Mapping salt-loads of the Murray River, Australia, using airborne and in-river electromagnetic methods

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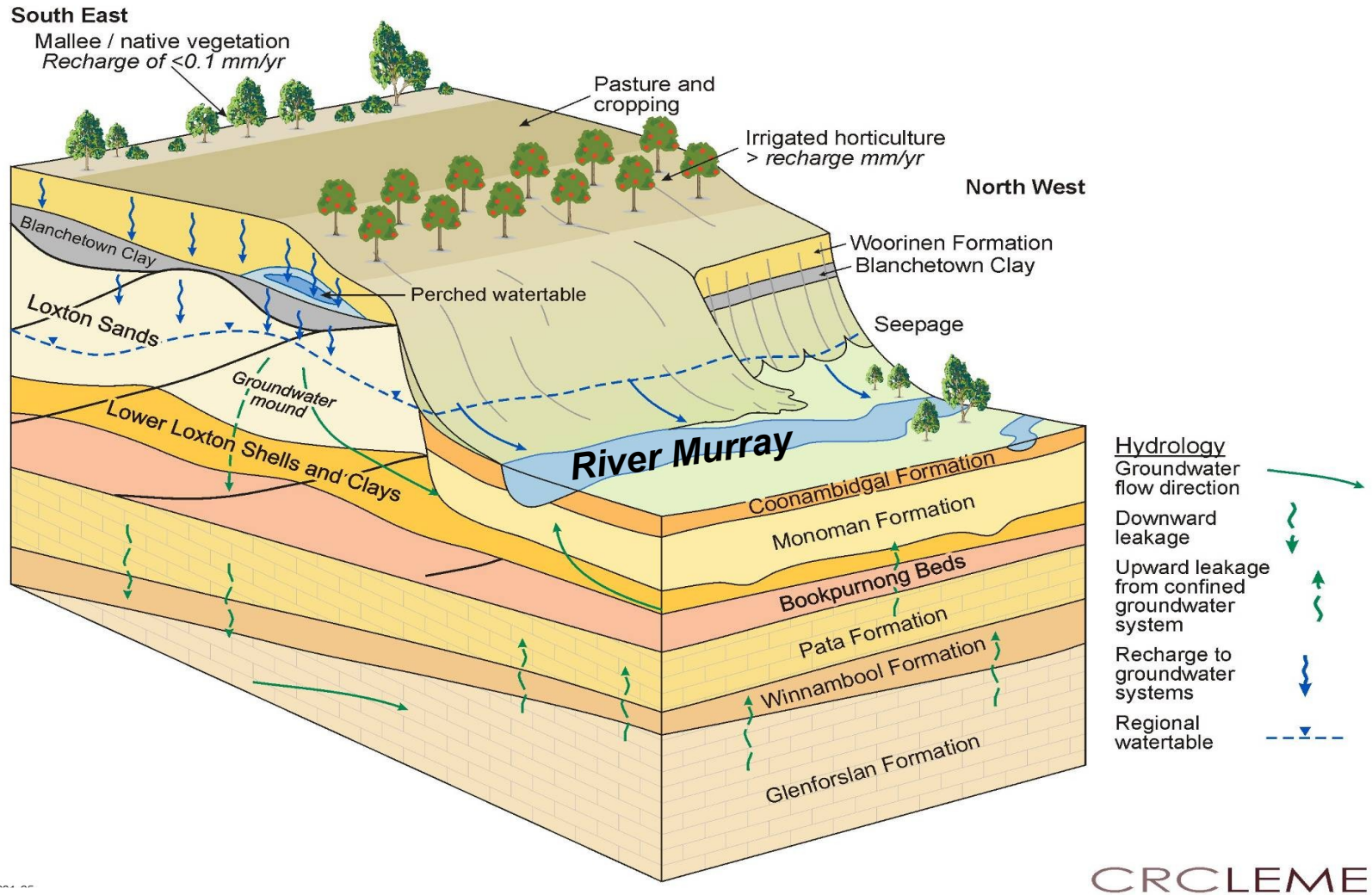
Murray River, Australia

- Highly saline groundwater (30000 g/L)
- Shallow groundwater on floodplains
- Artificially flooding to restore vegetation health
- Salt interception schemes

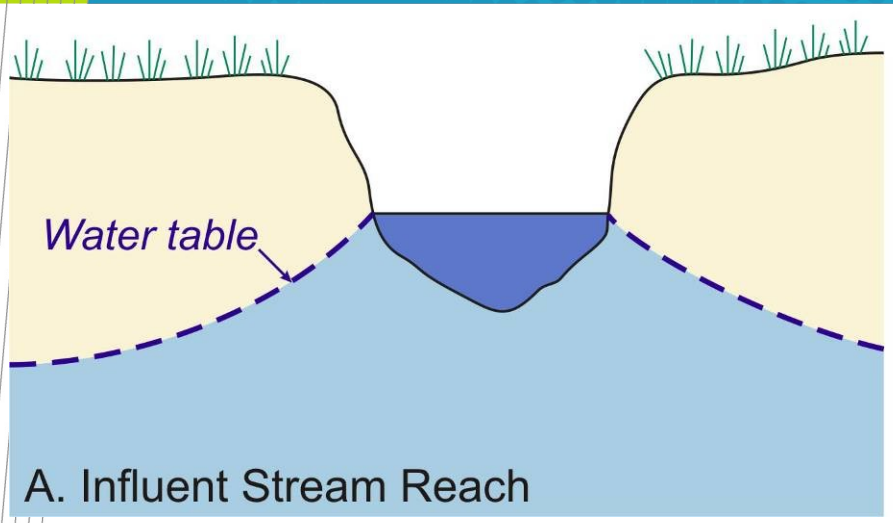
Hydrogeological Framework

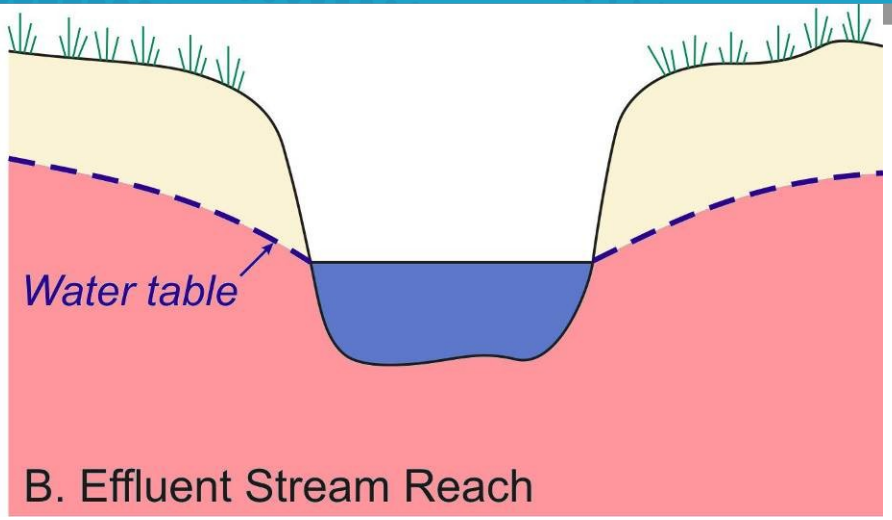


CRCLEME

Adapted from DWLBC 2004

Groundwater-surface water interactions



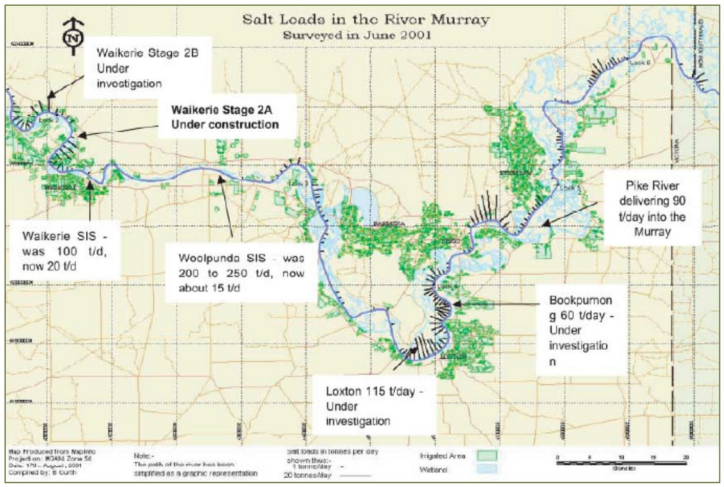


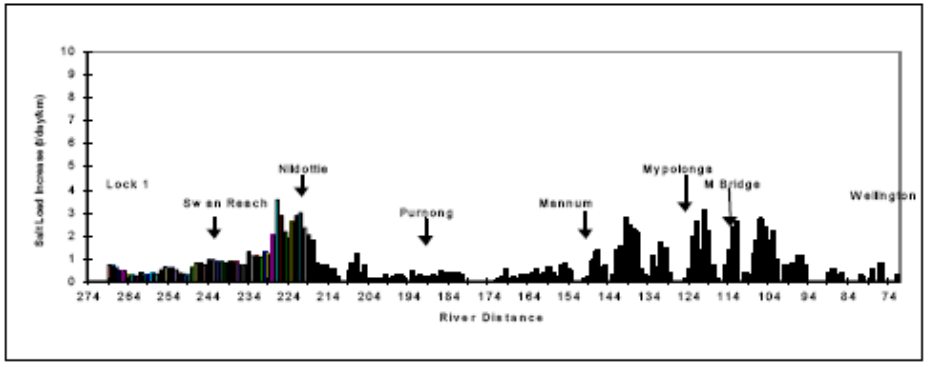
Negative baseflow "Losing stream"

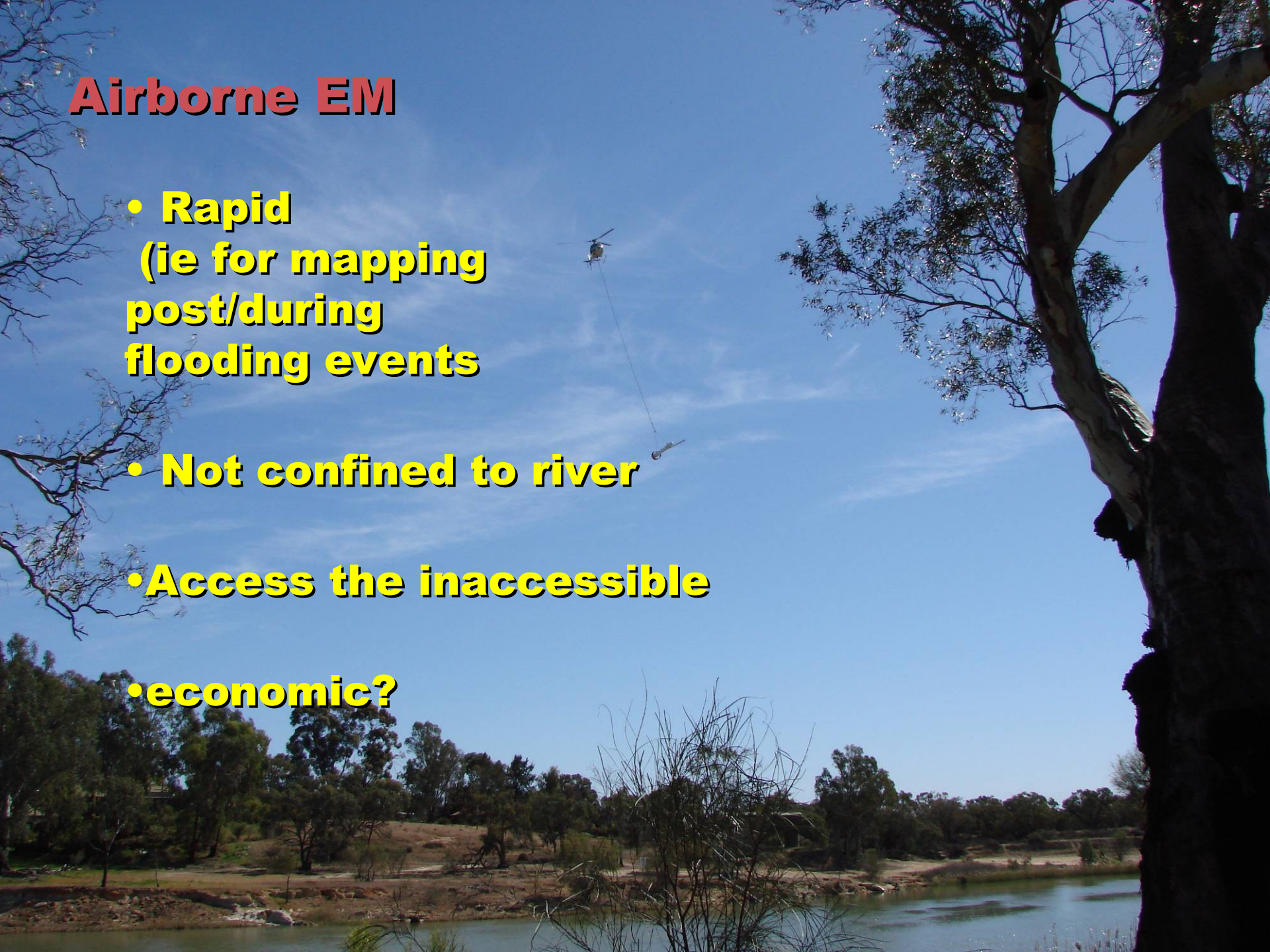
Positive baseflow "Gaining stream"

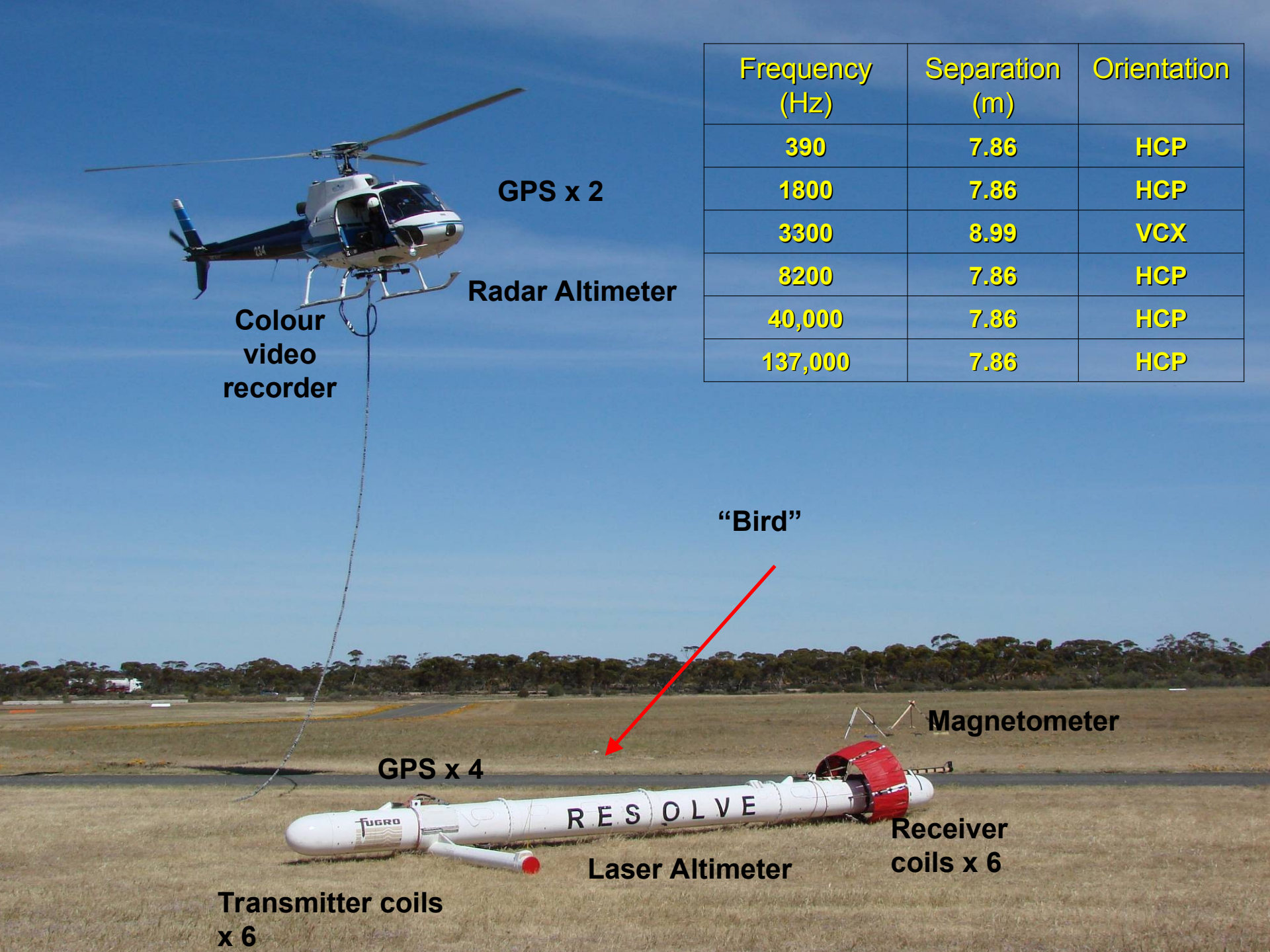
Current River Monitoring

- **Run of the river (EC profiling)**
- **In-river NanoTEM**



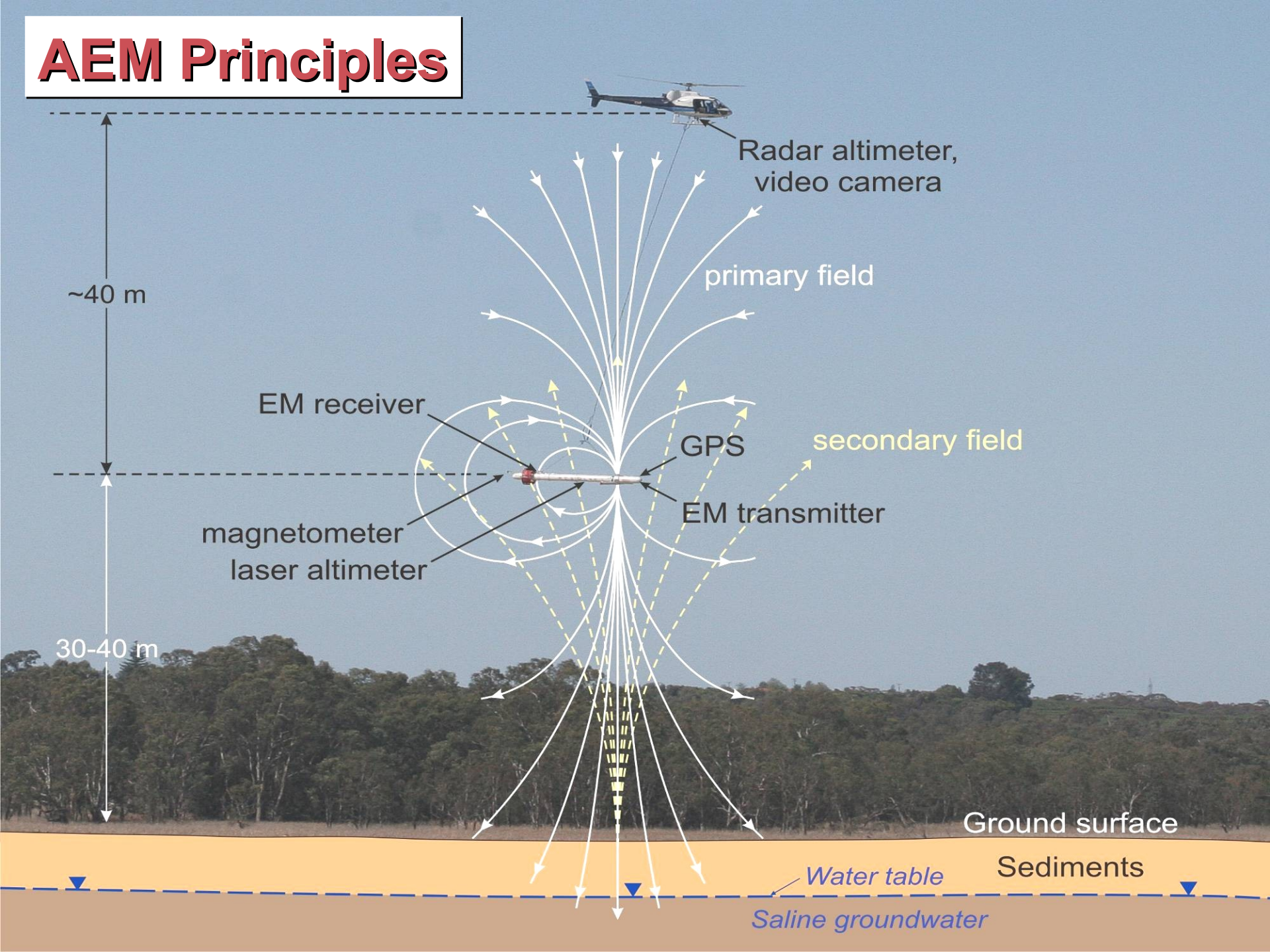


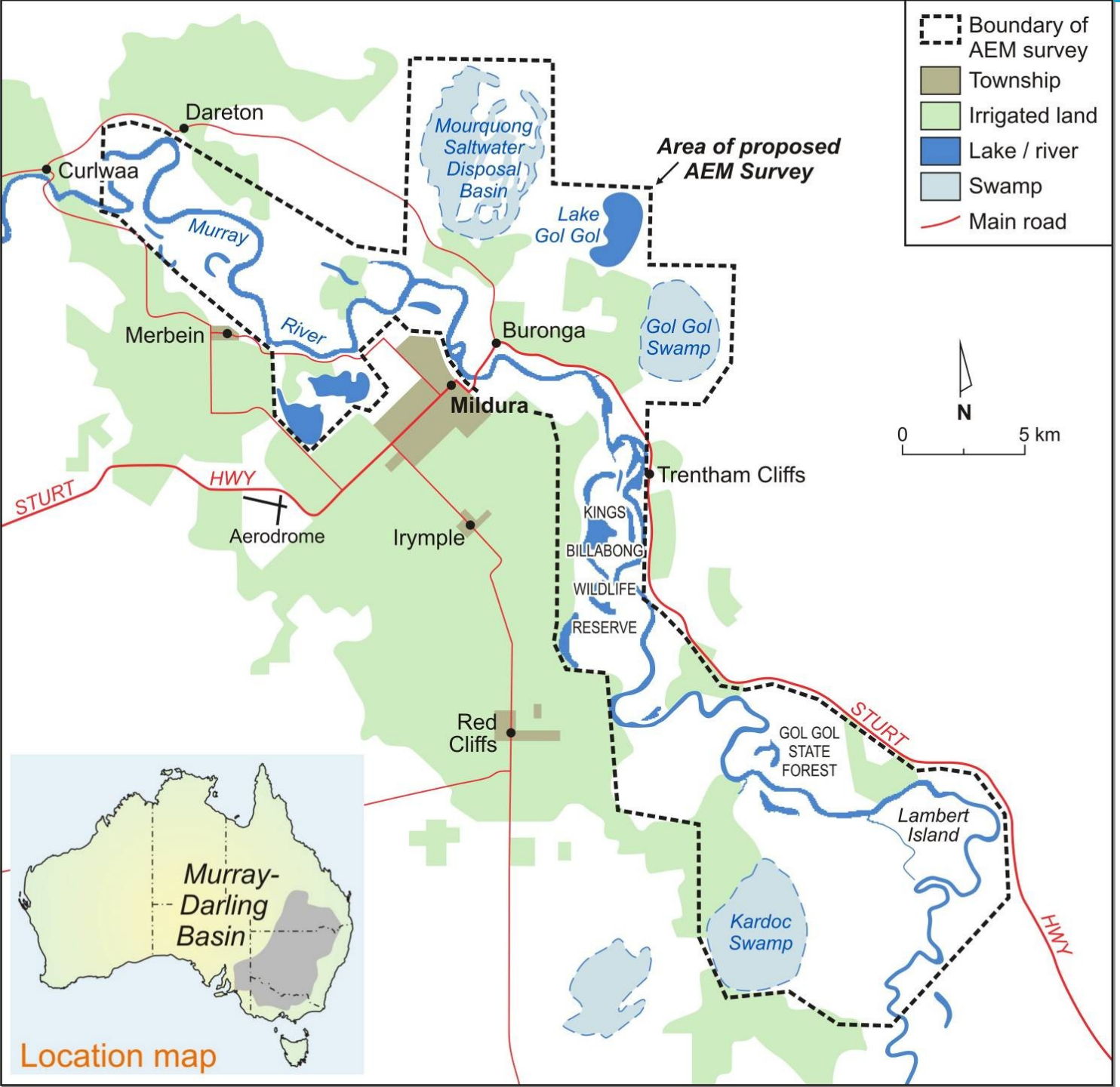

Airborne EM
• Rapid
(ie for mapping
post/during
flooding events
• Not confined to river
•Access the inaccessible
•economic?



Frequency (Hz)	Separation (m)	Orientation
390	7.86	HCP
1800	7.86	HCP
3300	8.99	VCX
8200	7.86	HCP
40,000	7.86	HCP
137,000	7.86	HCP

AEM Principles

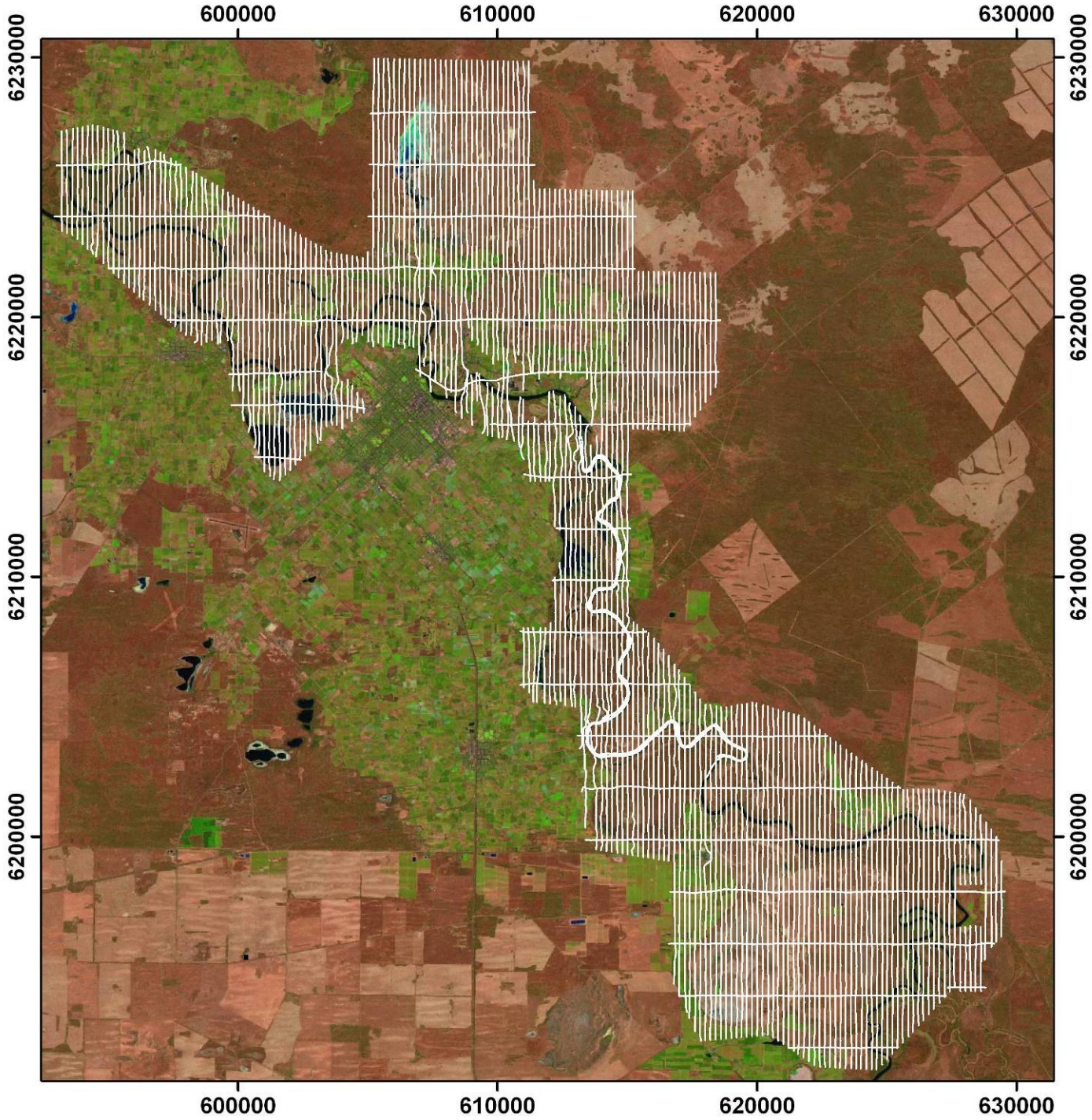




SUNRAYSIA RESOLVE SURVEY

0 2.5 5 10

Kilometers



SUNRAYSIA RESOLVE SURVEY

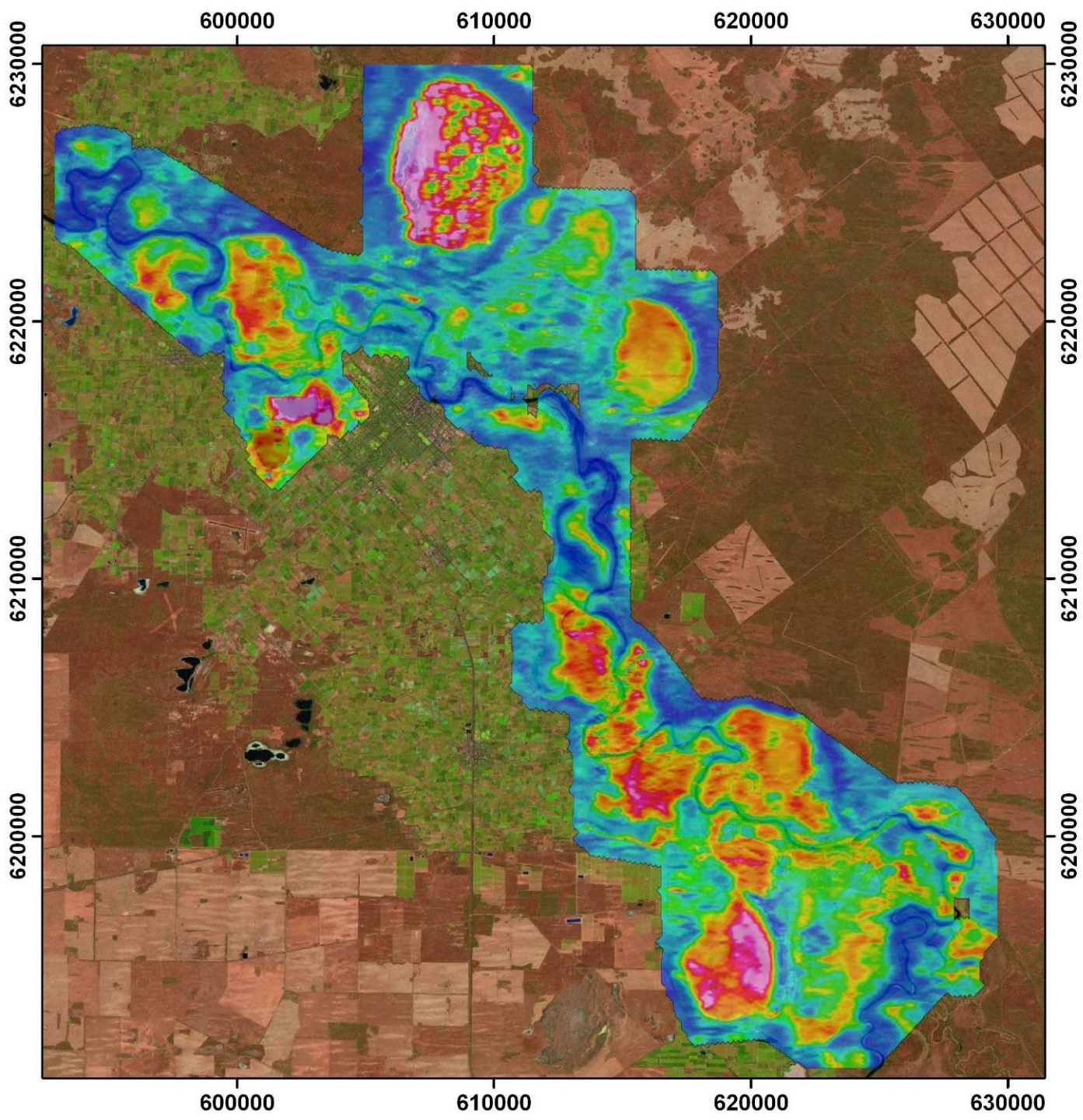
~2400 Line km

200 m line spacing

2000 m tie lines

0 2.5 5 10

Kilometers

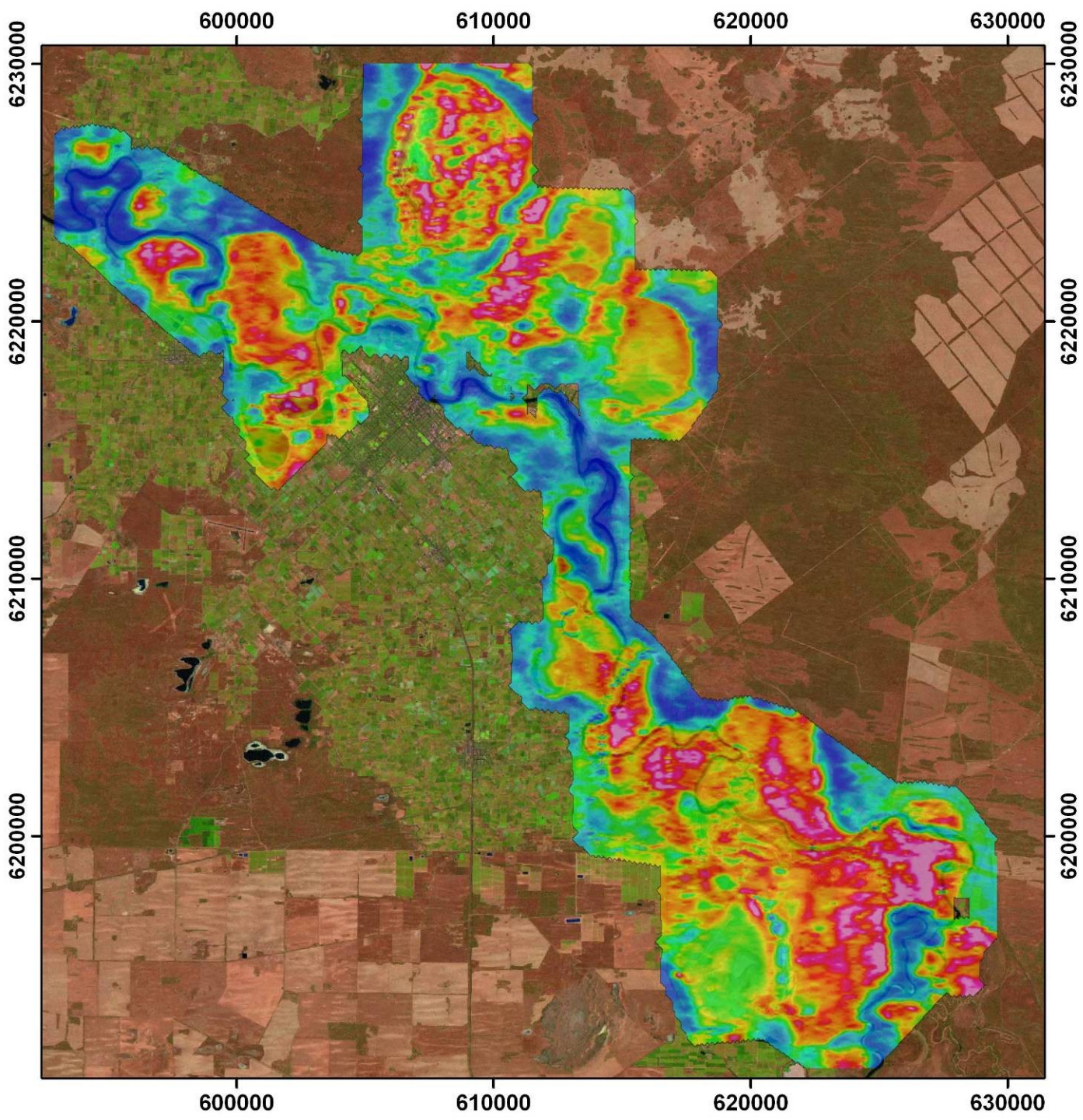


SUNRAYSIA RESOLVE SURVEY

1000
800
600
400
200
0
mS/m

0 2.5 5 10
Kilometers

Conductivity-Depth Interval 0-2 metres

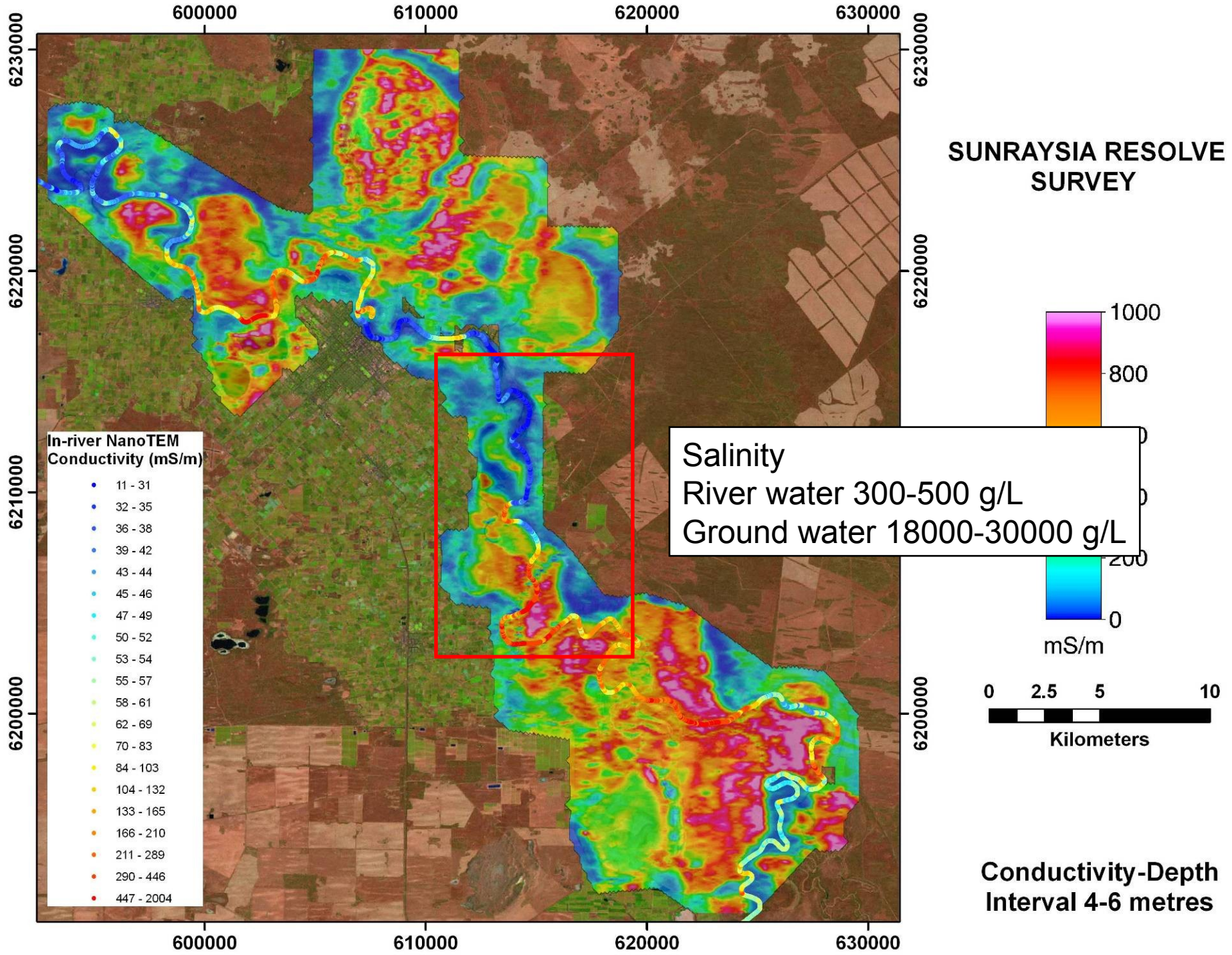


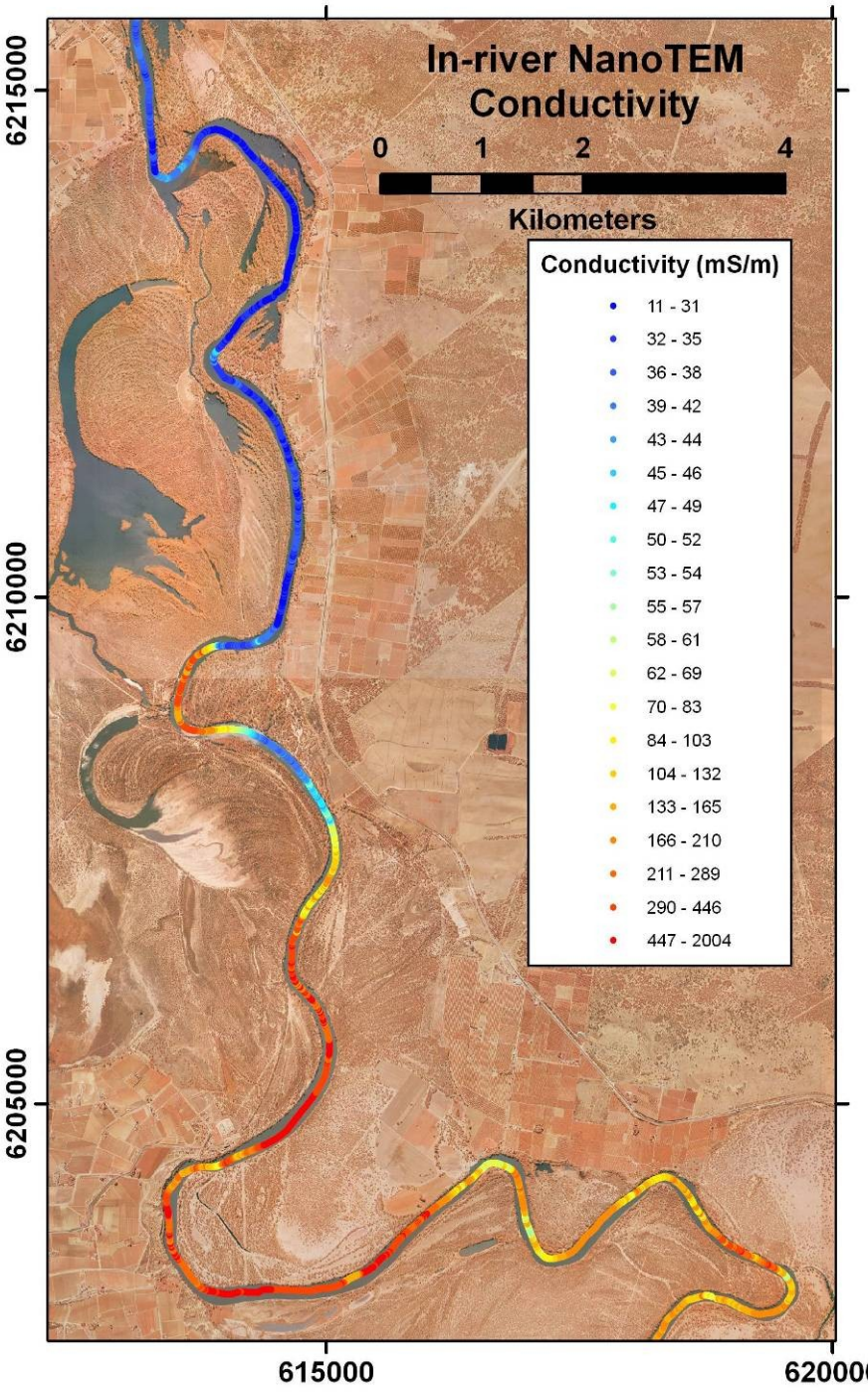
SUNRAYSIA RESOLVE SURVEY

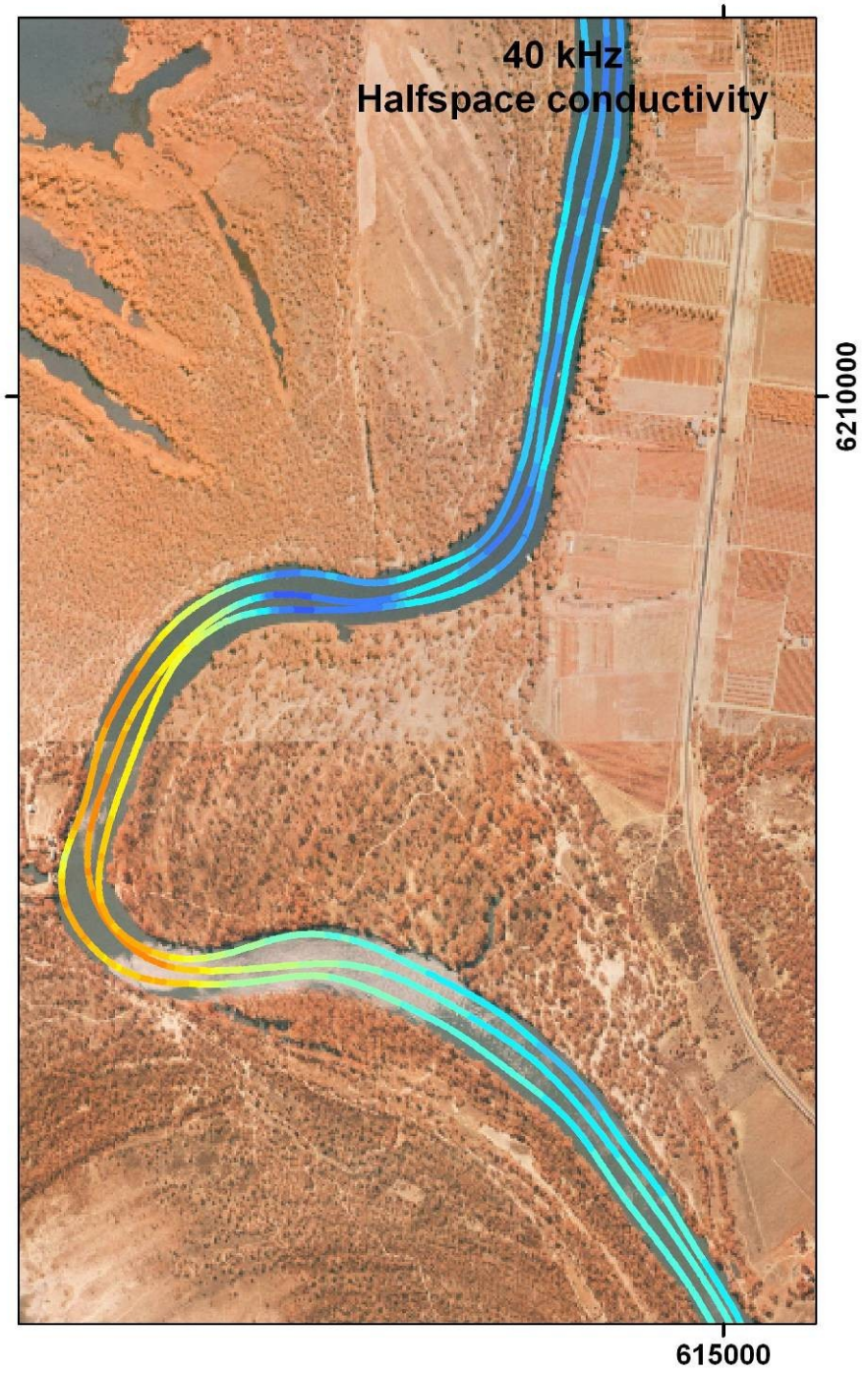
1000
800
600
400
200
0
mS/m

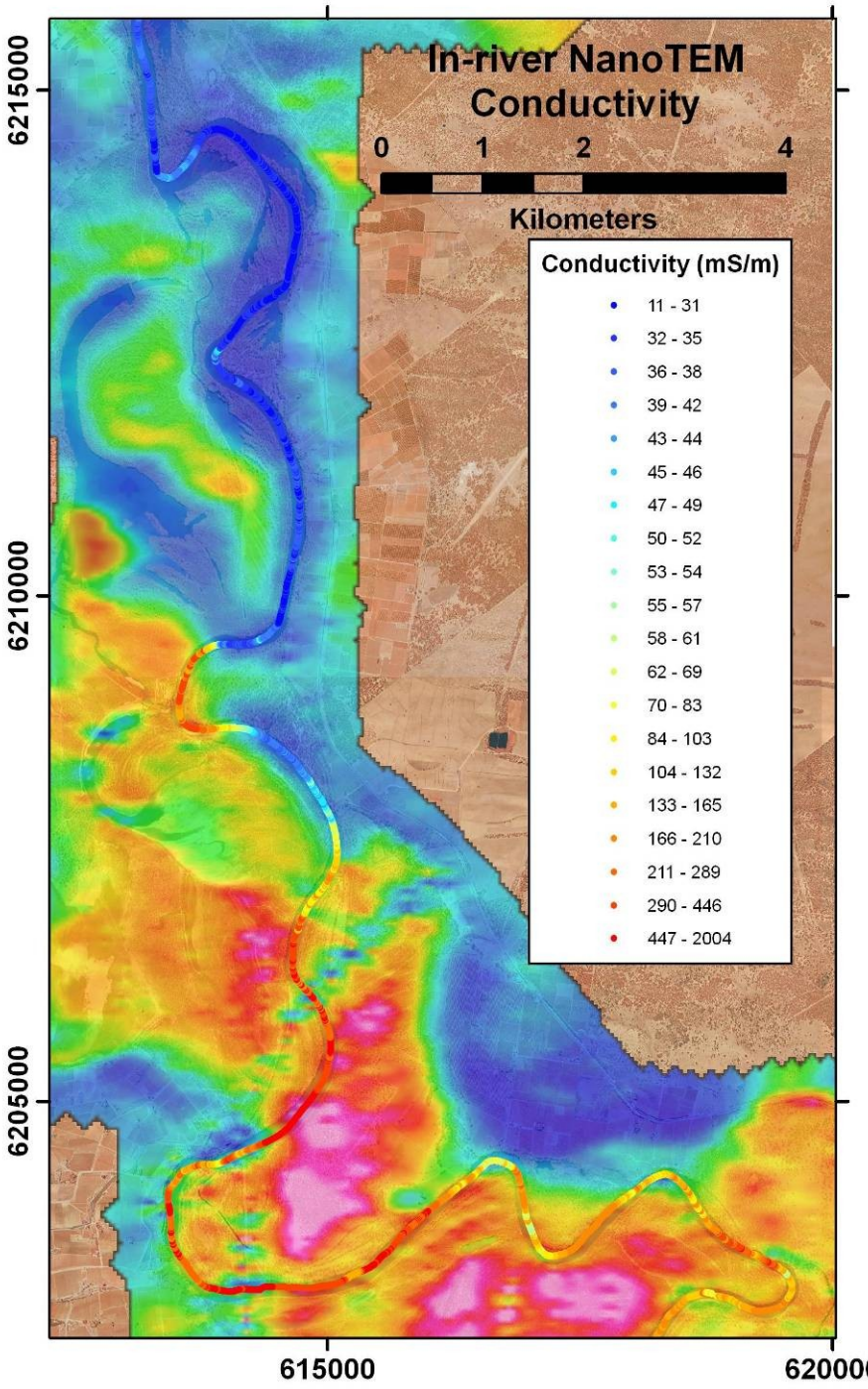
0 2.5 5 10
Kilometers

Conductivity-Depth Interval 4-6 metres


600000
610000
620000
630000
6230000
6220000
6210000
6200000
SUNRAYSIA RESOLVE SURVEY
In-river NanoTEM Conductivity (mS/m)
11 - 31
32 - 35
36 - 38
39 - 42
43 - 44
45 - 46
47 - 49
50 - 52
53 - 54
55 - 57
58 - 61
62 - 69
70 - 83
84 - 103
104 - 132
133 - 165
166 - 210
211 - 289
290 - 446
447 - 2004
Salinity
River water 300-500 g/L
Ground water 18000-30000 g/L
1000
800
200
0
mS/m
0 2.5 5 10
Kilometers
Conductivity-Depth Interval 4-6 metres


In-river NanoTEM
Conductivity
0 1 2 4
Kilometers
Conductivity (mS/m)
11 - 31
32 - 35
36 - 38
39 - 42
43 - 44
45 - 46
47 - 49
50 - 52
53 - 54
55 - 57
58 - 61
62 - 69
70 - 83
84 - 103
104 - 132
133 - 165
166 - 210
211 - 289
290 - 446
447 - 2004
6215000
6210000
6205000
615000
620000


40 kHz
Halfspace conductivity
6210000
615000


In-river NanoTEM
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Kilometers
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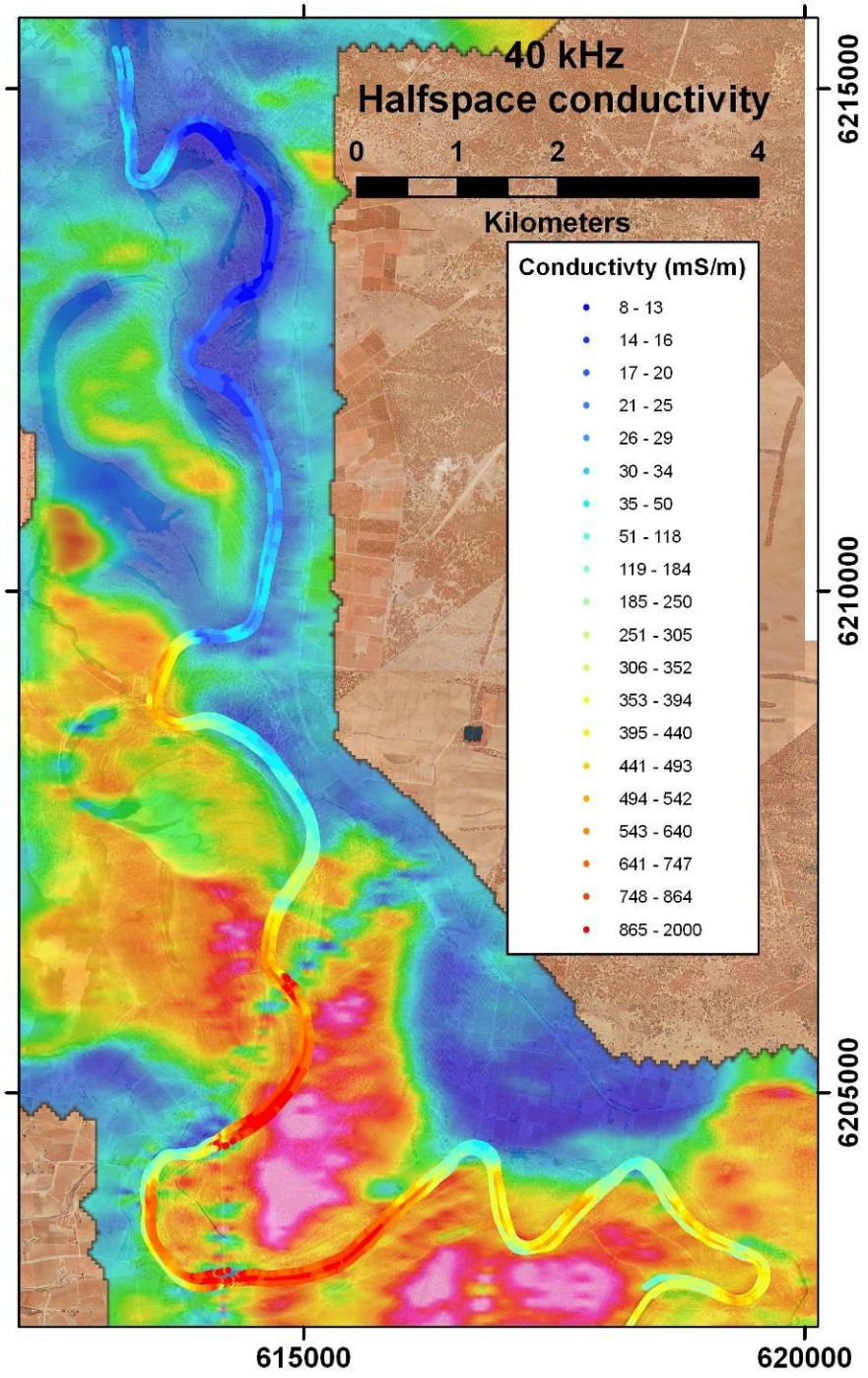
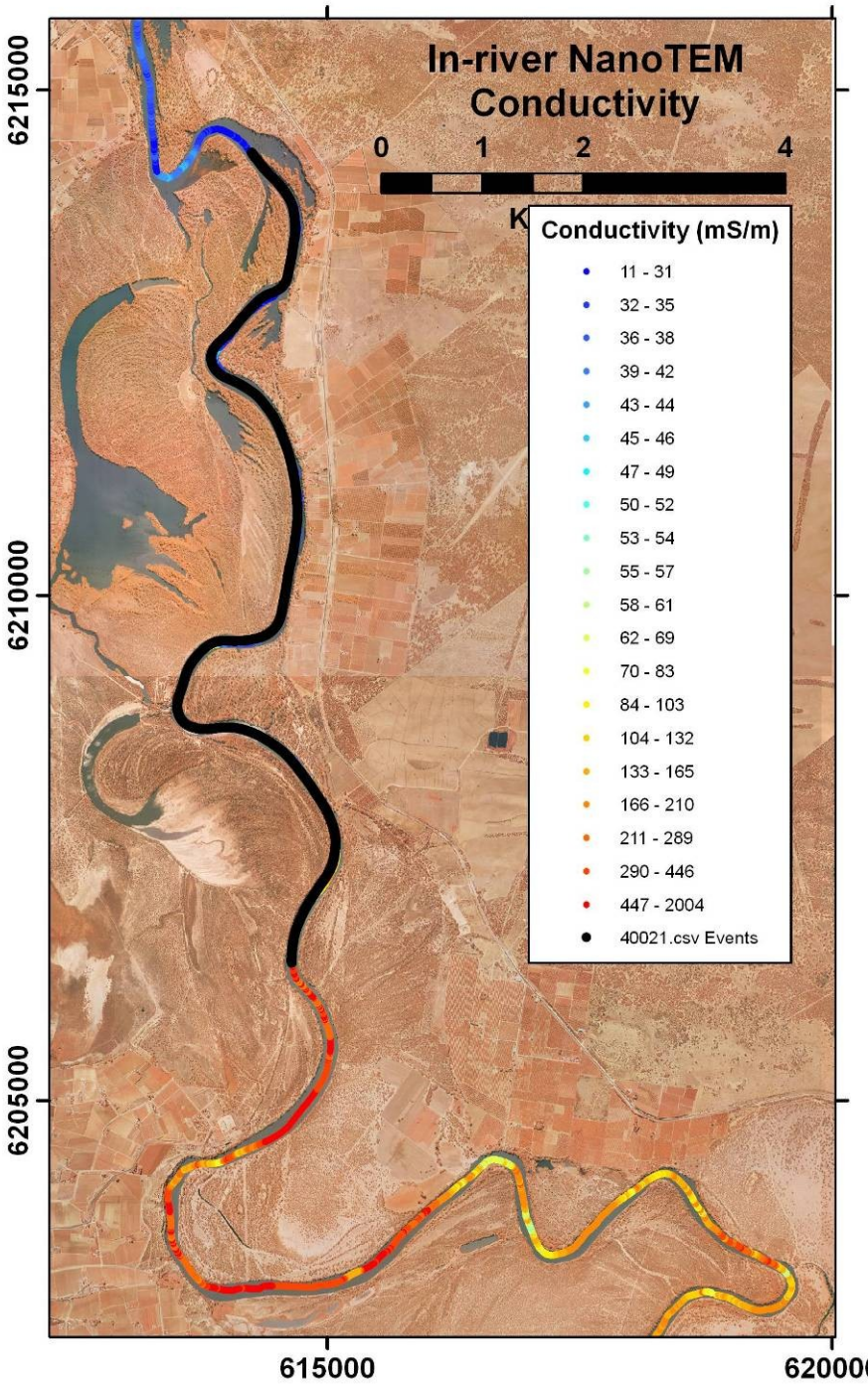
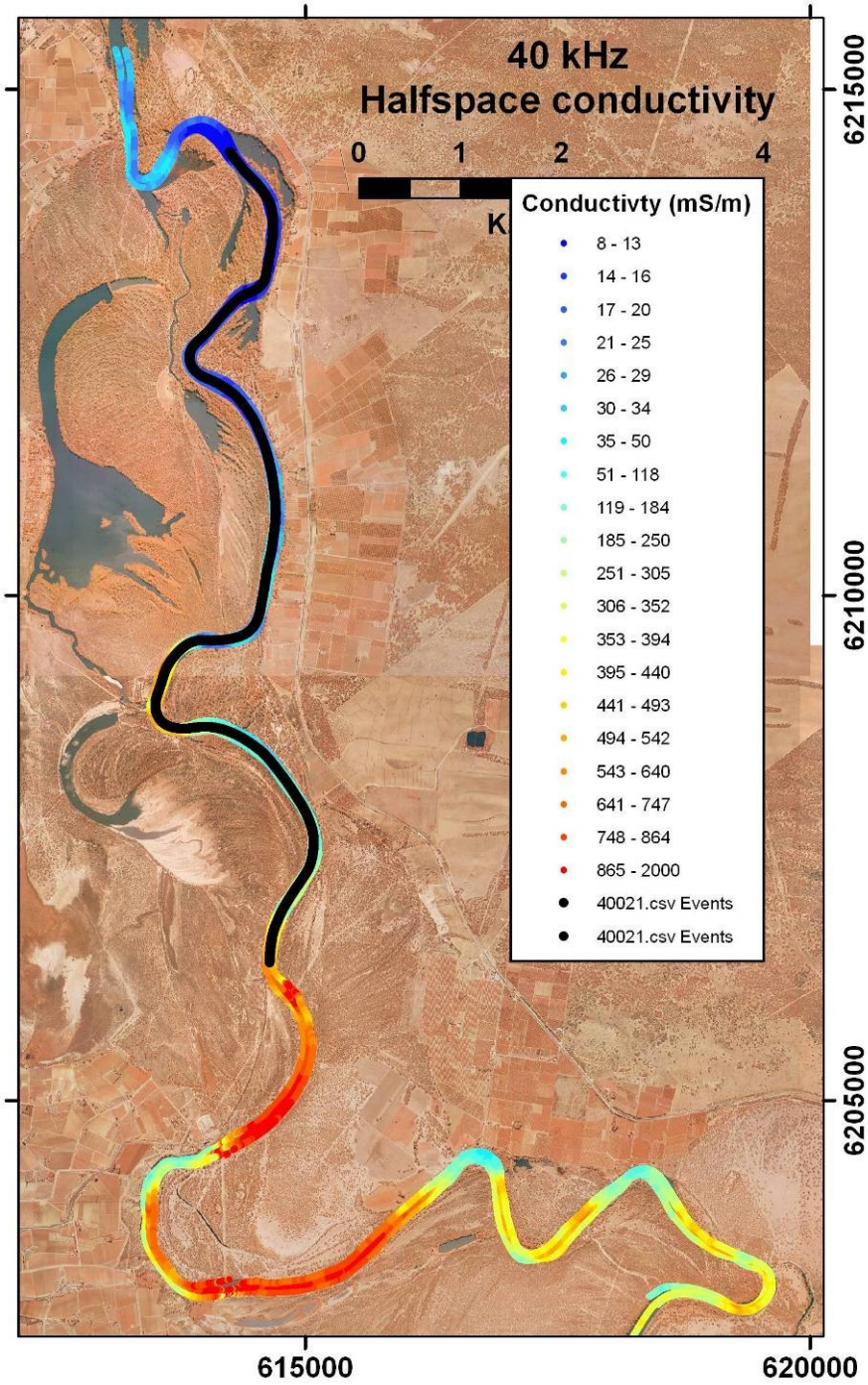
104 - 132
133 - 165
166 - 210
211 - 289
290 - 446
447 - 2004
6215000
6210000
6205000
615000
620000


40 kHz
Halfspace conductivity
0 1 2 4
Kilometers
Conductivty (mS/m)
8 - 13
14 - 16
17 - 20
21 - 25
26 - 29
30 - 34
35 - 50
51 - 118
119 - 184
185 - 250
251 - 305
306 - 352
353 - 394
395 - 440
441 - 493
494 - 542
543 - 640
641 - 747
748 - 864
865 - 2000
6215000
6210000
6205000
615000
620000


In-river NanoTEM
Conductivity
0
1
2
4
K
Conductivity (mS/m)
11 - 31
32 - 35
36 - 38
39 - 42
43 - 44
45 - 46
47 - 49
50 - 52
53 - 54
55 - 57
58 - 61
62 - 69
70 - 83
84 - 103
104 - 132
133 - 165
166 - 210
211 - 289
290 - 446
447 - 2004
40021.csv Events
6215000
6210000
6205000
615000
620000


40 kHz
Halfspace conductivity
0
1
2
4
K
Conductivty (mS/m)
8 - 13
14 - 16
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40021.csv Events
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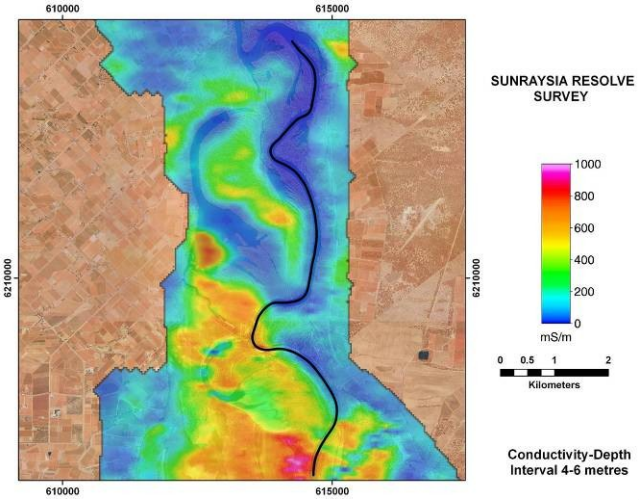
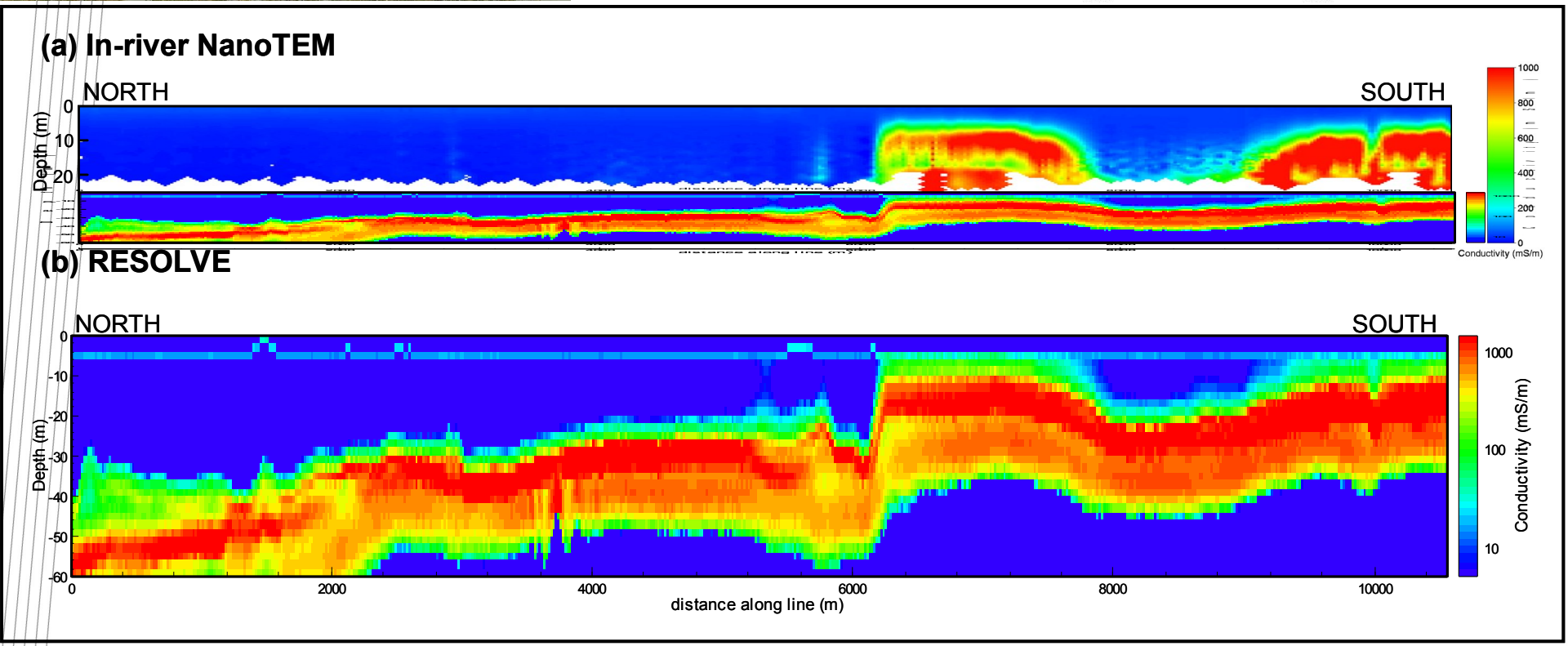
6215000
6210000
6205000
615000
620000

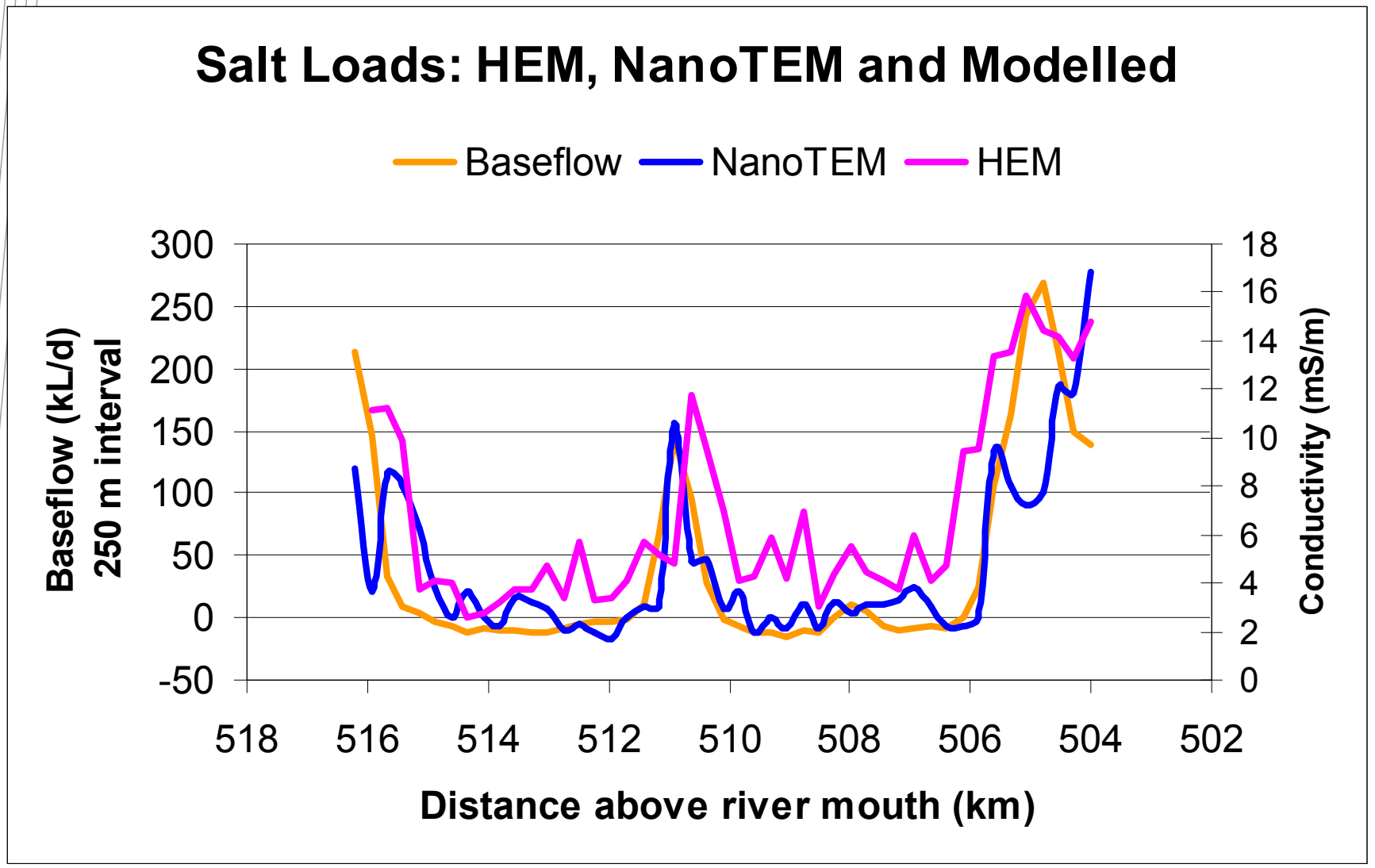




Conductivity model: In-river NanoTEM 1D inversion

RESOLVE Conductivity depth transform

Model validation (from previous survey)



Costings for Swath Approach

In-river NanoTEM
+ Land NanoTEM

50 km in-river a day
1 km a day land NanoTEM

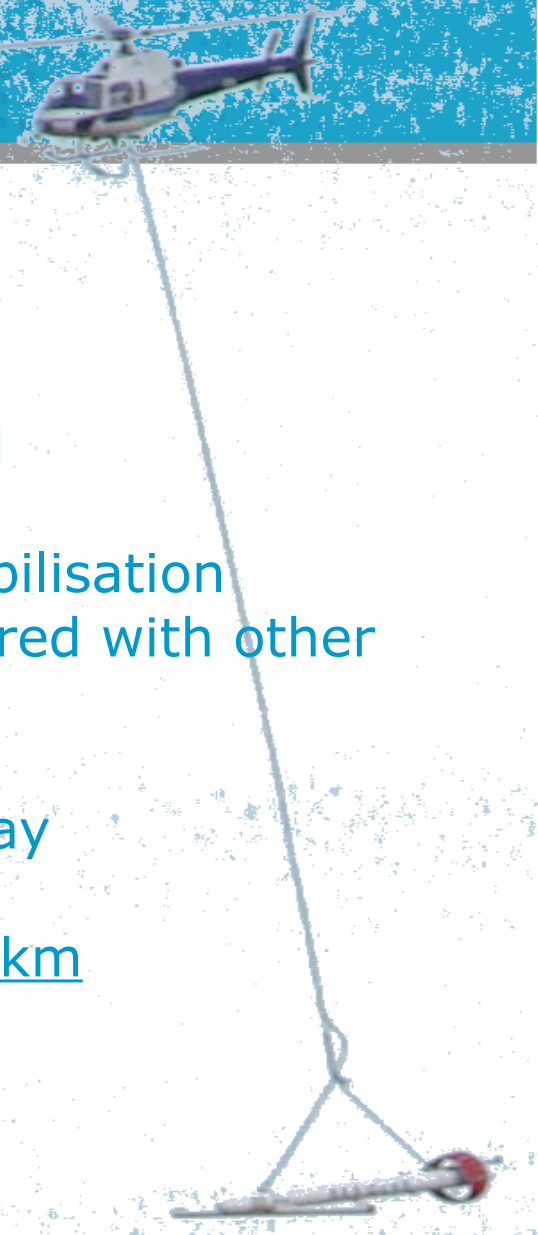
$60 a line km in-river
$2000 a line km land

Airborne EM

$30000 mobilisation
(can be shared with other clients)

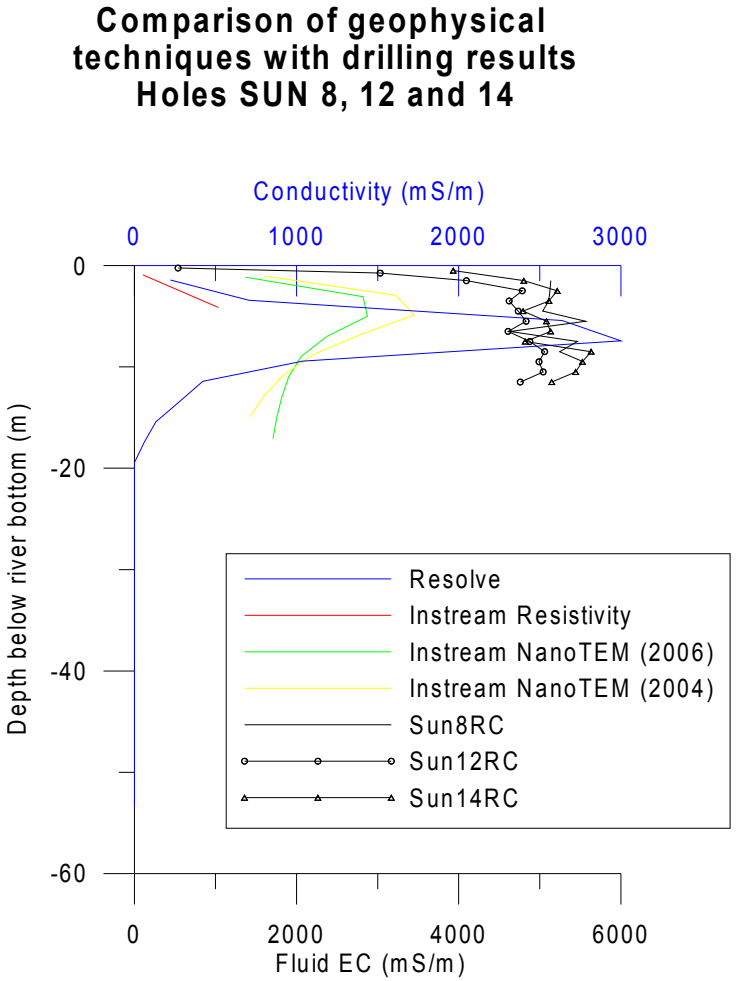
300 km a day

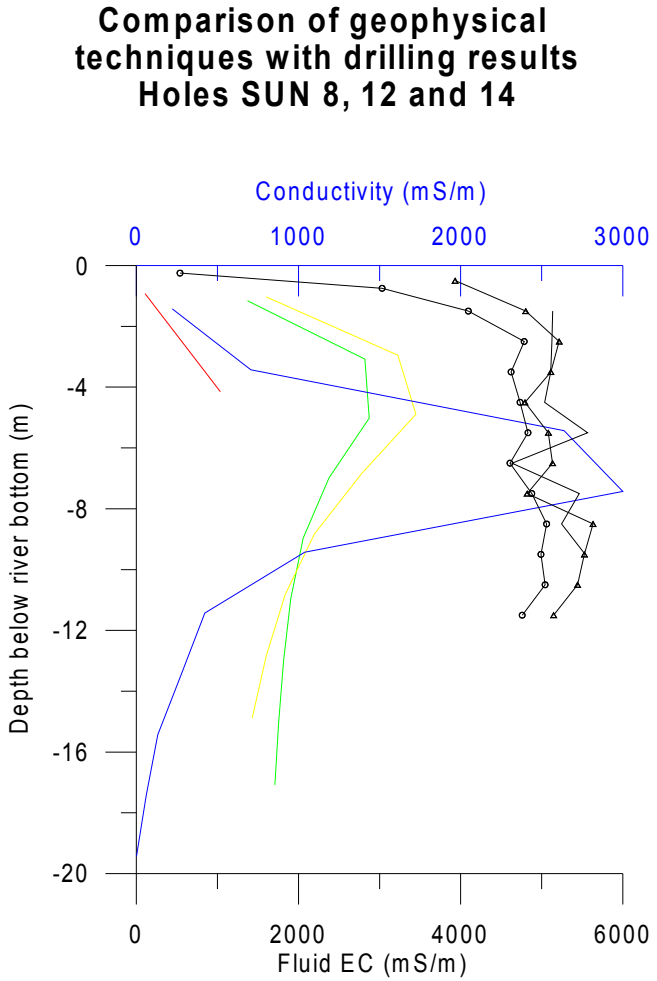
$120 a line km



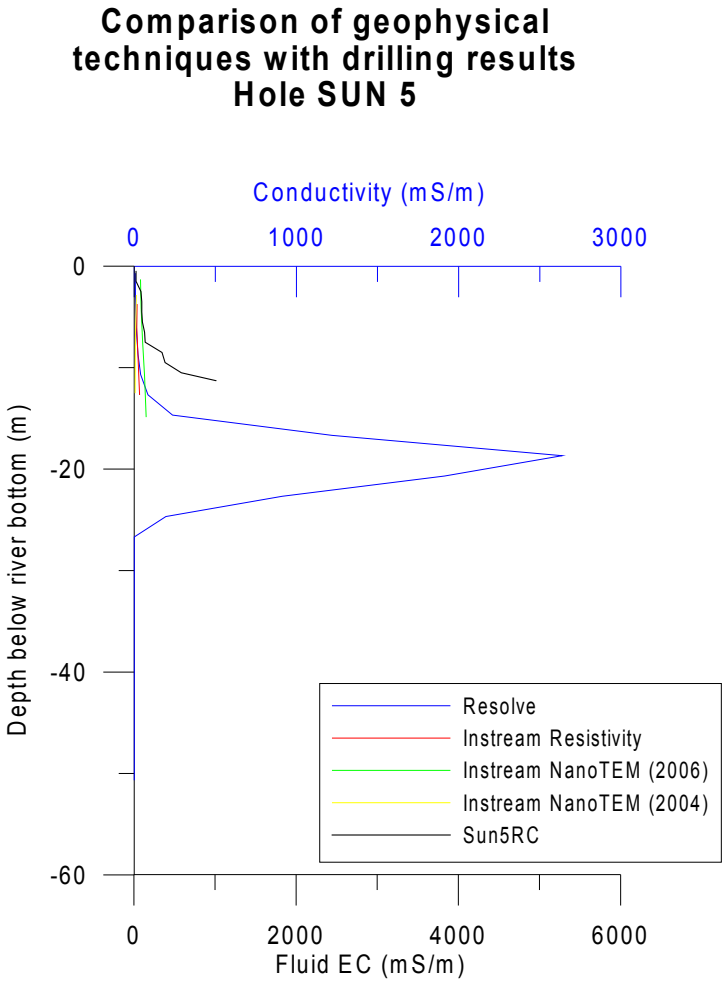
Further work- validation…

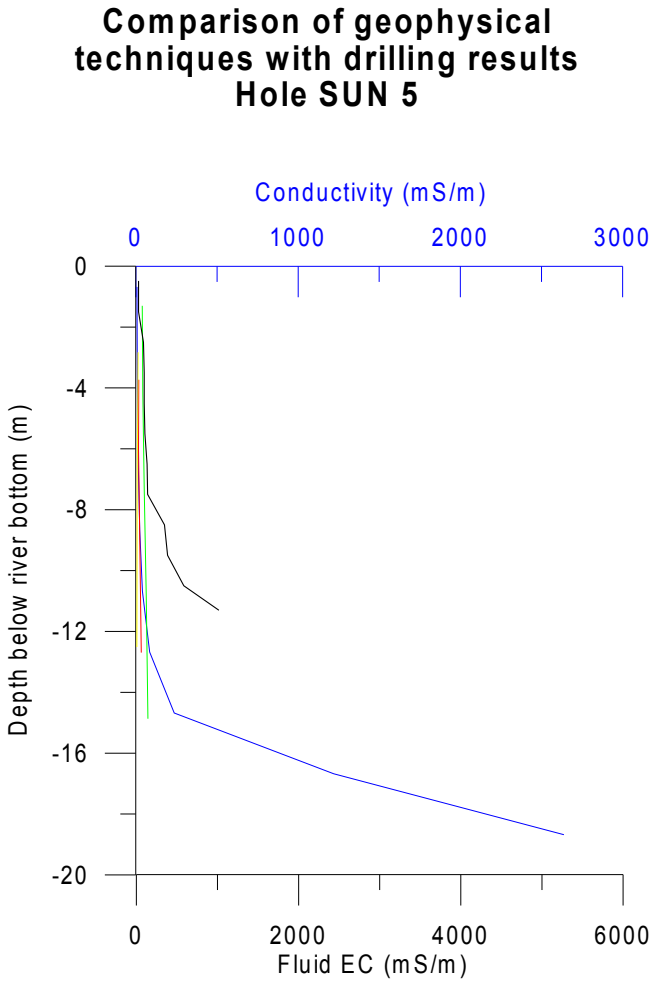
Results from drilling- gaining stretch



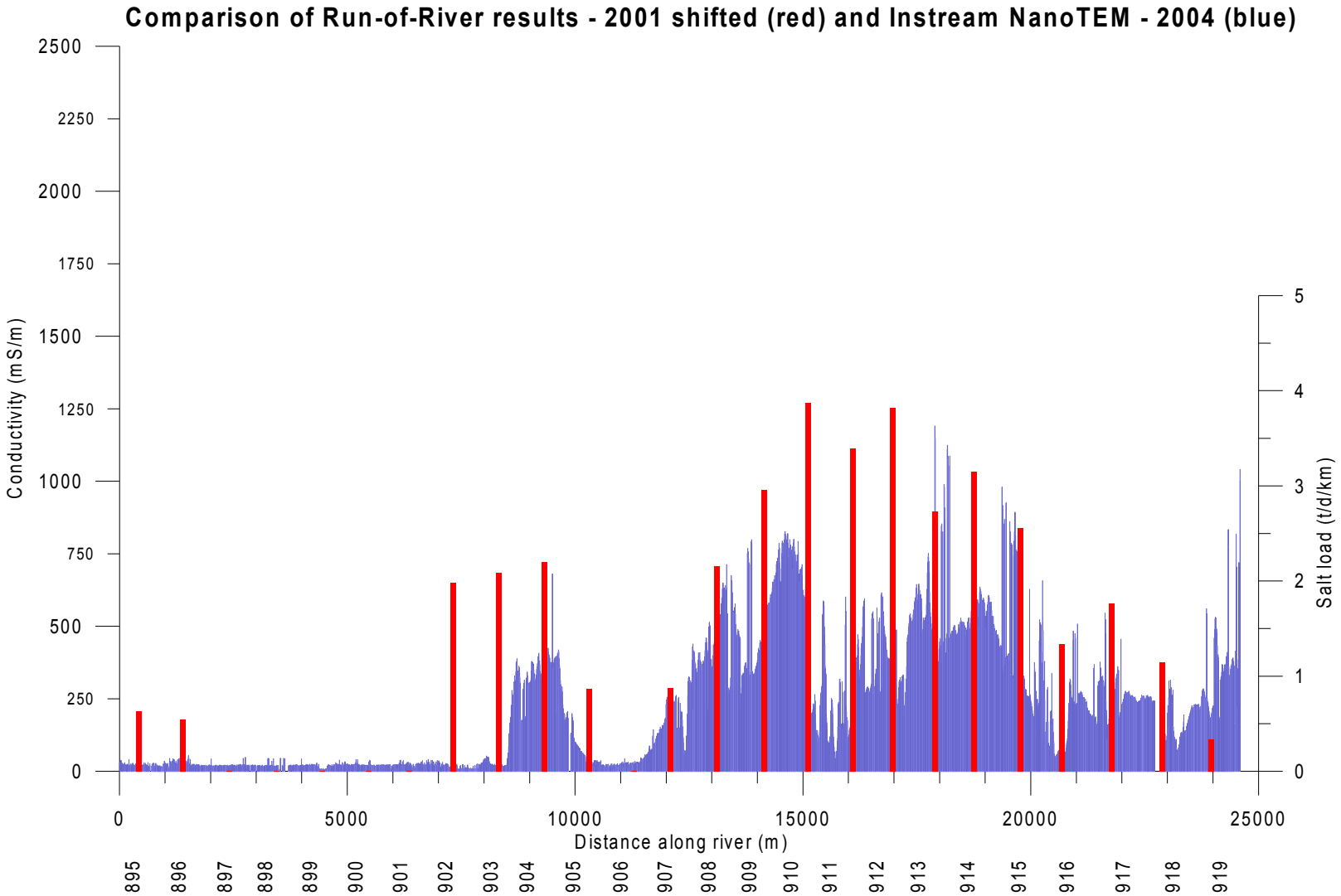


Results from drilling- losing stretch

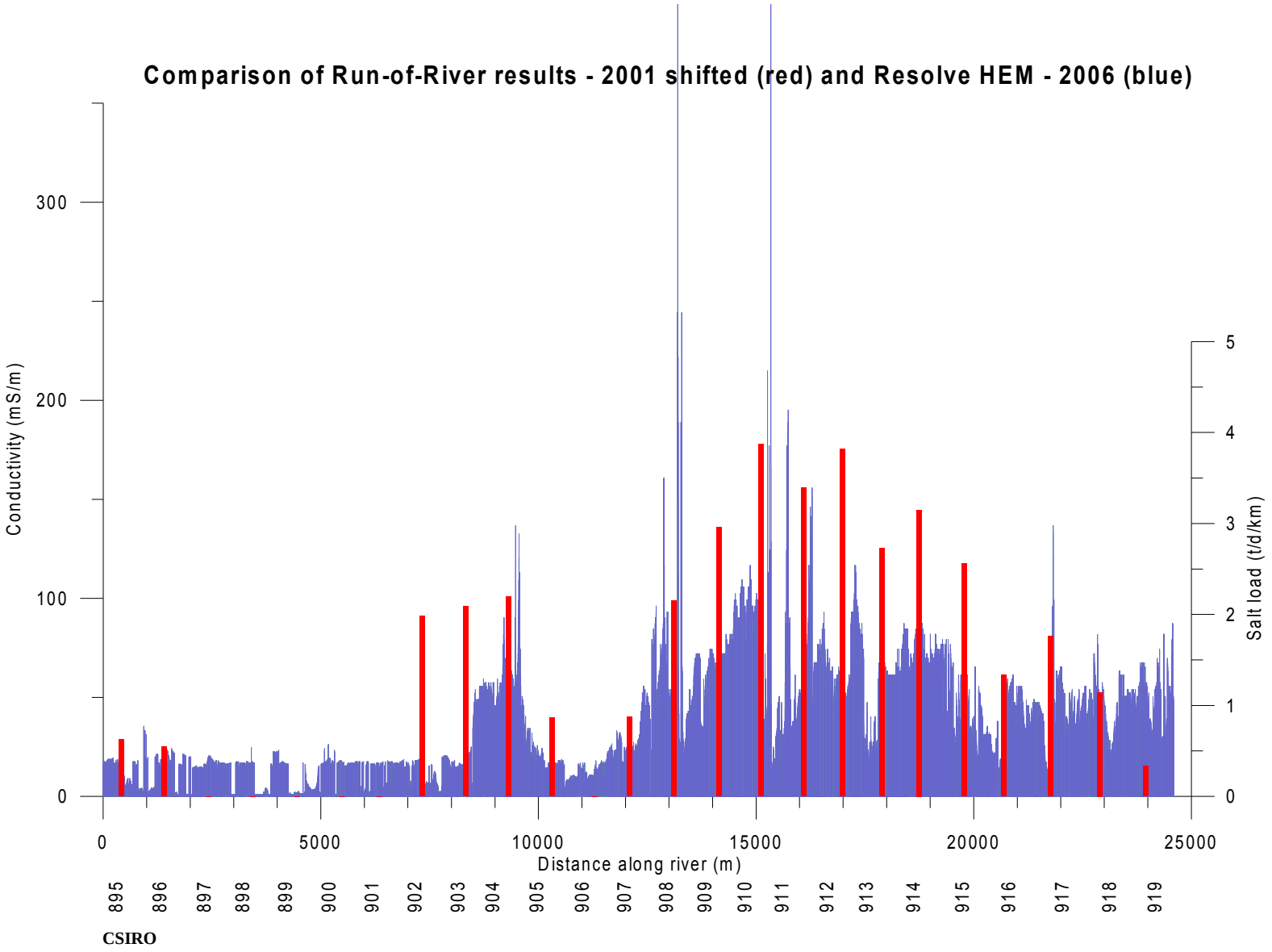




Run of River Survey vs NanoTEM



Run of River Survey vs RESOLVE



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Conclusions

- AEM provide spatial data on the distribution of salt concentrations in floodplain and river sediments
- Comparable results between HEM and in-river NanoTEM
- HEM deeper penetration than in-river NanoTEM
- HEM data suggest that the connectivity between the regional groundwater system and the river may vary with depth
- The HEM data were useful in identifying fine scale variations in baseflow supported by in river nanoTEM data
- High conductivities observed within and adjacent to the river coincide with high salt loads in the river (gaining reaches)
- Demonstrated the presence of an extensive flushed zone (losing conditions)
- HEM is a useful tool for monitoring river conditions, and can provide a ‘snap shot’ of river’s conditions during time critical conditions; ie flood event

Exploration and Mining
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Thank you

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