. The current 150mm vacuum sewer rising main that traverses the site along the eastern and northern boundary of the site that will need to be relocated into the future road reserve.

Vacuum sewer works on the basis of having small gravity catchments of up to 8 lots discharging to a vacuum sewer pit which then has a separate vacuum sewer reticulation system back to the vacuum sewer pump station. The pump station for this catchment is located 200m north of the site on Murat Rd. Therefore, as it is in this catchment it is expected that its flows have been previously accounted for in the catchment design.

A sewer layout can be seen in Appendix D.

10.3 LANDSCAPING

The proposed POS area is to utilise a hydrozoned irrigation strategy to minimise overall water usage, while providing public amenity and assisting with plant establishment. Landscaping of the POS will use suitable native species and other waterwise species throughout. The objective of the landscaping is to implement strategies that minimise the quantity of irrigation required including mulching, low use of slow-release fertilisers, direct irrigation from stormwater runoff and utilisation of native plants in garden beds and shade trees.

The POS irrigation is to be predominately supplied from the subject land's groundwater with potential top up from the Water Corporation's scheme water.

The irrigation volume for implementation of the POS areas will be partly determined by the final water source mix and the corresponding vegetation plants.

The final irrigation strategy is to be outlined in the approved Landscaping Plan.

10.4 FIREFIGHTING WATER SUPPLY

Fire hydrants will be provided throughout, as per the relevant regulations.

11 WATER DEPENDENT ECOSYSTEMS MANAGEMENT STRATEGY

11.1 EXISTING ECOSYSTEM PROTECTION

The treatment of water prior to it entering the Exmouth Gulf or the deeper groundwater system, which may contain subterranean fauna will assist with protecting these systems. The strategies used to achieve this are outlined in Sections 8 and 9.

11.2 NEW HABITAT CREATION

The planted drainage basins will also act as new ephemeral riparian habitat, due to the ephemeral inundation and locally native vegetation suited to these conditions. This will be complimented by the use of other native plants within the surrounding POS areas.

11.3 DISEASE VECTOR AND NUISANCE INSECT MANAGEMENT

The ephemeral nature of bioretention infiltration basins, means that they do not offer a suitable habitat for mosquito breeding. The basins are designed to drains significantly quicker than the guideline of 96 hours of rain ceasing. This will be achieved through the use of suitable media and the subsoil network.

12 MONITORING & MAINTENANCE

12.1 SURFACE AND GROUNDWATER MONITORING

As there are no natural surface water features on site, there will be no pre or post development surface water monitoring.

As the groundwater level is more than 2m below the surface, there will be no pre or post groundwater level or quality monitoring.

12.2 OTHER ITEMS - CONSTRUCTION PHASE

Installation of drainage control structures ahead of the construction phase of the subdivision development will be utilised. This will include the use of water sensitive urban design techniques such as sediment curtains, hydro mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction.

Any temporary basins will be monitored for any damage, including compaction, sediment build up, oils and litter during and at the completion of construction to ensure the structure's effectiveness is not diminished.

Sediment and litter on roads will be monitored, with removal as necessary with street sweeping. Further details can be seen in Table 8.

12.3 OTHER ITEMS - POST-DEVELOPMENT

LANDSCAPED POS BASINS

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements will generally require routine maintenance that is generally of a landscape maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/or qualifications as they will be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

Maintenance inspections should be scheduled to be conducted after a significant storm event (mobilises sediments and coarse material). Inspections should focus on ponding time for the different systems, unequal surface flow distribution and scouring. As well as this, the maintenance will also include the factors outlined for the temporary basins above.

Performance monitoring of the basins will be undertaken to ensure the effective working of the system. Indicators will be used to provide cost effective methods to evaluate the adequacies of the operation and performance of WSUD elements. It can be assumed that if the WSUD elements operate in accordance with the designs, then it can be expected that they are delivering the desired management objectives.

The key aspects monitored will include:

- ensuring the inlet and outlet structures are free of debris;
- vegetative cover of the systems is maintained;
- sediment build up is not impeding the functionality;
- erosion is not present;
- soils are not compacted;
- litter is removed; and
- excessive hydrocarbons are not present in the system
- weeds controlled
- infiltration of stormwater is maintained

These are outlined further in Table 8.

The drainage pit and pipe network is to be monitored for functionality. This includes blockages of pits or pipes, sediment accumulation, blockages of outlets and cracking of pipes.

POS IRRIGATION

The POS irrigation source is to be monitored to make sure that it is functioning as designed. This includes suitable flow rates and that the water quality is suitable for the plants being irrigated.

Table 8 Monitoring and Maintenance Schedule

Function	Item to Monitor	Details Monitored	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency during maintenance period	Responsible Authority (Timeline)
CONSTRUCTION PHASE & POST-DEVELOPMENT						
Drainage Management Systems (includes traditional and WSUD systems)	Structural Design	Systems are constructed to engineer detailed design specification	Systems constructed differs to design specifications.	Remedial work to rectify systems to meet design specifications.	During and after construction	Developer until handover to Local Authority
	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect systems for any erosion related issues.	Monthly	Developer until handover to Local Authority
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Monthly	Developer until handover to Local Authority
	Sediment Build Up	Inspection for sediment accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to Shire standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed. Undertake street sweeping	Event based (mobilisation of sediments) and a minimum of every 3 months	Developer until handover to Local Authority
	Compaction	Inspection of filter media for compaction, could include being driven on.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without	Monthly	Developer until handover to Local Authority
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Monthly	Developer until handover to Local Authority
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill planting may be required.	Monthly	Developer until handover to Local Authority
	Organic Litter	Inspection for the presence of organic litter (e.g.. leaves) on surface.	Organic litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response e.g. alter landscaping maintenance practices, community education).Remove litter.	Monthly	Developer until handover to Local Authority
	Rubbish	Inspection for the presence of rubbish.	Rubbish is blocking structures or detracting from the visual appearance of the system.	Identify source of rubbish and undertake appropriate responses, including removal.	Every 3 months	Developer until handover to Local Authority
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks.	Notify the EPA of the spill, if significant and clean up requirements.	Every 3 months	Developer until handover to Local Authority
	Infiltration/Standing water	Inspection of basins to determine if water is infiltrating after rain events in basins	Water is still present after 96 hours, excluding small volumes of groundwater inflow from subsoil	Check subsoil network and filter media is functioning as designed and repair/upgrade.	Every month over winter and spring	Developer until handover to Local Authority
POS Water Source	Irrigation Management in POS	Water source is effective for POS e.g. quality and quantity	Water quality is deemed not suitable for irrigation. Water availability is likely to be compromised.	Treat water or find alternative water	Monthly during irrigation season.	Developer until handover to Local Authority

13 IMPLEMENTATION PLAN

The developer is committed to undertaking the water management strategies outlined in this report. The following information details the actions and works to be undertaken by the developer and relevant authorities as part of the development of the subject land.

Implementation of the strategies outlined in this report will be undertaken prior to developmental works, as part of subdivisional works and into the post development phase. The following is a breakdown of commitments by the developer and other relevant entities to achieve the development of the site.

COMMITMENTS BY DEVELOPERS

- Detailed drainage modelling including connections to surrounding drainage networks and flood levels within Cobia Close.
- Design and construction of overall drainage and subsoil system including basins.
- Appropriate fill to be used across the site.
- Sediment control during construction.
- Maintenance during agreed maintenance periods of the stormwater drainage systems and infrastructure.
- Construct the Sewer and Potable water systems.
- Produce a waterwise detailed Landscape Plan including irrigation requirements.
- Implementation of approved landscaping plans.
- Produce a Dewatering Management Plan, if required.
- Production of a Local Development Plan that outlines the requirements for each lot including finished floor levels and on lot detention of stormwater.
- Working with the Shire to determine suitable stormwater management along Mortiss Street as part of Stage 2.

REQUIREMENTS OF THE SHIRE OF EXMOUTH

- Review and approval of UWMP's
- Approval of drainage design and other water management works.
- Approval of building licenses including on lot stormwater detention systems for all lots in line with the UWMP and LDP.
- Reviewing building licenses and other necessary documentation in relation to potential contaminant management for commercial operations for industry best practice and Shire guideline compliance.
- Responsibility for the maintenance of the stormwater system after handover
- Encouragement of Waterwise and nutrient wise practices for residents.
- Efficient and sustainable use of POS irrigation water.
- Determination of suitable stormwater management on Mortiss St.

REQUIREMENTS OF THE DEPARTMENT OF WATER AND ENVIRONMENTAL REGULATION

- Provide advice in relation to UWMP as an advisory agency to the Shire.
- Assist the Shire in relation to assessing the UWMP as required.
- Licencing of any Prescribed Premises

REQUIREMENTS OF THE WATER CORPORATION

- Review and approval of water servicing.
- Manage the potable water service post handover.
- Manage the wastewater servicing post handover.

14 REFERENCES

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APPENDIX B SURVEY AND HEAT MAP

MURAT ROAD

COBIA CLOSE

Speed Bump

128.97

135°2'

135°2'

157°27'35"

11.08

15.08

164°39'

157°27'35"

0.2m High Brick R/Wall

0.2m High Core Kraft with 1.7m High Colorbond Fence

207 DP64252 (SP84149)

206 DP64252

205 DP64252

204 DP64252

203 DP64252

202 DP64252

201 DP64252

200 DP64252

199 DP64252

119°33'12"

117.44

125°26'10"

1.7m High C/Bond Fence

0.2m High Brick R/Wall

198 DP64252

140.23

Concrete Jetty / Boardwalk

3.5m Reinforced Concrete Seawall

R47981
3004
DP73137

A: 37.21
R:23.12

33.32

133°5'16"

133°55'20"

61.21

CANALS

170°57'28"

5.01

72°1'36"

136°8'14"

33.14

R:23.87
A: 36.63

R47981
3004
DP73137

149.81

150°38'10"

CANALS

157.54

1.0m High Wire Fence

Water Corp Sewer Easement
See C/T for details

Centre Of Power Pole

Bottom Insulator RL. 13.43

483.65

Bottom Insulator RL. 13.07

Bottom Insulator RL. 14.79

Derelict Brick Buildings

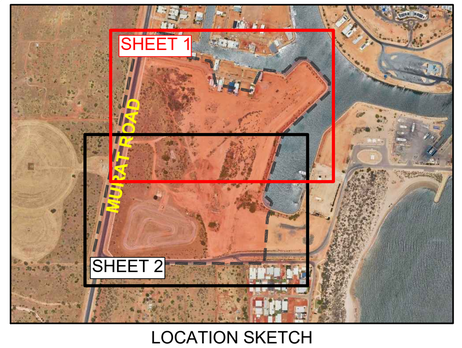
9510
P55557

Cnr. Pollard St

MURAT ROAD

LOCATION SKETCH

NOT TO SCALE



SYMBOL LEGEND

- Earth Pit
- Power Pole
- Light Pole
- Steel Wire Anchor
- Stay Pole
- Consumer Pole
- Electrical Cable Pit
- Telstra Pit
- Telstra Marker
- Telstra Pillar
- NBN Pit
- Sewer Manhole
- Sewer Connection
- Drainage Invert
- Drainage Obvert
- Tap
- Hydrant - Ground
- Hydrant - Pillar
- Stop Valve
- Flushing Point
- Natural Surface
- Driveway Level
- Road Surface Level
- Sign (One Pole)
- TOW Top of Wall
- Unknown Service
- Unknown Marker
- Reflective Post
- U/G Telstra
- Tree

LINESTYLE LEGEND

- 29.0 Contour Major 1.0m Intervals
- Contour Minor 0.2m Intervals
- Cadastral Boundary
- Kerb Line / Edge of Bitumen
- Road Centreline
- Pedestrian Ramp
- Driveway Edge
- Track
- Edge of Resurfacing
- Top of Bank
- Bottom of Bank
- Building
- Wall
- Concrete Edge
- Fence Line
- Gate
- Line of Levels
- Overhead Power
- Drainage Pipe
- Rocky Outcrop
- Linemarking - Solid
- Linemarking - 1m x 1m
- Wire Anchor Cable

DBYD LINESTYLE LEGEND

- S Gravity Sewer Pipe
- S Presure Main Sewer Pipe
- W Water Pipe
- E Underground HV

24132-F01-2.0.dwg

VER.	DATE	BY	AMENDMENTS	FILE SOURCE
1.0	28.02.2025	MDB	Issued for Information	24132-1.0-17022025-EX2020-F
2.0	10.03.2025	MDB	Data added	24132-2.0-10032025-EX2020-F

Scale @A1 1:750

0 10 20 30 40 50

Notes:
1. Boundary constructed from cadastral connection.
2. True position of Boundary is subject to a re-establishment survey.
3. Heights established from SSM ONSLOW 7 via GPS connection.
4. Dimensions, Areas and Offsets subject to re-establishment survey.
5. Refer to Certificate of Title for limitations, Interests, Encumbrances and Notifications.
6. Insulator RL does not include sag of power lines.

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Ph: 9450 7188
email: admin@jbasurveys.com.au
web: www.jbasurveys.com.au

CLIENT:

EXMOUTH SUPERLOT PTY. LTD.
ACN 657526086

JOB NO: 24132 | TITLE: FEATURE SURVEY

PROJECT:
LOT 9510 ON DP55557
MURAT ROAD
EXMOUTH WA
C/T 2729-825

DATUM
VERT: AHD
HORIZ: EX2020

SCALE: 1:750

DWG NO: 24132-F01 | VER. 2.0

SHEET NO: 1 OF 2 | A1

SURVEYOR: JT | DATE OF SURVEY: 17.02.2025 | DRAWN BY: MDB | APPROVED BY: NRW

N



LOCATION SKETCH
NOT TO SCALE

SYMBOL LEGEND

- Earth Pit
- Power Pole
- Light Pole
- Steel Wire Anchor
- Stay Pole
- Consumer Pole
- Electrical Cable Pit
- Telstra Pit
- Telstra Marker
- Telstra Pillar
- NBN Pit
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- Sewer Connection
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- Stop Valve
- Flushing Point
- Natural Surface
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- Road Surface Level
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- Reflective Post
- U/G Telstra
- Tree

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- Contour Major 1.0m Intervals
- Contour Minor 0.2m Intervals
- Cadastral Boundary
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- Top of Bank
- Bottom of Bank
- Building
- Wall
- Concrete Edge
- Fence Line
- Gate
- Line of Levels
- Overhead Power
- Drainage Pipe
- Rocky Outcrop
- Linemarking - Solid
- Linemarking - 1m x 1m
- Wire Anchor Cable

DBYD LINESTYLE LEGEND

- Gravity Sewer Pipe
- Presure Main Sewer Pipe
- Water Pipe
- Underground HV

24132-F01-2.0.dwg

VER.	DATE	BY	AMENDMENTS	FILE SOURCE
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Scale @A1 1:750
0 10 20 30 40 50

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CLIENT:

EXMOUTH SUPERLOT PTY. LTD.
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JOB NO: 24132 | TITLE: FEATURE SURVEY

PROJECT:
LOT 9510 ON DP55557
MURAT ROAD
EXMOUTH WA
C/T 2729-825

DATUM
VERT: AHD
HORIZ: EX2020
SCALE: 1:750
DWG NO: 24132-F01 | VER: 2.0
SHEET NO: 2 OF 2 | A1

SURVEYOR: JT | DATE OF SURVEY: 17.02.2025 | DRAWN BY: MDB | APPROVED BY: NRW

NSL HEIGHT

10	to	5.2	m
5.2	to	5.1	m
5.1	to	5	m
5	to	4.9	m
4.9	to	4.8	m
4.8	to	4.7	m
4.7	to	4.6	m
4.6	to	4.5	m
4.5	to	4.4	m
4.4	to	4.3	m
4.3	to	4.2	m
4.2	to	4.1	m
4.1	to	4	m
4	to	3.9	m
3.9	to	2	m

COBIA CLOSE

MURAT ROAD

R47981
3004
DP73137

CANALS

198 DP64252

207 DP64252 (SP84149)

206 DP64252

205 DP64252

204 DP64252

203 DP64252

202 DP64252

201 DP64252

200 DP64252

199 DP64252

0.2m High Brick ROWall

Concrete Jetty / Boat Ramp

9510

EXMOUTH KART CLUB

GO-KART CLUB OFFICE/FACILITIES

MORTISS STREET

1.0m High Wire Fence

Bottom Insulator RL 13.92

Bottom Insulator RL 14.10

Bottom Insulator RL 14.98

Bottom Insulator RL 14.50

Bottom Insulator RL 14.40

Bottom Insulator RL 12.73

APPENDIX B PREVIOUS FLOOD ASSESSMENT

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www.jdahydro.com.au

To :	Development WA	**Date :**	26 May 2023
Attention :	John Milici	**Our Ref :**	J7207d
Email :	*John.Milici@developmentwa.com.au*	**Pages :**	26

LOT 9510 MURAT ROAD (SUPERLOT D), EXMOUTH
ASSESSMENT OF FLOOD RISK MITIGATION OPTIONS

Dear John,

Please find below JDA report detailing flood risk mitigation options for Lot 9510 Murat Road, Exmouth, as requested. This report is presented in the following sections:

1. Introduction
2. Exmouth Floodplain Management Study (SKM, 2007)
3. Refinement of Exmouth Floodplain Management Study (JDA, 2022)
4. Exmouth Marina Village Drainage Design & Management Plan (RPS, 2010)
5. 10 June 2021 Flood Event and Impacts to Existing Development
6. Finished Floor Level Design Guidelines
7. Flood Mitigation Options
8. Summary

1. INTRODUCTION

1.1 Background

Lot 9510 Murat Road, Exmouth (also known as Superlot D) is located in the south-west corner of Exmouth Marina and is bound by Cobia Close to the north, Murat Road to the west, Mortiss Street to the south and Neale Cove to the east. Note that Mortiss Street was formerly referred to as Market Street (Figure 1).

Superlot D is zoned Future Residential in the Shire of Exmouth Local Planning Scheme and is designated as Future Residential Area 7 (TBB, 2019). Proposed development is currently subject to the Exmouth Marina Village Outline Development Plan (2003) which proposes dry lot residential, caravan park, recreation, mixed use residential/low key marine based uses. JDA understands residential or tourist/temporary workers accommodation is the likely future land use for the area.

Site survey (Denada, 2015) (see Appendix A) shows existing topography across the lot generally ranges from 4 to 5 mAHD with higher elevations in the south-west of lot at 5.5 to 6.5 mAHD. A 3m wide bund with top elevation between 5.7 to 5.5 mAHD also exists along the northern boundary of Superlot D, to protect lots fronting Cobia Close from any flood water from Superlot D.

Geotechnical investigation by Golder Associates (2006) shows surface soils generally comprise clayey sands, sandy clays and clayey gravel to depths of between 1 and 5 m. An area of uncontrolled fill, likely of topsoil from other parts of the marina development, was identified in the north of the lot and recommended to be removed.

1.2 Objective

Flood mapping presented in the *Exmouth Floodplain Management Study* (SKM, 2007b) for the Exmouth townsite shows Superlot D inundated during the 1 in 10, 25 and 100 year (10%, 4% and 1% AEP) flood events.

Whilst Superlot D is zoned for development, we understand the urban form and engineering design is impacted by the potential risk of flooding, restricting viability of development.

JDA has therefore investigated three possible flood risk mitigation options for Superlot D as follows:

- Importation of fill;
- Construction of a levee or bund; or
- Use of an alternative built form.

Presented below is a summary of flood mapping, proposed design criteria and a desktop review of the options.

2. EXMOUTH FLOODPLAIN MANAGEMENT STUDY (SKM, 2007A&B)

SKM was commissioned by the then Department of Water (now Department of Water and Environmental Regulation) to develop the Exmouth Floodplain Management Study for the town of Exmouth. This study consisted of a Flood Modelling Report (SKM, 2007a) and a Floodplain Management Strategy (SKM, 2007b). Hydrologic modelling of the upper catchments west of the townsite were modelled in RORB for the 10, 25, 100 and 500 year ARI flood events and inputted into a 2D MIKE-21 hydraulic model at the upstream (western) boundary of the Exmouth townsite.

Aerial laser scanning survey data was collected by Fugro pre-2007 and provided as irregularly spaced elevation data points from which a 5 m resolution digital elevation model [DEM] was developed for input into the MIKE-21 hydraulic model (SKM, 2007a). The coarser resolution resulted in the DEM not adequately accounting for some infrastructure smaller than the grid size, such as the higher elevation of Murat Road compared to the surrounding topography and therefore stormwater flow was assumed to flow unimpeded locally east to west across Murat Road.

Whilst SKM (2007b) considered and modelled 9 scenarios for the 100 year ARI flood event, the 'Existing Case' DEM scenario is used as the basis for assessment in this report. This 'Existing Case' scenario includes pre-approved catchment modifications including lot filling, inclusion of additional canal arms, designation of specific weir crest elevations and the breakout flow from the adjacent Market Street Creek Catchment. The exclusion of the constructed Market Street Creek bund in this scenario is consistent with recent investigations that have questioned the structural integrity of the bund, and it's future viability to be repaired or upgraded.

In this scenario, the pre-approved fill level adopted for the Exmouth Marina Village lots was 5.25 mAHD, with the barrier walls around the canal set at 5.3 mAHD.

The north-eastern portion of Superlot D was assumed to be filled in the SKM (2007a) model at 5.25 mAHD, with the south-western portion retained in existing condition unfilled.

Figure 2 shows the SKM (2007a&b) 100 year ARI 'Existing Case' flood inundation depth and level mapping. For Superlot D, flood level ranges from 5.3 mAHD along the canals (the adopted barrier wall level) to 6.5 mAHD in the south-west corner of the Lot. The modelled lot fill level of 5.25 mAHD in the north-east portion of the Lot is discernible by the low modelled flood depths (< 0.2 m) in this area, and by the higher flood depths immediately along the western boundary of the fill. The lower lying south-west portion of the Lot was filled between 2007 and 2011 by approximately 0.8 to 1 m with approximate present-day topography apparent for Superlot D from the Denada (2015) survey (attached as Appendix A).

Figure 3 shows the SKM (2007a) 'Existing Case' scenario flood hazard and zoning mapping with floodway and flood fringe delineated. Superlot D was assumed to be filled for development in this scenario, and was not shown as being within the floodplain of the Marina or Market Street Creek catchments.

An area to the south-east of Superlot D in SKM (2007b) was not given a floodplain classification but instead described as an 'Area Under Further Investigation'. Some of this area has since been developed as the Sea Raven Estate residential precinct. The remaining areas along with additional areas west to Murat Road form part of Future Residential Area 6 in the Local Planning Scheme (TBB, 2019). JDA has not been provided with further details of the existing development and therefore cannot comment on the impact of this development to the surrounding Market Street Creek floodplain.

Note that in JDA (1999) a floodway was proposed to convey water from Mortiss Street into the southern canal, alongside the eastern boundary of Superlot D. This floodway was one of two outlets proposed to alleviate floodwater from the Market Street catchment contained behind the coastal dune system. The other proposed

outlet was a dune breakout located approximately 900 m further south. Flood modelling in SKM (2007b) did not include the Mortiss St floodway, and all water was assumed to discharge to the southern outlet.

Also note that flood modelling performed by SKM (2007a) was conducted using the rainfall intensity frequency duration (IFD) data from the now superseded 1987 version of Australian Rainfall and Runoff (IEAust, 1987). This IFD has been replaced by new IFDs from the Bureau of Meteorology (BoM, 2016) which have been incorporated into the current version of Australian Rainfall and Runoff (Ball et al., 2019) and account for over 30 years of additional rainfall data. The revised design rainfalls in Exmouth for the 100 year ARI (1% AEP) event have reduced approximately 30% across durations of 1 and 3 hours; which were deemed critical for the Exmouth townsite catchments in the SKM (2007b) modelling.

3. REFINEMENT OF EXMOUTH FLOODPLAIN MANAGEMENT MODELLING (JDA, 2022)

In December 2022, JDA refined the Exmouth flood model presented in SKM (2007a) for the Market Street Creek catchment area, which includes Superlot D. The refinement included use of updated rainfall IFD data, Australian Rainfall & Runoff 2019 revised flood modelling methodology and a finer hydraulic model DEM resolution grid from 5 m to 2 m of the original SKM DEM.

JDA revised modelling indicated maximum flood water levels across Superlot D were substantially lower than those shown in SKM (2007). This was due to the combined effect of lower IFD design rainfall depths, more accurate representation of the elevation profile of the Market Street Creek flood protection bund, Murat Rd and the catchment as defined by the Fugro (2006) and De Nada (2015) LiDAR survey dataset.

The flood modelling also showed the Market Street Creek flood protection bund (in 2007 survey condition) withstands the 1 in 100 AEP event, and in particular, there was no discharge of floodwater across Murat Road and into Superlot D between Cobia Close to the north and Mortiss Street to the south, in both the 20% AEP and 1% AEP flood events (see Figure 4).

These modelling refinements were presented to DWER, to review the requirement for importation of fill to raise lot level to achieve DWER's floodplain management guideline for minimum habitable floor levels to be 500 mm above the 1 in 100 AEP.

DWER advised JDA on 27 January 2023 that whilst the modelling demonstrates the Market Street Creek flood protection bund withstands the 1 in 100 AEP event, additional flow from a break-out should the bund fail, and due to other aspects of its design and maintenance, they are unable to comment on whether the bund is suitable to provide 1 in 100 AEP flood protection.

Notwithstanding the above, DWER recommend minimum habitable floor levels along the western and southern boundary of the lot should be above the adjacent 1 in 100 AEP flood levels, however a lower freeboard (say 250 mm to 300 mm) than their recommended 500 mm may be considered.

4. EXMOUTH MARINA VILLAGE DRAINAGE DESIGN & MANAGEMENT PLAN

The Exmouth Marina Village Drainage Design and Management Plan (RPS, 2010) describes the drainage design features of the Marina Village. Previous drainage management plans were adopted but updated following the severe rainfall and flooding event in June 2002 and the associated revisions to the then current Exmouth Flood Management Strategy (JDA, 2002).

Stormwater generated within the Marina Village was proposed to be either infiltrated at-source or piped to the downstream contaminant traps during the 'normal' rainfall events. During intense rainfall events associated with thunderstorms or cyclones, stormwater would be trapped and flow within road reserves and swales to the downstream canals.

Internal drainage within Superlot D was proposed to flow north-east via a table drain towards a continuous deflective separator and thereafter outflow to the canal.

A minimum lot level of 5.5 mAHD was recommended in JDA (2002) and adopted in RPS (2010) for development adjacent to floodways and 5.25 mAHD elsewhere within the Marina Village, the latter of which is applicable to Superlot D.

5. 10 JUNE 2021 FLOOD EVENT AND IMPACTS TO EXISTING DEVELOPMENT

A flood event occurred at Exmouth on the 10 June 2021 with 173.4 mm recorded in the 24 hours to 9 am at the Bureau of Meteorology's Exmouth Town gauge (Site ID: 005051). Anecdotal reports in Gorman (2021) suggest rainfall of 193 mm in the north of the townsite and 218 mm in the south, with most of the rain recorded between 3 and 4 am. Imagery captured after the 10 June 2021 flood event and presented in Gorman (2021) shows significant ponding of water south of Superlot D on Mortiss Street, adjacent to the Sea Raven Estate subdivision.

Imagery from 2018/19 indicates that Mortiss Street and Neale Cove east of Superlot D were re-aligned and that a drain/floodway along the eastern boundary of Superlot D from Mortiss Street to the southern canal was filled-in.

Whilst the inundation was restricted to the road reserve adjacent to the Sea Raven Estate subdivision, it is unclear whether this is the intended stormwater design of this road and the estate.

Aerial photographs of Superlot D after the flood event showed shallow areas of ponded water, likely resulting from infiltration excess overland flow into localised depressions within the lot.

6. FINISHED FLOOR LEVEL DESIGN GUIDELINES

5.1. Local Planning Strategy

As per the Local Planning Scheme, proposed development in Superlot D is to have adequate protection from the 100 year ARI flood, and not detrimentally impact the existing 100 year ARI flooding regime of the general area.

It recommends minimum lot level within the Marina Village should be generally set at 5.25 mAHD, and filled to a level not less than 500 mm above the 1:100 year ARI flood level as advised by Department of Water, described in the next section below.

Figure 3 from SKM (2007b) also indicates Superlot D is not within the floodplain of the Market Creek or Marina Creek catchments, and development of this site is therefore unlikely to cause detrimental impact to the existing flooding regime of these catchment areas.

5.2. Department of Water & Environmental Regulation

Department of Water and Environmental Regulation (DWER) has provided floodplain management advice on two occasions as follows:

1) 22 Jun 2022 – Minimum floor levels based on *Exmouth Flood Modelling Report* (SKM, 2007)
2) 27 Jan 2023 – Minimum floor levels based on *JDA Refinement of Exmouth Flood Modelling Report* (JDA, 2022)

Advice initially provided by Department of Water and Environmental Regulation (DWER) on 22 June 2022 is presented in Appendix B and is summarised as follows:

DWER provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage. It uses the following guiding principles to ensure proposed development in floodprone areas is acceptable with regard to major flooding:

- *Proposed development has adequate protection*
- *Proposed development does not detrimentally impact on the existing flooding regime*

DWER's floodplain management guidelines stipulate minimum habitable floor levels to be 500 mm above the appropriate 1 in 100 AEP flood level to ensure adequate flood protection.

DWER 1 in 100 AEP flood levels based on modelling presented in SKM (2007) without the Market Street Bund, ranges from 5.0 to 6.5 mAHD for Superlot D (Appendix D). Adopting the 1 in 100 AEP flood level plus 500 mm, minimum floor level recommended by DWER for Superlot D ranges from 5.5 to 7.0 mAHD.

DWER also advise an impact assessment of filling Superlot D is not required, if minimum floor levels in the existing Mortiss Street Subdivision (Sea Raven Estate) are greater than 5.25 mAHD. As-constructed survey for Stage 1 of this subdivision indicates finished fill levels in lots are around 5.20 mAHD. DWER has reviewed this survey and subsequently advised minimum habitable floor levels are expected to exceed 5.25 mAHD and that no additional modelling is considered necessary (see Appendix B).

On 27 January 2023, DWER provided additional advice following review of *JDA Refinement of Exmouth Flood Modelling Report* (JDA, 2022). It recommended minimum habitable floor levels along the western and southern boundary of the lot could have a lower freeboard between 250 mm to 300 mm above the adjacent 1 in 100 AEP flood levels, rather than 500 mm.

Therefore adopting the 1 in 100 AEP flood levels provided by DWER from SKM (2007) plus 300 mm freeboard, minimum floor level recommended by DWER for Superlot D ranges from 5.3 to 6.8 mAHD.

5.3. Department of Transport

Preliminary advice provided by Department of Transport (DoT) on 4 May 2022 is presented in Appendix C and is summarised as follows:

State Planning Policy 2.6 State Coastal Planning Policy (WAPC, 2013) requires that the allowance for storm surge inundation ('S4 Inundation') be set at the maximum extent of inundation from a 500 year ARI (0.2% AEP) storm surge event plus the predicted extent of sea level rise.

Seashore Engineering (2018) provides estimates of extreme design water level at a number of WA coastal locations including Exmouth. These estimates are deliberately conservative and are for preliminary analysis of coastal inundation risk associated with tropical cyclones. For Exmouth, the 500 year ARI (0.2% AEP) design water level is 5.2 mAHD, similar to the adopted barrier floor level of 5.3 mAHD in SKM (2007b) along the canals.

Assuming a planning horizon to 2110 and associated potential sea level rise of 0.9 m, the potential inundation level for Superlot D is 6.1 mAHD for the 500 year ARI (0.2% AEP). This indicates the minimum lot levels adopted in RPS (2010) for the Marina Village of 5.25 mAHD are inadequate for managing storm surges under a future climate scenario.

A Coastal Hazard Risk Management and Adaptation Plan [CHRMAP] for the Exmouth townsite is currently in preparation and due for completion in late-2023, which may result in revised flood levels for Superlot D.

Notwithstanding the above, JDA understand MP Rogers & Associates have been commissioned by DevelopmentWA to prepare a separate coastal inundation assessment report for Superlot D, and will confirm minimum lot levels required from a coastal inundation perspective.

5.4. Recommended Minimum Floor Level

Recommended minimum floor level based on the above guidelines for 1 in 100 AEP flooding from stormwater is summarised below. Minimum floor levels for coastal inundation is addressed by MP Rogers & Associates separate from this report.

Local planning design guidelines indicate minimum floor level for Superlot D to be 5.25 mAHD.

DWER floodplain management guidelines and advice indicate minimum floor level is to be the 1 in 100 AEP flood level + 300 mm freeboard, resulting in floor level between 5.3 to 6.8 mAHD. These values applicable to the boundary of Superlot D is shown in Figure 5.

7. FLOOD RISK MITIGATION OPTIONS

Preliminary investigation by JDA suggests flood risk mitigation options for Superlot D may include, but not be limited to:

- Importation of fill;
- Construction of a levee or bund; or
- Use of an alternative built form.

Presented below is a desktop review of each of these options.

7.1 Importation of Fill

Importation of clean sand fill can be used across Superlot D to ensure it remains above flood water, and also has sufficient separation from the finished lot level to any potential groundwater perching on any underlying low permeability soils.

Section 5.4 outlines the guidelines for the minimum recommended floor level. Figure 5 presents these levels around the boundary of the site ranging from 5.3 to 6.8 mAHD.

Based on current natural surface level of approximately 5.0 mAHD, this represents importation of between 0.3 m to 1.8 m of sand fill.

7.2 Levee/Bund

To protect from inland flooding along the western and southern boundaries, a levee/bund could be constructed with top elevation at DWER recommended minimum floor level of 1 in 100 AEP flood level + 300 mm. Engineering design, extent, form and maintenance requirements would need to be further assessed during detail design.

Construction of a levee/bund may be a more economic method to protect Superlot D against flooding compared to importation of fill.

7.3 Use of Alternative Built Form

An alternative built form is construction of elevated houses on poles/stilts. Whilst common in the eastern states, this construction form is rare across Western Australia. The existing topography of Superlot D would need to be earthworked and graded to allow surface runoff towards the canals.

Stormwater flow from within the lot and any potential overflow from Murat Road would flow within road reserves or for larger events overland beneath housing floor levels. Habitable floor levels would need to be a minimum 300 mm above the 1 in 100 AEP flood level. Stilted housing will not detrimentally impact surrounding floodplains as the general landform is mostly unchanged, if not improved, as grading of the lots to the canals would reduce impedance to flow from surrounding areas.

Stilted housing is likely more appropriate should Superlot D be developed as tourist or temporary workers accommodation rather than residential, as aesthetically there will be a height differential compared to surrounding Marina Village lots.

8. SUMMARY

Flood mapping presented in the *Exmouth Floodplain Management Study* (SKM, 2007b) for the Exmouth townsite shows Superlot D inundated during the 1 in 10, 25 and 100 year (10%, 4% and 1% AEP) flood events.

DWER floodplain management guidelines and advice indicate minimum floor level is to be the 1 in 100 AEP flood level + 300 mm freeboard to protect against inland flooding, resulting in floor level between 5.3 to 6.8 mAHD.

Based on this review, JDA consider construction of a levee/bund along the western and southern boundaries, is the most appropriate measure to mitigate the 1 in 100 AEP flood risk event for Superlot D.

Attachments

Figure 1: Location Plan

Figure 2: SKM (2007b) 'Existing Case' 100 year ARI Flood Depths and Levels

Figure 3: SKM (2007b) 'Existing Case' 100 year ARI Flood Zoning

Figure 4: Minimum Fill Levels

Appendix A: Superlot D Detail Survey (Denada, 2015)

Appendix B: DWER Email Correspondence (22 June 2022)

Appendix C: DoT Email Correspondence (4 May 2022)

References:

Ball J., Babister M., Nathan R., Weeks W., Weinmann E., Retallick M. & Testoni I. (*Eds*) (2019) *Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.*

Denada Surveys (2015) *Detail Survey, Murat Road Exmouth*. Date Surveyed 03-04 February 2015, Sheets 1 to 3 Rev B, 18 February 2015.

Golder Associates (2006) *Geotechnical Studies Exmouth Marina Village Superlot D, Exmouth.* Prepared for Benchmark Projects Australasia, Report no 05642078-R03, August 2006

Gorman, V. (2021) *Holiday town Exmouth flooded as some residents experience heaviest rain of their lives*. ABC News, 10 June 2021. Available from <https://www.abc.net.au/news/2021-06-10/exmouth-wa-floods-as-storm-dumps-200-millimetres-of-rain/100205868>

Institute of Engineers Australia [IEAust] (1987) *Australian Rainfall and Runoff: a Guide to Flood Estimation.*

JDA (2002) *Review of Exmouth Flood Management Strategy: Assessment of June 2002 Flood Event*. Doc Ref: J3058h. Prepared for Shire of Exmouth, September 2002.

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Seashore Engineering (2018) *Design Storms for Western Australian Coastal Planning: Tropical Cyclones*. Doc Ref: SE015-01 Rev B. Prepared for Department of Transport, 24 January 2018.

SKM (2007a) *Exmouth Floodplain Management Study – Flood Modelling Report*. Prepared for Department of Water, Dec 2007.

SKM (2007b) *Exmouth Floodplain Management Study – Floodplain Management Strategy*. Prepared for Department of Water, Dec 2007.

Taylor Burrell Barnett [TBB] (2019) *Shire of Exmouth Local Planning Scheme.* Rev 10, March 2019.Prepared in association with Terra Rosa Cultural Resource Mapping and Hyd2o Hydrology.

Western Australian Planning Commission [WAPC] (2013) *State Planning Policy 2.6 - State Coastal Planning Policy*. Western Australian Planning Commission, Perth.

Should you have any queries with this report, please do not hesitate to contact Matthew Yan matt@jdahydro.com.au.

Regards,



JDA CONSULTANT HYDROLOGISTS

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Data Source:

Coordinate System: GDA 94, Zone 50

JDA Consultant Hydrologists

Job No. J7207

Scale: 1:7,500 @A4

0 100 200 300 400 Metres

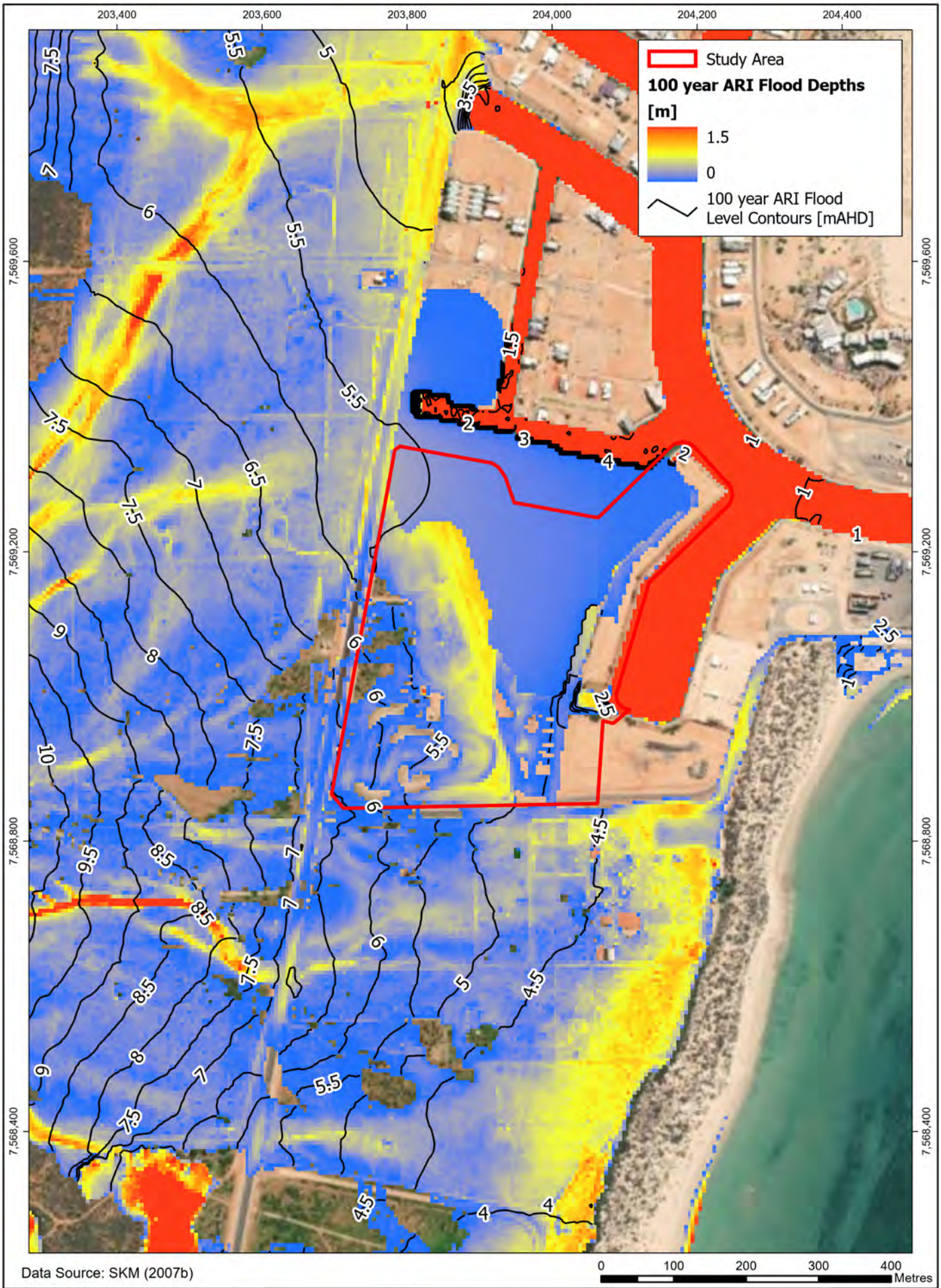
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Development WA

Lot 9510 Murat Road (Superlot D), Exmouth: Flood Resolution Options

Figure 1: Location Plan



JDA

Job No. J7207
Scale: 1:7,000 @A4
Coordinate System: GDA 1994 MGA Zone 50
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Development WA
Lot 9510 Murat Road (Superlot D), Exmouth: Flood Resolution Options
Figure 2: SKM (2007b) 'Existing Case' 100 year ARI Flood Depths and Levels



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Scale: 1:7,000 @A4
Coordinate System: GDA 1994 MGA Zone 50
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Development WA
Lot 9510 Murat Road (Superlot D), Exmouth: Flood Resolution Options

Figure 3: SKM (2007b) 'Existing Case' 100 year ARI Flood Zoning



Data Source: Detail Survey Murat Road, Exmouth, Plan No. 101550-001b Rev. B, De Nada Surveys for Landcorp, 10/02/2015; (Figure 6 from J7207b, 16/12022)

Coordinate System: GDA 1994 MGA Zone 50

JDA

Job No. J7207

Scale: 1:3,000 @A3

0 50 100 150 200 Metres

N

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Development WA

Lot 9510 Murat Road (Superlot D), Exmouth: Flood Resolution Options

Figure 4: Revised 1% AEP 1 Hour Flood Mapping



Data Source: SKM (2007b)

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Job No. J7207
Scale: 1:7,000 @A4
Coordinate System: GDA 1994 MGA Zone 50
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Development WA
Lot 9510 Murat Road (Superlot D), Exmouth: Flood Resolution Options

Figure 5: Minimum Fill Levels

APPENDIX A

Superlot D - Detail Survey
(Denada, 2015)

See Sheet 2 of 3

See Sheet 2 of 3

ROAD

MURAT

MARKET

STREET

Lot 9510
DP 55557

Go Kart Track

Canal

Scrub

Medium Grass

Track

Bitumen

Gravel Crossover

Box Culvert 600mm high 875m Wide

MkBox on Cons. Pole

Concrete Slab Base

Steel Slab Base

Shade Structure

Toilet Block

Info Kiosk

Play Ground

Go Kart Shed

Raceway Tower

Rock Armour

Rock Armour

Hallmark Found

Overt 2.29

Overt 2.82

Powerline with High Tension Wires

1m high Steel Post and Wire Fence

1.2m high Steel Post and Wire Fence

Access

Accessway

Bitumen

Track

Fence

Powerline

Creek

Drain

Water

Wall

Rock

Levee

Edge

Pond

Gate

Gates

Grass

Medium

Bitumen

Track

Powerline

Fence

Wire

Water

Levee

Edge

Rock

Wall

Drain

Creek

Pond

Gate

Gates

Grass

Medium

Bitumen

Track

Powerline

Fence

Wire

Water

Levee

Edge

Rock

Wall

Drain

Creek

Pond

Gate

Gates

9501

9502

9503

9504

9505

9506

5018

5020

5021

5022

5023

5024

5025

3B021

129°16'14"

28.45

129°16'14"

350.04

157.54

115.06

91°44'30"

56°9'30"

5.45

29.20

14.69

80°22'18"

23.97

R 8.13
A 25.64
C 24.69

N

E

S

W

DE NADA surveys

BUILDERS/CLIENTS

SITE SURVEY only. The information shown on this drawing is current as at the Date of Survey. Boundaries established by best fit from marks found. Boundary Information, Easements etc. to be verified from Title Certificate / Deposition Diagram etc. Boundaries not established. Dimensions, Position of Improvements or Services in relation to the boundary lines have not been confirmed. All services visible at time of survey have been located, however service information to be confirmed with relevant AUTHORITIES. For underground services - ring "DIAL BEFORE YOU DIG" for confirmation of those services.

Table of Revisions

Rev.	Date	By	Comments
A	10/02/15	A.M.	Initial Issue
B	15/02/15	A.M.	Roads Revised

SURVEY CODE LEGEND

DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	TREE DETAIL
3100 EDGE OF BITUMEN		3125 ELECT POWER DOME		3221 TELSTRA PIT	SIGNS	3267 GRATED PIT		3408 INVERT		3699 STAR IRON PICKET		0.3m D - TRUNK DIAMETER
3101 SHOULDER		3186 LIGHT POLE		3222 TELSTRA PILLAR		3270 DRAINAGE MANHOLE		3409 OVER		3701 CADASTRAL PEG_POST		5m H - TREE HEIGHT
3104 CENTRE OF ROAD		3200 POWERPOLE		3223 TELSTRA MARKER		3272 SIDE ENTRY PIT		3451 EDGE OF WATER LT		3709 RIP WALL PIPE		2m RC - TREE CANOPY RADIUS
3105 KERB TOP		3204 STAY TO POLE		3236 TELSTRA MANHOLE		3280 SEWER MANHOLE/PITS		3500 EDGE WALL RT		3799 TREE 0.1M D->0.5M D		
3106 KERB BOTTOM		3205 ELECT GIRE ANCHOR		3237 C.O.T.TELSTRA - SURFACE		3281 SEWER INSPECTION SHAFT		3501 EDGE OF CONCRETE RT		3800 TREE 1.0M D->1.5M D		LOT DETAIL
3111 EDGE OF DRIVEWAY		3210 ELECT CABLE BOX		3241 STOP VALVE		3282 TRAFFIC SIGNALS JA		3600 NATURAL SURFACE		3801 TREE 1.0M D->1.5M D		PF - PEG FOUND
3112 PEDESTRIAN RAMP		3215 ELECT SUPPLYPOLE		3242 HYDRANT GROUND		3313 SIGN I POLE		3601 BOTTOM BANK		3820 FENCE		PG - PEG GONE
3114 TRACK		3219 CONDUMER POLE		3255 FLUSHING POINT		3314 SIGN MULTIPLE POLES		3602 TOP BANK RT		3822 WALL LT		
3122 EARTH		3220 TELSTRA MANHOLE		3258 MARKER UNKNOWN		3401 HEADWALL		3605 ROCK OUTCROP RT		3825 GATE		
										3835 FOOTPATH		

DE NADA surveys
UNIT 4 / 14 HALLEY ROAD
BALCATTA, WA 6021
EMAIL : info@denadasurveys.com.au
ABN: 55 123 232 575
PH: 08 9344 8885
FAX: 08 9344 8889

CLIENT:

LANDCORP

Detail Survey

Murat Road - Exmouth

Surveyed By :	Drawn by :	Checked by :	Approved by :	Date :	Scale :
Peter Peard	C.Wylde/A.M.	Peter Peard	Peter Peard	10/02/2015	1 : 500

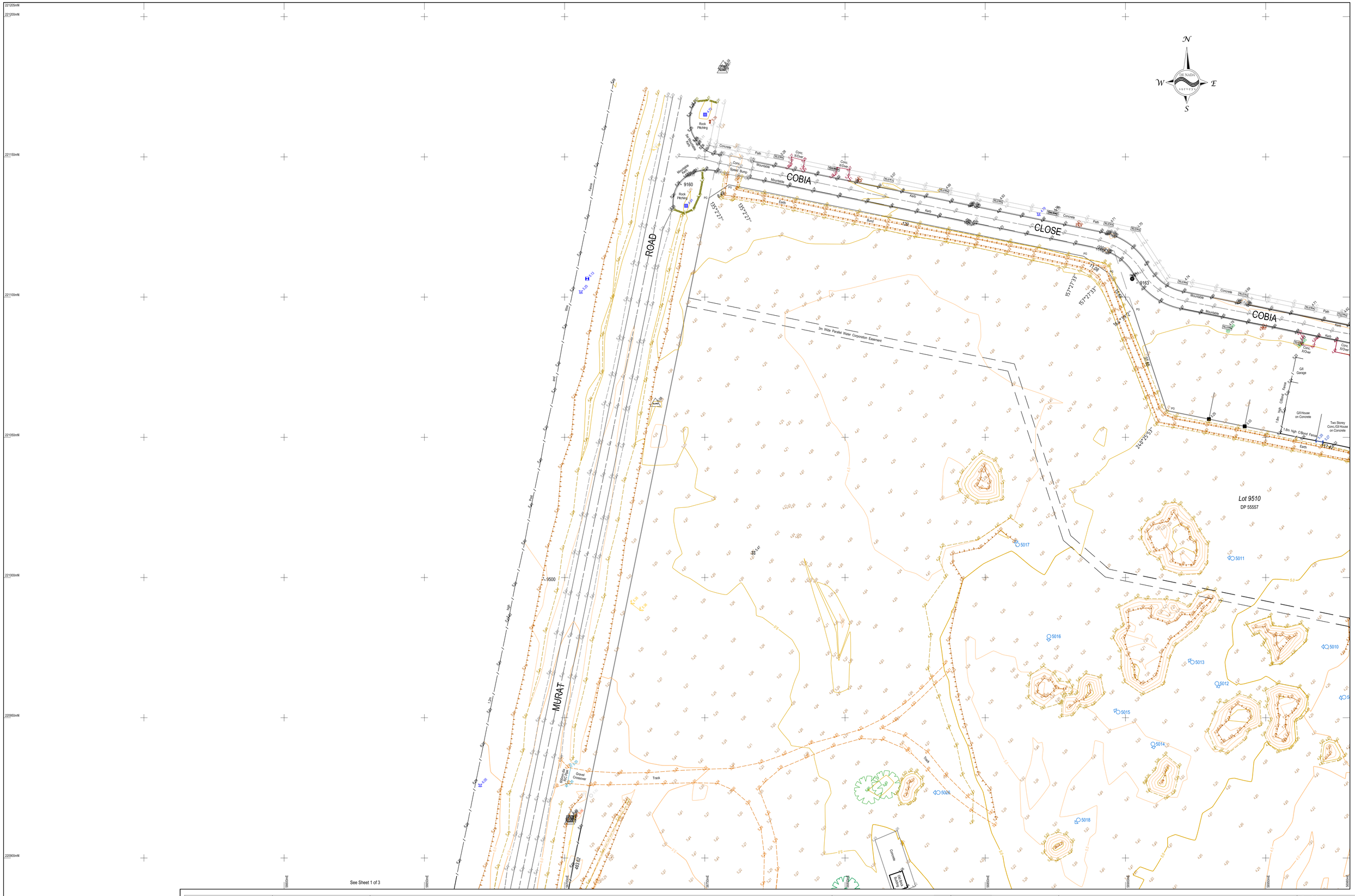
TXT/GSI REF:	101550 150203PPedit.RW5	Date Surveyed:	3-4 Feb 2015	Datum:	Horiz - Exmouth,94 Vert - AHD
Plan Number:	101550-001b				

0 10 20 30 40 50m

Revision : B

Sheet Size : ISO B1

Sheet 1 of 3



BUILDERS/CLIENTS

SITE SURVEY only. The Information shown on this drawing is current as at the Date of Survey. Boundaries established by best fit from marks found. Boundary Information, Easements etc. to be verified from Certificate of Title/Diagram or Survey Boundaries to be established before any construction commences or prior to relation to the boundary lines have not been confirmed. All services visible at time of survey have been located, however service information to be confirmed with relevant AUTHORITIES. For underground services - ring "DIAL BEFORE YOU DIG" for confirmation of those services.

Table of Revisions

Rev.	Date	By	Comments
A	10/02/15	A.M.	Initial Issue
B	18/02/15	A.M.	Roads Revised

SURVEY CODE LEGEND

	DESCRIPTION		DESCRIPTION		DESCRIPTION		DESCRIPTION		DESCRIPTION		DESCRIPTION		DESCRIPTION		TREE DETAIL
3100	EDGE OF BITUMEN	3125	ELECT POWER DOME	3221	TELSTRA PIT	3267	GRATED PIT	3408	INVERT	3699	STAR IRON PICKET			0.3m D	- TRUNK DIAMETER
3101	SHOULDER	3199	LIGHT POLE	3222	TELSTRA PILLAR	3270	DRAINAGE MANHOLE	3409	OVERT	3701	CADASTRAL PEG_POST			5m H	- TREE HEIGHT
3104	CENTRE OF ROAD	3200	POWERPOLE	3223	TELSTRA MARKER	3272	SIDE ENTRY PIT	3451	EDGE OF WATER LT	3703	REF MNL_PEG			2m RC	- TREE CANOPY RADIUS
3105	KERB TOP	3204	STAY POLE	3230	COVERS_MINI PIT	3275	SEWER MANHOLES	3550	BUILDING FT	3799	TREE 0.5MD<3MD			LOT DETAIL	
3106	KERB BOTTOM	3208	ELECT WIRE ANCHOR	3235	SEWER INSPECTION SHAFT	3280	WATER VALVE - SURFACE	3600	TOP OF BANK	3800	TREE 1.0MD<3MD			PF - PEG FOUND	
3111	EDGE OF DRIVEWAY	3210	ELECT CABLE BOX	3241	STOP VALVE	3303	TRAFFIC SIGNALS A	3601	NATURAL SURFACE	3820	FENCE			PG - PEG GONE	
3112	PEDESTRIAN RAMP	3215	ELECT SUPPLY POLE	3242	HYDRANT GROUND	3313	SIGN I POLE	3601	BOTTOM BANK	3822	WALL LT				
3114	TRACK	3219	CONDUMER POLE	3255	FLUSHING POINT	3314	SIGN MULTIPLE POLES	3602	TOP BANK RT	3825	GATE				
3122	EARTH	3220	TELSTRA MANHOLE	3258	MARKER UNKNOWN	3401	HEADWALL	3608	ROCK OUTCROP RT	3830	FOOTPATH				

DE NADA surveys
UNIT 4 / 14 HALLEY ROAD
BALCATTA, WA 6021
EMAIL : info@denadasurveys.com.au
ABN: 55 123 232 575
PH: 08 9344 8885
FAX: 08 9344 8889

CLIENT: LANDCORP

Detail Survey

Murat Road - Exmouth

Surveyed By :	Drawn by :	Checked by :	Approved by :	Date :	Scale :
Peter Peard	C.Wylde/A.M.	Peter Peard	Peter Peard	10/02/2015	1 : 500

TXT/GSI REF: 101550 150203PPedit.RWS | Date Surveyed: 3-4 Feb 2015 | Datum: Horiz - Exmouth,94 Vert - AHD

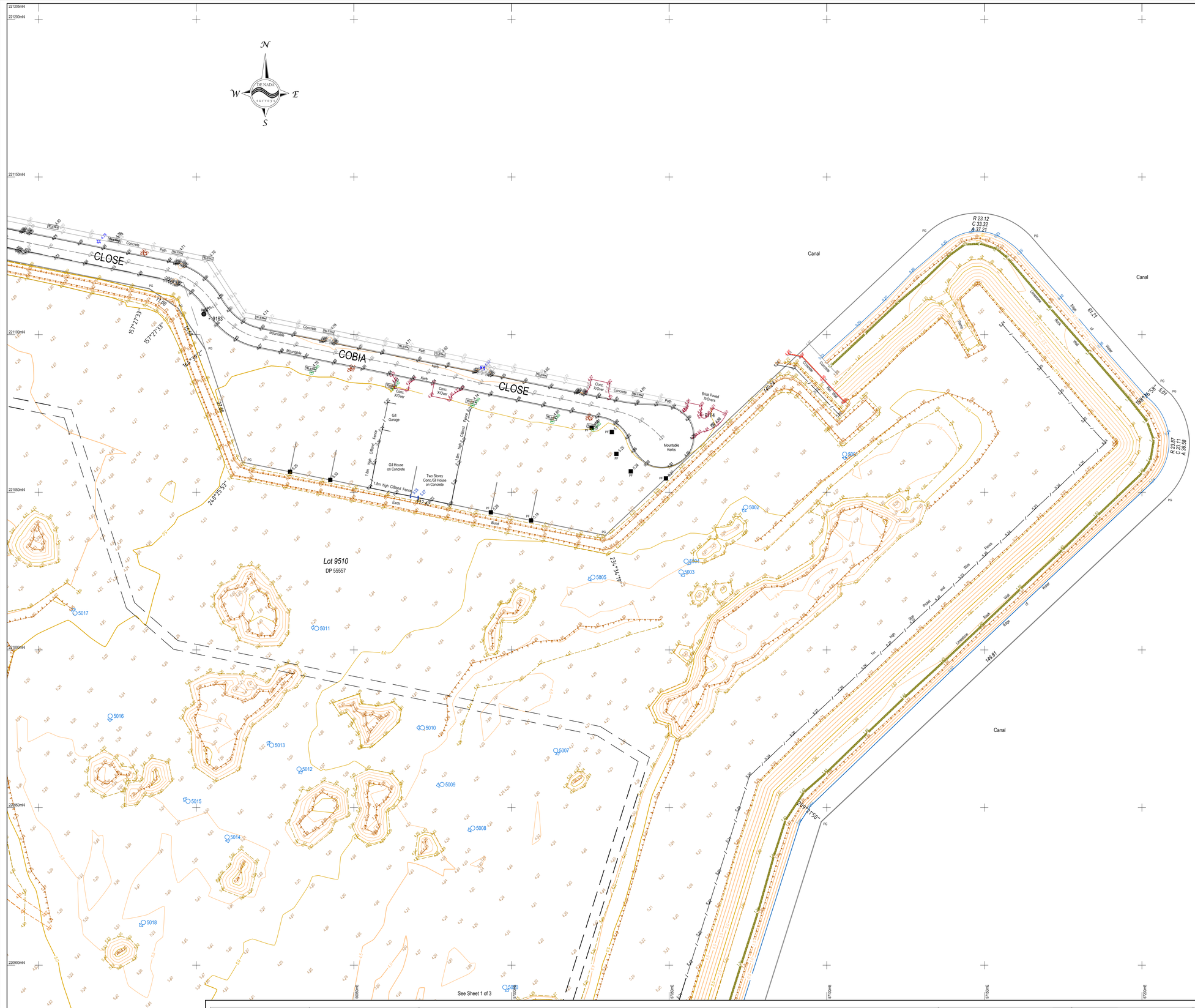
Plan Number: 101550-001b

0 10 20 30 40 50m

Revision : B

Sheet Size : ISO B1

Sheet 2 of 3



BUILDERS/CLIENTS

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Table of Revisions

Rev.	Date	By	Comments
A	10/02/15	A.M.	Initial Issue
B	18/02/15	A.M.	Roads Revised

SURVEY CODE LEGEND

DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	DESCRIPTION	POINT SYMBOL	TREE DETAIL
3100 EDGE OF BITUMEN		3125 ELECT POWER DOME		3221 TELSTRA PIT	TELPIT	3267 GRATED PIT		3408 INVERT		3690 STAR IRON PICKET		0.3m D - TRUNK DIAMETER
3101 SHOULDER		3156 LIGHT POLE		3222 TELSTRA PILLAR		3270 DRAINAGE MANHOLE		3409 OVERT		3703 CADASTRAL PEG_POST		5m H - TREE HEIGHT
3104 CENTRE OF ROAD		3200 POWERPOLE		3223 TELSTRA MARKER		3272 SIDE ENTRY PIT		3451 EDGE OF WATER LT		3704 RIP WAL_PEG		2m RC - TREE CANOPY RADIUS
3105 KERB TOP		3204 STAY POLE		3230 CONTROL MON PT		3273 SEWER MANHOLES		3550 BUILDING PT		3799 TREE 0.5MD<1.5MD		
3106 KERB BOTTOM		3205 STAY WIRE ANCHOR		3240 STOP VALVE - SURFACE		3280 SEWER INSPECTION SHAFT		3556 EDGE OF CONCRETE RT		3800 TREE 1.5MD>3MD		LOT DETAIL
3111 EDGE OF DRIVEWAY		3210 ELECT CABLE BOX		3241 STOP VALVE		3282 TRAFFIC SIGNALS 2A		3600 NATURAL SURFACE		3820 FENCE		PF - PEG FOUND
3112 PEDESTRIAN RAMP		3215 ELECT SUPPLYPOLE		3242 HYDRANT GROUND		3313 SIGN 1 POLE		3601 BOTTOM BANK		3822 WALL LT		PG - PEG GONE
3114 TRACK		3216 CONDUMER POLE		3255 FLUSHING POINT		3314 SIGN MULTIPLE POLES		3602 TOP BANK RT		3825 GATE		
3122 EARTH		3220 TELSTRA MANHOLE		3258 MARKER UNKNOWN		3401 HEADWALL		3608 ROCK OUTCROP RT		3835 FOOTPATH		

DE NADA surveys
UNIT 4 / 14 HALLEY ROAD
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EMAIL : info@denadasurveys.com.au
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FAX: 08 9344 8889

CLIENT: LANDCORP

Detail Survey

Murat Road - Exmouth

Surveyed By :	Drawn by :	Checked by :	Approved by :	Date :	Scale :
Peter Peard	C.Wylde/A.M.	Peter Peard	Peter Peard	10/02/2015	1 : 500

TXT/GSI REF: 101550 150203PPedit.RWS | Date Surveyed: 3-4 Feb 2015 | Datum: Horiz - Exmouth,94 Vert - AHD

Plan Number: 101550-001b

0 10 20 30 40 50m

Revision : B

Sheet Size : ISO B1

Sheet 3 of 3

APPENDIX B

DWER Email Correspondence (22 June 2022)

Matthew Yan

From: Simon Rodgers <simon.rodgers@dwer.wa.gov.au>
Sent: Wednesday, 22 June 2022 9:52 AM
To: Matthew Yan
Subject: Floodplain management advice - Lot 9510 Murat Rd, Exmouth - Matthew Yan - 22062022
Attachments: Ascon levels - Market St - Stage 1.pdf

Categories: Other

Hi Matthew

Based on the survey information provided, that shows finished fill levels of ~ 5.20 m AHD and an assumption that subsequent stages of the development (ie, Lots 21 to 23 and 37 to 44) have been constructed to similar levels, minimum habitable floor levels are expected to exceed 5.25 m AHD. Consequently, additional modelling to demonstrate the impact of the proposal on major flooding is not considered necessary.

Regards

Simon Rodgers
Supervising Engineer
Surface Water Assessment and Flood Risk Science

Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace, JOONDALUP WA 6027
Locked Bag 10, Joondalup DC, WA 6919
T: (08) 6364 6923 M: 0429 080 517
E: simon.rodgers@dwer.wa.gov.au | www.dwer.wa.gov.au

From: Matthew Yan <Matt@jdahydro.com.au>
Sent: Monday, 20 June 2022 5:50 PM
To: Simon Rodgers <simon.rodgers@dwer.wa.gov.au>
Subject: RE: Floodplain management advice - Lot 9510 Murat Rd, Exmouth - Matthew Yan - 22042022

Hi Simon,

Further to your email below, particularly with reference to the highlighted text regarding confirmation of finished levels in the Sea-Raven Estate on Mortiss Street, please find attached the Stage 1 as-constructed survey levels as requested.

The survey indicates earthwork levels generally around 5.20 mAHD. We presume earthworks contract for the site may have been let with minimum earthworks level of RL 5.20 for all lots, with requirement that finished floor levels (FFL) having a minimum top of slab level at 5.25 mAHD.

Based on the above, can you confirm the Department is now satisfied that proposed development of Lot 9510 Market Street will not impact other development and that no further flood modelling is required.

Please do not hesitate to contact me should you have any queries or need to discuss further, thanks.

Regards,

Matthew Yan
Principal Environmental Hydrologist

JDA CONSULTANT HYDROLOGISTS
Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |
Direct: (08) 6380 3423 | Reception: (08) 9388 2436 | www.jdahydro.com.au

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Please consider the environment before printing this e-mail

From: Simon Rodgers <simon.rodgers@dwer.wa.gov.au>
Sent: Friday, 22 April 2022 3:53 PM
To: Matthew Yan <Matt@jdahydro.com.au>
Subject: Floodplain management advice - Lot 9510 Murat Rd, Exmouth - Matthew Yan - 22042022

Hi Matthew

The Department of Water and Environmental Regulation provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage. The department uses the following guiding principles to ensure proposed development in floodprone areas is acceptable with regard to major flooding:

- proposed development has adequate protection
- proposed development does not detrimentally impact on the existing flooding regime

The *Exmouth Floodplain Management Study (2007)* and Market Street Levee, Exmouth – Flood Mitigation Works Detailed Design Report (2014) is used as the basis of the following discussion. Hydraulic modeling has determined the extent and levels of 1 in 100 AEP flooding for the following 2 scenarios:

(1) complete failure/breaching of the entire existing Market Street bund
(2) no failure/breaching/overtopping of the entire existing Market Street bund

Based on the above modeling and a recognition that only partial failure of the existing Market Street bund would be expected, the more likely 1 in 100 AEP flood levels at 6 key locations are shown on the attached plan (refer Attachment). It is considered that these flood levels represent a more realistic estimation of 100 year ARI flooding due to the unknown extent of actual levee failure/breaching. Based on our floodplain development guidelines and the above discussion, minimum habitable floor levels of 500 mm above the appropriate 1 in 100 AEP flood level (as shown on attached plan) to ensure adequate flood protection.

The above modelling was used to provide advice during the planning for the existing developments within the Exmouth Marina Village and the subdivision at the western end of Mortiss Street. The modelling included filling within both the Mortiss Street developed area and Lot 9510. If you are able to confirm the minimum floor levels within the existing Mortiss Street subdivision are greater than 5.25 m AHD, no additional flood modelling is necessary to assess the impact of proposed development on Lot 9510.

My understanding is that the State Coastal Planning Policy (SPP2.9) would be applicable to this location. The Shire of Exmouth and/or Department of Transport (Fangjun Li in their Coastal Management team may be a good contact) should be contacted for the latest information on Coastal Hazard Risk Management and Adaptations Planning for the Exmouth area.

It should be noted that this advice is related to major flooding only and other planning issues, such as stormwater drainage, environmental and ecological considerations, may also need to be addressed.

Regards

Simon Rodgers
Supervising Engineer
Surface Water Assessment and Flood Risk Science

Department of Water and Environmental Regulation
Prime House, 8 Davidson Terrace, JOONDALUP WA 6027
Locked Bag 10, Joondalup DC, WA 6919
T: (08) 6364 6923 M: 0429 080 517
E: simon.rodgers@dwer.wa.gov.au | www.dwer.wa.gov.au

From: Matthew Yan Matt@jdahydro.com.au
Sent: Wednesday, 13 April 2022 4:09 PM
To: Simon Rodgers simon.rodgers@dwer.wa.gov.au
Subject: Lot 9510 Murat Rd, Exmouth - Flood Advice

Hi Simon,

JDA have been appointed by DevelopmentWA to assist with hydrological advice associated with future urban development of Lot 9510 Murat Rd, Exmouth (location plan attached). Are you able to provide confirmation and/or guidance on the following queries:

Flood Level
Attached is an image from the SKM 2007 Exmouth Flood Study showing 100 year ARI flood mapping, with flooding across the Lot (Figure A-14).

With regards to finished lot levels, the Exmouth Marina Village Drainage Design Management Plan (RPS, 2010) states:

"The Shire of Exmouth, in consultation with the Department of Water, is using this study as a reference to determine minimum finished development levels for future development within the Exmouth Marina Village. The Shire will require land proposed for residential development to be filled to a level not less than 500 mm above the 1:100 year ARI flood level, as part of the Exmouth Floodplain Management Study (2007).

Based on the above, can you please confirm minimum floor levels required for Lot 9510?

Flood Storage
To achieve required flood clearance, the site would be filled or a flood mitigation structure such as a bund is constructed around the affected perimeter of the site. This would reduce available flood storage volume and impact adjacent flood levels and flow in neighbouring properties. In the Flood Zoning Existing Case attachment (Figure B-4), Lot 9510 is shown clear of being in any designated Flood Way or Flood Zone.

Can you confirm development of this Lot with fill above the 100 yr ARI flood level (ie. without flood storage) has already been considered as part of this Flood Study and is acceptable (ie. has negligible impact on adjacent properties)?

SPP 2.6
We note SPP 2.6 has come into effect since the SKM 2007 Flood Study was prepared. Can you advise if this is applicable, and if so what levels we need to be cognisant of?

Thanks in advance. Feel free to call if you have any queries or need to discuss further, thanks.

Regards,

Matthew Yan

Principal Environmental Hydrologist

JDA CONSULTANT HYDROLOGISTS

Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |

Direct: (08) 6380 3423 | Reception: (08) 9388 2436 | www.jdahydro.com.au

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Lot 9510 Murat Rd

EXMOUTH



Datum and Projection Information
Vertical Datum: AHD71
Horizontal Datum: GDA94
Projection: MGA Zone 50
Spheroid: GRS80

Project Information
Client: Simon Rodgers
Map Author: Andrew Watson
Task ID: B1305
Compilation date: 22/04/2022
Edition: Version 2

SOURCES

The Department of Water and Environmental Regulation acknowledges the following datasets and their custodians in the production of this map:

Road Centrelines, DLI - Landgate - 2016
Land Tenure (LGATE_226) - Landgate - 2021
Exmouth Townsite 10cm Orthomosaic - Landgate - 2020

Government of Western Australia
Department of Water and Environmental Regulation

This map is a product of the Department of Water and Environmental Regulation and was printed on 22/04/2022.

This map was produced with the intent that it be used for display purposes at the scale of 1:5,000 when printing at A4.

While the Department of Water and Environmental Regulation has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

Path: J:\gisprojects\Project\DWER\3000_SCI_PLA\3531_FLD_RISK_SC\0001_FPM_Enquires\mxd\Exmouth\FPM Exmouth Lot 9510 Murat Rd EXMOUTH (1 in 100yr) v2.mxd

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220636.388
R.L 4.192m

21 22 23 24 25 26 27 28 29

40 39 38 37 36 35 34 32 33

LOT 12

SEARAVEN CRESCENT

42 43 44 45 46 47 49 50

41

STAGE 1A, 1B & 2
- LOT 11-

8001

CREVALLE WAY

58 57 56 55 54 53 51 52

59 60 61 62 63 64 65 66

57000 57050 57100 57150 57200

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	SAH	23.02.2010	

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of the plans currency by contacting McMullen Nolan and Partners Surveyors

NORTH

EXMOUTH
LOT 11 MARKET STREET
FINAL EARTHWORKS LEVELS

McMULLENNOLAN
www.mapsurvey.com.au
Land Survey Hydrographic Survey 3D Laser Scanning 3D Visualisation
Mapping Solid Terrain Models Cartographics GIS

Scale	1:500 @ A1	Datum	EXM94/AHD
Drawn	SAH	Job No.	94395
Surveyor	M.HAWKER	Drawing	94395-023
Surveyed	10/02/2010	Revision	A

A1 ORIGINAL

SCALE 1 : 500 @ A1 - 1 : 1000 @ A3

0 25 50

ALL DISTANCES ARE IN METRES

The boundaries shown on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Existing easements, encumbrances or interests are not depicted and a title search is recommended to obtain this information. Re-establishment of the cadastral boundaries recommended for any proposed works on or near existing boundaries.

FILES
Precal: 10.12.09
Survey - Plan No:
94395B - 94395de-023a

Level 1
2 Sabre Cres.
Jandakot
W.A. 6164

PO Box 3526
Success
WA 6964
Australia

Tel: (08) 6436 1599
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maps@mapsurvey.com.au
www.mapsurvey.com.au

McMullen Nolan and
Partners Surveyors Pty Ltd
ABN 90 009 363 311

Quality Assured Company

APPENDIX C

DoT Email Correspondence (4 May 2022)

Matthew Yan

From: Li, Fangjun <Fangjun.Li@transport.wa.gov.au>
Sent: Wednesday, 4 May 2022 11:25 AM
To: Matthew Yan
Cc: Meuleners, Michael
Subject: RE: Lot 9510 Murat Rd, Exmouth - Flood Advice

Categories: Other

Hi Matthew
The Schedule One of SPP 2.6 requires the allowance for the risk of inundation to be the maximum extent of storm inundation (defined as the peak steady water level plus wave run-up)
plus the sea level rise value of 0.9m. The allowance for storm inundation is to be based on ocean forces and coastal processes that have a 0.2 percent or one-in-five hundred probability of being equalled or exceeded in any given year of the planning timeframe.
As you have mentioned that the Exmouth cyclone modelling is not available at the moment. A conservative estimate of peak steady water level during a 500-year ARI cyclone for the Exmouth coast is 5.2m AHD at present day. Add on the 0.9m sea level rise allowance the ocean cyclone inundation level for 100 year planning timeframe will be 6.1m AHD, which is quite high.
We are open for other suggestions with justifiable cyclone modelling document.
Regards,

#
Fangjun Li
Manager Coastal Engineering and Management | Maritime | Department of Transport
5 Newman Court, Fremantle WA 6160
Tel: (08) 94357545 | Mob: 0408926512
Email: Fangjun.Li@transport.wa.gov.au | Web: www.transport.wa.gov.au



From: Matthew Yan <Matt@jdahydro.com.au>
Sent: Wednesday, 4 May 2022 11:02 AM
To: Li, Fangjun <Fangjun.Li@transport.wa.gov.au>
Subject: FW: Lot 9510 Murat Rd, Exmouth - Flood Advice
Importance: High

CAUTION: This email originated from outside of DOT. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hi Fangjun,

Just a quick email to see if you've had a chance to peruse my email below?

If you need any additional information or clarification, feel free to contact me by phone or email. Thanks.

Regards,

Matthew Yan
Principal Environmental Hydrologist

JDA CONSULTANT HYDROLOGISTS
Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |
Direct: (08) 6380 3423 | Reception: (08) 9388 2436 | www.jdahydro.com.au

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From: Matthew Yan
Sent: Tuesday, 26 April 2022 1:51 PM
To: Fangjun.Li@transport.wa.gov.au
Subject: FW: Lot 9510 Murat Rd, Exmouth - Flood Advice

Hi Fangjun,

JDA are assisting DevelopmentWA with hydrological advice associated with future urban development of Lot 9510 Murat Rd, Exmouth (location plan attached).

Simon Rodgers (DWER) has provided advice with regards to floodplain development (see email attached), and recommended that I contact you with regards to State Coastal Planning Policy (SPP 2.9).

I understand that a Coastal Hazard Risk Management and Adaptations Plan is being prepared for the Exmouth area, but unlikely to be completed until next year. Consequently, are you able to advise any implication or guideline that we would need to be aware of for future development of Lot 9510?

Feel free to contact me if you have any queries or need to discus further, thanks.

Regards,

Matthew Yan
Principal Environmental Hydrologist

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From: Matthew Yan
Sent: Wednesday, 13 April 2022 4:09 PM
To: 'Simon Rodgers' <simon.rodgers@dwer.wa.gov.au>
Subject: Lot 9510 Murat Rd, Exmouth - Flood Advice

Hi Simon,

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With regards to finished lot levels, the Exmouth Marina Village Drainage Design Management Plan (RPS, 2010) states:

"The Shire of Exmouth, in consultation with the Department of Water, is using this study as a reference to determine minimum finished development levels for future development within the Exmouth Marina Village. The Shire will require land proposed for residential development to be filled to a level not less than 500 mm above the 1:100 year ARI flood level, as part of the Exmouth Floodplain Management Study (2007).

Based on the above, can you please confirm minimum floor levels required for Lot 9510?

Flood Storage

To achieve required flood clearance, the site would be filled or a flood mitigation structure such as a bund is constructed around the affected perimeter of the site. This would reduce available flood storage volume and impact adjacent flood levels and flow in neighbouring properties. In the Flood Zoning Existing Case attachment (Figure B-4), Lot 9510 is shown clear of being in any designated Flood Way or Flood Zone.

Can you confirm development of this Lot with fill above the 100 yr ARI flood level (ie. without flood storage) has already been considered as part of this Flood Study and is acceptable (ie. has negligible impact on adjacent properties)?

SPP 2.6

We note SPP 2.6 has come into effect since the SKM 2007 Flood Study was prepared. Can you advise if this is applicable, and if so what levels we need to be cognisant of?

Thanks in advance. Feel free to call if you have any queries or need to discuss further, thanks.

Regards,

Matthew Yan
Principal Environmental Hydrologist

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SINCLAIR KNIGHT MERZ
SKM

Department of Water
Government of Western Australia

Exmouth Floodplain Management Study



FLOODPLAIN MANAGEMENT STRATEGY

- Final
- December 2007

Executive Summary

Sinclair Knight Merz was commissioned by the Western Australia Department of Water (DoW) to develop a floodplain management strategy for the Shire of Exmouth. The Shire of Exmouth has an existing Strategy based on flooding events in the recent past. This new investigation is based on detailed hydrologic and hydraulic modelling of the investigation area. It also covers the area to the north and south of the existing development to take in all areas currently planned for future development under Council and Department of Planning and Infrastructure (DPI) strategic land planning.

The objectives of the Floodplain Management Strategy were aligned with the Standing Committee on Agriculture and Resource Management Report 73 (SCARM73), "*Floodplain Management in Australia, Best Practice Principles and Guidelines*" (CSIRO, 2000). The objectives are:

1) Limit the impacts of existing flooding problems on the well-being of individuals to acceptable levels;
2) Limit the property impacts of existing flooding problems to acceptable levels;
3) Preserve, and enhance where possible, the natural function of the floodplain to convey flood waters and/or sustain flood dependent ecosystems;
4) Encourage the compatible planning and use of floodplains as a resource for the use of the whole community.

The scope of services requested to achieve these objectives were:

- Hydrologic modelling of the catchments of the Cape Range creeks including tide and storm surge analysis in the Exmouth Gulf;
- 10, 25, 100 and 500 year ARI floodplain modelling and mapping;
- Development of a floodplain management strategy;
- Flood damage assessment study;
- Assessment of flood management options that will increase Exmouth's flood protection; and
- Evaluation of possible water harvesting opportunities.

A review of earlier studies identified that two major flooding events have occurred in the recent past. These events were associated with severe Tropical Cyclone Vance in March 1999 and a major rainfall event in June 2002. These events have been used as the basis for floodplain planning by Council. Actual flood damage costs from these events were not recorded.

A review of Council's existing floodplain planning showed that developments and flood mitigation measures were not aligned with the SCARM objectives. Two such examples are the Exmouth Marina Village (EMV) development and the Market Street bund separating the Market St Creek and Marina Creek.

Hydrologic and hydraulic modelling was performed for the investigation area. It was found that the EMV has caused a significant alteration to the existing flooding regime in the investigation area and that measures would be required to mitigate these impacts. It was found that the Light Industrial Area (LIA)was prone to shallow flooding as was the Town Centre area.

Council requested that a series of flood mitigation measures be tested including improvement to existing drainage floodways and opening/enlarging natural breakouts to Exmouth Gulf. It was found that opening/enlarging breakouts to Exmouth Gulf had negligible impacts on regional flood levels. It was found that improvements to the LIA drainage would reduce flood damages in the LIA and would mitigate flood damage on Murat Road caused by the EMV.

The existing Market Street bund was found to be too low to be an effective flood mitigation measure and no evidence could be found to support the quality of its design or construction. Therefore, it was not considered to be suitable as a flood mitigation measure. At the time of the study, Council was required to assess the EMV development. Without the bund, the EMV development level was too low and would be costly to elevate to the appropriate flood immunity. Therefore, Council requested that the Market Street bund be considered as part of the flood mitigation strategy and agreed that its design and construction requires a full and immediate review.

The resulting Floodplain Management Strategy recommended the following.

Flood Mitigation Measure	Description	Discussion
Structural	LIA Creek Improvements	The improvement of drainage structures where LIA Creek crosses Reid Street and the extension and upgrade of floodway levees to contain the 100 year ARI flow in bank for conveyance to the east of Murat Road
	Replacement / Upgrading of Market Street bund	Engineering assessment of the Market Street bund for adequacy. Raising and extending the levee and potentially replacing/upgrading the existing structure to convey Market St Creek across Murat Road.
	Murat Road Causeways	• Initial work to upgrade the crossing of Market Street Creek over Murat Road to allow for the increased flow due to the Market Street bund. • The gradual replacement of floodways along Murat Road with culvert or bridge structures to increase accessibility along Murat Road to the town centre during flood events.
Non-Structural	Land Use Planning	Setting aside land under "floodway" designation in Council planning to avoid inappropriate development. Planning and management of land under "flood fringe" designation to avoid regional flooding impacts.
	Building Development Controls	Setting of minimum floor levels for future developments to ensure adequate 100 year ARI flood protection.
	Flood Emergency Response Planning	Planning for flood emergencies by ensuring plans are in place for evacuating isolated communities and avoiding damage or isolation of critical Council and emergency services infrastructure.
	Streamflow / rainfall gauging, data collection and ongoing review	Installation of streamflow and rainfall gauging to provide ongoing data. This will enable the findings of this study to be monitored and reviewed.

As part of the study, the Shire of Exmouth required that SKM also investigate the capacity to harvest some of the floodwaters to supplement the town water supply. Based on the intensity and infrequency of rainfall events in Exmouth and the high evaporation rates, it was deemed that it was not feasible to undertake harvesting and storage of surface water. The only likely method of harvesting water was through improving inflow to the regional groundwater aquifer.

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1. Background

Sinclair Knight Merz was commissioned by the Western Australia Department of Water (DoW) to develop a Floodplain Management Strategy (Strategy) for the Shire of Exmouth. The Shire of Exmouth has an existing Strategy based on past flooding events. This new investigation is based on detailed hydrologic and hydraulic modelling of the investigation area. It also covers the area to the north and south of the existing development to take in areas currently planned for future development under Council and Department of Planning and Infrastructure (DPI) strategic land planning

1.1 Study Objectives and Scope

The Standing Committee on Agriculture and Resource Management Report 73 (SCARM73), "*Floodplain Management in Australia, Best Practice Principles and Guidelines*" (CSIRO, 2000) sets out four principal objectives to floodplain management:.

1) Limit the impacts of existing flooding problems on the well-being of individuals to acceptable levels;
2) Limit the property impacts of existing flooding problems to acceptable levels;
3) Preserve, and enhance where possible, the natural function of the floodplain to convey flood waters and/or sustain flood dependent ecosystems;
4) Encourage the compatible planning and use of floodplains as a resource for the use of the whole community.

These objectives were adopted for this investigation. The scope of services requested to achieve these objectives were:

- Hydrology of the catchments of the Cape Range creeks including tide and storm surge analysis in the Exmouth Gulf;
- 10, 25, 100 and 500 year ARI floodplain modelling and mapping;
- Development of a floodplain management strategy;
- Flood damage assessment study;
- Assessment of flood management options that will increase Exmouth's flood protection; and
- Evaluation of possible water harvesting opportunities.

1.2 Investigation Area

This section gives a brief introduction and description of study area elements. The investigation area is shown in Figure 1-1 and Figure 1-2.

Exmouth Marina Village (EMV) – The Exmouth Marina Village is a recent development that is ongoing at the time of the development of this Strategy. The EMV is a canal development that is being constructed east of Murat Road, interfacing with the Exmouth Gulf at the existing Exmouth Boat Harbour. The canal is constructed in an area of land that was previously a depression and drainage path for all of the flow from the Market Street and Marina Creek catchments and a portion of the LIA Creek catchment.

The EMV passes the flow from these catchments via a spillway on the southernmost canal arm fronting Murat Road (Canal Arm 4) and a spillway to the north on Madaffari Drive.

The EMV has not experienced flooding as it was developed after the last major flooding events in 1999 and 2002.

Exmouth Boat Harbour – The boat harbour is a small harbour that services some local fishing vessels and provides permanent moorings to recreational and commercial craft. The harbour is at the mouth of the EMV canal development.

The boat harbour suffered damages in the 1999 and 2002 flood events. A fishing vessel was sunk in 1999 when a surge of floodwaters entered the harbour from upstream. It is believed that this surge was the result of the failure of an upstream embankment, possibly a road, which had been holding back floodwaters. Several fishing trawlers were also damaged whilst moored in the harbour during the June 2002 event.

Murat Road – Murat Road is the main road into Exmouth and provides the primary evacuation route for residents into and away from the town. The road is elevated above the water level that naturally ponds behind the eastern coastal dunes.

Murat Road is crossed by all of the drainage lines in the investigation area. The crossings are causeways with some minor culvert drainage structures to pass low flows.

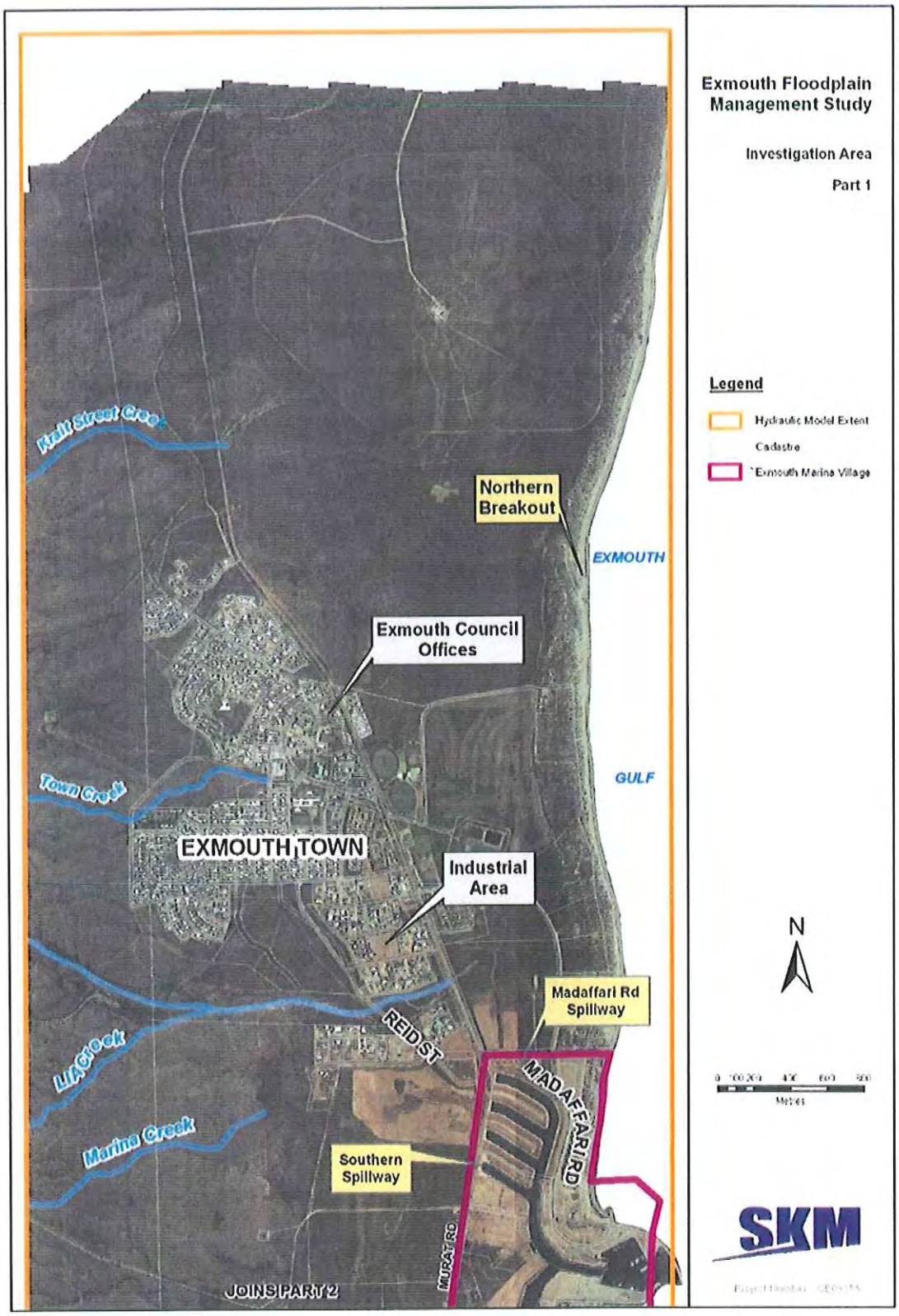
Reid Street – Reid Street is an important road that leads from Murat Road, up into higher terrain behind the LIA and into the west of town. Reid Street has a number of causeway crossings of drainage lines that flow into the ponded area behind the coastal dunes.

McLeod Street Breakout – This breakout is to the south of the EMV and is known to have opened during the 2002 flood event as part of natural coastal processes. The breakout is being kept open through sand extraction activities managed by Council.

Northern Breakout – The Northern Breakout is an opening through the coastal dunes north of the townsite. It is the largest of the breakouts that drain the area that ponds behind the coastal dunes. The Northern Breakout is subject to coastal process of wind and waves that will close the breakout over time. With each significant flood event, the breakout is generally reformed.

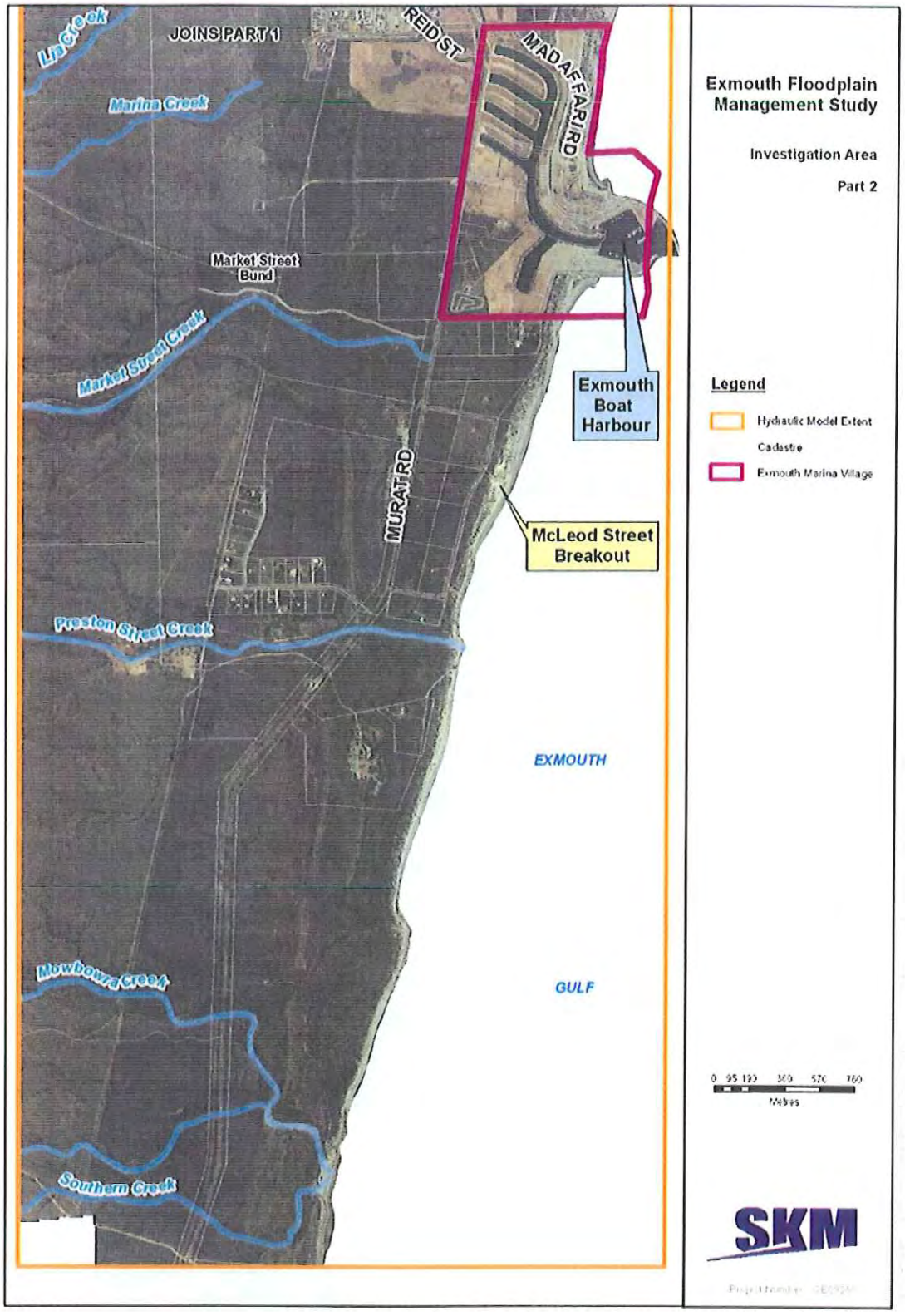
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Figure 1-1 Investigation Area North



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- Figure 1-2 Investigation Area South



1.3 History of Flooding

Two recent flood events dominate the records of major flooding for Exmouth. These events occurred in March 1999 and June 2002. The March 1999 flood event was the result of severe Tropical Cyclone Vance which crossed the coast near Exmouth. This is discussed further in Section 3.1.1.

The second major flooding event occurred in June 2002. It was a significant rainfall event occurring in winter. The event caused widespread flooding through a longer, more drawn out rainfall event which included the wettest June day on record in Western Australia (BoM, 2002). More detail is provided in Section 3.1.2.

Both of the recorded flood events broke the banks of the drainage lines from the upstream catchments. Damage was focussed in the Light Industrial Area (LIA). The flooding in both instances damaged roads. Boats in the Exmouth Boat Harbour were damaged in both these events. During Cyclone Vance, an upstream embankment was breached by floodwaters and sent a surge of water into the boat harbour. There was only one report of residential impacts in the March 1999 event and this was in Preston Street where a resident reported that the Preston Creek bund was breached (JDA, 1999).

1.4 History of Floodplain Development

Development in the investigation area has generally been limited to the higher terrain away from the floodplain around the central business area. The town site has experienced some flooding from the Town Creek catchment but this has been limited and without extensive damages.

As development has expanded away from the Town Centre, it has encroached into the LIA Creek floodplain with the development of the Light Industrial Area. Flood mitigation measures have been put in place to pass LIA Creek flooding while avoiding flooding impacts on the industrial development.

The EMV has been developed on and adjacent to the drainage path that once flowed from the LIA Creek, Marina Creek and Market Street Creek catchments. The EMV has incorporated spillway structures to pass floods from these catchments and detailed hydraulic modelling has been done in this investigation to understand the impacts of the development.

A bund has been constructed on the floodplain between the Market Street Creek and Marina Creek catchments. The structure prevents flow from Market Street Creek from crossing into the Marina Creek catchment and flowing into the EMV. A discussion on the effectiveness and impacts of this measure is contained in Section 4.2.2.

1.5 Institutional Framework

The Department of Water is the State's lead floodplain management institution and provides guidance on floodplain management issues in Western Australia. It is the Department's responsibility to "*develop plans for and provide advice on flood management*". These activities are advisory only as the Department of Water is not an approving authority.

The DoW uses the following guideline principles to ensure proposed development in floodprone areas is acceptable with regard to major flooding:

- Proposed development has adequate flood protection from a 100 year ARI flood.
- Proposed development does not detrimentally impact on the existing flooding regime of the general area.

The DoW assists Council in guiding appropriate landuse planning and establishing building development controls to ensure developments conform to their guiding principles. DoW adopts risk based floodplain management principles as set out in documents such as *Floodplain Management in Australia – Best Practice Principles and Guidelines* (SCARM73, CSIRO, 2000).

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2. Physical and Social Setting

The town of Exmouth is remote in the north west of Western Australia. The nearest communities are Carnarvon, 350km to the south, and Karratha, 570km to the north east. The area has a short European history. The economy of the area is driven by tourism, based on the natural assets of the nearby Cape Range and Ningaloo Marine Park.

2.1 Area History and Tourism

The town site of Exmouth was initially developed from the early 1940s. Most of the development seen today was built in the early 1960s, based on joint Australian and United States military interests in the area. Prior to that time there was limited settlement in the area that serviced pearling and sparse pastoral interests. A nomadic indigenous tribe was known to pass through the area frequently up to the early 1900s.

The major growth in Exmouth occurred with the establishment of the North West Cape Communications Station and development of a local prawning and pearling industry in the area.

There is limited European cultural heritage in the area due to its recent settlement however the area is rich in natural assets such as the Cape Range National Park and the nearby Ningaloo Marine Park and Ningaloo Reef.

2.2 Cape Range

The catchments draining through the investigation area flow from Cape Range. The Cape Range National Park is approximately 40 kilometres from Exmouth on the west coast of the North West Cape and the eastern flanks of Cape Range drain to the Exmouth Gulf.

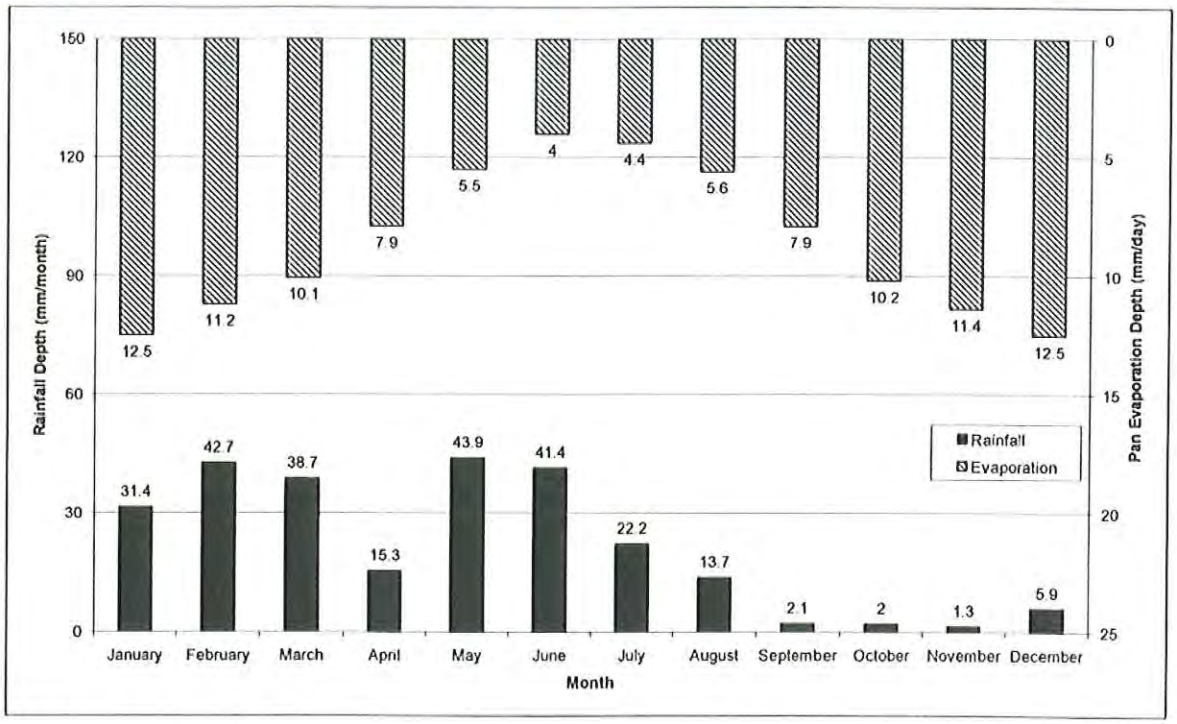
The Cape Range is rugged limestone with sparse vegetation that drains east to the coastal plans. Coastal dunes detain runoff to create ponded water behind the coastal dunes which help to sustain diverse, sparse vegetation communities in the lowland areas.

2.3 Climate

The climate of the region is characterised by very hot summers and temperate winters. Most of the rainfall occurs either during January to March or from May to July. During January to March rain is generally associated with thunderstorms and cyclonic low pressure systems. The area has a history of cyclones passing into the Exmouth Gulf and causing storm surge, high winds and rain. From May to July, tropical cloud bands often bring heavy rains from the northwest (BoM, 2007). Average annual rainfall is approximately 260mm with evaporation well exceeding this at over 3100mm. Figure 2-1 to Figure 2-3 show the average climatic data for the area on a monthly basis.

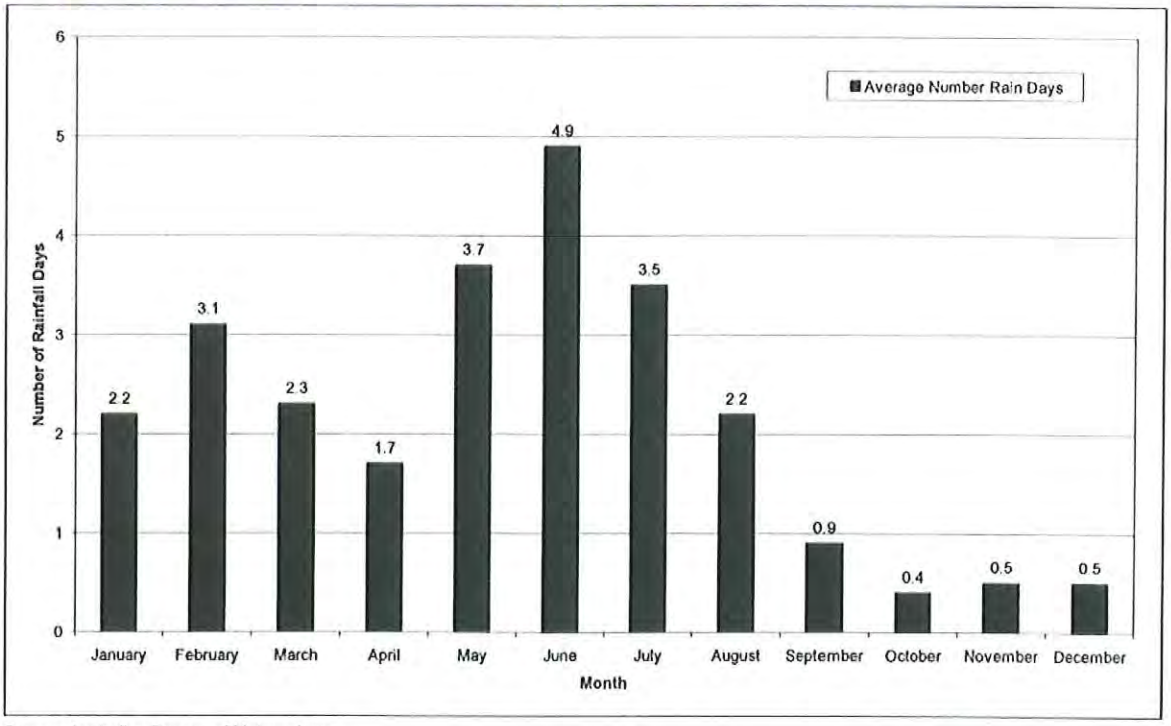
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- Figure 2-1 Average Rainfall and Daily Evaporation by Month (Learmonth Airport)



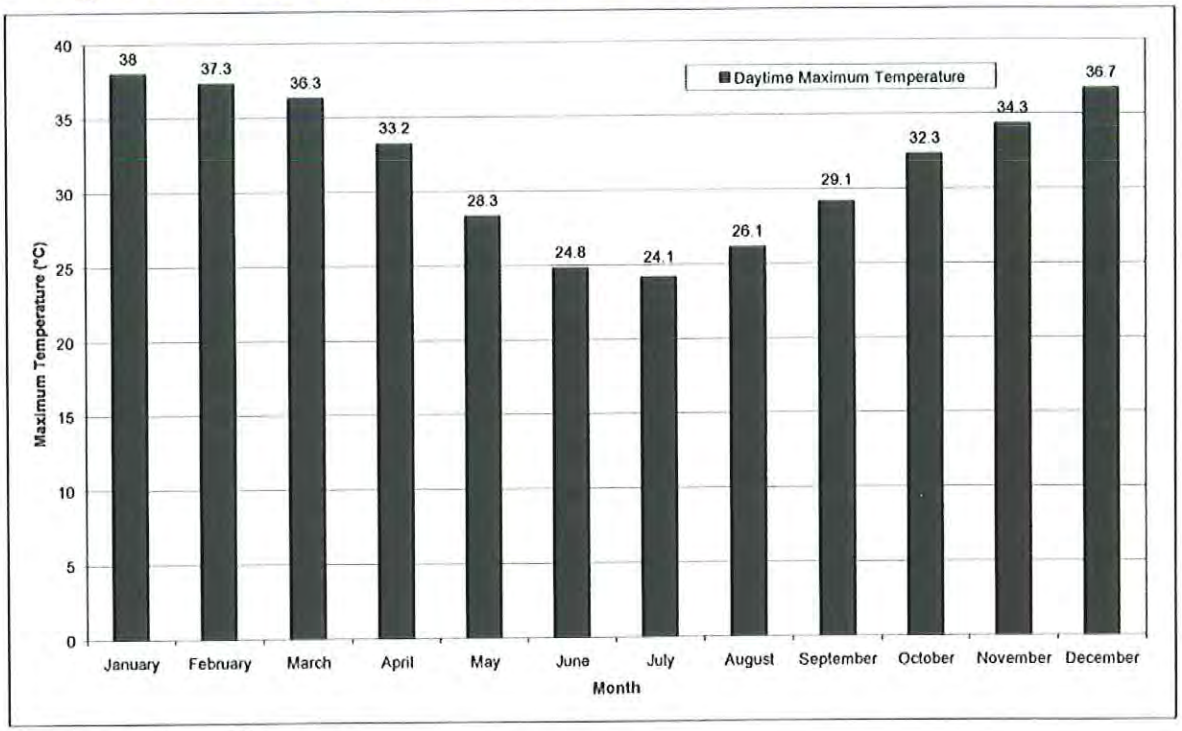
Source: Australian Bureau of Meteorology

- Figure 2-2 Average Number of Rain Days by Month (Learmonth Airport)



Source: Australian Bureau of Meteorology

Figure 2-3 Average Daytime Maximum Temperature by Month (Learmonth Airport)



Source: Australian Bureau of Meteorology

2.4 Living with Floods

The residents of Exmouth are familiar with flooding. However, with a large transient residential and tourist population, the awareness of Exmouth's flooding is assumed to be not high. The only access road to the town and its services is Murat Road. Murat Road has numerous causeway crossings along its length and these causeways flood during runoff events affecting vehicular and pedestrian access to the township. Flooding is normally short in duration and the community can manage, however, it creates risk as it isolates the population from emergency services.

In recent years, Exmouth has experienced two significant rainfall runoff events that have caused flooding. They occurred with Cyclone Vance in March 1999 and in a very large rainfall event of June 2002. The June 2002 event was a significant winter event with 304.6mm of rainfall recorded in 24 hours, which broke the previous single day June rainfall record for Western Australia by more than 30mm. The June 2002 event also exceeded the town's average annual rainfall in a single day.

Both the 1999 and 2002 rainfall events were large and an assessment of 24 hour regional rainfall data placed the 2002 event between 100 years and 200 years annual recurrence interval (ARI). The rainfall events caused extensive flooding behind the coastal dune system. This was exacerbated by high tide levels, particularly in the 1999 event, coincident with cyclonic storm surge.

Exmouth is the subject of extensive planned growth. New development must be conscious of the area's flooding potential and cognisant of the isolation that flooding may cause. This Floodplain Management Strategy, combined with detailed hydrologic and hydraulic modelling, is required to better understand the flooding issues and predict potential flooding impacts.

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3. Hydrologic and Flooding Characteristics

The worst recorded flooding in the investigation area was attributed to cyclonic activity or deep low pressure systems impacting the western coast and Exmouth Gulf. In particular, two flooding events were referred to extensively during consultation in the community. These were the March 1999 Tropical Cyclone Vance and a major rainfall event in June 2002. Both events caused flooding and damage.

This Section describes the history of flooding in the study area and summarises the hydrologic and hydraulic modelling that has been undertaken to develop this Floodplain Management Strategy.

This report refers to a number of watercourses in the investigation area being (listed from north to south):

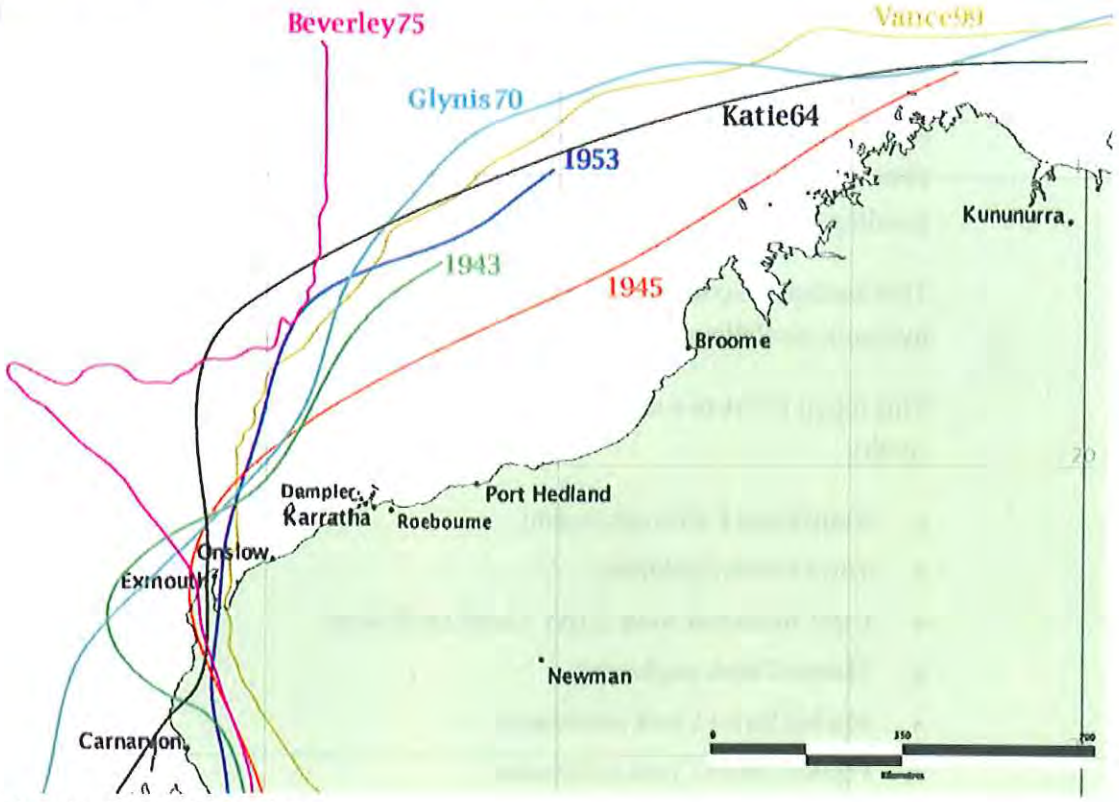
- Krait Street Creek catchment;
- Town Creek catchment
- Light Industrial Area (LIA) Creek catchment;
- Marina Creek catchment;
- Market Street Creek catchment;
- Preston Street Creek catchment;
- Mowbowra Creek catchment; and
- Unnamed southern catchment

Figure 1-1 and Figure 1-2 show the investigation area and locate the various watercourses within the area.

3.1 Historical Cyclonic and Flooding Events

The North West Cape and Exmouth Gulf is the most cyclone prone area of Australia. In March 1999, it experienced one of the most powerful cyclones in Australia's recorded history (BoM, 2000) with Cyclone Vance. Figure 3-1 shows a track of significant cyclones that have impacted on the Gulf area. The Bureau of Meteorology predicts that a cyclone can be expected in the Exmouth region every second or third year on average. However, the interval between cyclones varies greatly as climatic patterns take multi-decadal cycles.

Figure 3-1 Recorded Exmouth Gulf Cyclone Tracks



Source: Australian Bureau of Meteorology

3.1.1 Severe Tropical Cyclone Vance – March 1999

Severe Tropical Cyclone Vance crossed onto the mainland at Exmouth on 22 March 1999. More than 10% of the buildings of the town suffered damage and the cyclone brought a damaging storm surge. A winds gust of 267km/hr was recorded at Learmonth Meteorological Office and this was the highest wind gust ever recorded on mainland Australia.

The majority of the damage relating to the cyclone resulted from wind damage and there is little record of major flooding damage. Rainfall from this event was approximately 207mm measured at the Learmonth gauge. A storm surge of 3.6m at Exmouth caused extensive beach erosion and stranded marine vessels. The cyclone produced a maximum storm surge of over 5.0m near Onslow.

3.1.2 June 2002 Flood Event

On 4 June 2002, Exmouth had the wettest June day on record for Western Australia with 304.6mm of rain recorded in 24 hours. The rainfall was generated by a deep low pressure system that was trapped in the Exmouth Gulf. The system was widespread and also provided rains as far south as Perth in the same 24 hours.

The rainfall event caused extensive inundation, especially in the coastal flats behind the dunes.

3.2 Consultation

The Exmouth community and Council were consulted as part of the development of this study and this Section outlines the discussions.

Previous investigations, as outlined in Section 4.1, also contain anecdotal evidence of the two major flood events and this information was collected soon after the events occurred. This information was referred to extensively to understand the flooding characteristics of the investigation area.

3.2.1 Exmouth Golf Course

Kerry Graham, former CEO of the Shire of Exmouth, toured the investigation area and described his experience through the two significant flood events of town. Mr Graham confirmed flood behaviour and was able to show a June 2002 flood mark in the golf course area. Mr Graham confirmed that the flood filled the ponded area behind the coastal dunes and discussed how the water levels dropped quite rapidly once the rainfall ceased. The flood mark supplied was used as part of the hydraulic model validation exercise discussed in a subsequent Section.

The Exmouth Golf Course holds photographs of the June 2002 flood event which were reviewed as part of the investigation.

3.2.2 Video of June 2002 Flood Event

A video was supplied by Council which films the progress of a four wheel drive vehicle in transit from the north of Exmouth to the south beyond the Exmouth Boat Harbour to the McLeod Street Breakout during the June 2002 flood event. The video provides numerous interesting pieces of validation data.

The video shows that a very small area of higher land remained free from flooding, believed to be on the corner of McLeod Street and Murat Road where a vehicle appears stranded. This point was validated to confirm that it was predicted to remain flood free in the June 2002 event.

The video captured the flow velocity and depth in the area of the petrol station on the corner of Murat Road and Maidstone Crescent and the station owner provided photographs to confirm this aspect.

3.2.3 Light Industrial Area Flooding

Properties through the LIA were inspected. Flood marks were still present through a workshop in Griffiths Way and this showed that the flooding was approximately 300mm deep through the area. The description of the flooding suggested that the hydraulic structures upstream of the LIA were not adequate to pass flooding and the water flowed onto Reid Street.

Once the water was on Reid Street, it was able to break from the banks of the LIA Creek and flow through the LIA.

3.2.4 Service Station on Murat Road

Photographs were provided at the intersection of Murat Road and Maidstone Crescent. The photography showed that the flooding through this intersection was a high velocity and this was confirmed through the video of the June 2002 event. The high velocities at this location were evident in the subsequent flood modelling.

3.2.5 Previous Investigations

The *Exmouth Flood Management Study* (JDA, 1999) provided anecdotal evidence and photography of the March 1999 event. The *Review of Exmouth Flood Management Study – Assessment of June 2002 Flood Event* (JDA, 2002) provided similar anecdotal evidence and photography of the June 2002 event. It also included a field assessment to photograph, survey and document flood debris levels throughout the town for the June 2002 event.

3.3 Catchment Response to Rainfall

Flood modelling was undertaken to better understand the catchment response to rainfall. This was done in two parts, by constructing a hydrologic model of the catchments to estimate the runoff from rainfall and then a hydraulic model to predict flow patterns and inundation from the runoff. The development of the hydrologic and hydraulic models was presented in detail in a separate report *Exmouth Floodplain Management Strategy – Flood Modelling Report* (SKM, 2007) and a summary is presented.

The hydrologic model predicted that the catchments are slow to respond to rainfall due to high initial losses and continuing losses in the upper catchment. This was due to the exposed, fractured limestone absorbing much of the rainfall unless the rainfall was intense enough to overwhelm its uptake. The lower catchment was more responsive, notably in areas where the limestone was covered with a thin soil layer.

Further details and mapping of the flooding behaviour is contained in Section 3.3.3.

3.3.1 Model Calibration

The hydrologic modelling could not be calibrated as there are no streamflow monitoring gauges in the area. It was necessary to use an iterative approach whereby the hydrologic model was developed on parameter values based on regional estimates and the resulting flows were tested in the hydraulic model. The flooding extent and inundation depths were then verified against recorded and anecdotal flood records to check for consistency. Parameters in the hydrologic model were then modified and the hydraulics tested again until a suitable calibration was achieved.

A sensitivity analysis was undertaken to improve the confidence in the results of the hydraulic model. The sensitivity to numerous elements was tested including tidal boundary conditions, surface roughness and the elevation of the Northern Breakout. The sensitivity analysis showed that the inundation of the upper reaches of the model area was sensitive to the hydraulic roughness adopted. In the lower reaches, the hydraulics was dominated by the storage available behind the dunes. Making changes to tidal conditions, roughness or breakout elevation had little effect due to the large volume available for flood storage.

The validation successfully replicated the flooded extent of the investigation area for the June 2002 flood event. However, this cannot be considered to be a thorough calibration of the hydrology nor the hydraulics. The work completed here should be fully calibrated and validated once flow information and flood level data is collected for future flood events.

3.3.2 Design Rainfall and Runoff Estimation

Design storm rainfall depths (Table 3-1) were derived using the method of *Australian Rainfall and Runoff* (IEAust, 1998) and input to the hydrologic model discussed in the previous section. Design flows were developed for the 10, 25, 100 and 500 year ARI events. The one hour and three hour storms were found to be critical for the Creeks within the investigation area. Peak flow discharges are reported for the "Existing Case" at specific locations (Table 3-2).

Table 3-1 Summary of Design Rainfall Depths (mm)

Duration (hours)	Event (1 in y ARI)			
	10	25	100	500
1	57	74	106	146
3	82	109	161	230

Table 3-2 Summary of Design Flood Peak Discharges in the Investigation Area

Catchment	Peak Discharge (m^3/s)				Critical Storm
	Q10	Q25	Q100	Q500	
Krait St – Nth	2.0	8.7	23.9	43.3	1 hr
Krait St – Sth	22.1	52.9	124.0	200.7	1 hr
Town Creek	4.0	6.3	11.2	17.5	3 hr
LIA Creek	27.5	65.9	151.9	277.5	1 hr
Marina Creek	12.8	27.3	53.9	85.6	1 hr
Market Street Ck	44.3	112.1	271.8	473.8	1 hr
Preston Street Ck	4.3	10.8	26.1	45.3	3 hr
Mowbowra Creek	8.2	19.6	45.8	78.9	3 hr
Southern	28.3	69.6	159.1	274.9	1 hr

3.3.3 Design Flood Inundation and Flow Behaviour

The design floods were modelled in a hydraulic model. Inundation extents and flow characteristics were developed for the 10, 25, 100 and 500 year ARI events. Numerous flow durations were considered and it was found that the 1 hour and 3 hour duration storms were critical at various locations in the investigation area. Therefore, both the 1 hour and 3 hour duration events were modelled and the results were interrogated to produce a single map that showed only the peak inundation from these two durations for each single event. Mapping of flood inundation and flow velocity are provided in Appendix A.

Two scenarios were modelled when establishing the initial hydraulic model. These were:

1) ***Existing Case*** – this scenario used the terrain data collected at the commencement of the study and included all cut and fill for development that had already been approved by Council. This scenario included the proposed flood mitigation around the EMV but excluded the Market Street bund and this is discussed later in Section 4.2.2.
2) ***Pre-Canals Case*** – this scenario was used to assess the flow behaviour prior to the construction of the canals of EMV. This used the terrain data captured at the commencement of the study and the area of EMV was replaced with survey data from prior to its construction. Areas of fill that had occurred since the 1999 flood event were removed and returned to an approximation of the pre-development terrain.

The hydraulic model found that flow would approach the investigation from the upland slopes with speed and intensity. It was generally contained in defined channels until it reached the lowlands behind the coastal dunes. Here it would pond and slowly discharge to the Exmouth Gulf via a number of breakouts through the coastal dune system.

The hydraulic modelling suggested that the amount of storage behind the coastal dune system was significant when compared to the quantity of floodwaters flowing off the catchment. The area behind the dunes was able to fill and cater for the volume of a large flood without impacting on the existing Exmouth townsite. Here it would remain stored unless a breakout was available. This was an important finding in the hydraulic modelling as it meant that this land is critical as it could be set aside as it provided a large detention area, thus buffering the townsite from flooding.

The hydraulic modelling found that the flow patterns of the investigation area had been greatly modified by recent development. The drainage of the LIA, Marina and Market Street Creeks previously flowed to the Exmouth Gulf via the Exmouth Boat Harbour after ponding behind the coastal dunes. This area has subsequently been developed into the canal estate of the EMV and has been engineered to reduce the flow into the canal system through a bund diverting the Market Street catchment and walls on the western face of each canal, facing Murat Road. The EMV canal system and a bund between the Market Street Creek and the Marina Creek catchments have been constructed subsequent to the large floods and have yet to be tested by major flooding.

Development in the Light Industrial Area was found to encroach onto the LIA Creek floodplain with the area experiencing shallow and rapid flooding. This is exacerbated by low capacity culverts on Reid Street, upstream of the LIA, which causes overtopping of roads and passing floodwaters down roads rather than inside defined floodway channels and protective bunding.

The outputs of the Existing Case hydraulic modelling for the 10, 25, 100 and 500 year ARI events are shown in Appendix A. The 100 year ARI inundation mapping for the Pre-Canal Case is also shown in Appendix A.

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4. Effectiveness of Current Floodplain Management

Previous assessment of development on the floodplain in Exmouth has been based on historical flooding. Previous investigations had quantified the discharges of catchment flow around the townsite and in the LIA Creek and Market Street Creek catchments. Limited work has been done in areas to the north and south of this general area.

Regional scale hydraulic modelling of design flood events had not been done. Therefore, there was a limited understanding of how various elements of the floodplain interact.

This Section discusses previous floodplain management investigations and the flood mitigation measures that have arisen from those studies.

4.1 Previous Studies

Two investigations currently guide Council in floodplain development in Exmouth:

1) *Exmouth Flood Management Study* (JDA Consultant Hydrologists, 1999)
2) *Review of Exmouth Flood Management Study – Assessment of June 2002 Flood Event* (JDA Consultant Hydrologists, 2002)

4.1.1 Exmouth Flood Management Study (JDA, 1999)

This flood management study was triggered by the flooding impacts experienced by Cyclone Vance. The study objectives were to:

- Identify drainage catchments within the townsite;
- Document and map areas of the townsite inundated by surface water during Cyclone Vance;
- Estimate 100 year ARI rainfall, flow rates and potential inundation areas in the townsite;
- Develop flood management options;
- Assess flood risk within the townsite given existing drainage infrastructure and future development proposals; and
- Develop a recommended flood management strategy.

The study reported issues with the current drainage scheme along Preston Street where residences were flooded in the Cyclone Vance flood event. It also reported that the drainage along LIA Creek was inadequate and required further consideration to avoid flooding of the Light Industrial Area.

The study considered the then proposed development of the EMV and the expansion of the Light Industrial Area to the south of Welsh Street.

Flood mitigation options were proposed on the basis of anecdotal flood records projected onto a coarse terrain model. No regional hydraulic modelling was done to validate existing flood hazards or the benefits of the proposed measures.

Figure 4-1 is extracted from the JDA (1999) report showing the proposed flood mitigation measures. The Study investigated options for:

- Detention basins;
- Additional ocean outlets; and
- Constraints on floodplain development

The recommended strategy for the investigation is summarised below:

Floodway Designation

Designated floodways in accordance with Figure 4-1 with flood impact assessment required for development in the floodways.

Flood Protection Bunds

Flood protection bunds to:

1) Preston Street Creek catchment to protect residential properties of Preston Street
2) LIA Creek catchment along Griffiths Way to protect the Light Industrial Area
3) Marina Creek catchment in the area of Welsh Street and Koolinda Way to protect existing development
4) No additional bunding in Town Creek, Market Street Creek or Quarry Creek with natural breakout flows to continue.

Flood Channel Maintenance

Regular maintenance of existing channels with the removal of sediment deposited from large events.

Flood Detention Basins

Detention opportunities considered to be limited if the intention was to mitigate large floods. The EMV canal development proposed compensatory storage upstream of Murat Road for small rainfall runoff events.

Ocean Outlets

Maintenance of the existing ocean outlet recommended and additional outlets considered after maintenance of the strategy.

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Monitoring

The strategy was to be monitored subsequent to future flooding events.

Funding

Funding to be sought for clearing of creek channels in developed areas.

4.1.2 Review of Exmouth Flood Management Study – Assessment of June 2002 Flood Event (JDA, 2002)

This report arose after the June 2002 flood event which damaged boats in the Exmouth Boat Harbour and caused some minor property impacts. The scope of the works of the review was:

- A site inspection to identify the extent and severity of flooding for the June 2002 event, and recording of debris levels and their location;
- Comparison of the June 2002 event with previous significant flood events in March and May 1999;
- Comparison of the June 2002 event with the estimated 100 year ARI flood estimates in JDA (1999); and
- Based on the outcomes of the above analysis, review the recommended flood management strategy of JDA (1999)

The review found that the rainfall event of June 2002 approximated the 100 year ARI, 24 hour rainfall depth and the maximum 12 hour rainfall depth exceeded the 100 year ARI, 12 hour rainfall depth.

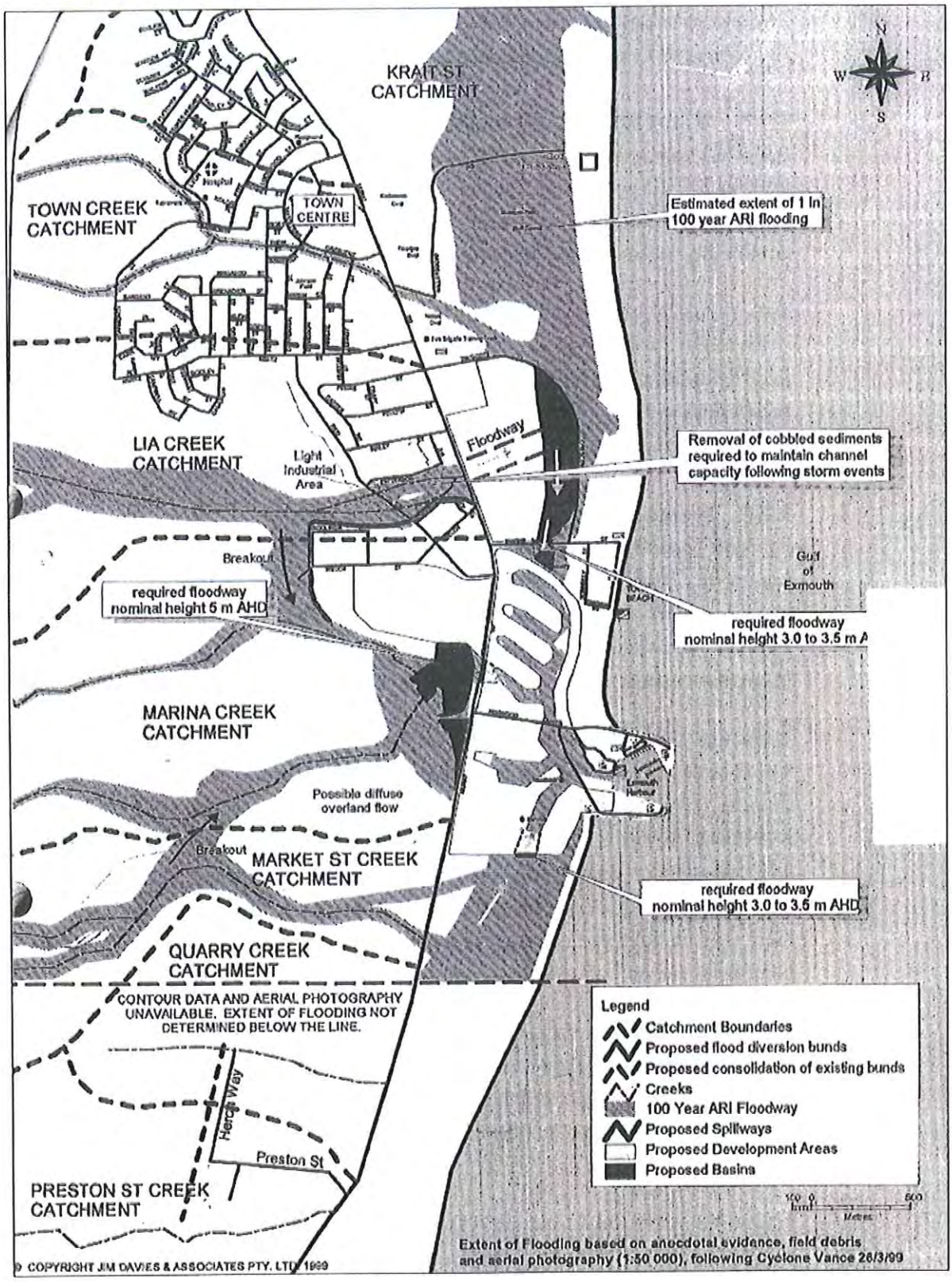
The June 2002 event occurred independently of a storm surge which increased discharge velocity through the Exmouth Boat Harbour that damaged moorings and vessels. The anecdotal evidence of flood behaviour and extent was recorded as being similar between the 1999 and 2002 events despite the 2002 event being almost twice the runoff volume. A new outlet to the Exmouth Gulf formed south of the Exmouth Boat Harbour during the event (McLeod Street Breakout).

The revised strategy extended designated floodways based on recorded flooded extents. It recommended that the new ocean breakout be maintained and advised that the proposed compensatory storage basins associated with the canal development had been deleted from the canal design planning.

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- Figure 4-1 JDA (1999) Proposed Flood Management Measures



4.2 Existing Floodplain Development and Management Measures

The site investigation and hydraulic modelling identified existing floodplain development and flood mitigation measures that are considered worthwile and these are discussed below:

4.2.1 Murat Road Causeways

All of the catchments of the Cape Range drain across Murat Road via causeways. As discussed in Section 2.4, the permanent residents of Exmouth are familiar with the flooding in the area and are aware that runoff events cut Murat Road. However, this is possibly not the case with tourists or community members who frequent the area outside the rainfall season.

This investigation was undertaken to understand the limitations to development to the south and north of Exmouth townsite. As development extends to the north and south it will further isolate itself from the services of the town including emergency care. Therefore, development should be undertaken with awareness of this limitation and causeways may have to be replaced with bridges or culverts to lower the frequency and duration of road closure.

4.2.2 Market Street Bund

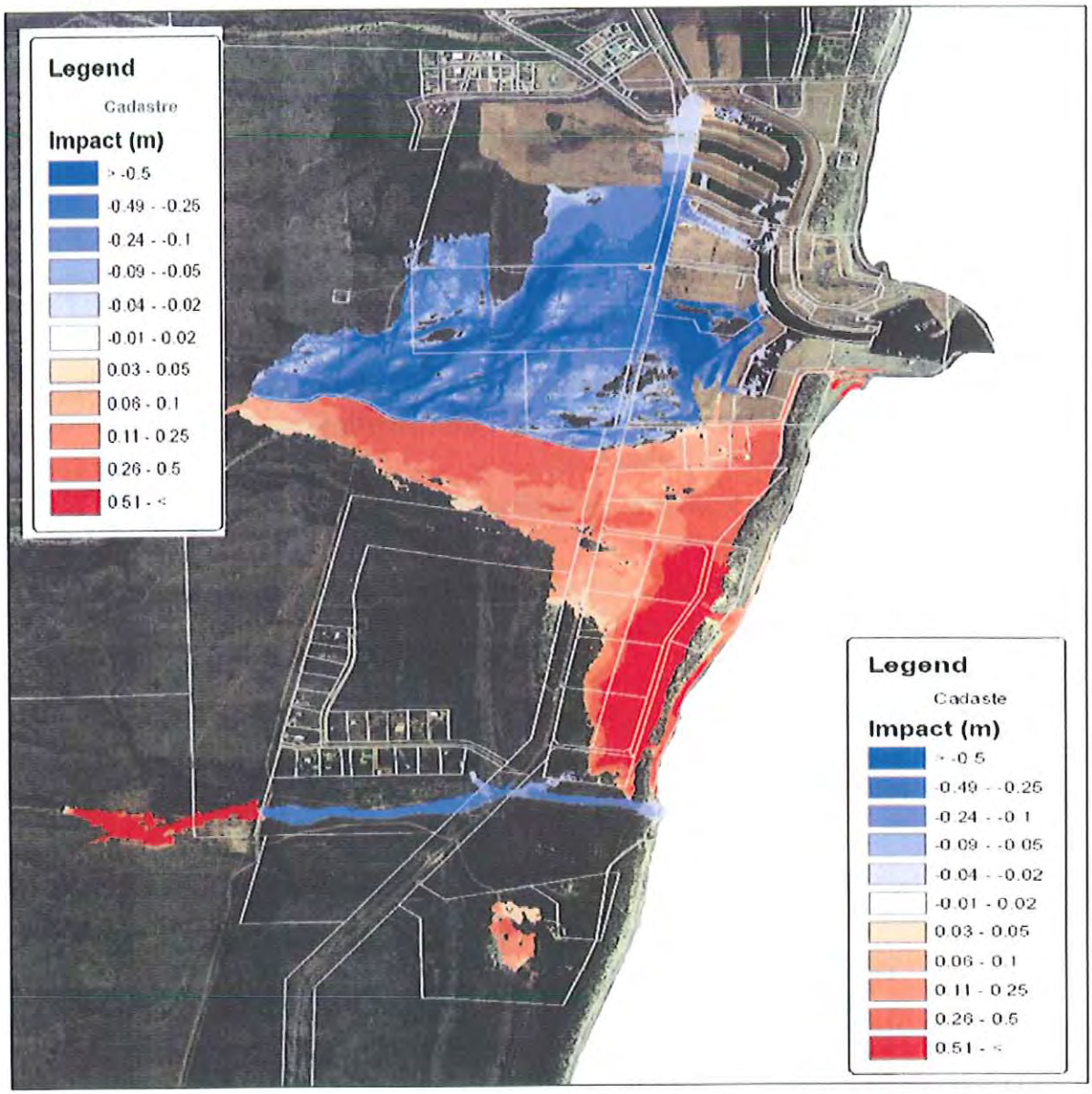
An earth levee was constructed on the ridge separating the Market Street Creek and Marina Creek catchments after the June 2002 flood event. This was constructed on the recommendation of Landcorp (pers. comm. Keith Woodward, ESC, 2006). The intent of the design appears to be to stop the interconnection of the Market Street and Marina Creeks in larger flow events and thus lessen the quantity of flow towards the EMV and through into the Exmouth Boat Harbour.

Initial runs of the hydraulic model found that the bund was very effective at diverting flow that would have otherwise passed into Marina Creek. However, the subsequent impact of this is to increase flow and the level of flooding south of the Exmouth Marina Village and around existing residences. It was also found that the bund was unlikely to cope with a 100 year ARI flood event as it was not high enough and would be overtopped. The quality of the material or the design / construction was not assessed and design information could not be supplied by Council. Therefore, there was a heightened risk that the failure could cause increased flooding problems downstream if a failure occurred.

Through discussions with the Department of Water and Council, it was decided that the bund was an unacceptable floodplain management practice due to the impact it would have on existing residential developments and the limited benefit that it provided existing flood affected areas. Therefore, it was agreed that the bund should be considered not to be in place in the "Existing Case" scenario.

Figure 4-2 shows the difference in flood levels caused by the Market Street bund. Areas in red show where flood levels have increased and the degree of increase is shown in the legend.

Figure 4-2 Impact of the Market Street Bund on Q100 Flood Levels



The Figure shows that the bund dramatically reduced flood levels north of the structure and all the way through Marina Creek and to the EMV. The Figure shows that south of the EMV, the Market Street bund pushes flood levels up by more than 500mm and has increased flood levels at existing residences by 100 to 250mm.

During the course of the investigation, the residences affected by the bund were demolished and the land was subject to development conditions that would require the land to be filled. On this basis, the Market Street bund was considered as a flood mitigation measure in the "Developed Case" and this is discussed in Section 5.4.6.

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4.2.3 EMV Canal Development

EMV canal development has involved extensive filling of an area of floodplain storage behind the coastal dunes. The filling has occurred without providing compensatory storage for floodwaters and the canal spillways have not been designed to provide adequate conveyance to pass all of the flow previously passing through the original breakout into the Boat Harbour. The JDA (1999) discusses a southern spillway and upstream detention storage for the EMV however these measures have not been included in the development construction.

Hydraulic modelling found three key elements of the EMV development needed further consideration and mitigation:

1) EMV development forces floodwaters from the LIA Creek to flow south down Murat Road at high velocity where it previously passed directly across the road and flowed out of the Exmouth Boat Harbour;
2) EMV development increases flood levels south of Market Street and in areas of existing development; and
3) EMV development is not constructed to a level that will provide 100 year ARI flood immunity in the Existing Case – that is assuming the Market St bund will fail.

The EMV has resulted in a concentration of flood flows and higher peak discharges and water levels through the Exmouth Boat Harbour. Table 4-1 compares the peak discharge from the Q100 flood at various locations around EMV before and after development.

Table 4-1 Changes in 100 year ARI Peak Discharges Due to EMV Development

Location	Peak Discharge Pre-Canals (m^3/s)	Peak Discharge Existing Case (m^3/s)
Flow over Madaffari Drive to the Exmouth Boat Harbour	13.2	15.9
Exmouth Boat Harbour ocean outfall	142	218
Flow southward along Murat Road	N/A – flow crossed Murat Road	26.3

Prior to the EMV development, the floodwaters of LIA, Marina and Market Street Creeks and some of the floodwaters ponded from Town and Krait Street Creeks would pass through a main breakout to the Exmouth Gulf via the Exmouth Boat Harbour. Before it could pass through the Exmouth Boat Harbour, it would fill low-lying land behind the coastal dunes which provided flood detention storage, lessening the peak discharge.

The filling of the floodplain area has impacted on the flooding regime as now floodwaters must enter the canals before they can flow through the Exmouth Boat Harbour. There are only two points of ingress to the canals. These are:

1) A constructed spillway on Madaffari Drive; and
2) A constructed spillway on Murat Road

A third spillway proposed to the south of the canals in JDA (1999) does not appear to have been considered in the design and has contributed to higher flood levels south of the EMV.

The spillway on Madaffari Drive was found to be adequate to pass a flow discharge similar to the Pre-Canals scenario. Prior to development, water ponded north of Warne Street from the LIA and Town Creeks. It would flow generally across a broad length of Warne Street to the Exmouth Boat Harbour. However, the discharge was limited because the controlling elevations of the outlet to the Exmouth Gulf were high. With the constructed spillway, the flow is concentrated to a narrow spillway into the canals, passing a similar peak discharge.

It is important to note that the spillway will drain water ponded behind the dunes for the length up to the Northern Breakout. As discussed previously, this storage zone is very large and can hold almost the entire volume of the 100 year ARI flood event. The spillway has only a small capacity and thus, it is possible that it will flow for much longer than the causeways on Murat Road. Therefore, there is the potential to isolate the community of the new canal estate from town for a lengthy period if this road is the only point of egress from the residential area.

The flood modelling found that water breaks out from the LIA Creek and flows down Reid Street and through the Light Industrial Area. This water cannot enter the EMV without flowing south down Murat Road to the southern spillway. The 100 year ARI flood event will flow down approximately 500m of Murat Road at a high velocity and would cause damage and scour. In the lesser 10 year ARI event, it was still flowing with damaging depth and velocity. Therefore, consideration would need to be made to resolve this. Mitigation options were developed to limit the flooding out of the LIA Creek catchment and an assessment was made of how long Murat Road might be cut by flooding and how often and how long it would take to be repaired to a serviceable standard after flooding has subsided.

Figure 4-3 shows the impact predicted for the 100 year ARI flood event due to the EMV development.

The hydraulic modelling also showed that the EMV development level is too low if the Market Street bund failed during the 100 year ARI flood event. The southern area of the EMV is most susceptible to flooding and areas to the north have inadequate freeboard to the constructed levels.

To the south of the EMV, floodwaters from the Market Street catchment cannot flow into the EMV and Boat Harbour as they did in the Existing Case. A spillway proposed in the designs presented in JDA (1999) was not constructed. The flooding is forced to the south and it directly impacts on existing dwellings and land. This floodwater has no egress to the Gulf except through dune breakouts further south. The impact of this is well represented in the hydraulic modelling however it is likely that broader environmental impacts will occur due to this increased flow causing a change to the geomorphology of the dune breakouts south of the EMV. These impacts have not been assessed in this study.

All the three EMV development impacts required thorough assessment to undertsand how they could be managed and mitigated.

4.2.4 Filling of Floodplain North of EMV

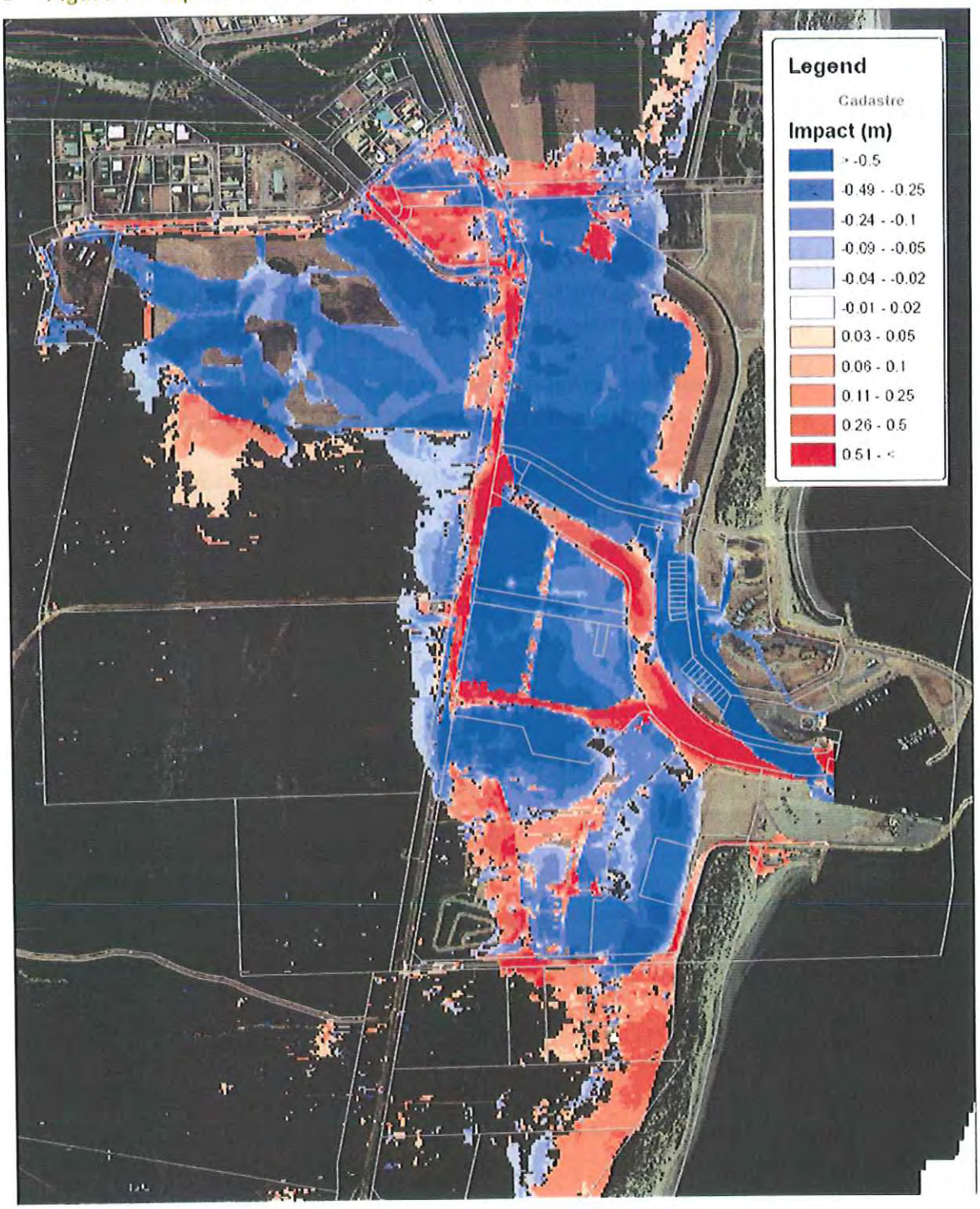
Future development was planned for land north of EMV and east of Murat Road. Filling had commenced at the time of the study. As discussed previously, this is an area that was very important as it provides flood storage behind the coastal dunes. If this filling activity continues, it will remove floodplain storage and concentrate flows and increase peak discharges similar to what has been experienced at the mouth of the Exmouth Boat Harbour due to the EMV development.

4.2.5 Filling in the Marina Creek Floodplain

Fill was placed on the floodplain of a creek that forms a part of the Marina Creek floodplain, south of Welch Street. This area previously conveyed the flood flow of this small creek and breakout flow from the LIA Creek. Channel works may be required to give this channel definition and to convey the water more effectively to the Exmouth Boat Harbour. At the time of this study, the flows from Marina Creek will run into, and along, the edges of the fill. In the absence of any channel works, it is recommended that scour protection of the affected edges (particularly in the south west corner) is carried out to prevent the erosion of this imported fill.

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- Figure 4-3 Impact of the EMV Development on Regional Q100 Flood Levels



4.3 Summary of Findings

A review of the previous studies shows that the Council's current floodplain management planning was focussed on managing existing flooding problems. Council has previously focussed development on the higher land west of Murat Road and away from creeks and this had avoided flood damages from significant flood events. Current planning and ongoing development has begun to encroach on the natural flooding regime and thus flooding impacts are likely, as shown in the hydraulic modelling.

To date, floodplain management planning has been undertaken on the basis of anecdotal flood records of recent significant flood events. No hydraulic modelling has been done to validate the hydraulic impacts of development and quantify impacts at a regional scale.

Existing floodplain management practices has been founded on sound principles and objectives except for the development of the EMV and the Market Street bund.

In summary, Council has been successful in avoiding flood damages through controlled development however, as development pressure of the waterways and the floodplains increase, so will the level of assessment required to manage flood impacts increase. The EMV and Market Street bund are recent developments and have not been tested by floods.

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5. Options for Floodplain Management

Floodplain management measures can be broadly categorised into four categories as described in SCARM73 and summarised in Table 5-1.

Table 5-1 Summary of Available Floodplain Management Measures

Floodplain Management Measure	Description	Appropriate for
Non-Structural Measures		
Land use planning	This non-structural measure was accepted as being the most cost effective through controlling development on flood prone land. Aspects of this measure includes: ▪ Incorporate land use planning for floodplain management into statutory planning instruments; ▪ Voluntary land acquisition in more hazardous flood areas ▪ Assess the cumulative regional impact of developing areas of floodplain rather than ad-hoc assessment of individual developments	Planning for future development and fixing existing problem areas where voluntary acquisition can occur.
Development and building controls	This non-structural measure encourages planning construction methods that reduce the likelihood of permanent damages to properties. Measures include: ▪ Appropriate siting of dwellings and planning for road corridors to support evacuation and flood mitigation; ▪ Encourage construction methods appropriate to flood prone lands; and ▪ Consider the introduction and certification of flood proofing of individual dwellings	Planning for future development and fixing existing flooding problems if dwellings can be flood proofed after initial construction.
Flood emergency response plans	Flood emergency response plans accept that there is a residual flood risk and plans for appropriate response and recovery. This measure requires the development of a flood emergency response plan complimentary to this floodplain management plan and with consideration of flood events up to the probable maximum flood.	Planning for existing and future development.
Structural measures		
	Structural measures need to be developed with consideration that, unless designed for the probable maximum flood, they may eventually be overwhelmed. When this occurs, they may exacerbate flooding problems rather than alleviate them. Structural measures need continuous maintenance and upkeep and, therefore, must be accepted as an asset by the Council and managed as such. Such measures include: ▪ Levees; ▪ Detention basins; and ▪ Diversion channels	Planning for future development and fixing existing flooding problems.

This Section outlines the objectives of the floodplain management plan and the methodology used to develop floodplain management options. It discusses the existing flood hazard and the relative effectiveness of the mitigation measures that have been considered.

5.1 Objectives for Floodplain Management

SCARM73 set out four principal objectives to floodplain management:

1) Limit the impacts of existing flooding problems on the well-being of individuals to acceptable levels;
2) Limit the property impacts of existing flooding problems to acceptable levels;
3) Preserve, and enhance where possible, the natural function of the floodplain to convey flood waters and/or sustain flood dependent ecosystems;
4) Encourage the compatible planning and use of floodplains as a resource for the use of the whole community.

These objectives were adopted for this investigation.

5.2 Assessment of Existing Flood Hazard

The development of floodplain management options was guided by SCARM73 and the Department of Water.

SCARM73 recommended that flood hazard should be considered as a function of flood depth and velocity as well as considering the ability to evacuate populated areas. Figure 5-1 schematises the SCARM73 flood hazard categories. The assessment of flood hazard by this method required that the flood depth and velocity be known throughout the investigation area and the combination of the results were assessed against the graph to give the relevant hazard category.

The following Table 5-2 described the typical flow conditions associated with each hazard category as defined by the SCARM73 report.

The WA Department of Water has provided their recommended floodplain development strategy which is shown on Figure 5-2.

Figure 5-1 SCARM73 Flood Hazard Categories

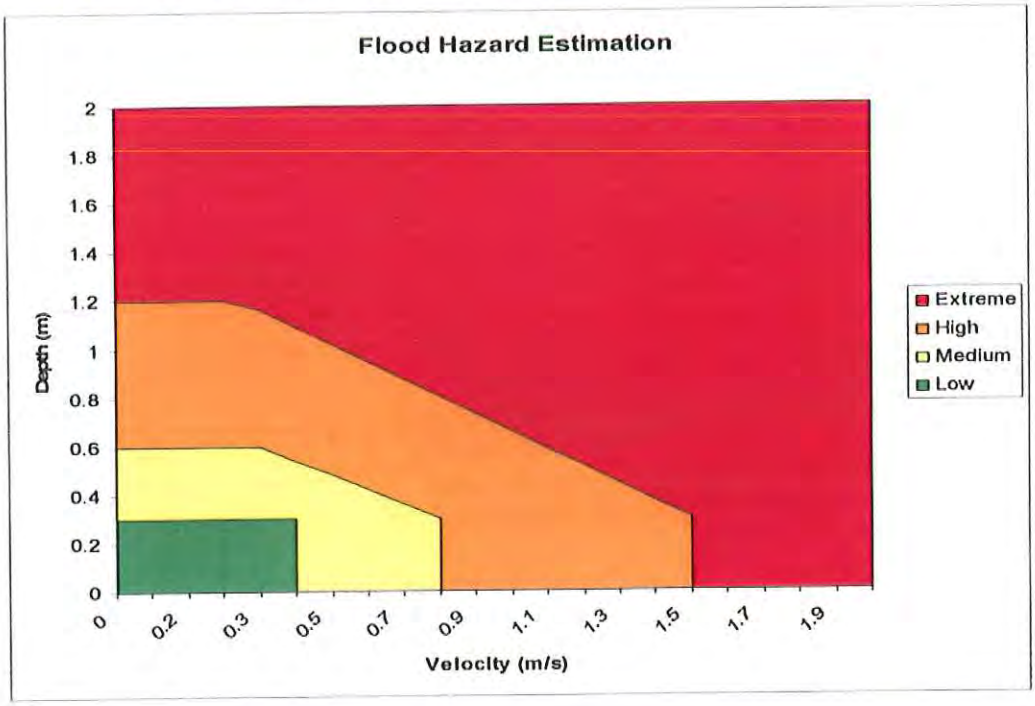
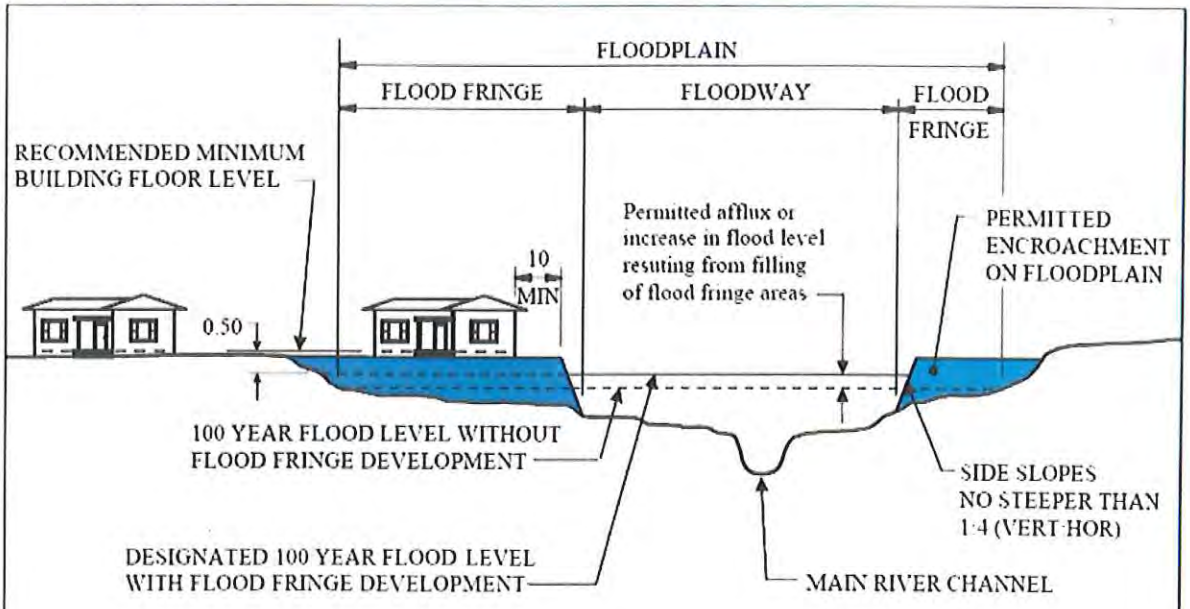


Table 5-2 SCARM73 Hazard Category Descriptions and Appropriate Land Uses

Hazard Category	Description	Appropriate Land Uses
Low	▪ No significant evacuation problems with short evacuation distances. ▪ Children and the elderly can wade safely. ▪ Evacuation is possible in a small sedan vehicle. ▪ There is ample time for flood warning and flood forecasting and evacuation.	▪ All including residential and commercial. ▪ Emergency services. ▪ Communication facilities.
Medium	▪ Fit adults can wade safely but children and adults may have difficulty. ▪ Evacuation distances are longer. ▪ Maximum flood depth and velocities are higher. ▪ Evacuation by small sedan type vehicle is possible in the early stages of flooding after which 4WD vehicles are suitable.	▪ Residential and commercial ▪ No emergency services.
High	▪ Fit adults can wade with difficulty. ▪ Flood depths are up to 1.0m and velocities exceeding 1.5m/s ▪ 4WDs and trucks are the only vehicles able to evacuate. ▪ Boats and helicopters may be required. ▪ Evacuation routes remain trafficable only up to the minimum time.	▪ Open space ▪ No residential. ▪ Commercial and industrial with acceptance of flood risk as a "business risk" ▪ Club houses with appropriate protection.
Extreme	▪ Boats and helicopters are required for evacuation. ▪ Wading is not an option. ▪ Flood depths exceed 1.0m and velocity exceeds 1.5m/s	▪ Open space ▪ Club houses with appropriate protection

Figure 5-2 Department of Water Recommended Floodplain Development Strategy



GENERAL NOTES

1. Development (ie. filling, building, etc) that is located *within the flood fringe* is considered acceptable with respect to major flooding. However, a minimum habitable floor level of 0.50 metre above the adjacent 100 year flood level is recommended to ensure adequate flood protection.

2. Development (ie. filling, building, etc) that is located *within the floodway* and is considered obstructive to major river flows is not acceptable as it will increase flood levels upstream.

A hydraulic assessment of the existing flood hazard was required to understand how flood risks affect the investigation area. This was needed before assessing options for floodplain management and flood mitigation.

The hydraulic model of the 100 year ARI flood event for the Existing Case was used as the basis of a flood hazard assessment and development of options for floodplain management. The model results were tested using the flood hazard estimation techniques outlined in SCARM73.

Flood hazard mapping was generated from the hydraulic modelling results using the project Geographic Information System (GIS). The GIS analysis is based on the results of 100 year ARI peak flood depth and velocity. This is a conservative analysis because it assumes that peak flood depth is coincident with the peak flood velocity. Experience with using this methodology has found that it does not exaggerate flood hazard and gives sound results.

The area of the EMV raised some concern because of its risk of isolation during flooding. The only road access was severed by a causeway and pedestrian access was limited due to floodwaters flowing southwards along Murat Road.

Appendix B contains the output from the flood hazard assessment.

5.3 Comparison of Existing Flood Hazard and Development Planning

Council's current land use planning was compared to the flood hazard mapping. It identified a number of conflicts between current planning and the existing flood hazard through the investigation area and is discussed in this Section.

5.3.1 Krait Street Creek Catchment

The Krait Street Creek catchment experiences flooding but the area currently has no planning for future development. Flood fringe areas and floodways should be defined for in this area before it experiences development pressures.

5.3.2 Town Creek Catchment

The hydraulic modelling results show that shallow flooding is expected through the Town Centre during a large flood event. Flood fringe areas can be suitable for commercial development if owners are willing to take the flooding risk as a business risk. The modelling shows that flooding can occur through areas designated as Town Centre and retailers and Council should make suitable plans for flood protection to protect town assets.

Flooding is expected to occur in an area of existing residential development downstream of Learmonth Street on Town Creek. This needs to be addressed in floodplain management. Downstream of this is an area of land designated as residential that was not developed at the time

of this investigation. This area should be developed with caution and should be tested for regional flood impacts.

5.3.3 LIA Creek Catchment

Upstream of Reid Street, the high hazard areas are confined to areas proposed for public open space. There are also areas susceptible to inundation of low and medium hazard that are proposed for future urban. If this is to occur, these areas will require careful modelling to ensure that flood impacts are minimised.

Downstream of Reid Street the flood fringe covers the majority of the LIA. Although the floodway appears to cover some of the LIA, this land is not developed. Therefore, this land should be set aside for floodways and not developed.

Overall the LIA Creek catchment should be investigated to examine options to remove or mitigate the existing flood hazard.

5.3.4 Marina Creek Catchment

The Marina Creek catchment flow crosses over to interact with the LIA Creek catchment flow upstream of the existing LIA development. This results in low and medium hazard however the land is zoned for industrial use. Such development needs to be cognisant of the flooding risk and floodplain filling should only occur with careful consideration for regional flooding impacts.

The main channel of the Marina Creek catchment does not align with the area of zoned open space upstream of Murat Road. This area was also being filled at the time of this investigation, thus rendering it unsuitable for the development of a drainage corridor or a diversion. Therefore, a floodway designation should be provided for land zoned future urban upstream of Murat Road to allow for Marina Creek flow.

5.3.5 Market Street Creek Catchment

The Market Street Creek catchment breaks into a number of flow paths that should be taken into consideration in the planning of development in the areas zoned future urban upstream of Murat Road. The area of future urban should be hydraulically modelled to understand the amount of encroachment that can occur into the floodplains without causing regional flooding impacts. Once this is known, land should be defined as floodways.

The areas behind the coastal dunes, downstream of Murat Road, are zoned for long term future urban. Given the findings of this investigation it is more appropriate that this area be set aside for floodplain storage. As a minimum, the areas of high and extreme hazard should be set aside as floodways and filling should not be allowed. This will ensure that the natural function of the area is maintained and unnecessary damage to the coastal dunes and coastal processes does not occur. If development is to occur in the areas of low and medium hazard then it should only be done with

consideration of the impacts on flood levels and with an understanding of broader environmental impacts.

5.3.6 Southern Investigation Area

The existing rural residential areas at the southern extent of the investigation area have housing developed in areas of low and medium hazard. The house floor levels of this area should be considered to ensure that they are immune from 100 year ARI flooding and, if not, measures should be taken to rectify this situation.

5.4 Development and Testing of Structural Mitigation Measures

Structural flood mitigation measures were tested in an attempt to alleviate flooding of existing properties. Some testing was done on the effectiveness of increasing the capacity of the natural breakouts. A summary of the structural measures tested are reported below:

- LIA Creek Improvements:
  - Improved drainage over/through Reid Street culverts to keep flooding in the LIA Creek and to avoid it flowing down Reid Street to Murat Road.
  - Flood mitigation bunding along LIA Creek between Reid Street and Murat Road and improved channel conveyance.
  - Constructed drainage along Reid Street table drain to manage flows overtopping onto Reid Street.
- Murat Road Drainage:
  - Culverts under Murat Road with capacity of the 10 year ARI flood event to manage floodwaters flowing down Reid Street and avoid damaging flow down Murat Road to the canal spillway.
- Widening of McLeod Street Breakout:
  - Lowering and widening this breakout to increase drainage of the ponded area south of the canal developments.
- Alteration of the Northern Breakout:
  - Testing of the sensitivity of the opening of the northern breakout on flood levels in the ponded area behind the coastal dunes.
- Development of a Warne Street Breakout:
  - Testing the impacts of opening a new breakout at Warne Street.
- Market Street Bund
  - A properly engineered levee preventing flow crossing from Market Street Creek to Marina Creek in the 100 year ARI flood event.

5.4.1 LIA Creek Improvements

This mitigation option resulted in improved flooding conditions through the light industrial area by increasing the floodway capacity to the storage available east of Murat Road. Two separate tests were run. One test looked to reduce the flooding through LIA providing partial 100 year ARI flood immunity. The second assessment provided for full 100 year ARI flood protection for the LIA.

The impact of the two options is shown in Figure 5-3 and Figure 5-4

Figure 5-3 shows that the option provides benefit through the target area while increasing flooding in the floodways and in the ponded area. The areas of increased impact do not cause property impacts and serve only to make a minor rise in the ponded level east of Murat Road. Despite this, flooding still breaches the floodway and flows down Reid Street. Although flood levels were reduced along Murat Road, they were still deep and damaging.

Figure 5-4 was more beneficial and completely removes the flooding problems in the Light Industrial Area and along Murat Road. However, the works and associated costs to achieve this are greater than the previous option as it will include works on Reid Street to raise its approaches to the floodway and works on the floodway bunds plus a new bunding system west of the Light Industrial Area.

5.4.2 Murat Road Drainage

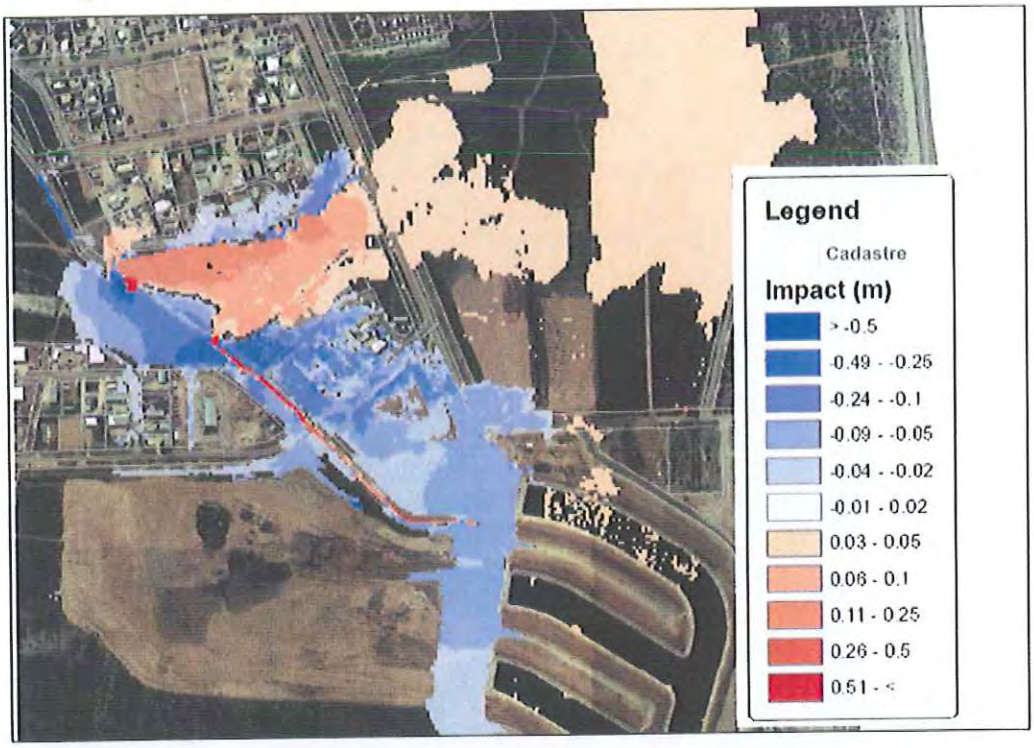
This mitigation option improved drainage out of the Light Industrial Area and delivered it to the EMV with less impact on Murat Road. This option was specifically focussed on drainage in smaller flood events to increase the serviceability of the Murat Road during floods. The impact of the option on the 10 year ARI flood event is shown in Figure 5-5.

The option was found to be effective in reducing the Q10 flooding down Murat Road however the terrain was not conducive to capturing the amount of flow required to make the option totally effective. The option would require the installation of large culverts under Murat Road and into the EMV and this would be an expensive undertaking given that it would now need to be retro-fitted.

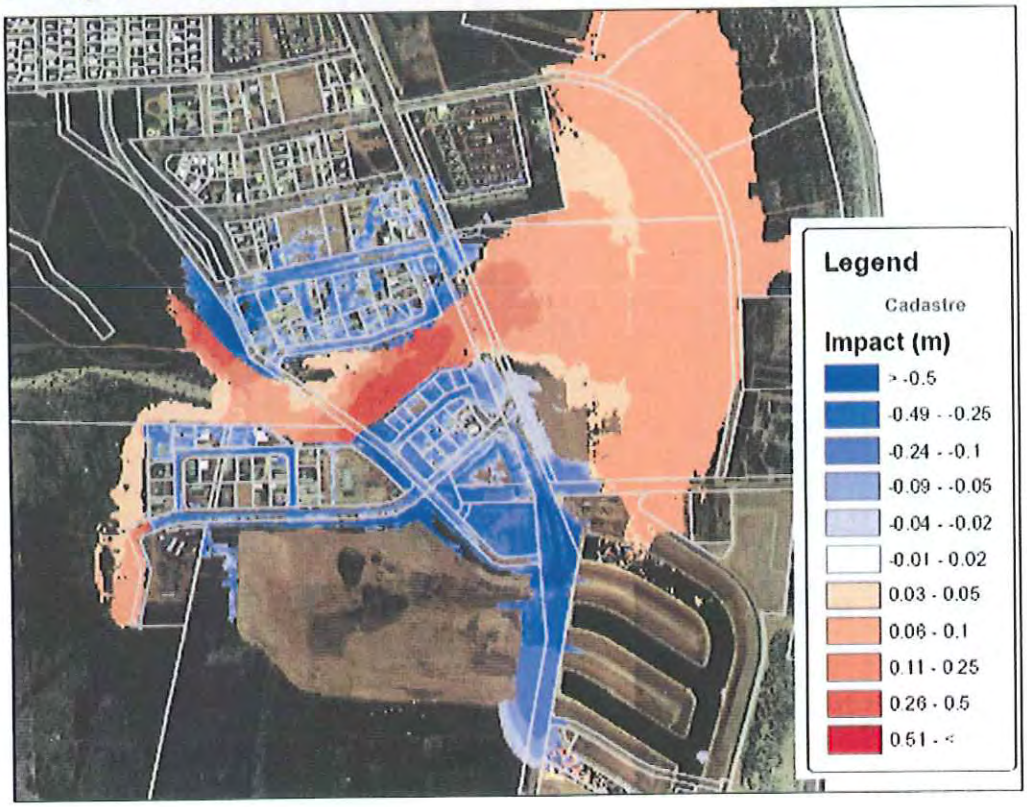
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- Figure 5-3 Impact of LIA Mitigation Option – Partial 100 year ARI Flood Protection

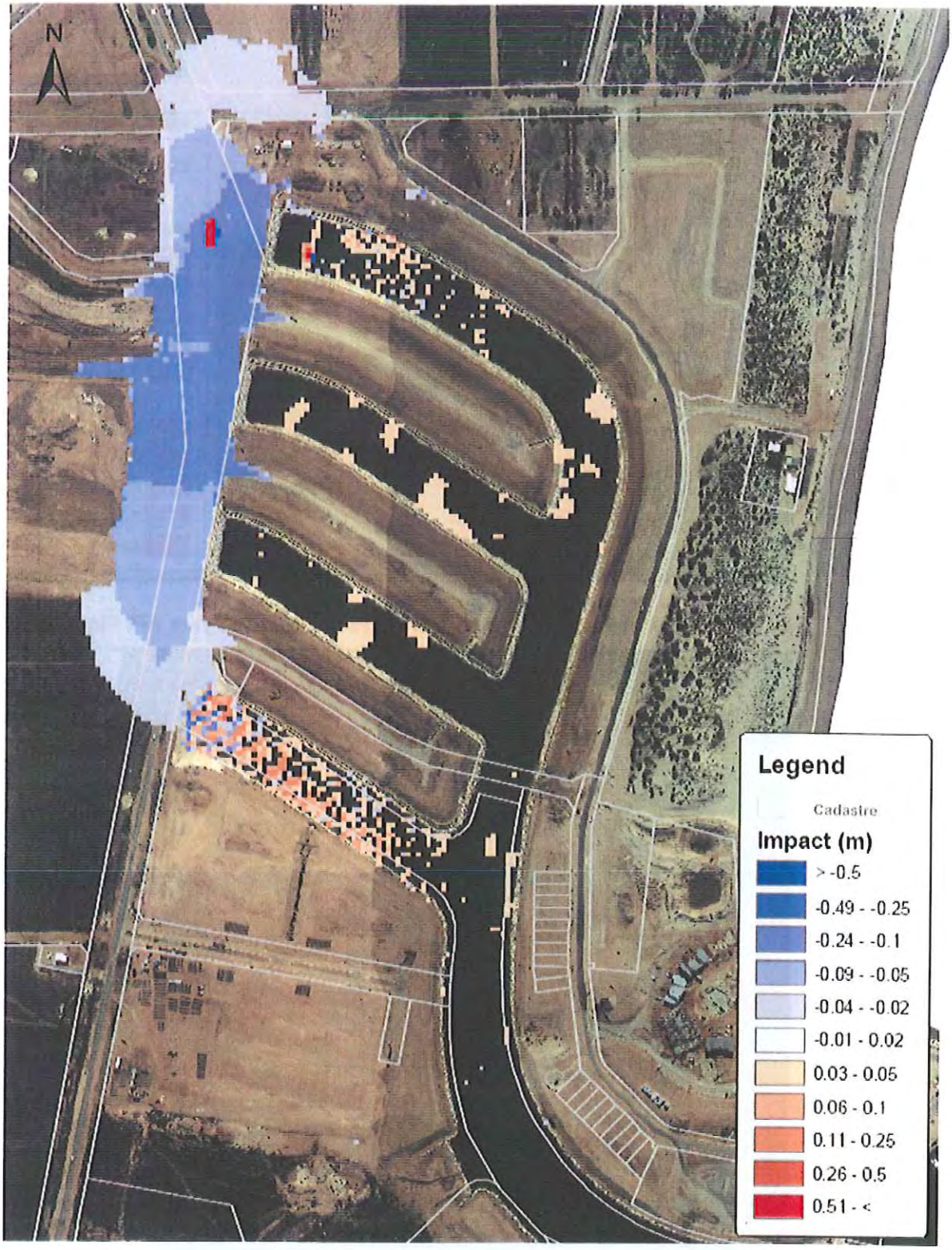


- Figure 5-4 Impact of LIA Mitigation Option – Full 100 year ARI Flood Protection



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- Figure 5-5 Impact of Murat Road Drainage on 10 year ARI flooding



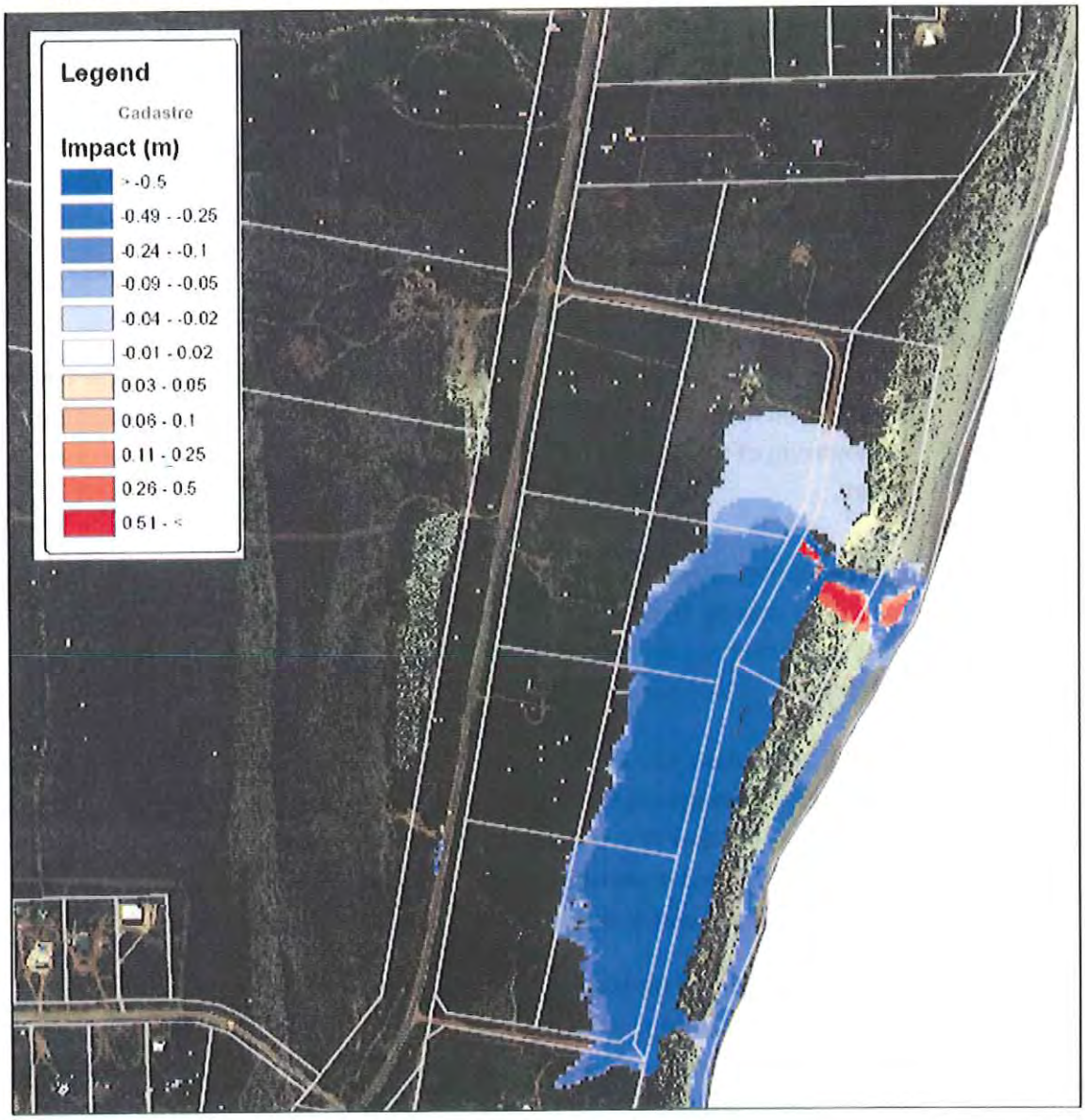
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5.4.3 Widening of McLeod Street Breakout

This mitigation option increased the width of the existing McLeod Street breakout. The breakout width was doubled to 60m. The aim of the option was to provide additional drainage south of the EMV canal development and to mitigate existing flooding in the area. The modelling of the 100 year ARI flood event shows that the option would reduce flood levels generally but because of the size of the storage area, the extent of the inundation did not reduce significantly. It provided limited benefit for the costs involved in maintaining such an opening and benefit did not extend to existing residences affected by the EMV canal development. Figure 5-6 shows the impact of the widening on the regional flood levels.

Figure 5-6 Impact of Widening McLeod Street Breakout on 100 year ARI flooding



5.4.4 Alteration of the Northern Breakout

This option was not tested specifically as a flood mitigation measure. It was assessed during the sensitivity analysis of the hydraulic model to see how the regional flooding responded to changes in the level of the breakout. The modelling found that the flood levels were sensitive to the northern breakout trigger level but this did not affect the inundation extent greatly. The ponded area takes the flow from the LIA, Town and Krait Creek catchments but the volume available in the area was so large that it could store the volume of large floods. Therefore, the operation of the Northern Breakout did not have a great affect on flood levels.

Figure 5-7 shows the impact of altering the northern breakout so that it is completely blocked. Despite the blockage, no properties are affected and the impacts do not extend as far south as EMV.

5.4.5 Development of a Warne Street Breakout

This option tested the construction of a new breakout at Warne Street. The proposed breakout was set to a width equivalent to the road reserve and the level was set at the same level as the Madaffari Drive spillway.

Figure 5-8 shows the impact of the mitigation option. It was found that the option had little improvement to regional flood levels beyond an area that is currently zoned for recreational use. The lowering of flood levels was less than 50mm in this area and in most cases, little more than 20mm.

5.4.6 Market Street Bund

There is an existing levee aimed at preventing Market Street Creek overflowing into the Marina Creek catchment and thus reducing the flow into the EMV. This levee was assessed as being inappropriate as discussed in Section 4.2.2.

Through negotiation with DoW and Council, it was agreed that a levee on Market Street Creek was a suitable flood mitigation measure to test as it would reduce the amount of fill required to develop the EMV. At the time of this study, the construction of the EMV was nearing completion and the Council was required to provide development clearances. Further filling of the development would result in delays and cost to the developer.

The current impact of the bund is discussed in Section 4.2.2. Through discussion with Council and DoW, it was concluded that the bund could be reconstructed to a suitable standard and height and that this could be deemed an appropriate flood mitigation option for the EMV and the land directly north of the structure. It is noted that levees are not considered current best practice in floodplain management however, in this situation, it was considered the only viable flood management option.

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- Figure 5-7 Impact of Closing the Northern Breakout on 100 year ARI Flooding

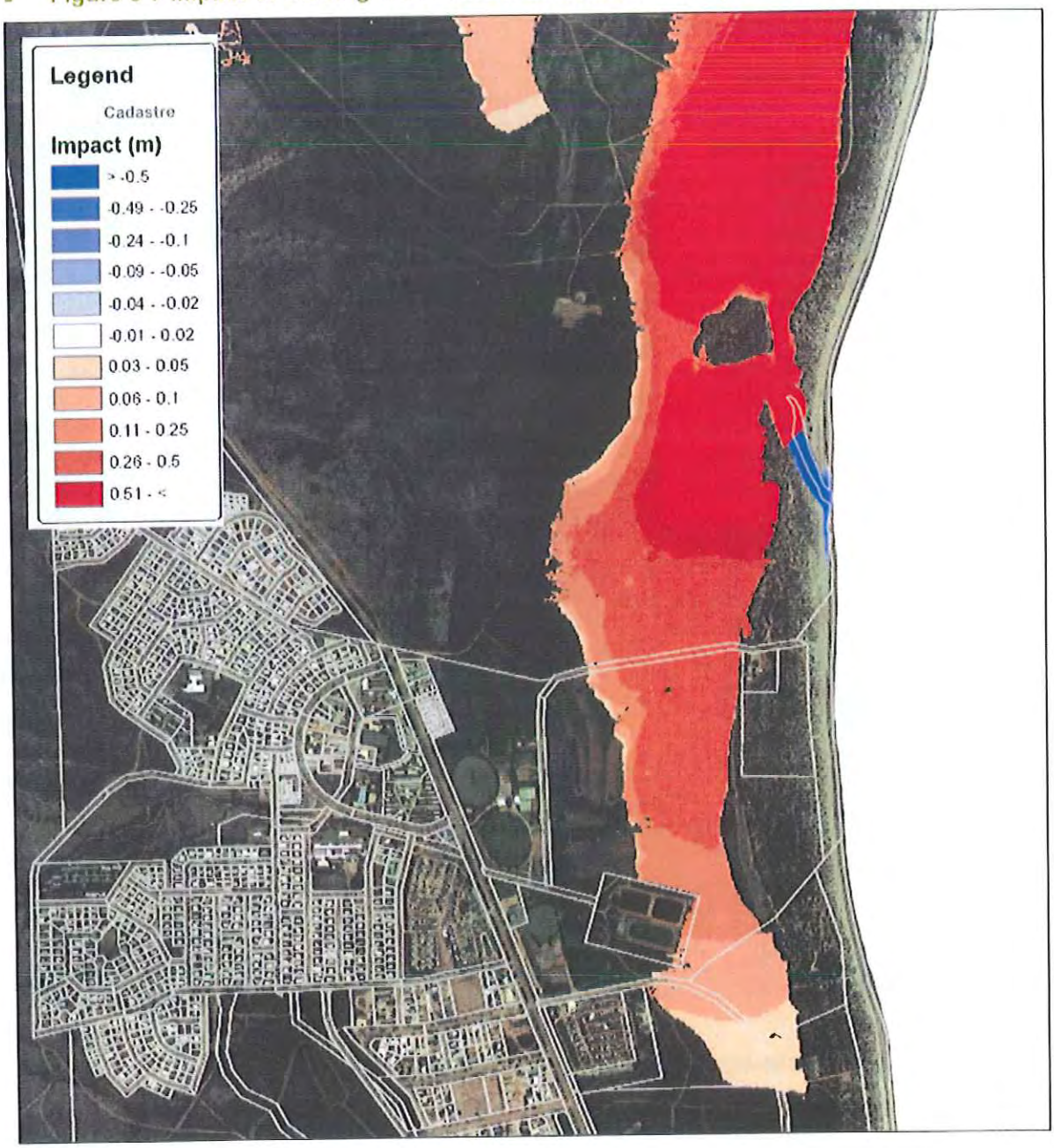
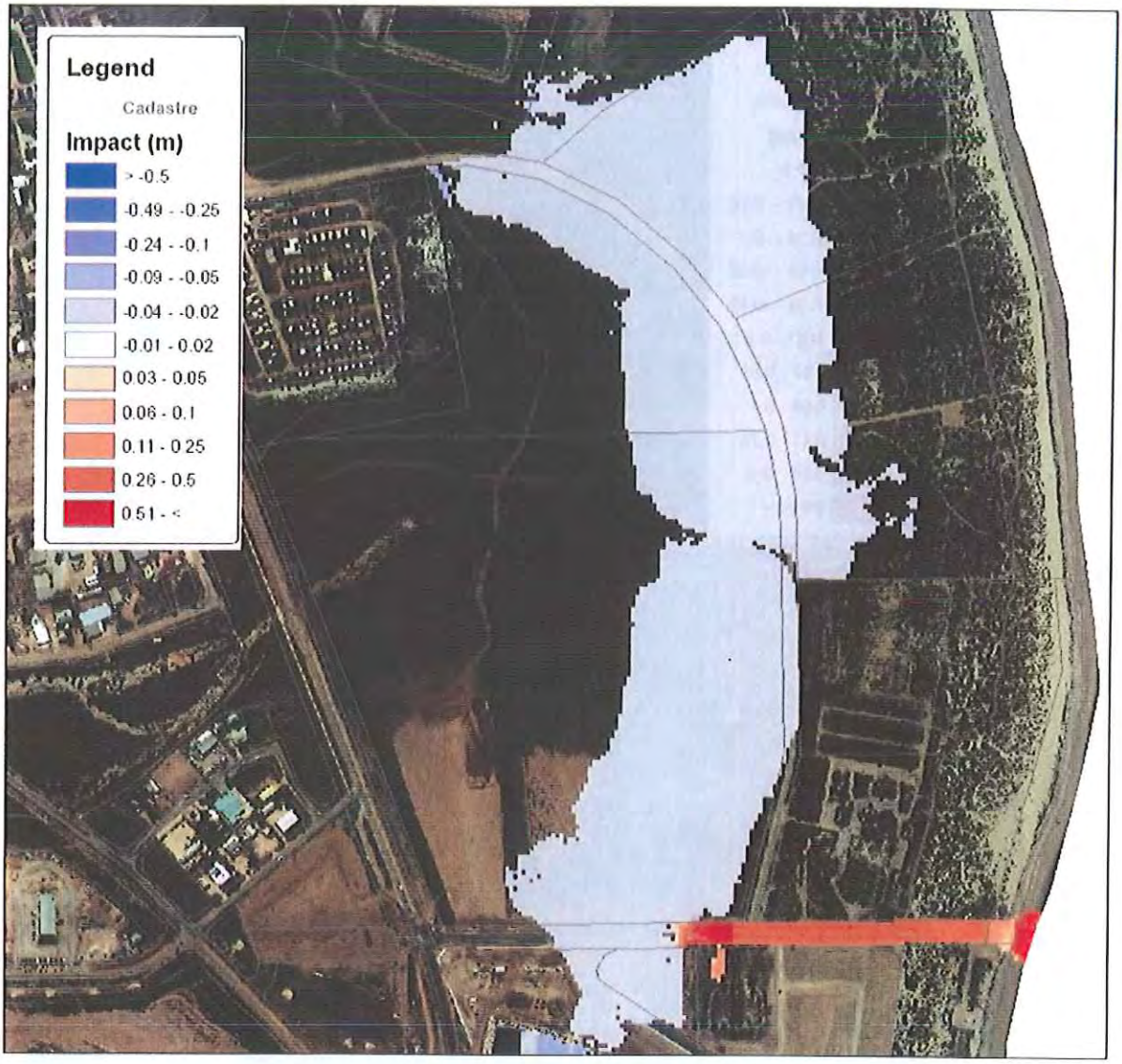


Figure 5-8 Impact of Developing a Breakout at Warne Street on 100 year ARI Flooding



5.5 Non-structural Mitigation Options

5.5.1 Land Use Planning

The raw flood hazard maps discussed in Section 5.3 were interpreted in accordance with the guidance from the Department of Water contained in Figure 5-2.

"Low" and "Medium" SCARM73 hazard categories generally represented areas of shallow floodplain and the fringe of ponded areas and thus, these were used to define "Flood Fringe". It was considered likely that these areas could be filled in a way that it did not impact greatly on regional flood levels however each development application in this zone would require hydraulic assessment.

"High" and "Extreme" SCARM73 hazard categories generally correlated with areas of high conveyance or deep ponded water and these were used to define "Floodway". It was assumed that development in these areas would cause afflux in the surrounding floodplain and therefore development should favour less flood prone areas.

Further assessment of the hazard mapping was required to identify areas isolated by flooding. The raw flood hazard maps for the investigation area are attached in Appendix B.

It is proposed that the flood zones are adopted by Council for future floodplain development planning to provide guidance for land-use suitability. This is discussed further in Section 6.

5.5.2 Building Development Controls

Shallow flooding of the LIA and Preston Street areas was known to have occurred in recent rainfall events. The area of Preston Street is rural residential and the LIA is a mix of commercial, industrial with some residential areas. These areas should be subject to building development controls. All future development in these flood prone areas should be set at 0.5 m above the 100 year ARI flood levels described in this document. Opportunities should be sought for the voluntary raising of the affected residences to be above the 100 year ARI flood level.

5.6 Assessment of Flood Management Options

5.6.1 LIA Creek Improvements

Of all of the options, the greatest benefit comes from providing improvements to the drainage and existing protection measures in the LIA Creek catchment. If the bunding along LIA Creek is improved along with the drainage and drainage structures under Reid Street, it would remove the majority of the flooding problems through the LIA and mitigate the impacts of the EMV on Murat Road.

Further, if the flow is contained in the channel, the water would be delivered to the ponded area behind the coastal dunes and not down Reid Street to the EMV. By doing this, the mitigation measure uses the natural storage behind the dunes to offset regional flooding impacts.

5.6.2 Murat Road Drainage

This option provided limited benefit and if the improvements were made to LIA Creek as discussed above (Section 5.6.1), this option would not be necessary. The construction of drainage under Murat Road would be expensive and costly to maintain.

5.6.3 Construction or Altering of Breakouts

Two options were tested for the altering of existing breakouts; closing the Northern Breakout and widening McLeod Street Breakout. One option was tested for the construction of a new breakout at Warne Street.

The action of the breakouts is a natural process and they will open and close through climatic and coastal cycles. The maintenance of a breakout will be expensive and an ongoing cost for Council as the natural coastal wind and tide action deposit new material onto the coast. The maintenance of breakouts is a common flood mitigation measure for coastal communities however it should be avoided if possible as it is direct interference with a natural process.

The hydraulic modelling found that the volume of the floodplain in the storage area behind the coastal dunes was very large when compared to the volume of 100 year ARI flooding. Further, the flow capacity of the existing breakouts, based on bed invert and channel width, was much less than the inflow rates coming off the catchments. In all, this balanced out and the modelling found that increasing the breakouts' conveyance capacities did little to alter the flood risk to the existing populated areas of Exmouth. The flood effects on the storage area behind the coastal dunes had a clear separation from the effects on flowing floodwaters in the LIA and through the town catchment.

Based on the hydraulic modelling, it is recommended that the natural coastal processes be left in place along the coastal dunes and that the available storage area behind the coastal dunes be left undeveloped to serve that purpose. More suitable land for development is available to the east of Murat Road along the length of the investigation area.

Breakouts could be opened up as a measure to drain water that may become trapped after a flood if breakouts do not reopen. This would reduce the risk of mosquito borne disease after a flood and reinstate the flood storage for subsequent rainfall events. However, ongoing widening and maintenance would be costly for Council unless there was a market that could be established for the sand products and if the appropriate environmental approvals could be gained.

The storage area behind the coastal dunes is a vital element to the management of flood waters in Exmouth and currently provides storage that prevents flooding in the town. The area behind the dunes is a "high" hazard based on the SCARM guidelines and therefore, the area should be set aside for the floodplain and only appropriate land uses should be developed such as passive recreation. No further filling of this floodplain should be allowed to occur as it will reduce the quantity of flood storage and has the potential to impact on the area's habitat values.

5.6.4 Market Street Bund

Through discussion with Council and DoW, it was deemed that the Market Street bund could deliver flood mitigation results that would reduce the development costs of the EMV and allow it to be an approved development. At the time of this investigation, the EMV construction was nearing completion and seeking final development clearances from the Council.

However, it was agreed that a levee would require redesign and reconstruction unless suitable documentation could be produced to evidence that it was of a suitable standard. It was also agreed

that the levee would alter the flow regime and would require that Murat Road be armoured so as to pass floods without damage.

It was agreed that the levee would increase flood levels to the south of the EMV however the land was not developed and Council considered that there were no direct property impacts. It was also agreed that the flow regime of the area would alter greatly and more flow would exit from the McLeod Street Breakout than would have previously and naturally passed through the mouth of the Boat harbour. This is likely to result in the McLeod Street Breakout increasing in size to find a new equilibrium during future flood events.

It was agreed that the primary beneficiary of the bund was the EMV with some secondary benefit in reducing the length of flooding across Murat Road.

5.7 Flood Damages Assessment

A flood damages assessment was undertaken to understand the benefits of the various flood mitigation options. A detailed flood damages assessment was not required as part of this project and that was mainly due to the being limited information on flood damage. Fortunately, the town has avoided major damages to date.

The hydraulic modelling has found that flood damages in the LIA and the adjacent roads can be reduced or removed through the construction of the improvements to LIA Creek as discussed previously. This option would also mitigate damages due to the filling of the floodplain for the EMV because it will send floodwaters to the storage area behind the coastal dunes.

However, the construction of the Market Street bund counteracts some of this benefit by increasing flood levels south of the EMV without providing benefit to existing dwellings. It does reduce the length of Murat Road flooded however it will require for the length of Murat Road affected to be structurally formalised into a floodway.

The impact of existing and developed conditions flooding on residential and commercial properties was assessed for the 100 year ARI event. The modelled flood extent and aerial photography were used to manually identify the location of 117 buildings potentially affected by flooding.

Based on the site investigations, it was considered that most of the flood prone properties had a floor level at least 200mm higher than the surrounding terrain and, based on this assumption, approximately 32 properties were deemed to be affected by the 100 year ARI event for the Existing Case.

With the flood mitigation strategies in place, this was reduced to 27 properties however this does not account for the number of properties that would be benefited in the EMV by the reduced flood levels from the market Street bund.

Of the affected properties, a series of commercial buildings to the west of Murat Road near Maidstone Street are inundated with approximately 300mm of water in both the Existing and Developed Cases. Similarly, four residential buildings off Learmonth Rd experience inundation levels of approximately 200mm in both the Existing and Developed Cases.

Five buildings within the LIA area inundated in the Existing Case 100 year ARI event are no longer inundated in the Developed Case due to the protection provided by flood mitigation works at Reid Street. These works also reduce flows along Reid Street to Murat Road. Under existing conditions water breaks out of LIA Creek and flows approximately 1km down Reid Street. In the Developed Case, only 220m of Reid Street is inundated and water flows over the floodway rather than down the road. Flooding along Murat Road is confined to approximately 220m in comparison with 2 km under the Existing Case.

The upgrade and extension of the Market Street bund increases ponding of water to the south of the EMV where there are several rural properties, currently used as stables.

Further discussion and mapping on the flood damages assessment is contained in the *Flood Modelling Report (SKM, 2007).*

In conclusion, the flood damages assessment found that the mitigation works will provide a reduction in flood damages. The damages reduction will assist to mitigate the impacts of the EMV on Murat Road and will provide flood protection to approximately five industrial properties.

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6. Floodplain Management Strategy

Based on the investigations, a Floodplain Management Strategy is proposed for the Shire of Exmouth. The strategy incorporates both structural and non-structural measures to manage the flooding risks associated with the floodplains of the area.

6.1 Structural Measures

A number of structural flood mitigation measures were adopted. These were combined in a single hydraulic model referred to as a "Developed Case" scenario. The inundation mapping of the Developed Case is included in the appendices.

6.1.1 LIA Creek Improvements

It is proposed that the existing flood mitigation measures on LIA Creek are enhanced. The existing bund system should be raised and extended to control the flooding through LIA Creek and prevent it from flowing down Reid Street to the EMV.

This measure is proposed to avoid the existing minor flooding experienced through the LIA but, more importantly, it is proposed to offset the impact that will occur due to the development of the EMV in the floodplain. The option will prevent large volumes of flow passing at a high velocity along Murat Road that would likely cause significant damage to roads and create a hazard to the community.

6.1.2 Replacement / Upgrading of Market Street Bund

Through discussion with Council and DoW, it was deemed that the Market Street bund could deliver flood mitigation results to reduce the construction and maintenance costs of the EMV. It was agreed that it would increase the flood levels south of the EMV and alter the geomorphology of the McLeod Street Breakout. However, the Market Street bund was deemed necessary by Council to ensure the development clearances for the EMV. Therefore, the Market Street bund was adopted as part of the Strategy.

It is proposed that the Market Street bund be assessed for adequacy. If a review of its design and construction finds that it is inadequate then it should be removed and replaced with a properly engineered structure. It is known that the structure is susceptible to overtopping in the 100 year ARI flood and should be raised to beyond this level as a minimum to avoid failure of the levee and damaging downstream impacts.

The proposed properly engineered bund should convey flood waters across Murat Road and extend east to also protect new development south of the EMV that has been under formal consideration by the Shire and other statutory authorities since 2003.

6.1.3 Murat Road Causeways

Murat Road is the main access to the amenity and emergency services of Exmouth. The road is currently cut by flooding due to a series of low floodways into town. As development extends away from Exmouth, Council must consider the serviceability of these structures in the event of a flood and the population at risk of being isolated from emergency services. Council should plan to replace the causeways with bridges or culverts over time or provide alternative access through higher roads up into the catchments.

Immediate attention will be required for the crossing of Market Street Creek as this area will experience increased flooding with the Market Street bund in place. It is understood that this currently not a designed floodway structure.

6.2 Non-Structural Measures

6.2.1 Land Use Planning

It is proposed that Council adopt the findings of this report and utilise its mapping outputs in future floodplain development planning. Land should be set aside and designated as "floodways" and "flood fringe" in accordance with the mapping provided in Appendix B. This should be done to avoid impacts on existing floodplain residents and to maintain the existing function of the floodplain through the investigation area.

The "Existing Case" mapping should be used as a default for determining flood levels and development controls until such time as the Market Street Bund measures are completed. After that time, the "Developed Case" mapping should be used. In any areas where the "Developed Case" flood levels are greater than the "Existing Case", the Developed Case levels must be adopted as a precautionary measure.

Careful consideration prior to any future development of flood prone land is recommended and the Department of Water should be consulted for the most appropriate controls and land uses for the land. Section 5.3 outlines where there is current conflict between Council's strategic plan and modelled flood hazard and specific guidance is given in the treatment of these areas.

Land designated "floodway" should not be interfered with and should be left to perform its drainage function.

Land designated "flood fringe" should only be developed after assessing regional flood effects. Such an assessment cannot be undertaken ad-hoc. If an area is being considered for future development and it lies in the flood fringe, the entire region should be assessed to see how much of the land can be developed without impacts rather than doing the assessment on a lot-by-lot or development-by-development basis.

An "area of special consideration" classification should be given to land that would be affected by flooding if the Market Street Bund were to fail. Although it is recommended that the levee be constructed to a sound, engineered quality and an appropriate elevation, there is always the chance that the levee will be overwhelmed by floods greater than its design capacity. In such an event, levees are prone to failure and, as a minimum, flooding will be experienced on properties that may be otherwise considered to be flood immune.

The nature of this development condition is consistent with floodplain planning throughout WA and the requirements of DoW.

No development should occur within the zone shown on the land use zoning maps without consideration of the impacts of a levee failure. No residential, industrial or commercial development should occur at all within 100m of the levee. Minimum floor levels in the area should be developed at least 500mm above natural surface.

Council should ultimately undertake land use planning over the entire investigation area to identify where future residential development may occur in the floodplains. This should be assessed to establish the maximum developable land and maximum possible encroachment that can occur on the floodplains without flooding impacts. Once this is done, it will give Council surety in its planning and development assessment process.

6.2.2 Building Development Controls

The flood levels reported from this investigation should be used to adopt standards for minimum floor levels for new developments. New residential properties should be constructed with a floor level at least 500mm above the relevant 100 year ARI flood level defined in this investigation. These levels will be subject to change as the investigation goes through ongoing review over time.

The floor levels in the rural residential areas to the south of the investigation area should be investigated to ensure that they are above the 100 year ARI flood level. If not, further investigation should be undertaken into the cost for voluntary house raising or other flood protection measures.

6.2.3 Flood Emergency Response Planning

The EMV, elements of key Council infrastructure and emergency services are currently at risk of isolation from flooding. It is recommended that Council review the flood risk across the investigation area and that this is reviewed regularly, particularly if development continues to extend away from the townsite.

Flood emergency response planning should look at large flood events, greater than the 100 year ARI flood and up to the Probable Maximum Design Flood.





6.2.4 Streamflow and Rainfall Gauging, Data Collection and Ongoing Review

The hydrologic and hydraulic modelling tools used to develop this Strategy could not be calibrated. This is due to a lack of flood level and flood flow data available at the time of the study and the ongoing change occurring to the terrain of the study area.

It is recommended that at least one streamflow gauging station be installed in the investigation area coupled with a pluviograph to measure rainfall. It is also recommended that Council collects flood debris marks after every significant flow event in the catchments of the investigation area. This data should be used to calibrate hydrologic and hydraulic modelling as it becomes available.

This Strategy should be reviewed regularly in light of the findings of revised hydrologic and hydraulic models.

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7. Potential Water Harvesting

As part of the investigation, Council requested that an investigation be carried out to understand the ability to harvest surface water to supplement the Shire's existing water supply. This section outlines that investigation.

Drinking water supplies for the Shire of Exmouth are currently supplied from a limestone groundwater aquifer within the Cape Range. The aquifer is a lens of fresh water greater than 150m in thickness (Coleman, 1994) and, according to JDA (1999) this suggests that the beds of the creeks and gullies of the upper catchments are highly permeable.

Council was consulted at the commencement of the project. It was requested that SKM investigate the potential to develop storages in the channels or the valleys of the drainage lines to store surface waters.

7.1 Water Balance Methodology

After a preliminary assessment of the terrain of the site and the climatic patters of the region, it was apparent that it would be difficult to find a surface water storage able to meet the demands of the town. To determine this, a water balance was developed based on the regional climatic patterns.

A water balance was created using the recorded daily rainfall and evaporation data from the Learmonth gauges (005051 and 005007 respectively). The daily water balance sought to find a storage that could reliably supply water to the town. The basis of the water balance assumptions are described in Table 7-1.

Table 7-1 Water Balance Base Assumptions

Input	Value	Assumption
Storage surface area	1ha	Assumes a large storage area can be found to accommodate
Average depth	3m	Assumes that a deep storage area will be achieved given the steep upper catchment terrain
Storage catchment area	100ha	Assumes that a large catchment area is available to supply the storage.
Water Demand	250kL/day	Assumes that the storage will supply 1000 equivalent people with 300L/d/EP
Upper soil store	50mm	Assumes that the upper soil layer will store 50mm of rainfall prior to running off. It is assumed that all of the excess above 50mm will run off and not seep to groundwater. These assumptions are expected to give a conservatively high estimation of the amount or runoff from the catchments

7.2 Water Balance Results

The water balance with the base assumptions showed that a large storage described above would be unreliable. The daily reliability was less than 25%. That is, the storage could only meet the demand less than 25 % of the days of the record. The cause of this was twofold.

Firstly, when rainfall did occur, the rainfall was highly infrequent and the resulting runoff was very sharp and short lasting. The runoff could fill the storage quite easily given the intensity that it would fall however, the demand and the evaporation was quick to remove it from the storage.

Manipulation of the water balance found that the storage would be 90% reliable for a demand of just 37kL/d which would meet the demand of approximately 120EP. Given the cost of construction of such a large storage, it was considered that a surface water storage was not cost effective. It is known that the geology of the area is highly permeable and the engineering feasibility of constructing a storage in such geology would need thorough investigation.

7.3 Discussion and Conclusions

Previous reports identified that the geology of the area is highly permeable and caused significant rainfall losses in the upper catchment. This has resulted in a deep aquifer that supplies water for the town.

Given the infrequent nature of rainfall in the area and the high evaporation experienced, it was concluded that surface water diversion or storage schemes near Exmouth should be ruled out as an option for harvesting water.

However, based on the findings, the pervious nature of the upper catchments could allow for the exploiting of surface water resources through increasing groundwater interception in the upper catchments. A series of small storages could be developed in areas where the aquifer is exposed or where it has been specifically exposed for the purpose of harvesting. This could maximise infiltration to the aquifer and, given that the aquifer would not evaporate, could improve aquifer yields. Such a plan would require detailed geological and hydrogeological investigations. Given that the works would be best done in the upper catchments, they would be constructed in a National Park and thus need detailed environmental impact assessments and approvals.

In conclusion, no feasible water harvesting options were identified through the process.

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8. References

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JDA Consultant Hydrologists (2002); *Review of the Exmouth Flood Management Study Assessment of the June 2002 Flood Event*; Technical report for the Shire of Exmouth

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Government of Western Australia

Appendix A Design Floods Mapping

- Figure A-1 Q100 "Pre-Canals Case" Inundation Mapping Part 1
- Figure A-2 Q100 "Pre-Canals Case" Inundation Mapping Part 2
- Figure A-3 Q100 "Pre-Canals Case" Velocity Mapping Part 1
- Figure A-4 Q100 "Pre-Canals Case" Velocity Mapping Part 2
- Figure A-5 Q10 "Existing Case" Inundation Mapping Part 1
- Figure A-6 Q10 "Existing Case" Inundation Mapping Part 2
- Figure A-7 Q10 "Existing Case" Velocity Mapping Part 1
- Figure A-8 Q10 "Existing Case" Velocity Mapping Part 2
- Figure A-9 Q25 "Existing Case" Inundation Mapping Part 1
- Figure A-10 Q25 "Existing Case" Inundation Mapping Part 2
- Figure A-11 Q25 "Existing Case" Velocity Mapping Part 1
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- Figure A-13 Q100 "Existing Case" Inundation Mapping Part 1
- Figure A-14 Q100 "Existing Case" Inundation Mapping Part 2
- Figure A-15 Q100 "Existing Case" Velocity Mapping Part 1
- Figure A-16 Q100 "Existing Case" Velocity Mapping Part 2
- Figure A-17 Q500 "Existing Case" Inundation Mapping Part 1
- Figure A-18 Q500 "Existing Case" Inundation Mapping Part 2
- Figure A-19 Q500 "Existing Case" Velocity Mapping Part 1
- Figure A-20 Q500 "Existing Case" Velocity Mapping Part 2
- Figure A-21 Q100 "Developed Case" Inundation Mapping Part 1
- Figure A-22 Q100 "Developed Case" Inundation Mapping Part 2
- Figure A-23 Q100 "Developed Case" Velocity Mapping Part 1
- Figure A-24 Q100 "Developed Case" Velocity Mapping Part 2

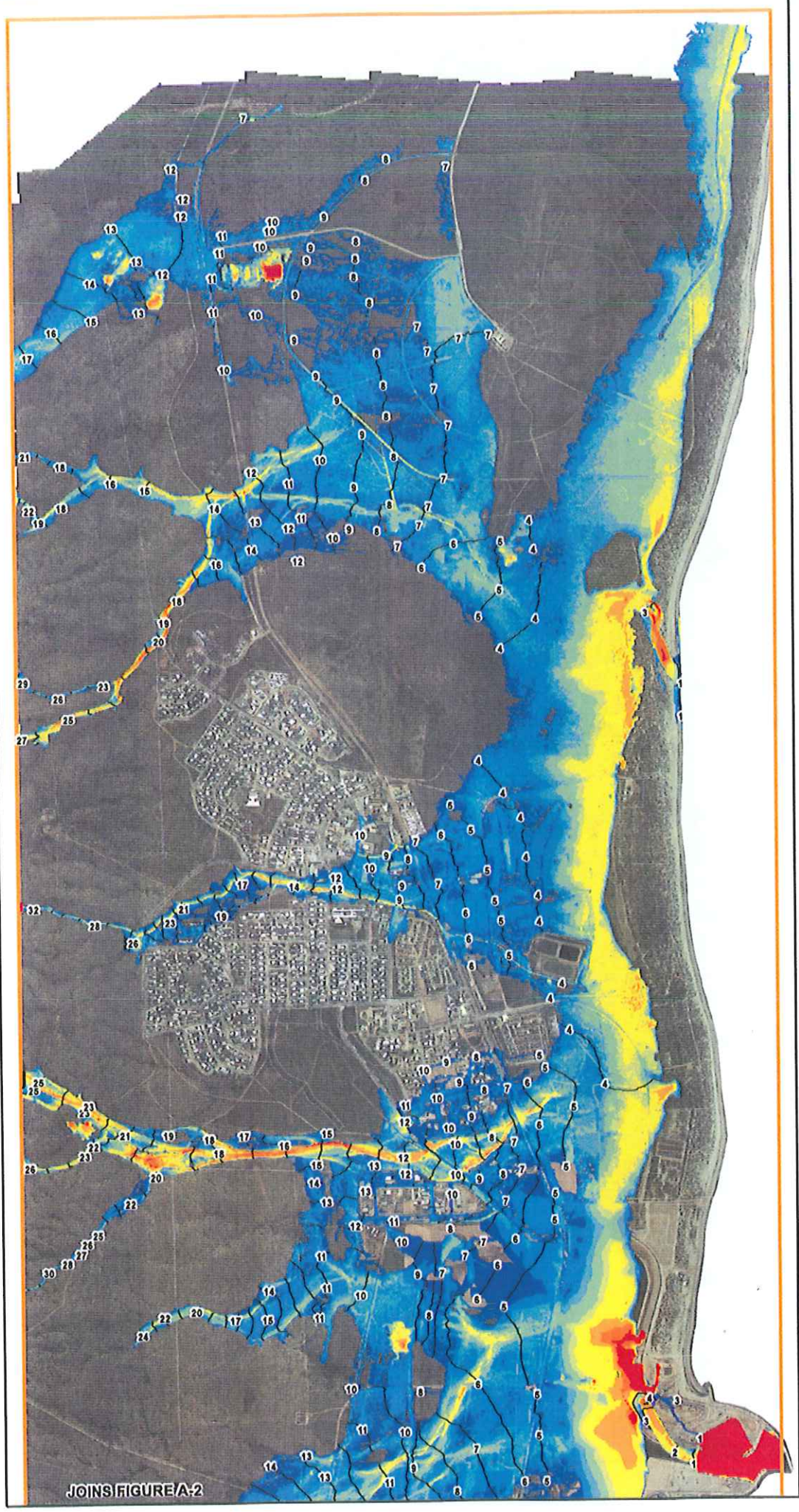


Figure A-1

Exmouth Floodplain Management Study

Q100 Pre-Canals Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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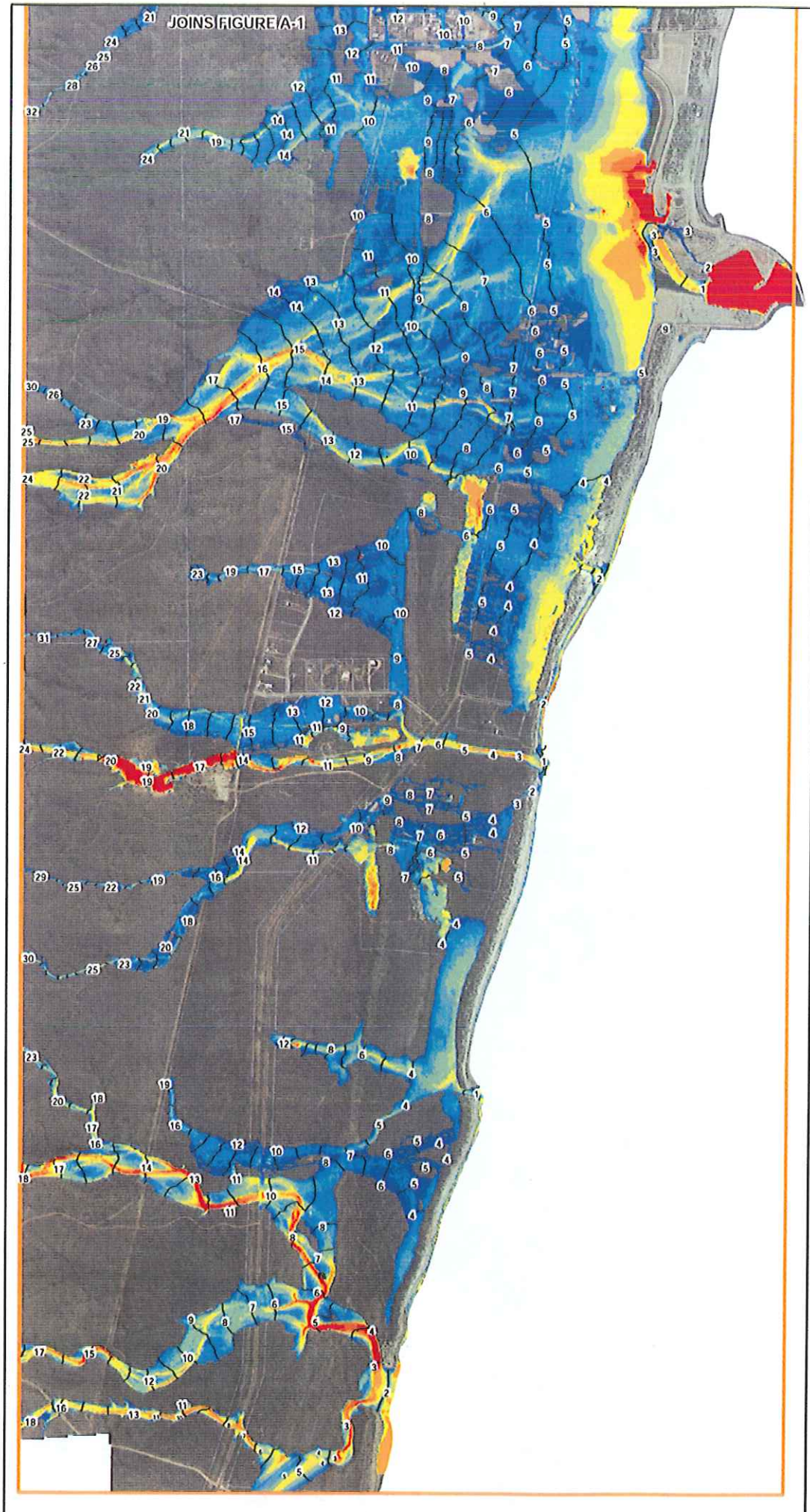


Figure A-2

Exmouth Floodplain Management Study

Q100 Pre-Canals Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m Interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

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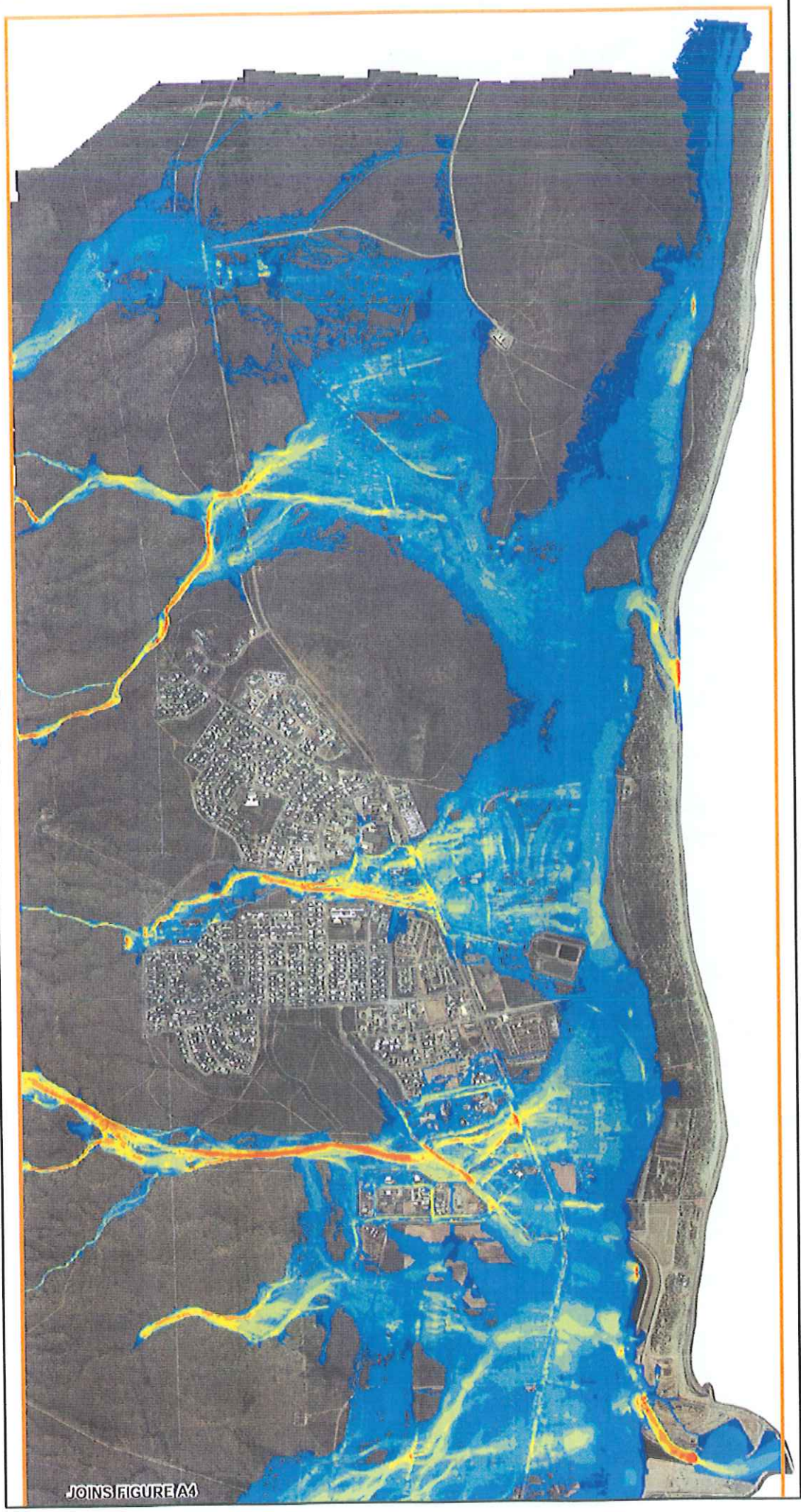


Figure A-3

Exmouth Floodplain Management Study

Q100 Pre-Canals Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

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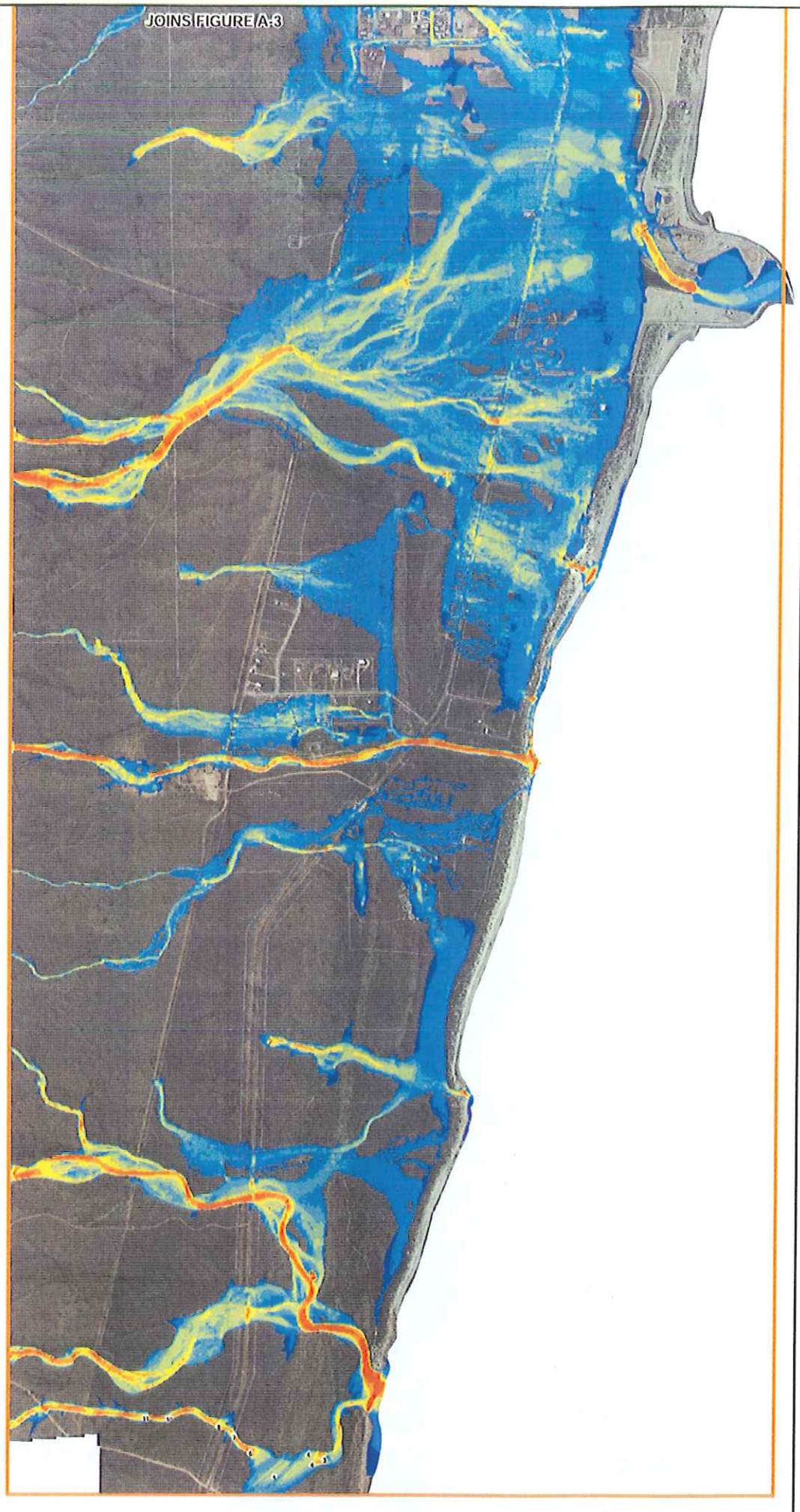


Figure A-4

Exmouth Floodplain Management Study

Q100 Pre-Canals Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

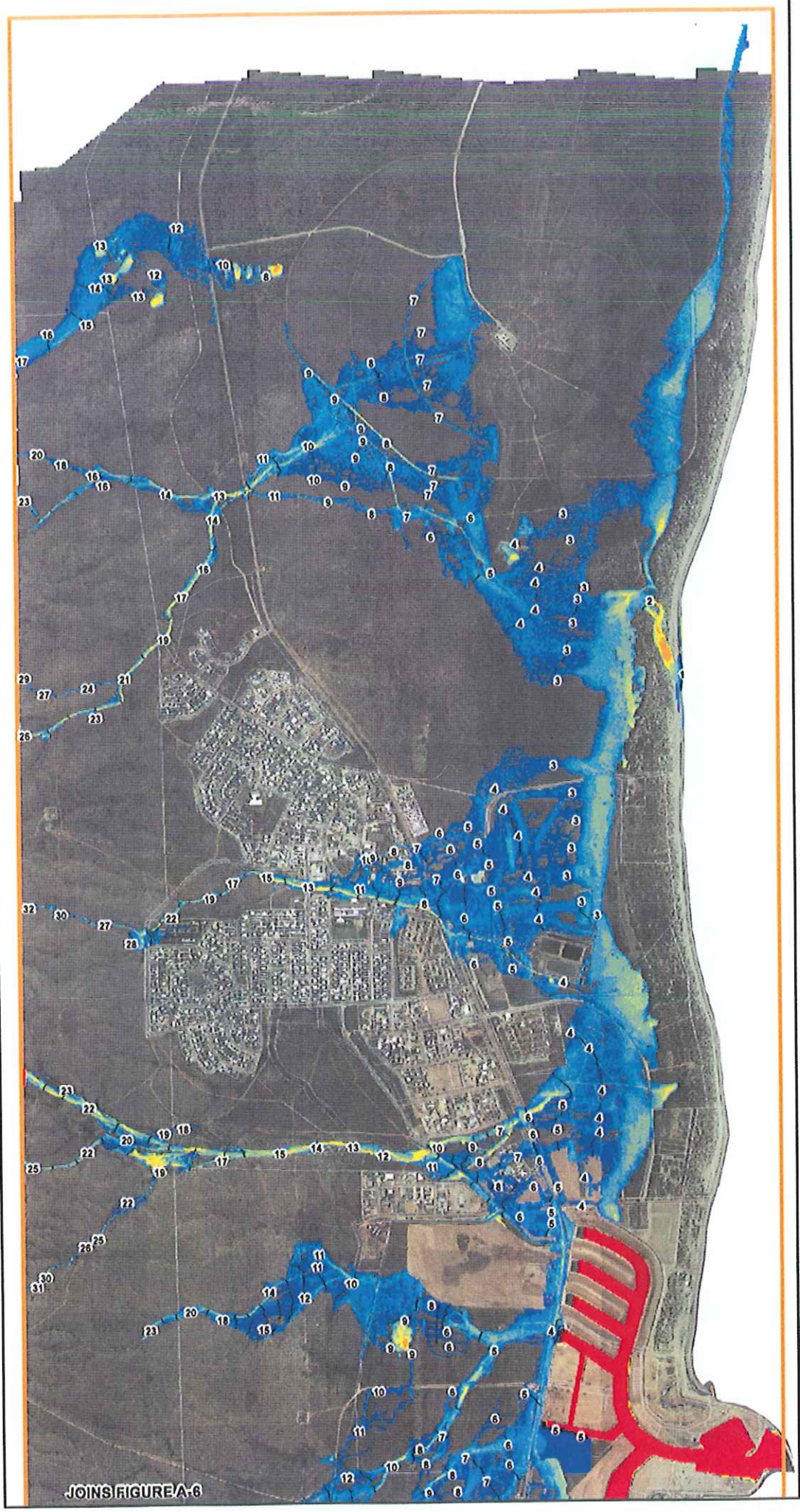


Figure A-5

Exmouth Floodplain Management Study

Q10 Existing Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355



Figure A-6

Exmouth Floodplain Management Study

Q10 Existing Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m interval)
- 12 — Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

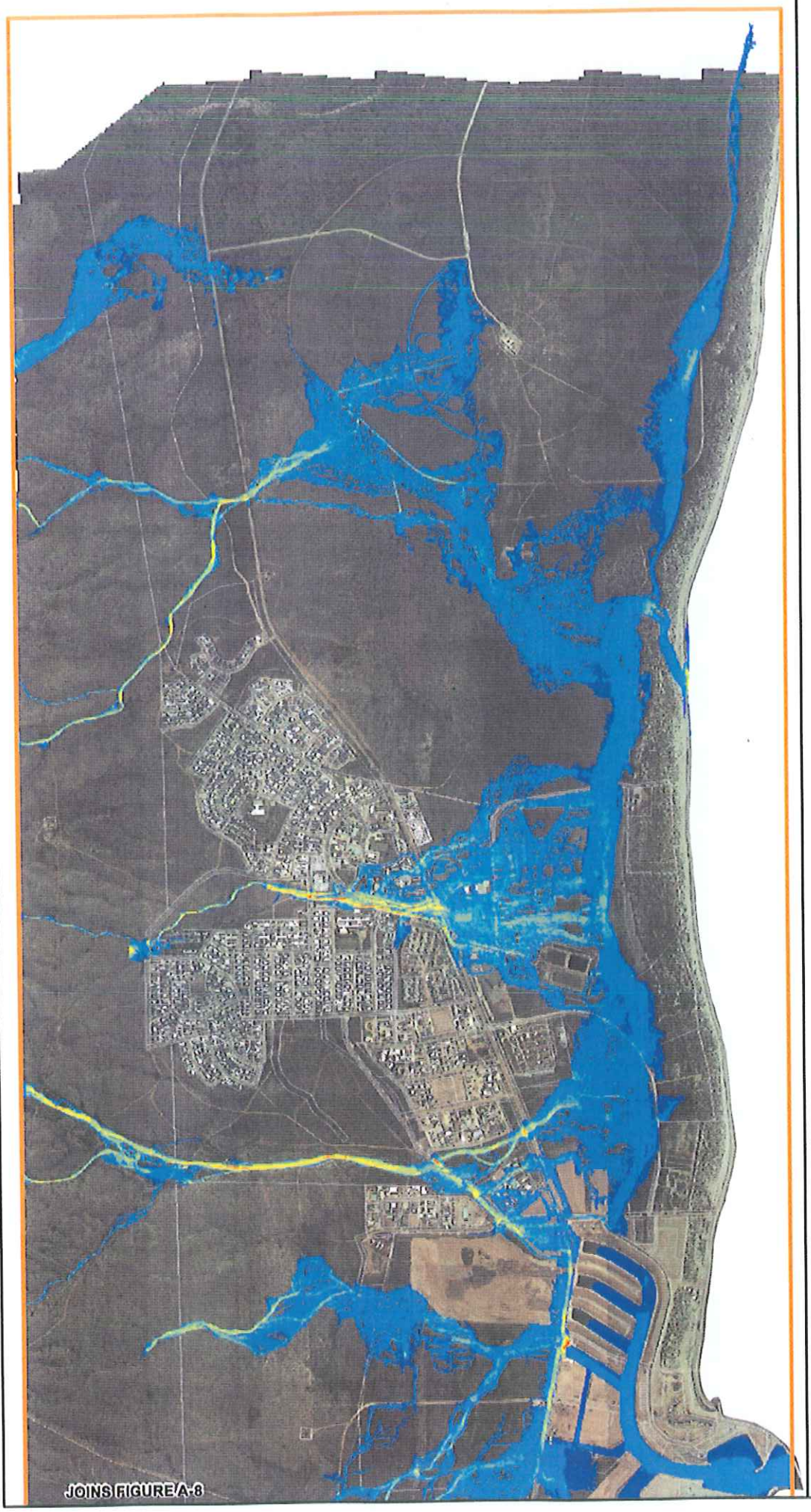


Figure A-7

Exmouth Floodplain Management Study

Q10 Existing Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 105 210 420 630 840

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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Figure A-8

Exmouth Floodplain Management Study

Q10 Existing Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 105 210 420 630 840

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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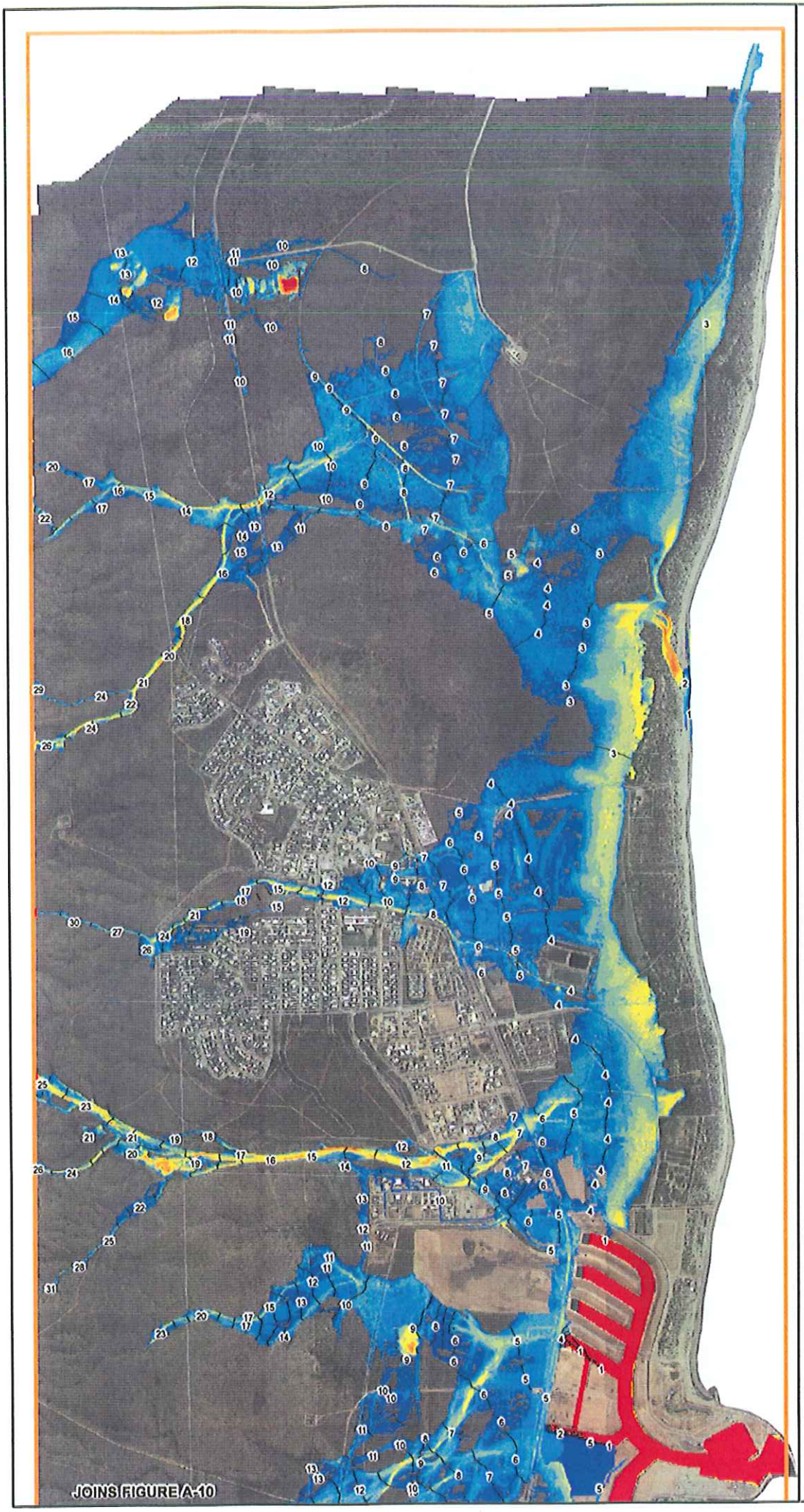


Figure A-9

Exmouth Floodplain Management Study

Q25 Existing Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

25 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

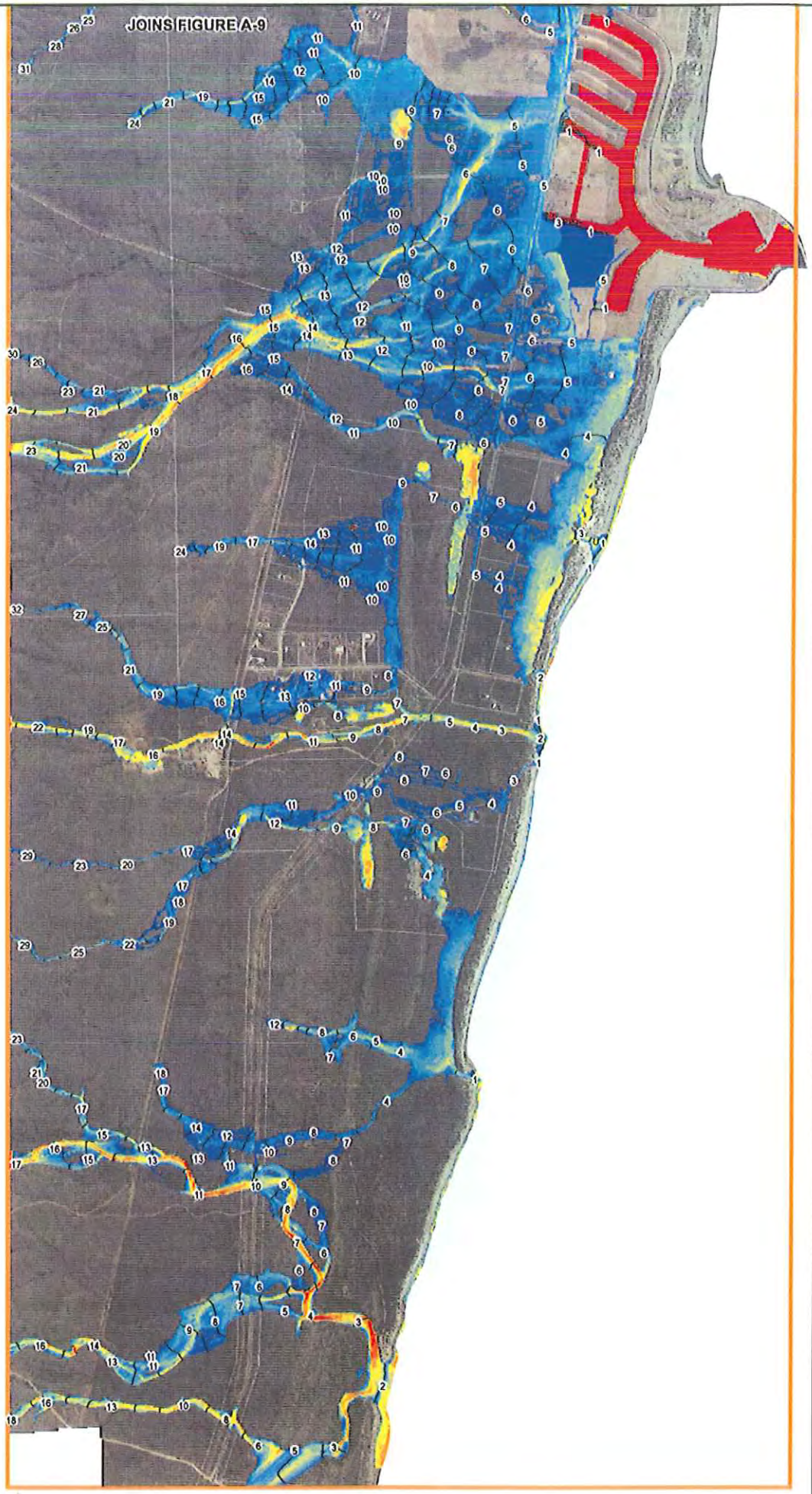


Figure A-10

Exmouth Floodplain Management Study

Q25 Existing Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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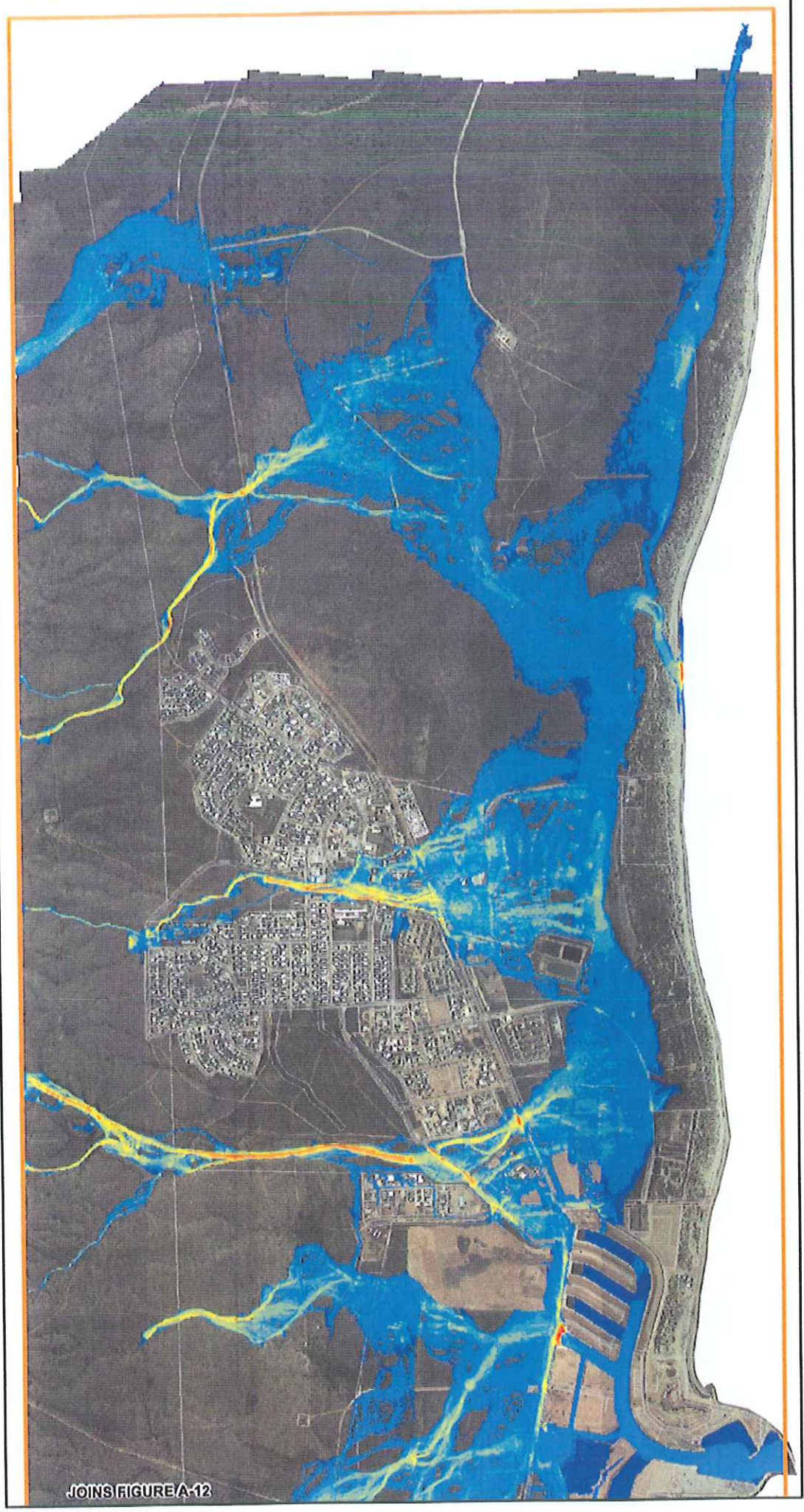


Figure A-11

Exmouth Floodplain Management Study

Q25 Existing Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

25 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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Figure A-12

Exmouth Floodplain Management Study

Q25 Existing Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

25 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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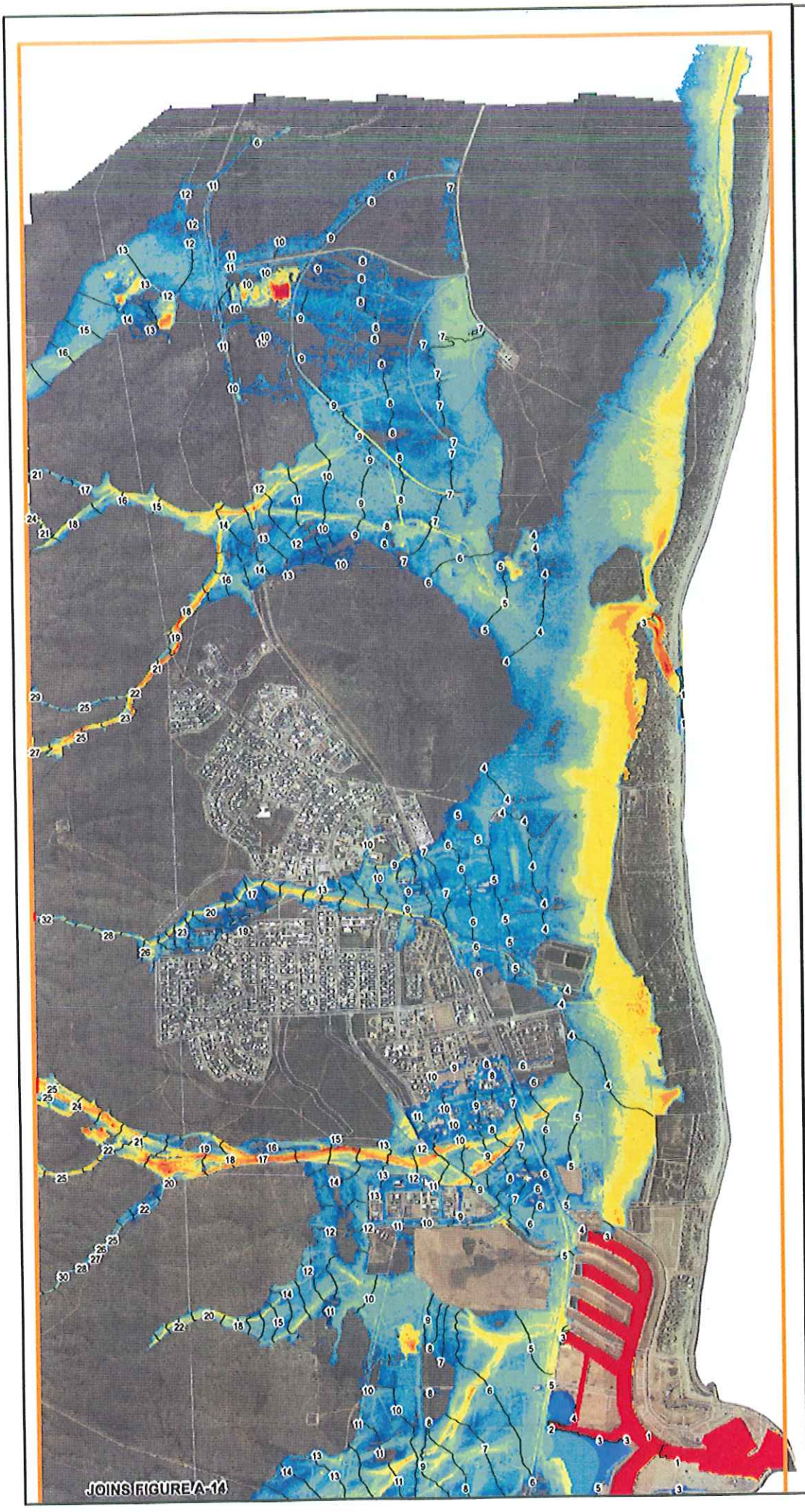


Figure A-13

Exmouth Floodplain Management Study

Q100 Existing Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 — Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.04
- 0.05 - 0.1
- 0.11 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.5
- 1.51 - 2.0
- 2.01 - 2.5
- 2.51 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

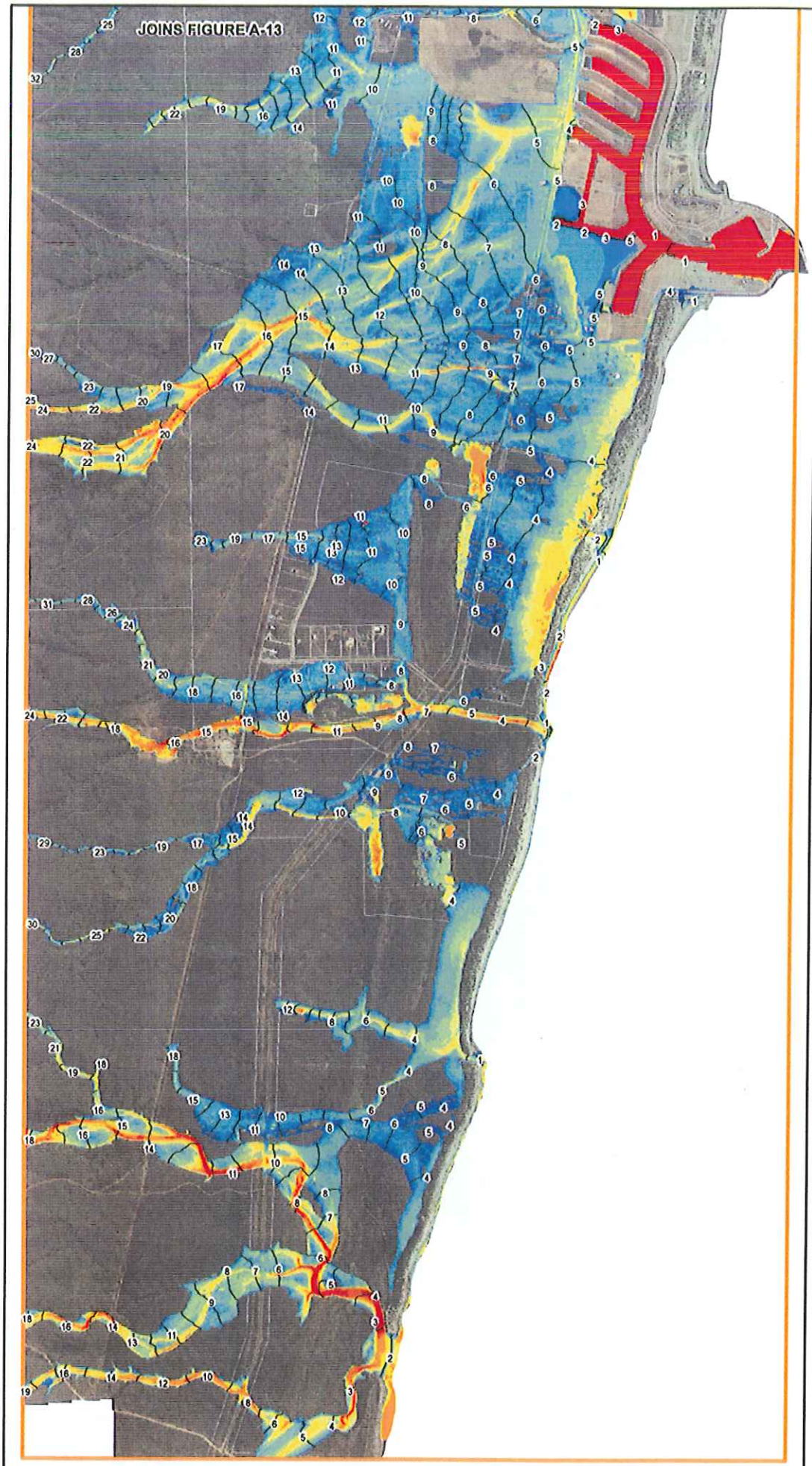


Figure A-14

Exmouth Floodplain Management Study

Q100 Existing Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.04
- 0.05 - 0.1
- 0.11 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.5
- 1.51 - 2.0
- 2.01 - 2.5
- 2.51 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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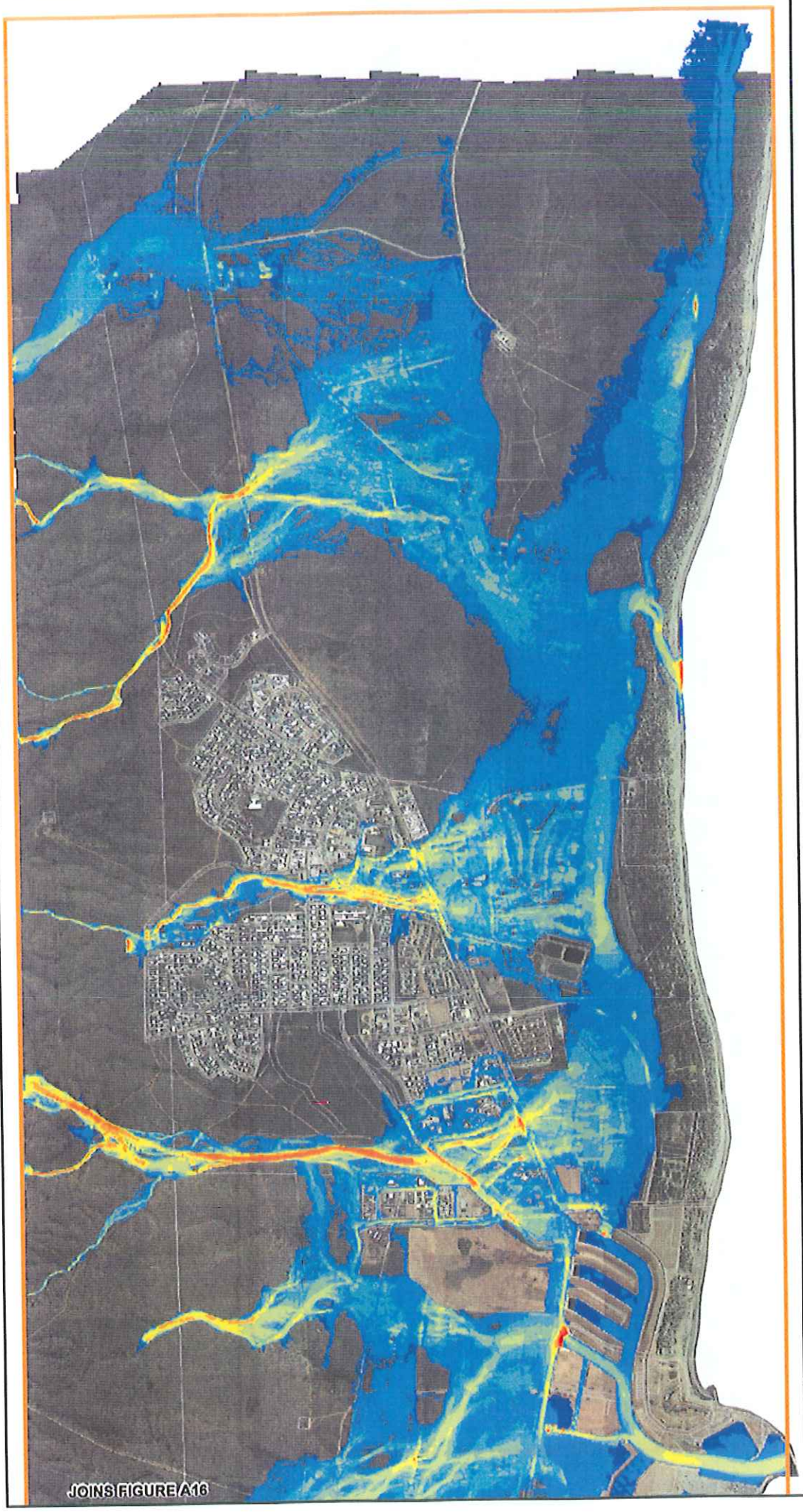


Figure A-15

Exmouth Floodplain Management Study

Q100 Existing Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

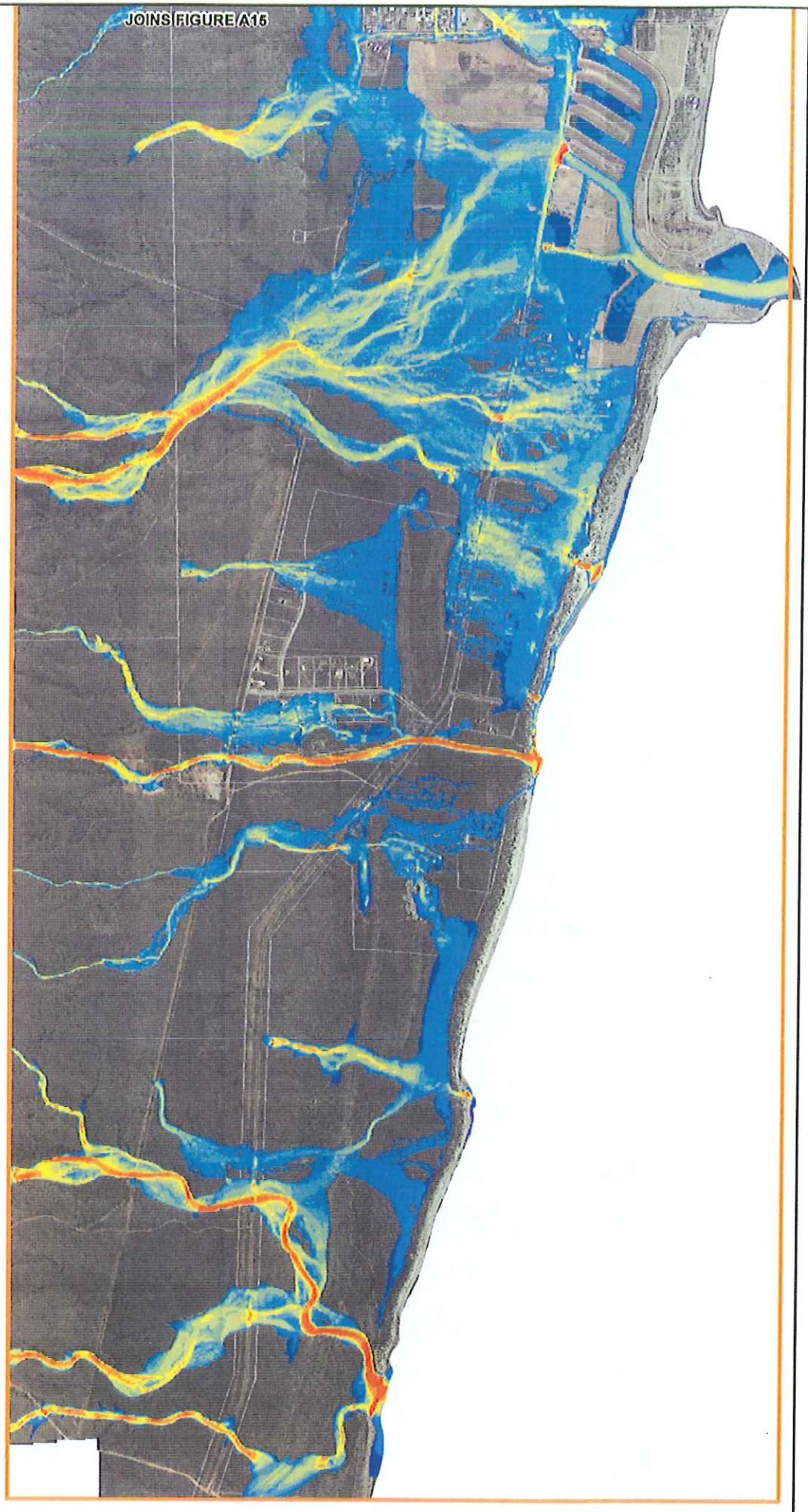


Figure A-16

Exmouth Floodplain Management Study

Q100 Existing Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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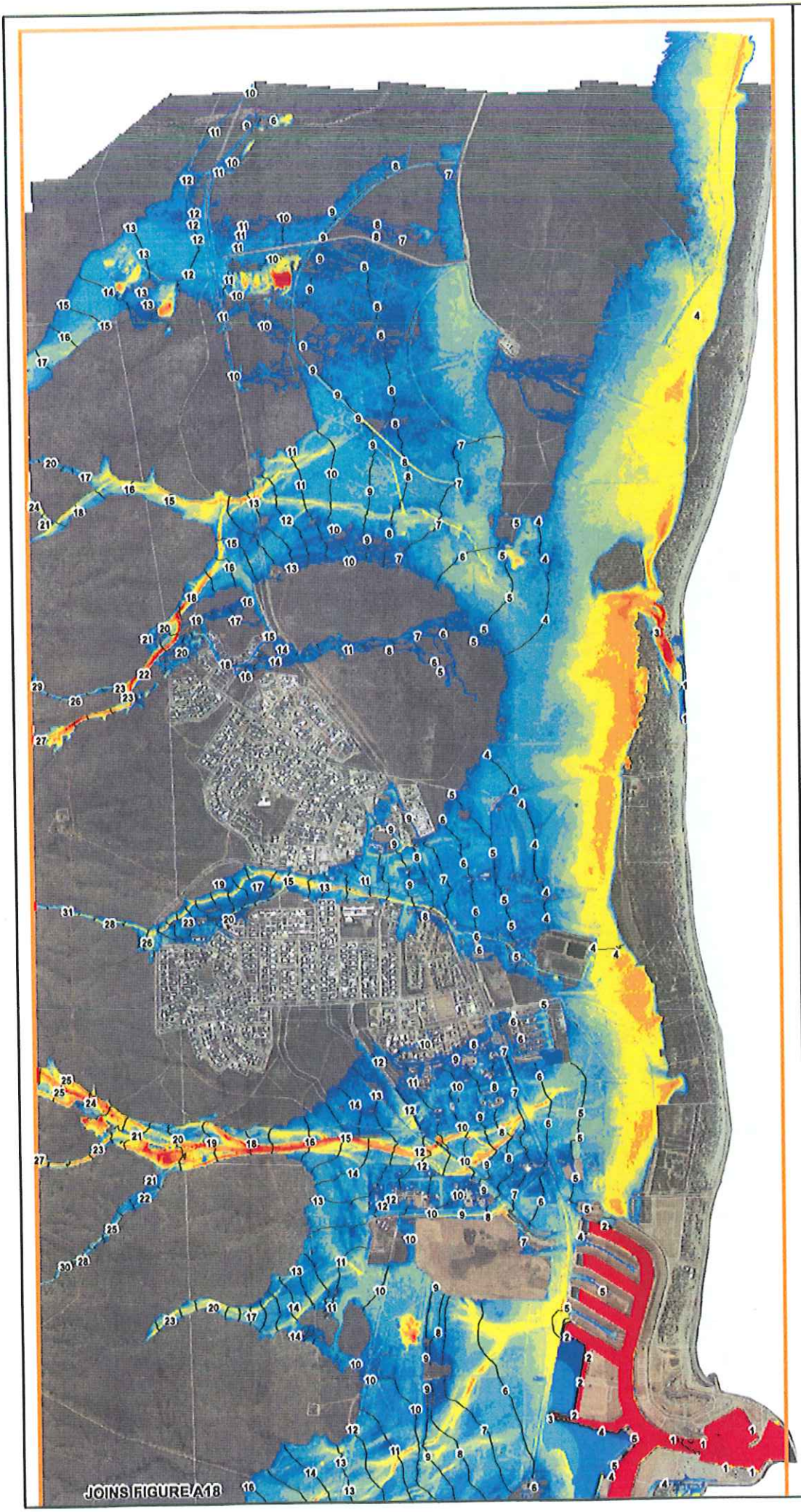


Figure A-17

Exmouth Floodplain Management Study

Q500 Existing Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 — Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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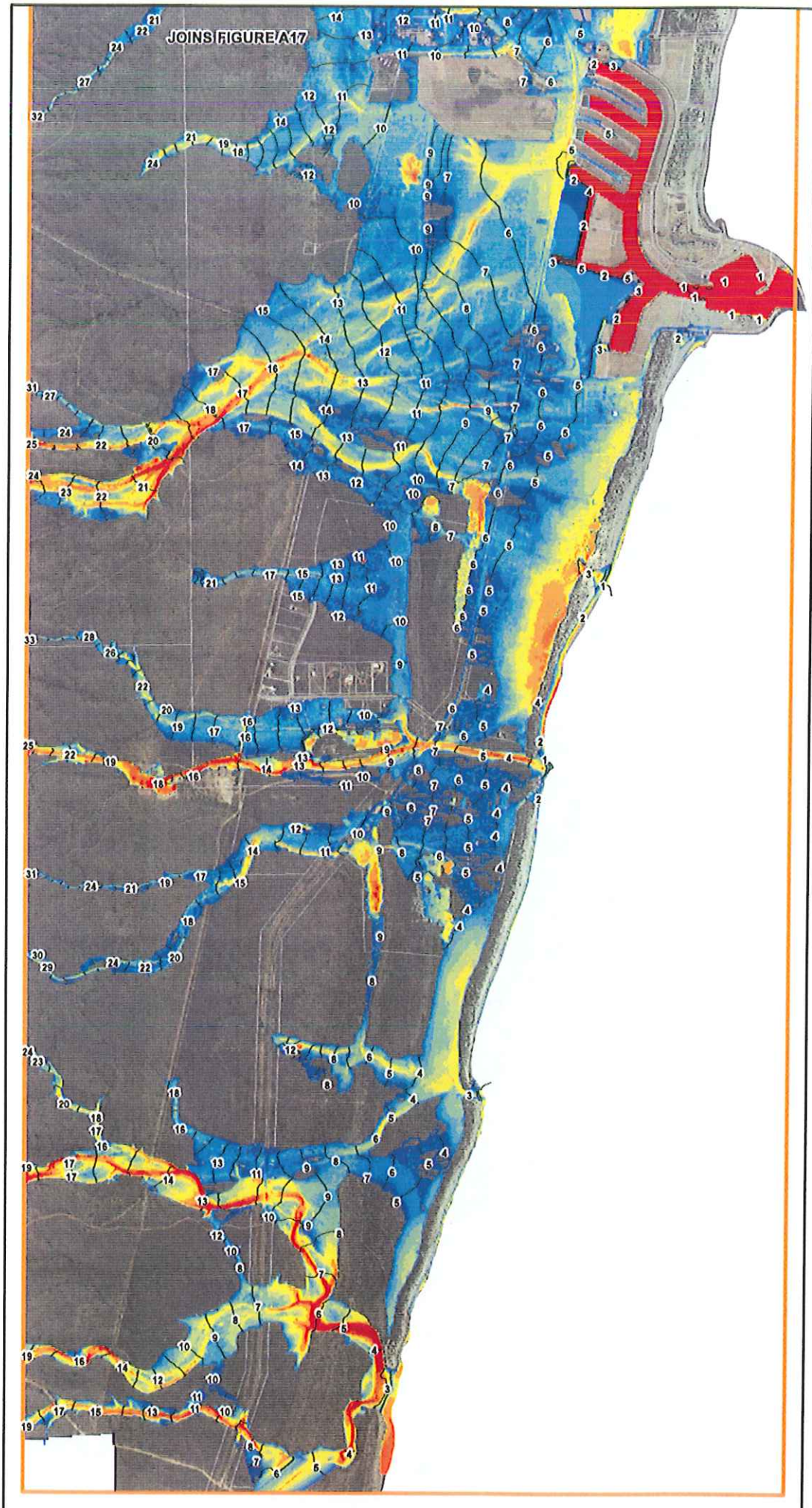


Figure A-18

Exmouth Floodplain Management Study

Q500 Existing Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

10 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.3
- 0.4 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

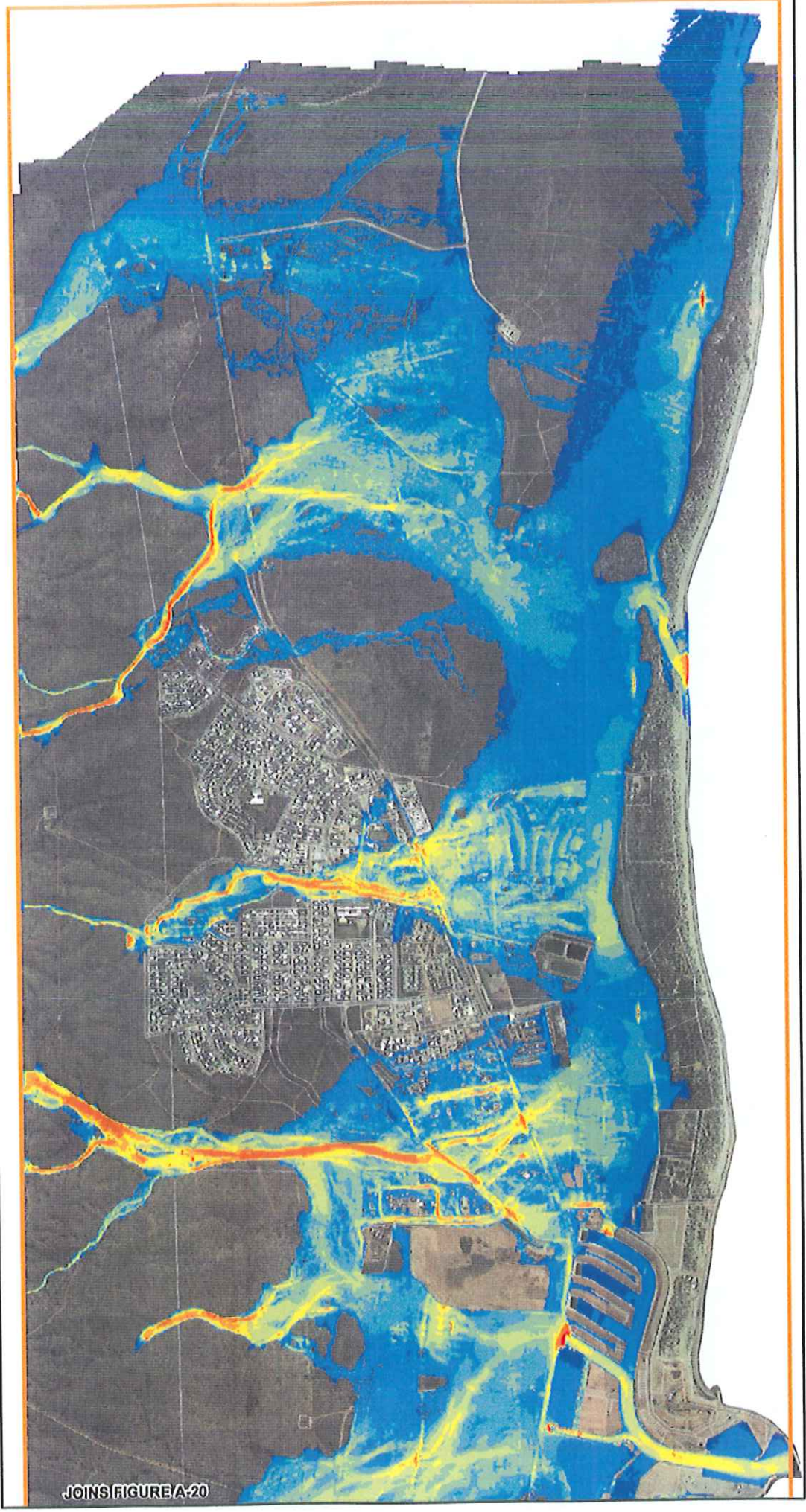


Figure A-19

Exmouth Floodplain Management Study

Q500 Existing Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

500 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

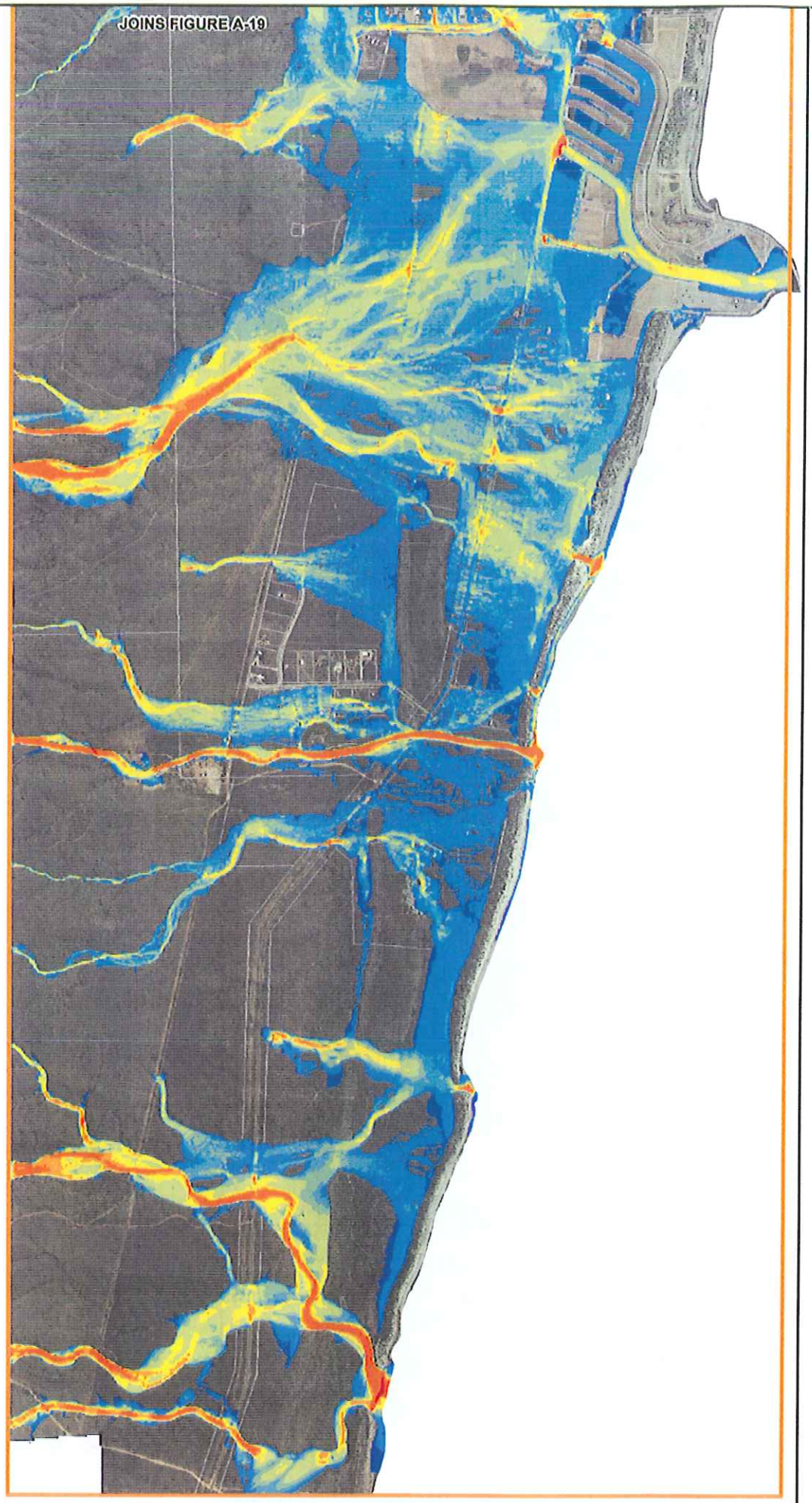


Figure A-20

Exmouth Floodplain Management Study

Q500 Existing Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

500 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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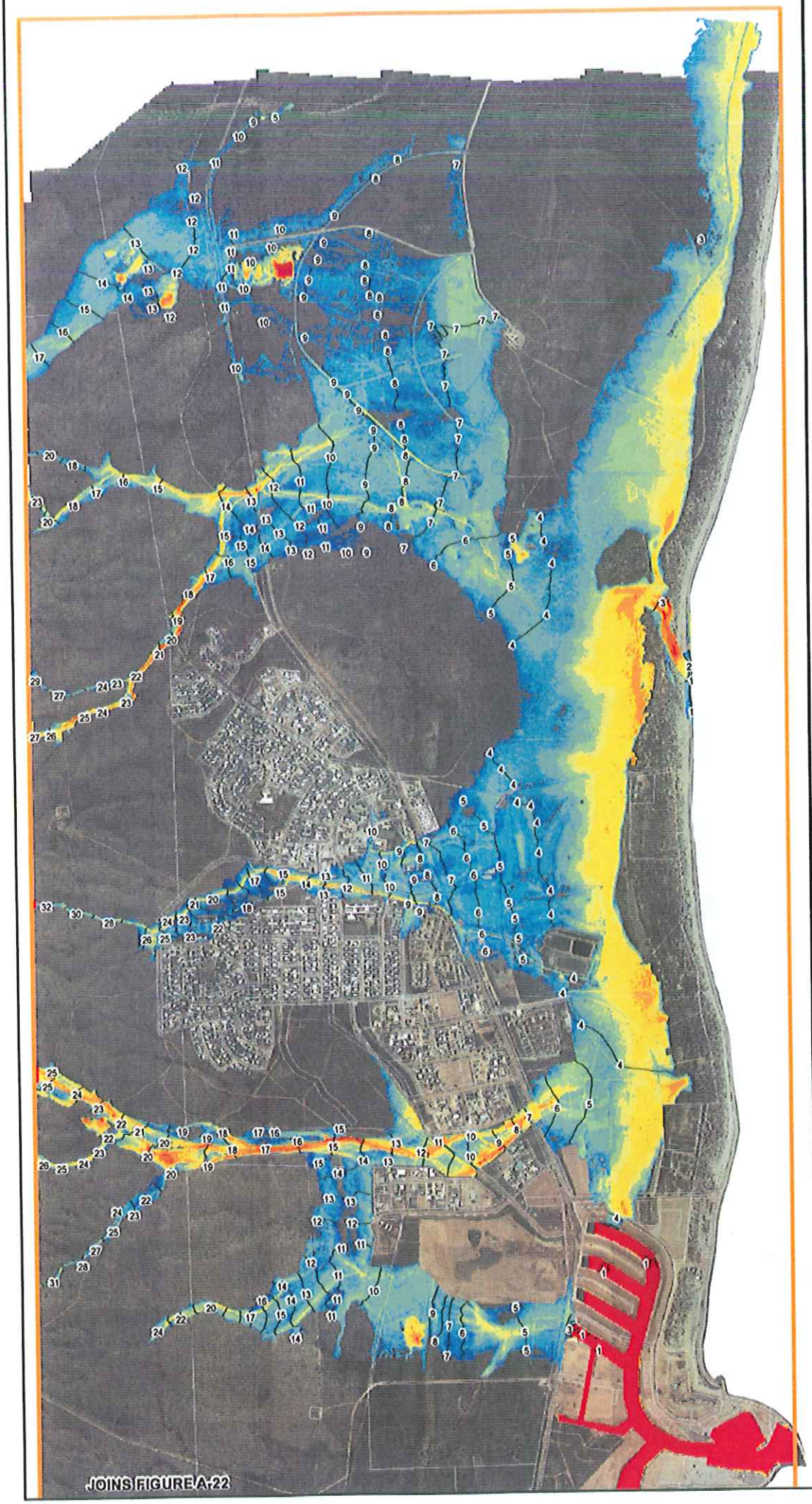


Figure A-21

Exmouth Floodplain Management Study

Q100 Developed Case Inundation Mapping

Part 1

Legend

- Peak Flood Level Contour (1m interval)
- 12 — Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.04
- 0.05 - 0.1
- 0.11 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.5
- 1.51 - 2.0
- 2.01 - 2.5
- 2.51 - 5.0

N

0 110 220 440 660 880

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

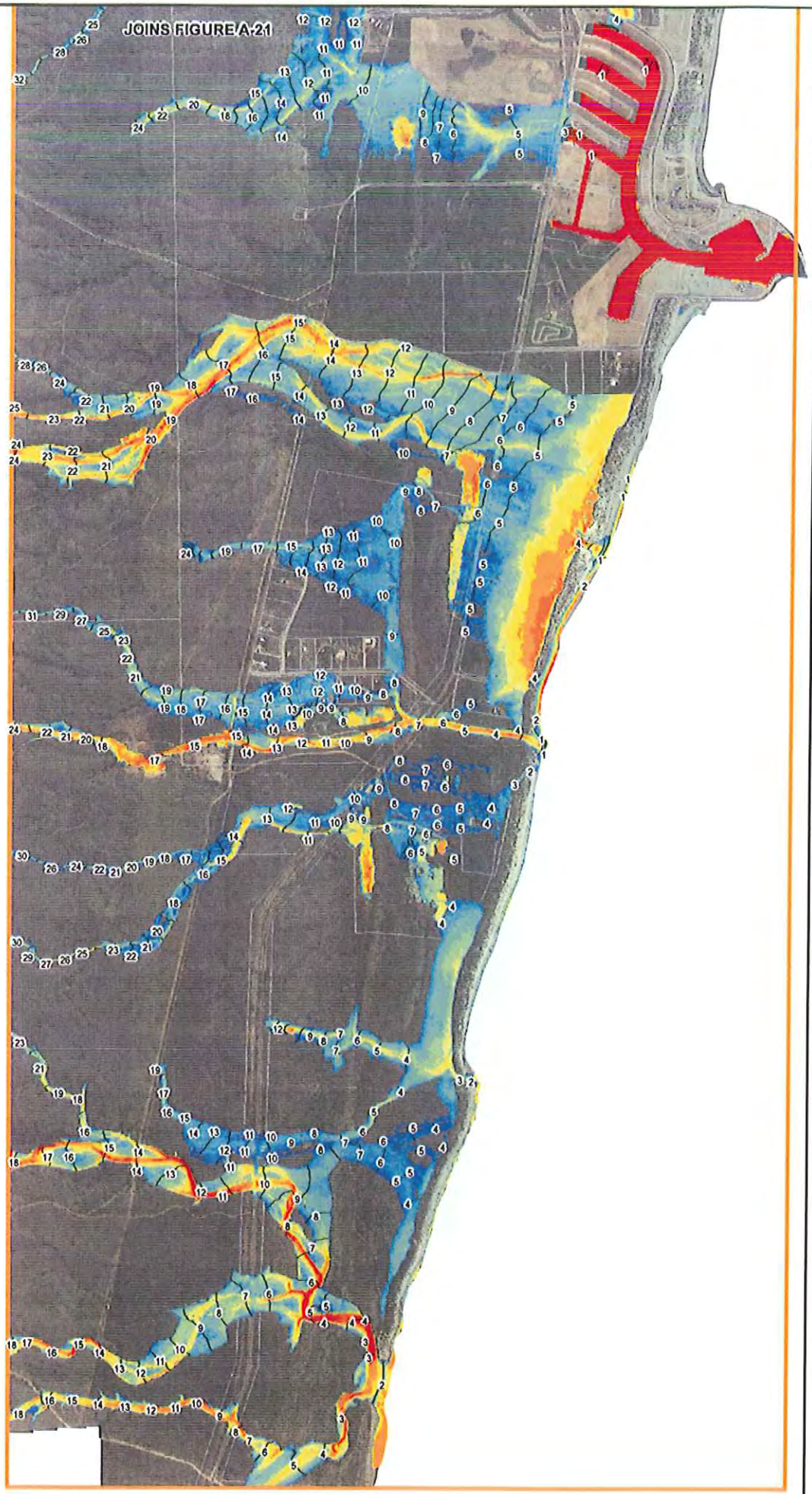


Figure A-22

Exmouth Floodplain Management Study

Q100 Developed Case Inundation Mapping

Part 2

Legend

- Peak Flood Level Contour (1m interval)
- 12 Flood Level (m, AHD)
- Hydraulic Model Extent
- Cadastre

Compiled Peak Flood Depth (m)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.04
- 0.05 - 0.1
- 0.11 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- 1.01 - 1.5
- 1.51 - 2.0
- 2.01 - 2.5
- 2.51 - 5.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

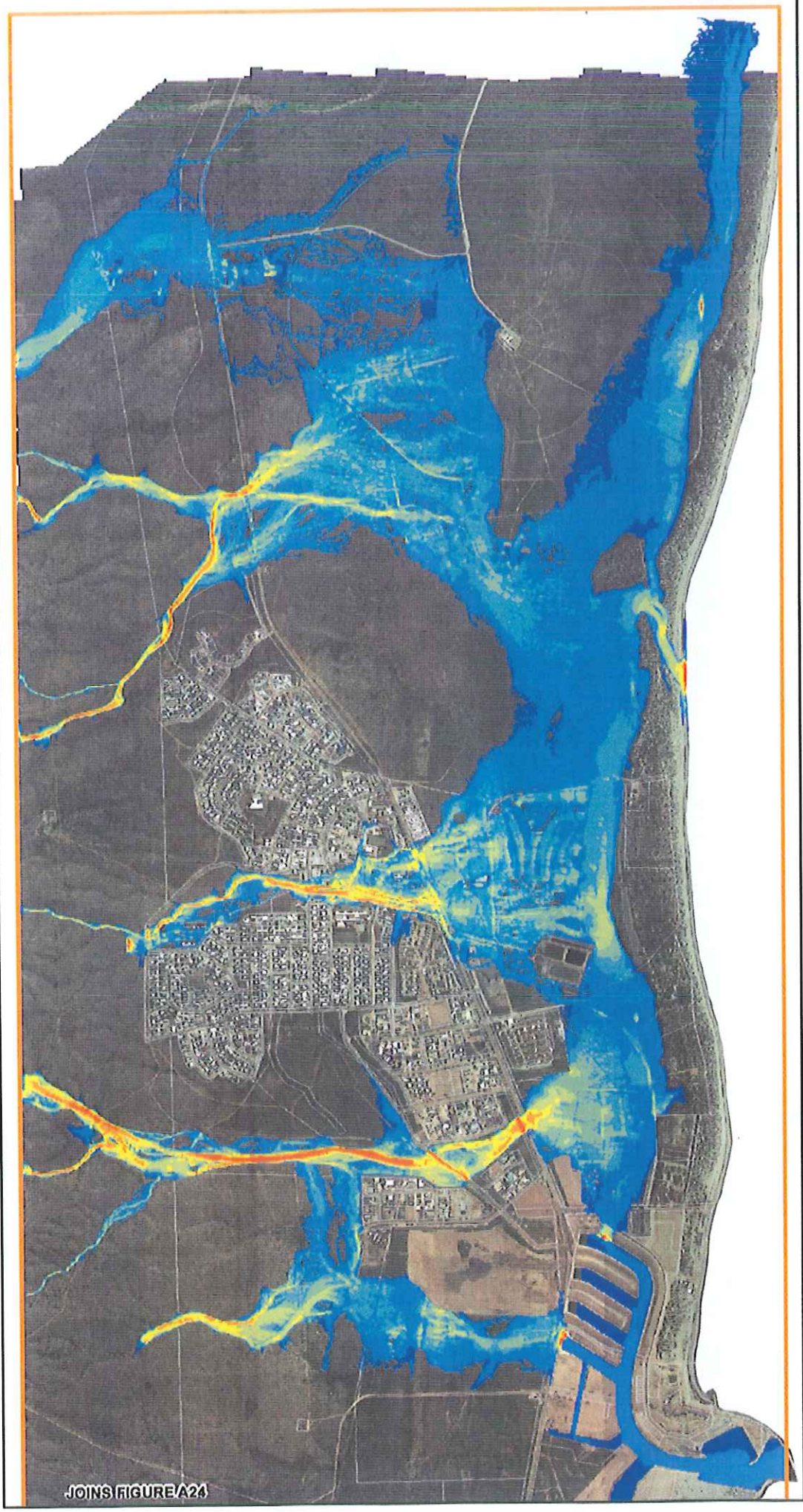


Figure A-23

Exmouth Floodplain Management Study

Q100 Developed Case Velocity Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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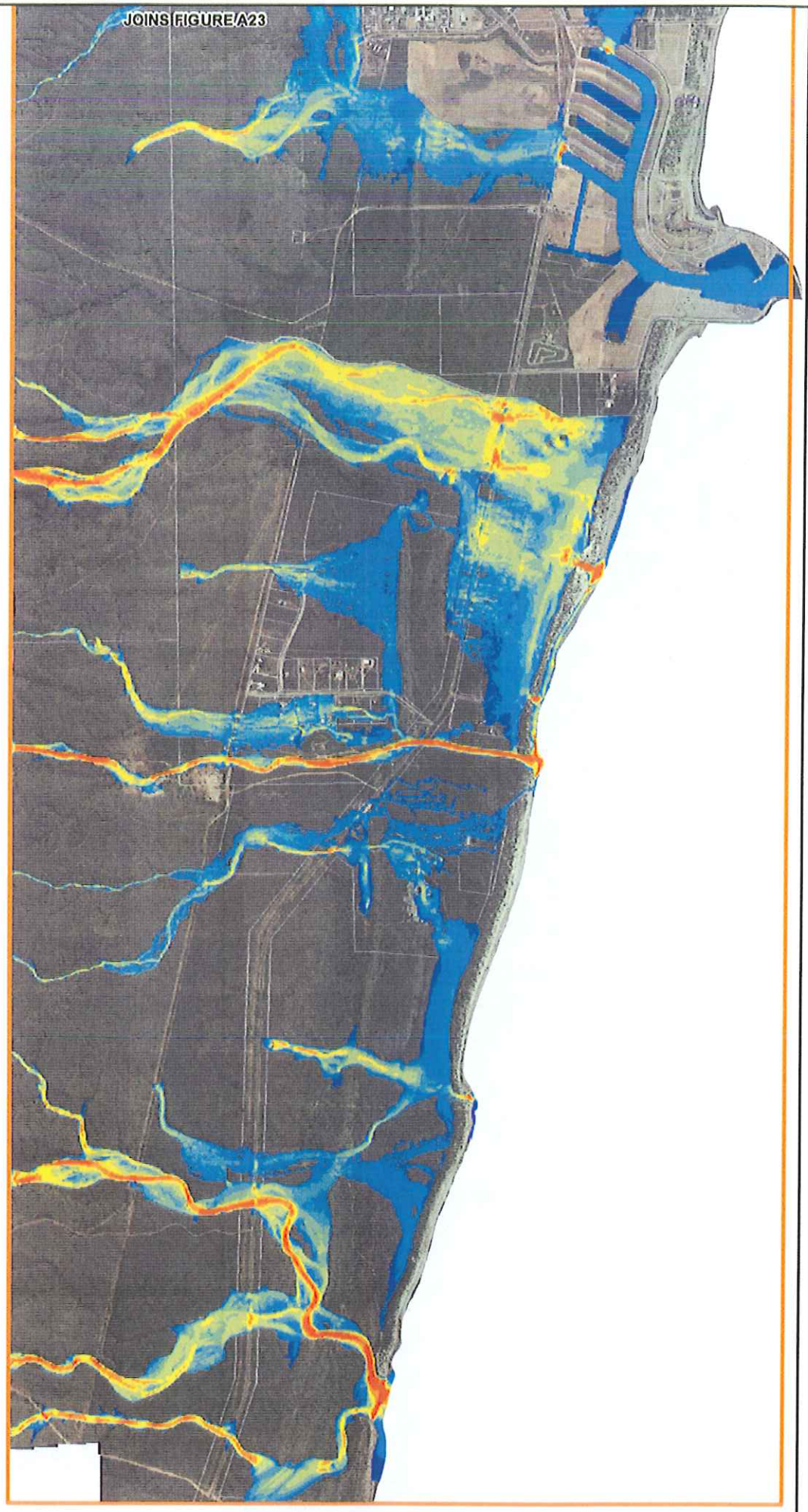


Figure A-24

Exmouth Floodplain Management Study

Q100 Developed Case Velocity Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Compiled Peak Velocity (m/s)

100 year ARI

- 0.0 - 0.01
- 0.01 - 0.1
- 0.2 - 0.5
- 0.6 - 0.8
- 0.9 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 5.0
- 5.1 - 8.0

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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- Figure B-2 Q100 "Existing Case" Hazard Mapping Part 2
- Figure B-3 Floodplain Management "Existing Case" Land Use Zoning Part 1
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- Figure B-5 Q100 "Developed Case" Hazard Mapping Part 1
- Figure B-6 Q100 "Developed Case" Hazard Mapping Part 2
- Figure B-7 Floodplain Management "Developed Case" Flood Zoning Part 1
- Figure B-8 Floodplain Management "Developed Case" Flood Zoning Part 2

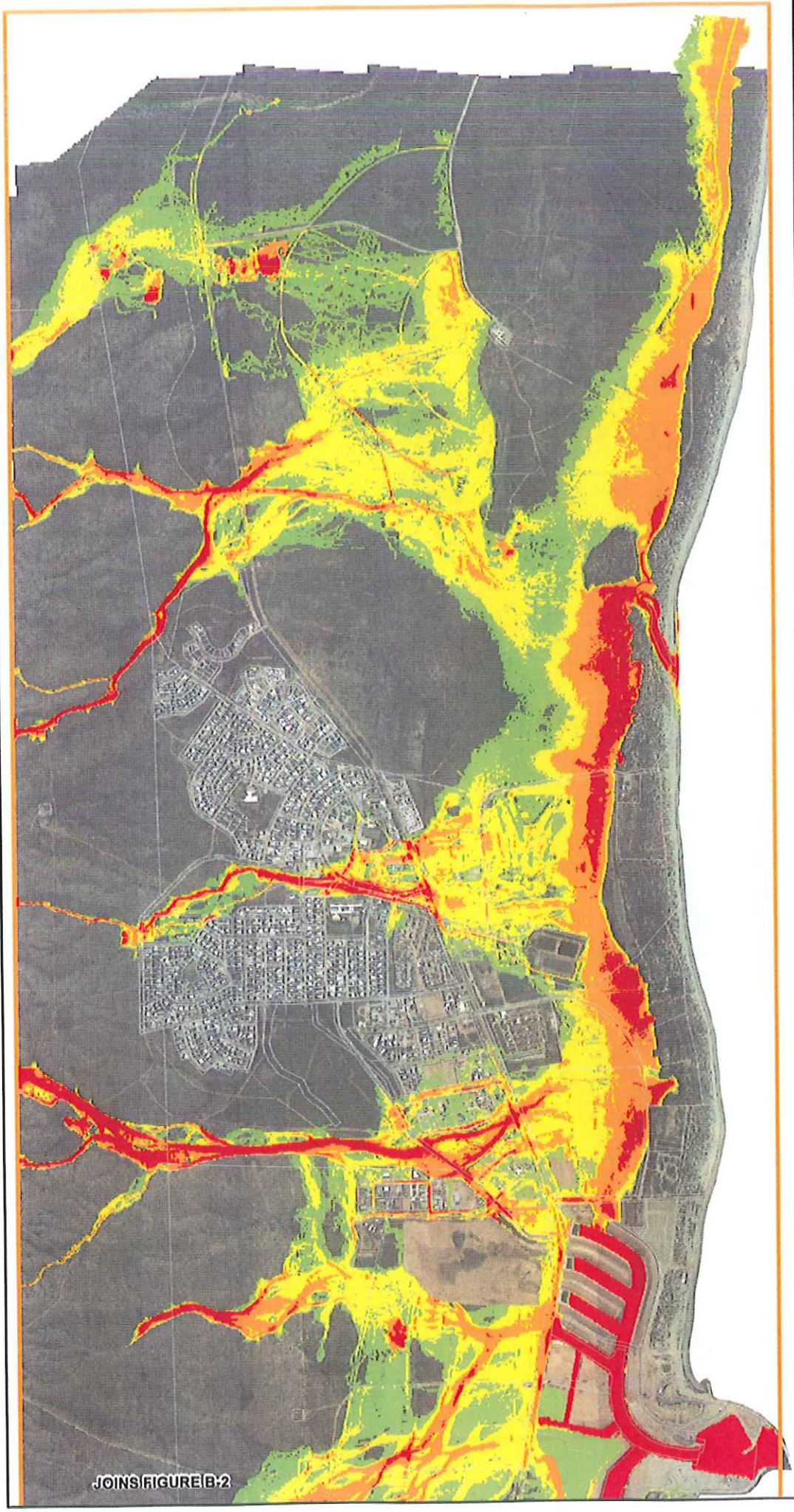


Figure B-1

Exmouth Floodplain Management Study

Q100 Existing Case Hazard Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Flood Hazard Classification

- Low
- Moderate
- High
- Extreme

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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Figure B-2

Exmouth Floodplain Management Study

Q100 Existing Case Hazard Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Flood Hazard Classification

- Low
- Moderate
- High
- Extreme

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

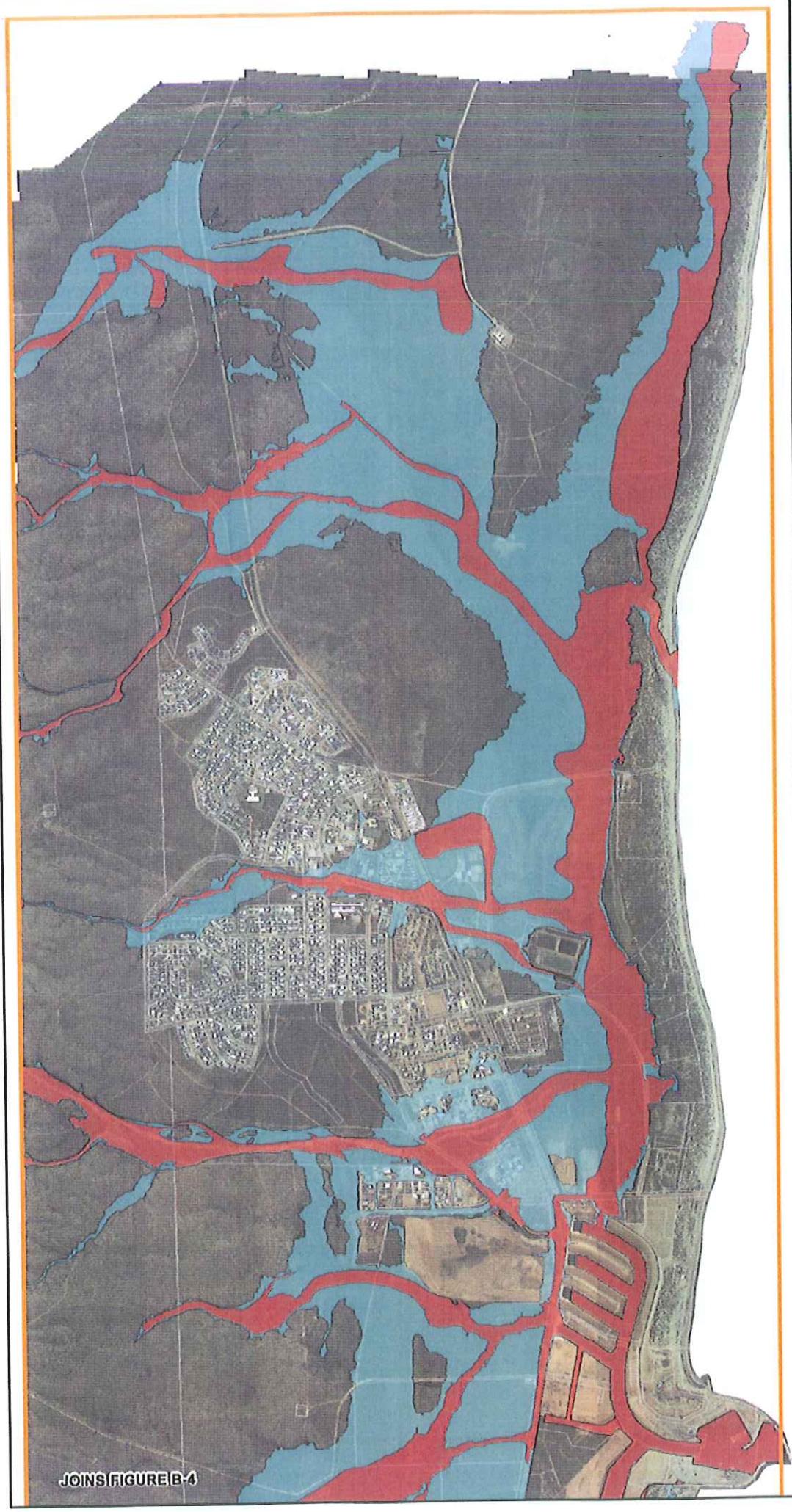


Figure B-3

Exmouth Floodplain Management Study

Floodplain Management Strategy
Flood Zoning
Existing Case
Part 1

Legend

- Flood Way
- Flood Zone
- Area Under Further Consideration
- Hydraulic Model Extent
- Cadastre

N

0 100 200 400 600 800
Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

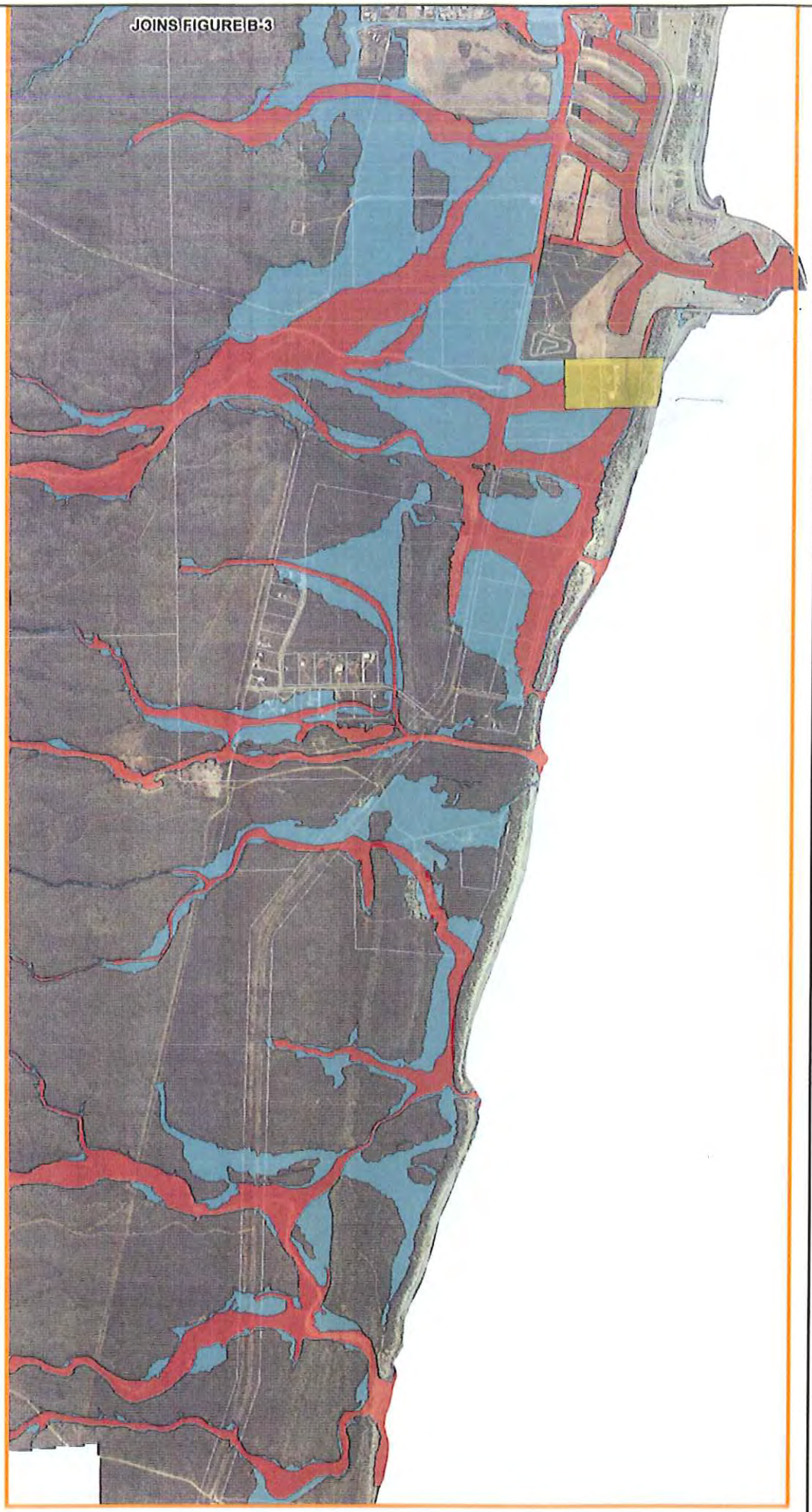


Figure B-4

Exmouth Floodplain Management Study

Floodplain Management Strategy

Flood Zoning Existing Case

Part 2

Legend

- Flood Way
- Flood Zone
- Area Under Further Consideration
- Hydraulic Model Extent
- Cadastre

N

0 95 190 380 570 760

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

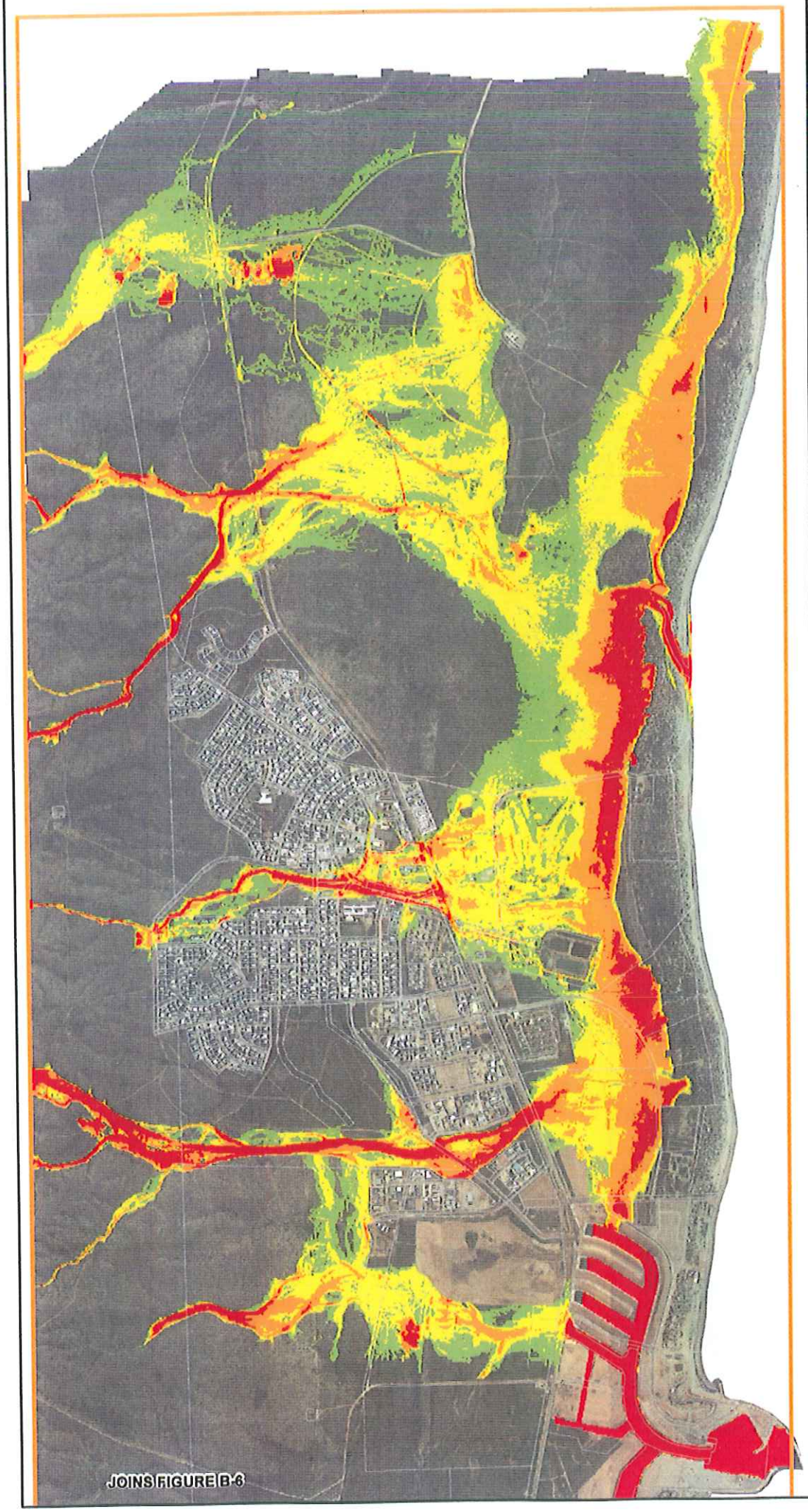


Figure B-5

Exmouth Floodplain Management Study

Q100 Developed Case Hazard Mapping

Part 1

Legend

- Hydraulic Model Extent
- Cadastre

Flood Hazard Classification

- Low
- Moderate
- High
- Extreme

N

0 105 210 420 630 840

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

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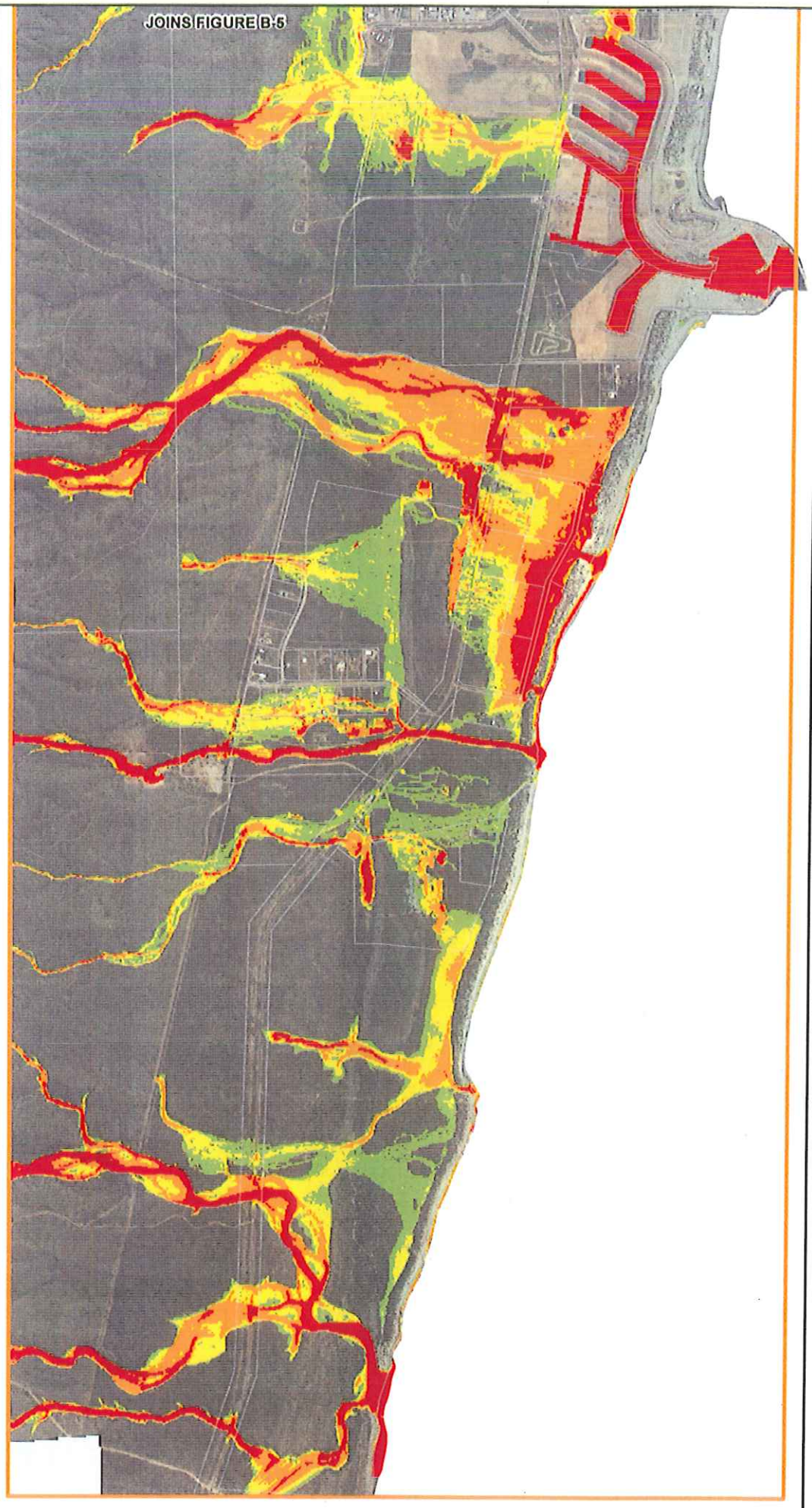


Figure B-6

Exmouth Floodplain Management Study

Q100 Developed Case Hazard Mapping

Part 2

Legend

- Hydraulic Model Extent
- Cadastre

Flood Hazard Classification

- Low
- Moderate
- High
- Extreme

N

0 100 200 400 600 800

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

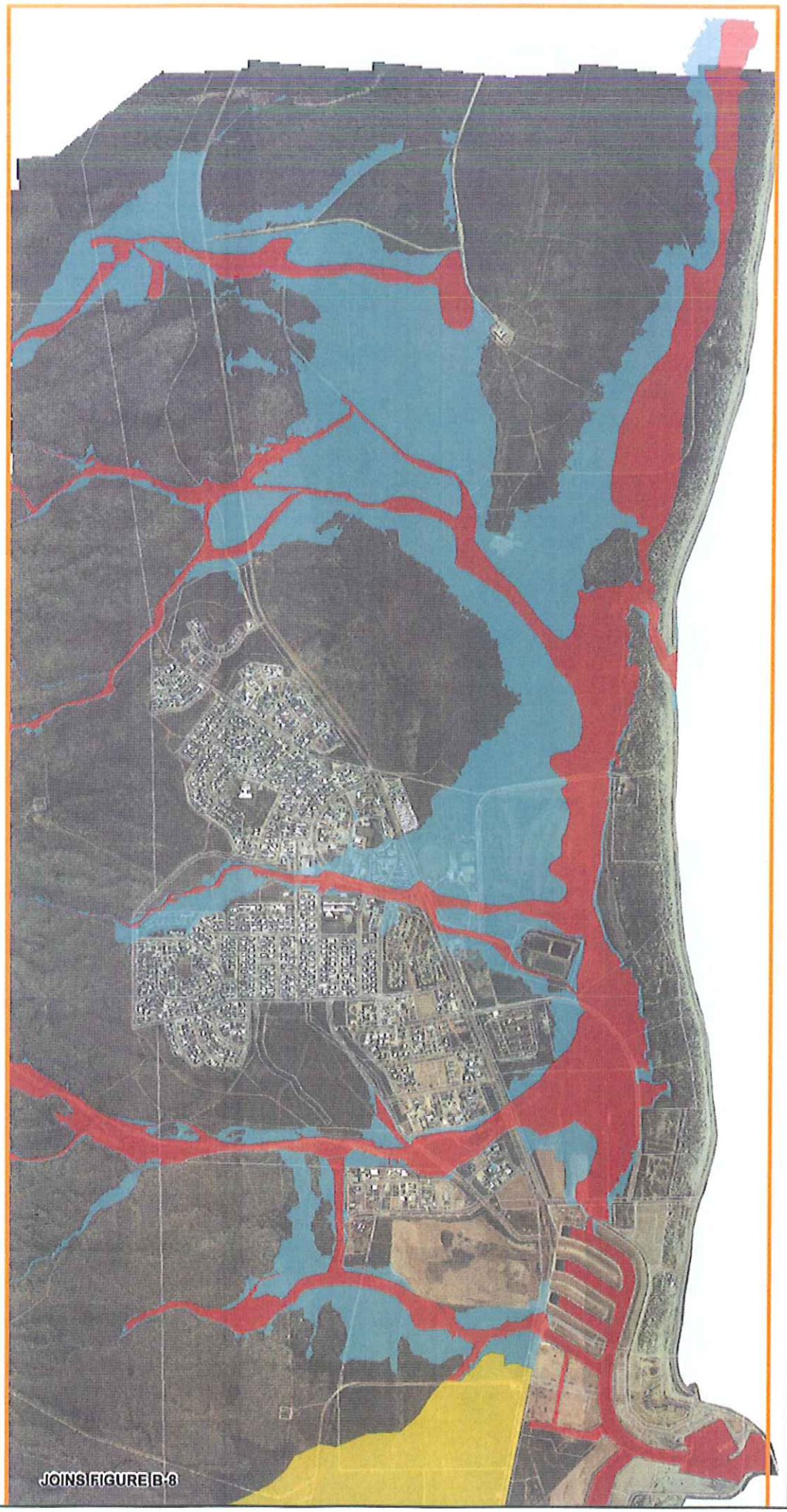


Figure B-7

Exmouth Floodplain Management Study

Floodplain Management Strategy
Flood Zoning
Developed Case
Part 1

Legend

- Flood Way
- Flood Zone
- Area of Special Consideration
- Hydraulic Model Extent
- Cadastre

N

0 100 200 400 600 800
Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

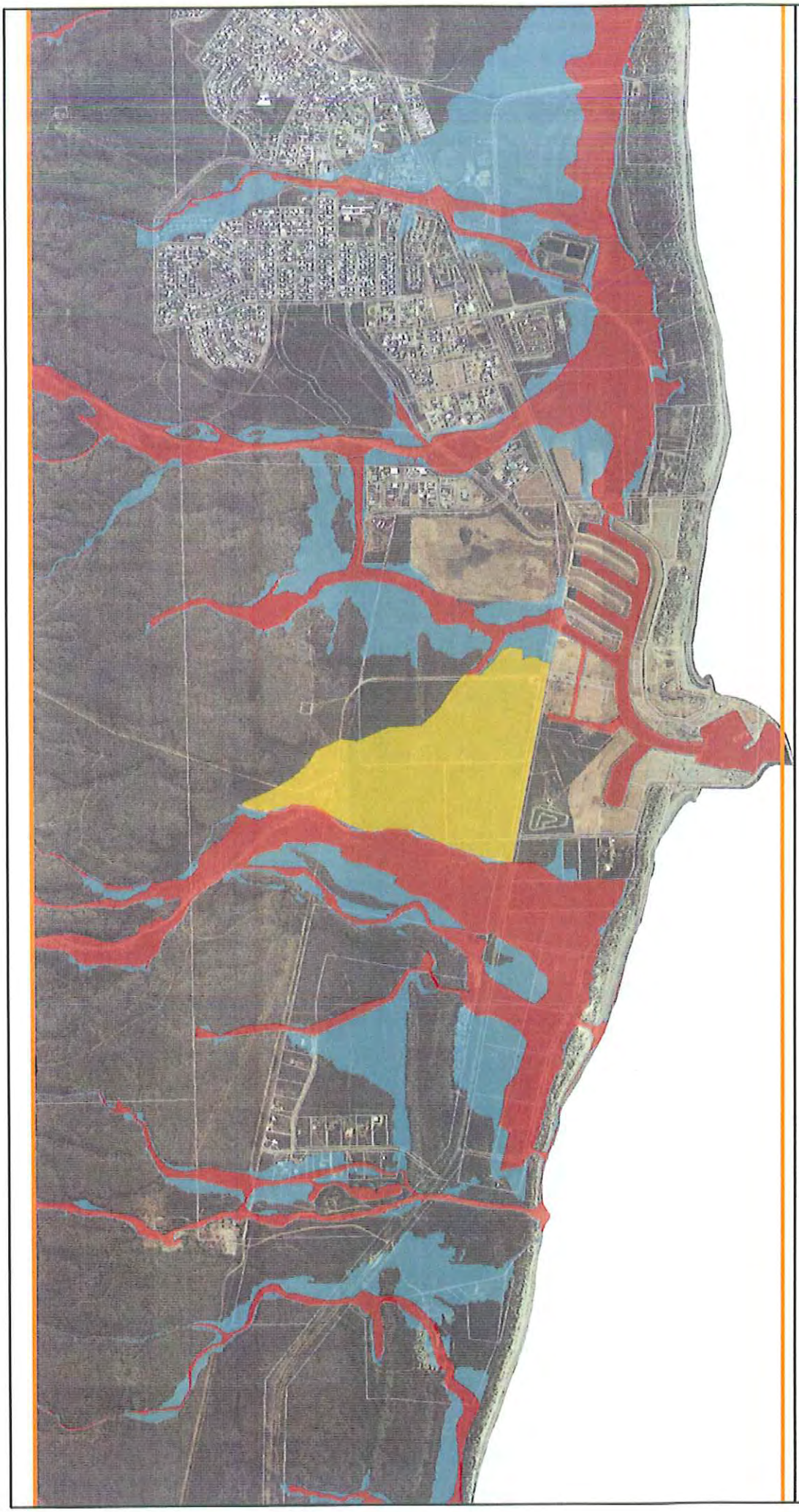


Figure B-8

Exmouth Floodplain Management Study

Floodplain Management Strategy

Flood Zoning Developed Case

Part 2

Legend

- Flood Way
- Flood Zone
- Area of Special Consideration
- Hydraulic Model Extent
- Cadastre

N

0 90 180 360 540 720

Metres

Scale 1:25,000 (at A4)

SKM

Project Number - QE09355

APPENDIX C DWMS

District Water Management Strategy

Shire of Exmouth

Job Number: V11049

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Author: Justine Jones
Position Title: Practice Leader - Water

Reviewer: Carrie Kruchell
Position Title: Section Leader: Water, Waste and CLASS

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Executive Summary

The Shire of Exmouth (SoE) is currently proposing the expansion of the existing Townsite to accommodate the future population projection of Exmouth. As part of this process a District Structure Plan (DSP) (TBB, 2011) has been prepared to identify the potential opportunities and constraints for future development. Exmouth is located on the North West Cape within the Gascoyne Region of Western Australia, 1260km north west of Perth.

The District Water Management Strategy (DWMS) is a key supportive document for the DSP. The development of the DWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a 'total water cycle management' approach described in this document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide future Local Water Management Strategies (LWMS) and Urban Water Management Plans (UWMP) that will support subdivision approval.

This DWMS has been developed to:

- Provide a broad level stormwater management framework to support future development.
- Incorporate appropriate best management practices into the drainage systems that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and Shire of Exmouth.
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area.

A regional environmental context for the LWMS has been detailed within **Section** 2 and is summarised below:

- Exmouth experiences very hot summers and mild winters, receiving an average of 267mm of rainfall principally between January and July, with heaviest falls related to tropical cyclones;
- The Exmouth Townsite is largely unconstrained by its slightly sloping westerly topography, however the dunal ridge to the east may result in flooding;
- No detailed mapping of soil type has occurred, however there is the potential for Karst formations and perched groundwater;
- Current information illustrates that ASS is contained to the eastern boundary of the site.
- The site is dominated by a Hummock grassland with the possibility of 19 DEC priority listed species;
- 14 terrestrial species have been identified that may inhabit the area, including Oroglobites and Stygofauna;
- Cape Range Subterranean Waterway is the closest wetland to the site, located 5kms south and is not considered to be a constraint upon the Exmouth Townsite DSP;
- Cameron's Cave is the only environmentally sensitive area within the site, being declared as critically endangered by the DEC, requiring a 500m buffer;
- DoW do not have any long term data for groundwater quality and quantity under the Townsite
- Four floodplains have been located throughout the site by a SKM study;
- Nine sites are located within the Townsite that may have potential for contamination;
- No areas of Aboriginal significance have been recorded; however three sites have been recorded adjacent to the study area; and
- Eight sites have been identified within the site as important to European heritage.

The DWMS outlines the proposed water supply and conservation strategy, stormwater management strategy, groundwater management strategy and a monitoring strategy. These strategies have been

determined based on the physical constraints of the site, as well as to achieve the requirements of government authorities.

Monitoring of both groundwater levels and quality is required prior to commencement of any LWMS for the development within the townsite as existing site specific information is not currently available. A number of management measures have been proposed should groundwater levels be close to ground level with **Section 5.4**. Monitoring of groundwater quality should be implemented to ensure that the nutrient concentrations within the underlying aquifers are not significantly increased due to development. This monitoring is particularly important given the sensitive subterranean ecosystems noted within the townsite.

The principle behind the stormwater management strategy is to detain the first 15mm of rainfall onsite within lot gardens or swales and Public Open Space area. All remaining stormwater should be directed towards the existing creek lines for quick removal offsite. Broad scale calculations have been provided which show the anticipated volume of stormwater detention required for each catchment. These volumes are meant for catchment scale planning only. It is not proposed that flood storage areas are designed to detain this stormwater. Full details are provided within **Section 5.3**.

The DWMS covers an extended area across which both Water Corporation systems are available and connection to serviced utilities is not currently available. The availability of freshwater is limited across the townsite and is therefore carefully controlled and managed by the Department of Water. Currently the Exmouth North and Town sub areas are over allocated, with no further allocations for access made available. Exmouth Central and South have groundwater available, with new applications to be made available with further developments. New applications for groundwater access will have to involve total water cycle management principles to achieve a more efficient use of water application and detail the rate at which groundwater is planned to be extracted. At a lot scale, households will be required to implement water saving strategies including rainwater tanks (where appropriate), water efficient appliances and water efficient gardens.

The Exmouth DWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based on site specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Shire of Exmouth. The responsibility for working within the framework established within the DWMS rests with the individual landowners, although it is anticipated that future LWMPs/UWMPs will be developed in consultation with the Shire of Exmouth, Department of Water and in consideration of other relevant policies and documents as well as this DWMS.

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List of Abbreviations

ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soils
ATUs	Aerobic Treatment Units
BMP	Best Management Practices
BOM	Bureau of Meteorology
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DoH	Department of Health
DoW	Department of Water
DSEWPaC	Department of Sustainability, Environment, Water, Populations, and Community
DSP	District Structure Plan
DWMS	District Water Management Strategy
EFMS	Exmouth Floodplain Management Study
EPBC Act	Environmental Protection and Biodiversity Conservation Act
LIA	Light Industrial Area
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
MGL	Maximum Groundwater Level
MU	Multiple Use
NTU	Nephelometric Turbidity Unit
POS	Public Open Space
PRI	Phosphorus Retention Index
RR	Rural Residential
SOE	Shire of Exmouth

SPP	State Planning Policy
UWMP	Urban Water Management Plan
WA	Western Australia
WAPC	Western Australian Planning Commission
WC	Water Corporation
WSUD	Water Sensitive Urban Design
WWTF	Wastewater Treatment Facility

1 Introduction

1.1 Background

The Shire of Exmouth (SoE) is currently proposing the expansion of the existing townsite to accommodate the future population projection of Exmouth. As part of this process, a District Structure Plan (DSP) (TBB, 2011) has been prepared to identify the potential opportunities and constraints for future development. Exmouth is located on the North West Cape within the Gascoyne Region of Western Australia (WA), 1260km north west of Perth.

The Exmouth Townsite ('Townsite') has historically been utilised for residential and commercial purposes, with some rural residential development located on the fringes. The growth of the SoE has increased the demand of developable land, however, a number of constraints limit the extent of future development. Due to the semi-arid climate, rainfall mainly occurs in the wet season (January to July) and can involve tropical cyclones, including high wind speeds and heavy rainfall. As a result the key issues identified for the Townsite expansion are flooding and stormwater conveyance.

This District Water Management Strategy (DWMS) has been produced in conjunction with the 2011 Exmouth Townsite Structure Plan (TBB 2011) as a statutory document to guide proposed development across the 300+Ha Townsite. The provision of a DWMS is a requirement of the Department of Water (DoW) document *Better Urban Water Management* (WAPC 2008). This DWMS will provide an outline to the key environmental opportunities and constraints and the future work to be considered at more detailed stages of the planning process. The establishment of overall objectives, constraints and opportunities for whole water cycle management will be outlined. **Table 1** below provides a checklist of the Better Urban Water Management requirements for a DWMS.

Table 1 Better Urban Water Management DWMS Checklist

	Status	Comments/proposal
Introduction		
Principles and objectives	✓	See Section 1.2
Previous Studies and recommendations	✓	See Section 1.3
Design and Management Objectives		
Design objectives for potable water use, stormwater quality and quantity (including flood management), groundwater quality and quantity, wastewater and water re-use	✓	See Section 4
Pre-development Environment		
Site characteristics – opportunities, constraints, areas requiring specialised investigation and management – discussed and mapped	✓	See Section 2, mapping provided where available
Hydrologic information – previous work, recent investigations, groundwater levels, flow and availability, groundwater and surface water quality identified and mapped, environmental water requirements identified including waterways/wetland buffers	✓	See Section 2, mapping provided where available
Analysis of Development Impacts and Options		
Assessment of proposed land use scenario by DoW (SQUARE)	N/A	Proposed land uses were provided by the Shire of Exmouth.
Response to assessment	N/A	
Strategies and recommendations for planning precincts to guide and control land use and development where necessary	N/A	Shire of Exmouth to undertake this work in response to developer enquiry.
Fit-for-purpose Water Source Planning		
Site water balance	✓	See Section 5
Allocation of water for all types of uses, including discussion of options	✓	See Section 5
Infrastructure (potable, non-potable, wastewater) – existing and required	✓	See Section 5
Water Management Strategy		
Drinking water conservation and efficiency of water use	✓	See Section 5.1
Surface water management strategy – flood management (flow paths, flow rates and levels at control points), conceptual stormwater management system, best planning practices, appropriate best management practices	✓	See Section 5.3
Groundwater management strategy – groundwater contours, levels and quality, allocation availability	✓	See Section 5.4
Wastewater management strategy	✓	See Section 5.2
Implementation Framework		
Considerations and requirements for local planning	✓	See Section 6
Monitoring – pre-development, post development, data analysis, presentation and reporting mechanisms	✓	See Section 6.2.2.1
Technical review	✓	See Section 6.6
Funding and ongoing maintenance responsibilities	✓	See Section 6.7 and Table 7

1.2 Aim and Objectives

1.2.1 Aim

To demonstrate that the land zoned in the District Structure Plan (DSP) 2011 is capable of supporting urban development. This would be undertaken through the development and documentation of strategies for sustainable best practices for water conservation, groundwater protection, wetland dependent ecosystem production, maintenance of existing hydrological regimes, assessment of any

further work that may be required at future stages of development and monitoring programmes that may be implemented to ensure that these strategies are achieved.

1.2.2 Objectives

This DWMS has been developed to meet the following major objectives:

- Provide a broad level stormwater management framework to support future urban development and allow for the determination of shared stormwater management costs across multiple landholdings;
- To provide clarity for agencies involved in water management;
- Incorporate appropriate Best Management Practices (BMP) into the drainage systems that address the environmental and stormwater management issues identified;
- Minimise ongoing operation and maintenance costs for the land owners and SoE; and
- To maintain and improve surface and groundwater quality and total water cycle balance within development areas relative to pre-development conditions.

1.3 Methodology

The State Water Strategy (Government of WA, 2003a) promotes a total water cycle management plan, endorsing the application of Water Sensitive Urban Design (WSUD) principles. These initiatives are intended to provide improvements for the management and efficient use of existing water supplies and stormwater.

Total water cycle management therefore addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Management design objectives should therefore seek to deliver better outcomes in terms of:

- Consideration of all water sources, including wastewater, stormwater and groundwater;
- Sustainable use of all water sources;
- Allocating and using water equitably including potable water consumption;
- Integrating water use with natural water processes, including maintaining environmental flows and water equality;
- Stormwater quality management;
- Shallow groundwater management; and
- Flood mitigation.

A fundamental first step in applying total water cycle management in catchments for rural and urban use is to establish agreed environmental values for receiving waters and associated ecosystems. Guidance regarding environmental values and criteria is provided by a number of National and State policies, guidelines and Townsite specific studies undertaken in and around the Townsite.

The DWMS was prepared having undertaken a Townsite visit and review of previous relevant studies undertaken within the Townsite geographical area. These documents included:

- Exmouth-Learmonth (North-West Cape) Structure Plan 1998 (WAPC 1998)
- Ningaloo Coast Regional Strategy Carnavon to Exmouth 2004 (WAPC 2004)
- Exmouth Structure Plan (TBB 2011)
- Exmouth Flood Management Study (SKM 2007)
- Exmouth Water Reserve Water Source Protection Review (DoW 2011)

In addition, a number of State Government documents were consulted. These policies include:

- State Sustainability Strategy (WAPC, 2003);
    - Environmental and Natural Resources (SPP 2);
    - State Coastal Planning Policy (SPP 2.6);

  - Public Drinking Water Source Policy (SPP 2.7);
  - Water Resources (SPP 2.9);
  - Urban Growth and Settlement (SPP 3);
  - State Industrial Buffer Policy (SPP 4.1);
- State Water Strategy (Government of WA, 2003a);
- State Water Plan (Government of WA, 2007);
- Better Urban Water Management (WAPC, 2008); and
- Stormwater Management Manual for Western Australia, Department of Environment and Conservation (DEC 2007).

The DWMS requires a good understanding of the quality and quantity of the surface water and groundwater across and beneath the proposed development area. A sound understanding of these constraints and opportunities enables appropriate management strategies to be presented.

Groundwater levels across the Townsite are used to determine the most appropriate post development land use (e.g. areas of shallow watertable are more suitable for Public Open Space (POS) than for dwellings or flood storage areas). The quality of groundwater and the surface runoff leaving the Townsite also needs to be determined. Water exiting the Townsite has the potential to deposit pollutants into the waterbody that it drains into; therefore an understanding of the water quality is the first step to managing it to acceptable standards. No groundwater monitoring was undertaken as part of the production of this report.

The quantity of surface runoff is the most visually obvious constraint to management, nevertheless it should be considered equally as important as groundwater quantity, quality and surface water quality. The management of surface runoff rates and volumes are important to protect areas from flooding and potential erosion.

1.3.1 Modelling Assumptions

Due to the high level planning detail associated with the structure plan the following assumptions have been made regarding the land use types:

- Tourism: Considered to be urban in nature and therefore stormwater runoff will be generated rapidly in a storm event. Where more permeable forms of development are incorporated, such as golf courses, this will reduce peak storm runoff due to the permeable nature of the land use, resulting in a reduction in the detention volumes required.
- Proposed Urban, Town Centre, Service Commercial/Service Industry, Mixed Use, Light Industry, Public Purposes, Marine precinct and Boat-Harbour Precinct: Considered to be 100% impermeable. Should the detailed design of these areas incorporate permeable areas into the design this will reduce the volume of attenuation required to be detained.

2 Pre-Development Environment

2.1 Geotechnical Conditions

2.1.1 Climate

Exmouth is located within a hot, semi-arid climatic zone, with very hot summers and mild winters. The average annual rainfall is 267mm, however, rainfall is highly variable and is offset by high evaporation rates. According to the Bureau of Meteorology (BOM), the majority of rainfall occurs during the wet season from January to July, with heaviest falls occurring early in the season (February to March) as a result of tropical cyclones (BOM, 2011).

2.1.2 Topography

The Townsite ranges in elevation from 20mAHD in the west where the Townsite is bounded by Cape Range National Park gently sloping to 0mAHD along the eastern boundary. Dune formation along the eastern boundary of the Townsite can restrict drainage of heavy rainfall, leading to flooding along the foreshore corridor (**Figure 1**).

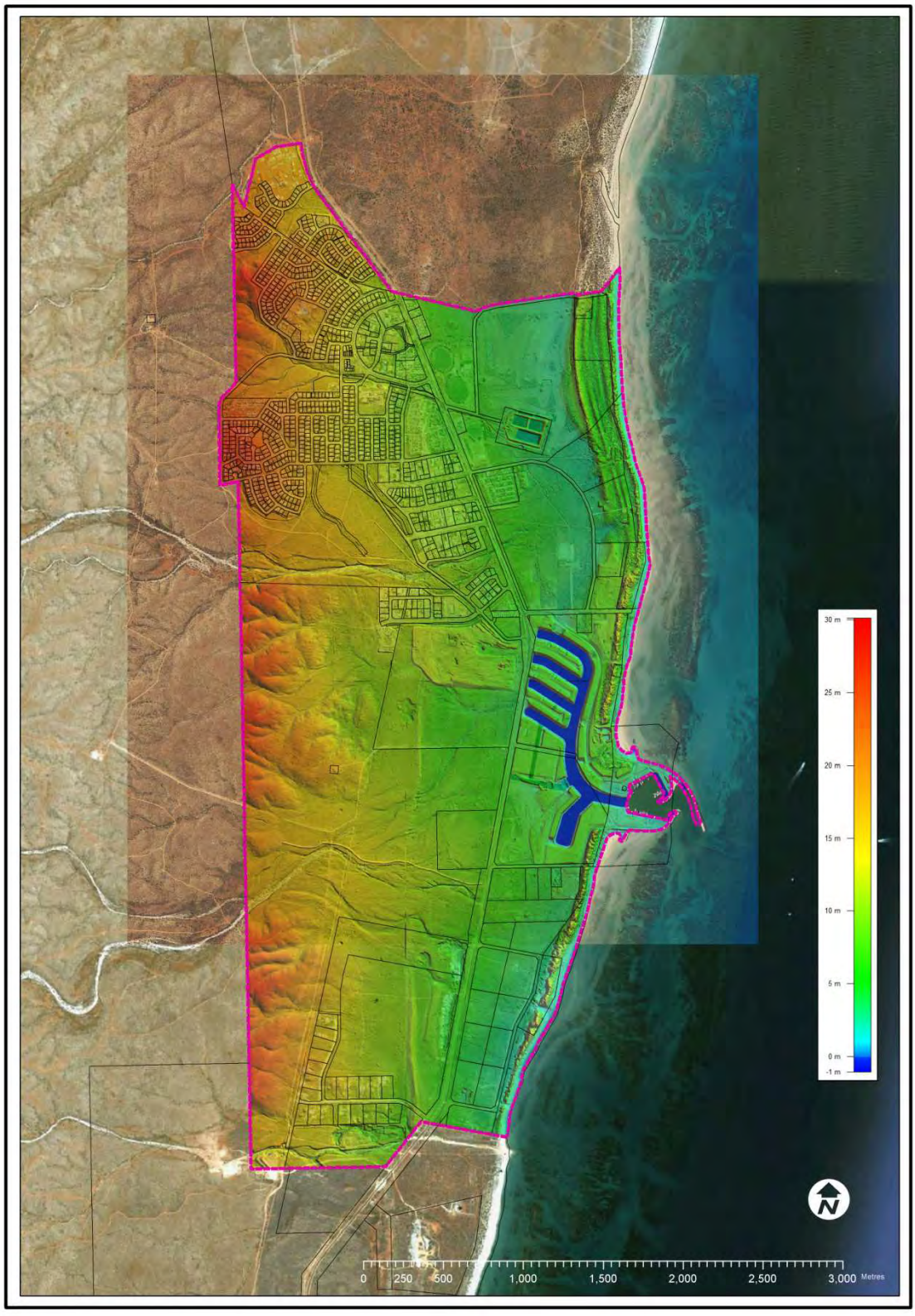


Figure 1 Townsite Topography

2.1.3 Soils

At present, no detailed soil mapping has been undertaken. The peninsular is composed of Cenozoic (Tertiary and Quaternary) marine limestone and sediments with Colluvium soils and some Trealla

Limestone deposits on the western fringe of the Townsite (**Figure 2**). Sedimentary deposits have largely been stripped from across the site, exposing limestone deposits. It is considered that there is a low soil depth, with the potential for Karst formations and perched groundwater. The hydraulic conductivity will need to be determined through geotechnical investigation.

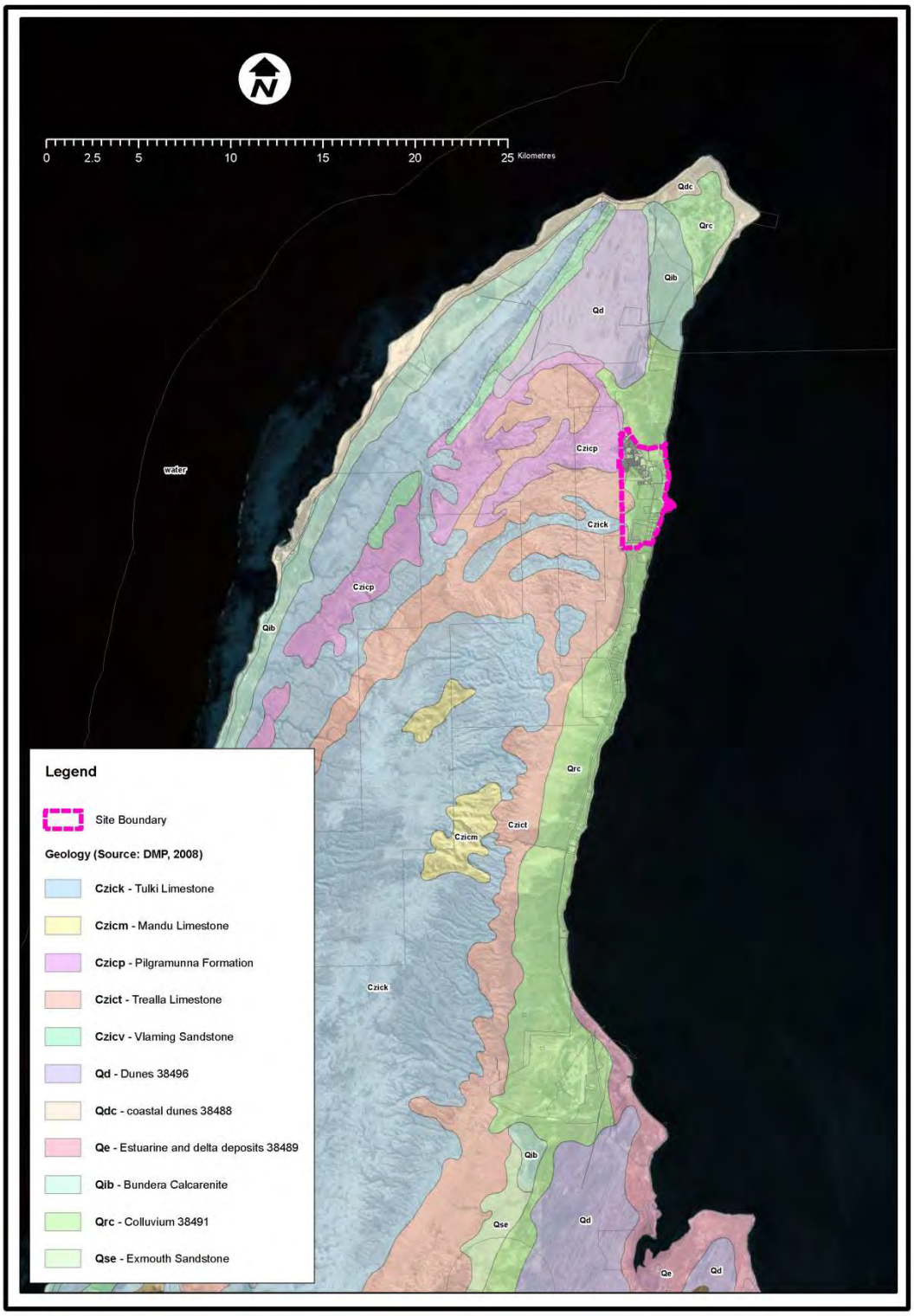


Figure 2 Soils

2.1.4 Acid Sulfate Soils

Regional mapping prepared by the DEC (2011a) indicates that the majority of the Townsite is unconstrained by Acid Sulfate Soils (ASS) (**Figure 3**). The eastern boundary of the Townsite adjoining the estuarine soils of Market Street Creek and LIA Creek have been mapped as "moderate to low risk of ASS occurring up to 3.0 m below ground surface". The coastal soils within the dunal ridge on the eastern perimeter of the Townsite are at risk of "high to moderate ASS disturbance occurring up to 3.0 m below ground surface".



Figure 3 Acid Sulfate Risk Mapping

During the production of a Local Structure Plan (LSP), a preliminary Townsite assessment for ASS may be required.

2.1.5 Drinking Source Protection Zones

The Townsite is known to adjoin the eastern boundary of the Exmouth Water Reserve, which is a sensitive water resource. Regional groundwater flows to the east and therefore away from the reserve, however, as the aquifer is unconfined there is a potential for contamination to occur through poor management. DoW guidance *Rezoning and Subdivision of Land in Public Drinking Water Source Areas* (DoW, 2009a) should be referred to for advice.

2.2 Environmental Assets

2.2.1 Flora

Broad scale mapping of vegetation across the Townsite indicates that the area is dominated by a Hummock Grassland (DSEWPaC, 2007) (**Figure 4**).

Given the proximity of the Townsite to the Cape Range National Park, there may be significant flora present across the areas of remnant vegetation; however, historical land use suggests that past grazing may limit the diversity of flora species.

A search of the DEC 'Declared Rare and Priority Flora' database in 2011 (DEC, 2011b) identified the following flora species may potentially occur throughout the Townsite:

- *Abutilon sp. Quobba* (H Demarz 3858) (Priority 2);
- *Abutilon sp. Cape Range* (A.S. George 1312) (Priority 2);
- *Acacia alexandri* (Priority 3);
- *Acacia ryaniana* (Priority 2);
- *Acacia startii* (Priority 3);
- *Acanthocarpus rupestris* (Priority 2);
- *Brachychiton obtusilobus* (Priority 4);
- *Corchorus congener* (Priority 3);
- *Crinum flaccidum* (Priority 2);
- *Daviesia pleurophylla* (Priority 2);
- *Eremophila forrestii subsp. capensis* (Priority 3);
- *Eremophila occidens* (Priority 2);
- *Eremophila youngii subsp. lepidota* (Priority 4);
- *Grevillea calcicola* (Priority 3);
- *Harnieria kempeana subsp. rhadinophylla* (Priority 2);
- *Livistona alfredii* (Priority 4);
- *Stackhousia umbellata* (Priority 3);
- *Tinospora esiangkara* (Priority 2); and
- *Verticordia serotina* (Priority 2).

A search was conducted using the federal protected matters search tool (DSEWPaC, 2011) on the 18th July 2011. DSEWPaC maintains a list of species regarded to be of national environmental significance, as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). No flora species listed as rare and as such protected under the EPBC Act were noted to be within the Townsite search area at the time of the search.



Figure 4 Environmentally Sensitive Areas

2.2.2 Fauna

The Exmouth Townsite DSP identifies 14 species of terrestrial fauna that have been declared rare or likely to become extinct which inhabit the area. This includes subterranean fauna such as troglobites and stygofauna.

A number of significant fauna species are listed by the DEC and Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) as potentially utilising the site, however, it is considered that potential fauna habitats are limited to remnant native vegetation. Species listed under the DSEWPaC protected species database include:

- *Macronectes giganteus* (Southern Giant-Petrel) listed as Endangered;
- *Dasycercus cristicauda* (Mulgara) listed as Vulnerable;
- *Petrogale lateralis* (Black-flanked Rock-wallaby) listed as Vulnerable;
- *Apus pacificus* (Fork-tailed Swift) listed as Migratory;
- *Ardea alba* (Great Egret, White Egret) listed as Migratory;
- *Ardea ibis* (Cattle Egret) listed as Migratory;
- *Haliaeetus laucogaster* (White-bellied Sea-Eagle) listed as Migratory;
- *Hirundo rustica* (Barn Swallow) listed as Migratory; and
- *Merops ornatus* (Rainbow Bee-eater) listed as Migratory.

While these species are listed within the Townsite search area, no site specific survey has been undertaken to confirm their presence.

2.2.3 Environmentally Sensitive Areas

2.2.3.1 Wetlands

The Exmouth Townsite contains no listed wetlands. The Cape Range Subterranean Waterway (WA006) is the closest recognised wetland, circa. 5km south of the Townsite (**Figure 4**). This wetland is listed as a nationally important wetland (DSEWPaC, 2011). As such a buffer of 5m is required to be maintained for all development.

2.2.3.2 Cameron's Cave

Cameron's Cave is a Karst formation relief located just north of the Preston Street rural residential area, within the southern section of the Townsite (**Figure 4**). This formation is the habitat for both aquatic and terrestrial species found in the Cameron's Cave Troglobitic Community. This community is considered Critically Endangered by the DEC and has been placed on the 'Threatened Ecological Community' list. Management plans are being prepared to ensure the protection of this ecological community. The North West Cape Karst Management Advisory Committee have recommended a 500m land use buffer be installed, which has been included within the Exmouth Townsite DSP.

2.2.4 Hydrology

2.2.4.1 Flooding

The Townsite for the DWMS includes a number of watercourses which flow eastwards from a source in the Cape Ranges towards the Exmouth Gulf. These watercourses were identified within the Exmouth Floodplain Management Study (EFMS) prepared by SKM (2009) and are detailed in **Figure 5** below. The principal watercourses of note within the Townsite are Town Creek, Light Industrial Area (LIA) Creek, Market Street Creek and Preston Street Creek.

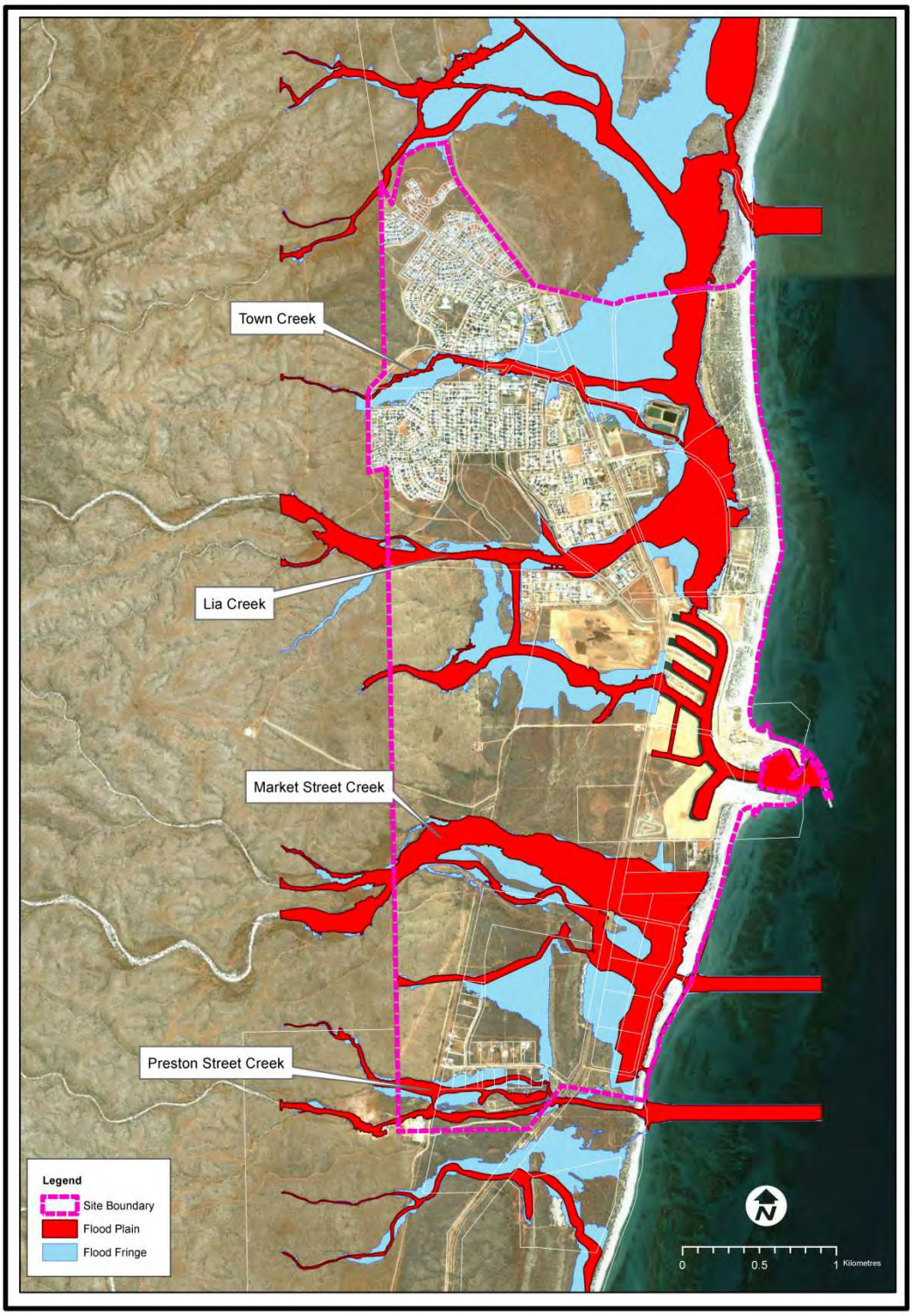


Figure 5 Major Waterways within the Townsite and Associated Flood Zones

Flood history summarised in the EFMS states that flood events in March 1999 and June 2002 are notable in magnitude. These events reflect both cyclonic flooding (March 1999) and flooding associated with heavy winter rainfall (June 2002). Both events are notable for being one of the most powerful cyclones (Cyclone Vance) recorded in Australia and the wettest June day on record in

Western Australia, respectively. Both these events resulted in out of bank flooding within the upstream catchments of the Townsite.

The EFMS established the floodplain extent for a 100 year Annual Recurrence Interval (ARI) event throughout the Townsite (**Figure 5**).

2.2.4.2 Surface Water Quality

Across the Exmouth Townsite there are no permanent surface water bodies. As detailed above there are a number of ephemeral creek lines, however, these only flow during the wet season for short periods of time, conveying stormwater.

2.2.4.3 Groundwater Levels and Quality

The *Exmouth Water Reserve Drinking Water Source Protection Review* (DoW, 2011) details a number of production boreholes which are located to the west of the Exmouth Townsite within Crown Reserve Land. Regular monitoring of these boreholes is undertaken by the Water Corporation (WC) for aesthetic related characteristics (non-health related) and health related characteristics. A summary of the results of this monitoring is provided in **Table 2**. It should be noted that these results are compared against the Australian Drinking Water Guidelines (ADWG) as a conservative approach, however, the water tested undergoes further treatment prior to being released to the general public of Exmouth.

Table 2 Summary of Long Term Water Quality Monitoring (Water Corporation)

Parameter	Units	ADWG Guideline Value	Median Result
Aesthetic Characteristics			
Chloride	mg/l	250	260
Hardness as $CaCO_3$	mg/l	200	330
Iron (unfiltered)	mg/l	0.3	<0.003
Sodium	mg/l	180	135
Total Filterable Solids	mg/l	500	831
Turbidity	NTU	5	<0.1
pH	No unit	6.5-8.5	7.3
Health Characteristics			
Nitrate (as Nitrogen)	mg/l	11.29	1.8
Nitrite (as Nitrogen)	mg/l	0.91	<0.002
Nitrite + Nitrate (as Nitrogen)	mg/l	11.29	1.9
Fluoride	mg/l	1.5	0.2

A review of the DoW database identified that there is no long term groundwater level and quality monitoring data available for the site.

2.3 Potable and Wastewater

2.3.1 Water Supply

The Townsite extracts circa. 832,000kl/yr of groundwater from the unconfined Tulki and Trealla Limestone Aquifers within the Cape Ranges. This water is abstracted via 40 boreholes to the west and south of the existing town. Prior to distribution the water is treated through aeration and filtration to remove iron and manganese to stabilise the pH, and disinfected through chlorination to ensure microbiological quality is maintained.

Potential land uses within the bore field include livestock grazing and limestone mining, both of which have the potential to cause contamination of the water supply. To limit the potential for contamination, a number of BMP have been detailed within the Exmouth Water Reserve (2011) document and will generally be managed through the borehole licensing application process and through guidance such as:

- Water Quality Protection Note 35: Pastoral Activities in Rangelands; and
- Statewide Policy No 13: Policy and Guidelines for Recreation within Public Drinking Water Source Areas on Crown Land.

2.3.2 Wastewater

WC is responsible for the provision of wastewater services within the town centre. Currently Exmouth is serviced by a Wastewater Treatment Facility (WWTF) within the town boundaries. In the future this WWTF will be relocated to the periphery of the town. Where connection to the WC serviced sewer is not available, septic tank sewerage is provided.

2.4 Contamination

A search of the DEC's Contaminated Sites database on the 18th of July 2011 indicated that there are nine known contaminated sites that have been identified for remediation within the Townsite (**Figure 6**). These sites are located within existing developed areas, including:

- 23 and 29 Pelias St, Exmouth (Contaminated – remediation required);
- 24 Nimitz St, Exmouth (Contaminated – remediation required);
- 4, 6 and 8 Huston St, Exmouth (Contaminated – remediation required);
- 12 and 16 Christie St, Exmouth (Contaminated – remediation required); and
- 8 Murat Road, Exmouth (Contaminated – remediation required).

Landcorp have also identified an old waste disposal site located south of Welch Street as historically containing chemical storage or potentially contaminating land uses. Landcorp are due to remediate this area prior to development.

An existing petrol station located on the corner of Murat Road and Maidstone Crescent also raises concerns. This site is located within a mapped floodway and has the potential to result in contamination transport during a significant rainfall and flooding event.



Figure 6 Contaminated Sites

2.5 Heritage Land Uses

2.5.1 Aboriginal Heritage

A search of the Department of Indigenous Affairs (DIA) database on the 18th of July 2011 for known sites of Aboriginal significance indicates that there are no known locations of significance within the Townsite (**Figure 7**). However, three sites of significance were identified adjacent to the site, and include:

- DIA 6115 Exmouth North-East; Skeletal material/Burial;
- DIA 6116 Exmouth South-West; Skeletal material/Burial; and
- DIA 19839 Waterhole, Exmouth; Artefacts/Scatter, Water Source.

2.5.2 European Heritage

A search of the Heritage Council of Western Australia's database (Heritage Council of WA, 2011) found that there are eight known sites of European Heritage that are located within the Townsite (**Figure 7**). The known heritage sites include:

- Community Hall (3053), Corner of Maidstone Crescent and Learmonth Street, Exmouth;
- Exmouth Fire Station (14506), Payne Street, Exmouth;
- Exmouth Police Station and Lockup (17339), Maidstone Crescent, Exmouth;
- Exmouth War Memorial (12290), Maidstone Crescent, Exmouth;
- First Trees planted in Exmouth (10622), Maidstone Crescent, Exmouth;
- Shire Library (10632), Maidstone Crescent, Exmouth;
- Staff House (10637), Corner of Bennett Street and Fyfe Street, Exmouth; and
- Transit House (10639), Lot 263 Christie Street, Exmouth.

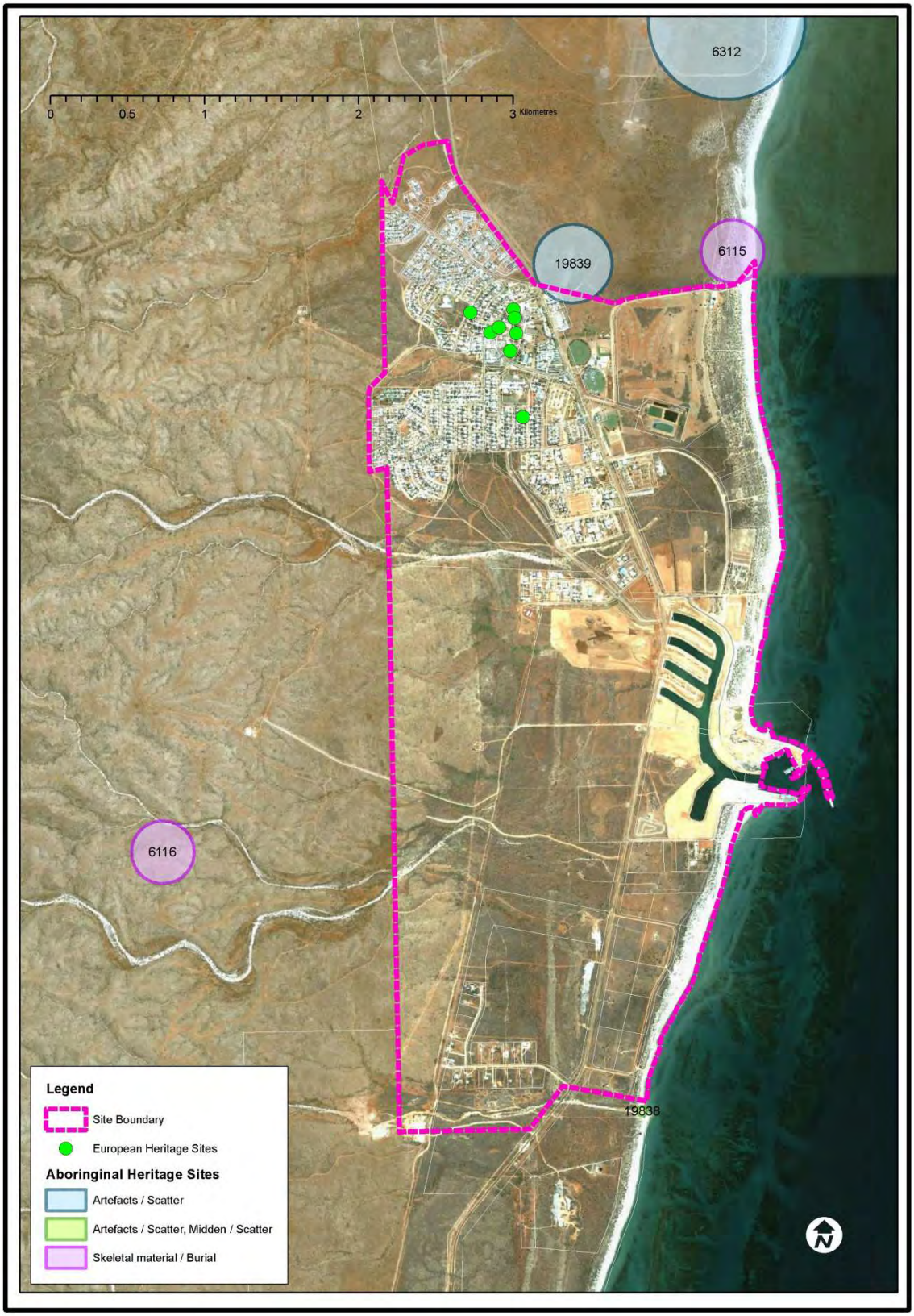


Figure 7 Heritage Land Use

3 Proposed Development

A DWMS is typically produced prior to or concurrently with the development of a DSP or LSP, so that the structure plan can use the information gathered in the DWMS investigation to facilitate the development of a design that best suits the existing natural environment, while ensuring sufficient space for water is provided.

In June 2011, the SoE released the Exmouth DSP (**Figure 8**). This DSP displays consideration of the current known constraints and opportunities of the Townsite. Additional knowledge gathered through future detailed Townsite investigation, however, may result in the structure plan undergoing some modification in the future.

The Exmouth Townsite DSP has classified the Townsite to comprise of a mixture of land uses, including:

- Residential Infill 1and 2 (RI);
- Multiple Use (MU) upgrade of 1 Reid Street to a 1 in 100 year storm event;
- MU zoning of 2 Murat Road;
- MU zoning of 3 Murat Road/Warne Street;
- Rural Residential (RR) of 1 Preston Street;
- Town Centre upgrade;
- Possible Harbour Extension to Residential 25 (R25);
- Introduction of three specialised tourism zoned sites, T1: Strategic Tourism Site, T2: Approved Site, T3: Zoned land for tourist accommodation;
- Murat Road Upgrade; and
- Minimum Lot Density of residential 17.5 (R17.5).

This will result in a total potential yield of 3078 dwellings for a total increase in 7076 residents, with 120ha available for residential and 8.1ha available for rural residential.

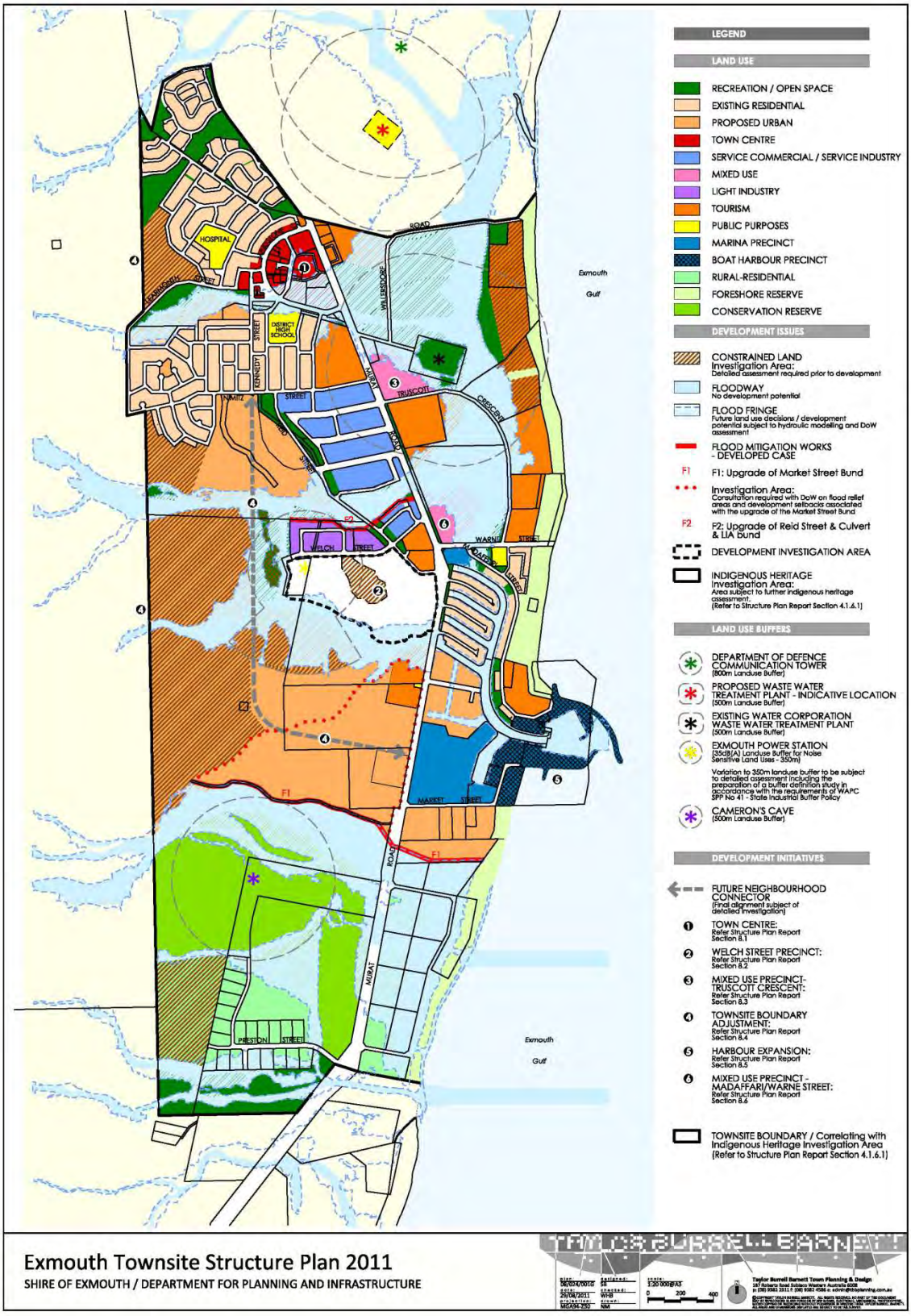


Figure 8 Exmouth District Structure Plan

4 Water Management Design Criteria and Objectives

4.1 Total Water Cycle Management for Water Conservation

The overall objective for preparing a total water cycle management plan for a proposed development is to minimise pollution and maintain an appropriate water balance. Therefore allocation and water use should be used sparingly where appropriate.

4.1.1 Wastewater Reuse

Wastewater should be recycled and used as potable or non-potable water depending on the quality of the treatment. Exmouth currently has a WWTF, with water utilised from non-potable sources for the irrigation of POS.

4.1.2 Grey Water Reuse

Grey water (wastewater used in the home, excluding toilets and potentially kitchens, with moderate concentrations of solids and nutrients) can be used for subsoil irrigation and in some other non-potable water uses. There is the potential for nutrient leaching if the water is used for irrigation, however, there are no wetlands within the site, therefore grey water could be used on a development scale to conserve water.

4.2 Stormwater Management

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DoW, 2007). This is used in conjunction with the *Decision Process for Stormwater Management in WA* (DoW, 2009) as guidance to how urban development can achieve compliance within the objectives, principles and delivery approach. The *Stormwater Management Manual for WA* also provides guidance on the broad principles of WSUD.

4.2.1 Stormwater Quantity

Discussions undertaken with the DoW (personal communication 22 July 2011) determined the following key design criteria that should be adopted to manage stormwater quantity:

- Detain the first 15 mm of rainfall within lots where practical;
- Convey flood waters offsite without detention where practical;
- Stormwater quantity should be managed using open drains and roads rather than piped drainage;
- Culverts can be used where required to convey stormwater under roads;
- Minor roads should be set 0.3 m above the 100-yr ARI level;
- Major roads should be 0.5 m above the 100-yr ARI level; and
- Existing waterways and natural drainage lines should be retained with the aim of minimising changes to the pre-development hydrology. These waterways should also be restored where required.

4.2.2 Stormwater Quality

Water quality treatment systems and WSUD structures must be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2007) and *Australian Runoff Quality* (Engineers Australia, 2006). The *Better Urban Water Management* (WAPC, 2008) principle outlines how existing surface and groundwater quality should be maintained as a minimum, and preferably

improved prior to discharge from the development area. This will involve a water quality management approach that establishes pre-development water quality standards. Targets for post development scenarios that reflect the pre-development water quantity parameters can then be implemented as part of any Local Water Management Strategy (LWMS).

If catchment ambient conditions have not been determined, water quality targets should be derived from the *National Water Quality Management Strategy* (ANZECC, 2000). Pollutant outputs for pre-development environments are hard to determine, with limited opportunity to measure all of the runoff from the area within a sheet flow environment such as Exmouth. Stormwater treatment is possible, however, this will depend on the intended usage and treatment requirements.

4.3 Groundwater Management

Manipulation of groundwater levels can have a range of detrimental effects on the local Karst community, including increasing nutrient levels within superficial aquifers and ASS potential. BMPs for groundwater levels and quality presented within WSUD need to be considered within further planning. These principles should include:

- Minimising changes to the underlying groundwater levels as a result of development;
- Groundwater quality leaving the Townsite should be at least the same, or better, than the water entering the site;
- Subdivisional lots should have a separation distance from the Maximum Groundwater Level (MGL) of at least 1.2m to ensure protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels;
- Bio-retention systems and drainage inverts should operate as dry basins with a minimum clearance of 0.3m between the MGL and the invert of the basin; and
- If subsurface drainage is to be utilised it must:
  - Be installed at or above the MGL.
  - Be designed with free draining outlets.

5 Water Management Strategy

5.1 Potable Water Management

5.1.1 Introduction

Available water sources for the expansion of the Townsite are limited to what is available within the surrounding area and therefore will increase the dependency on efficient use and water sourcing. The objective of 'fit for purpose' water is to achieve the highest degree of efficiency and appropriate allocation of a water source for a particular application. The provision of a medium term water supply for the area was released in 2010 by the WC. The *System Planning: Exmouth Water Supply Planning 2010* identified that Exmouth water usage will increase over the coming years as follows:

- By 2015 the system is estimated to grow by around 390 services to a total of 1,865 services; and
- By 2023 the system is expected to grow by 950 services to a total of 2,425 services.

To allow for appropriate planning to ensure the continuation of available water, the fit for purpose strategy needs to be executed at every possible opportunity.

5.1.2 Design Objectives

Ensure the efficient use of all water resources and aim to achieve the highest value use of fit for purposes water in all new developments such as the use of grey water for subsoil irrigation and in other non-potable water uses where appropriate.

Maintain opportunities for future generations by using water more efficiently. This could be achieved by raising community awareness, regulation, facilitating the recognition of the true value of water and financial incentives.

5.1.3 Management Strategies

5.1.3.1 Retention of Rainwater

Tropical cyclones can generate large amounts of rain within a very short period of time. This degree of rain can be too large for gutters and downpipes to efficiently transport, having the potential to result in internal flooding. It is therefore recommended that roofs do not have gutters or downpipes installed, with the first 15mm of rainfall detained on the Townsite if practical.

Rainwater tanks are encouraged where possible, particularly in rural residential developments, for collection and storage of water for use within landscaping in place of reticulated water.

5.1.3.2 Water Efficient Appliances

Significant reduction in in-house water uses can be achieved with the use of water efficient appliances. **Table 3** gives an example of the water uses of typical appliances verses water efficient appliances. These water use rates have been used in the water balance investigation.

Table 3 Water Efficient Appliances

Appliance	Water Use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Flush	40 Litres/Flush
Shower Head	15-25 Litres/Minute	6-7 Litres/Minute
Taps	15-18 Litres/Minute	5-6 Litres/Minute

The water conservation strategy purposes that all dwellings use water efficient appliances. Water efficient shower heads and tap fittings are already mandated as part of the *Building Code of Australia* (ABCB 2011). However, uptake of the other devices will be encouraged through state government rebates as well as education and additional incentives from developers.

5.1.3.3 Water Efficient Gardens

Studies by the WC (WC, 2003) have found that for a typical Perth dwelling, 56% of water consumed by the lot is used on gardens. There is no published data of garden water usage for the Gascoyne region, however, water will be needed within gardens throughout the dry season. Therefore, reductions in water irrigation by employing water efficient garden measures can significantly reduce the total water usage of a development. The following water efficient measures could be used within development gardens:

- Installing an irrigation system that was designed and installed according to best water efficient practices;
- Irrigation controller must be able to irrigate different zones with different irrigation rates;
- Emitters must disperse coarse drops or be subterranean;
- Gardens should include large permeable areas such as lawn, gravel, dry creek bed features or swales;
- Limit the amount of turfed area within the design and consider the use of mulch or gravel as alternatives;
- Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454; and
- Strongly encourage gardens are planted with local plant species. Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted.

Water conservation can also be reduced on a development scale within POS areas. As well as using the lot scale garden measures on POS gardens, the following additional measures should be utilised:

- Retention of remnant native trees where possible, reducing demands for water during establishment of POS areas;
- Minimal proportion of the POS areas will be turfed. Instead the POS will be largely vegetated with local native species to enhance the environmental values;
- Turf should be a low water and nutrient species;
- The adoption of Xeriscaped POS gardens, where garden beds within POS and community areas are landscaped using ‘waterwise plants’, which are local native species from regions with similar climates that require less water inputs than exotic species; and
- Managing irrigation practises within POS areas to minimise losses to evaporation (e.g. amount applied is not excessive, timing irrigation to avoid wastage, etc.).

5.1.3.4 Community Awareness and Education

Each development should provide a strategy which will be implemented to ensure future occupants of the Townsite are appropriately educated on possible water saving strategies applicable to the development. This should include the provision of reputable reference material from sources such as the WC's *Waterwise Programme* (2011) and the *Your Home* initiative (Commonwealth of Australia 2011).

5.1.3.5 Groundwater Allocation

The availability of freshwater is limited across the Townsite, therefore requires careful control and management. The Exmouth Area is divided into five sub areas (Exmouth West, North, Town, Central and South) and is managed by DoW in accordance with the *Groundwater Allocation Plan: Exmouth Groundwater Subarea* (WRC 1999). Currently the Exmouth North and Town sub areas are over allocated, with no further allocations for access made available. Exmouth Central and South have groundwater available, with new applications to be made available with further developments. New applications for groundwater access will have to involve total water cycle management principles to achieve a more efficient use of water application and detail the rate at which groundwater is planned to be extracted.

5.2 Wastewater Management

5.2.1 Introduction

Within Exmouth's DSP, it is intended to move the WWTF from its current location to the north west of the Townsite.

5.2.2 Principle

Minimise the use of potable water for non-essential use such as irrigation and industry. This should be undertaken through a commitment to meet the WC's target consumption of 40-60kl/person/year.

5.2.3 Design Objectives

Where possible recycle wastewater and use as potable or non-potable water depending on the level of treatment.

5.2.4 Management Strategies

5.2.4.1 Septic Tank Use

Where feasible further wastewater treatment should be implemented through the mandating of septic tanks and Aerobic Treatment Units (ATU) within individual housing developments. These systems are able to treat effluent to the Department of Health (DoH) standards, allowing disposal of the liquid fraction of the waste via leach drains or onsite irrigation. Only DoH approved ATUs should be used within developments.

5.2.4.2 Leaching Prevention

Where required, future Urban Water Management Plan (UWMP) will propose methodologies which ensure systems have a minimal potential for nutrients to leach from the systems installed. These measures would typically include the importation of an amended sand medium that has a high Phosphorous Retention Index (PRI) while retaining adequate infiltration characteristics. Where

required, the future UWMP will need to specify the ongoing management requirements for these systems (e.g. maintenance regime for irrigation/leach drain areas). The DoW's water quality protection note *Wastewater Treatment: Onsite domestic systems* (DoW, 2010) should be referenced when implementing systems at the UWMP stage.

5.3 Stormwater Management Strategy

5.3.1 Introduction

A stormwater management strategy principally should maintain the existing hydrology through retaining and detaining surface flows and the infiltration of stormwater runoff as close to source as possible. This ensures the peak discharges and volumes of runoff in main drainage corridors do not increase through the introduction of impermeable areas associated with development, which could lead to flooding downstream.

Developments typically have a high proportion of impervious surface area (roads, paths and roofs) when compared to the pre-development environment. The increased imperviousness results in:

- Increased total volume of runoff;
- Increased maximum runoff rate (peak discharge); and
- Decreased time for runoff to occur.

Sufficient groundwater and surface water monitoring should be undertaken to provide "proof of concept" for the development.

5.3.2 Principle

5.3.2.1 Stormwater Quantity

Preserve and enhance where possible the natural function of the floodplain to convey flood waters and sustain flood events. This should be achieved by limiting the impact of new development on the existing floodways through sustainable appropriate development.

5.3.2.2 Stormwater Quality

Reduce the loads of stormwater pollutants discharged by developments into the groundwater system through the removal of gross pollutants and reduction, where possible, of dissolved pollutants within the groundwater discharged from all developments/subdivisions.

5.3.3 Design Objectives

5.3.3.1 Stormwater Quantity

- *Detain the first 15mm of rainfall within lots where practical;*
- *Convey flood waters off site without detention where practical;*
- *Stormwater quantity should be managed using open drains and roads rather than piped drainage;*
- *Culverts can be used where required to convey stormwater under roads;*
- *Minor roads should be set 0.3m above the 100yr ARI level;*
- *Major roads should be 0.5m above the 100yr ARI level; and*
- *Existing waterways and natural drainage lines should be retained with the aim of minimising changes to the pre-development hydrology. These waterways should also be restored where required.*

5.3.3.2 Stormwater Quality

Existing surface and groundwater quality should be maintained as a minimum, and preferably improved prior to discharge from the development area.

5.3.4 Management Strategies

5.3.4.1 Stormwater Quantity

The basic principle of stormwater quantity management is to slow down the stormwater runoff and infiltrate as much as possible, mimicking the existing environment.

The design criteria specified in **Section 5.1.2** can be achieved through the use of various WSUD strategies. As a minimum, detention basins are required to achieve the discharge requirements, however, the size of these basins can be reduced through the introduction of various WSUD techniques. Typical WSUD techniques are discussed below, however, further investigation and negotiation with the DoW should be completed and presented in future LMWS documents.

Lot Soak wells

The large impermeable roof area of each lot produces considerable runoff. This surface water runoff can be reduced at source by the promotion of infiltration using soak wells, where ground conditions permit.

Rainwater Tanks

Rainwater tanks used for stormwater management are designed to create a dedicated air space within the rainwater tank to ensure that storage is available as needed. While not practical within a town centre development, rain tanks may be used within a more rural setting on advice from the SoE.

Roadside Swales

Swales and buffer strips are vegetated conveyance corridors that typically have slopes ranging between 1% to 4%. This gradual slope combined with the increased roughness provided by vegetation reduces the stormwater runoff rate. The swales also provide some storage and infiltration capacity, thus reducing the total volume of runoff.

Flush Kerbing and open drains

Contemporary street drainage uses hard kerbing and pits draining the stormwater runoff to a sub-surface pipe network. This pipe network quickly transports the runoff through the development causing increased peak discharges from the area. Flush and intermittent kerbing allows most of this runoff to be directed to roadside swales, where it is more slowly conveyed or infiltrated. Flush kerbing should direct overland flow into open drains and roads rather than piped drainage. This is furthered by the use of culverts to convey stormwater under roads. The location of flush kerbing must be approved by SoE Engineers.

Flood Storage Areas (FSA)

FSAs are designed to store runoff during large rainfall events, typically incorporated into POS areas and retained for recreational purposes for the majority of the year. A FSA can be designed to either retain or detain the runoff from the development. In detaining or “holding back” runoff, the FSA is designed to reach maximum capacity in a designated storm event and discharge excess runoff at a

reduced rate. Conveyed flood waters of downstream areas are not to be affected by the proposed development.

Porous Pavement and Non-porous Area Reduction

The majority of rain that falls on non-porous pavements will form stormwater runoff. The use of porous pavement or reduced area of non-porous pavement area can have a significant reduction in the total volume and peak discharge of the runoff. Large sustained rainfall events can result in increased sedimentation. As rainwater is not treated and no pipe systems are present, sedimentation may result in the clogging of porous pavement areas.

Junction Chamber Infiltration

Bottomless junction chambers can allow infiltration of water resulting in a reduction in the total stormwater runoff volume. Bottomless junction chambers are only suitable in locations with high infiltration rates and where the superficial aquifer is lower than the pipe junction inlet. Due to low infiltration rates and lack of a pipe network this technique is unlikely to be viable in the Exmouth area.

5.3.4.2 Stormwater Quality

The effective management of urban stormwater quality typically focuses on the treatment of frequent, low intensity stormwater events. Due to Exmouth's latitude and presence of tropical cyclones, conventional stormwater quality management techniques may not be applicable. Sedimentation and erosion are two key influences that can severely degrade stormwater quality. Strategies that will be adopted to minimise erosion and control sediment transport include:

- Vegetation will be retained on Townsite for as long as possible;
- The development will be cleared in stages to minimise erosion opportunities; and
- Ground disturbance activities will be avoided during intense rainfall events.

WSUD techniques should be investigated for the ability to improve the surface runoff water quality and presented in a future LWMS.

5.3.5 Demonstration of Compliance

5.3.5.1 Post-Development Drainage Strategy

The DWMS has utilised detention basins within catchments where new development is proposed to detain stormwater from the site. In catchments were development is existing, it has been assumed that stormwater detention has been included within the current layout and therefore was not included within modelling undertaken within this DWMS. Where no new development has been proposed stormwater detention has not been calculated as there will be no change to existing conditions.

In order to adhere to the design criteria stated in **Section 5.3.3.1**, the detention basins were sized to detain the 'first flush' 15mm of stormwater. This equates to a 2yr 15min storm event.

Flood Modelling

It has been assumed that the Flood Study undertaken (SKM 2007) accurately delimits the floodplains associated with the four major watercourses which flow through the development area. No additional modelling of these watercourses was undertaken as part of the work.

Modelling Parameters

The rate of runoff from an area is determined by the slope and roughness (Manning's n) of the surface. The total volume of runoff is determined by the amount of rainfall less the losses (e.g. infiltration, storage).

An "initial loss – continuing loss" infiltration model was adopted for the catchments, with loss values chosen based on Cardno's experience with similar vegetation, soil types and residential development modelling. The loss rates used are presented in **Table 4**.

Table 4 Initial and Continuing Loss Parameters for Hydrological Modelling

Infiltration Land Type	Initial Loss (mm)	Continuing Loss (mm/hr)
Urban	1	0.1
Rural residential	21.5	2.5
POS	12.5	2.5
Coastal reserve	17.5	2.5
Conservation Reserve	21.5	2.5

The infiltration rates were predominantly based on the following assumptions:

- POS areas will likely contain dense vegetation and turf over a sand base. This turfed area will become compacted over time and this will reduce the initial loss rates.
- Garden areas will have high infiltration rates as it is likely that sand or loamy soil will be used. Rural residential developments within the Townsite are anticipated to have relatively large lots. These are likely to have small landscaped gardens with the remainder of the lot unmodified. For these reasons, it is anticipated that the average initial loss and continuing loss for the remainder of the lot will be the same as for sparsely vegetated areas.
- There will be no infiltration on roads, pavement and driveways (considered urban). There will however be some minor absorption storage loss and this is reflected in an initial loss of 1mm and continuing loss of 0.1mm/hr.

Not all neighbourhoods within the Townsite are proposed to undergo new development. For these neighbourhoods, and for the purpose of surface water modelling, the area of each land use type shall remain consistent with the methodology described above. At this district scale, the area of each land use within proposed new developments must be estimated.

Modelling Results

The XPSWMM computational modelling programme was used to calculate the rate of runoff generated by each catchment. **Figure 9** illustrates the boundaries of post-development catchments. Many of these catchments do not experience a change in land use between pre-development and post-development and will not require storage.

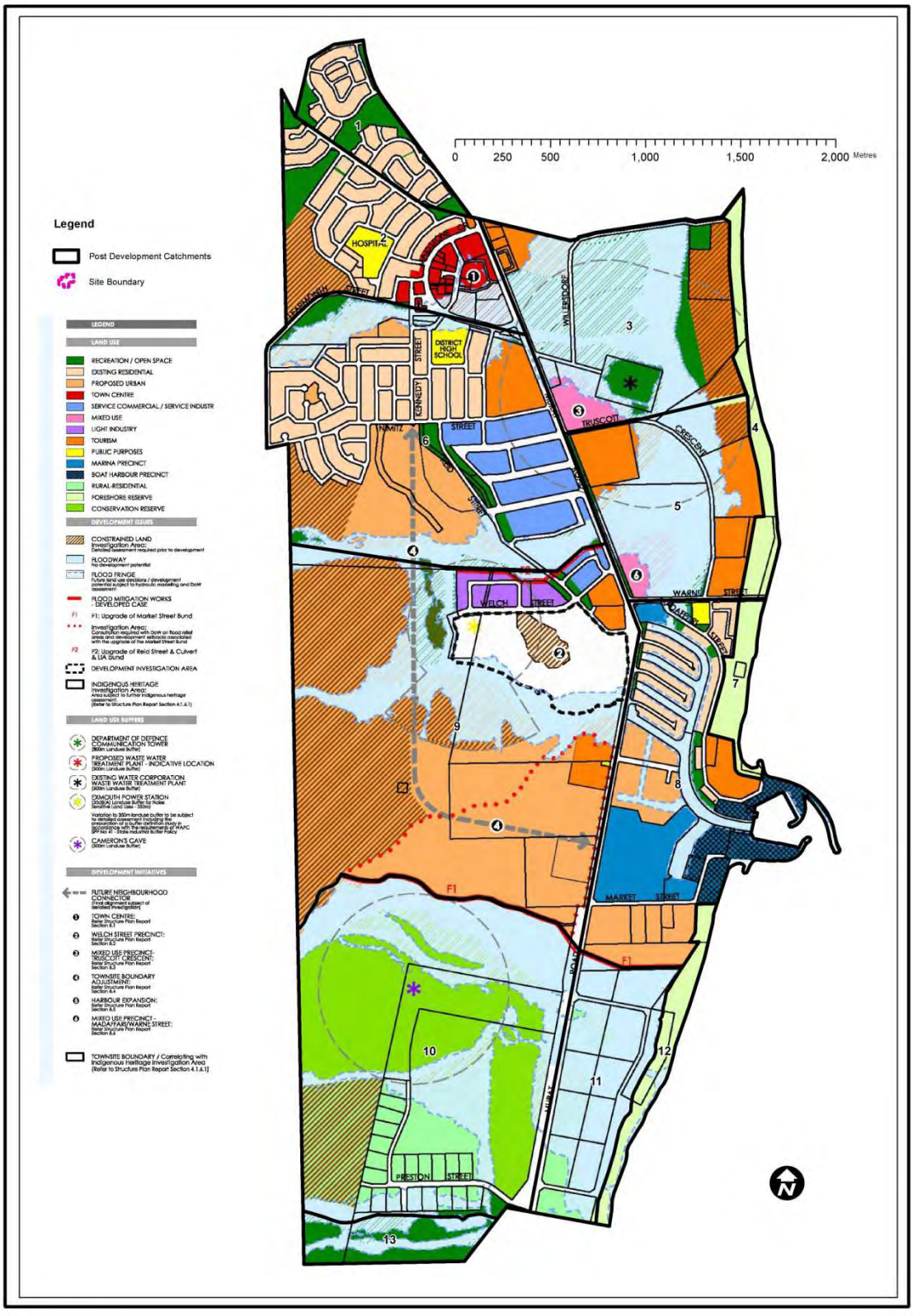


Figure 9 Post Development Catchments

Ground conditions across the Townsite vary with infiltration unlikely in the upland catchment areas, however, anecdotal evidence of flood waters infiltrating to ground near the foreshore suggest underlying ground conditions are likely to be conducive to infiltration. Consequently, infiltration through sides and base of basins was incorporated into the design in low lying catchments. It should

be noted that infiltration rates are based on technical experience of typical infiltration to sand. Prior to detailed design infiltration testing should be undertaken *in situ* to determine actual ground infiltration rates.

Table 5 details the total detention requirements for all catchments where development is proposed. This volume should be used when developing a masterplan for each catchment area to ensure sufficient space for water is provided within the design. As detailed below this could be provided within lot gardens and POS areas. It is not recommended that a single flood storage area is designed for each catchment.

Table 5 Detention Structure Dimensions

Catchment	Total Catchment Area (ha)	Infiltration (m/s)	Basin Area (m^2)		Volume (m^3)
			Base Area	Top Area	
2	81.6	-	1,078	2,010	1,520
3	109.6	$5x10^{-5}$	6,635	8,733	7,660
5	80.4	$5x10^{-5}$	4,300	6,018	5,135
6	200.0	-	10,002	12,546	11,250
8	114.7	$5x10^{-5}$	12,581	15,417	13,975
9	290.7	-	36,747	41,491	39,095

Detention basins are nominally designed to have 1:6 side slopes and a depth of 1m. These basins may be modified in future detailed designs as appropriate. Due to the lack of detailed masterplanning at this stage of the planning process, the volume detailed in **Table 5** details the total volume required to detain the first 15mm of rainfall from road reserves and from lots within each catchment**.**

It is noted and understood that in future drainage designs the scheme will separate detention of this first flush event with lots detaining this rainfall within gardens and rainwater tanks, where appropriate, and road drainage within swales and POS area. This will decrease the volume of detention structures, but will increase the overall surface area required for successful detention and retention of stormwater.

The locations of detention and retention structures will be affected by the structure plan layout, the final approach to earthworks across the Townsite and the nature of the downstream receiving environment. It is most likely that detention structures will be located at the low point of each individual catchment, precinct, structure planning or development area. The locations of these structures should be specified within the LWMS through consideration of the LSP and earthworks plan (as stated in **Section 6.2.1.11**). All detention structures would be constructed during the subdivision stage.

5.4 Groundwater Management Strategy

5.4.1 Introduction

Manipulation of groundwater levels can have a range of detrimental effects on the local Karst community, including increasing nutrient levels within superficial aquifers and ASS potential. BMPs for groundwater levels and quality presented within WSUD need to be considered within further planning.

5.4.2 Design Objectives

Groundwater management objectives principles should include:

- *Minimising changes to the underlying groundwater levels as a result of development;*

- *Subdivisional lots should have a separation distance from the MGL of at least 1.2m to ensure protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels;*
- *Bio-retention systems and drainage inverts should operate as dry basins with a minimum clearance of 0.3m between the MGL and the invert of the basin;*
- *If subsurface drainage is to be utilised it must:*
  - *Be installed at or above the MGL.*
  - *Be designed with free draining outlets; and*
- *Groundwater quality leaving the Townsite should be at least the same, or better, than the water entering the site.*

5.4.3 Management Strategies

5.4.3.1 Groundwater Level

Minimising Groundwater Level Changes

Developments can have reduced infiltration of rainfall into the underlying groundwater due to increased impervious areas (e.g. roads and buildings). Due to the impervious soils present within the site, infiltration to groundwater is not considered to be a dominant factor within the environmental water balance of the system. The use of WSUD techniques should prevent lowering the underlying groundwater levels due to reduced recharge. To ensure groundwater systems are not adversely affected, infiltration will be maintained via the use of FSAs where appropriate.

It is critical that groundwater levels are maintained in the long term as a number of subterranean fauna exist within the Townsite which rely on existing conditions to survive.

Subsoil Drainage

If there are any areas with less than 1.2m of separation distance, the groundwater level would need to be artificially controlled to an acceptable depth or ground level fill is required. Where additional fill is required subsoil drainage should be 0.3m above MGL.

Due to the low permeability within the Townsite, subsoil drainage may be required underneath bioretention areas and FSAs. This subsoil drainage is not positioned to lower groundwater levels, rather it would be aimed at ensuring the bioretention areas and FSAs empty within an adequate time period.

Drainage of WSUD Features

As the hardpan soil has a low hydraulic conductivity the bioretention areas and FSA would remain wet after a storm event as minimal water would infiltrate into the groundwater. This then would create issues for the next storm event as well as providing habitats for mosquito and midge breeding. An imported permeable base layer will be required to ensure infiltration within the bioretention areas and FSAs.

5.4.3.2 Groundwater Quality

The Exmouth Gulf, located to the east of the Townsite, receives both surface water runoff and groundwater that originates from the site. It is important that the quality of this water entering the Gulf is comparable to the pre-development environment and where possible, improved.

The DWMS aims to encourage infiltration at source to maintain the existing groundwater hydrology. At source infiltration may not be possible within some areas due to soil characteristics. A

geotechnical report is required to determine where this technique is appropriate. The soil profile and imported fill with high PRI soils will treat infiltrated water and remove phosphorous through natural processes. The approaches identified in **Section 5.3.4.1** will aim to infiltrate stormwater runoff, improving the quality of water infiltrating to the groundwater system. The Townsite drainage system should be designed to achieve the objectives and criteria stated in **Section 4.3**.

5.4.3.3 Perched Groundwater

As identified in **Section 2.1.3**, the Townsite is situated within a Karst environment. Karst environments where the limestone is near surface and has undergone secondary porosity, or partial dissolution, may allow for sinkholes to develop, which can lead to the deterioration of housing foundations and road surface pavement. A detailed geotechnical investigation will aim to identify the existence of clay layers and/or porous limestone within the soil profile. Subsoil drainage and/or imported fill will be used to mitigate the effects on the development from perched groundwater areas identified within the Townsite. The extent of these measures will be determined in context of the findings from the detailed geotechnical investigation, the LSP and the proposed earthwork strategy.

6 Requirements for LWMS & UWMP

6.1 Introduction

The development of the DWMS has been undertaken with the intention of providing a structure for subsequent development to be consistent with the total water cycle management approach described in this document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future LWMS and UWMP documents as outlined in Better Urban Water Management (WAPC 2008).

It is anticipated that future LWMS documents will be undertaken for all Precinct developments and UWMP at lot/subdivision scale. It is the responsibility of the land owner/developer to undertake these documents and for these documents to provide sufficient detail to the requirements outlined below and within this document, along with any additional requirements of the DoW or SoE.

6.2 Design and Management Objectives

As detailed in **Section** 5 a number of specific objectives have been presented in this document. **Table 6** below summarises these key principles (Armadale Redevelopment Authority, October 2006).

Table 6 Summary of WSUD Principles and Design Objectives

Key Guiding Principles		
• Facilitate implantation of suitable best practice in Urban water management • Encourage environmentally responsible development to meet the intent and recommendations of the UWMS • Provide clarity for agencies involved with implantation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk, including risk of injury or loss of life • To maintain the total water cycle		
Category	**Principals**	**Objectives**
Water Supply	• Consider all the potential water sources in water supply planning • Integration of water and land use planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • To maximise the reuse of stormwater • Minimise use of potable water where drinking quality water is not essential	• Residential consumption target for portable water of 40-60 kL/person/year
Surface Water and Groundwater	• To retain natural drainage systems and protect ecosystems health • To protect from flooding and waterlogging • To implement economically viable stormwater systems • To ensure stormwater management recognises and maintains social aesthetic and cultural values • Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined EWRs • Minimise change in peak winter levels at groundwater dependant wetlands due to change in groundwater flux associated with urbanisation	• For ecological protection, 1 in 1year ARI volume and peak flow rates maintained at predevelopment conditions • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as specified by the DoE/DoW • For flood management, manage up to the 1 in 100 year ARI event within the development area to predevelopment peak flows unless otherwise negotiated with Water Corporation • Post development end of winter operating levels at wetlands maintained at pre-development levels, unless otherwise determined by EWR's
Surface Water Quality	• To maintain or improve surface water quality within development areas • Reduce the average annual load of stormwater pollutants discharged by development compared to if it used a traditional piped conveyance system.	• As compared to a development which does not actively manage water quality: 60% reduction in TSS (annual loads) 60% reduction in TP 45% reduction in TN 70% reduction in Gross Pollutants
Groundwater Quality	• To maintain or improve groundwater quality within development areas • Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater to the waterway • Where development is associated with an ecosystem dependent upon a particular hydrological regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality and habitat in specified environment	• Where waterways/open drains intersect the water table, as compared to a development which does not actively manage water quality: 60% reduction in TP (annual loads) 45% reduction in TN • Where development associated with sensitive environment, as per DoE/DoW

The LWMS must be written making reference to the requirements of Better Urban Water Management (WAPC, 2008). In addition, where appropriate, the following aspects of stormwater management should be considered:

- Sensitive Environments
- Flora survey
- Geotechnical investigation
- Acid sulphate soils
- Groundwater monitoring
- Water Sensitive Urban Design
- Coastal vulnerability study
- Soil contamination and remediation
- Aboriginal heritage Building Standards
- Demonstration of Compliance
- Design and Location of Drainage Structures
- Water Consumptions Strategies
- Non-Structural Measures

6.2.1 Design Objectives

6.2.1.1 Sensitive Environments

Development of Precincts should be undertaken taking into account any requirements to manage or mitigate stormwater or flooding found at the site. Flood modelling has been undertaken (SKM, 2007) across the extent of the DWMS Townsite (see **Figure 5**). Any proposed development within flood prone areas is required to ensure the following has been considered;

- Adequate flood protection from a 100year ARI flood;
- Habitatable floor levels should be set a minimum of 0.5 m above the 100 year ARI flood level; and
- The development does not detrimentally impact on the existing flooding regime of the general area.

Where developments are proposed within the floodway the DoW assess the appropriateness of each development on a case by case basis. The factors examined by the DoW include:

- Depth of flooding;
- Velocity of flooding;
- The effect of the development on existing flood flow paths;
- Possible structural and flood damage potential evacuating during a major flood; and
- The regional benefits of the development.

6.2.1.2 Flora Survey

For all newly proposed developed areas it is recommended that Flora and Vegetation Surveys are undertaken in accordance with EPA Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*.

Any areas of remnant mangrove habitat identified in future Flora and Vegetation Surveys should be managed in line with the EPA Guidance Statement No. 1 *Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline*.

It is recommended that the Flora and Vegetation surveys be used to determine if a fauna assessment is necessary. This will be based on potential for suitable habitat for significant fauna species. The flora survey should be undertaken by the landowner and developer of each parcel of land.

6.2.1.3 Geotechnical Investigation

A geotechnical investigation will need to be conducted to confirm the regional geological mapping discussed in the DWMS and assist in the protection of Karst formations that support subterranean fauna species (as required by EPA Guidance Statement No. 54 *Consideration of subterranean fauna in groundwater and caves during Environmental Impact Assessment in Western Australia*). A number of test pits will be required to be installed at depths just below the ground surface (usually ~2.5m) to determine the soil characteristics and how this could impact on the proposed development. The investigation should include appropriate locations for onsite disposal of stormwater (flood detention structures and soakwells), soil types, suitability of soils for development and if treatment is required, settlement tests, bearing ratios and the hydraulic conductivity, which governs infiltration rates.

6.2.1.4 Acid Sulfate Soils

Given the soils and the hydrological characteristics at the site, it is recommended that a Preliminary Townsite Assessment for ASS is undertaken, especially if dewatering or excavation is required to facilitate development. This should to be undertaken by the landowner and developer of each parcel of land and is most applicable at the UWMP Stage.

6.2.1.5 Flood Risk

The DoW recommends that development is not undertaken within areas of the Townsite identified in **Figure 5** and that landfilling is not permitted within the floodplain. A Flood Emergency Response Plan should be submitted as part of the LWMS if the development is shown to be located near a flood prone area of the Townsite.

6.2.1.6 Water Sensitive Urban Design

The SoE mandate the use of WSUD across future development within the Townsite to allow for flood conveyance and minimise construction of impermeable surfaces. All stormwater drainage systems should be designed in accordance with *Guidelines and Specification for Design and Construction of Stormwater Drainage Systems* (SoE, March 2006). A summary of the main requirements relating to WSUD design principles is provided below:

- Road alignments should follow contours where possible to reduce stormwater flow velocities;
- Runoff from impermeable surfaces should discharge to detention basins and soft landscaping features prior to discharge offsite should be incorporated into the scheme design;
- Maximum flow velocities within unlined open drains should be limited to $1ms^{-1}$ and $2ms^{-1}$ in lined drains:
- All stormwater basins should be designed to hold a 10 year ARI storm event;
- Where stormwater management is within POS areas the whole POS should be subject to an agreement with the SoE to the extent and design of landscaping and grassing;
- Finished floor levels within developments should be 0.5m above the crown of adjacent roads where floodwater are discharged;
- Flood mitigation measures may be required, advise should be sought from the SoE;
- Building envelopes should be located to provide effective onsite stormwater detention, minimise peak flows and improve the quality of discharged water;
- Detailed consideration should be given to the nature, location, effectiveness and staging of stormwater management systems; and
- Visible stormwater management works should be constructed in keeping with the character of the area.

6.2.1.7 Coastal Vulnerability Study

The storm surge during Cyclone Vance was measured to be 3.6m and caused severe erosion of the marina and inundation of the beachfront. Developments proposed along the coastal fringe of the SoE are required to undertake appropriate consideration of possible storm surges, with coastal vulnerability studies recommended where development is proposed within or immediately behind the dunal systems.

6.2.1.8 Soil Contamination and Remediation

It is recommended, that should the developed lots that have been identified as contaminated sites undergo redevelopment, a Preliminary Townsite Investigation is undertaken.

6.2.1.9 Aboriginal Heritage

At present, Aboriginal heritage stakeholder consultation has been undertaken with the DIA. It is recommended that ethnographic and archaeological surveys be undertaken by developers to determine any additional areas of Aboriginal significance.

6.2.1.10 Building Standards

Flood protection infrastructure is a key criterion of all developments. The standard DoW requirement is for 0.3m above the 100 year flood level within subdivision roads and 0.5m above major waterways flood levels. This criterion is to be detailed within a LSP for individual developments.

6.2.1.11 Design and Location of Drainage Structures

This DWMS has provided preliminary volume requirements for flood detention structures (see **Table 5**). These are based on broad-scale assumptions. It is expected that as future investigations are undertaken, the designs developed will accommodate any constraints identified. The preliminary flood detention structure configurations should be reviewed to ensure that the stormwater management system can achieve all of the required objectives and blend into the surrounding environment. The DWMS has not provided indicative locations for these structures. The DWMS has recommended flood detention structures be located prior to, but nearby, the catchment discharge. Such details and design refinements should be presented in future LWMS.

6.2.1.12 Water Consumption Strategies

A number of potential measures have been discussed that can assist in achieving the state water conservation target (see **Section 4.1**). It is expected that future LWMS will clarify which measures are proposed to be integrated into the future built system. Additionally, Greenfields developments and most urban infill developments must verify that the measures will achieve the objective through an appropriate water balance.

Further investigation should be undertaken into the viability of the potential water sources available, where these are proposed to be utilised. The LWMS will need to provide a more detailed assessment of likely water requirements to maintain POS areas. A licence will need to be submitted and approved by the DoW for extraction of groundwater for non-potable uses.

6.2.2 Management Objectives

6.2.2.1 Water Balance

A detailed water balance will be undertaken as part of the LWMS strategy for all developments. This should include, but not be limited to, information on the following:

- Details of the Infrastructure requirements of the development and if appropriate allocation is available;
- Projected demand of potable and wastewater demand for the development;
- Where potable water and wastewater supplies will be serviced from; and
- How water will be used efficiently to maintain supply for future generations.

6.2.2.2 Groundwater Monitoring

Currently there is limited information on groundwater levels and quality within the site. It is recommended groundwater monitoring be conducted for a period of two years capturing two groundwater peak levels for each development Townsite as a proof of concept for the development. This is to be supported by conceptual design and flow paths and should be undertaken by the landowner and developer of each parcel of land. It is recommended this monitoring commences at the LWMS stage extending to the UWMP.

This may not be required if observation bores indicate there is sufficient 'groundwater to natural surface separation' that will not cause waterlogging. These observations will allow for the determination of active levels, degree of infill required and quality measurements. This is to include conceptual designs and flow paths.

6.2.2.3 Demonstration of Compliance

Modelling of local road drainage networks will need to be undertaken to demonstrate compliance with water quantity management criteria. Calculations supporting sizing of treatment retention structures and flood detention structures will need to be provided, such that detailed designs can proceed from this point and future water planning stages (i.e. UWMP) can demonstrate compliance with the design criteria via appropriate computational modelling of the proposed design.

6.2.2.4 Non-Structural Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual of Western Australia*. Some measures will be more appropriately implemented by SoE, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the POS within it.

It is expected that future LWMS and UWMP documents will provide reference to measures such as public education. It is also expected that future UWMP will provide detailed management and maintenance plans that will set out maintenance actions (e.g. rubbish removal from swales and vegetated retention structures), timing (e.g. who will be responsible for carrying out the actions), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions).

Given that approval from the SoE and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

6.2.2.5 Financial Contributions

All subdivision/new development will be subject to financial contributions towards the provision of outfall drains/upgrading of drainage capital works wherever a development/subdivision drains into a Shire controlled (constructed, to be constructed, upgraded etc.) drainage system.

To minimise the cost and impact on the Shire drainage infrastructure construction and maintenance programmes should be prepared where necessary.

6.3 Monitoring

Appropriate monitoring regimes both pre-development and after construction are an integral part of the whole water cycle approach required by *Better Urban Water Management* (WAPC 2008). Pre-development monitoring allows existing conditions to be assessed ensuring that appropriate compliance limits for groundwater quality are set and that accurate groundwater level data is available for detailed design. This allows water quality to be appropriately managed during the construction and long term life of the development.

6.3.1 Pre-Development Monitoring

Pre-development monitoring within the Townsite has not previously been undertaken, however, monitoring of groundwater level and quality data is available from bores to the west of the Townsite. While this information may give an indication of regional groundwater levels and quality prior to development Townsite specific groundwater data will be required.

Two rainy seasons of data is required, as such, it is proposed that this monitoring is undertaken prior to development. Groundwater level peaks to be recorded during the rainy season to provide the seasonal fluctuation of the Townsite. The pre-development groundwater quality data will be used in defining appropriate trigger values for the Townsite.

6.3.2 Post-Development Monitoring

Post-development monitoring aims to demonstrate compliance with design objectives and criteria.

The post-development monitoring programme should be conducted for at least two years from practical completion. It should be tailored to the development, quantifying potential impacts on surface water quality, surface water flows, groundwater levels, seasonal fluctuation and quality, where applicable. The monitoring results can then provide:

- A trigger for contingency action, as per the contingency action plan guide ongoing management of open space and other landscape areas;
- An interim internal assessment tool of the monitoring programme;
- The monitoring programme should be designed in conjunction with DoW advice and consistent with the *Stormwater Management Manual for Western Australia* (DoW, 2007) to ensure data is of an appropriate standard for analysis and interpretation;
- Monitoring should follow the Australian Standards AS/NZ 5667 series of water quality sampling guidance notes. A NATA accredited laboratory is required to perform water quality testing (DoE, 2001) and analytes selected should be consistent with those pollutants of concern; and
- The Sampling and Analysis Plan for the post-development monitoring programme will be prepared and outlined within future LWMS/UWMP documents.

6.4 Reporting

The results of pre-development monitoring should be provided within future LWMS. Where monitoring is proposed to continue beyond this, final pre-development data should be included, and taken into account within future UWMP.

The monitoring reporting framework will need to be established within the LWMS phase to report on the pre-development conditions of the Townsite and this will facilitate development of appropriately refined management strategies. Post-development monitoring methodologies should be further developed and documented within the UWMP.

6.5 Staging

The modelling associated with the DWMS has assumed the planning of the development will be undertaken as multiple projects. As portions of the Townsite are developed in isolation to the rest of the development, the LWMS and UWMP documents associated with the parcel of land will need to be consistent with the criteria identifies in the DWMS. In particular the structural measures such as bioretention areas and FSAs will need to be designed and implemented in each isolated land parcel to ensure appropriate stormwater attenuation is provided.

6.6 Technical Review

It is not expected this DWMS will be reviewed unless there are significant changes made to the Exmouth DSP.

The LWMS should be submitted to the SoE with an appropriate structure plan. The SoE will then ensure all appropriate stakeholders are consulted.

This process is consistent with Better Urban Water Management (WAPC 2008).

6.7 Roles and Responsibility

This Exmouth DSP DWMS provides a framework that the future developers of the land can utilise to assist in establishing stormwater management methods. These have been based on site-specific investigations, relevant State and Local Government policies and have been endorsed by the SoE. The responsibility for working within the framework established within the DWMS rests with developers, although it is anticipated that future LWMS/UWMP will be developed in consultation with stakeholders (see **Table 7**) and in consideration of other relevant policies and documents. The future LSP will need to be supported by a LWMS and will require approval from the Shire of Exmouth and the DoW.

Table 7 Major Stakeholders

Stakeholder	Component required for Specialist Consideration	Funding/Responsible
DoW	Stormwater management Floodplain management Groundwater abstraction	Developer
DEC	Wetlands Vegetation ASS	Developer
Water Corporation	Drinking water and wastewater infrastructure Environmental issues	SoE
DoH	Where septic tanks are considered	SoE
SoE	Submission to planning service Developer contribution Drainage maintenance Wetland and vegetation	SoE

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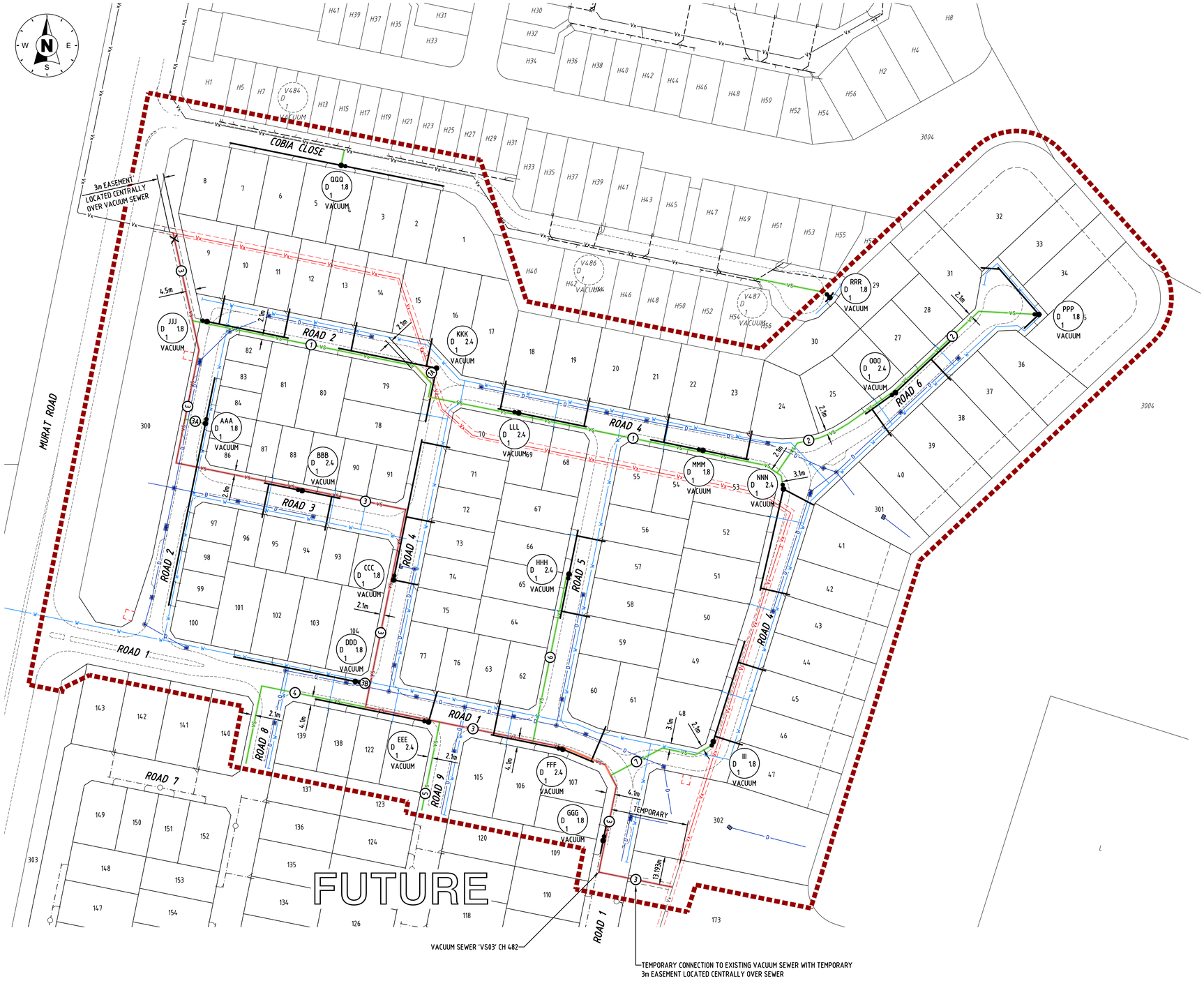
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APPENDIX D CIVIL ENGINEERING PLANS



LEGEND

- RETICULATION AREA BOUNDARY
- EXISTING GROUND SPOT LEVEL
- GROUND CONTOUR (0.5m INTERVAL)
- FINISHED LOT LEVEL
- RETAINING WALL
- EXISTING RETAINING WALL
- PROPOSED SEWERS & ACCESS CHAMBER (AC) WITH VALVE PIT
- PROPOSED VACUUM SEWER - DN150
- PROPOSED VACUUM SEWER - DN100
- FUTURE GRAVITY SEWER
- EXISTING GRAVITY SEWER
- PROPOSED RUNNING TRAP
- PROPOSED BOUNDARY TRAP ON PROPERTY CONNECTION
- PROPOSED CONNECTION UNDER RETAINING WALL
- EXISTING ROAD/ KERB
- EXISTING PATH
- EXISTING VACUUM SEWER MAIN
- PROPOSED DRAINAGE PIPE
- EXISTING DRAINAGE PIPE
- PROPOSED WATER MAIN
- EXISTING WATER MAIN
- EXISTING POWER LINE
- EXISTING HIGH VOLTAGE POWER LINE
- EXISTING OVERHEAD POWER LINE AND POLE
- EXISTING TELECOMMUNICATIONS
- AAAA D 2.1 1 D — PIT NUMBER / COVER CLASS - PIT DEPTH / PIT TYPE - DROP NOTATION
- U/S 12.50 Ø150/100 25.0m D/S 12.50 — INVERT LEVEL UPSTREAM / PIPE DIAMETER / GRADE / PIPE LENGTH / INVERT LEVEL DOWNSTREAM
- IS — I.S. SEWER WITH RISING SHAFT NOT AS PROPERTY CONNECTION POINT
- ISC — I.S. SEWER WITH RISING SHAFT AS PROPERTY CONNECTION POINT
- Dx — DUPLEX LOT
- GH — GROUP HOUSING SITE
- TIGHT — TIGHT CONNECTION
- NFR — LOT NOT FOR RELEASE
- 2.0m GWL — ANNUAL AVERAGE GROUND WATER LEVEL (0.1m INTERVAL)
- FUTURE LOT PROVIDED WITH CONNECTION (NO CLEARANCE WILL BE SOUGHT UNDER THIS STAGE)
- LOTS SERVED IN PREVIOUS STAGE BUT RELEASED IN THIS STAGE

NOTES

1. ALL WORKS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE WATER CORPORATIONS DESIGN STANDARDS 50 (DS50).
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH STANDARD NOTE SHEET DRAWING AA01-3-1 FROM WATER CORPORATION'S DESIGN STANDARD 50.
3. SURFACE LEVELS DERIVED FROM SITE SURVEY BY JBA SURVEYS. CONTRACTOR TO CHECK ON SITE PRIOR TO COMMENCEMENT AND NOTIFY THE ENGINEER OF ANY DISCREPANCY.
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17. ALL CROSSINGS UNDER EXISTING PAVEMENT TO BE UNDERBORED UNLESS OTHERWISE NOTED.
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24. CHAMBER DEPTHS ARE APPROXIMATE ONLY. CONTRACTOR SHALL CALCULATE DEPTHS AND ORDER MATERIALS ACCORDINGLY

0m 20.0 40.0 60.0m
1:1000

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NOTE
CONTRACTOR SHALL IMPLEMENT SAFE WORK PRACTICES FOR WORKS UNDER OVERHEAD POWER LINES.

WARNING
OPTIC FIBRE CABLE IN VICINITY OF WORKS. CONTRACTOR SHALL CONTACT THE RELEVANT AUTHORITY AT LEAST TWO (2) BUSINESS DAYS BEFORE STARTING ACTIVITY.

NOTE
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REFER TO THE RISK ASSESSMENT ANNEX IN THE INITIAL SUBMISSION RESPONSE FOR MORE INFORMATION.

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THIS PLAN IS ACCEPTED AS BEING IN ACCORDANCE WITH THE ENDORSED CONCEPT PLAN: TBC

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WAPC No. 201804

FILE No.

PROJECT:
SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
D	15-10-2025	VACUUM SEWER TEMPORARY CONNECTION RELOCATED	DLC
C	27-8-2025	ROAD AND DRAINAGE LAYOUT AMENDED, VALVE PITS SHOWN	DLC
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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ONLY PLANS WITH NUMERICAL REVISION (REV '0' OR HIGHER) AND PRINTED IN FULL COLOUR SHALL BE USED FOR CONSTRUCTION. IF THIS PLAN IS PRINTED IN BLACK AND WHITE OR GREY SCALE IT IS NOT TO BE USED FOR CONSTRUCTION.

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CLIENT:
EXMOUTH SUPERLOT PTY LTD

DRAWING:
VACUUM SEWER LAYOUT PLAN

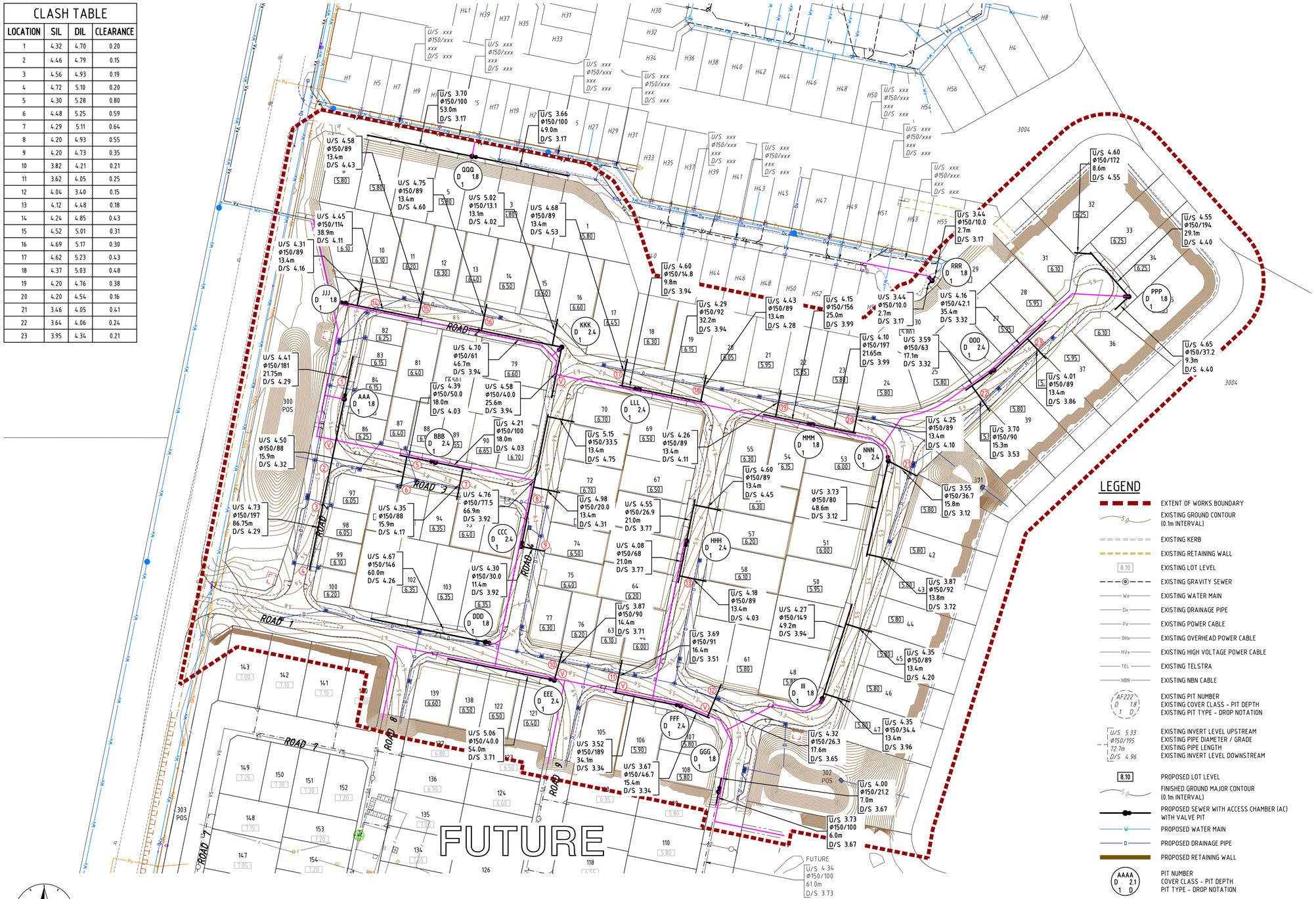
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SCALE	1:1000
DATE	Aug-25
DESIGN	DLC
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DRAWING No. 24-6-94/1/200
REV No. D
ORIGINAL DRAWING SIZE A1
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APP'D

CLASH TABLE

LOCATION	SIL	DIL	CLEARANCE
1	4.32	4.70	0.20
2	4.46	4.79	0.15
3	4.56	4.93	0.19
4	4.72	5.10	0.20
5	4.30	5.28	0.80
6	4.48	5.25	0.59
7	4.29	5.11	0.64
8	4.20	4.93	0.55
9	4.20	4.73	0.35
10	3.82	4.21	0.21
11	3.62	4.05	0.25
12	4.04	3.40	0.15
13	4.12	4.48	0.18
14	4.24	4.85	0.43
15	4.52	5.01	0.31
16	4.69	5.17	0.30
17	4.62	5.23	0.43
18	4.37	5.03	0.48
19	4.20	4.76	0.38
20	4.20	4.54	0.16
21	3.46	4.05	0.41
22	3.64	4.06	0.24
23	3.95	4.34	0.21



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LEGEND

- EXTENT OF WORKS BOUNDARY
- 5.0 EXISTING GROUND CONTOUR (0.1m INTERVAL)
- EXISTING KERB
- EXISTING RETAINING WALL
- 8.10 EXISTING LOT LEVEL
- EXISTING GRAVITY SEWER
- Wx EXISTING WATER MAIN
- Dx EXISTING DRAINAGE PIPE
- Px EXISTING POWER CABLE
- OHx EXISTING OVERHEAD POWER CABLE
- HVx EXISTING HIGH VOLTAGE POWER CABLE
- TEL EXISTING TELSTRA
- NBN EXISTING NBN CABLE
- AF222 D 1.8 1 D — EXISTING PIT NUMBER / EXISTING COVER CLASS - PIT DEPTH / EXISTING PIT TYPE - DROP NOTATION
- U/S 5.33 Ø150/195 72.7m D/S 4.96 — EXISTING INVERT LEVEL UPSTREAM / EXISTING PIPE DIAMETER / GRADE / EXISTING PIPE LENGTH / EXISTING INVERT LEVEL DOWNSTREAM
- 8.10 PROPOSED LOT LEVEL
- 5.0 FINISHED GROUND MAJOR CONTOUR (0.1m INTERVAL)
- PROPOSED SEWER WITH ACCESS CHAMBER (AC) WITH VALVE PIT
- W PROPOSED WATER MAIN
- D PROPOSED DRAINAGE PIPE
- PROPOSED RETAINING WALL
- AAAA D 2.1 1 D — PIT NUMBER / COVER CLASS - PIT DEPTH / PIT TYPE - DROP NOTATION
- U/S 12.50 Ø150/100 25.0m D/S 12.50 — INVERT LEVEL UPSTREAM / PIPE DIAMETER / GRADE / PIPE LENGTH / INVERT LEVEL DOWNSTREAM
- I.S. — I.S. SEWER WITH RISING SHAFT NOT AS PROPERTY CONNECTION POINT
- I.O. — INSPECTION OPENING SEWER
- (1) — SERVICE CLASH - NUMBERED (REFER TABLE)
- (V) — SERVICE CLASH - VACUUM SEWER (REFER LONGSECTIONS)

1:1000 0m 20.0 40.0 60.0m

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WAPC No. 201804

FILE No.

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THE CONTRACTOR SHALL COMPLETE AN ASSET PROTECTION RISK ASSESSMENT AND OBTAIN THE REQUIRED CLEARANCE TO WORKS PERMITS

PROJECT: SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
E	7-11-2025	SEWER AMENDED TO AVOID AMENDED DRAINAGE DESIGN	DLC
D	15-10-2025	DESIGN LEVELS AMENDED TO FACILITATE VACUUM SEWER CHANGES	DLC
C	27-8-2025	DESIGN LEVELS AMENDED, ROAD AND DRAINAGE LAYOUT AMENDED, VALVE PITS SHOWN	DLC
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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www.portereng.com.au
TUSMO Pty Ltd ACN 070 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: EXMOUTH SUPERLOT PTY LTD

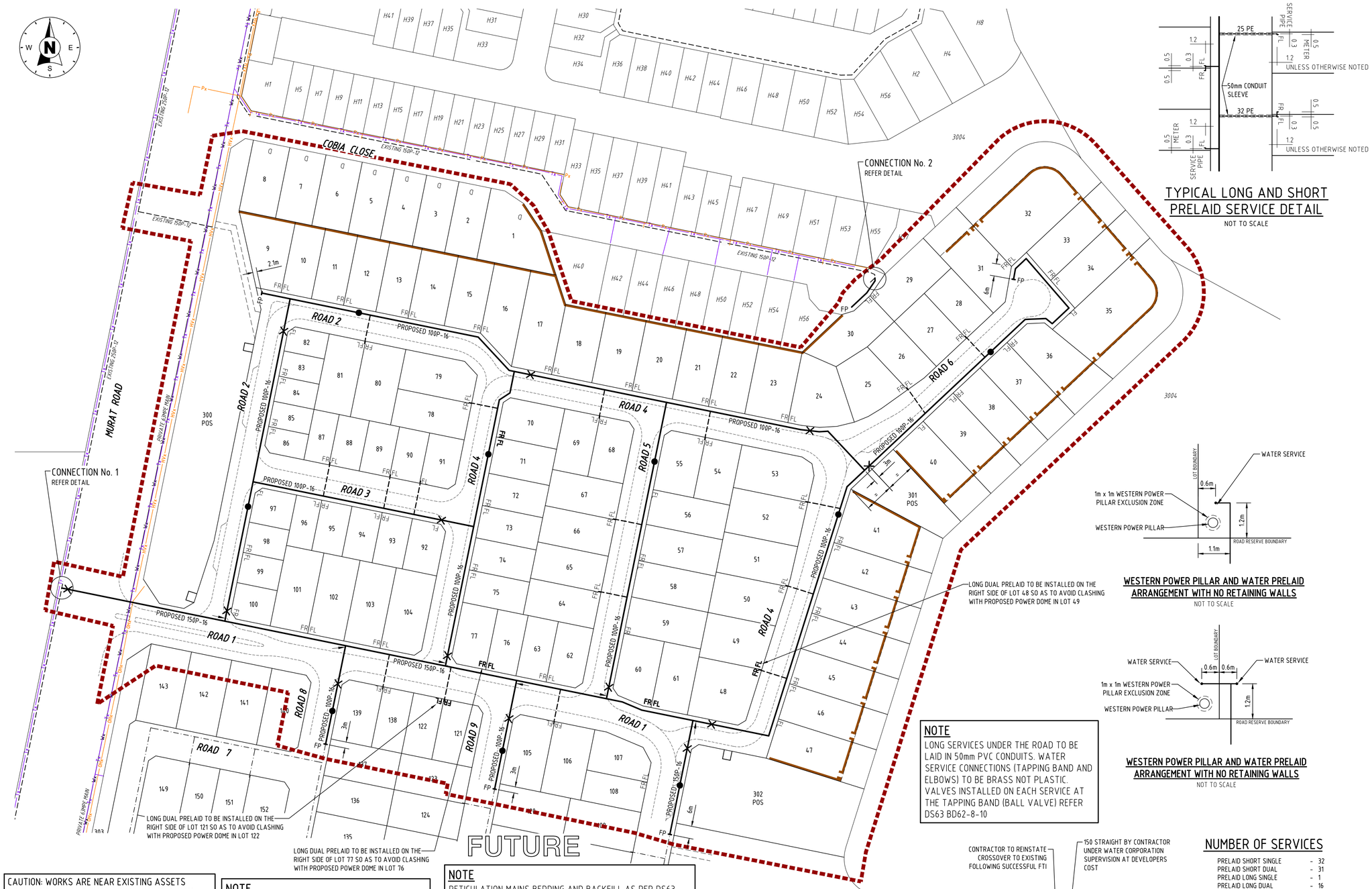
DRAWING: SEWER RETICULATION PLAN

STATUS: FOR TENDER

SCALE	1:1000
DATE	Nov-25
DESIGN	DLC
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 24-6-94/1/201 | REV No. E | ORIGINAL DRAWING SIZE A1

FILE NAME 94\ACAD\STAGE 1\24694-1-201.dwg



TYPICAL LONG AND SHORT PRELAID SERVICE DETAIL

NOT TO SCALE

WESTERN POWER PILLAR AND WATER PRELAID ARRANGEMENT WITH NO RETAINING WALLS

NOT TO SCALE

WESTERN POWER PILLAR AND WATER PRELAID ARRANGEMENT WITH NO RETAINING WALLS

NOT TO SCALE

GENERAL NOTES

1. ALL WORKS SHALL BE CONSTRUCTED IN ACCORDANCE WITH RELEVANT WATER CORPORATION DESIGN STANDARDS 63 (DS63) AND THEIR RELEVANT PRODUCT SPECIFICATIONS AND REGISTERS.
2. **SERVICES, SUCH AS SEWER, WATER, GAS, TELEPHONE, ELECTRICITY, AND DRAINAGE MAY BE ENCOUNTERED DURING CONSTRUCTION OF THE WORKS. SERVICES INFORMATION SHOWN ON DRAWINGS IS INDICATIVE ONLY AND MAY NOT BE COMPLETE. BEFORE EXCAVATION COMMENCES THE LOCATION OF ALL SUCH SERVICES SHALL BE OBTAINED FROM THE RELEVANT AUTHORITIES.**
3. **CO-ORDINATE THE LOCATION OF ALL EXISTING AND PROPOSED SERVICES PRIOR TO COMMENCEMENT OF WORK. ANY CONFLICTS ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.**
4. UNLESS OTHERWISE SHOWN ALL DIMENSIONS ARE IN METRES.
5. ALL PIPES SHALL BE INSTALLED TO WITHIN 4.0m OF EXISTING MAIN. LEVEL AND ALIGNMENT OF NEW WORKS SHALL MATCH EXISTING. CONNECTION TO EXISTING BY CONTRACTOR UNDER WATER CORPORATION SUPERVISION.
6. UNLESS OTHERWISE DIRECTED BY THE ENGINEER, COVER REQUIREMENTS SHALL COMPLY WITH THE WATER CORPORATION STANDARDS.
7. MINIMUM CLEARANCE TO GAS = 300mm, MINIMUM CLEARANCE TO OTHER SERVICES = 150mm.
8. ALL WORKS SHALL BE IN DRY GROUND. GROUND WATER SHALL NOT BE PERMITTED TO ENTER PIPES.
9. UNLESS OTHERWISE SHOWN ON THIS DRAWING OR VARIED BY THE ENGINEER ALL PIPES AND FITTINGS SHALL BE LAID ON AN ALIGNMENT OF 2.1m FROM THE CENTRE OF THE PIPE TO THE ROAD RESERVE BOUNDARY.
10. IN CUL-DE-SACS WHERE P.E. MAINS ARE DEFLECTED TO SUIT CADASTRAL BOUNDARY CHANGES IN DIRECTION, THE ALIGNMENT OF MAINS SHALL BE 2.1m +/- 0.3m THIS TOLERANCE SHALL ONLY APPLY IN THE VICINITY OF TRUNCATION POINTS AT ALL OTHER LOCATIONS THE MAINS SHALL BE LAID ON THE 2.1m ALIGNMENT (UNLESS OTHERWISE NOTED).
11. PE PIPE USED IN TRENCHLESS INSTALLATIONS SHALL BE MINIMUM CLASS PN25
12. FLUSHING POINTS SHALL BE INSTALLED ON ALL MAINS AT CONNECTION POINTS TO EXISTING MAINS OR WHERE SPECIFIED.
13. CONTRACTOR SHALL INSTALL FLUSHING POINTS AT ALL DEAD ENDS.
14. UNLESS DIMENSIONED OTHERWISE, MAINS SHALL EXTEND AT LEAST 8m ALONG THE FRONT OF LAST LOT SERVED.
15. ALL VALVES SHALL BE OPPOSITE BOUNDARY PEGS UNLESS DIMENSIONED OTHERWISE, ALL HYDRANTS SHALL BE POSITIONED IN THE MIDDLE OF LOTS OR OPPOSITE BOUNDARY PEGS AS SHOWN.
16. SERVICE CROSSINGS SHALL BE LOCATED AT RIGHT ANGLES TO BOUNDARY AND INSTALLED IN ACCORDANCE WITH THE WATER CORPORATION'S REQUIREMENTS.
17. THE CONTRACTOR SHALL ALLOW FOR ALL AS CONSTRUCTED INFORMATION (INCLUDING SURVEY) TO BE PLOTTED IN ACCORDANCE WITH THE WATER CORPORATIONS CURRENT PRACTICE AND DELIVERED TO THE ENGINEER FOR SIGNING AND PRESENTATION TO THE WATER CORPORATION.
18. IT IS DEEMED THAT THE AS CONSTRUCTED DOCUMENTS FORM PART OF THE WORKS. PRACTICAL COMPLETION CAN NOT BE AWARDED IF ACCEPTABLE AS CONSTRUCTED DOCUMENTS HAVE NOT BEEN PROVIDED TO THE ENGINEER.

LEGEND

- WATER RETICULATION BOUNDARY
- RETAINING WALL
- EXISTING RETAINING WALL
- OHx — EXISTING OVERHEAD POWER LINE AND POLE
- 150P-16 — PROPOSED WATER MAIN, PIPE SIZE AND MATERIAL DESIGNATION
- PROPOSED HYDRANT (X) AND SLUICE VALVE (X)
- EXISTING WATER MAIN, HYDRANT & SLUICE VALVE
- Wx — EXISTING PRIVATE WATER MAIN
- Tx — EXISTING TELECOMMUNICATIONS
- FUTURE WATER MAIN, HYDRANT & SLUICE VALVE
- CHANGE IN PIPE DIAMETER
- "FL" OR "FR" — DENOTES SIDE OF LOT TO BE SERVICED (VIEWED FROM THE ROAD)
- "D" — DEFERRED CONNECTION
- FP — FLUSHING POINT
- SERVICE LAID IN THIS STAGE FOR RELEASE IN FUTURE STAGE
- SERVICE LAID IN PREVIOUS STAGE TO BE RELEASED IN THIS STAGE
- PROPOSED POWER DOME
- REVISION CLOUD

CAUTION: WORKS ARE NEAR EXISTING ASSETS

THE PROPOSED WORK IS WITHIN PROXIMITY TO AN EXISTING WATER CORPORATION ASSET AND IS HIGHER IN RISK IN NATURE.

ASSET PROTECTION CONTROLS MAY APPLY.

REFER TO THE RISK ASSESSMENT ANNEX IN THE INITIAL SUBMISSION RESPONSE FOR MORE INFORMATION.

THE CONTRACTOR SHALL COMPLETE AN ASSET PROTECTION RISK ASSESSMENT AND OBTAIN THE REQUIRED CLEARANCE TO WORKS PERMITS

NOTE
CONTRACTOR SHALL IMPLEMENT SAFE WORK PRACTICES FOR WORKS UNDER OVERHEAD POWER LINES

WARNING
OPTIC FIBRE CABLE IN VICINITY OF WORKS. CONTRACTOR SHALL CONTACT THE RELEVANT AUTHORITY AT LEAST TWO (2) BUSINESS DAYS BEFORE STARTING ACTIVITY

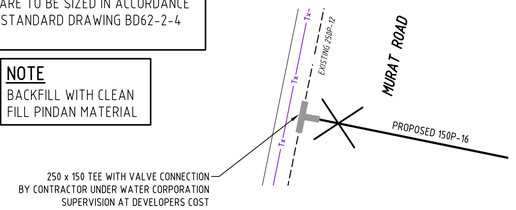
NOTE
PRIOR TO WORKS, CONTRACTOR SHALL MAKE AN APPLICATION TO WATER CORPORATION FOR A CLEARANCE TO WORKS PERMIT AND UNDERTAKE AN ASSET PROTECTION RISK ASSESSMENT (APRA)

NOTE:
LOW RISK ISOLATION - EXCAVATION, CONSTRUCTION AND PIECE UP WORKS BY THE DEVELOPERS' CONTRACTOR. ISOLATION BY THE WATER CORPORATION AT THE DEVELOPERS' COST.

HIGH RISK ISOLATION - WATER CORPORATION RESERVES THE RIGHT TO COMPLETE ALL, OR A PORTION OF THE PIECE UP WORKS AT THE DEVELOPERS' COST. ARRANGEMENTS FOR QUOTING AND PAYMENT FOR THOSE WORKS TO BE AGREED AT THE START-UP MEETING

NOTE
RETICULATION MAINS BEDDING AND BACKFILL AS PER DS63 BD62-1-1
CONCRETE THRUST BLOCKS ARE TO BE SIZED IN ACCORDANCE WITH WATER CORPORATION STANDARD DRAWING BD62-2-4 WHERE APPLICABLE

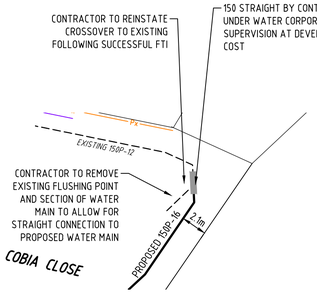
NOTE
BACKFILL WITH CLEAN FILL PINDAN MATERIAL



CONNECTION DETAIL No '1'

SCALE 1:250

NOTE
LONG SERVICES UNDER THE ROAD TO BE LAID IN 50mm PVC CONDUITS. WATER SERVICE CONNECTIONS (TAPPING BAND AND ELBOWS) TO BE BRASS NOT PLASTIC. VALVES INSTALLED ON EACH SERVICE AT THE TAPPING BAND (BALL VALVE) REFER DS63 BD62-8-10



CONNECTION DETAIL No '2'

SCALE 1:250

NUMBER OF SERVICES

PRELAID SHORT SINGLE	-	32
PRELAID SHORT DUAL	-	31
PRELAID LONG SINGLE	-	1
PRELAID LONG DUAL	-	16
DEFERRED SERVICES	-	8
TOTAL CONNECTION	-	80
TOTAL LOTS SERVED	-	112

EXTENSION

CONTRACTOR TO LAY 1187m 100P-16 PIPE
389m 150P-16 PIPE

CONNECTION

CONNECTIONS (2) TO BE MADE BY CONTRACTOR UNDER WATER CORPORATION SUPERVISION.

1:1000 0m 20 40 60m

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WATER RETICULATION DETAILS

WAPC No	:	201804
FILE	:	199349341
PLAN	:	OW43-103-001-01A

THIS PLAN IS ACCEPTED AS BEING IN ACCORDANCE WITH THE ENDORSED CONCEPT PLAN: **OV82-100-001-01A**

COMPLIANCE WITH THE RELEVANT DESIGN STANDARDS AND MANUALS REMAINS THE RESPONSIBILITY OF THE DESIGN ENGINEER.

NO WORKS ARE TO COMMENCE ON SITE UNTIL START-UP MEETING REQUIREMENTS HAVE BEEN MADE WITH THE RELEVANT ASSET INSPECTOR. REFER TO THE DEVELOPER'S MANUAL FOR CONTACT DETAILS.

..... FOR MANAGER LAND SERVICING

PROJECT:
SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No	DATE	REVISION	BY
0	28-10-2025	ISSUED FOR CONSTRUCTION	MEG
C	15-10-2025	WATER ALIGNMENT AND VALVE AMENDED TO AVOID DRAINAGE	DLC
C	3-9-2025	WATER CORPORATION DETAILS ADDED, ADDITIONAL VALVES ADDED AND RELOCATED, NOTES ADDED	MEG
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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www.porterseng.com.au
TUSMO Pty Ltd ACN 070 997 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:
EXMOUTH SUPERLOT PTY LTD

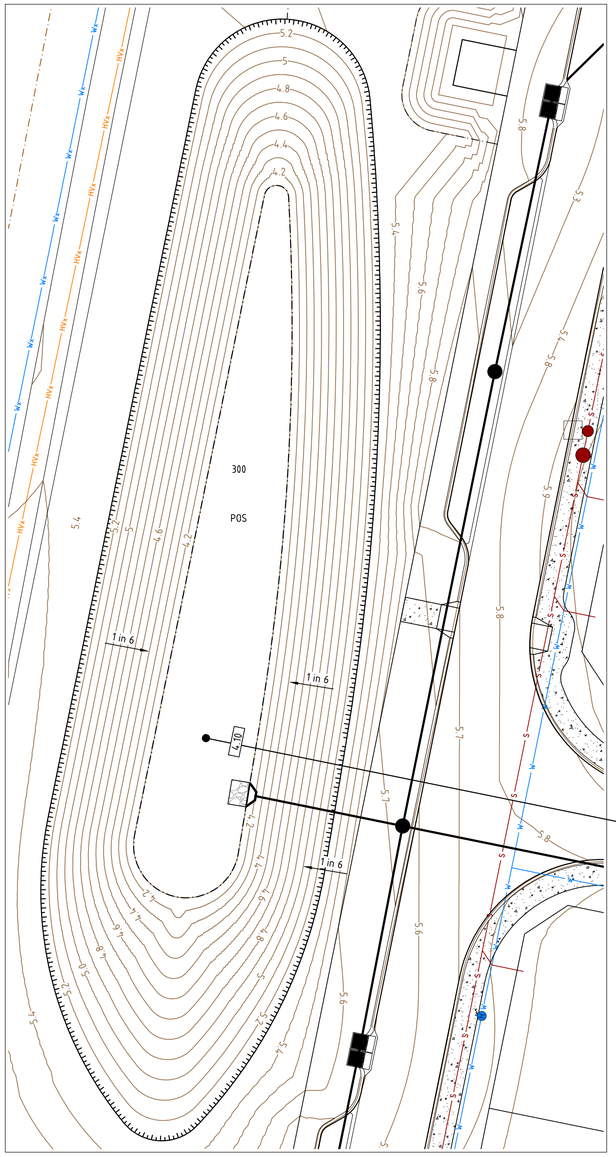
DRAWING:
WATER RETICULATION PLAN

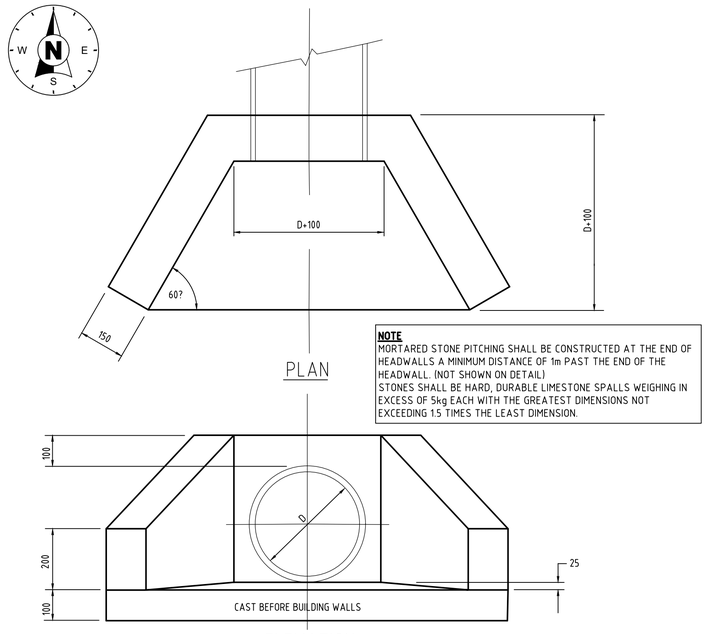
STATUS: **FOR CONSTRUCTION**

SCALE	1:1000
DATE	Oct-25
DESIGN	DLC
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 24-6-94/1/300 | REV No. 0 | ORIGINAL DRAWING SIZE A1

FILE NAME .94\ACAD\STAGE 1\24694-1-300.dwg

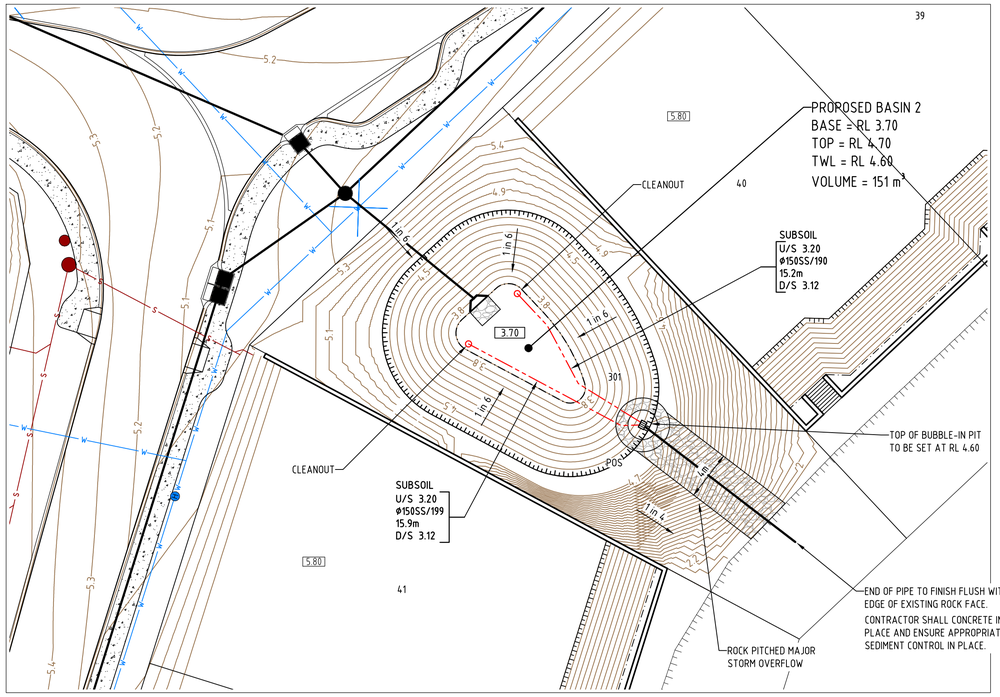


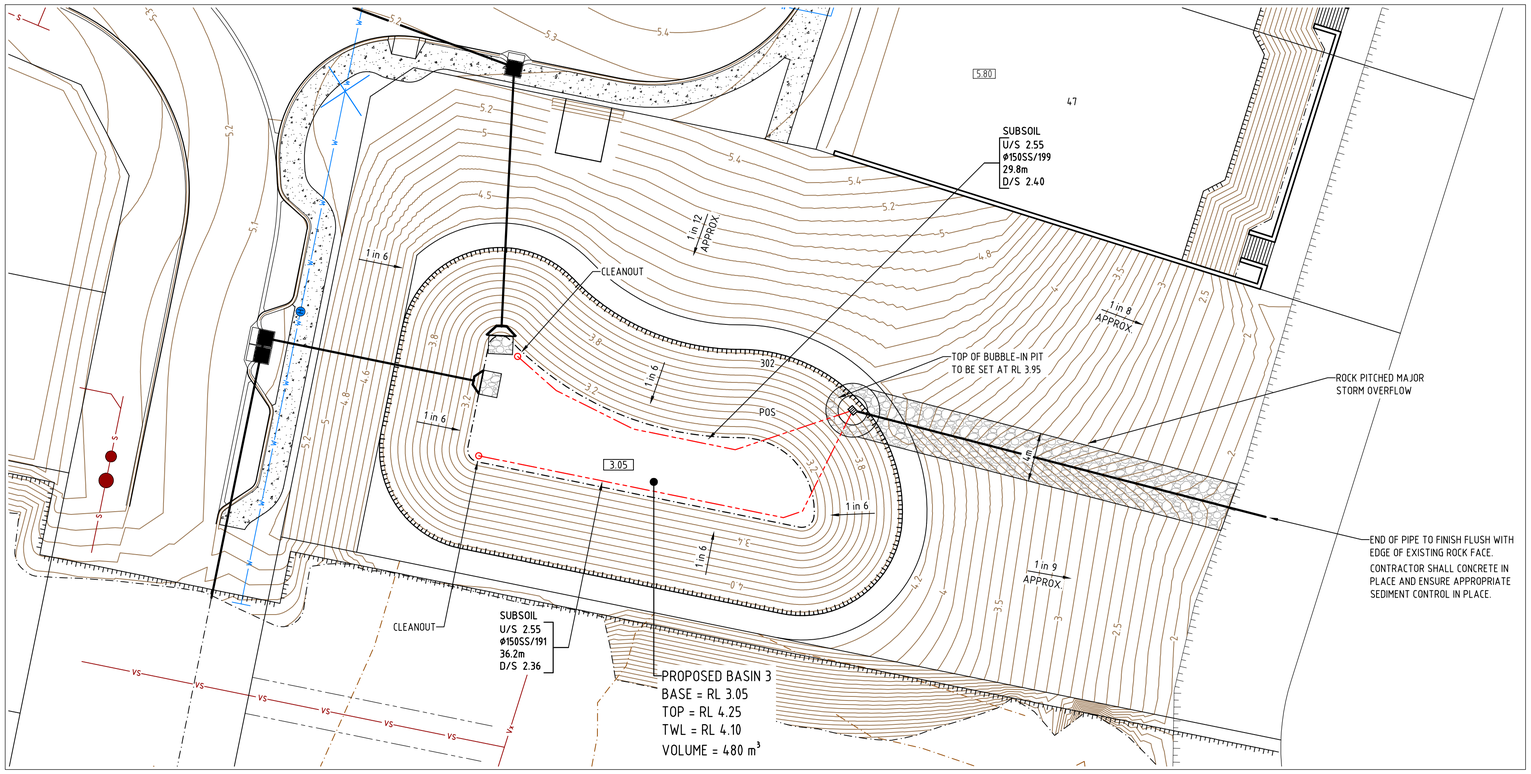


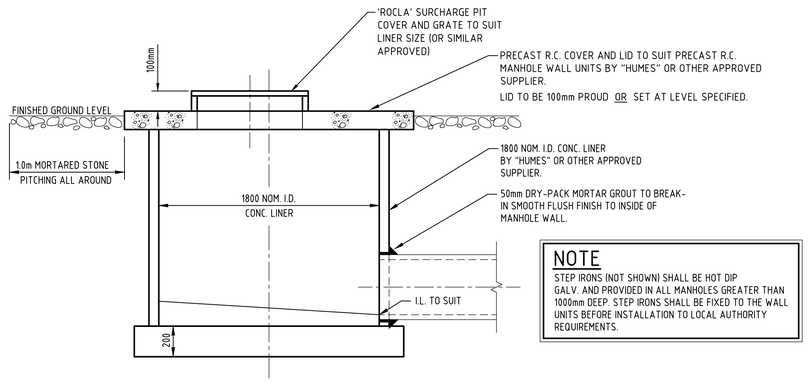
TYPICAL CULVERT HEADWALL

SCALE 1:20

NOTE
MORTARED STONE PITCHING SHALL BE CONSTRUCTED AT THE END OF HEADWALLS A MINIMUM DISTANCE OF 1m PAST THE END OF THE HEADWALL. (NOT SHOWN ON DETAIL)
STONES SHALL BE HARD, DURABLE LIMESTONE SPALLS WEIGHING IN EXCESS OF 5kg EACH WITH THE GREATEST DIMENSIONS NOT EXCEEDING 1.5 TIMES THE LEAST DIMENSION.







GRATED BUBBLE-IN PIT

SCALE 1:25

NOTE
STEP IRONS (NOT SHOWN) SHALL BE HOT DIP GALV. AND PROVIDED IN ALL MANHOLES GREATER THAN 1000mm DEEP. STEP IRONS SHALL BE FIXED TO THE WALL UNITS BEFORE INSTALLATION TO LOCAL AUTHORITY REQUIREMENTS.

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1:250 0m 5 10 15m

WAPC: 201804

PROJECT:

SUNDRIFT

LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
D	10-11-2025	BASIN 1 & BASIN 2 AMENDED	DLC
C	27-8-2025	DESIGN LEVELS AMENDED, BASIN 1 RAISED	DLC
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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Email office@porterceng.com.au
www.porterceng.com.au
TVOND Pty Ltd ACN 670 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

EXMOUTH SUPERLOT PTY LTD

DRAWING:

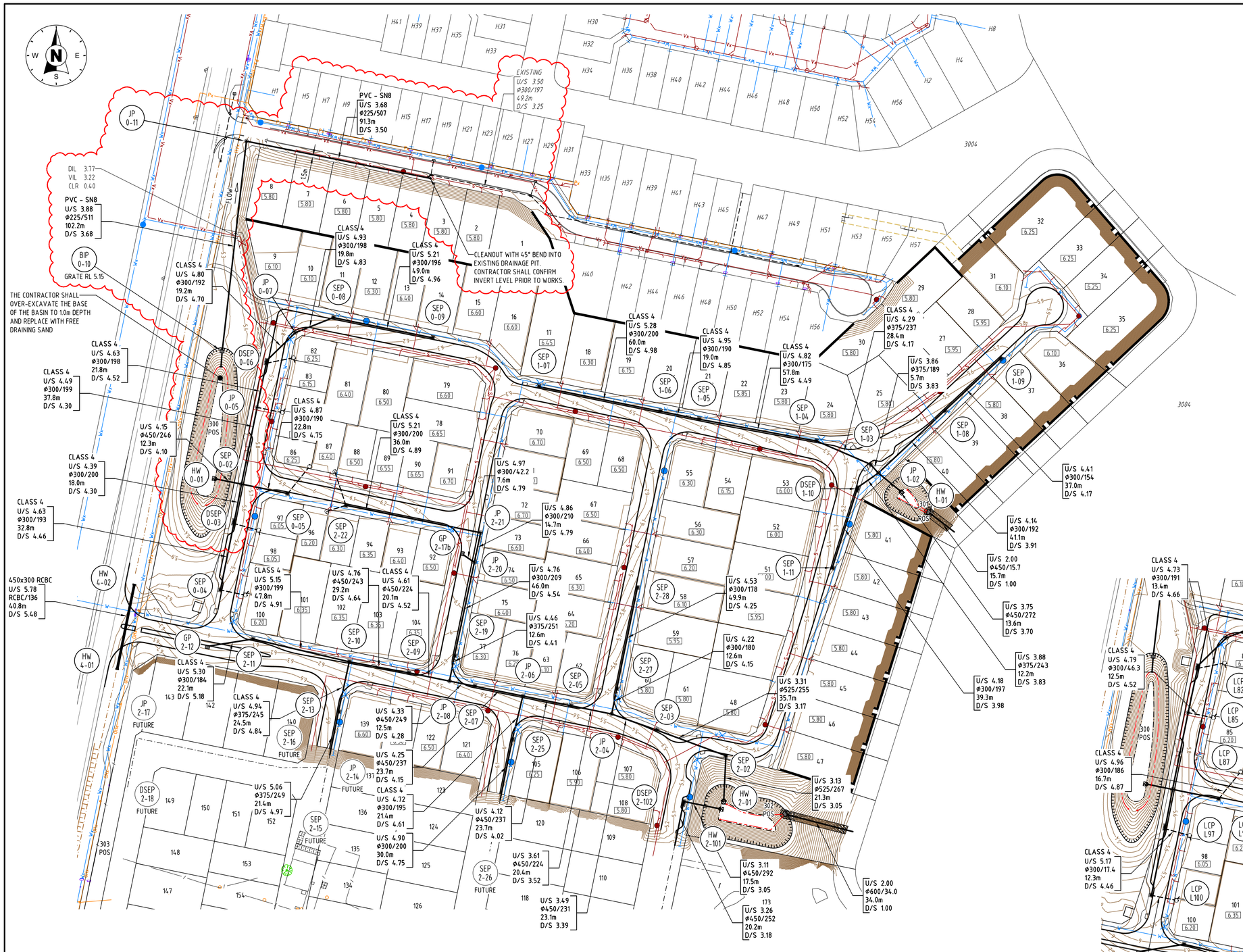
DRAINAGE BASIN DETAILS PLAN

STATUS: FOR TENDER

SCALE	1:250
DATE	Nov-25
DESIGN	DLC
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 24-6-94/1/402 | REV No. D | ORIGINAL DRAWING SIZE A1

FILE NAME ..94\ACAD\STAGE 1\24694-1-402.dwg



LOT DRAINAGE
SCALE 1:1000

DRAINAGE NOTES

1. THE CONTRACTOR SHALL CO-ORDINATE THE LOCATION OF ALL EXISTING AND PROPOSED SERVICES PRIOR TO COMMENCEMENT OF WORK. ANY CONFLICTS ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.
2. SERVICES, SUCH AS SEWER, WATER, GAS, TELEPHONE, ELECTRICITY, AND DRAINAGE MAY BE ENCOUNTERED DURING CONSTRUCTION OF THE WORKS. SERVICES INFORMATION SHOWN ON DRAWINGS IS INDICATIVE ONLY AND MAY NOT BE COMPLETE. BEFORE EXCAVATION COMMENCES THE LOCATION OF ALL SUCH SERVICES SHALL BE OBTAINED FROM THE RELEVANT AUTHORITIES.
3. THE CONTRACTOR SHALL CHECK INVERT LEVELS OF ALL EXISTING STORMWATER PRIOR TO COMMENCEMENT OF WORK. THE CONTRACTOR SHALL NOTIFY THE ENGINEER ON ANY DISCREPANCIES.
4. ALL WORKS SHALL BE TO THE PROJECT SPECIFICATION, BUT WHERE NO DETAIL IS PROVIDED, TO THE REQUIREMENTS OF THE LOCAL AUTHORITY.
5. DRAINAGE PIPE LENGTHS ARE INDICATIVE ONLY, CHAMBERS SHALL BE LOCATED AS SHOWN AND SETOUT IN ACCORDANCE WITH THE STANDARD DETAILS. THE CONTRACTOR SHALL ENSURE A MINIMUM SEPARATION OF 300mm IS PROVIDED IN BETWEEN DRAINAGE LINERS FOR DOUBLE PITS (TO ALLOW SUFFICIENT SPACE FOR COMPACTION) SUBJECT TO THE LINER AND LID MANUFACTURERS DETAILS.
6. EXCAVATION SHALL BE KEPT TO A MINIMUM AND TRENCHES SUPPORTED.
7. PIPES SHALL BE LAID ON THE PREPARED BASE OF THE TRENCH, TO A UNIFORM GRADE AT DESIGN LEVELS.
8. THE CONTRACTOR SHALL PILE AND KEEL IN SOFT GROUND AND WHERE DRAINS CROSS EXISTING SERVICES.
9. ALL PIPES SHALL BE CLASS (2) UNLESS OTHERWISE NOTED. THE CONTRACTOR SHALL NOTIFY THE ENGINEER WHERE MIN. COVER CAN NOT BE ACHIEVED. MINIMUM COVER ON DRAINAGE TO BE 900mm UNDER ROAD AND 600mm IN VERGE UNLESS OTHERWISE NOTED.
10. PIPES SHALL BE LAID OBVERT TO OBVERT TAKEN FROM THE CENTRE OF THE PITS UNLESS OTHERWISE NOTED.
11. FILLING SHALL BE CLEAN NONPLASTIC MATERIAL FREE FROM STONES OR CLAY LUMPS. EXCAVATED MATERIAL SHOULD BE USED WHERE POSSIBLE. FILLING SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 150mm IN THICKNESS AND COMPACTED TO ACHIEVE A DENSITY NOT LESS THAN 95% MAXIMUM DRY DENSITY.
12. THE CONTRACTOR SHALL PREPARE AS-CONSTRUCTED DRAINAGE DRAWINGS (INCLUDING SURVEY) TO THE SATISFACTION OF THE LOCAL AUTHORITY. AS CONSTRUCTED PLANS TO BE ISSUED TO THE ENGINEER FOR SIGNING AND PRESENTATION TO THE LOCAL AUTHORITY.
13. THE CONTRACTOR SHALL PREPARE AND PROVIDE DRAINAGE AS CONSTRUCTED DOCUMENTS IN 'D' SPEC FORMAT AS PER LOCAL AUTHORITY REQUIREMENTS
14. IT IS DEEMED THAT THE AS-CONSTRUCTED DOCUMENTS FORM PART OF THE WORKS. PRACTICAL COMPLETION CAN NOT BE AWARDED IF ACCEPTABLE AS-CONSTRUCTED DOCUMENTS HAVE NOT BEEN PROVIDED TO THE ENGINEER.

LEGEND

- PROPOSED GROUND CONTOUR
- EXISTING GROUND CONTOUR
- PROPOSED DRAINAGE
- PROPOSED DRAINAGE PITS
- EXISTING DRAINAGE
- EXISTING DRAINAGE PITS
- PROPOSED SUBSOIL DRAINAGE
- PROPOSED KERB
- EXISTING ROAD LAYOUT
- PROPOSED RETAINING WALL
- SEP 2 — PROPOSED DRAINAGE STRUCTURE NUMBER
- U/S 4.3.10 / ⌀300/100 / 10.0m / D/S 4.3.00 — INVERT LEVEL UPSTREAM / PIPE DIAMETER / GRADE / LENGTH / INVERT LEVEL DOWNSTREAM
- GP GRATED GULLY PIT
- HW HEADWALL
- JP JUNCTION PIT
- SEG COMBINATION GRATED - SIDE ENTRY PIT

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0m 20.0 40.0 60.0m
1:1000

WAPC: 201804

PROJECT:
SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
H	16-12-2025	ROAD AND PATH LAYOUT AMENDED	DLC
G	3-12-2025	BASIN 1 OVERFLOW PIPE SIZE INCREASED	DLC
F	25-11-2025	BASIN OUTLET PIPE ADDED	DLC
E	10-11-2025	DRAINAGE AMENDED TO SUIT HYDROLOGY ADVICE, HEADWALL NOTATIONS & SUBSOIL ADDED	DLC
D	16-10-2025	SP1-03 SHIFTED	MEG
K	18-2-2026	SUBSOIL DRAINAGE ADDED	DLC
J	21-1-2026	BASIN 3 OUTLET PIPE DETAILS AMENDED	DLC

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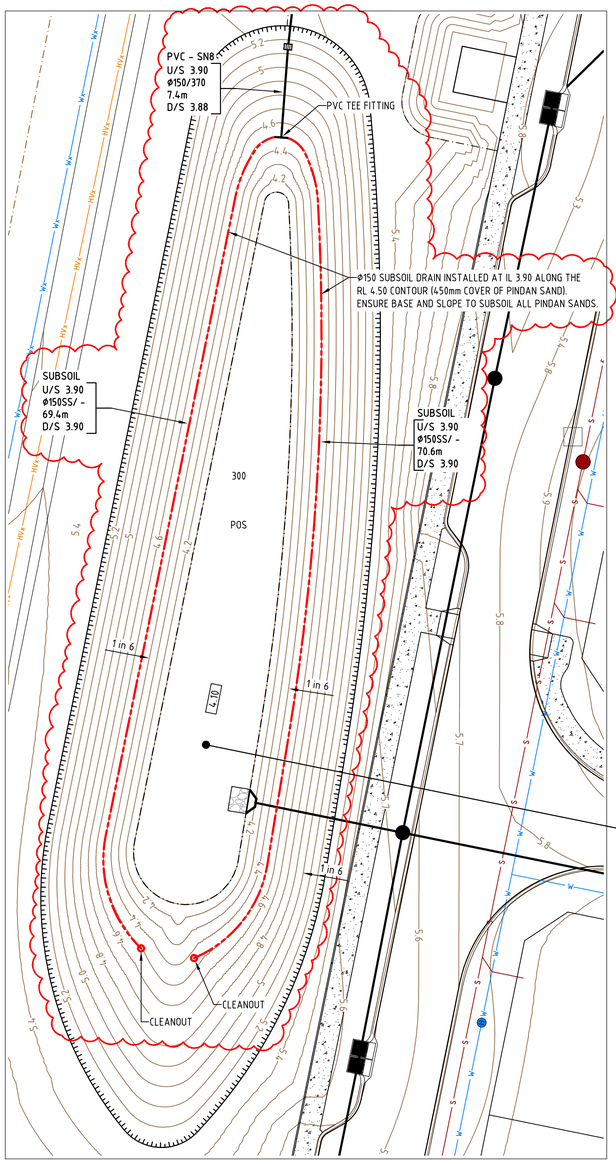
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TUOAD Pty Ltd ACN 670 097 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:
EXMOUTH SUPERLOT PTY LTD

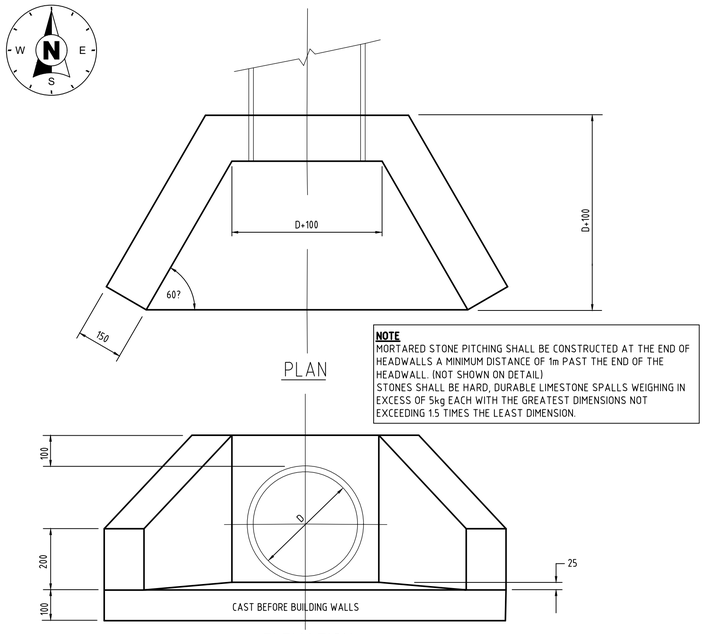
DRAWING:
DRAINAGE LAYOUT PLAN

STATUS: FOR TENDER

SCALE	1:1000
DATE	Feb-26
DESIGN	DLC
DRAWN	MEG
CHECK	
APP'D	
DRAWING No.	24-6-94/1/401
REV No.	K
ORIGINAL DRAWING SIZE	A1
FILE NAME	.94\1ACAD\STAGE 1\24694-1-401.dwg



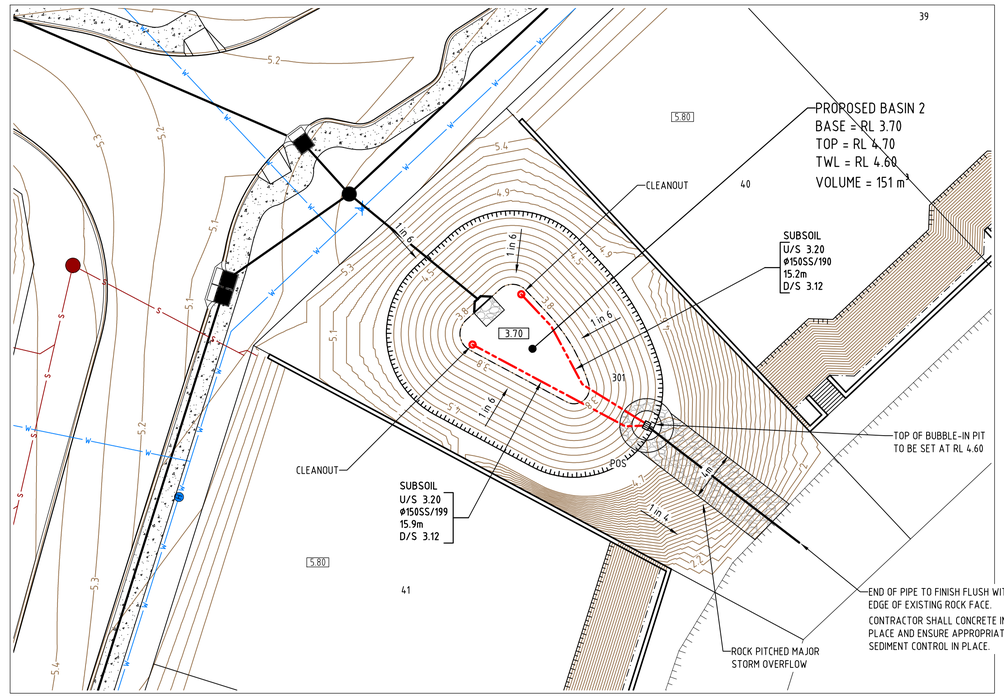
BASIN 1 DETAIL



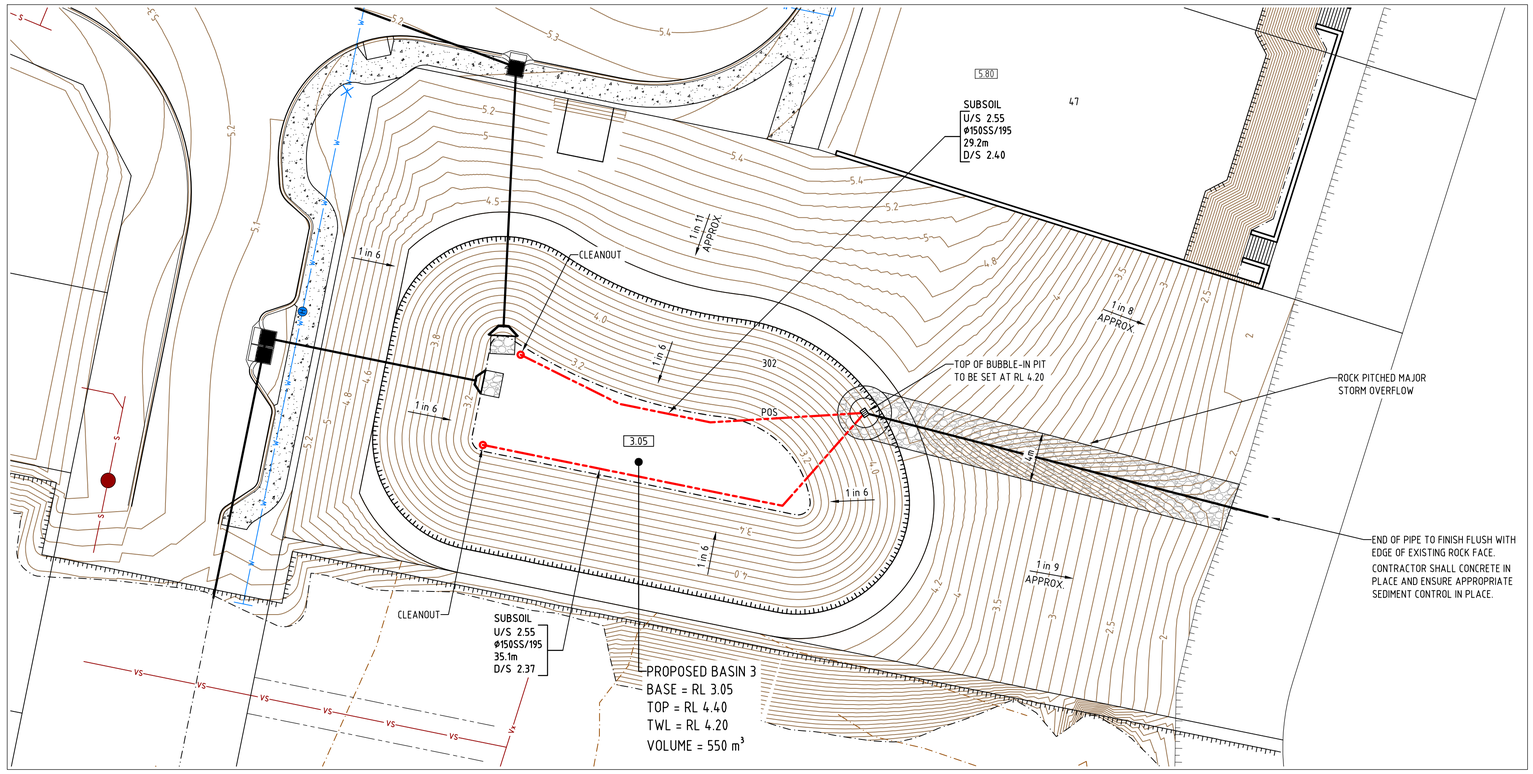
TYPICAL CULVERT HEADWALL

SCALE 1:20

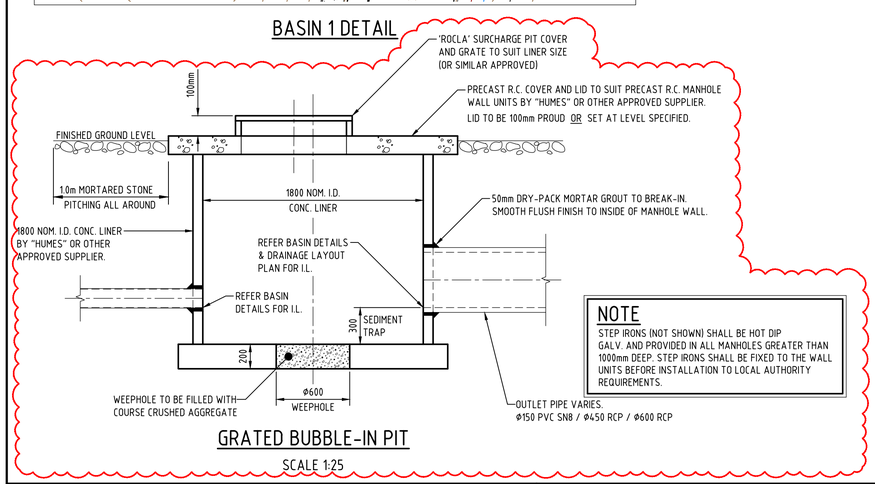
NOTE
MORTARED STONE PITCHING SHALL BE CONSTRUCTED AT THE END OF HEADWALLS A MINIMUM DISTANCE OF 1m PAST THE END OF THE HEADWALL. (NOT SHOWN ON DETAIL)
STONES SHALL BE HARD, DURABLE LIMESTONE SPALLS WEIGHING IN EXCESS OF 5kg EACH WITH THE GREATEST DIMENSIONS NOT EXCEEDING 1.5 TIMES THE LEAST DIMENSION.



BASIN 2 DETAIL



BASIN 3 DETAIL



GRATED BUBBLE-IN PIT

SCALE 1:25

NOTE
STEP IRONS (NOT SHOWN) SHALL BE HOT DIP GALV. AND PROVIDED IN ALL MANHOLES GREATER THAN 1000mm DEEP. STEP IRONS SHALL BE FIXED TO THE WALL UNITS BEFORE INSTALLATION TO LOCAL AUTHORITY REQUIREMENTS.

BEFORE YOU DIG www.byda.com.au

1:250 0m 5 10 15m

WAPC: 201804

PROJECT:
SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
G	18-2-2026	SUBSOIL DRAINAGE ADDED TO BASIN 1	DLC
F	21-1-2026	BASIN 3 LEVELS AMENDED AND SIZE INCREASED	DLC
E	16-12-2025	ROAD AND PATH LAYOUT AMENDED	DLC
D	10-11-2025	BASIN 1 & BASIN 2 AMENDED	DLC
C	27-8-2025	DESIGN LEVELS AMENDED, BASIN 1 RAISED	DLC
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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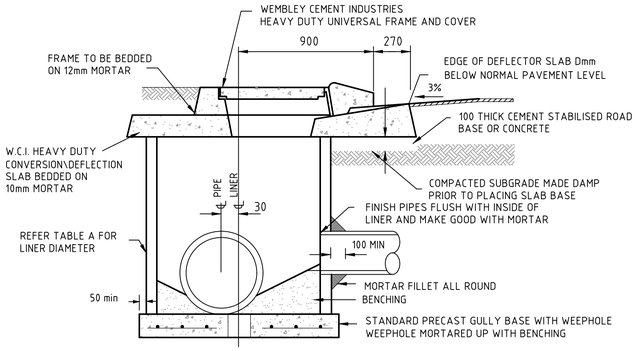
CLIENT:
EXMOUTH SUPERLOT PTY LTD

DRAWING:
DRAINAGE BASIN DETAILS PLAN

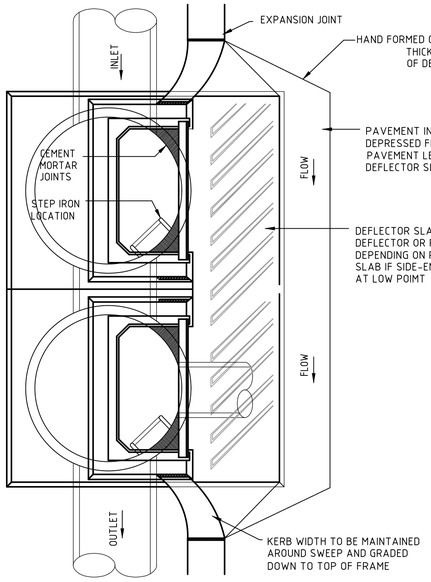
STATUS: FOR TENDER

SCALE	1:250
DATE	Feb-26
DESIGN	DLC
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CHECK	
APP'D	

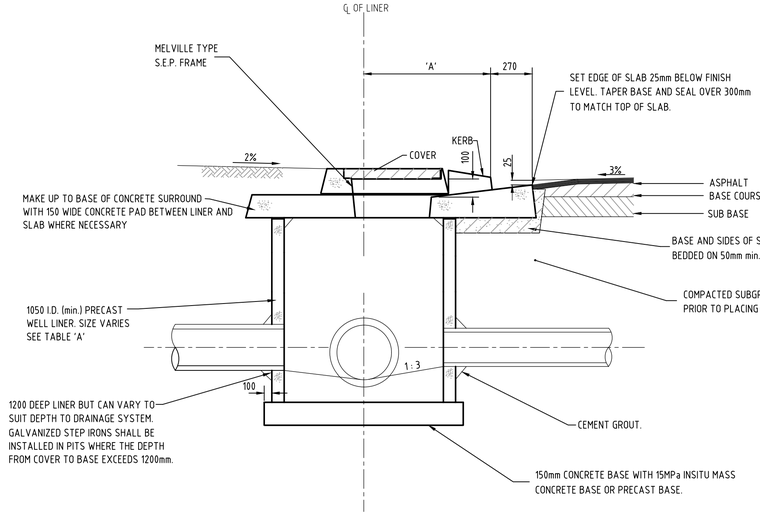
DRAWING No. 24-6-94/1/402
REV No. G
ORIGINAL DRAWING SIZE A1
FILE NAME ..94\ACAD\STAGE 1\24694-1-402.dwg



SIDE ENTRY PIT SECTION



SIDE ENTRY PIT - COVER REMOVED PLAN

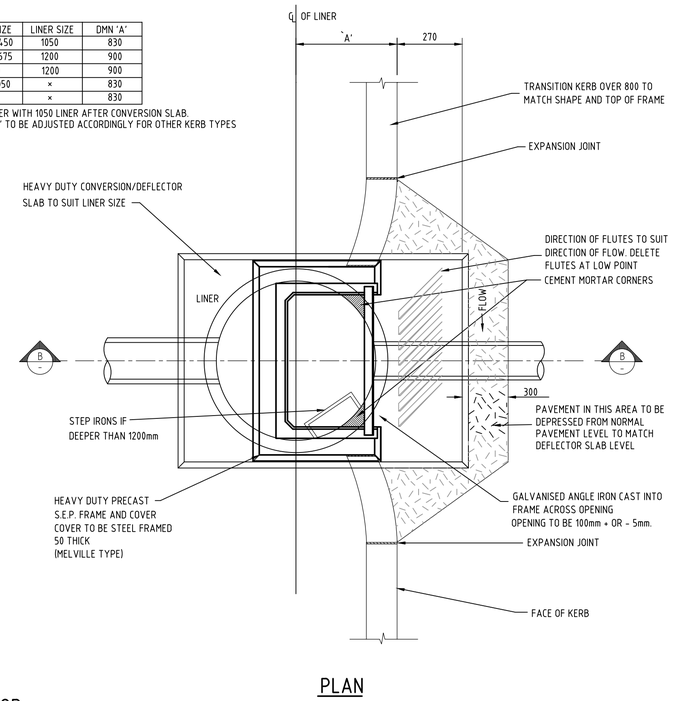


SECTION B-B

NOTE

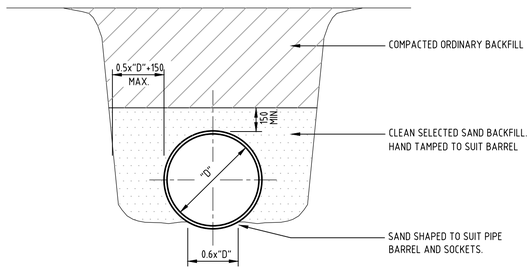
PIPE SIZE	LINER SIZE	DMN 'A'
225 - 450	1050	830
525 - 675	1200	900
750	1200	900
900-1050	×	830
1200	×	830

× BRICK CHAMBER WITH 1050 LINER AFTER CONVERSION SLAB. DIMENSION "A" TO BE ADJUSTED ACCORDINGLY FOR OTHER KERB TYPES

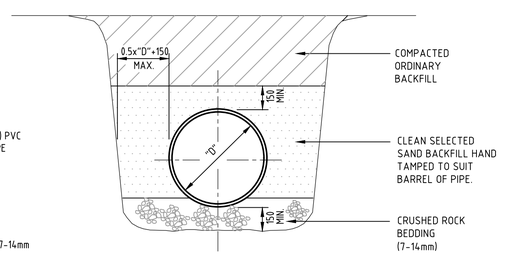


PLAN

SIDE ENTRY PIT WITH DEFLECTOR



DRY CONDITIONS



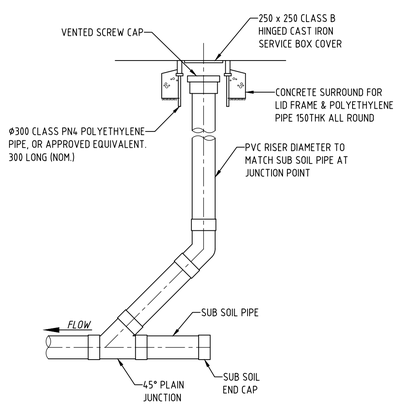
WET CONDITIONS

PIPE BEDDING DETAILS

NOT TO SCALE

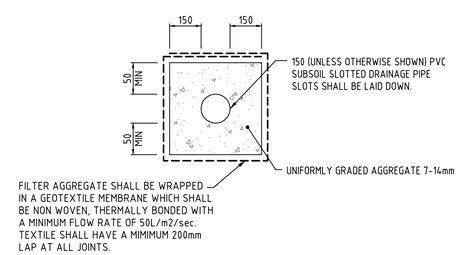
PIPE BEDDING NOTES

1. DRY CONDITIONS SHALL BE SAND SOIL WHERE THE MAXIMUM PREDICTED G.W.L. IS A MINIMUM 300mm BELOW PIPE INVERT.
2. WET CONDITIONS SHALL BE CONSIDERED AS BEING IN ROCK. CLAY OR SAND WHERE THE MAXIMUM PREDICTED G.W.L. IS HIGHER THAN 300mm BELOW PIPE INVERT.
3. SUB-SOIL DRAINAGE PIPES SHALL BE LAID WITH SLOTS DOWN.
4. WHERE PIPES ARE BEDDED ON CRUSHED ROCK, THE BEDDING CONDITION SHALL BE CARRIED PAST ALL MANHOLES, GULLIES AND OTHER DRAINAGE STRUCTURES DOWNSTREAM.



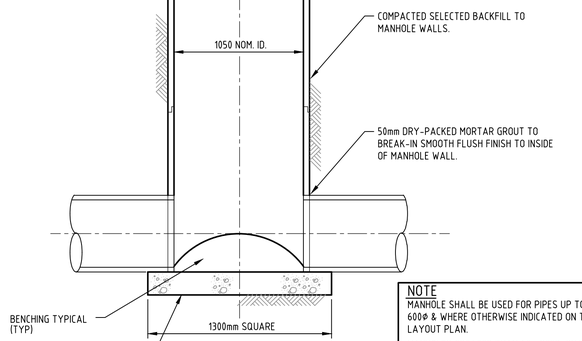
SUBSOIL CLEAN OUT & SERVICE COVER

NOT TO SCALE

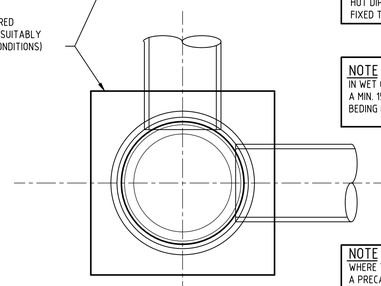


SUBSOIL DRAINAGE WITHOUT ADJACENT MAINLINE

NOT TO SCALE



NOTE
MANHOLE SHALL BE USED FOR PIPES UP TO 600Ø & WHERE OTHERWISE INDICATED ON THE LAYOUT PLAN.
MANHOLES GREATER THAN 1.0m DEEP, SHALL HAVE HOT DIP GALV. STEP IRONS. STEP IRONS TO BE FIXED TO WALL UNITS PRIOR TO INSTALLATION



NOTE
IN WET CONDITIONS BASE SHALL BE POURED ONTO A MIN. 150mm CRUSHED ROCK BEDDING. (SEE PIPE BEDING DETAILS)

NOTE
WHERE THE CONTRACTOR IS REQUIRED TO BREAK INTO A PRECAST MANHOLE ONLY THAT MUCH OF THE WALL SHALL BE REMOVED AS IS REASONABLY NEEDED TO MAKE THE CONNECTION

STORMWATER MANHOLE

SCALE 1:20

1:1000 0m 20.0 40.0 60.0m

WAPC: 201804

PROJECT:
SUNDRIFT
LOT 9510 MURAT ROAD, EXMOUTH

No.	DATE	REVISION	BY
C	10-11-2025	SUBSOIL DRAINAGE DETAILS ADDED	DLC
B	8-8-2025	ISSUED FOR TENDER	DLC
A	1-8-2025	ISSUED FOR TENDER	DLC

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CLIENT:
EXMOUTH SUPERLOT PTY LTD

DRAWING:
STANDARD DETAILS SHEET 2

STATUS: FOR TENDER

SCALE	AS SHOWN
DATE	Aug-25
DESIGN	DLC
DRAWN	MEG
CHECK	
APP'D	

DRAWING No. 24-6-94/1/602
REV No. C
ORIGINAL DRAWING SIZE A1
FILE NAME ..94\ACAD\STAGE 1\24694-1-601-602.dwg

APPENDIX E MORTISS STREET DRAINAGE MANAGEMENT

Drainage options to reduce current flooding on Mortiss St and Access Rd.

August 2025

1. Stage 1 development to retain a suitable flow channel from Mortiss St to the canal network.

2. Current channel (with potential modification that retain the flow capacity) through Superlot D to remain until alternative drainage management options installed.

3. Install suitable culverts under new entrance to maximise flow to north side of Mortiss St without overtopping. Exact size to be determined as part of detailed civil design and UWMP

4. Swale capacity along Mortiss St to be retained or enhanced as part of the development to maximise capacity of water to stay on north side of Mortiss St. Exact configuration to be determined as part of detailed civil design and UWMP

5. The current physical Mortiss St pavement and verge areas are to be separated into a new road reserve (currently within Crown Reserve 47981). The final road reserve should consider the requirements of the upgraded swale width.

6. Check if there is a pipe outlet from swale to allow for discharge of water at lower levels (based on their being an outlet pipe to the South). Potentially clean out and modify existing discharging pipe /pit or install a system that allows flows out prior to Weir level of RL 4.1. Would need to consider any impact on areas to the south.

7. Install Combination Side Entry Pit to minimise blockages and to maximise flow into pipe network

8. Install high flow raised lid grated pit to minimise blockages and to maximise flow into pipe network

9. Lower existing high point within swale (light blue dashed line) to encourage high flows to 600mm pipe. Swale invert lip lowered to approximately at RL 3.6 (subject to detailed design). Low flows will still head though existing 300mm culvert to Searaven Estate swale for treatment.

Shire to undertake service pickup within swale area and provide the Superlot design team for consideration as part of determining a suitable swale profile.

10. Install high flow raised lid grated pit to minimise blockages and to maximise flow into 600mm pipe.

Upgrading pits on both sides of road may assist with maximising water into pipe and reduce flooding in low point.

11. Install minor sediment capture points either side of high flow capture pit. eg locally lower swale prior to pit, allowing sediments to drop out.
Could be formalised with concrete structure if shallow services underneath eg reduces risk of damaging services when cleaning out captured sediment.

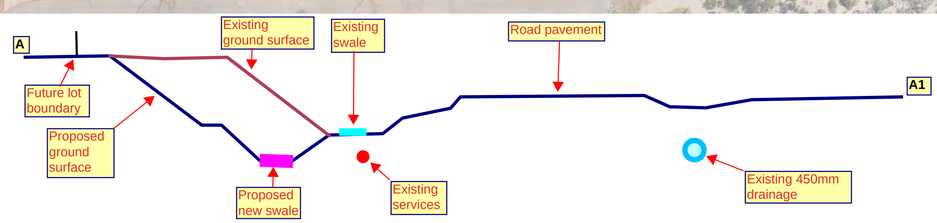
12. Potentially install another pipe/ upgrade size for maximise discharge during large events.

13. Install flap valve on 600mm outlet pipe to manage future storm surge from ocean and associated back flooding

Indicative future lot boundary, set far enough back so deep point of swale is not affecting the current services

Have wide verge that allows for the deeper portions of the swale to be alongside services (eg to the north/ west of the existing swale). See cross Section A- A1

RL 4.3m
RL 4.4m
RL 4.6m
RL 4.8m
RL 3.8m
RL 4.5m
RL 3.5m
RL 4.0m
EXISTING OVERLAND FLOW PATH FROM SOUTH TO NORTH
EXISTING FLOODWAY FLOW PATH FROM SOUTH TO NORTH
NEALE COVE EXISTING ROAD LEVELS
MORTISS ST
ACCESS RD
NEALE COVE
CREVALLE WAY
SEARAVEN ESTATE
U/S 0.90 DN 600 82 D/S 0.57
U/S 1.10 DN 600 14.5 D/S 0.90
U/S 1.56 DN 450 100 D/S 1.10
U/S 3.33 DN 300 18.5 D/S 3.27
U/S 2.34 DN 450 58.5 D/S 1.59
U/S 2.49 DN 375 10.5 D/S 2.46
U/S 1.85 DN 300 26 D/S 1.71
GYMH
JP
SEP
GY
A
A1



Note:

Final options for alleviating small and medium flooding along Mortiss St to be determined prior to or as part of the Superlot D Stage 2 detailed design.

APPENDIX F ON LOT DRAINAGE GUIDANCE NOTE

On-lot Drainage Requirements for Sundrift Builders and Residents

All Sundrift lots 350m^2 and over are required to retain and infiltrate at least the first 15mm of rainfall within the lot. This requirement is for the entire lot area. For all lots 350m^2 and over, the Shire of Exmouth are supportive of stormwater drainage in exceedance of the first 15mm of rainfall being discharged to the road drainage network. For applicable canal fronting lots, stormwater drainage in exceedance of the first 15mm may discharge directly to the canal.
For lots under 350m^2, the lot's stormwater may be discharged directly to the street drainage network via the lot connection pit, without detention.

The storage of stormwater is to be in a structure approved by the Shire. This may include soakwells, underground infiltration chambers, rain gardens or other similar infiltration devices.

Sundrift soakwell guidance

The following provides further guidance on 2 methods in relation to calculating the required storage using standard soakwells.

Method 1

To calculate the total required storage, the total lot area is to be multiplied by the first 15mm of rainfall.
As an example, for a 600m^2 lot

- Lot area: 600m^2
- Required rain event: 15mm
- Total storage: 600m2 x 0.015 (15mm) = 9m^3 (9000L)

The number of soakwells can then be determined by calculating the total storage divided by the chosen soakwells volume.
As an example:

- Total storage: 9m^3 (9000L)
- Storage within chosen soakwell (1.2m diam x 1.8m deep): 2.03m^3 (from Table 1)
- Number of 1.2m diam x 1.8m deep soakwells required: 9m^3 / 2.03m^3 = 4.4 soakwells

The installed number of soakwells is to always be rounded up, so the 4.4 soakwells becomes 5 soakwells (sized 1.2m diameter x 1.8m deep) to provide drainage for a 600m^2 lot.

Method 2

To calculate the total required storage, based on a chosen soakwell type the total lot area is divided by the volume that each soakwell type can store.
As an example, for a 600m2 lot

- Lot area: 600m^2
- Intended Soakwell Size: 1.5m diameter x 1.5m deep
- Lot Area Serviced by chosen soakwell type: 176.7m^2(from Table 1)
- Number of 1.5m diam x 1.5m deep soakwells required: 600m^2 / 176.7m^2 = 3.4 soakwells

The installed number of soakwells is to always be rounded up, so the 3.4 soakwells becomes 4 soakwells (sized 1.5m diameter x 1.5m deep) to provide drainage for a 600m^2 lot.

Table 1: Soakwell sizes and lot area serviced

Diameter (m)	Depth (m)	Soakwell Volume (m^3)	Base Infiltration Area (m^2)	Lot Area Serviced (m^2)
0.9	1.2	0.76	0.64	50.7
0.9	1.5	0.95	0.64	63.3
0.9	1.8	1.14	0.64	76.0
1.2	1.2	1.36	1.13	90.7
1.2	1.5	1.70	1.13	113.3
1.2	1.8	2.03	1.13	135.3
1.5	1.2	2.12	1.77	141.3
1.5	1.5	2.65	1.77	176.7
1.5	1.8	3.18	1.77	212

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Water and Environmental Management

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