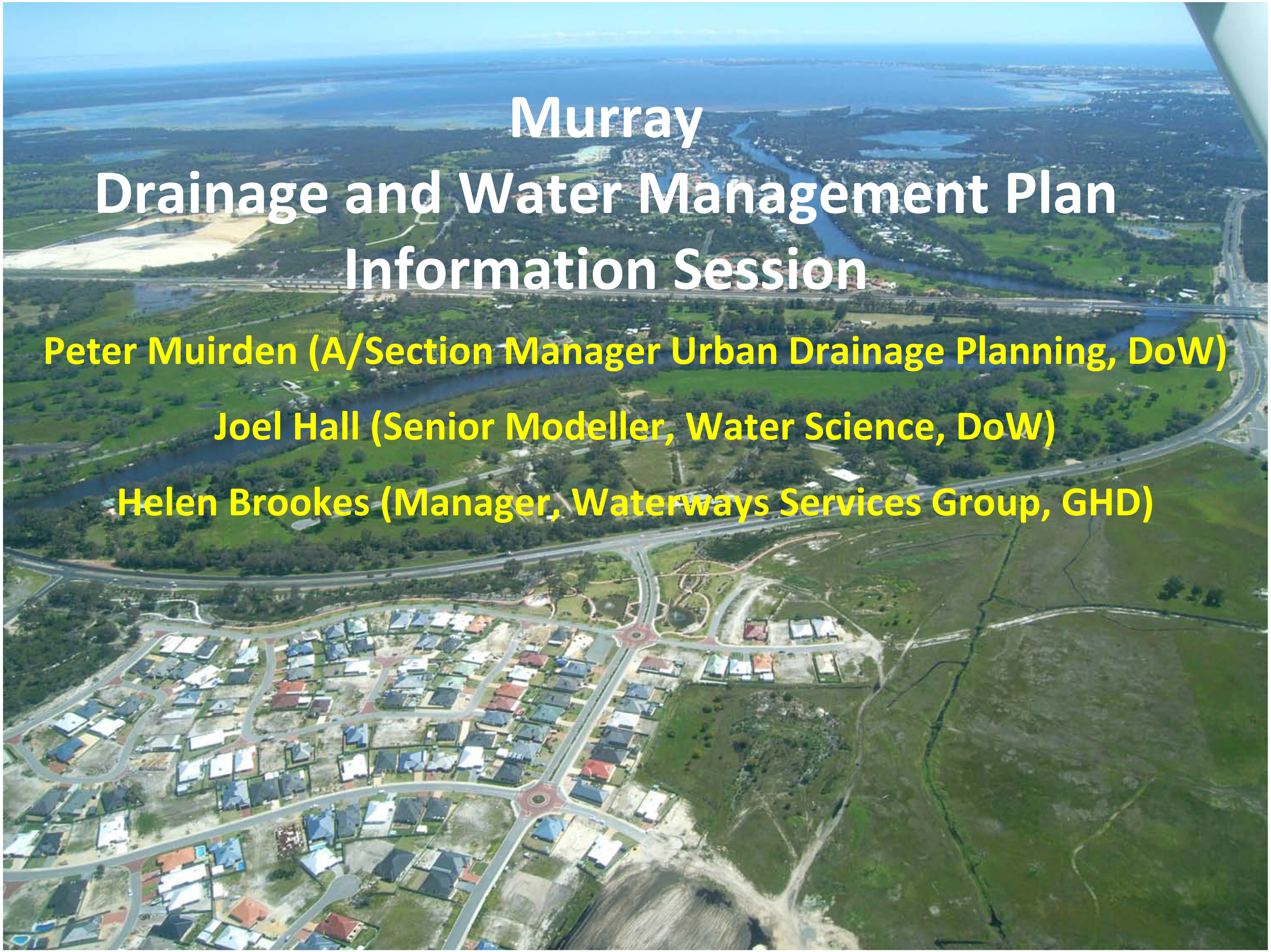
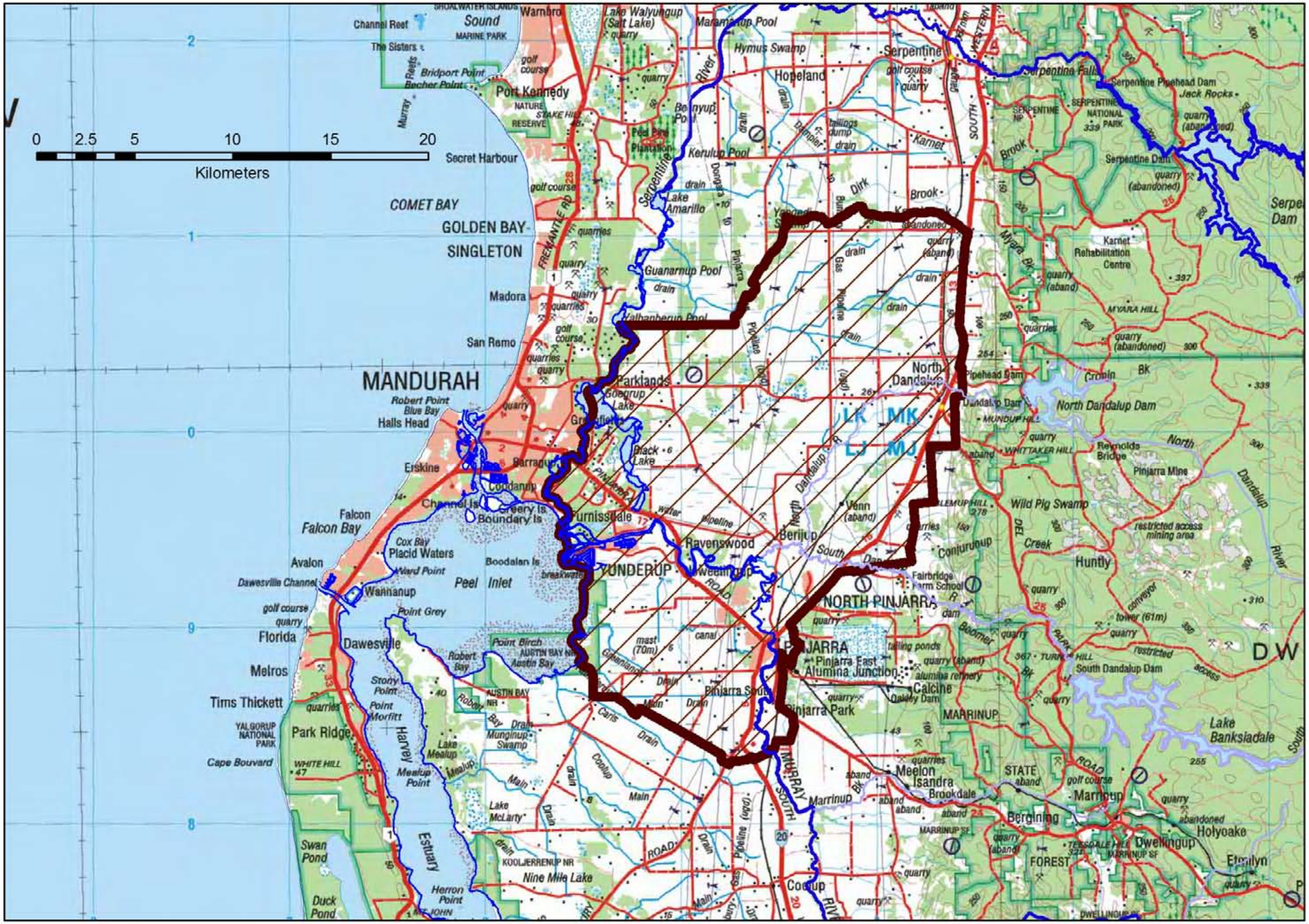


Murray
Drainage and Water Management Plan
Information Session

Peter Muirden (A/Section Manager Urban Drainage Planning, DoW)

Joel Hall (Senior Modeller, Water Science, DoW)

Helen Brookes (Manager, Waterways Services Group, GHD)


0 2.5 5 10 15 20
Kilometers
Channel Reef
The Sisters
Sound
MARINE PARK
Warnbro
Bridport Point
Becher Point
Port Kennedy
Secret Harbour
COMET BAY
GOLDEN BAY
SINGLETON
Madora
San Remo
MANDURAH
Robert Point
Blue Bay
Halls Head
Erskine
Falcon
Falcon Bay
Avalon
Dawesville Channel
Florida
Melros
Tims Thickett
Cape Bouvard
Park Ridge
Swan Pond
Duck Pond
Dawesville
Wannanup
Peel Inlet
Point Grey
Cox Bay
Placid Waters
Ward Point
Boodalan Is
Channel Is
Creery Is
Boundary Is
Coodanup
Barragup
Greenfields
Furnissdale
Ravenswood
YUNDERUP
Robert Bay
Austin Bay
Point Birch
Harvey Estuary
Herron Point
Mealup Point
Lake Mealup
Lake McLarty
Nine Mile Lake
Lake Walyungup
(Salt Lake)
Mandurah Pool
Hymus Swamp
Hopeland
Serpentine
Serpentine Falls
Serpentine Pipehead Dam
Jack Rocks
Serpentine Dam
Kerulup Pool
Lake Amarillo
Guanarnup Pool
Parklands
Goegrup Lake
Black Lake
North Dandalup
Pipehead Dam
North Dandalup Dam
LK MK
LJ MJ
Karnet Rehabilitation Centre
MYARA HILL
Cronin Bk
Reynolds Bridge
Pinjarra Mine
Wild Pig Swamp
Huntly
Venn
(aband)
Berlup
Conjurunup
Fairbridge Farm School
NORTH PINJARRA
PINJARRA
Pinjarra East
Alumina Junction
Calcine
Pinjarra South
Pinjarra Park
MARRINUP
South Dandalup Dam
Lake Banksiadale
Meelon
Isandra
Brookdale
Marrinup
Banksiadale
Dwellingup
Holyoake
Etmilyn
FOREST
Coolup
D W

DWMP

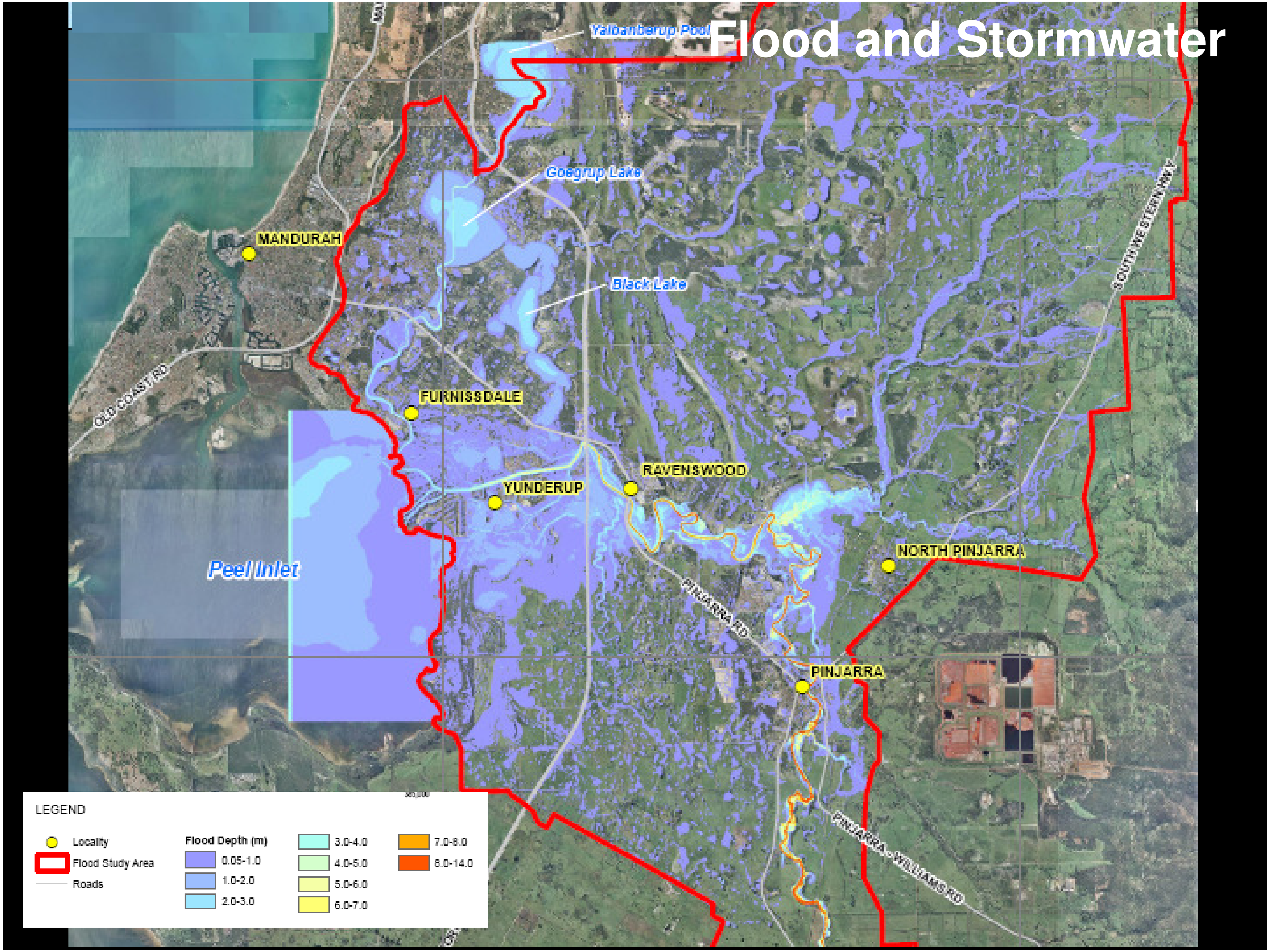
Supporting tech studies

- Flood & Stormwater
- Groundwater Interaction
- EWR Study (Wetlands & Ecology)
- Nutrients & Peel-Harvey Estuary
- Acid Sulphate Soils
- Water Use (Allocation and Reuse)
-

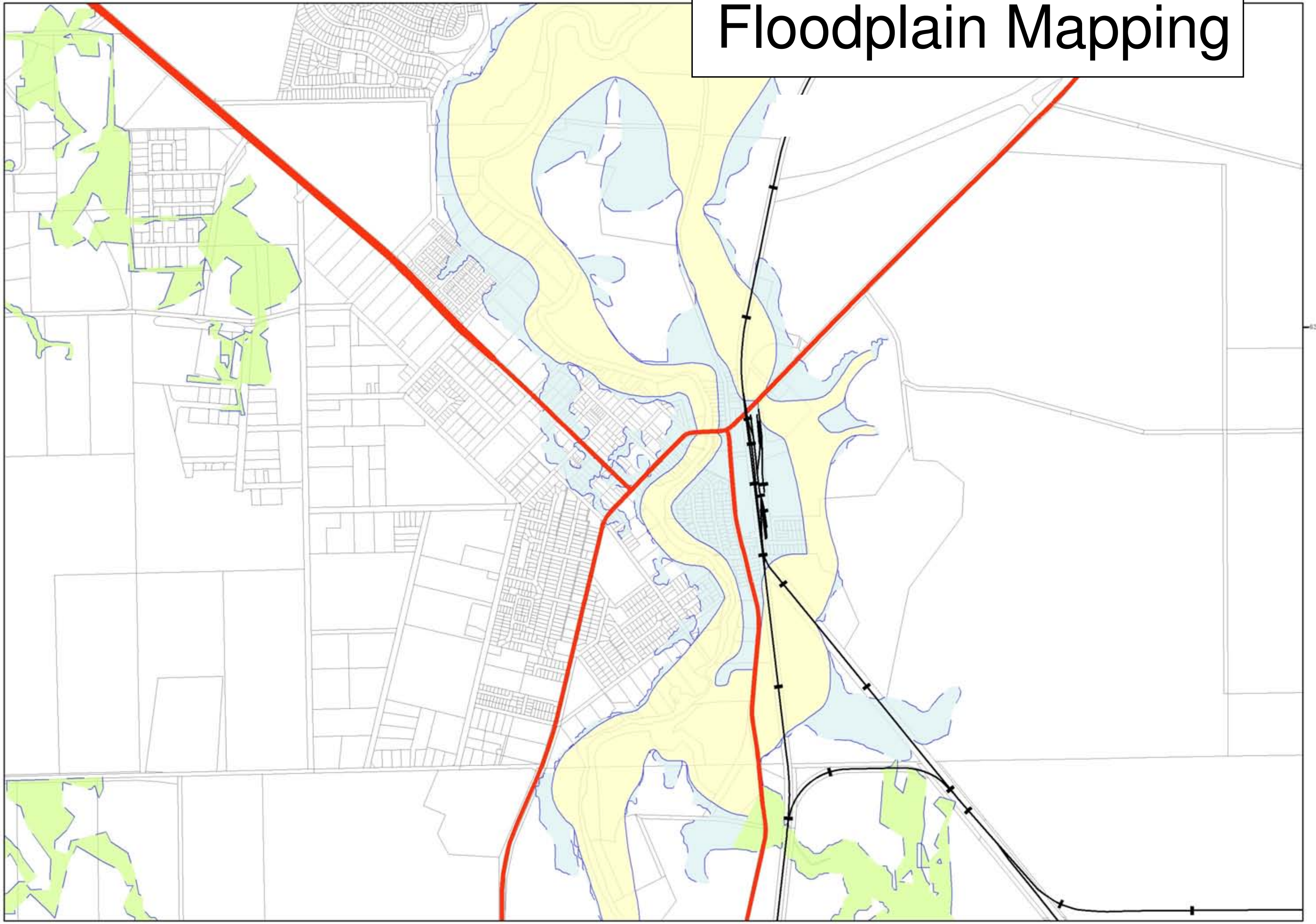
Combined into the:

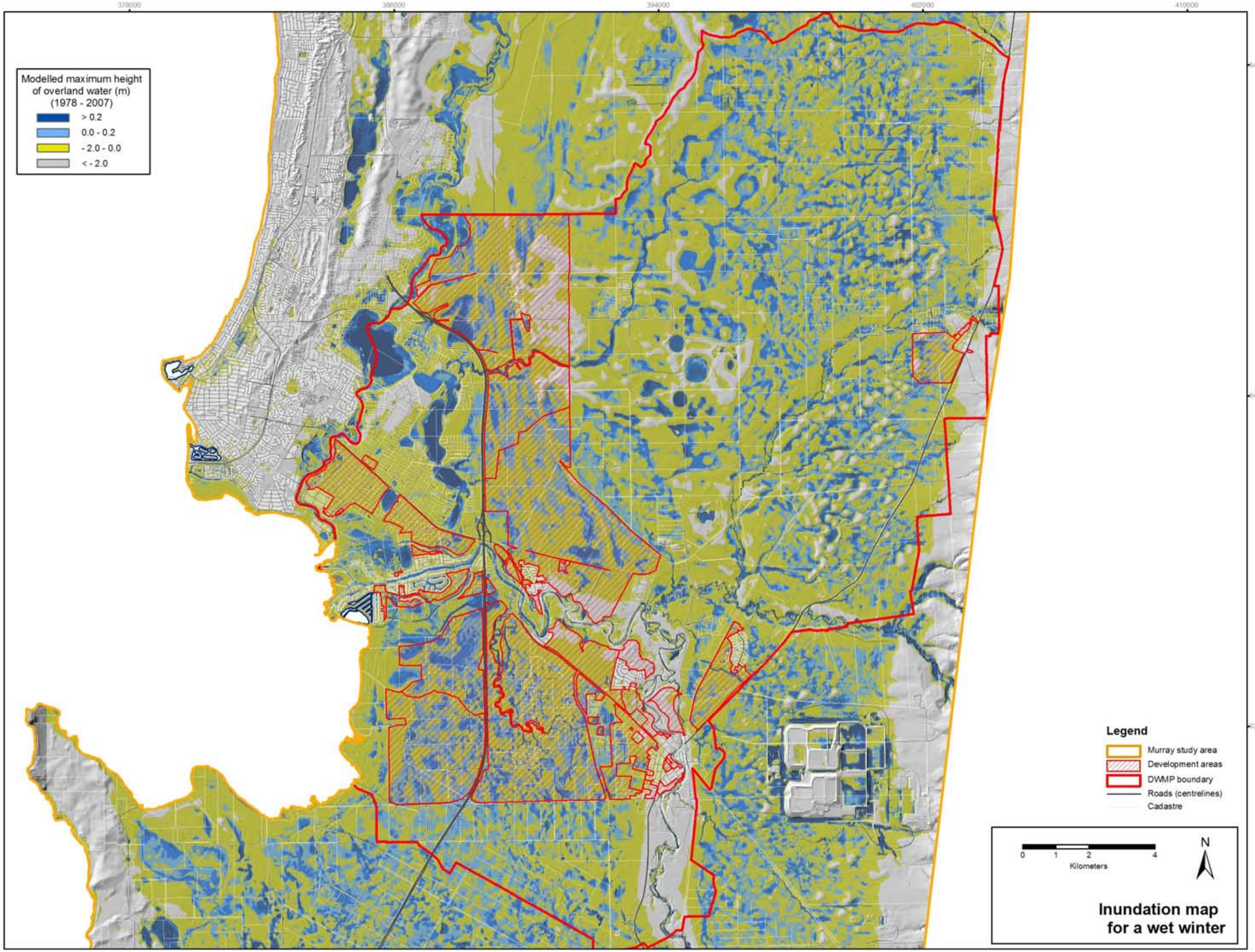
Murray Drainage and Water Management Plan

Flood and Stormwater

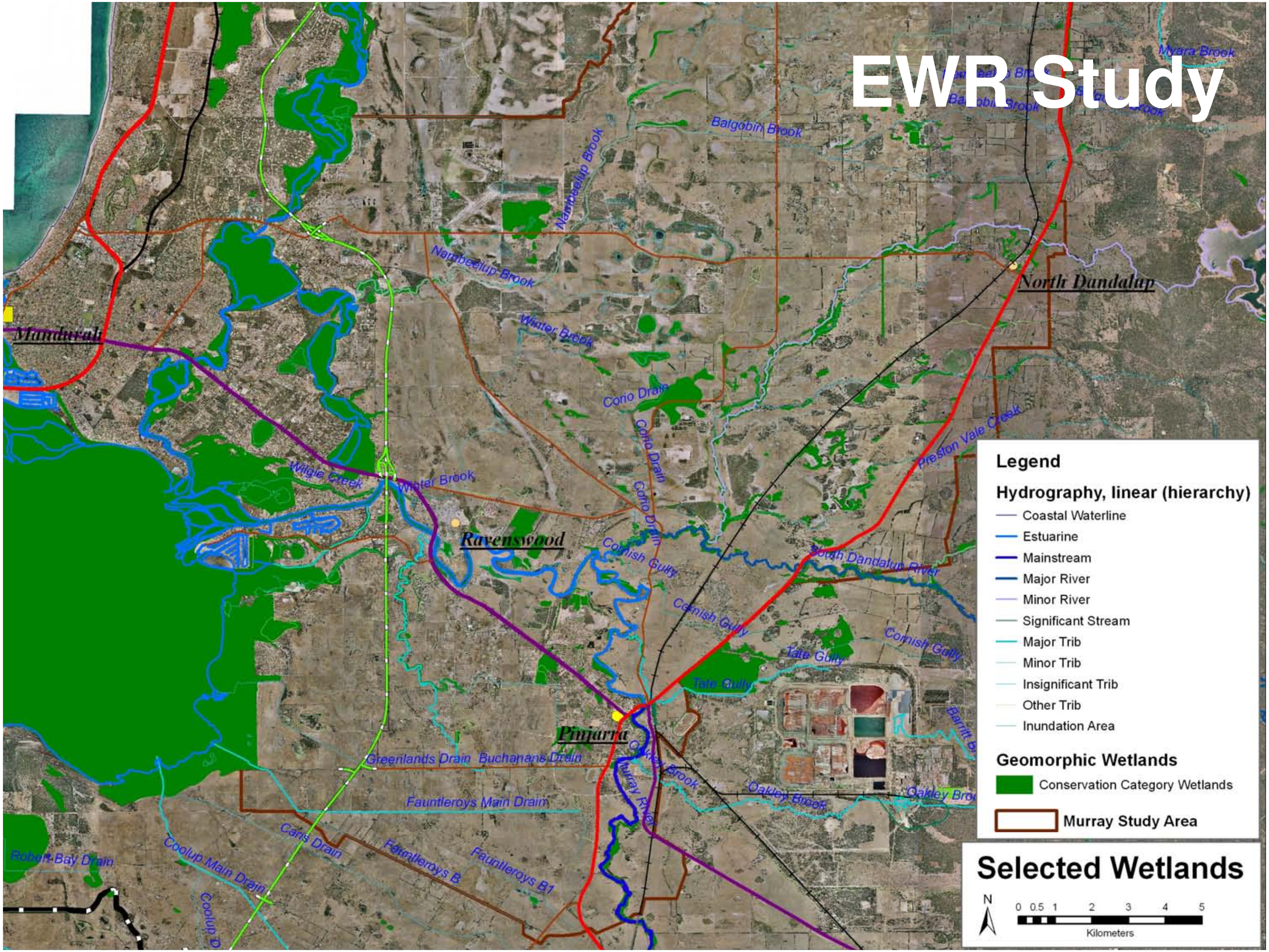


Floodplain Mapping

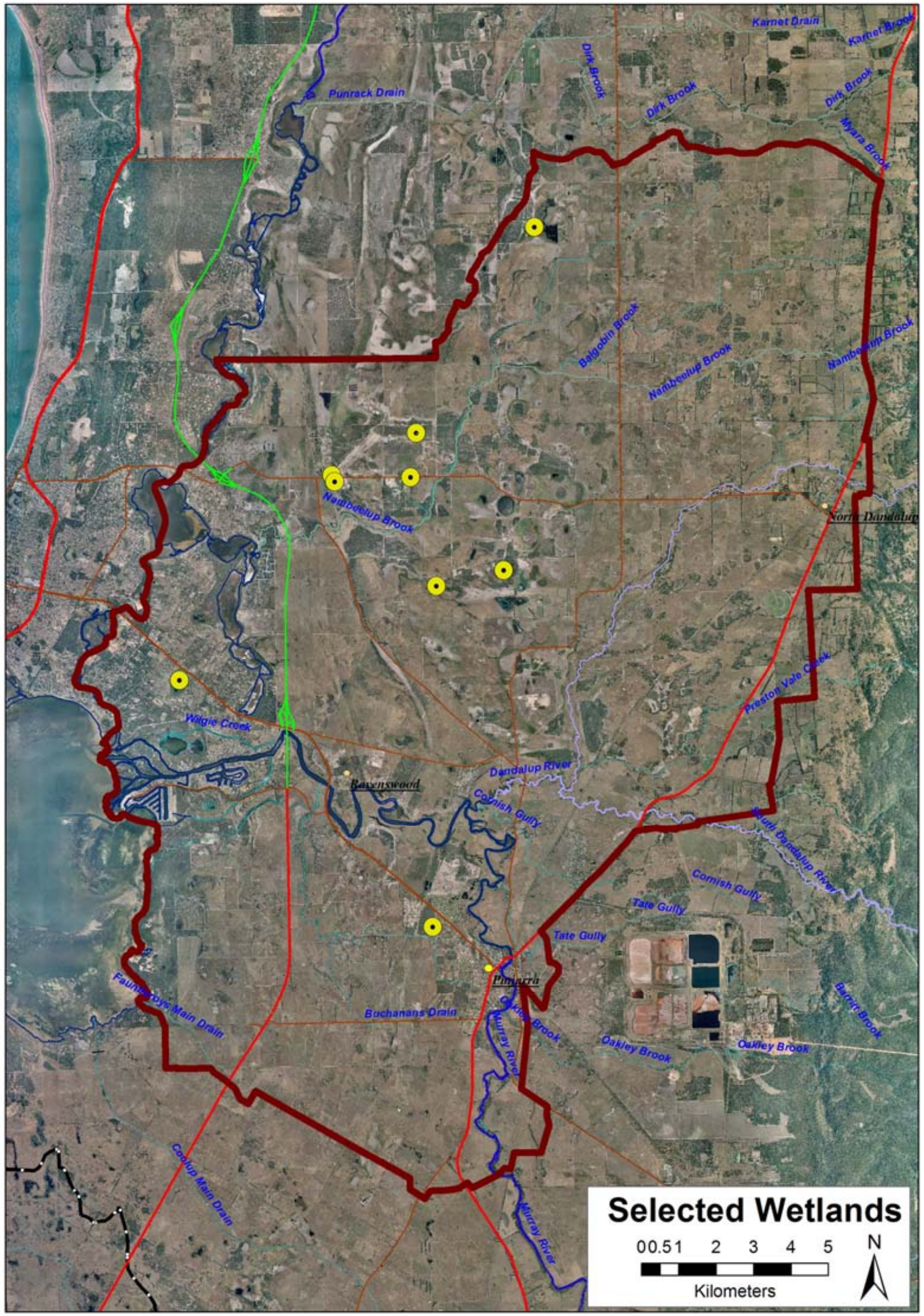


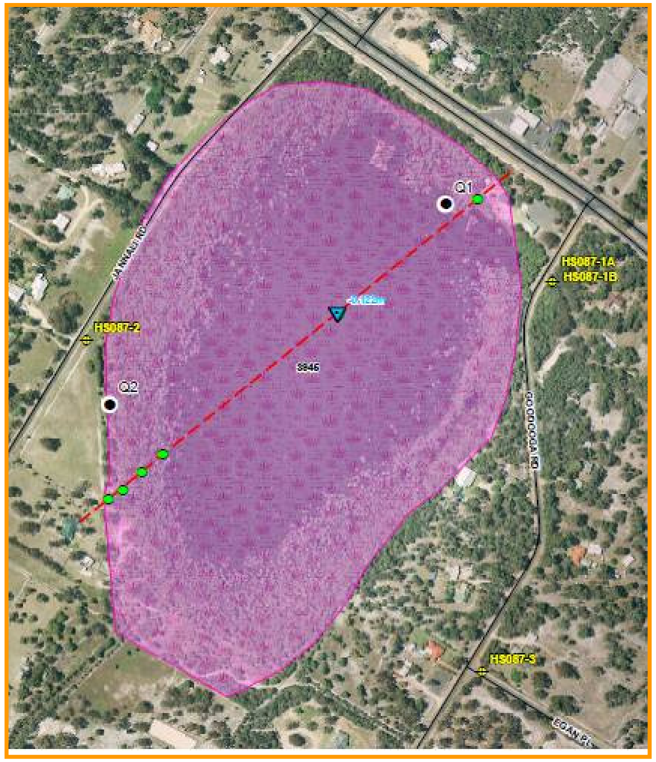


Inundation map for a wet winter



EWR Study
Myara Brook
Balgobin Brook
Nambeelup Brook
North Dandalup
Mandurah
Winter Brook
Cono Drain
Preston Vale Creek
Wilgie Creek
Ravenswood
Cornish Gully
South Dandalup River
Tate Gully
Pinjarra
Oakley Brook
Murray River
Greenlands Drain
Buchanans Drain
Fauntleroys Main Drain
Caris Drain
Fauntleroys B
Fauntleroys B1
Coolup Main Drain
Robert Bay Drain
Legend
Hydrography, linear (hierarchy)
Coastal Waterline
Estuarine
Mainstream
Major River
Minor River
Significant Stream
Major Trib
Minor Trib
Insignificant Trib
Other Trib
Inundation Area
Geomorphic Wetlands
Conservation Category Wetlands
Murray Study Area
Selected Wetlands
N
0 0.5 1 2 3 4 5
Kilometers





Wetland studies include:

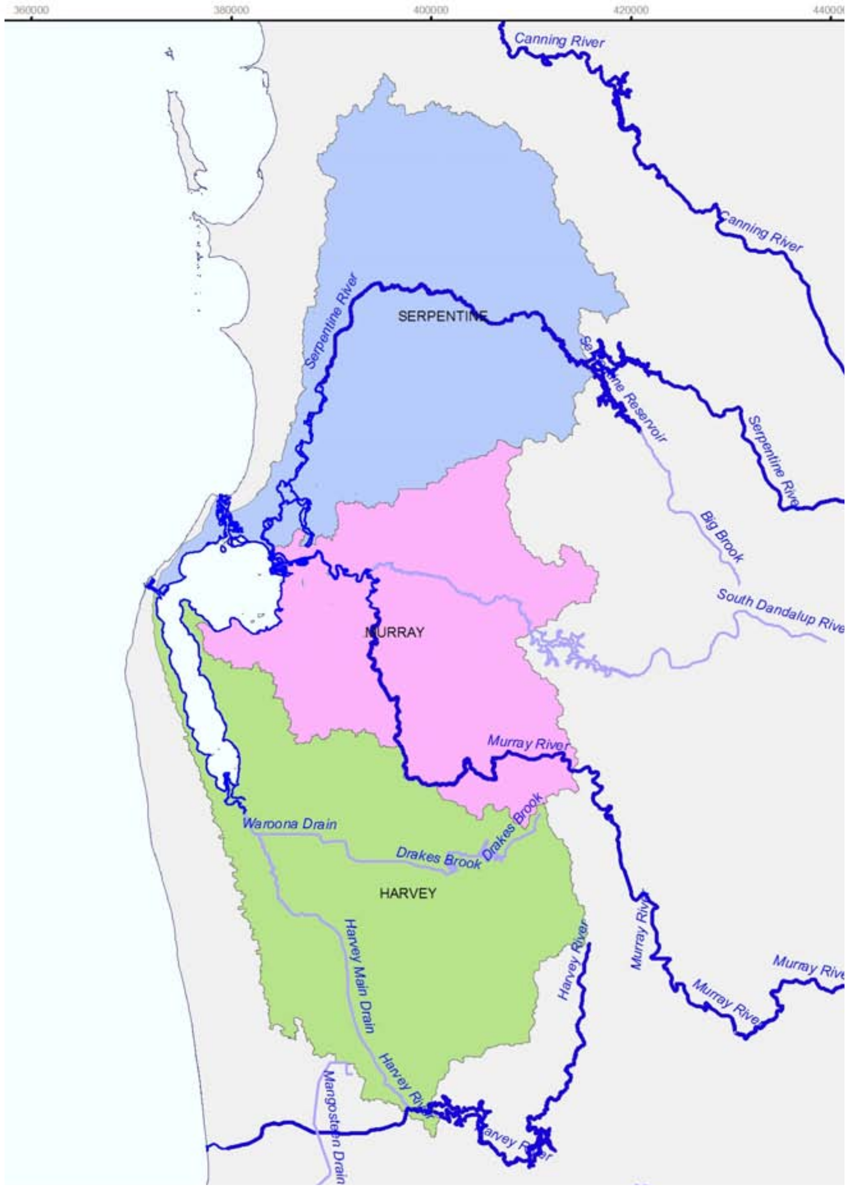
- surveying elevation along ecological transect (blue triangle is minimum),
- vegetation community locations (green dots),
- fish and frog assessment sites (black dots) and
- groundwater bores (yellow)

Ecological water requirements

- EWRs based on the modelled water level data for important aspects of the water regime including:
  - surface and groundwater minimum and maximum levels;
  - magnitude of change in water levels; and
  - periods of drying and inundation.
- The interim EWRs were compared to known eco-hydrological ranges for key species common to wetlands using ECU methodology (Froend and Loomes, 2004).

Urban development in the Peel-Harvey catchment needs to:

- **Maintain pre-development hydrology**
- **Reduce fertilisation inputs and/or**
- **T rap nutrient at its source**



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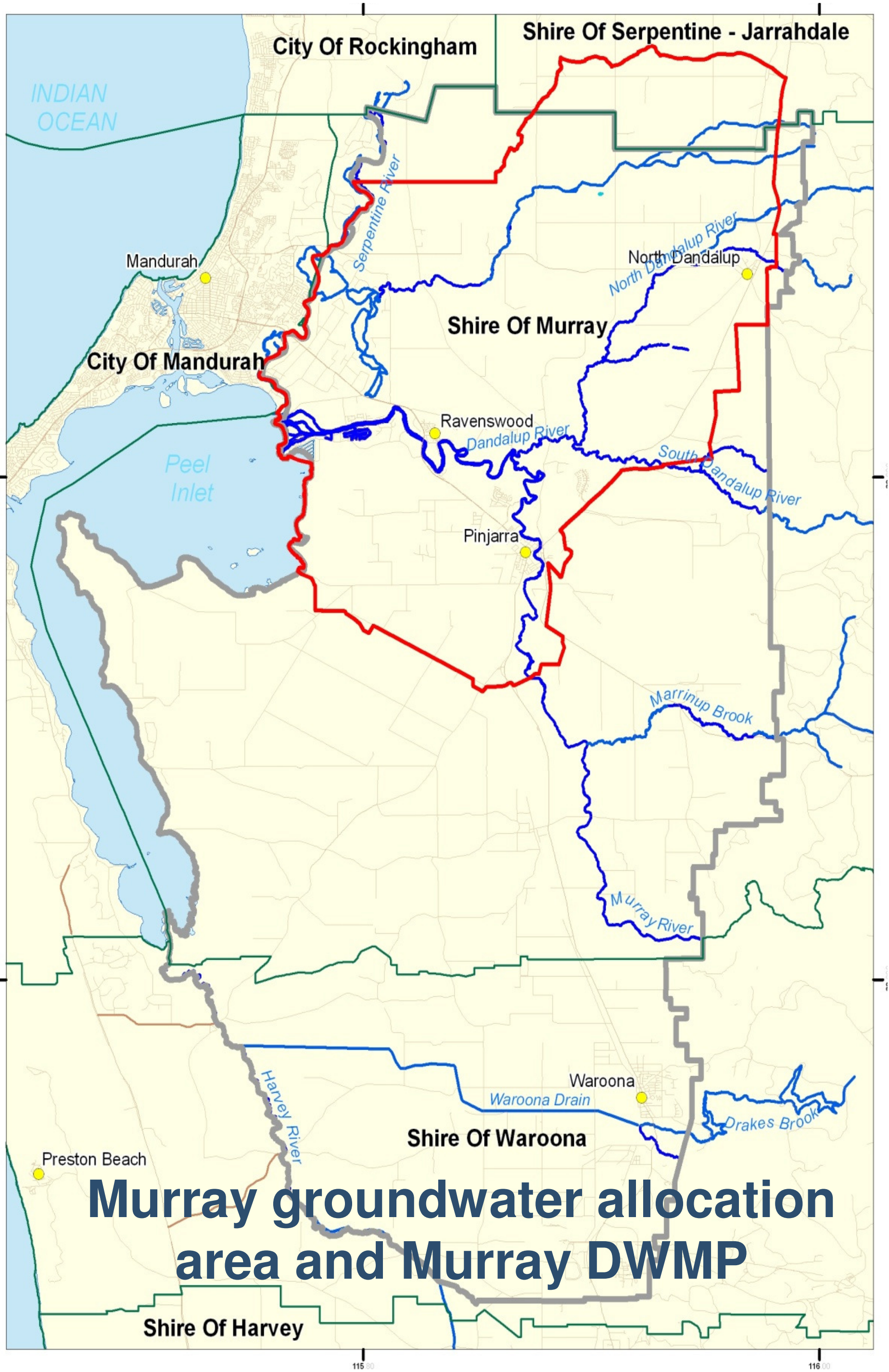
Murray groundwater area allocation plan

- **Describes groundwater resources**
- **Sets allocation limits**
- **Indicates water availability**
- **Identifies groundwater related issues**
- **Sets resource objectives**
- **How abstraction will be licensed.**
- **Monitoring program**
- **Evaluation process**



Murray groundwater allocation area and Murray DWMP

Murray
Drainage and Water Management Plan
Information Session

Joel Hall (Senior Modeller, Water Science, DoW)

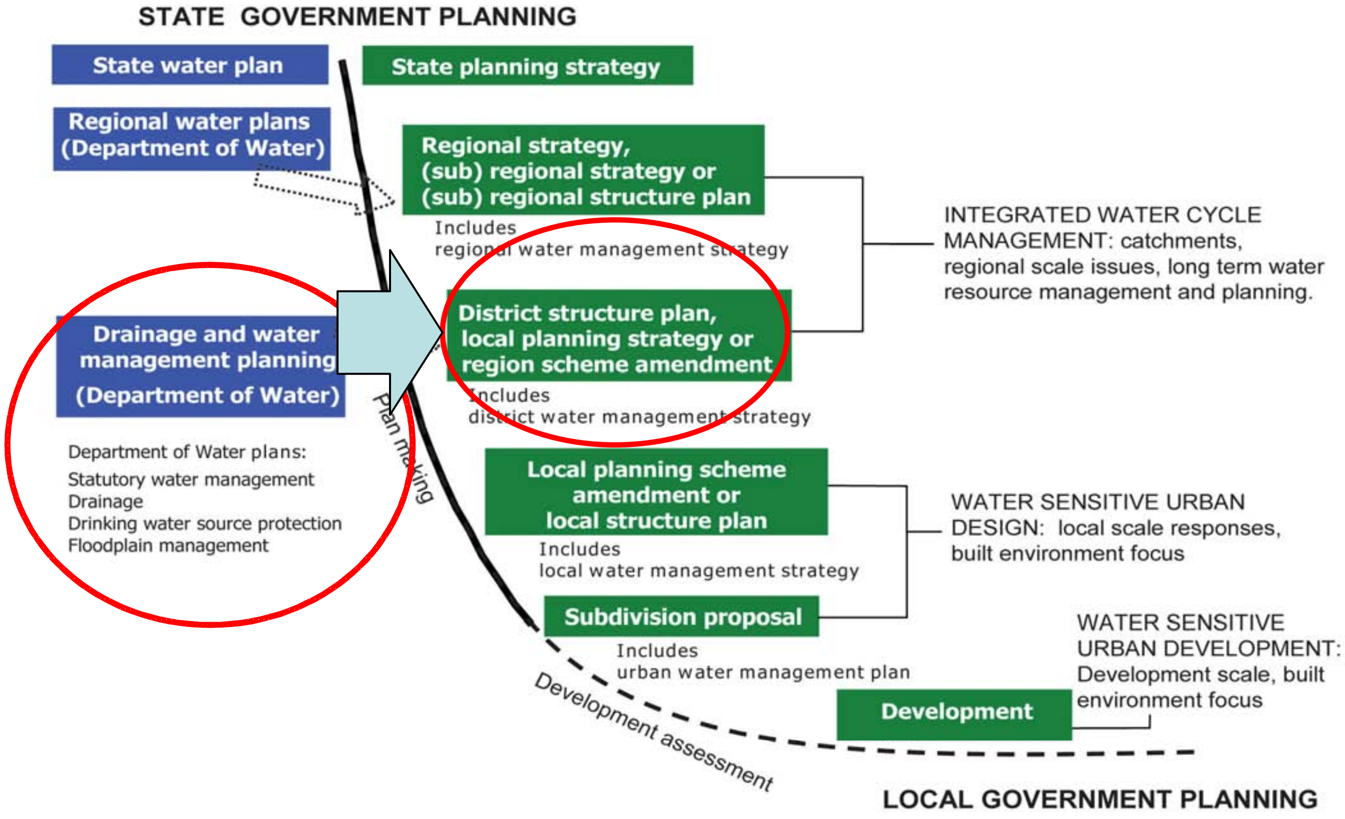
DWMP

- Flood & Stormwater
- Groundwater
- EWR Study (Wetlands & Ecology)
- Nutrients & Peel-Harvey Estuary
- Acid Sulphate Soils
- Water Use (Allocation and Reuse)
- Water Monitoring Guidelines

Combined into the:

Murray Drainage and Water Management Plan

DWMP Context



Note: The above diagram depicts the optimal process. In situations where there is existing zoning and a lack of guiding information, a flexible approach to implementation may be required. This is at the discretion of the Western Australian Planning Commission on advice of the Department of Water.

Murray
Drainage and Water Management Plan
Information Session

Helen Brookes (Manager, Waterways Services Group, GHD)

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Department of Water

How do we move forward?

- Public submissions
- Implementation
- DWMS
  (PRS rezoning)
- LWMS / UWMP
  (LPS amendment/ODP)
- DoW focus is strategic

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Department of **Water**

Key directions

- **'Whole of project' water requirements**
- **DWMP – Management Hierarchy**
- **Developer Contribution Schemes**
- **Policy and Guidance development**

Release Timeline

- **Consultation Draft DWMP Release:** **24 September 2010**
- **Water Sensitive Cities talk** **01 October 2010**
[Atrium Theatrette]
- **Technical Seminar** **07 October 2010**
  [State Library Theatre (All day)]
- **Community Information night** **29 October 2010**
  [DoW Mandurah Office]
- **Public submissions close** **29 November 2010**
- **Final Release Murray DWMP** **March 2011**

Murray drainage and water management plan

Helen Brookes | Principal author

Technical challenges

Technical challenges

Natural complexities and the legacy of agricultural land uses:

- Inter-connected wetlands, lakes, rivers and groundwater aquifers
- Internationally important ecology
- High levels of nutrients within soils and shallow groundwater
- Existing drainage systems designed to
  - lower groundwater
  - drain wetlands and seasonally inundated area




Technical challenges

Prevailing environmental conditions:

- Seasonally wet landscape
  - supporting important ecological systems
- Limited availability of allocated water resources
  - traditionally considered ‘useable’
- High discharged nutrient loads contributing to water quality problems in Peel-Harvey estuary

Technical challenges

Summary of environmental constraints:

- 84 km^2 proposed development areas, of which:
  - 33% seasonally inundated by maximum groundwater level
  - 91% with maximum groundwater level within 2 m of ground level
  - 11% flood fringe (floodways excluded)
  - 10% floodplain
  - 10% below 2.1 mAHD (storm surge risk zone)
  - 11% high risk acid sulfate soils
  - 88% medium risk acid sulfate soils

Technical Challenges

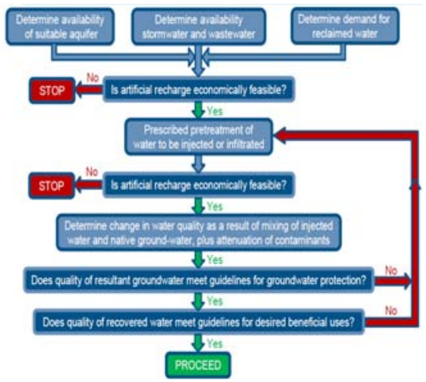
New policy position

“Rather than suggest the challenges make sections of the plan area unsuitable for urban development, the Department of Water considers that with sufficient initiative, effort and investment, they may be possible to overcome. Thus the landscape would become more suitable for urban development from a water management perspective.”

New policy position

Water sensitive urban design and the use of groundwater as a fit-for-purpose water source is now business as usual and a new benchmark is to be established:

- use of shallow groundwater reserves
- managed aquifer recharge
- innovative solutions to technical challenges
- consideration of climate change



New policy position

This plan differs from previous drainage and water management plans:

- Structure
  - Three key principles with strategies to deliver in the context of existing environmental conditions
  - Toolbox provides advice, additional guidance and in some cases design criteria that link to the principles and strategies
- Content
  - no post-development infrastructure has been sized or otherwise designed

Key principle 1:

"Manage catchments to maintain or improve water resources"

Key principle 2:

"Manage flooding and inundation risks to human life and property"

Key principle 3:

"Ensure the efficient use and re-use of water resources"

Principles and strategies

Key principle 1:

"Manage catchments to maintain or improve water resources"

- Provide water security for public and private water supply consumers
  (Perth-Peel regional water plan – Objective 3)

- Restore and protect waterway and wetland health
  (Perth-Peel regional water plan – Objective 5)

- Create water sensitive cities and towns
  (Perth-Peel regional water plan – Objective 6)

Key principle 1

Manage catchments to maintain or improve water resources

- Minimise changes to hydrology
- Maintain or improve water quality
- Manage and restore waterways and wetlands
- Safeguard the quality and availability of water resources for the future

Key principle 2:

“Manage flooding and inundation risks to human life and property”

- Create water sensitive cities and towns
  (Perth-Peel regional water plan – Objective 6)

  - Building integrity and construction methods
  - Major storm-event management and emergency planning for the plan area
  - Levels of service, governance and institutional arrangements
  - Sea-level rise

Key principle 2

Manage flooding and inundation risks to human life and property

- Provide adequate clearance from 1-in-100 year annual exceedance probability flooding and surface water or groundwater inundation
- Do not cause flooding or inundation of upstream or adjacent developed areas
- Manage surface water flows to prevent damage to downstream infrastructure and assets

Key principle 3:

"Ensure the efficient use and re-use of water resources"

- Take the drying climate into account in all aspects of water resource management (Perth-Peel regional water plan – Objective 1)

- Reduce water demand by using water more efficiently and effectively (Perth-Peel regional water plan – Objective 2)

- Facilitate the use of alternative sources of water supply (Perth-Peel regional water plan – Objective 4)

Key principle 3

Ensure the efficient use and re-use of water resources

- Minimise water use within developments
- Achieve highest-value use of fit-for-purpose water, considering all available forms of water for their potential as a resource

Toolbox:

“Contains advice and suggested design criteria, where relevant, for satisfying the strategies outlined in this plan. Alternative design criteria to achieve the aims of the strategies may, in some cases, be proposed by development proponents in subsequent water management strategies and plans – subject to the approval of the Department of Water”

Toolbox

- Stormwater best practice
- Groundwater management best practice
- Monitoring best practice
- Wetland and waterway management best practice
- Water re-use and efficiency best practice
- Wastewater management

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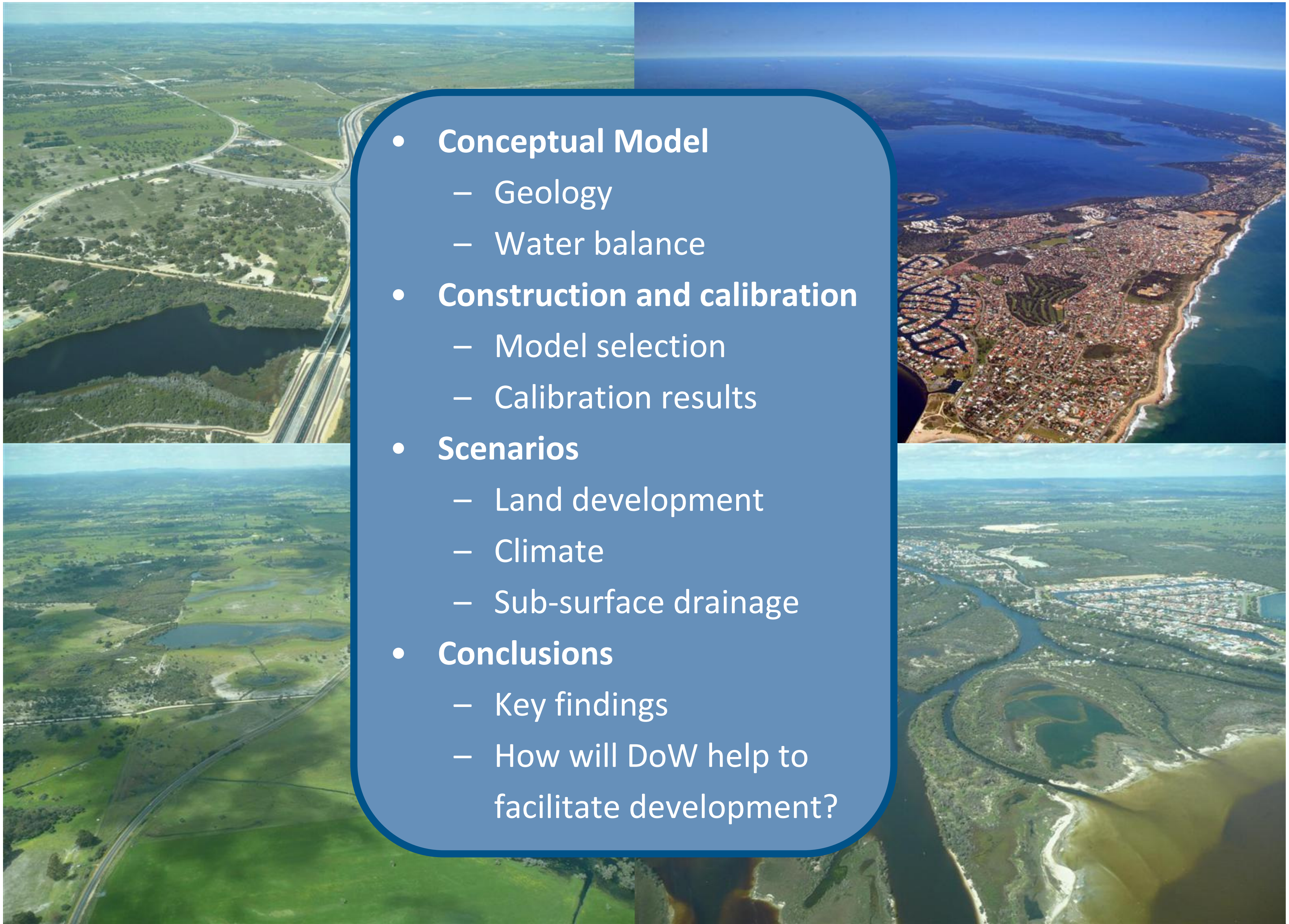
Murray hydrological studies:

Surface water, groundwater and environmental water

Modelling to support the Murray DWMP

Presented by Joel Hall, Water Science Branch, Department of Water, WA



- **Conceptual Model**
  - Geology
  - Water balance
- **Construction and calibration**
  - Model selection
  - Calibration results
- **Scenarios**
  - Land development
  - Climate
  - Sub-surface drainage
- **Conclusions**
  - Key findings
  - How will DoW help to facilitate development?

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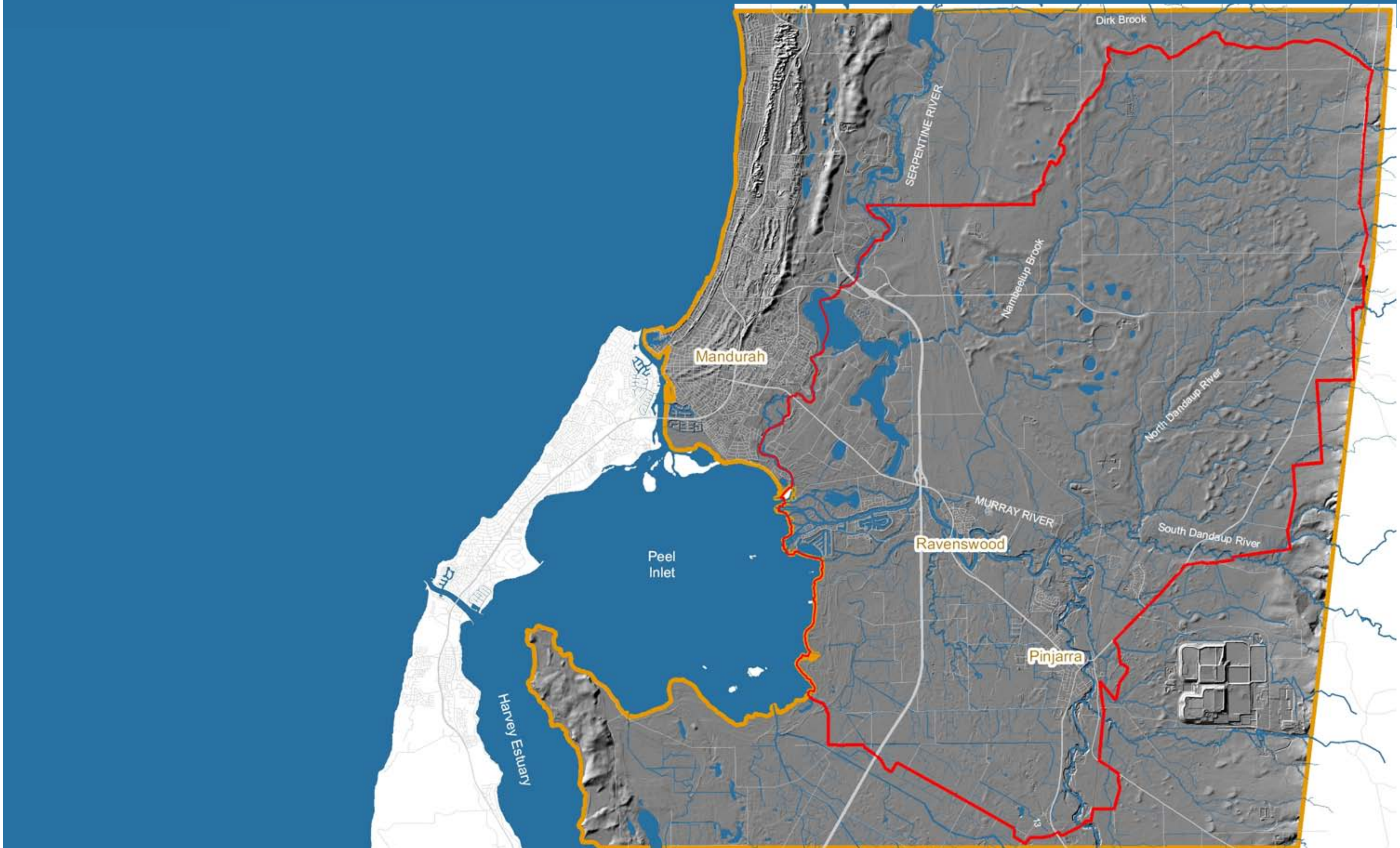
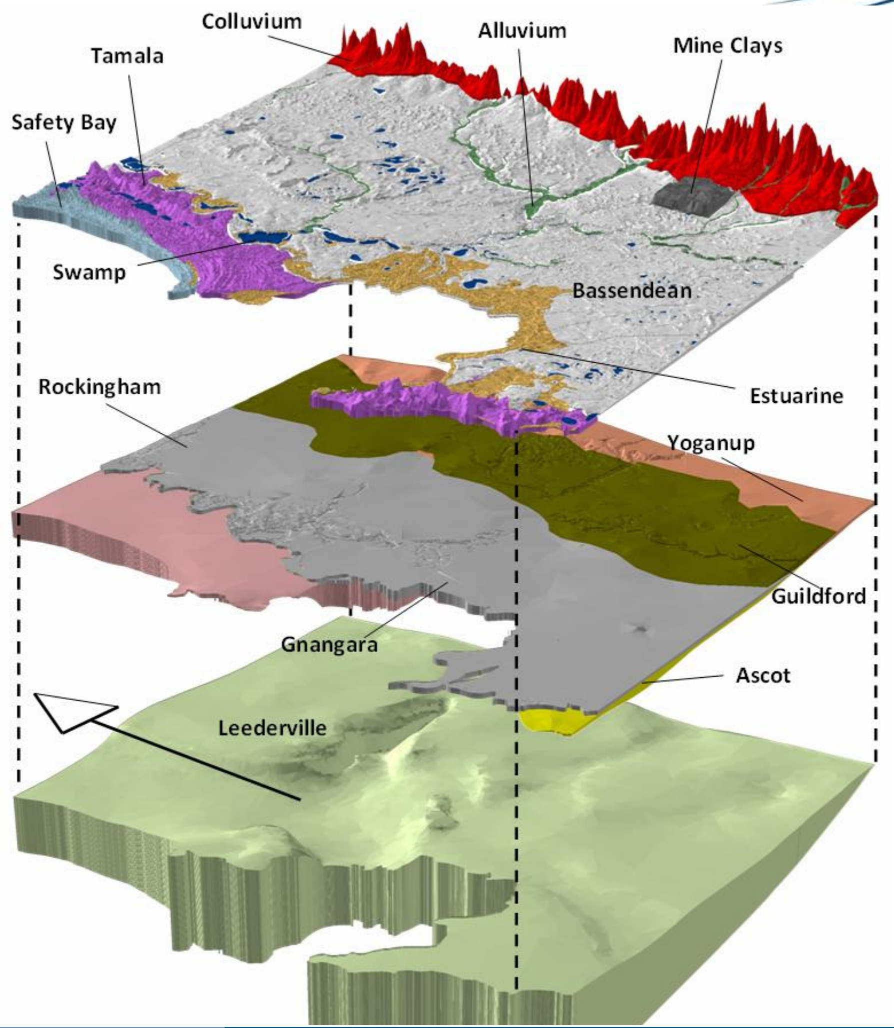
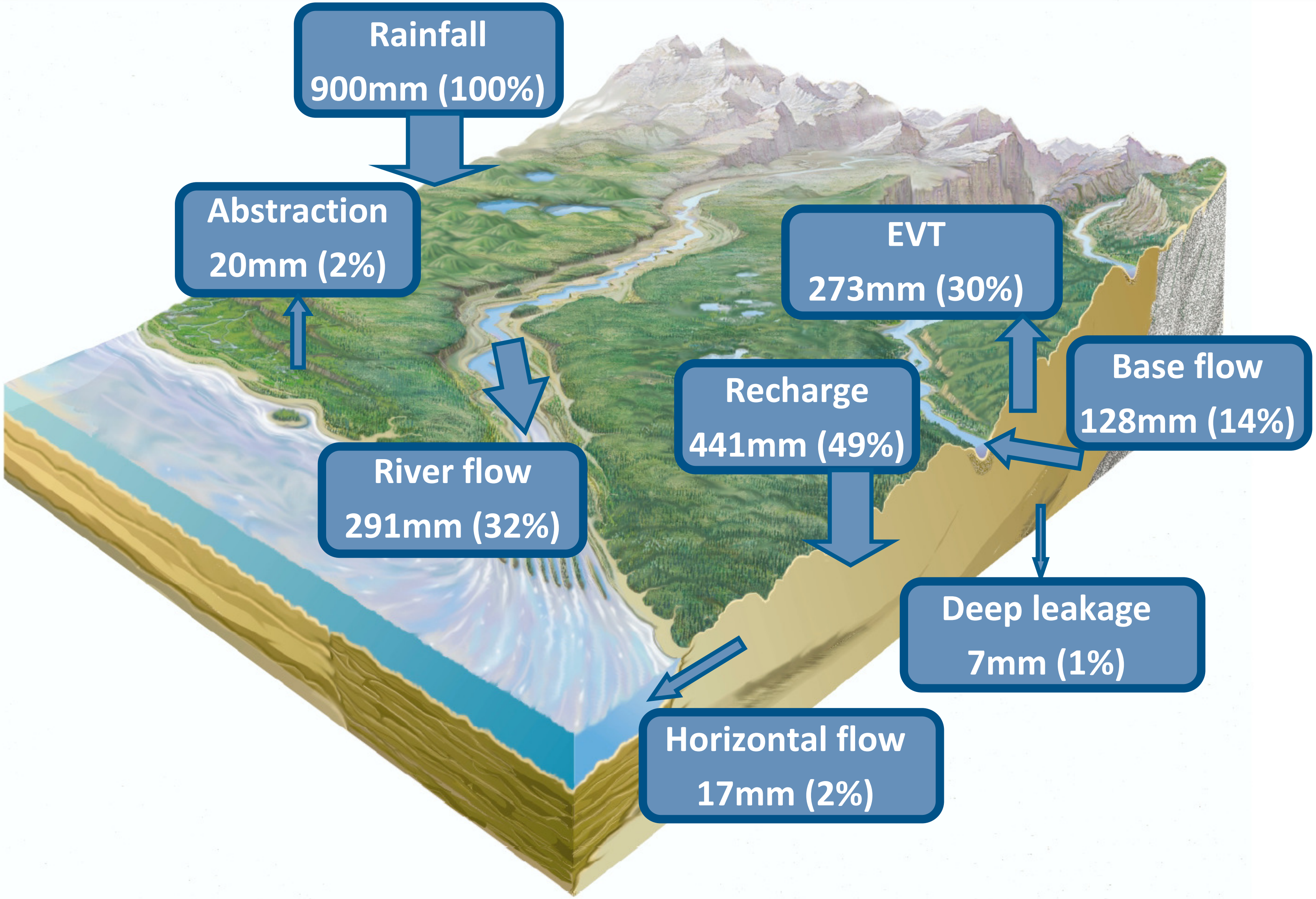
Plan area



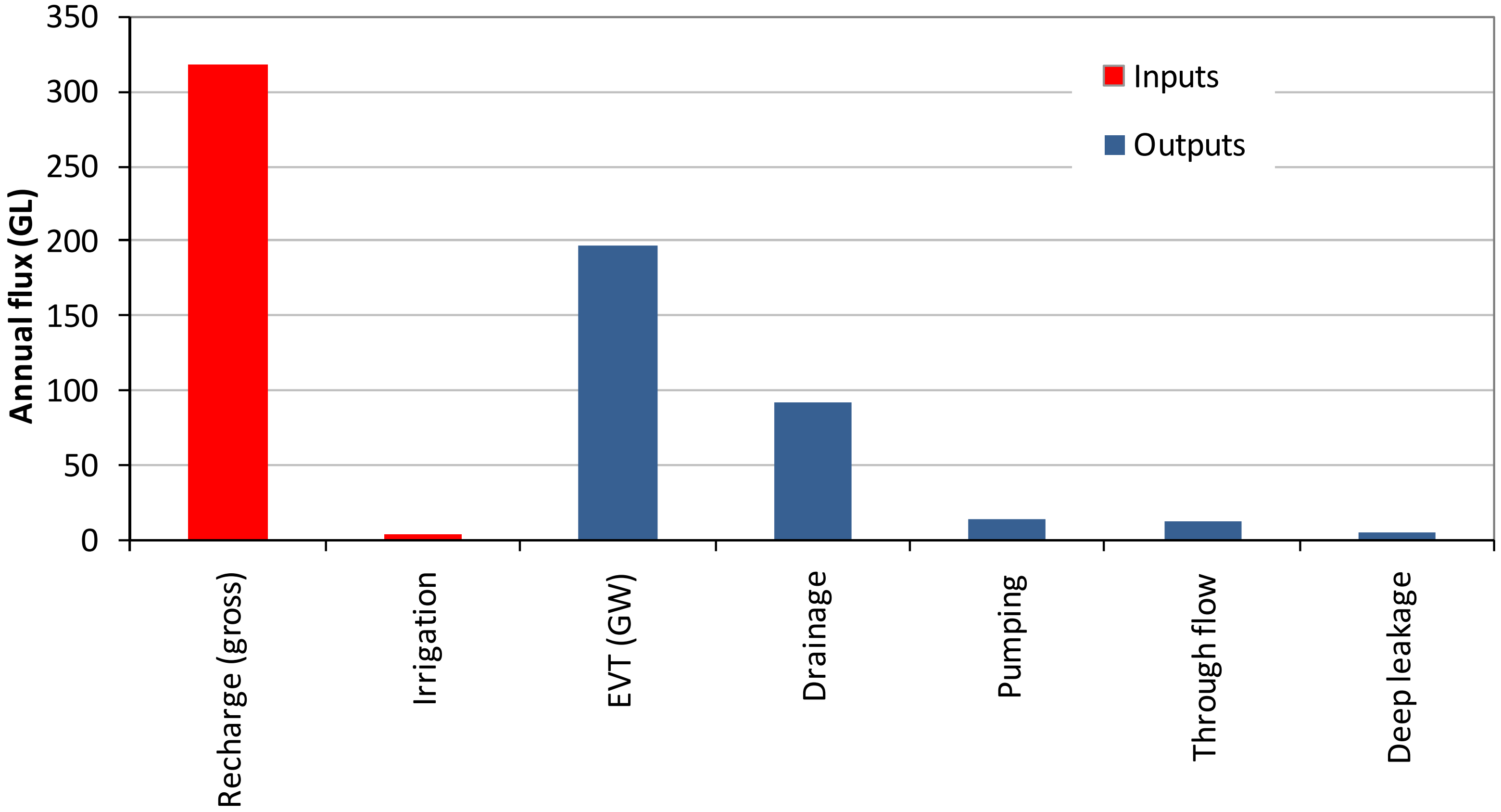
Conceptual geology



Conceptual model summary



Conceptual model summary



MIKE SHE – Modules for Murray

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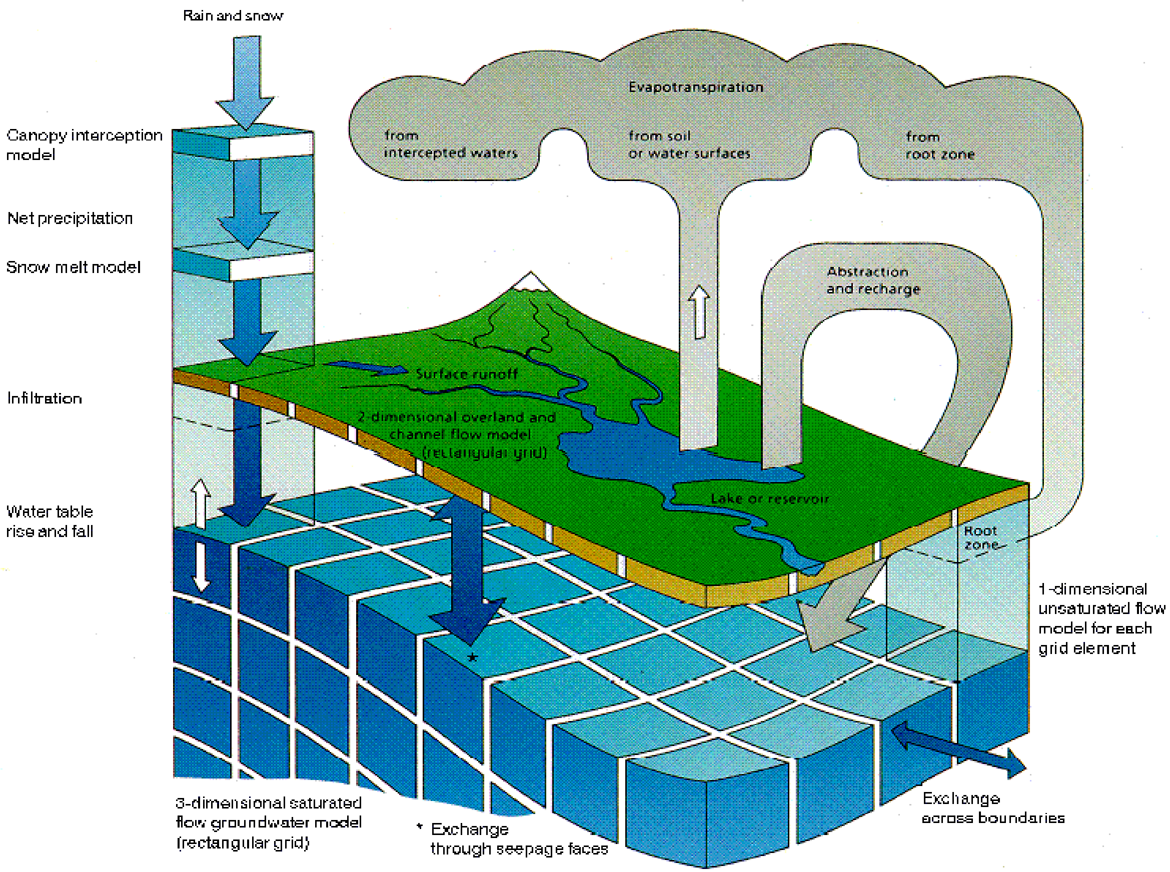
5 modules:

- Saturated zone
- Unsaturated zone
- Overland flow
- Evapotranspiration
- Rivers

INTERACTION



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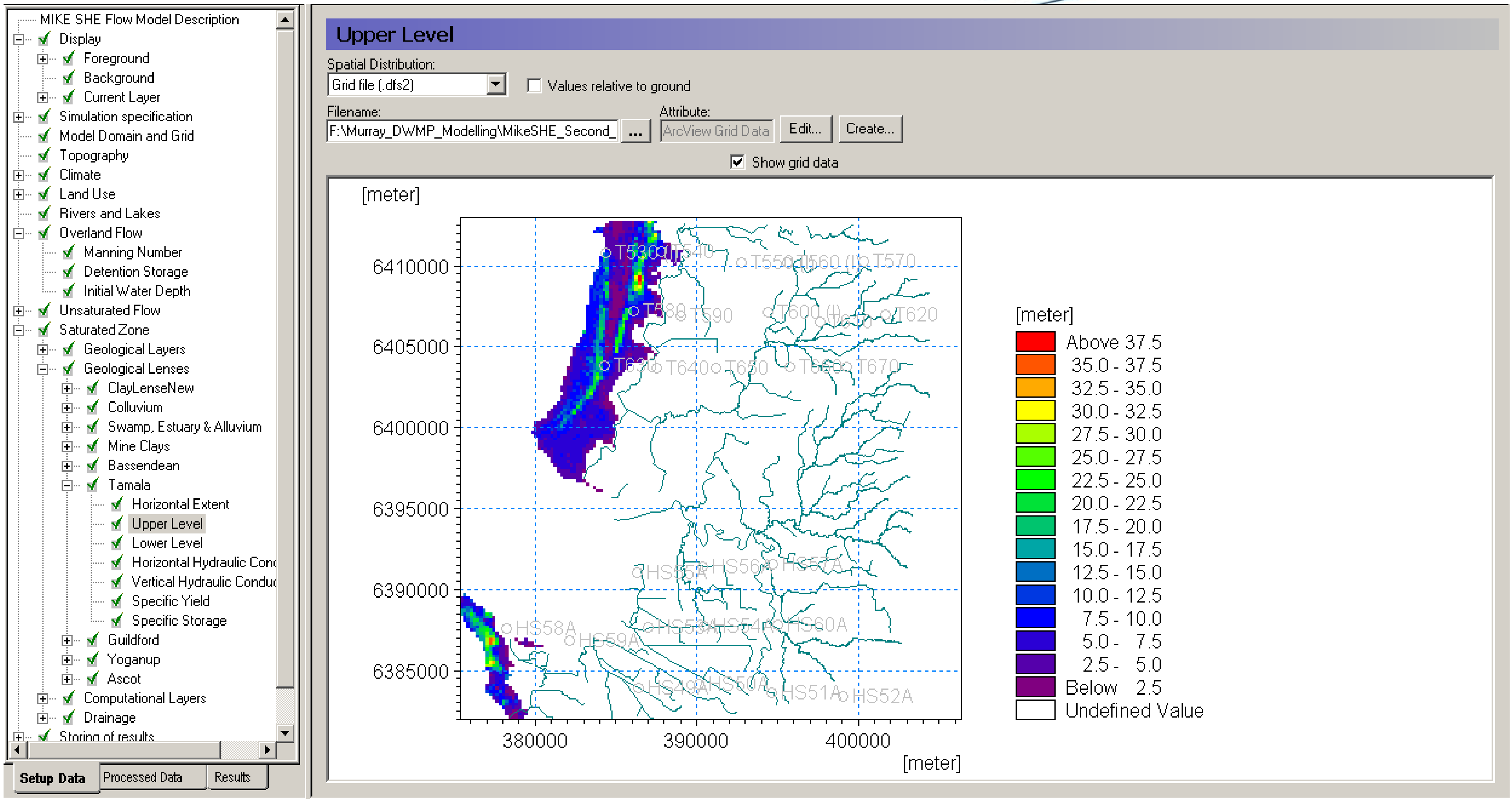
Geological lense – Tamala (top)



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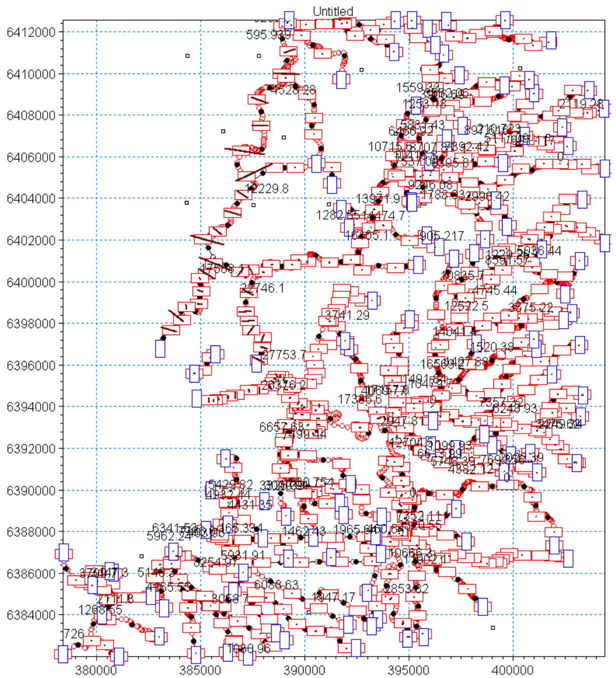
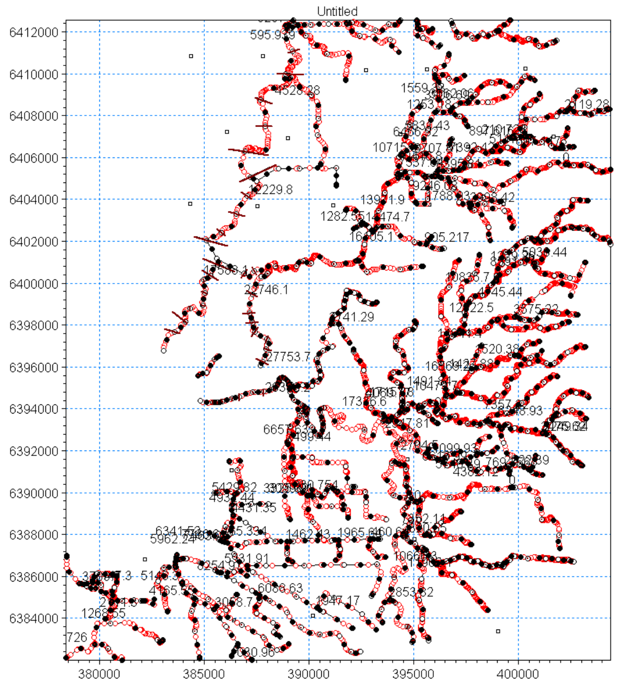
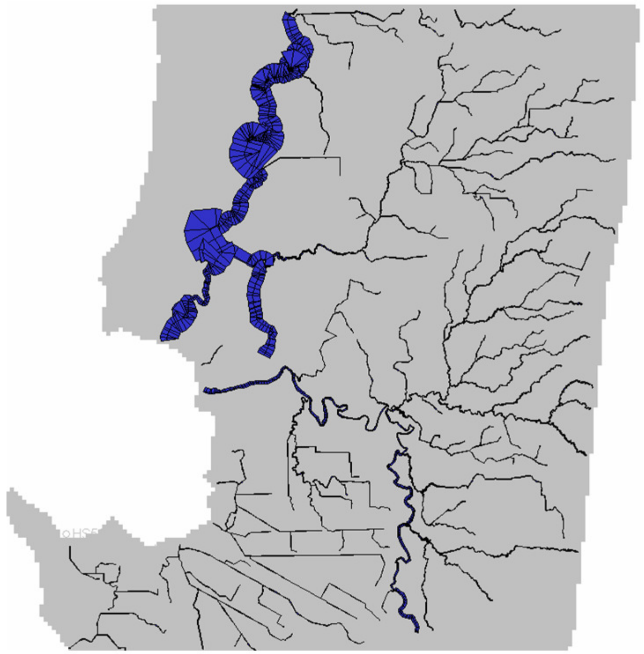
Rivers – Mike 11 - Network







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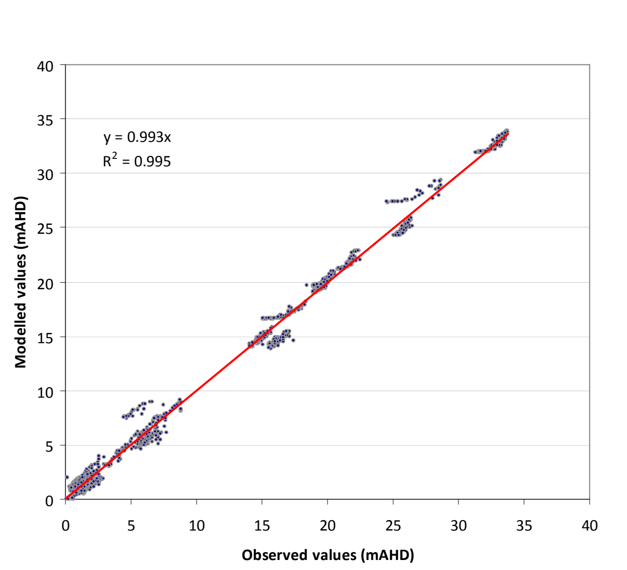
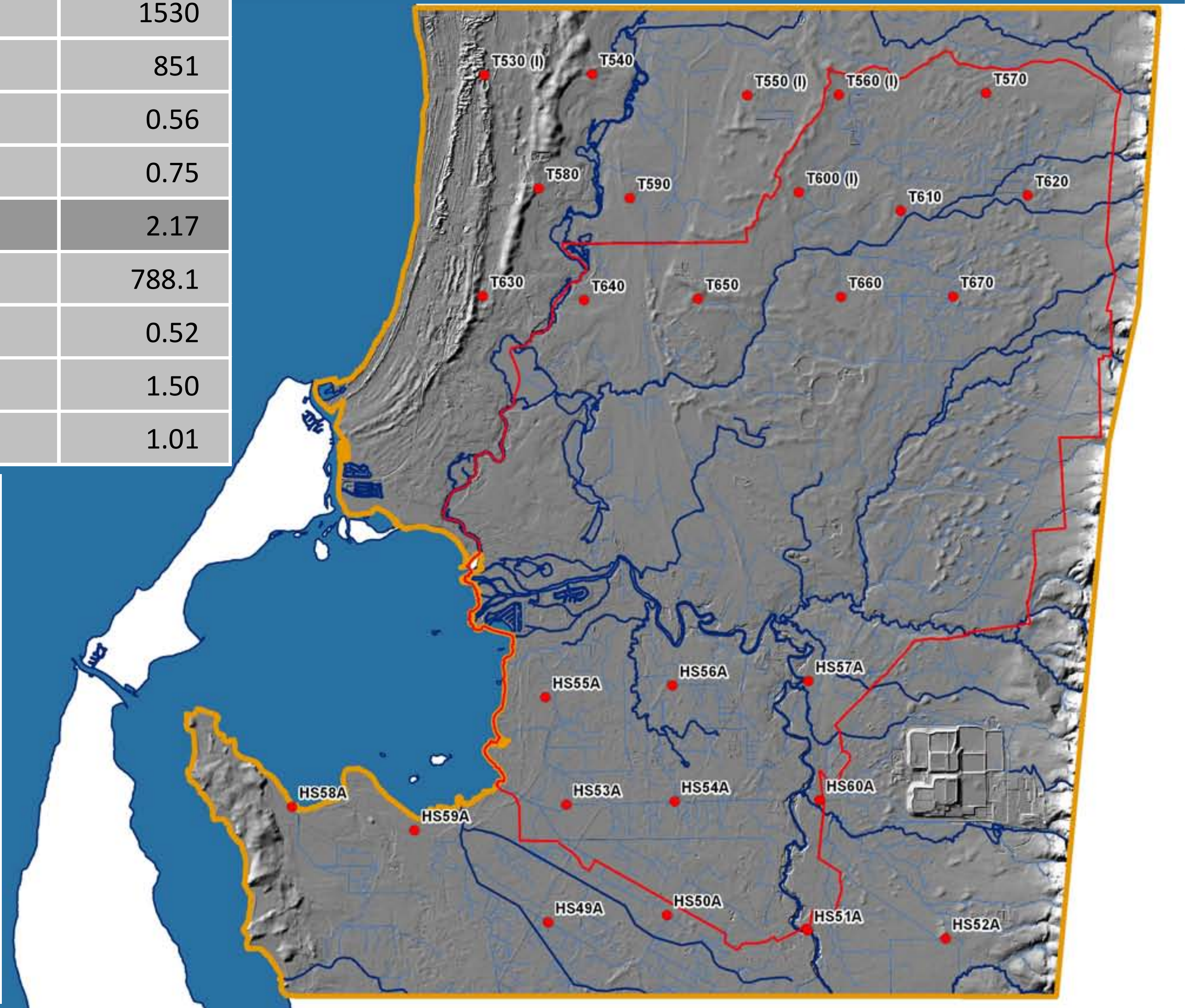
Calibration statistics (1985-2000)

Description	Symbol	Value
Count	n	1530
Sum of squares (m^2)	SSQ	851
Mean sum of squares (m^2)	MSSQ	0.56
Root mean square (m)	RMS	0.75
Scaled root mean square (%)	SRMS	2.17
Sum of residuals (m)	SRMS	788.1
Mean sum of residuals (m)	MSR	0.52
Scaled mean sum of residuals (%)	SMSR	1.50
Coefficient of determination ()	CD	1.01





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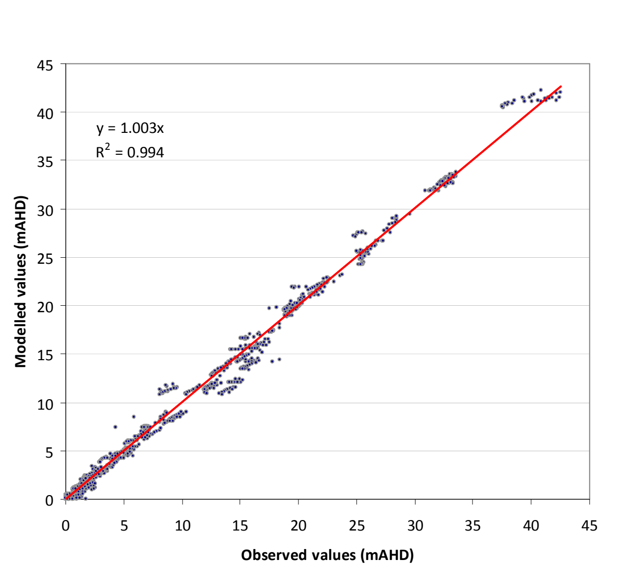
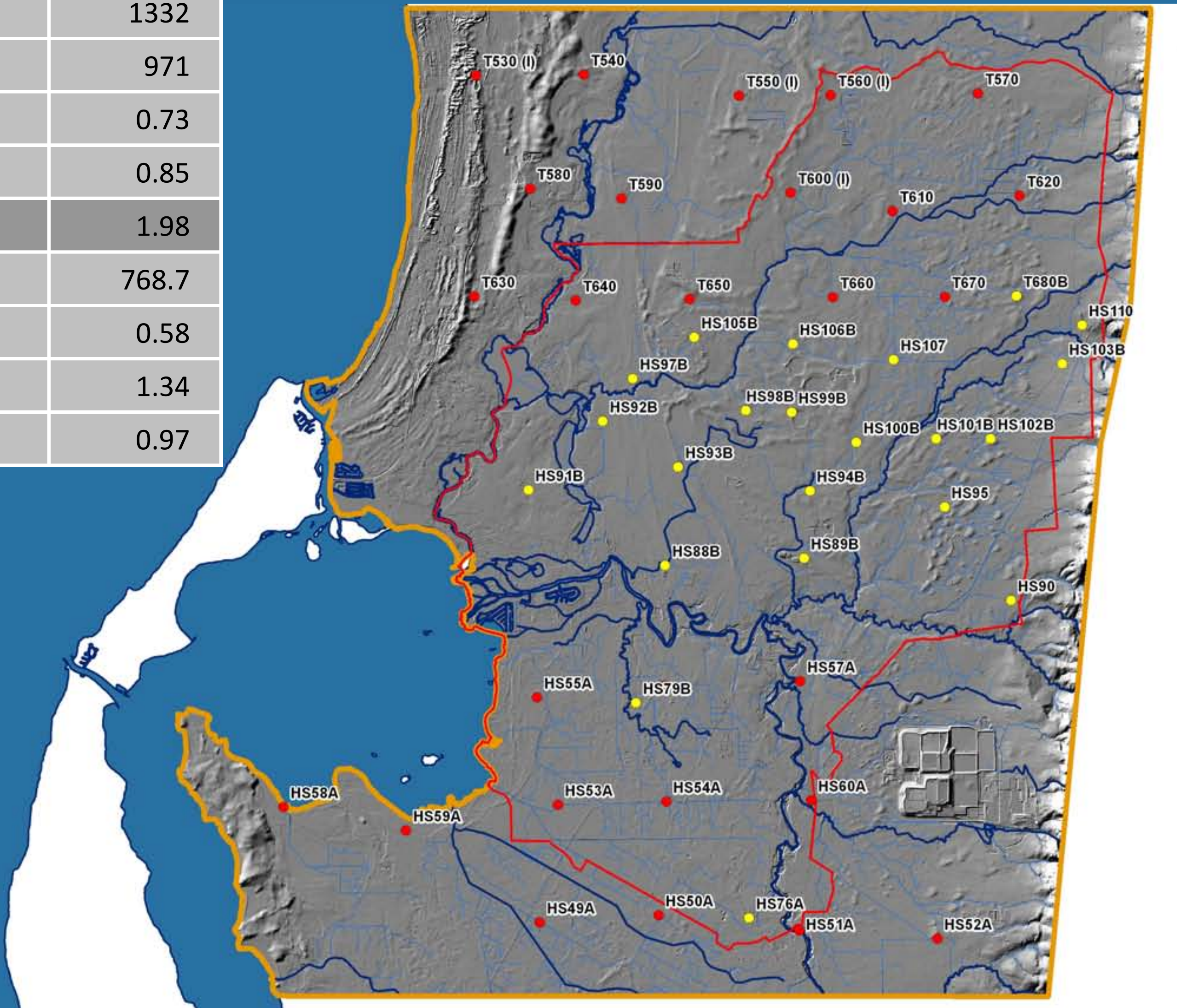
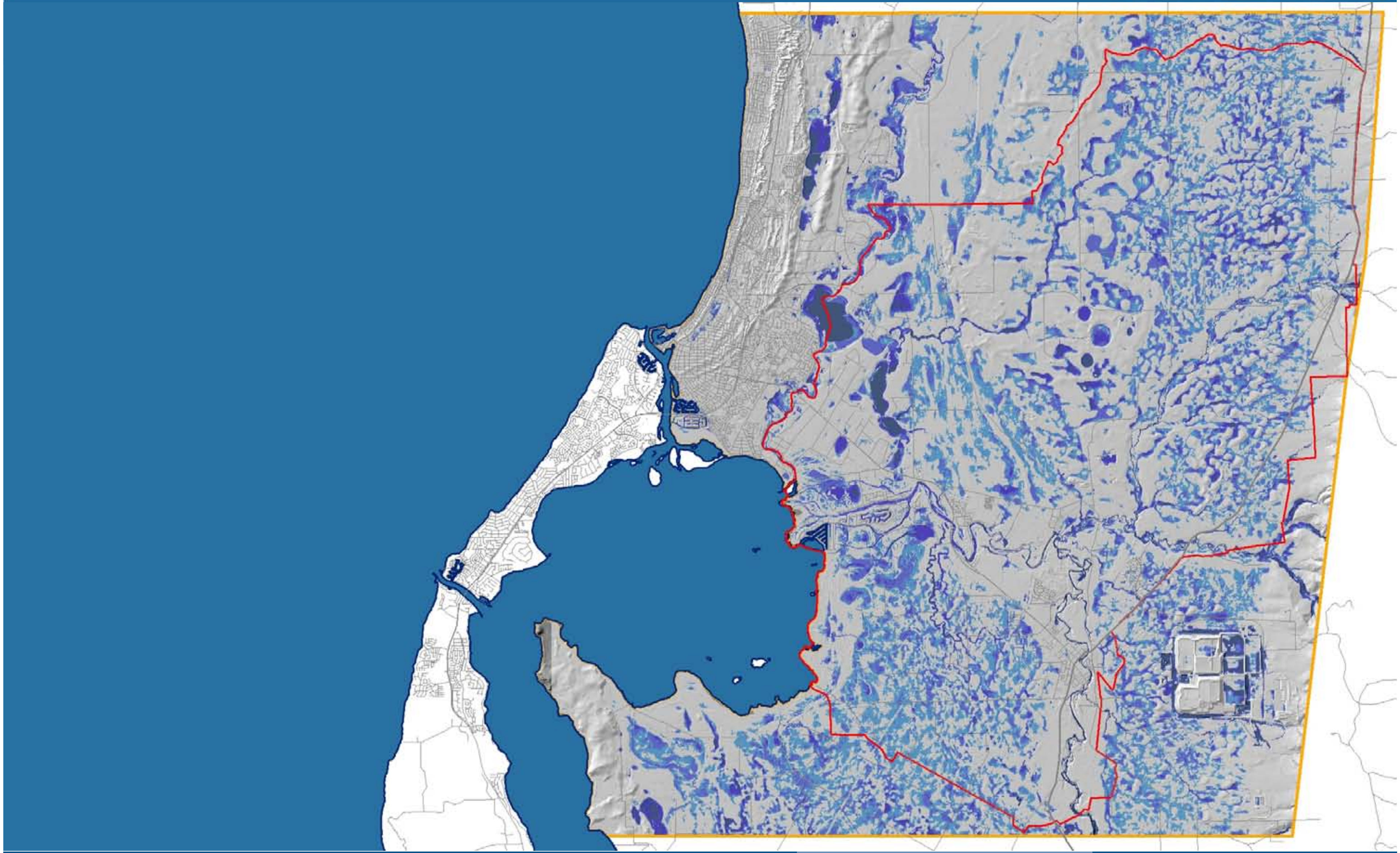
Validation statistics (2000-2009)

Description	Symbol	Value
Count	n	1332
Sum of squares (m^2)	SSQ	971
Mean sum of squares (m^2)	MSSQ	0.73
Root mean square (m)	RMS	0.85
Scaled root mean square (%)	SRMS	1.98
Sum of residuals (m)	SRMS	768.7
Mean sum of residuals (m)	MSR	0.58
Scaled mean sum of residuals (%)	SMSR	1.34
Coefficient of determination ()	CD	0.97





Waterlogging



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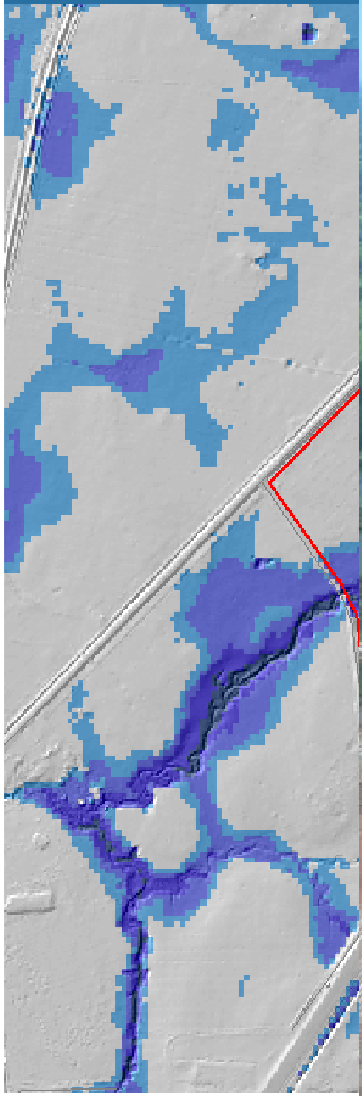
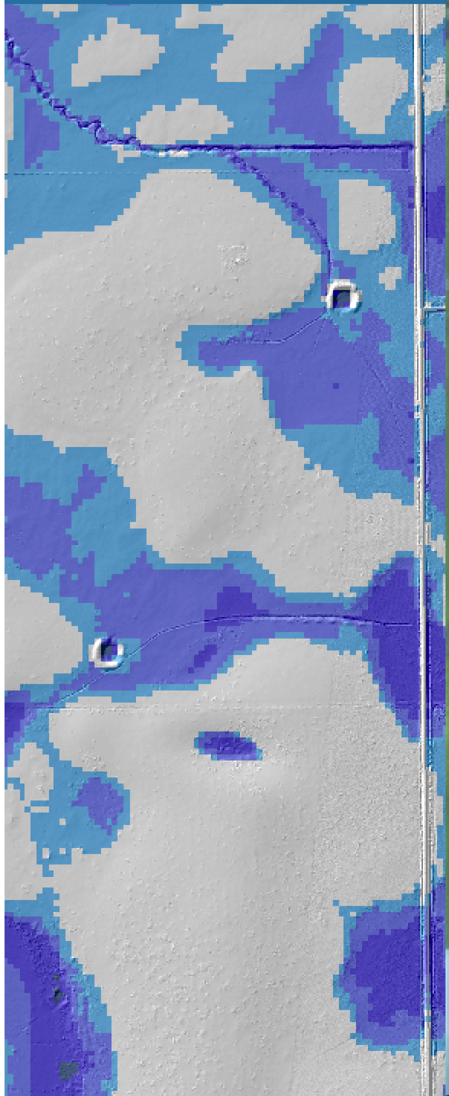
Waterlogging



Waterlogging



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Modelling scenarios

Climate scenarios
from IPCC and historical records

1	Future wet climate
2	Future medium climate
3	Future dry climate
4	Historical wet climate
5	Sea level rise

COMBINATIONS
(15 selected)

Drainage scenarios
from Department of Water

1	Subsoil drains at ground level with 1m fill
2	Drains at 0.5 mbgl with 0.5m fill
3	Drains at1 m bgl with no fill
4	Drains at AAMGL with at least 1m fill
5	Drains at MGL with at least 1m fill

Development scenarios
from Department of Planning

1	Immediate investigation
2	Further investigation

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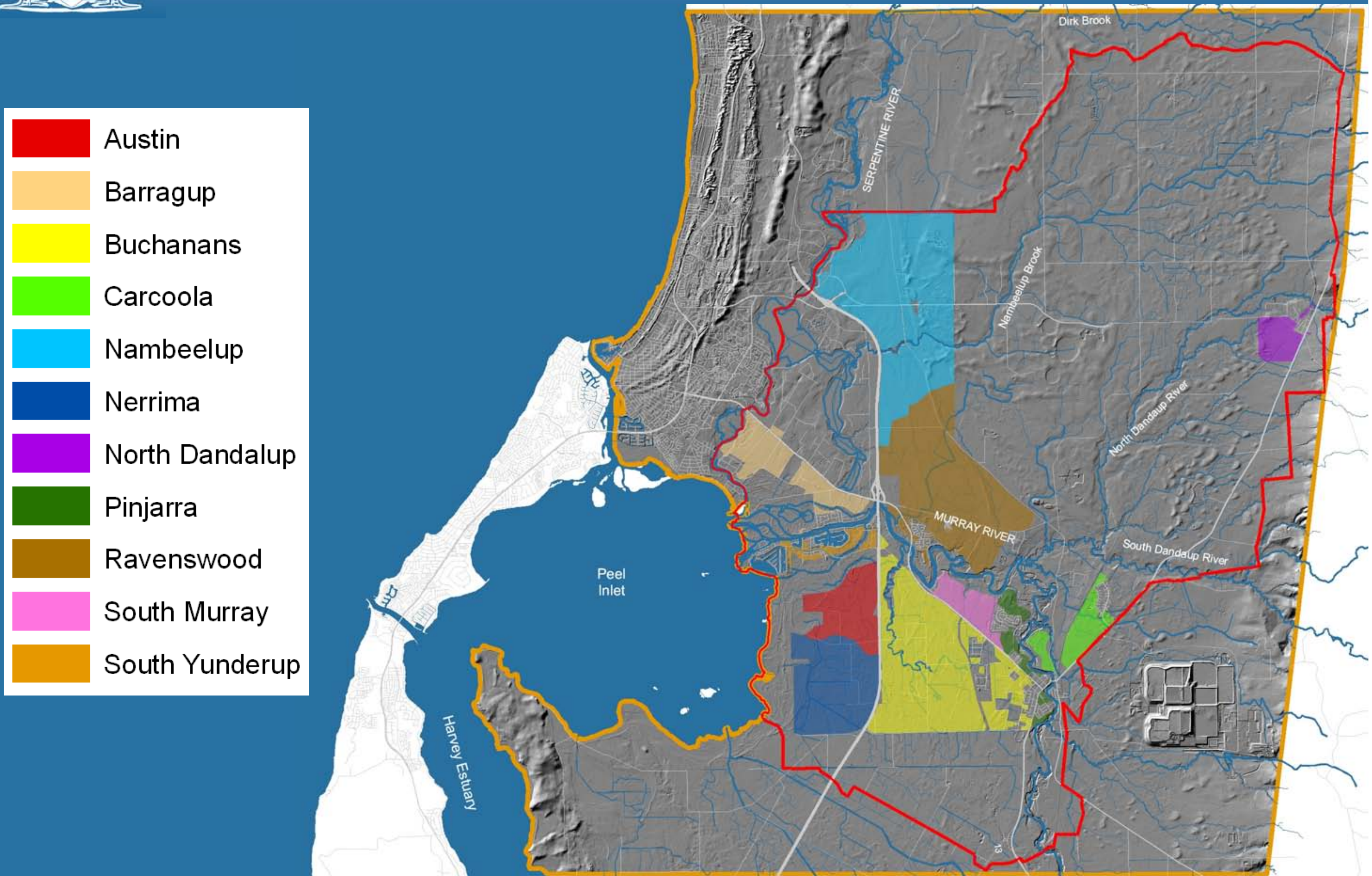
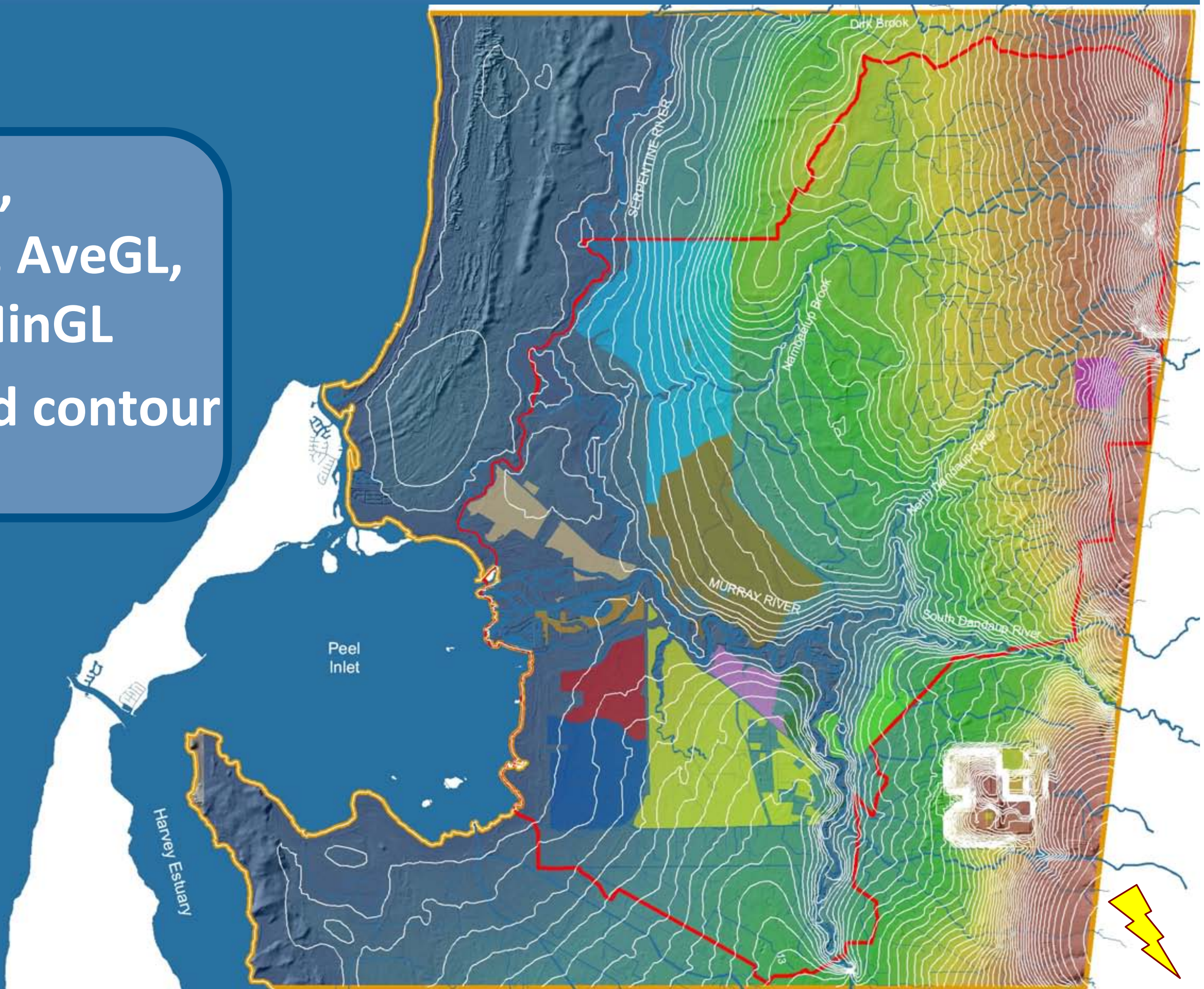
Development reporting areas



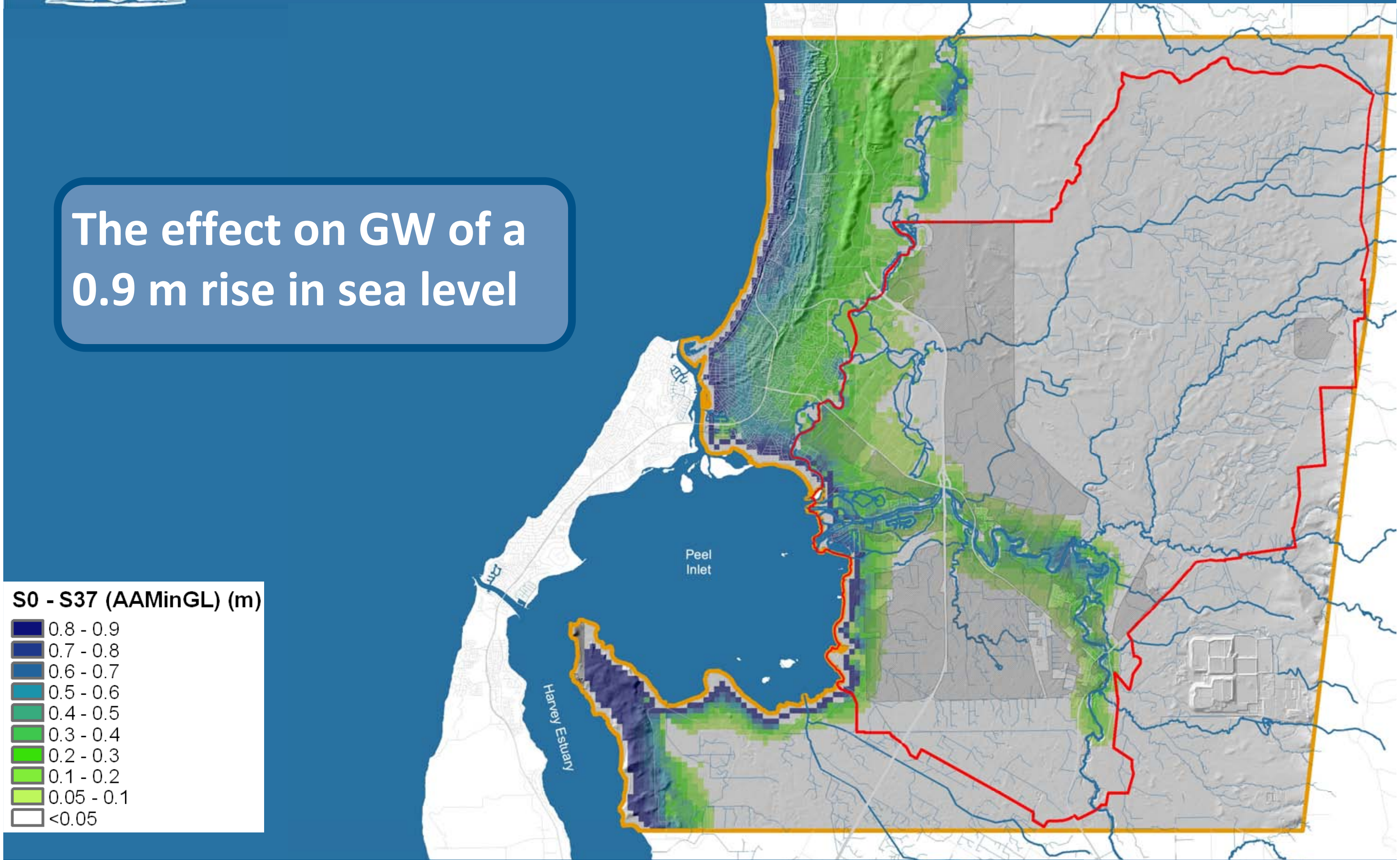
Results for each scenario

- **AAMaxGL, AAMinGL, AveGL, MaxGL, MinGL**
- **Raster and contour format**



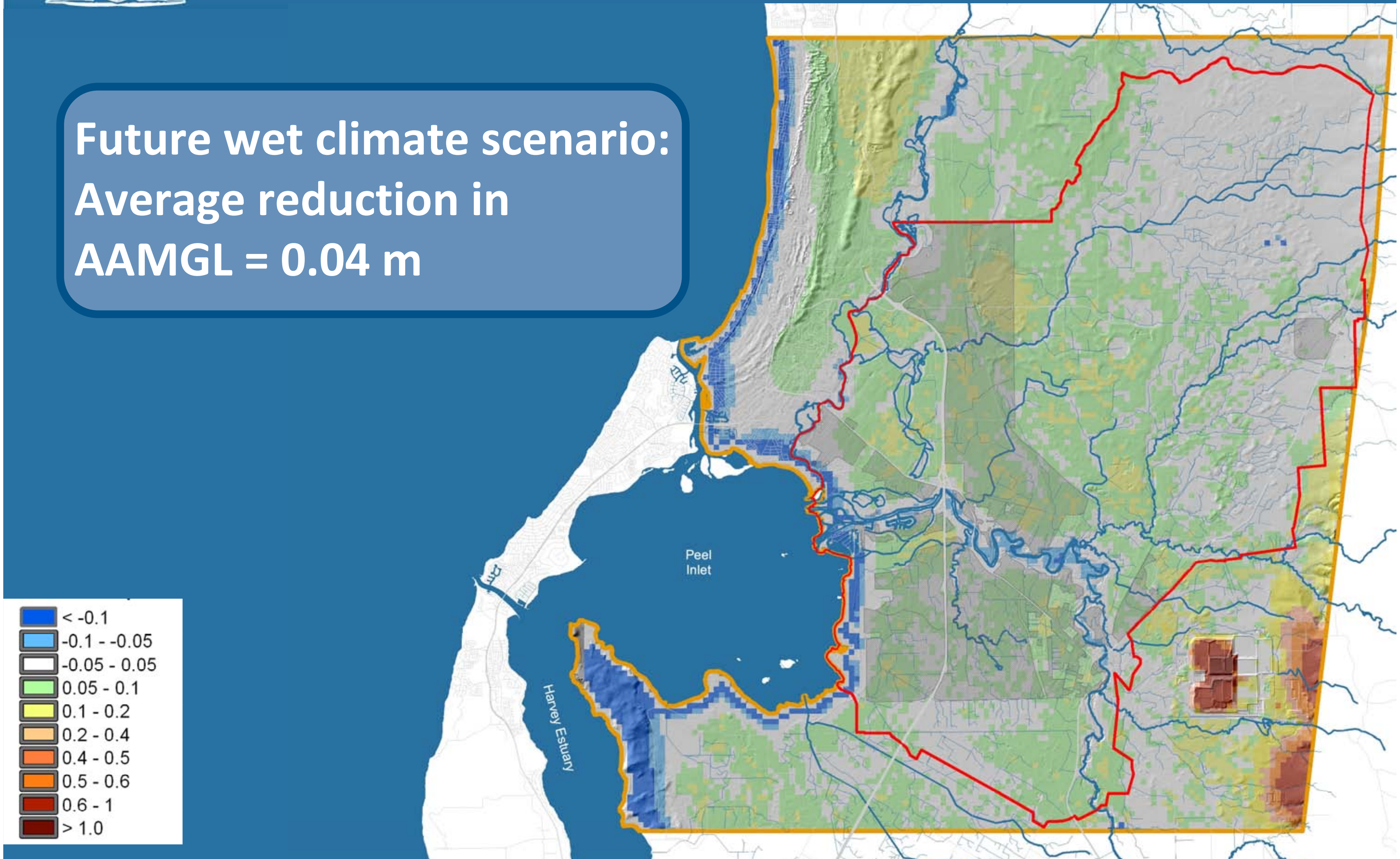
Sea-level rise scenario

The effect on GW of a 0.9 m rise in sea level



Future climate scenarios

Future wet climate scenario: Average reduction in AAMGL = 0.04 m



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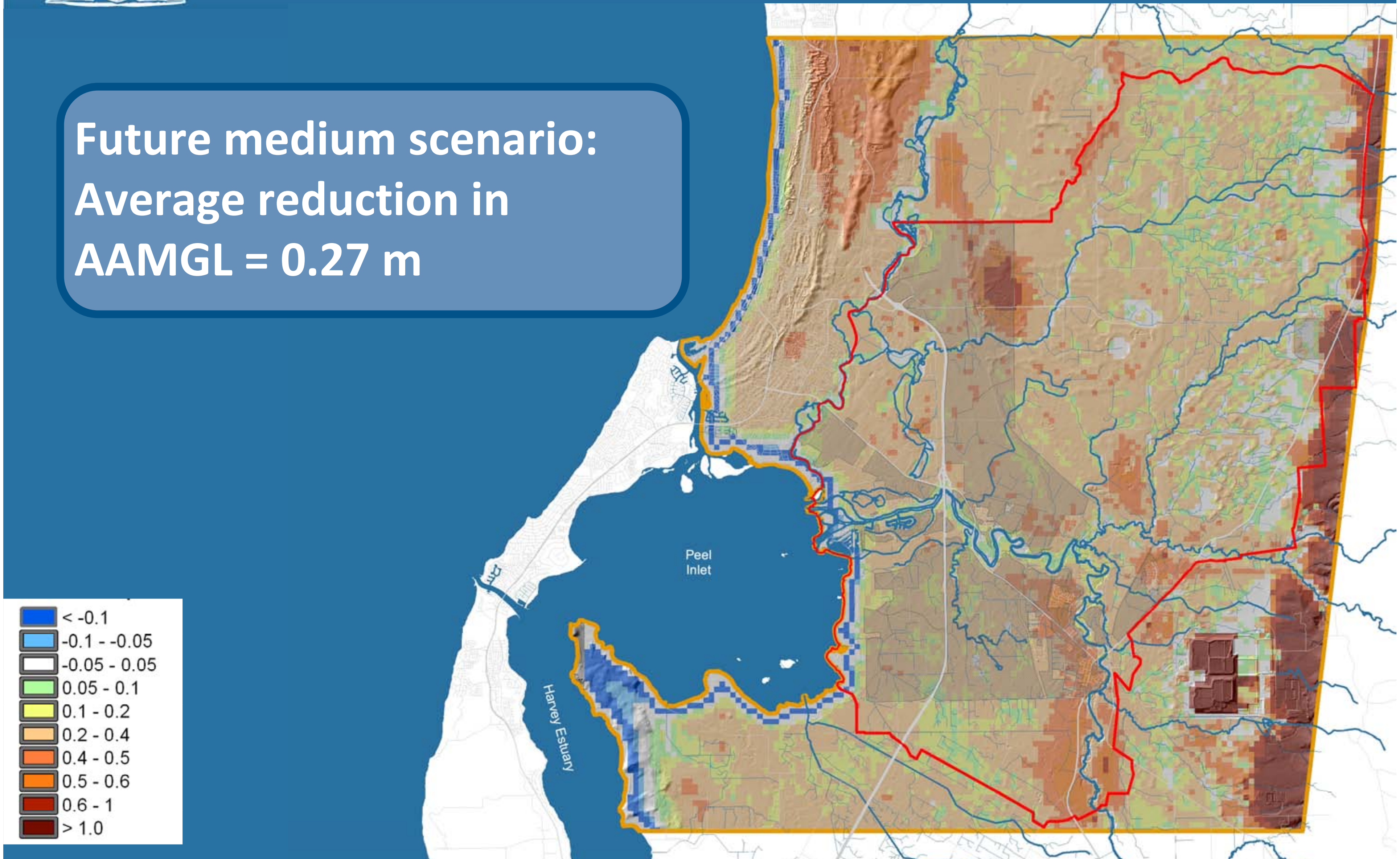
Future climate scenarios

Future medium scenario:
Average reduction in AAMGL = 0.27 m



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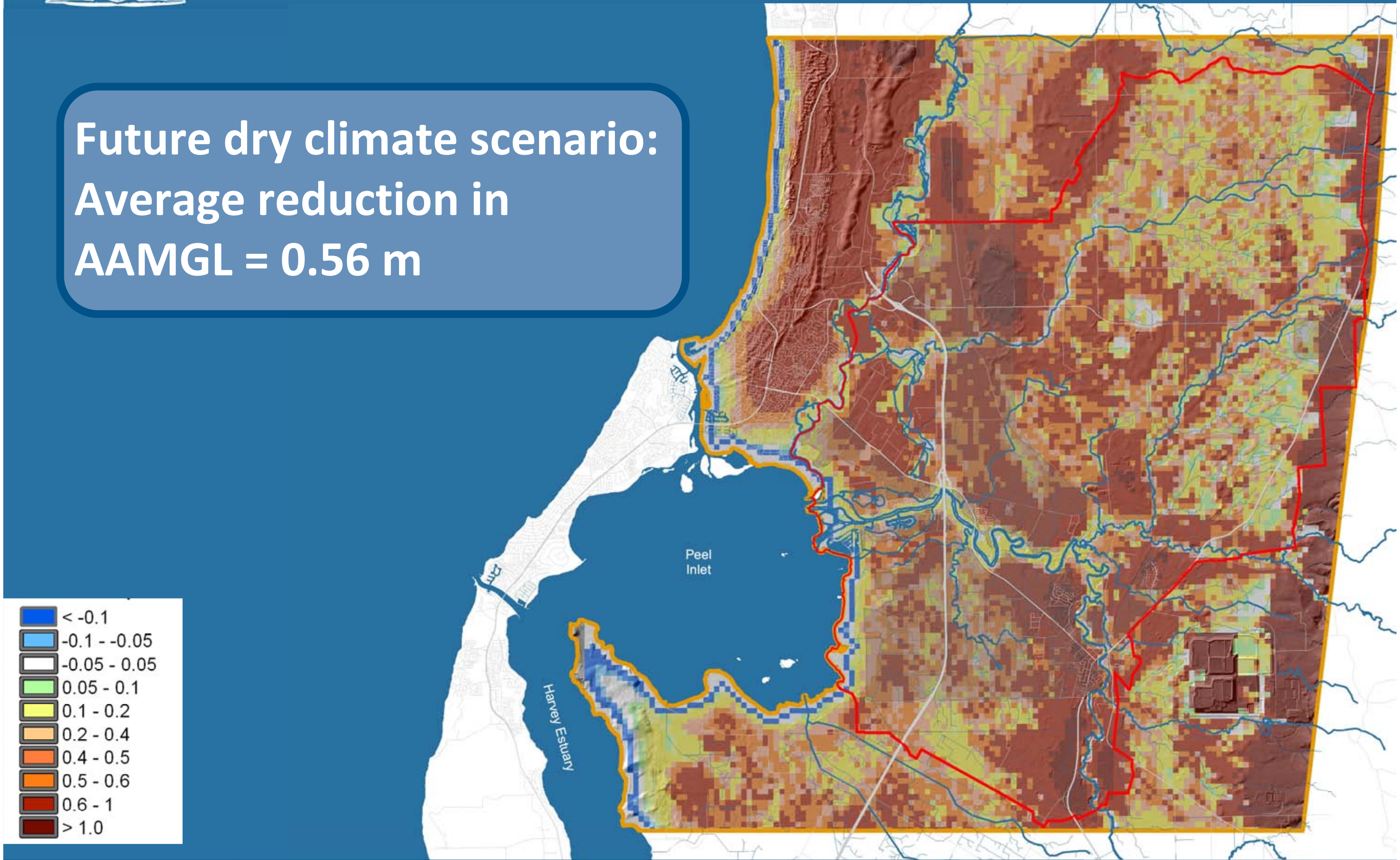
Future climate scenarios

Future dry climate scenario: Average reduction in AAMGL = 0.56 m



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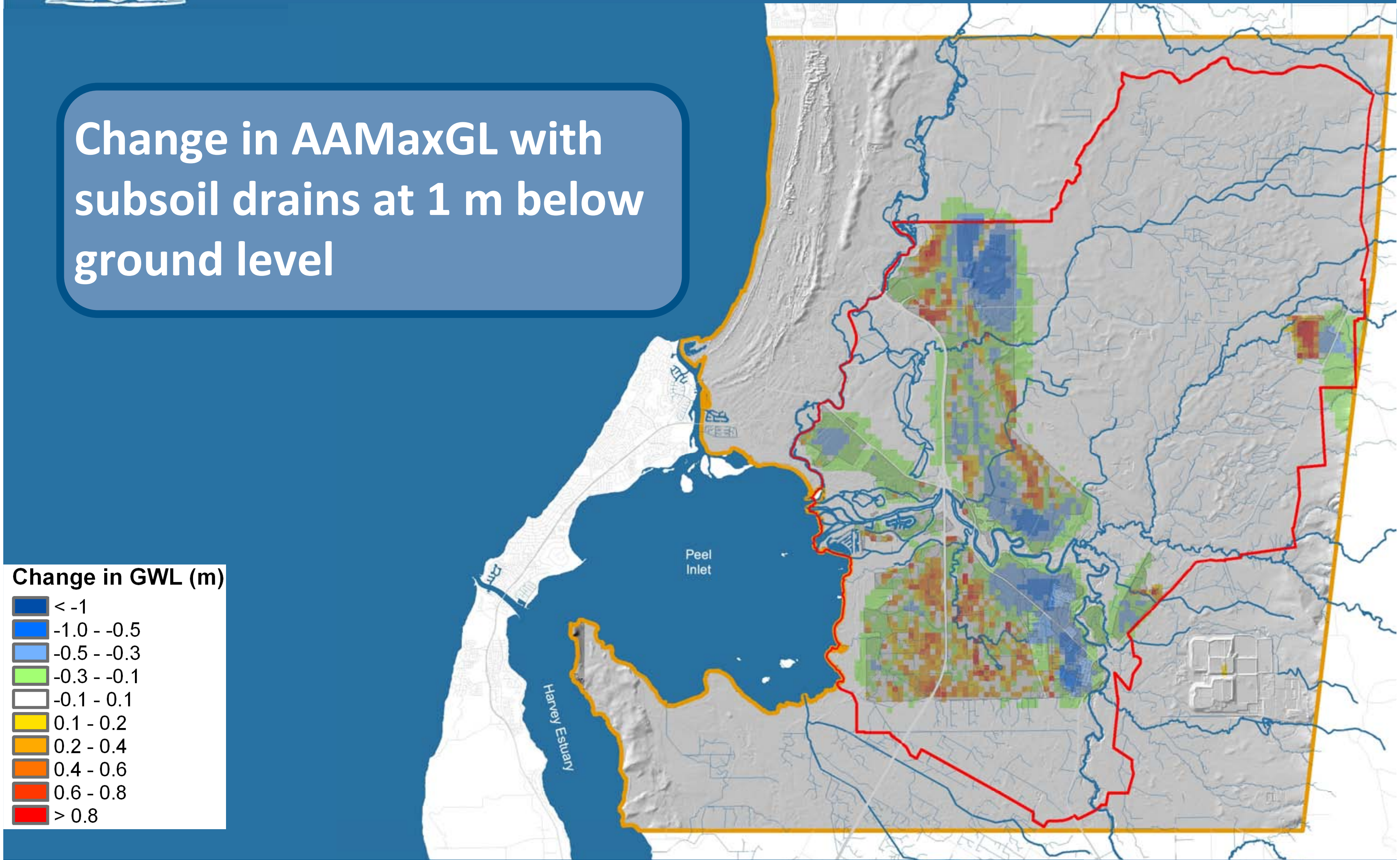
Development/drainage scenarios

Change in AAMaxGL with subsoil drains at 1 m below ground level



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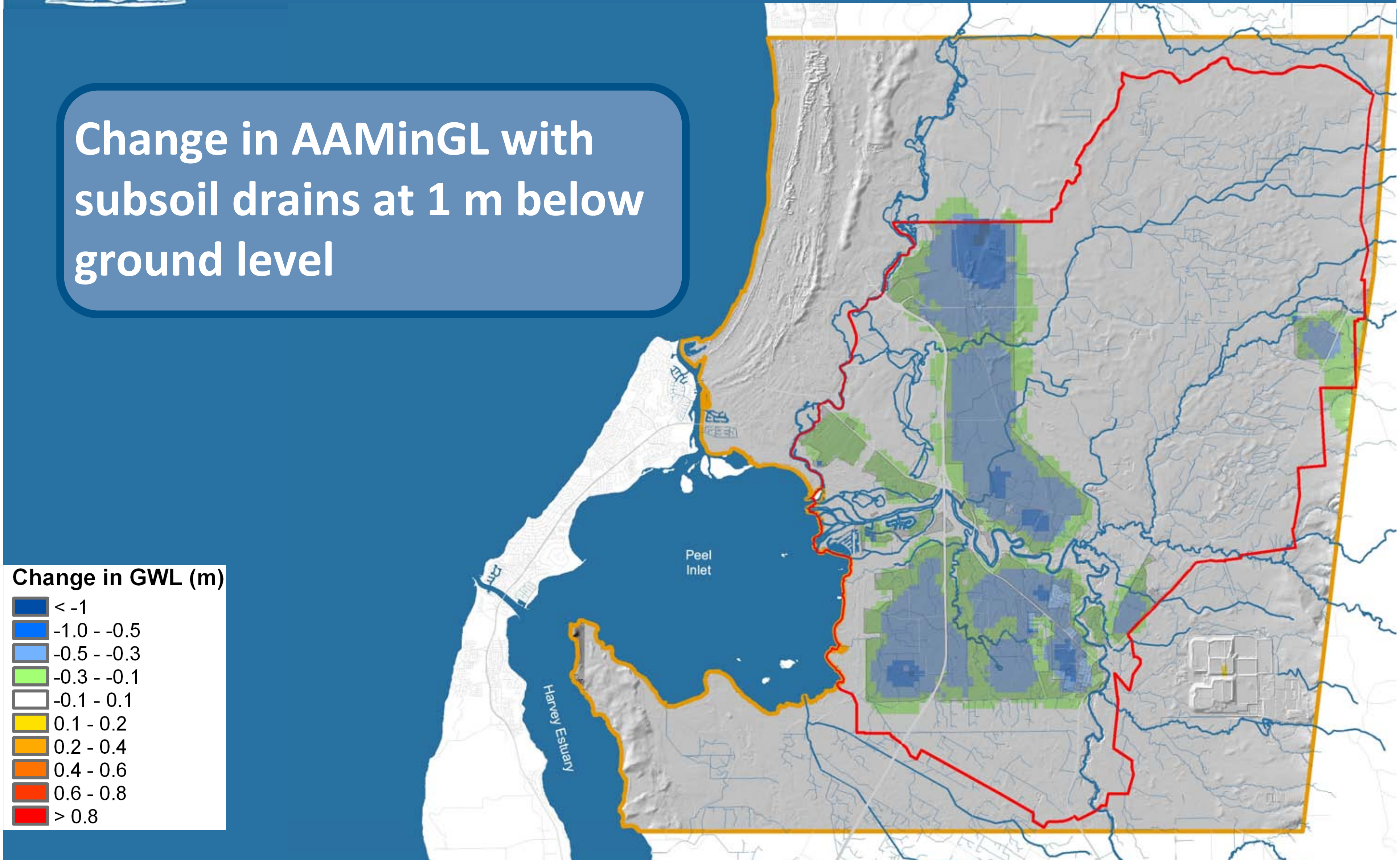
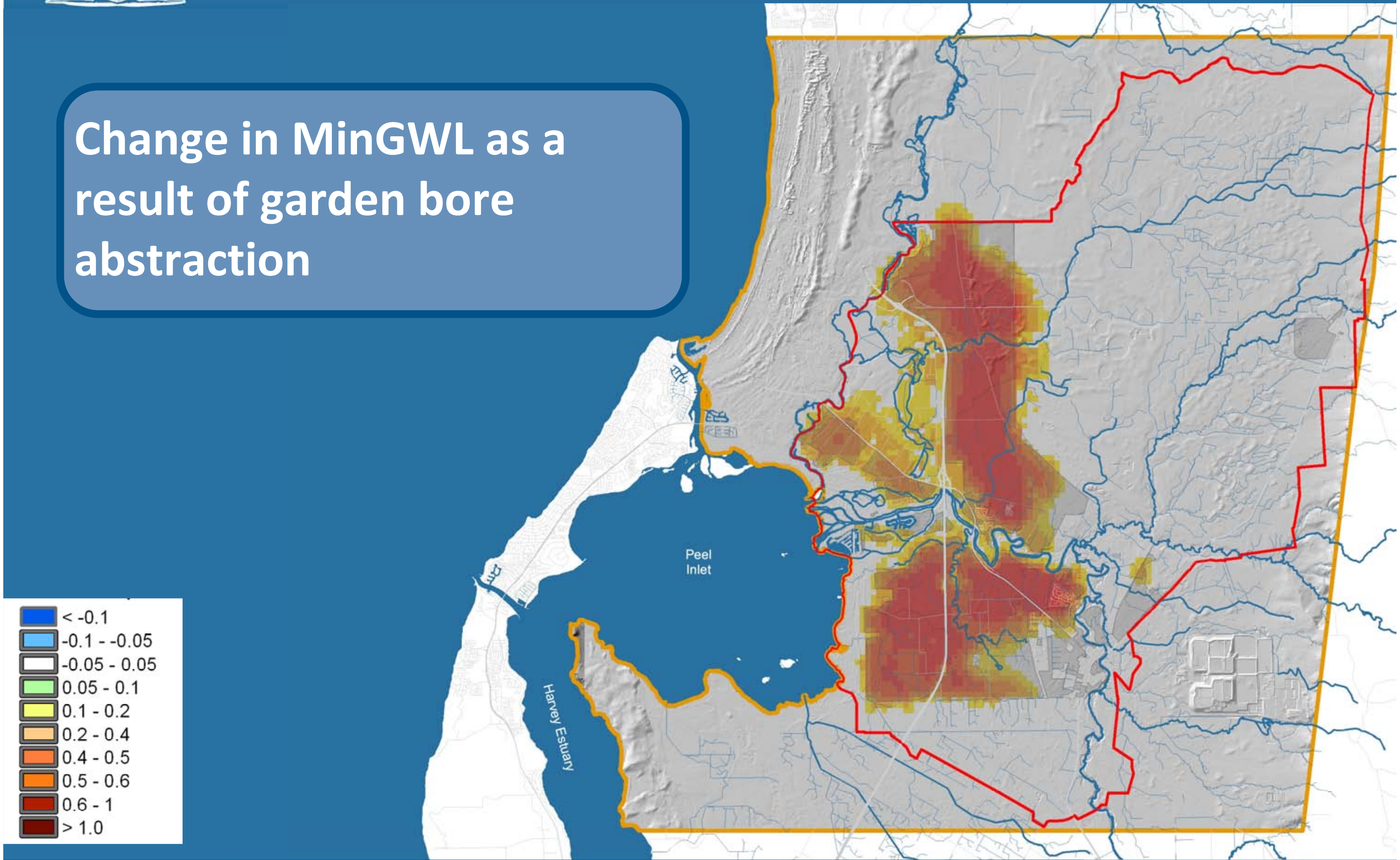
Development/drainage scenarios

Change in AAMinGL with subsoil drains at 1 m below ground level



Garden bore abstraction scenario

Change in MinGWL as a result of garden bore abstraction



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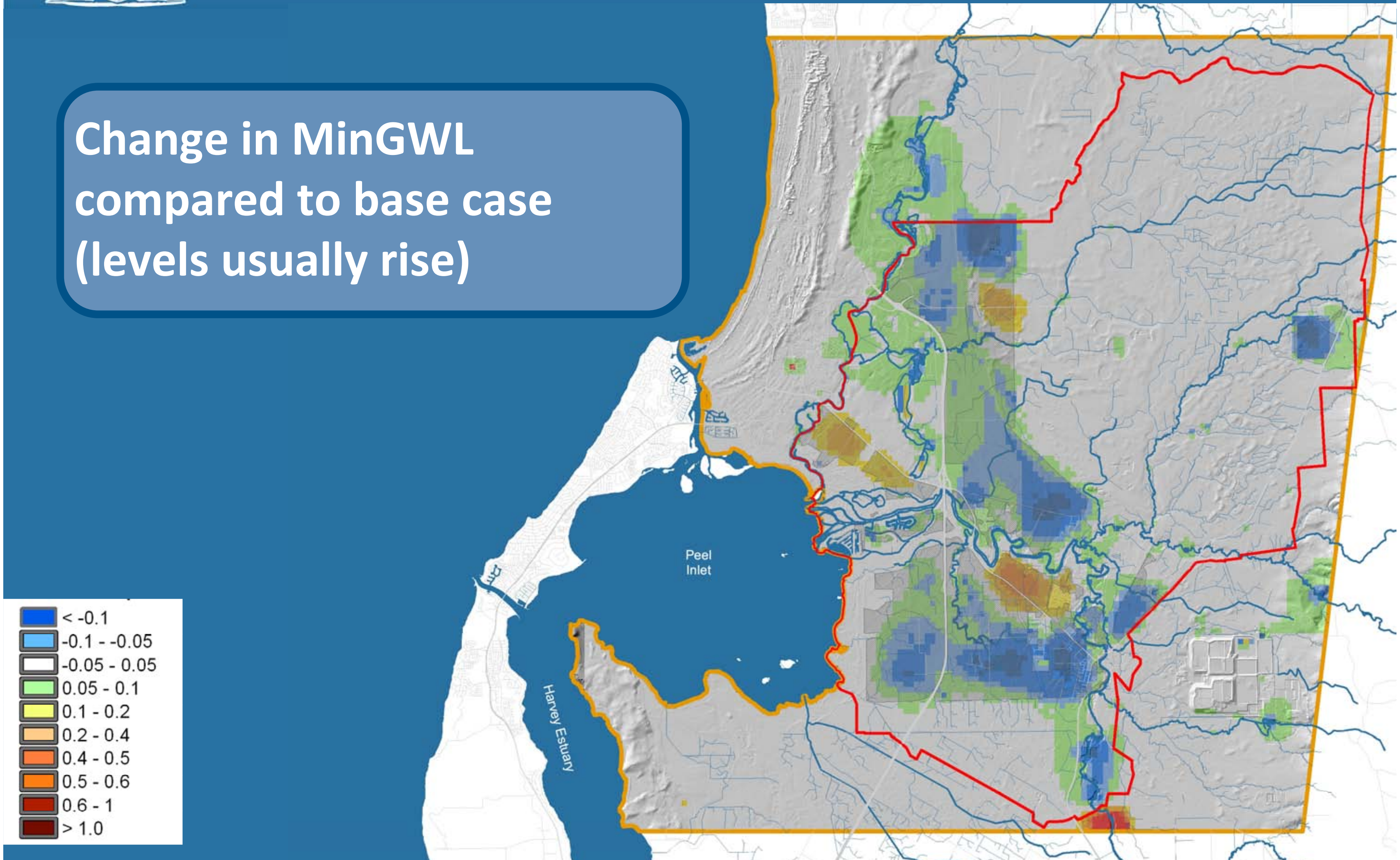
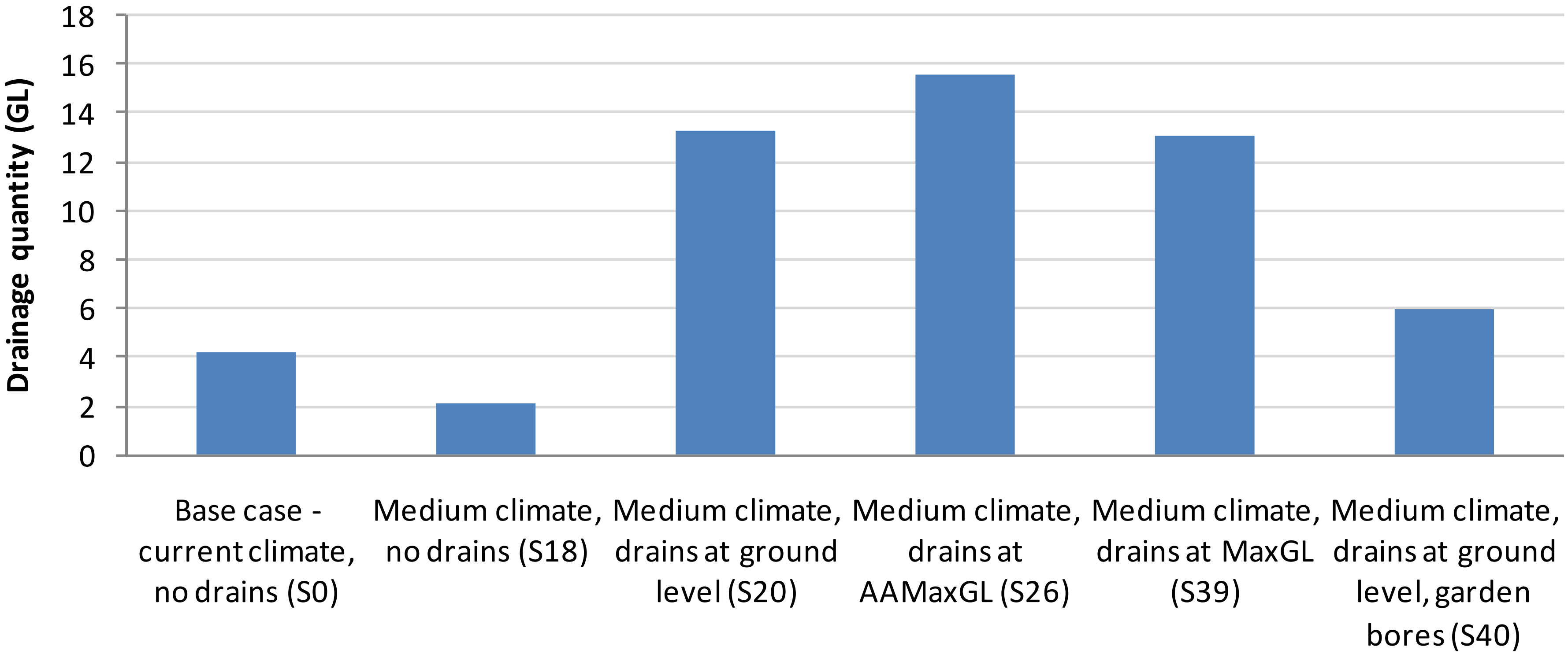
Garden bore abstraction scenario

Change in MinGWL compared to base case (levels usually rise)



Drainage volumes - all developments

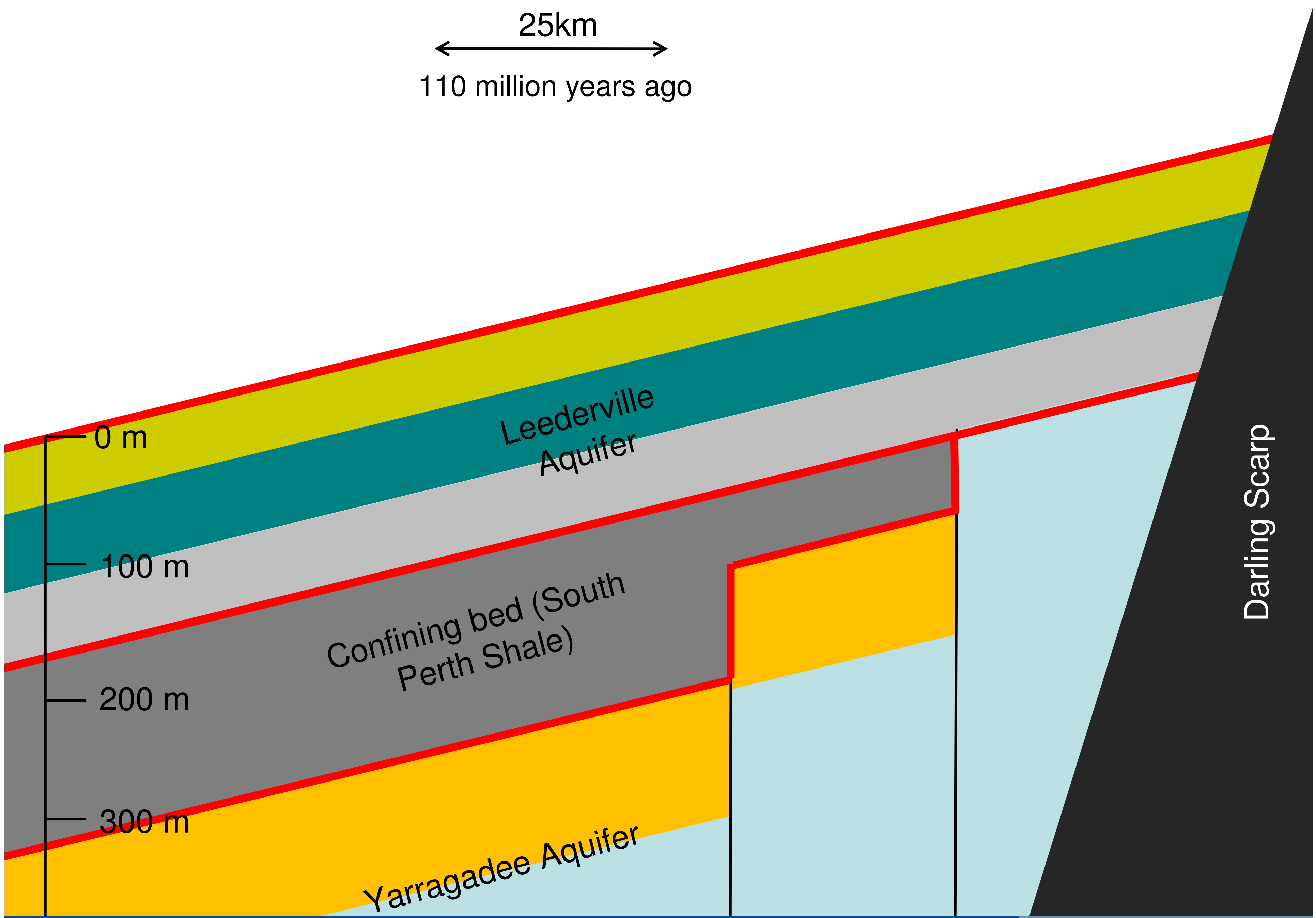


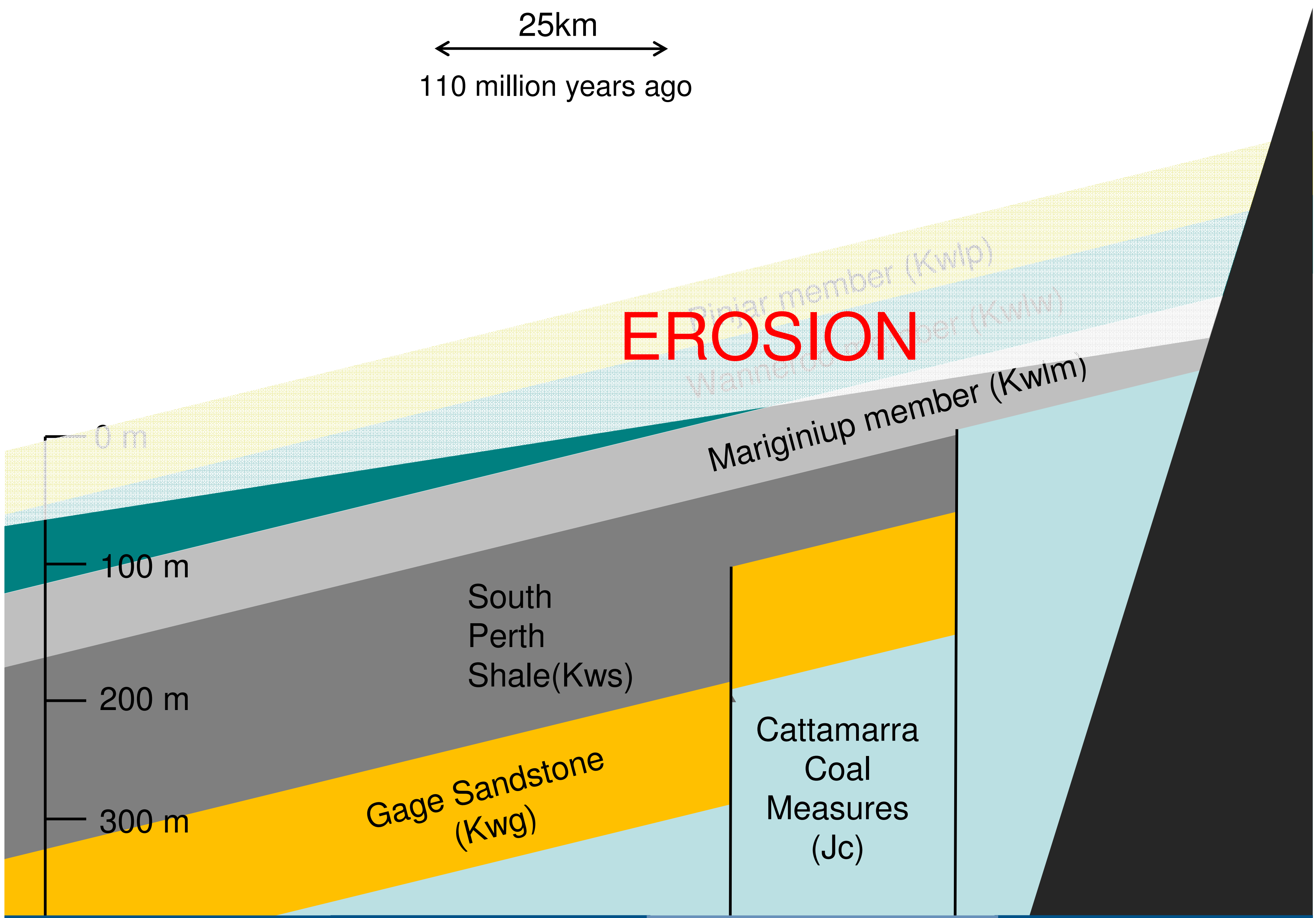
Drainage volumes – all scenarios

Drainage from developments (ML)	Base case - current climate, no drains S0	Wet climate - no drains S09	Wet - Drains ground level S11	Wet - Drains at 1 mBGL S15	Medium climate - no drains S18	Medium - Drains at ground level S20	Medium - Drains at AAMaxGL S26	Medium - Drains at MaxGL S39	Medium - Drains at GL, domestic bores S40	Dry climate - no drains S27	Dry - Drains ground level S29	Dry - Drains at 1 mBGL S33
South Yunderup	12	11	45	367	8	19	75	5	12	4	6	168
Austin Cove	115	75	1084	1599	29	834	919	765	280	7	690	1004
Nerimma	334	231	2223	2785	97	1817	1994	1799	682	27	1841	1833
Buchanans	1246	998	4471	5715	579	3615	4014	3528	2177	294	3509	3626
Pinjarra	385	368	441	418	332	401	436	395	394	286	349	333
South Murray	29	24	94	174	23	43	189	69	23	19	28	48
Barragup	21	10	82	493	0	40	297	56	18	0	15	145
Ravenswood	440	351	3394	4587	209	2597	3122	2609	226	135	2727	2742
Nambeelup	1002	817	3954	5554	431	2945	3460	2871	1182	165	2572	3137
Carcoola	285	253	474	672	212	371	460	353	366	161	278	376
North Dandalup	350	319	720	1024	223	567	581	560	562	135	426	674
TOTAL	4219	3457	16982	23387	2143	13249	15546	13008	5922	1232	12441	14087

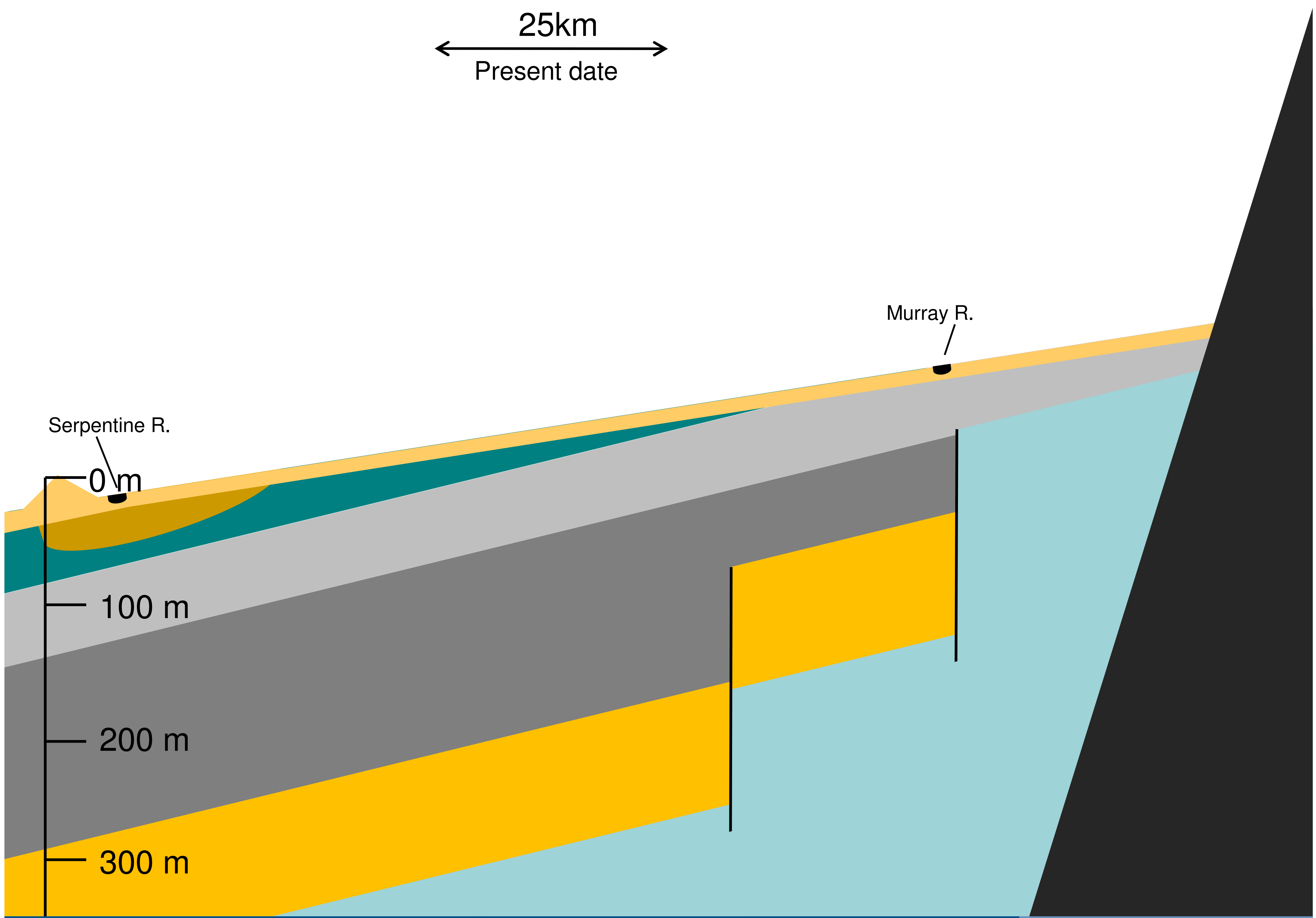
Conclusions

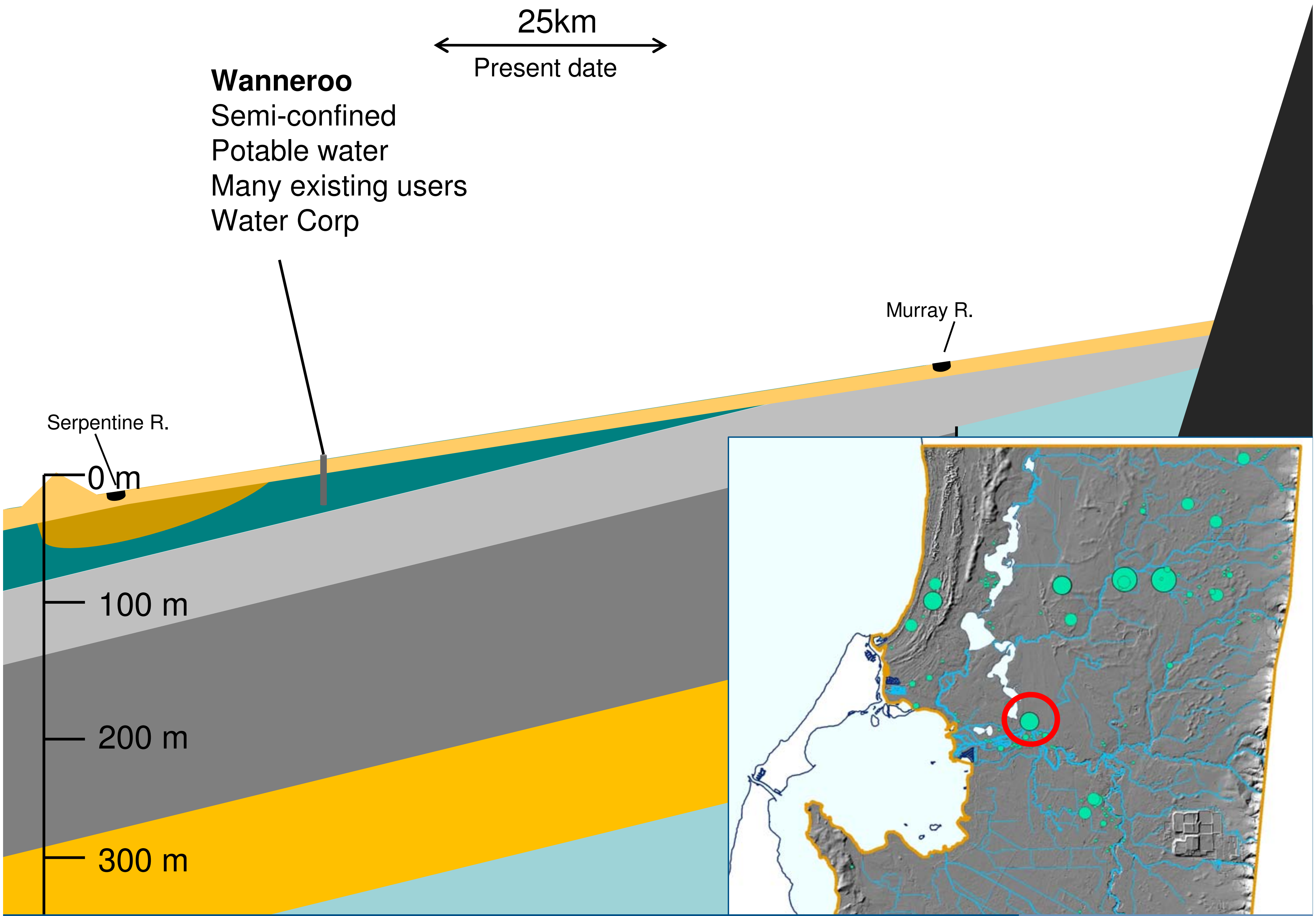
- Future climate scenarios show that GW levels will reduce by up to 0.5 m (much greater impact on SW flows)
- Urban development is likely to mobilise between 8 and 16 GL/yr of extra water
  - Managing this water will be an issue (flooding, nutrients)
  - Innovation could be the key (MAR, re-use, WSUD)
- Garden bores abstraction is not predicted to create ASS issues (if fill is used)
- Sea level rise (0.9 m) will only affect a small proportion of the near-estuary developments
- Extensive water-logging of all proposed urban areas is evident for all climate scenarios

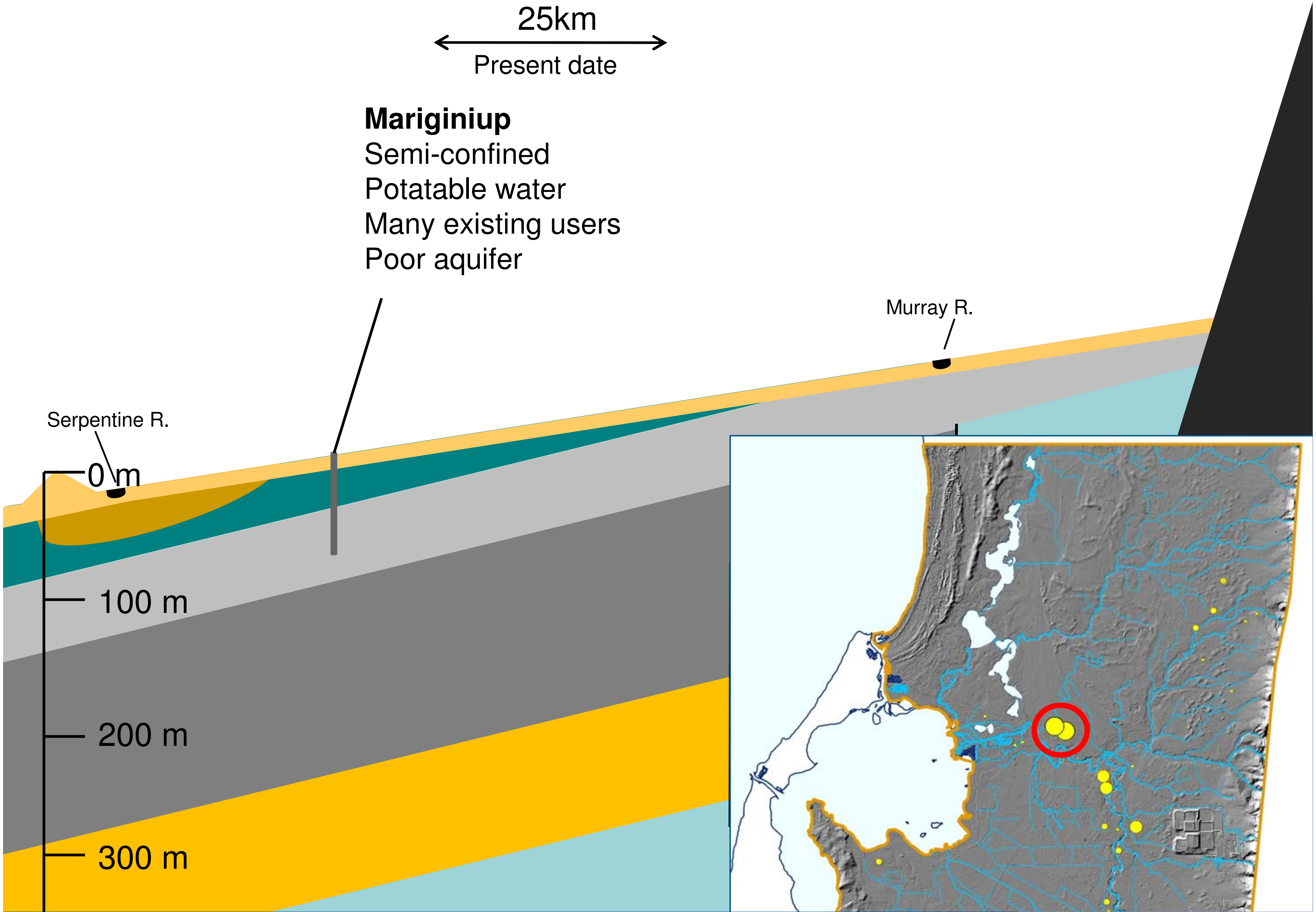

25km
110 million years ago
0 m
100 m
200 m
300 m
Leederville Aquifer
Confining bed (South Perth Shale)
Yarragadee Aquifer
Darling Scarp



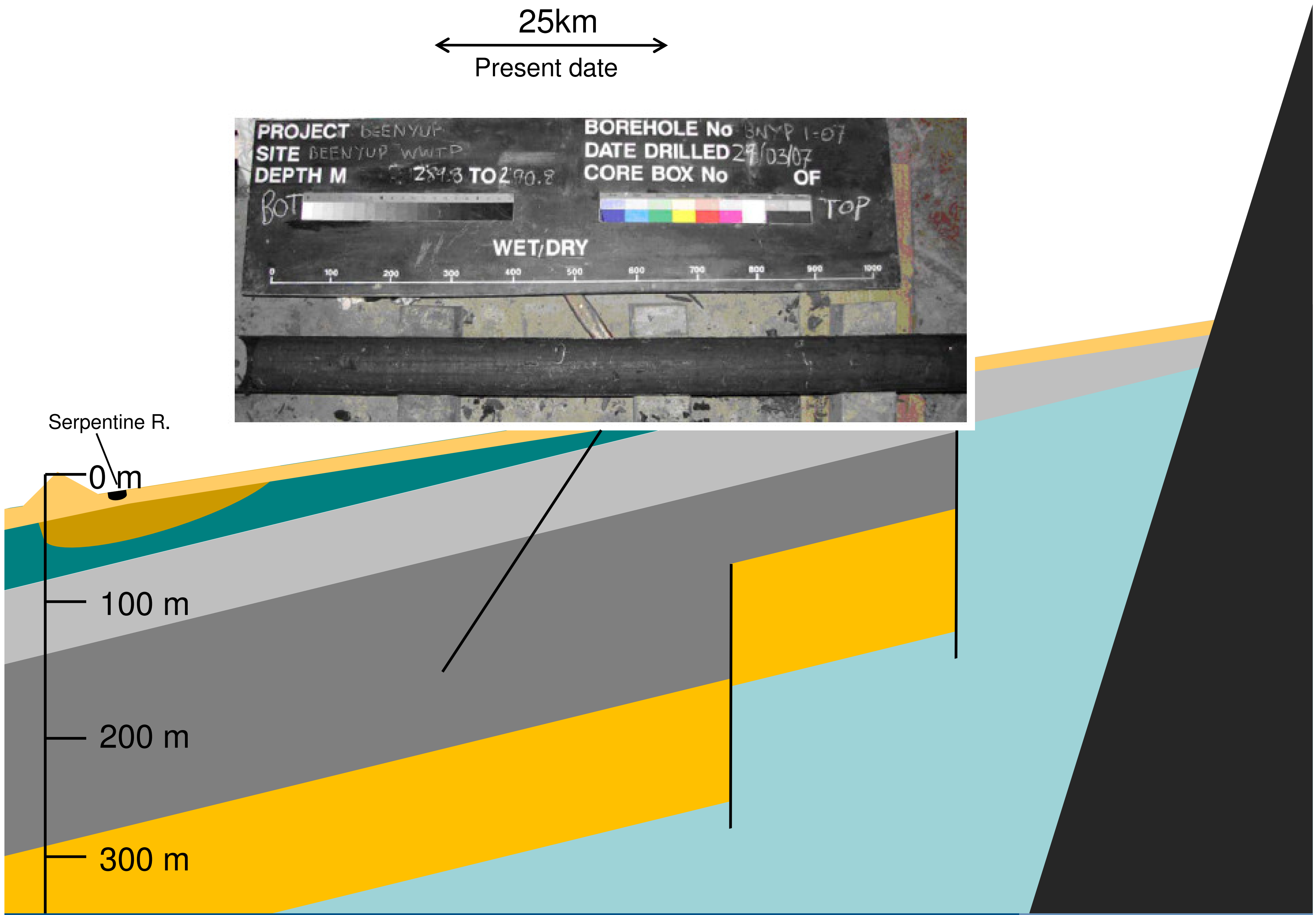
25km
110 million years ago
EROSION
Mariginiup member (Kwlm)
100 m
200 m
300 m
South
Perth
Shale(Kws)
Gage Sandstone
(Kwg)
Cattamarra
Coal
Measures
(Jc)

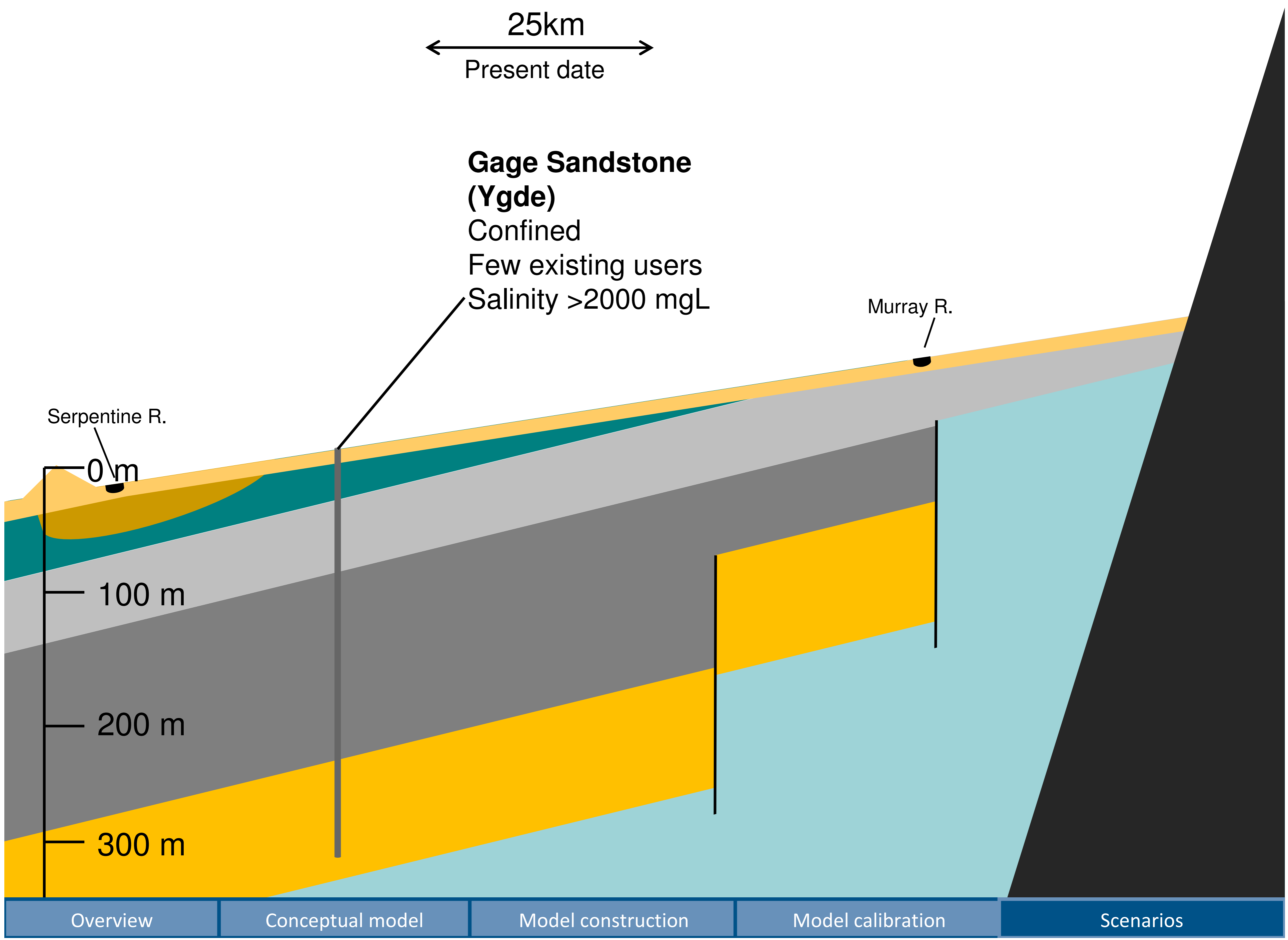

25km
Present date
Murray R.
Serpentine R.
0 m
100 m
200 m
300 m


25km
Present date
Wanneroo
Semi-confined
Potable water
Many existing users
Water Corp
Murray R.
Serpentine R.
0 m
100 m
200 m
300 m

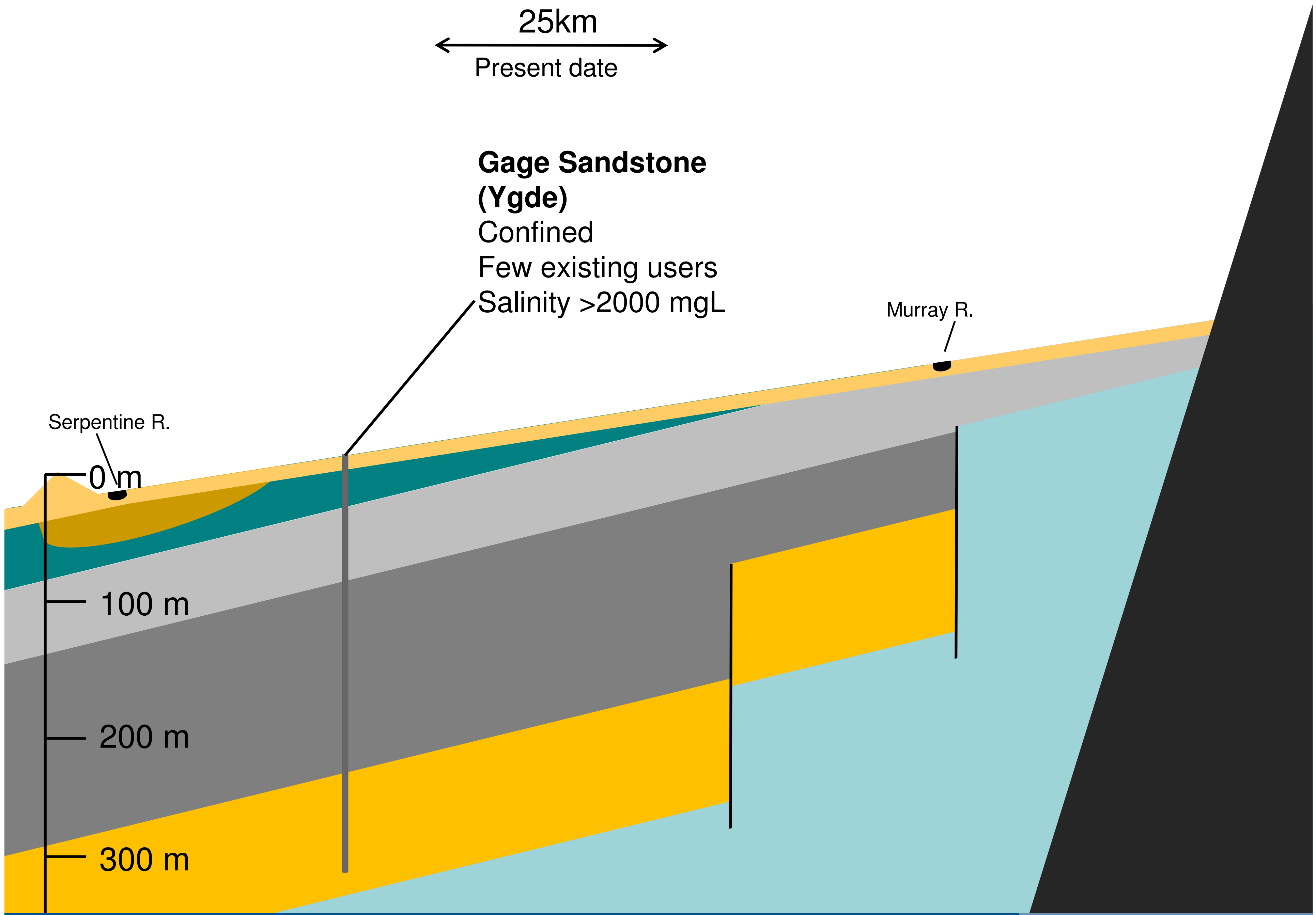


25km
Present date
Mariginiup
Semi-confined
Potatable water
Many existing users
Poor aquifer
Murray R.
Serpentine R.
0 m
100 m
200 m
300 m


25km
Present date
PROJECT
SITE
DEPTH M
TO
BOREHOLE No
DATE DRILLED
CORE BOX No
OF
BOT
TOP
WET/DRY
Serpentine R.
0 m
100 m
200 m
300 m



25km
Present date
Gage Sandstone
(Ygde)
Confined
Few existing users
Salinity >2000 mgL
Murray R.
Serpentine R.
0 m
100 m
200 m
300 m
Overview
Conceptual model
Model construction
Model calibration
Scenarios


25km
Present date
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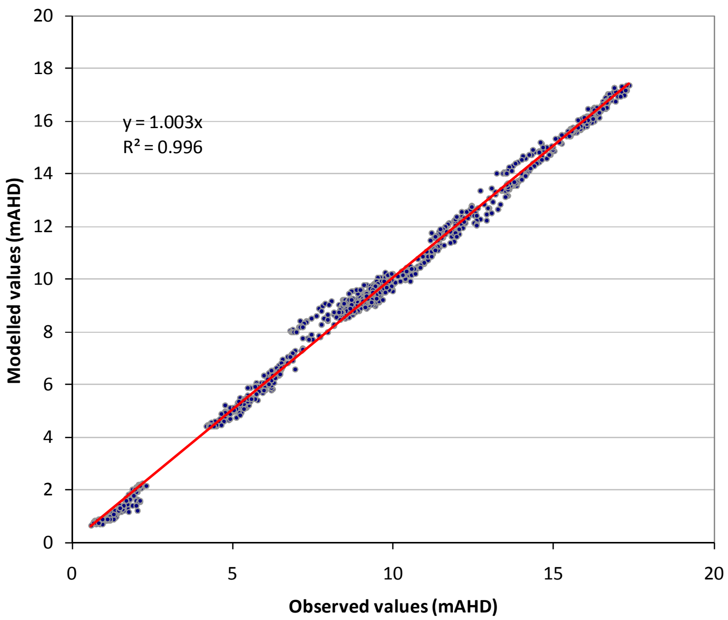
Murray R.
Serpentine R.
0 m
100 m
200 m
300 m

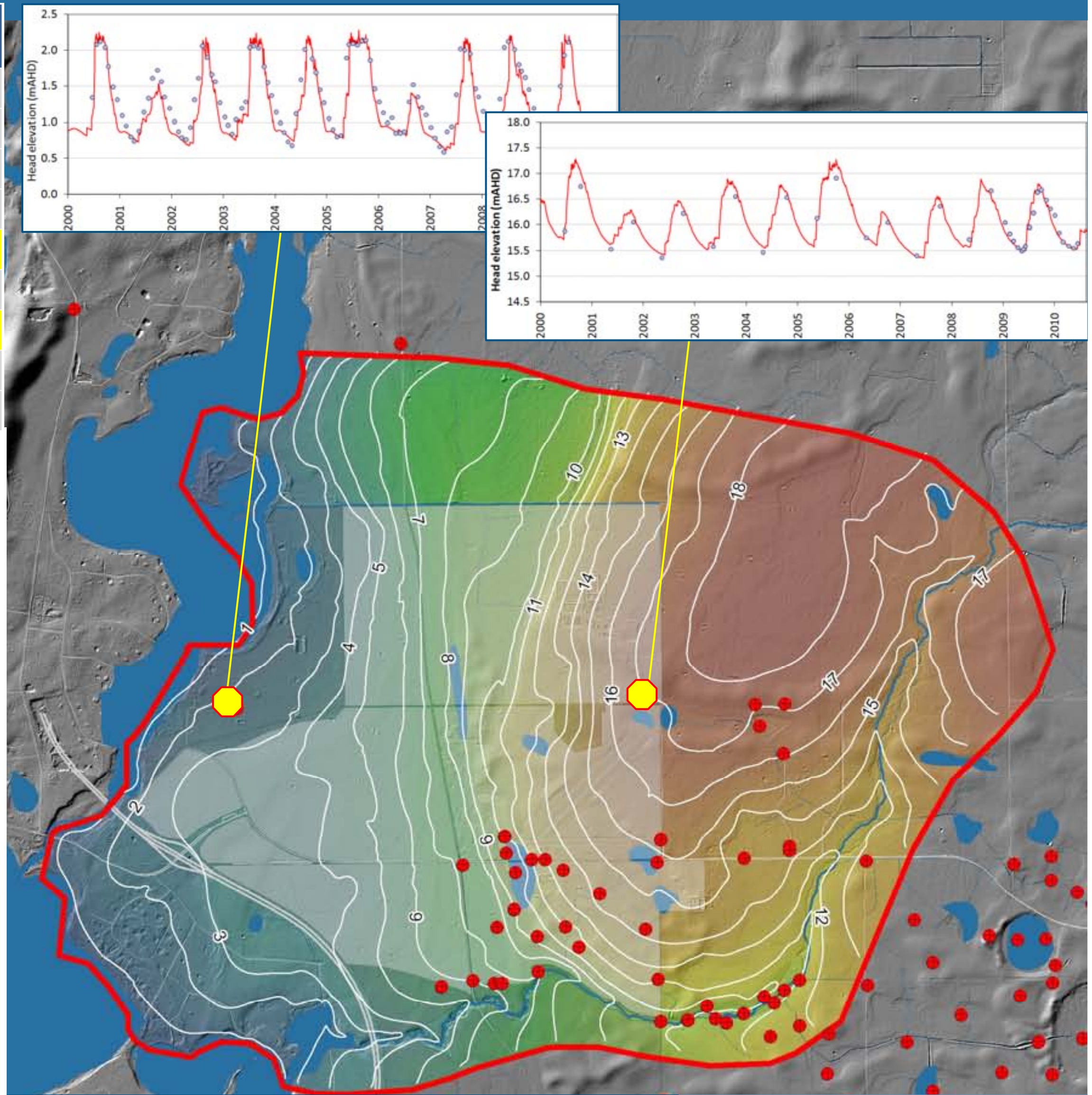
We are here to help……..!

- **On request, Department of Water will provide:**
  - Three reports on Murray model (DoW website)
  - Regional model outputs (rasters & contours)
  - GIS inputs (saturated zone layers, land-use etc.)
  - Model parameters
  - Boundary conditions
  - THE MODEL (and some support)

Nambeelup DWMS modelling

Description	Symbol	Value
Count	n	1149
Sum of squares (m2)	SSQ	99.6
Mean sum of squares (m2)	MSSQ	0.09
Root mean square (m)	RMS	0.29
Scaled root mean square (%)	SRMS	1.76
Sum of residuals (m)	SRMS	248.5
Mean sum of residuals (m)	MSR	0.22
Scaled mean sum of residuals (%)	SMSR	1.29
Coefficient of determination ()	CD	0.98





Overview | Conceptual model | Model construction | Model calibration | Scenarios

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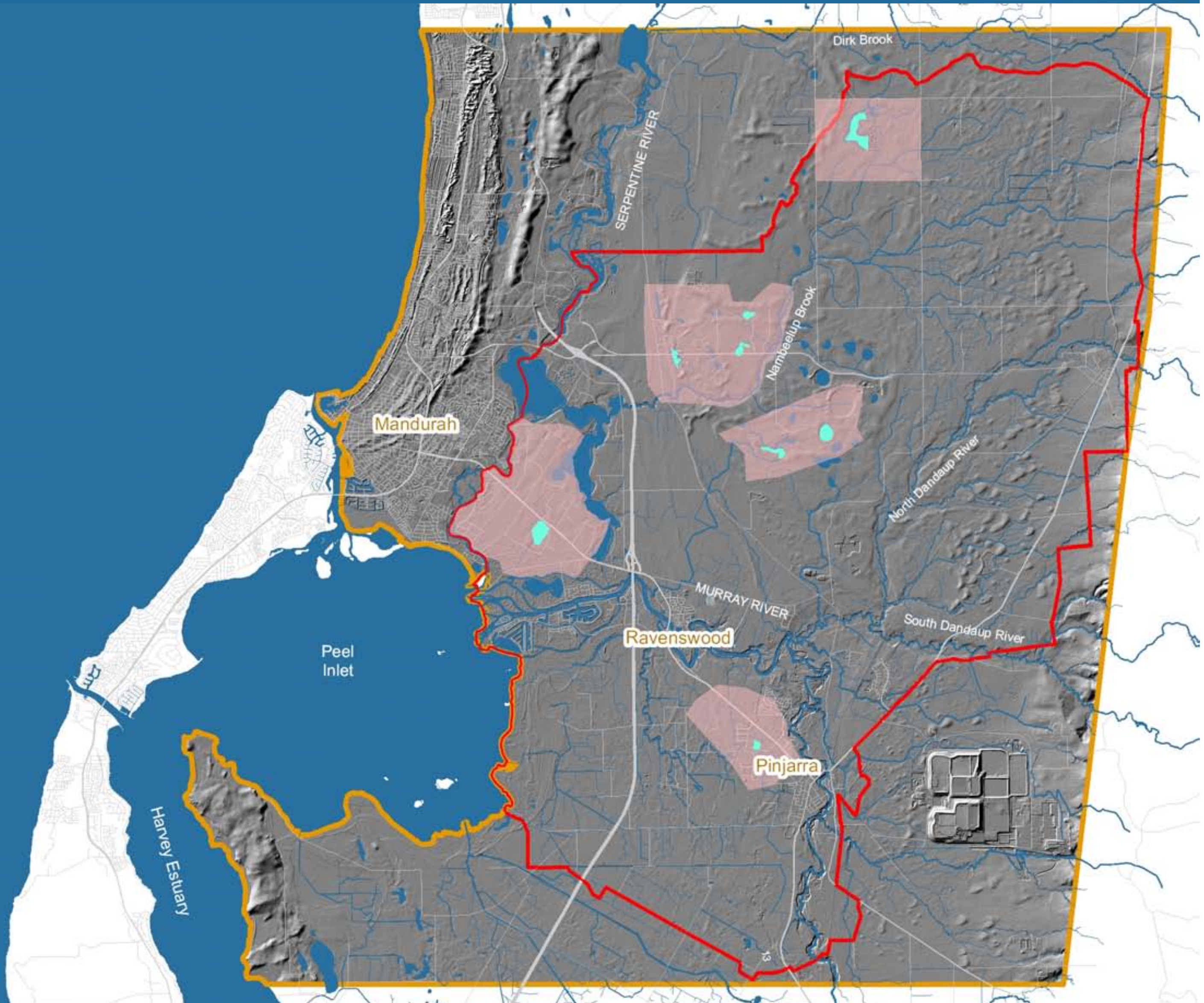
Wetland models



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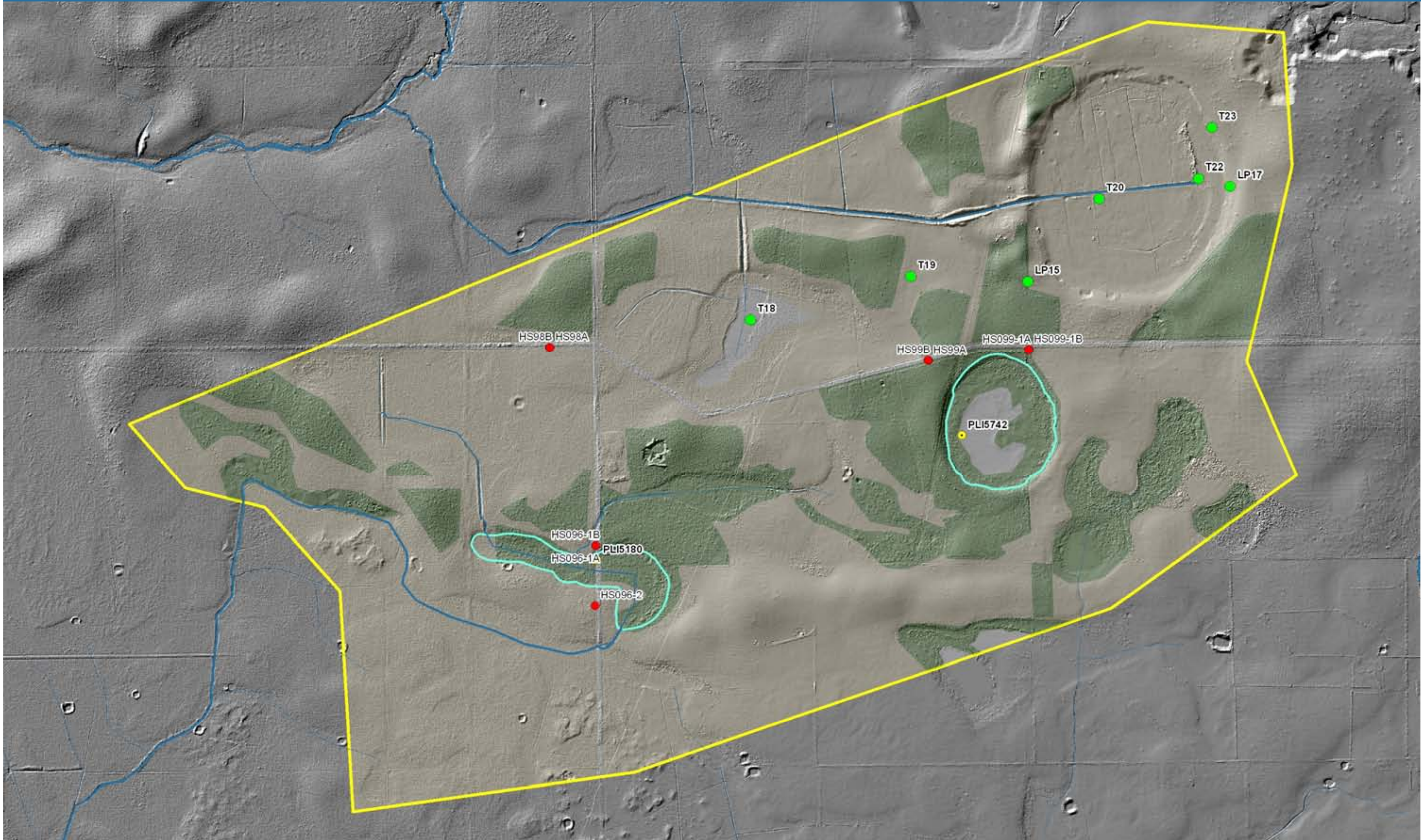
Scott Road wetland model



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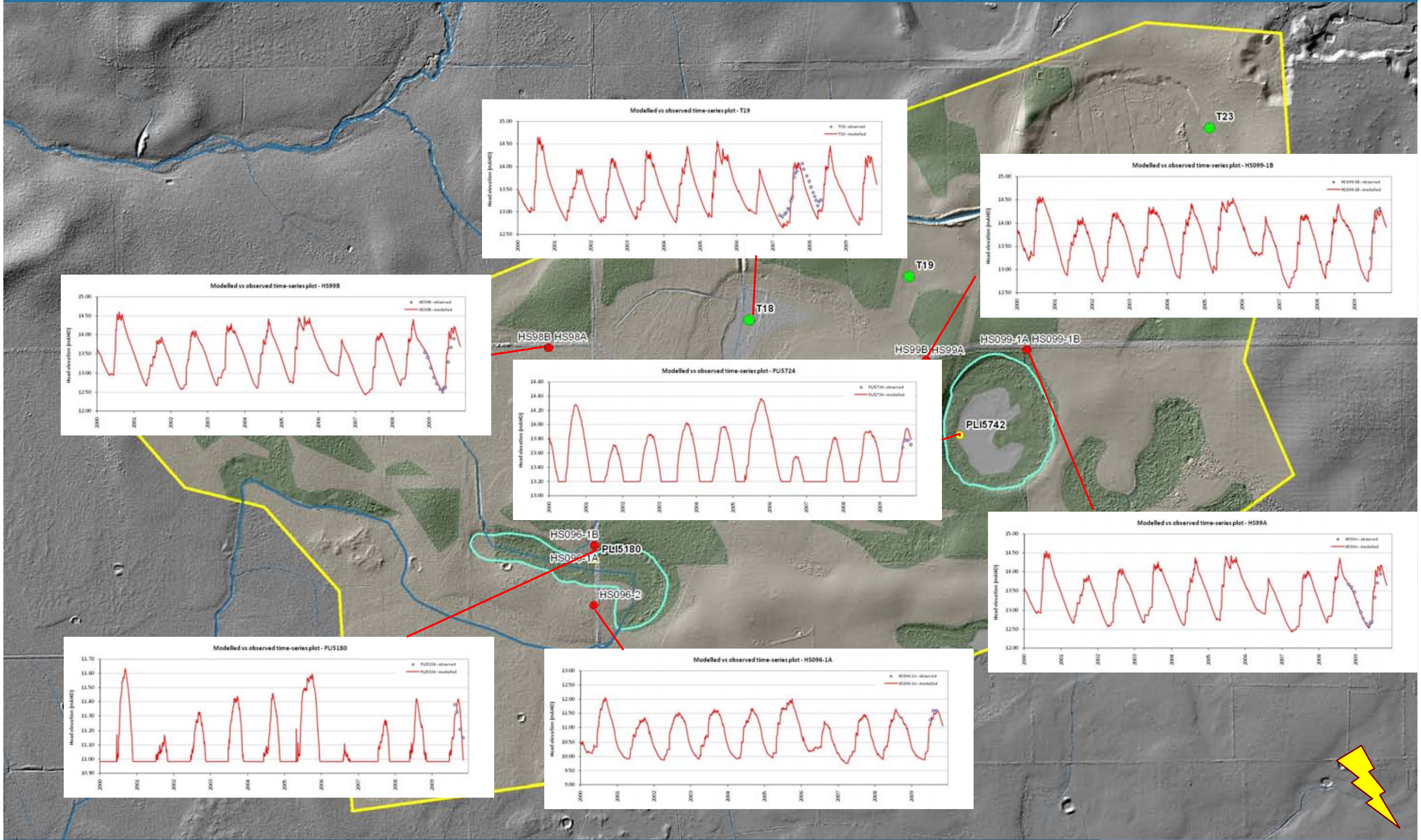
Scott Road wetland model



Wetland scenario results

Wetland	Change in average annual minimum GWL		
	Dry future climate	Sea level rise (0.9m)	Sand dune removal
Barragup Swamp	-0.24 m	+0.21 m	-
Benden Road	-0.60 m	-	-0.06 m
Scott Road	-0.34 m	-	-0.03 m
Airfield North	-0.28 m	-	-0.16 m
Airfield South	-0.23 m	-	-0.03 m
Greyhound Road	-0.13 m	-	-0.04 m
Phillips Road	-0.15 m	-	-
Lakes Road	-0.10 m	-	-
Elliot Road	-0.17 m	-	-