Groundwater Modelling and Ecological Water Requirements

Kemerton Industrial Estate

IAH Annual Seminar

Groundwater Resources of the Perth Basin

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KEMERTON WATER STUDY

- Large scale project investigating the groundwater resources of the Kemerton Industrial Estate

- Technical working group
  - Landcorp
  - Department of Mineral and Petroleum Resources
  - Water and Rivers Commission

PRESENTATION OUTLINE

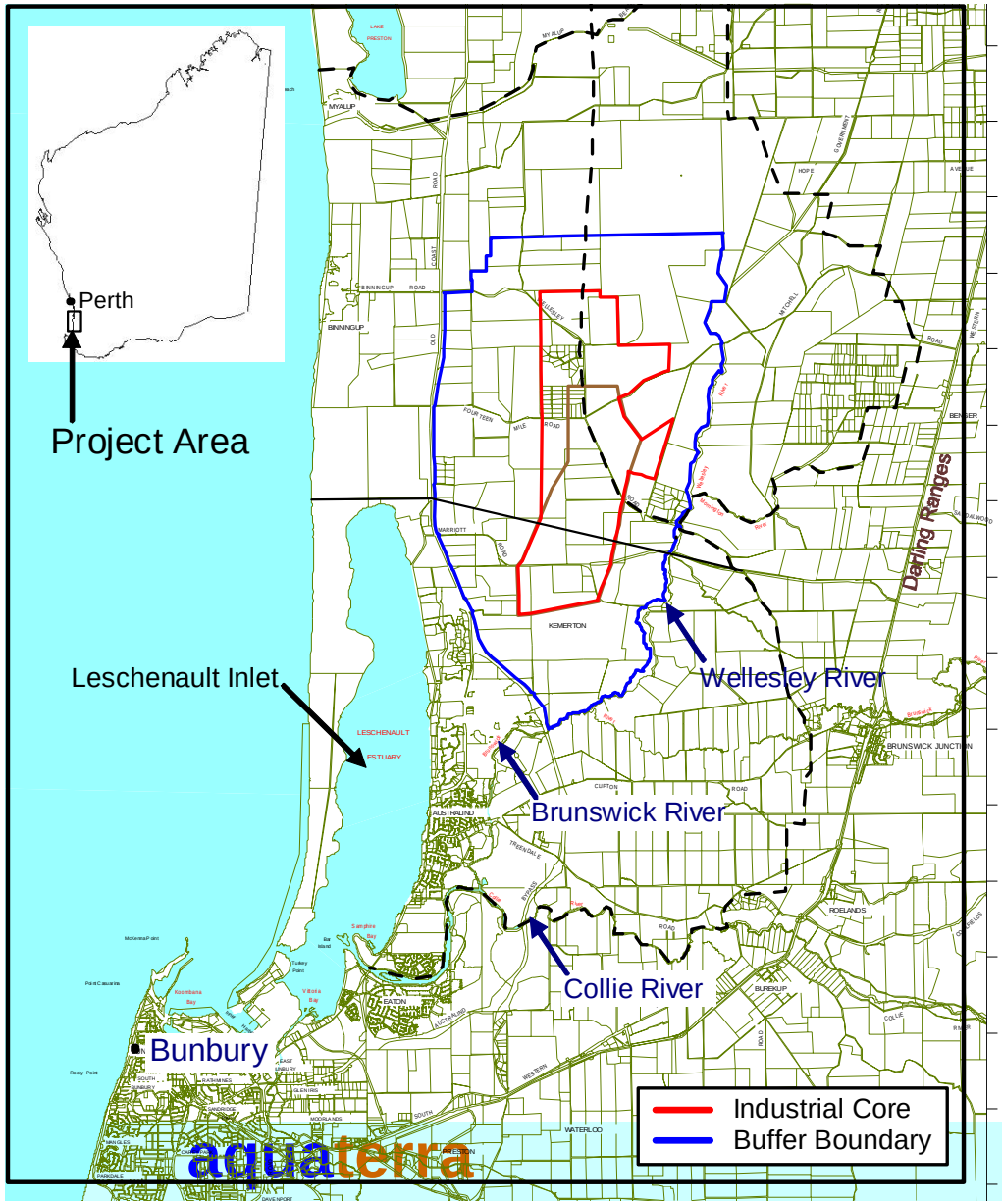
- Introduction
- Hydrogeological Investigations and Model
- Ecological Water Requirements (EWRs)
- Environmental Water Provisions (EWPs)
- Water Supply Modelling to find balance between abstraction, impacts and EWPs, and demonstrate new hydro-equilibrium

INTRODUCTION

- Overall Objective of Study
  - Comprehensive water management strategy (groundwater, surface water, ASR, engineering drainage, floor levels, etc)
  - Capable of practical implementation
  - Maximise development potential of Estate

- Water Management Strategy
  - Plan for sustainable and efficient water use
  - Minimise potential development impacts
  - Maintain environmental values
    - Significant wetlands
    - Groundwater dependent vegetation (GDV)
    - Water courses

KEMERTON INDUSTRIAL ESTATE



- 140km south of Perth
- 17km NE of Bunbury
- GMA's
  - Bunbury
  - South West Coastal
- GMSA's
  - Wellesley
  - Myalup
  - Australind

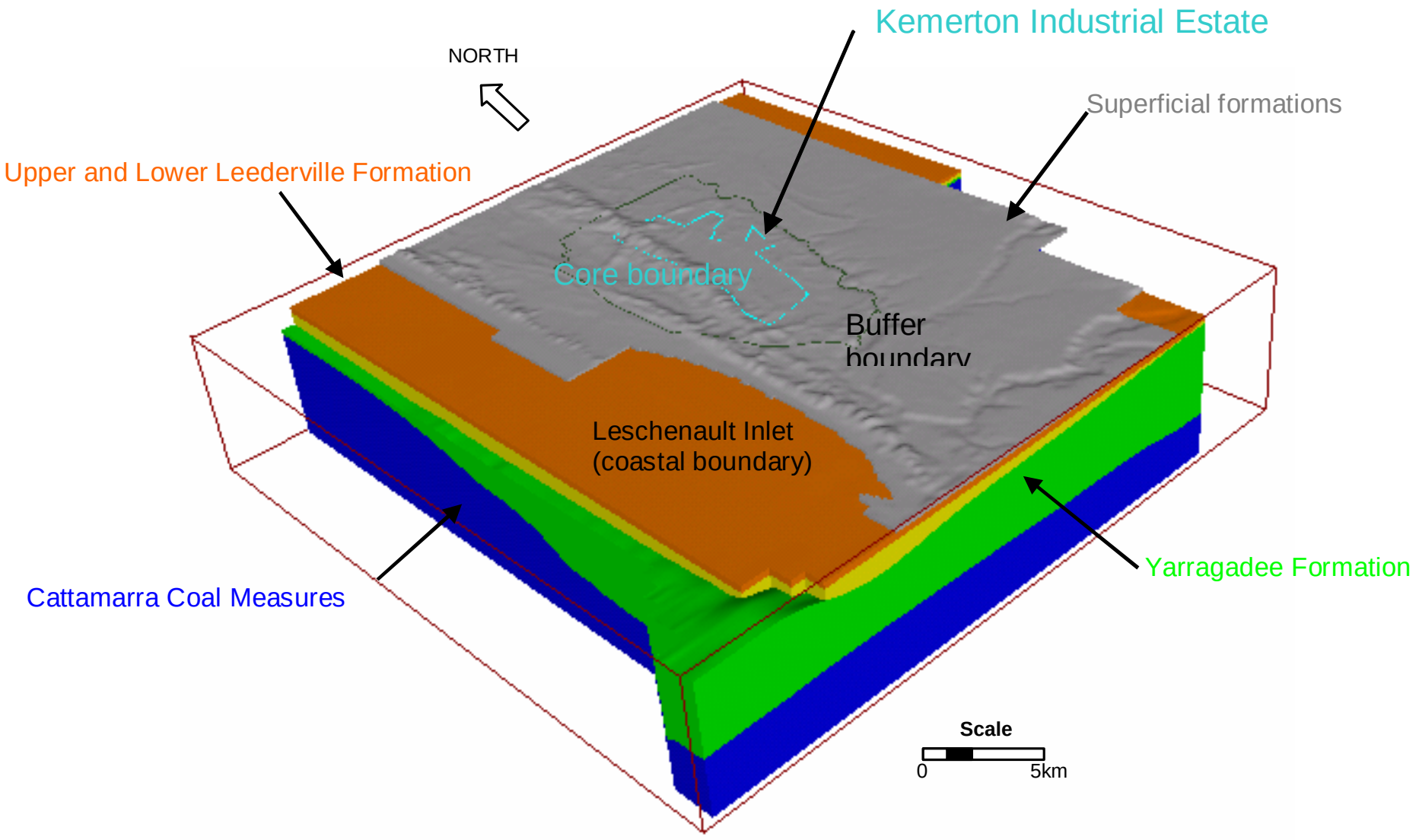
HYDROGEOLOGICAL INVESTIGATIONS

- Desktop review of groundwater allocation
- Development and sampling of existing groundwater monitoring network
- Installation of additional superficial and confined aquifer monitoring bores

GROUNDWATER MODEL

- Based on existing regional model (Rockwater, 1998)
- Original data used as basis for model geometry
- 5 Model Layers
  - Superficial formations (unconfined)
  - Leederville Formation (upper & lower)
  - Yarragadee Formation
  - Cattamarra Coal Measures
- Refined features & calibration (was steady state only)
  - River-aquifer interaction
  - Shallow irrigation drainage system
  - Evapotranspiration to represent GDEs, using latest research on Banksia woodland (Froend, ECU)

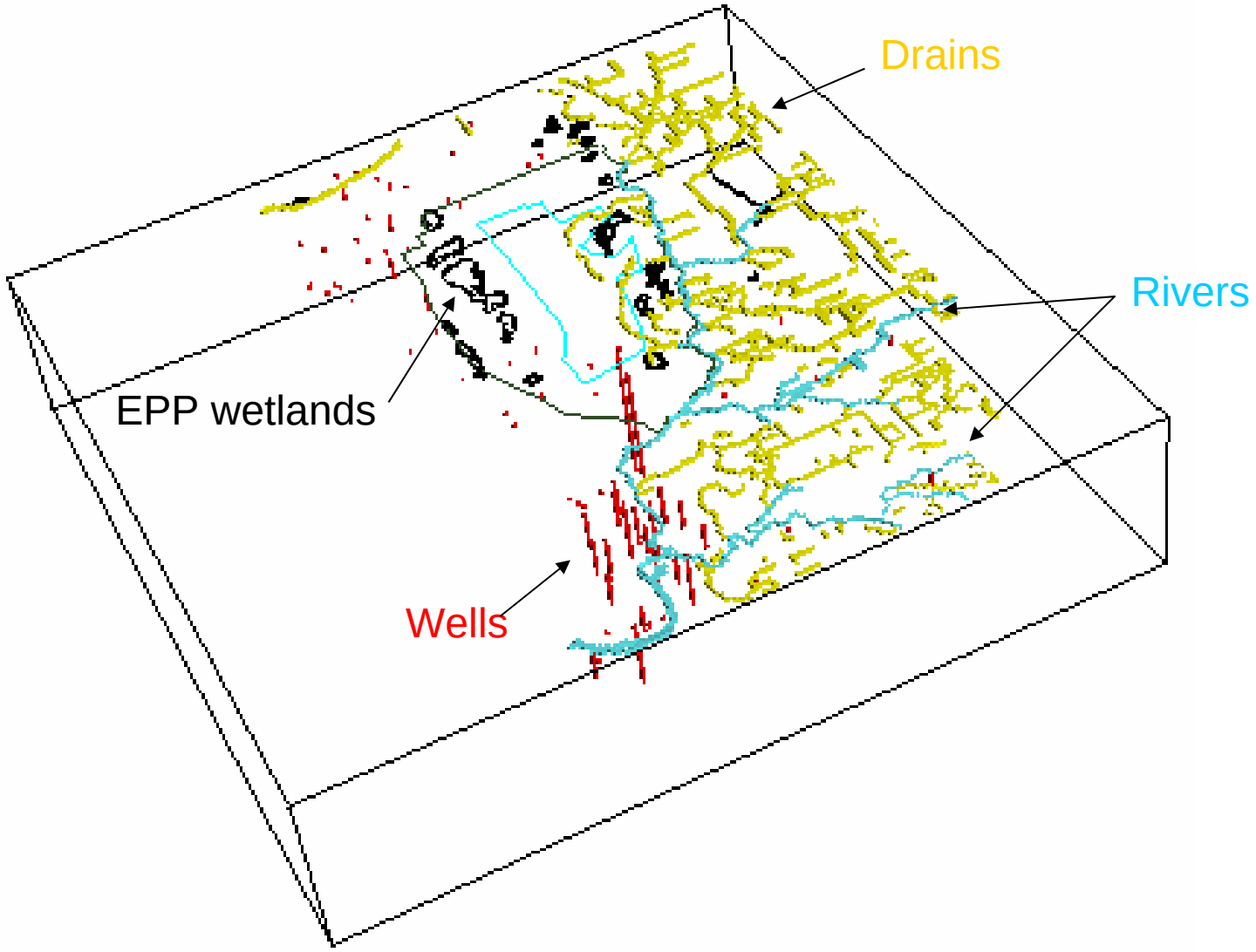
GROUNDWATER MODEL



MODEL FEATURES

- River-aquifer interaction and drain features
- Evapotranspiration
  - groundwater discharge to wetlands
  - groundwater use by vegetation (Banksia woodland, heathland, pasture etc)
- Groundwater Abstraction
  - Existing groundwater use by industries and private GWL holders
- Recharge (% of rainfall)

MODEL FEATURES



MODEL CALIBRATION

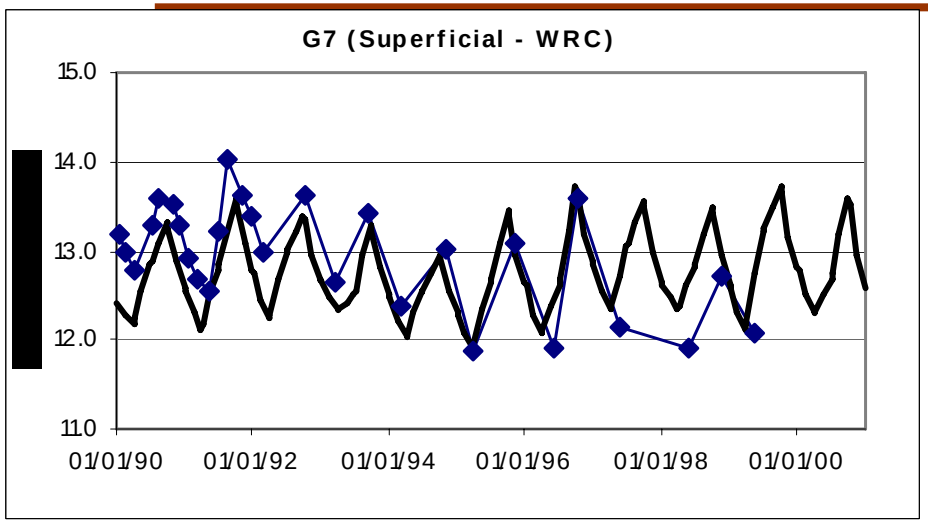
- 11 Year Calibration Period: 1990 – 2000
  - Number of relatively wet to relatively dry years
  - Within an overall period when the average rainfall has been 10% below the long term average

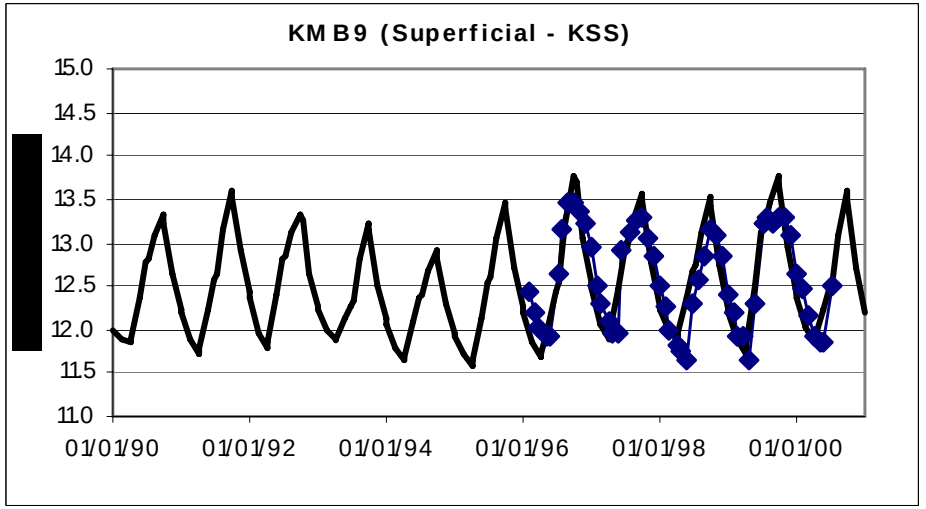
- Quarterly stress periods (periods of constant stress) to allow for seasonal variations in evaporation and rainfall

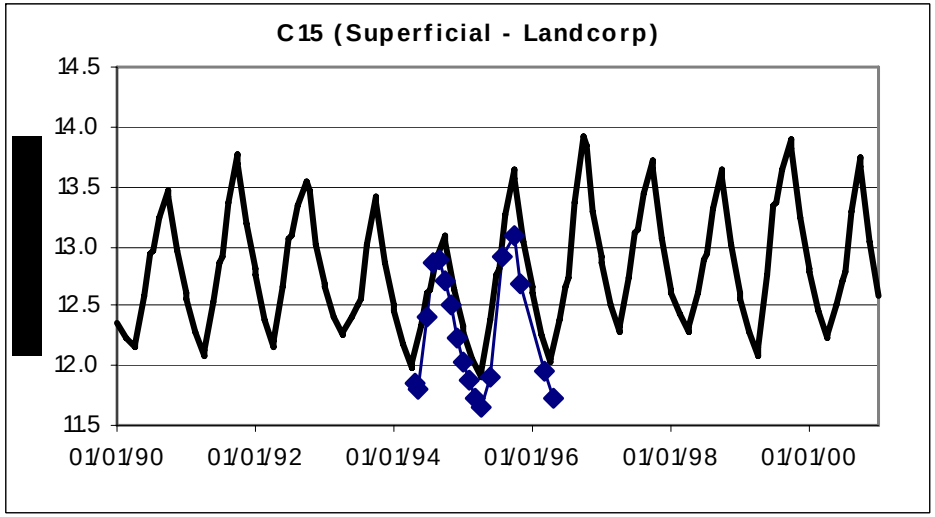
- Calibrated to 81 monitoring bores (70 in superficials, 11 in confined aquifers)

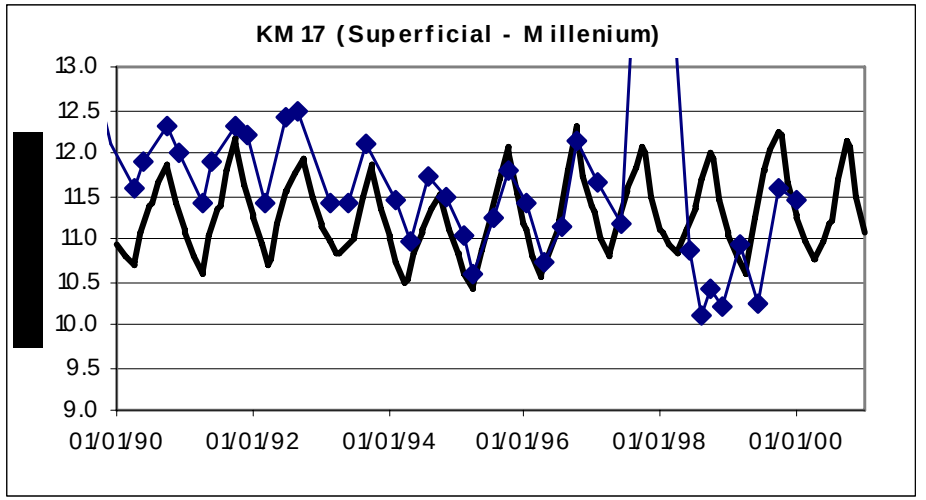
- RMS error of 3.7%
  - RMS from >2,000 data points over 11-year transient run

CALIBRATION PERFORMANCE EXAMPLES









MODEL CAPABILITY

- Sustainability of proposed abstractions
- Drawdown impacts on:
  - Nearby users
  - Key wetlands
  - Groundwater dependent vegetation
- Impacts on river-aquifer interaction, evapotranspiration and other water balance components
- Potential for inflows from the sea
- Different wellfield design scenarios
  - Minimise impacts
  - Optimise production

ECOLOGICAL WATER REQUIREMENTS (EWRs)
ENVIRONMENTAL WATER PROVISIONS (EWPs)

- WRC Policy
  - Protect water dependent ecosystems (meet EWRs if poss.)
  - Allow sustainable abstraction (provide EWP “allocations”)

- EWR Criteria
  - Original criteria related to studies from the Gnangara Mound (Froend et al, 1993)
    - Based on maximum annual, 2-year, 5-year and long term drawdown
  - Updated criteria used outcomes from basic research on Banksia woodland (the dominant natural landscape type) by Froend & Zencich (2002)
    - Based on depth to groundwater

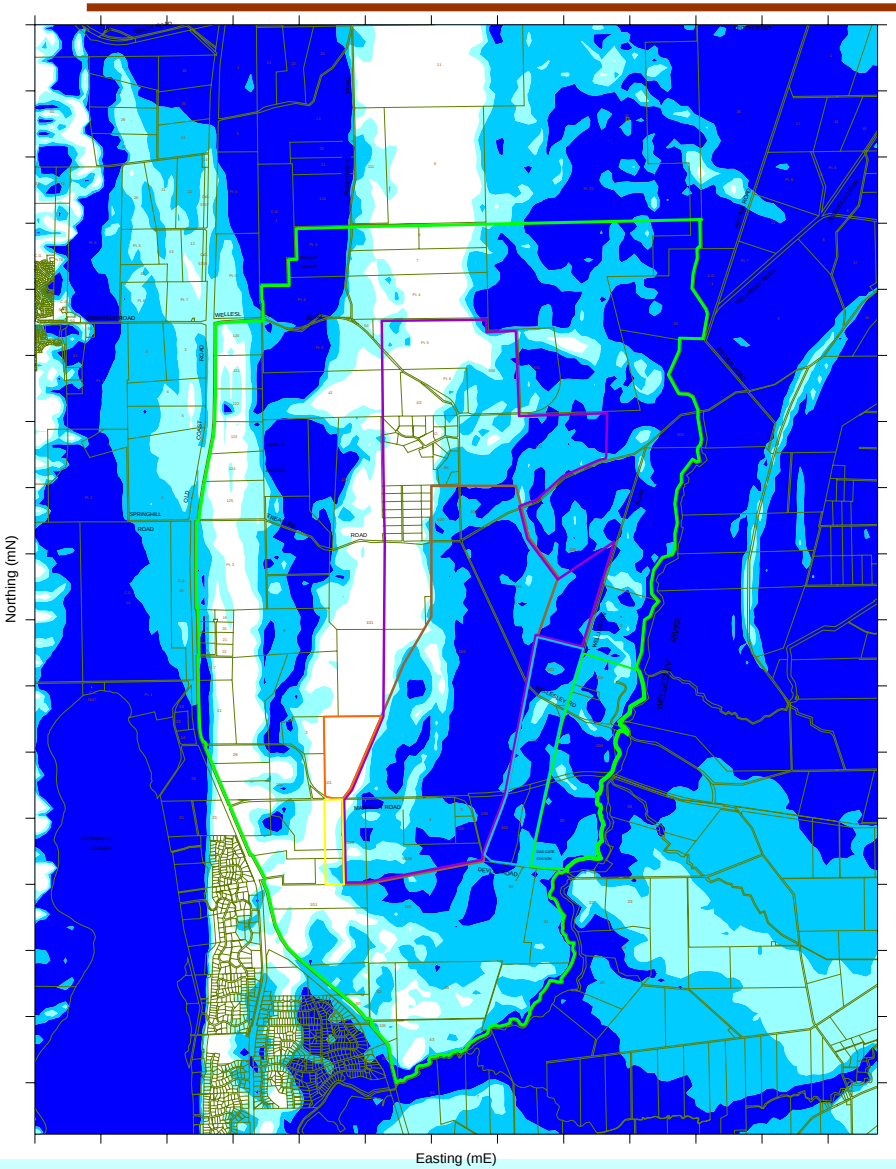
“ORIGINAL” EWR CRITERIA

Category	Description	Critical Drawdown Level
1	Long Term	1.5 m
2	Medium Term (5 year)	0.6 m
3	Short Term (2 year)	0.4 m
4	Annual	0.1 m

“NEW” EWR CRITERIA

Category	Description	Critical Drawdown Level
1	0 – 3m depth to groundwater	0.75 m
2	3 – 6m depth to groundwater	1.25 m
3	6 – 10m depth to groundwater	1.75 m
4 (wetlands)	Maximum annual drawdown Maximum allowable drawdown	0.1 m/yr 0.25 m

DEPTH TO GROUNDWATER



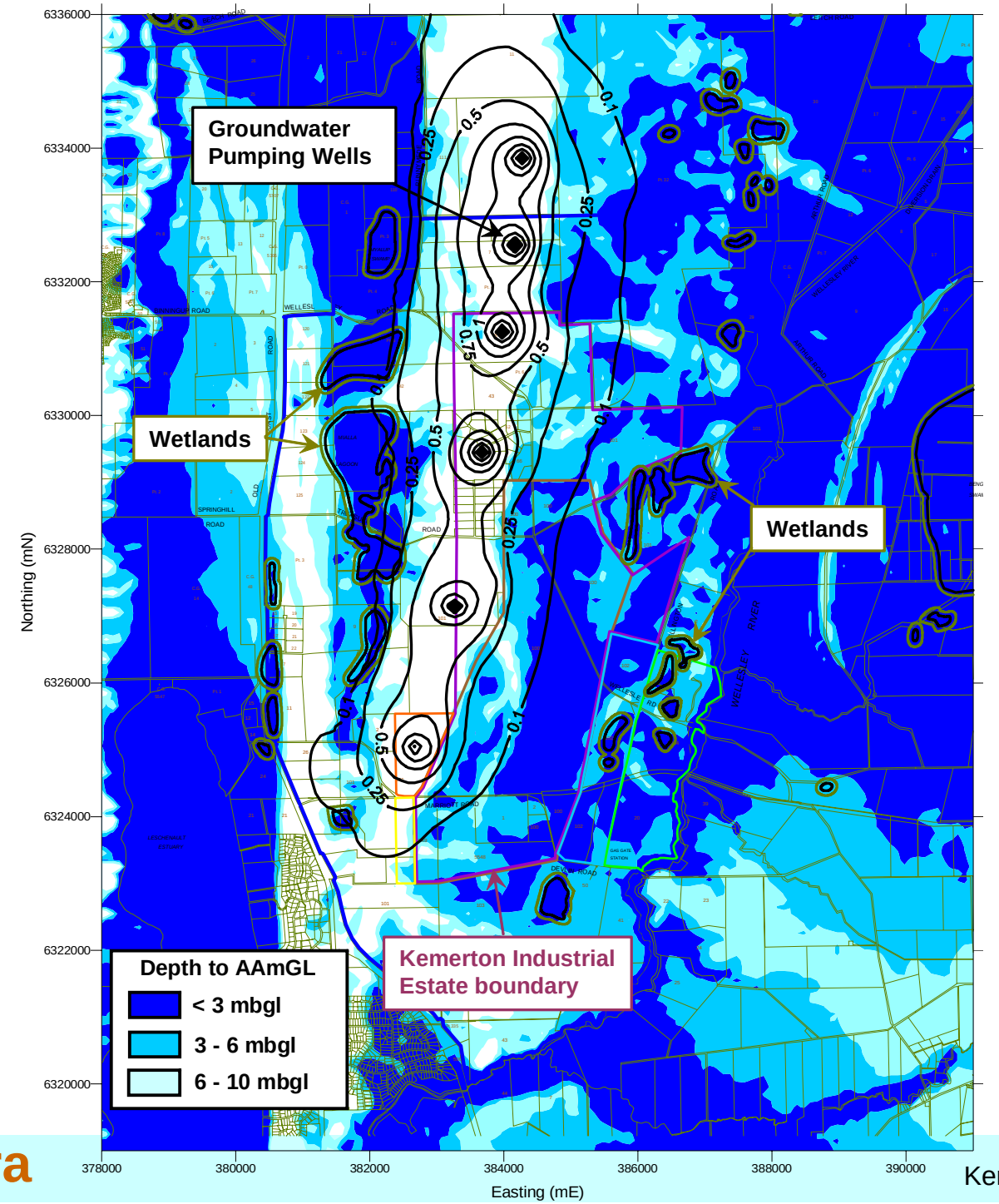
- Average annual minimum groundwater level (AAmGL)
  - Lowest level expected to occur in most areas
  - Vegetation adapted to this water table
- Developed using:
  - Monitoring data from 71 bores
  - 15km x 25km area
  - Monitoring period > 2 years
  - At least one annual summer record
- Depth to AAmGL calculated using detailed DEM on a 25m x 25m grid

WATER SUPPLY MODELLING

- Objectives:
  - Meet groundwater demand for the Estate
  - Satisfy EWR criteria
  - Minimise drawdown impacts and inflows from the coast
  - Minimise impacts on overall environmental water balance
    - River-aquifer interaction
    - Evapotranspiration (water use by GDEs)

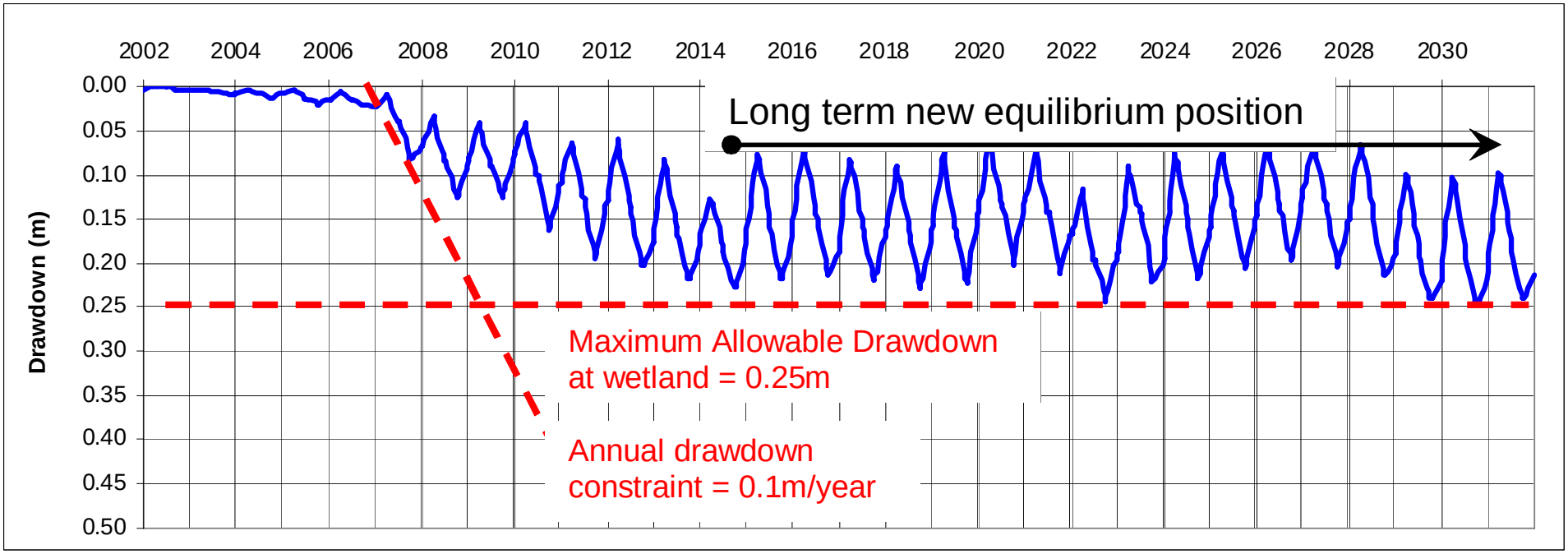
WATER SUPPLY MODELLING

- Abstraction Optimisation:
  - Limit abstraction from superficial formations (otherwise cannot satisfy EWR d/d criteria)
  - Major volume from confined Leederville Fm and Cattamarra Coal Measures (resulting in limited superficial d/d impacts)
- Abstraction from different aquifers also allows access to water of varying quality to cater for needs of different industries

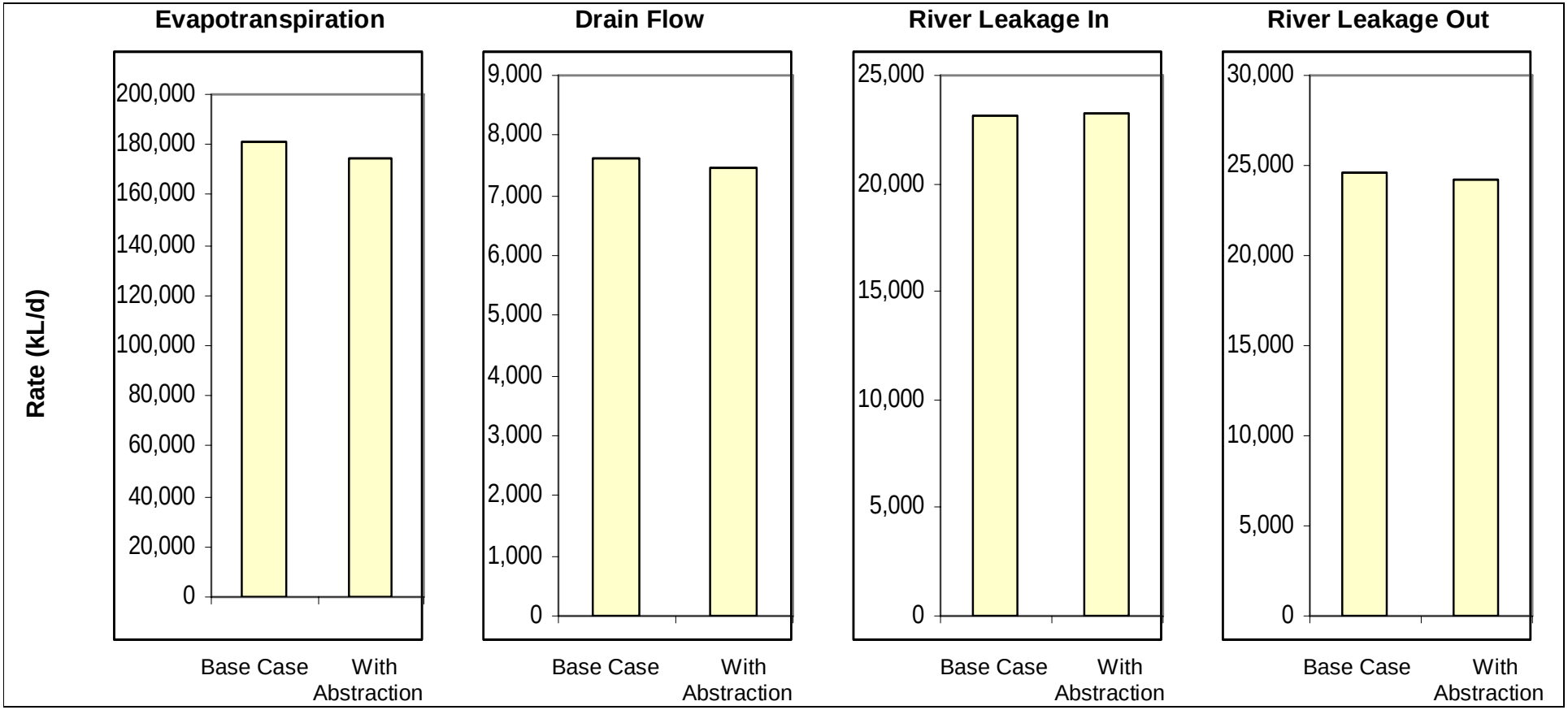

Groundwater Pumping Wells
Wetlands
Wetlands
Kemerton Industrial Estate boundary
Depth to AAmGL
< 3 mbgl
3 - 6 mbgl
6 - 10 mbgl
Northing (mN)
Easting (mE)
6336000
6334000
6332000
6330000
6328000
6326000
6324000
6322000
6320000
378000
380000
382000
384000
386000
388000
390000

Drawdown Impacts and EWRs/EWPs

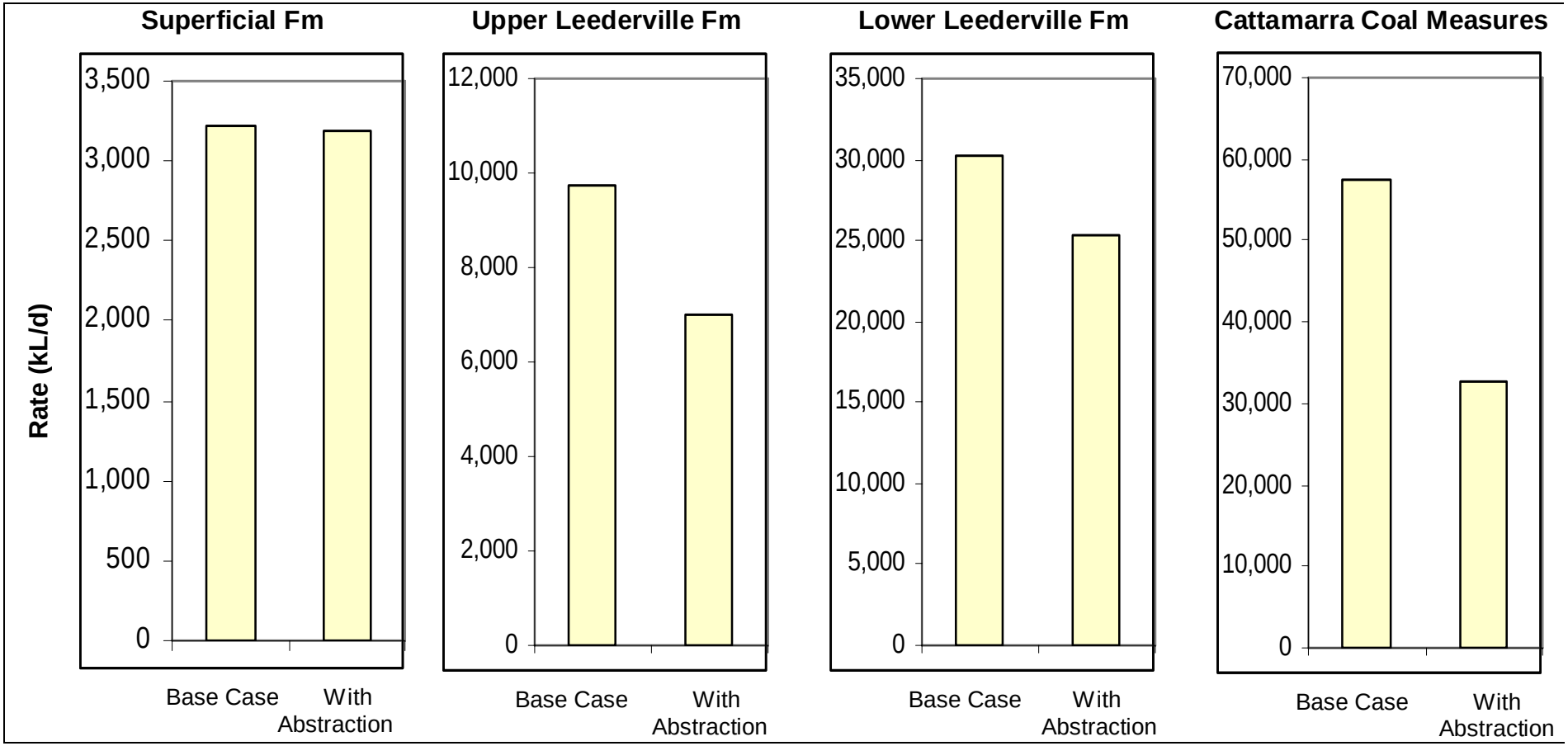
- short term d/d <0.1m/year (< annual constraint)
- long term d/d = 0.1 to 0.25m (< long term constraint)
- new equilibrium position within 20 years
- EWPs meet the EWRs in full.



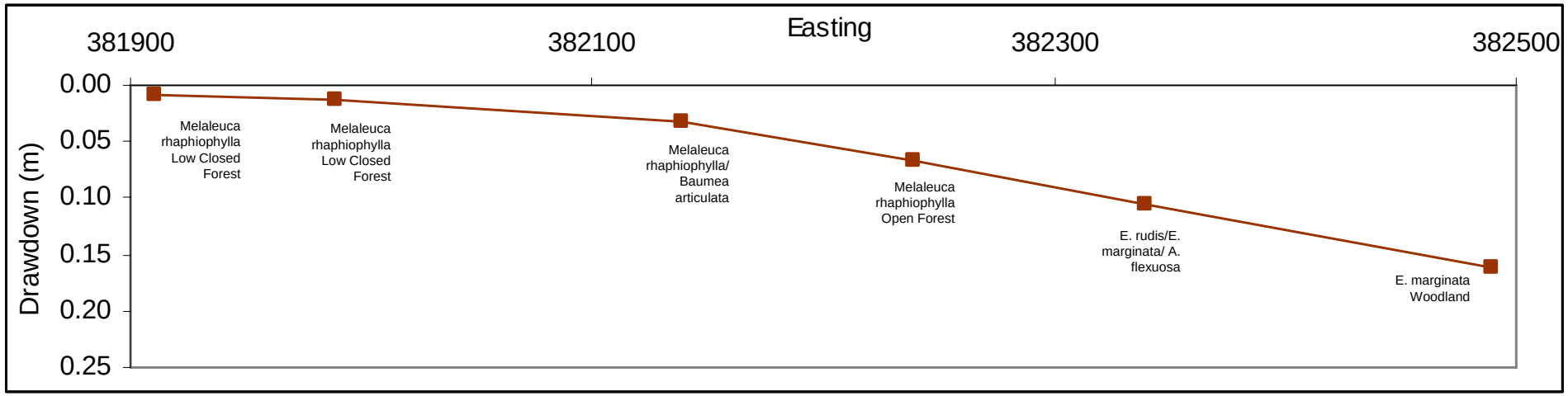
Predicted Annual Water Balance Change

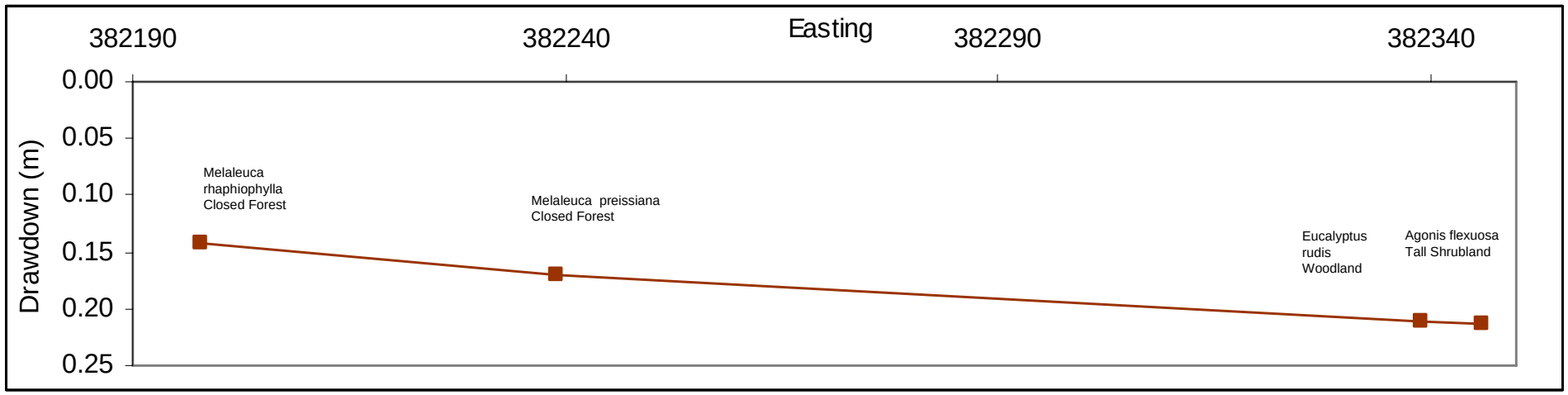


Predicted Annual Coastal Outflow Change



Wetland Veg & Drawdown Transects

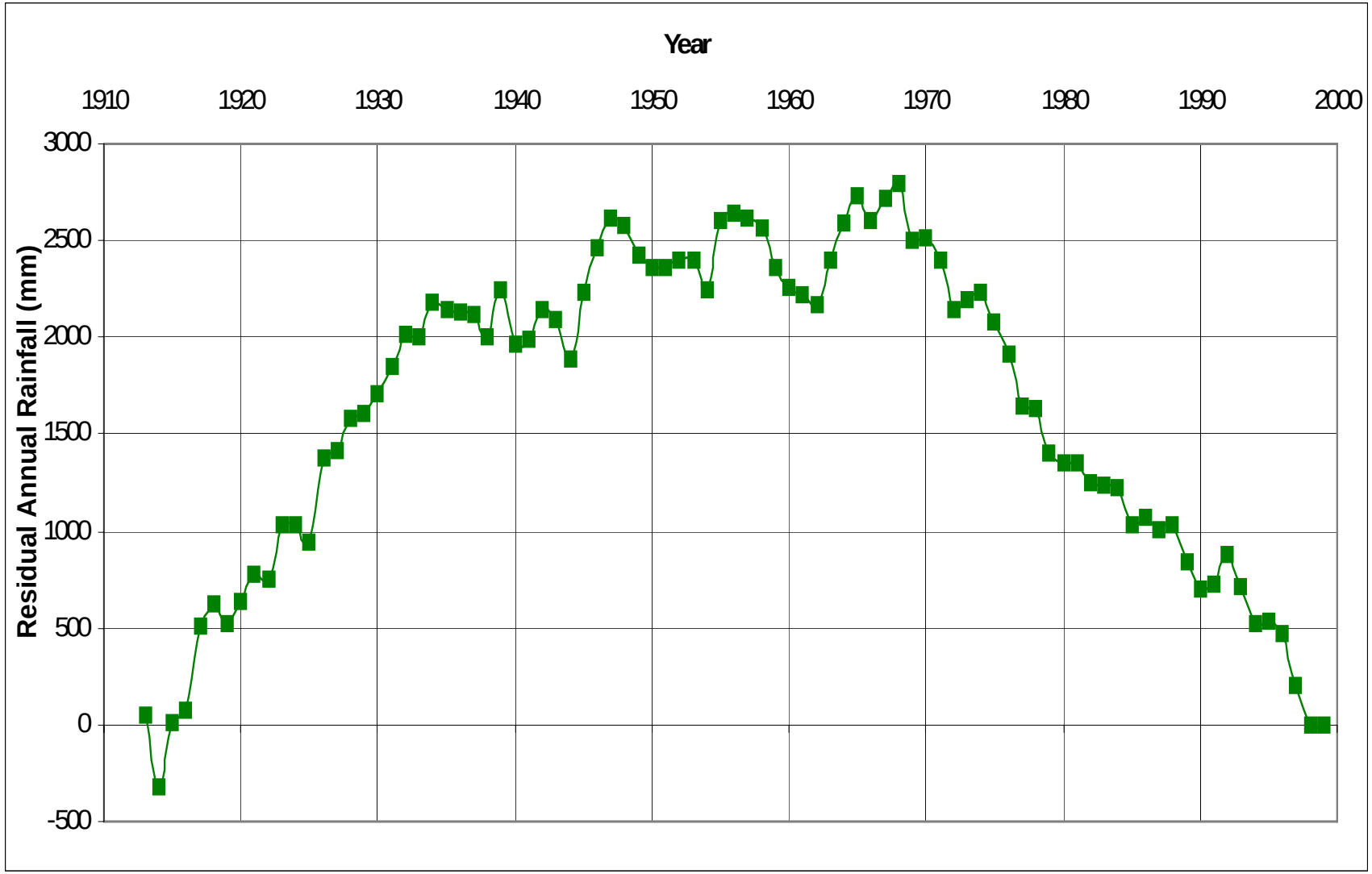




SENSITIVITY ANALYSIS

- Climate variability
  - fairly insensitive to ‘dry’ and ‘wet’ case scenarios
    - ‘Dry’ case – 10% lower than 1970-2000 rainfall
    - ‘Wet’ case – rainfall for 1914-1935
- Aquifer parameters
  - Sensitive to variations in hydraulic conductivity (horizontal and vertical), but still able to meet most of the demand for the estate
- Predicted long term impacts still within environmental constraints

RESIDUAL RAINFALL CURVE



Sustainable Outcome: EWPs meet EWRs