Southern Cross GeoScience

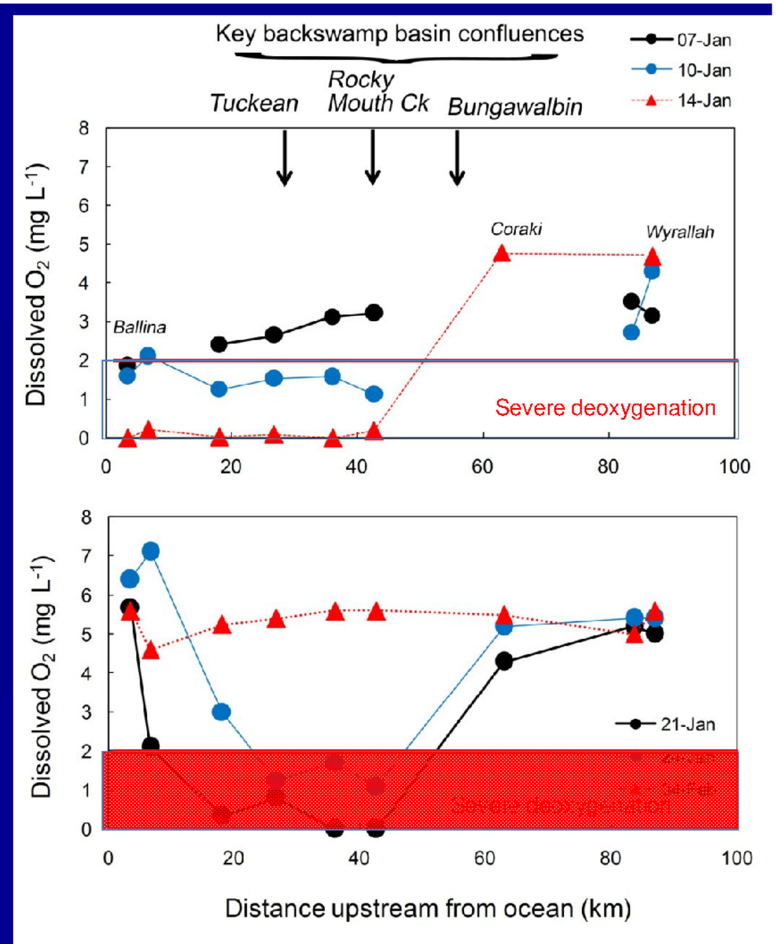
Developing practical management options to reduce deoxygenation of the Richmond

Professor Leigh Sullivan

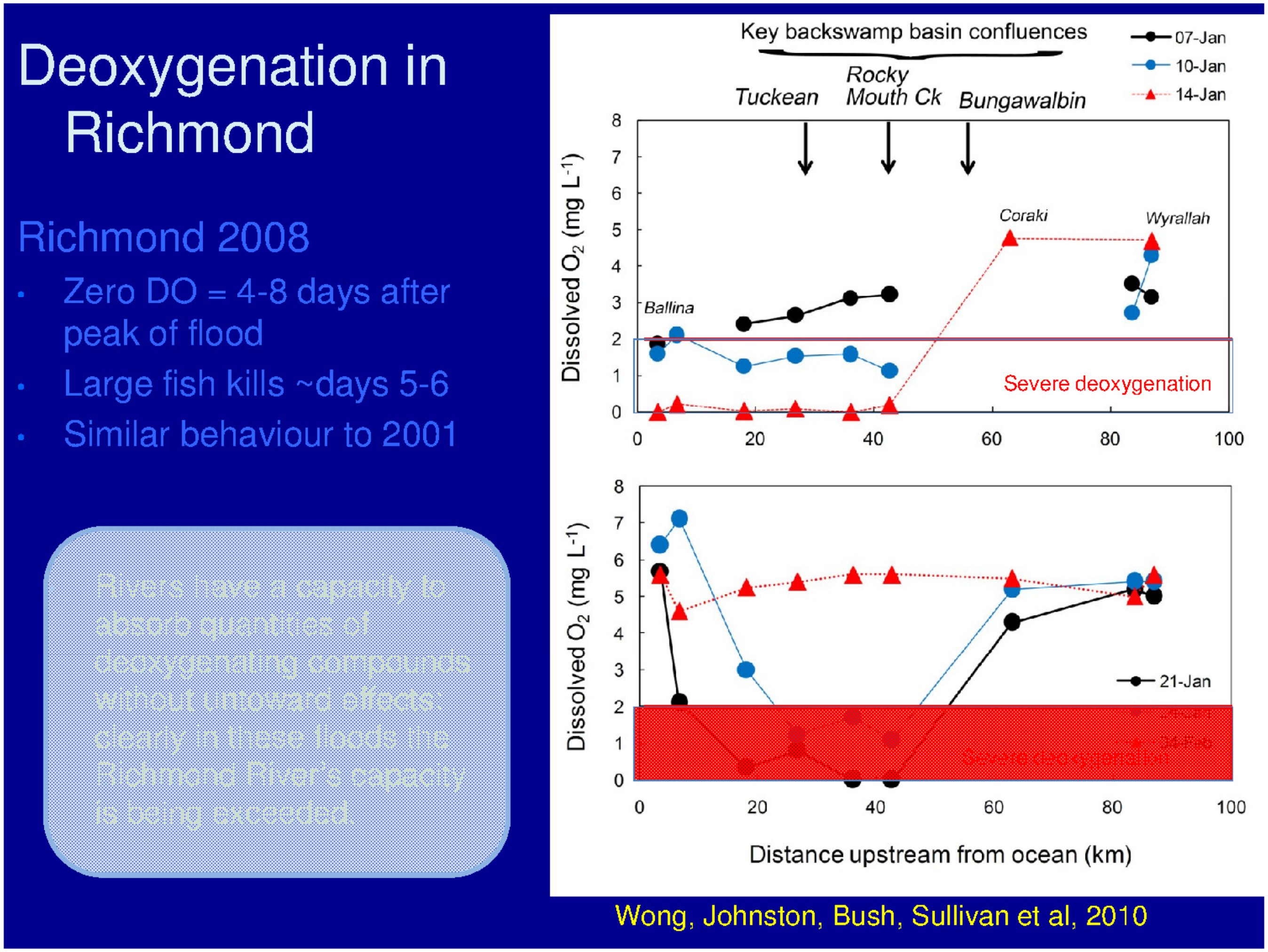
Deoxygenation in Richmond

Richmond 2008

- Zero DO = 4-8 days after peak of flood
- Large fish kills ~days 5-6
- Similar behaviour to 2001



Wong, Johnston, Bush, Sullivan et al, 2010


Deoxygenation in Richmond
Richmond 2008
• Zero DO = 4-8 days after peak of flood
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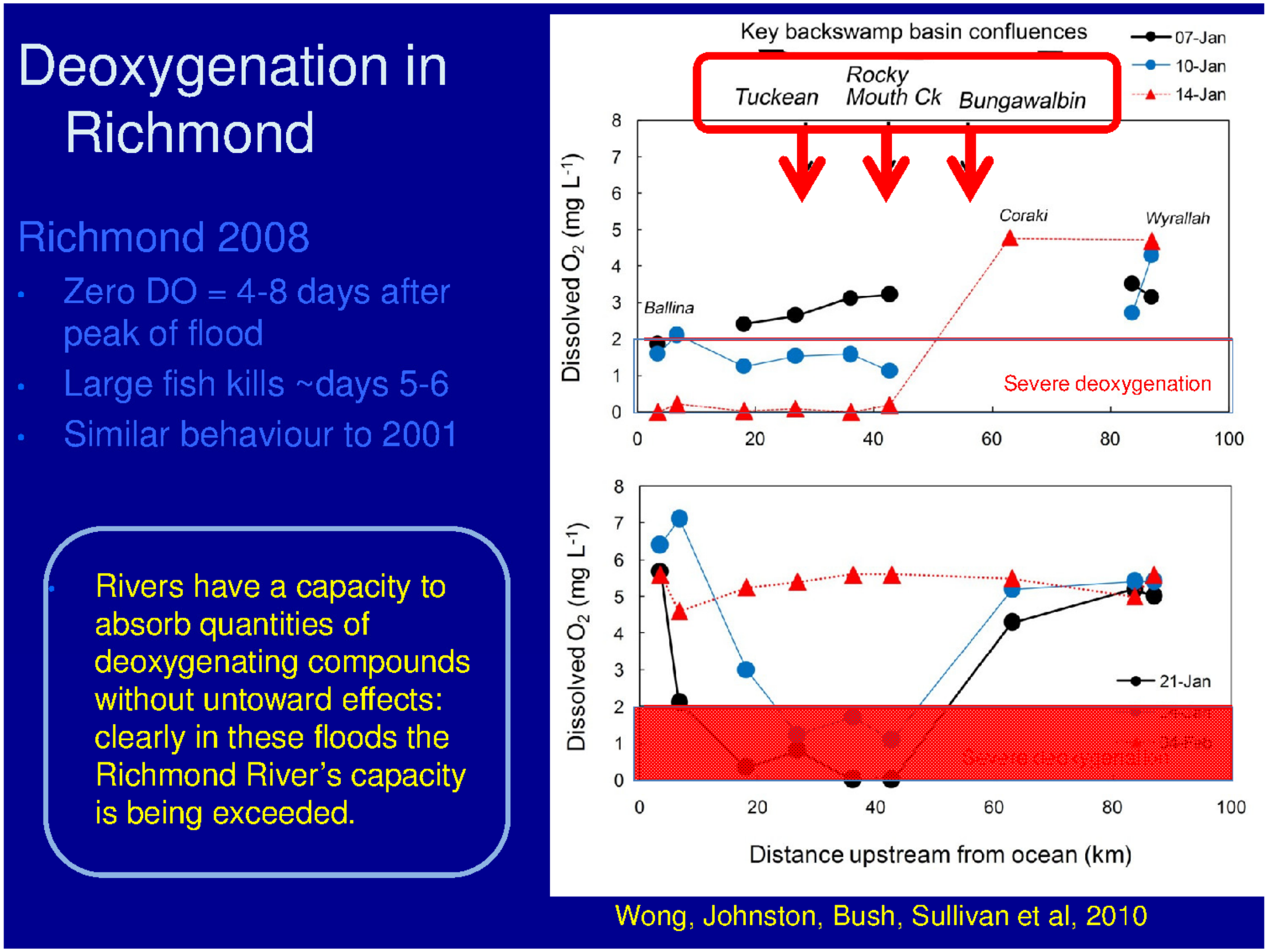
Rivers have a capacity to absorb quantities of deoxygenating compounds without untoward effects: clearly in these floods the Richmond River's capacity is being exceeded.
Key backswamp basin confluences
Tuckean
Rocky Mouth Ck
Bungawalbin
07-Jan
10-Jan
14-Jan
Ballina
Coraki
Wyrallah
Severe deoxygenation
Dissolved O_2 (mg L^{-1})
21-Jan
Distance upstream from ocean (km)
Wong, Johnston, Bush, Sullivan et al, 2010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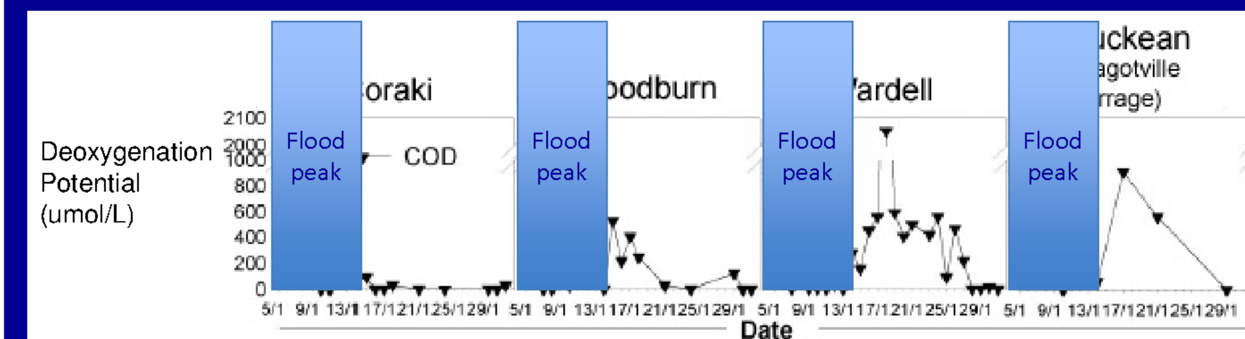
The Deoxygenation Potential (DOP) of the floodwaters is mainly derived from these three sub-catchments below Coraki.



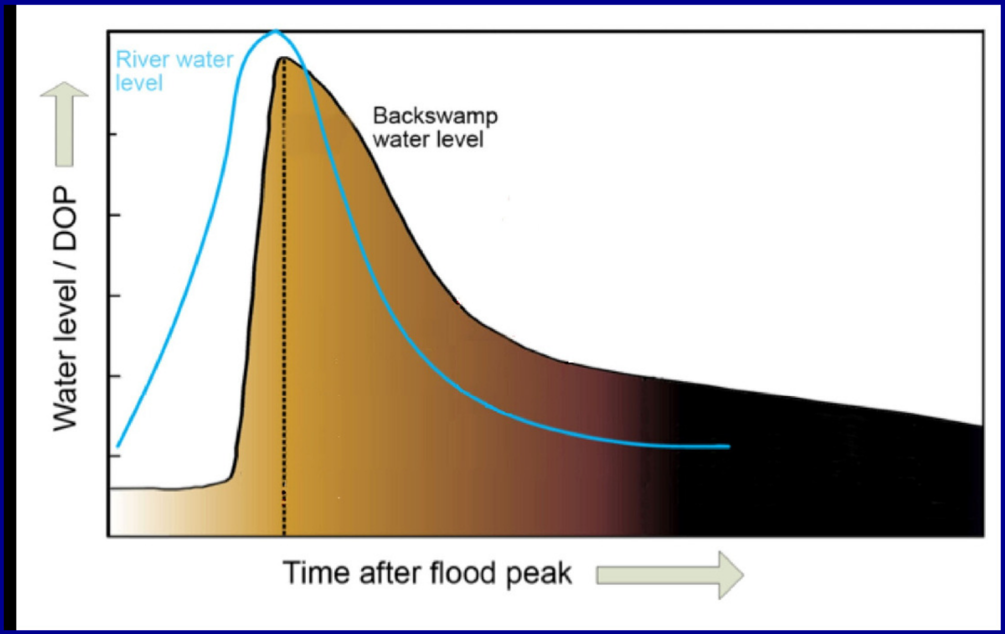
Wong, Johnston, Bush, Sullivan et al, 2010

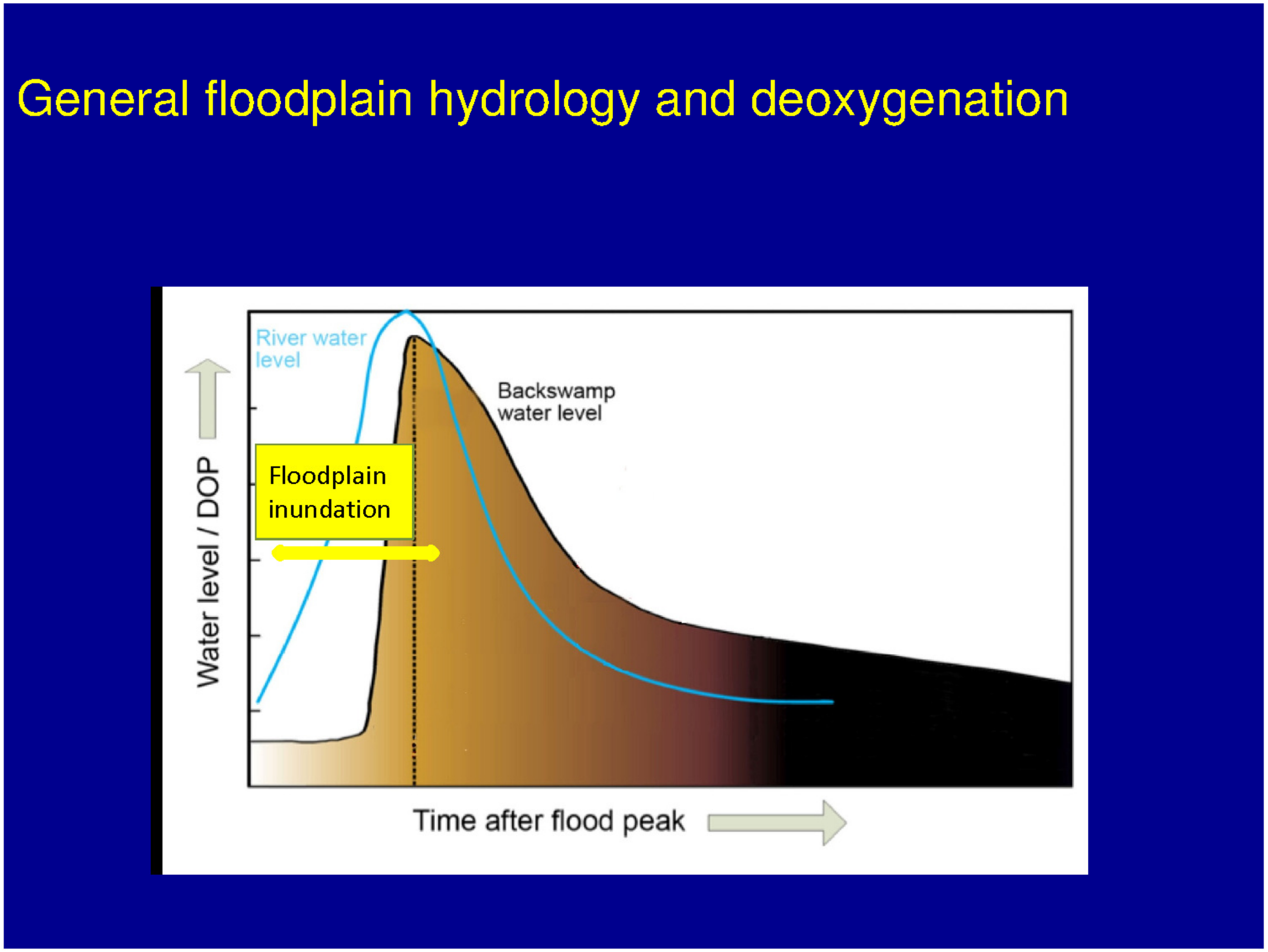
Area of these three key backswamps

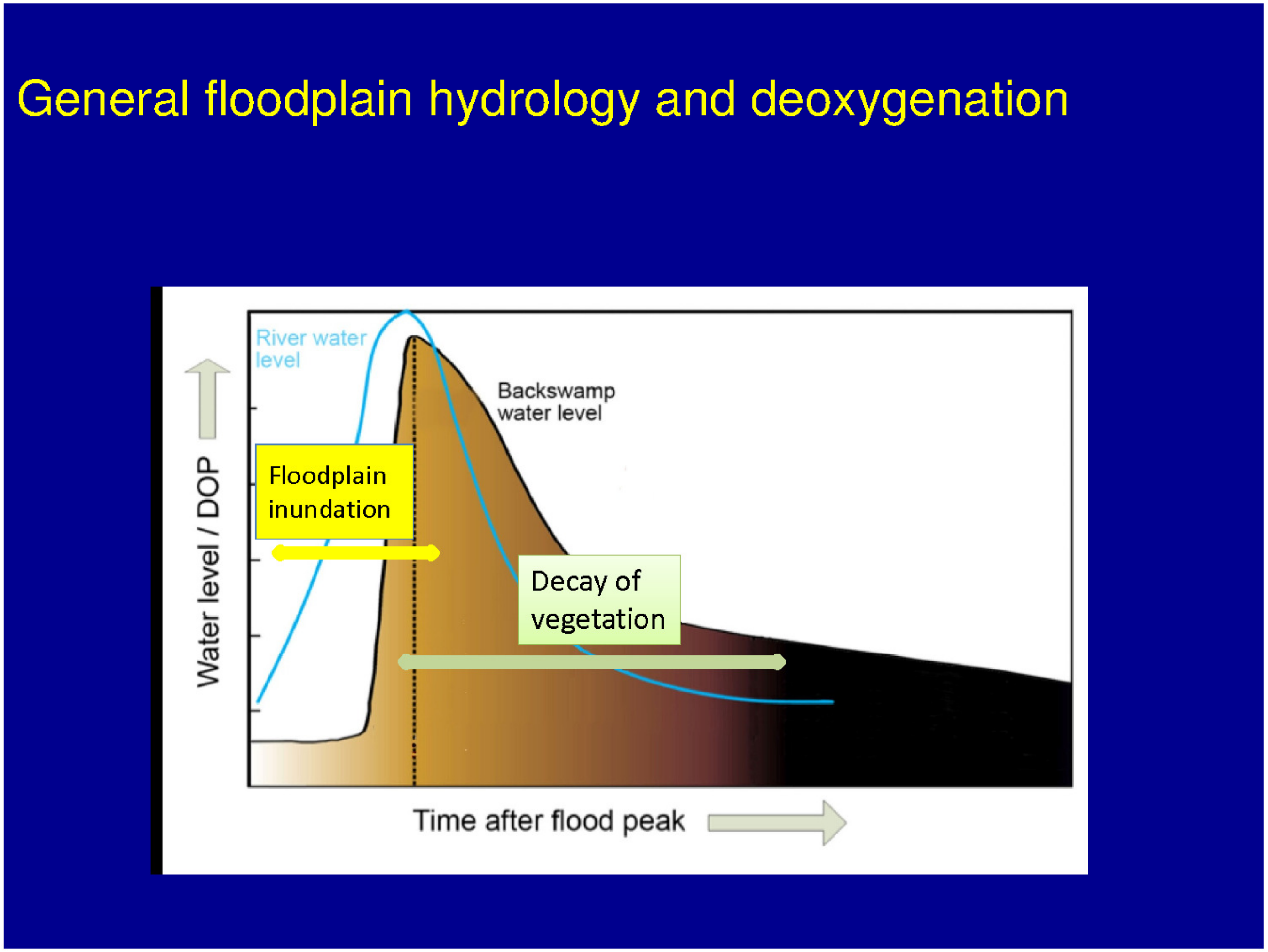
(Tuckean, Bungawalbin, Rocky Mouth Creek)

Wetland area in mid and upper Richmond estuary according to elevation	Area (km^2)	Proportion of Richmond River catchment (7,000 km^2)
-1.0 to 0 m AHD	24	0.35%
0 to 0.5 m AHD	35	0.51%

General floodplain hydrology and deoxygenation




General floodplain hydrology and deoxygenation
River water level
Backswamp water level
Floodplain inundation
Water level / DOP
Time after flood peak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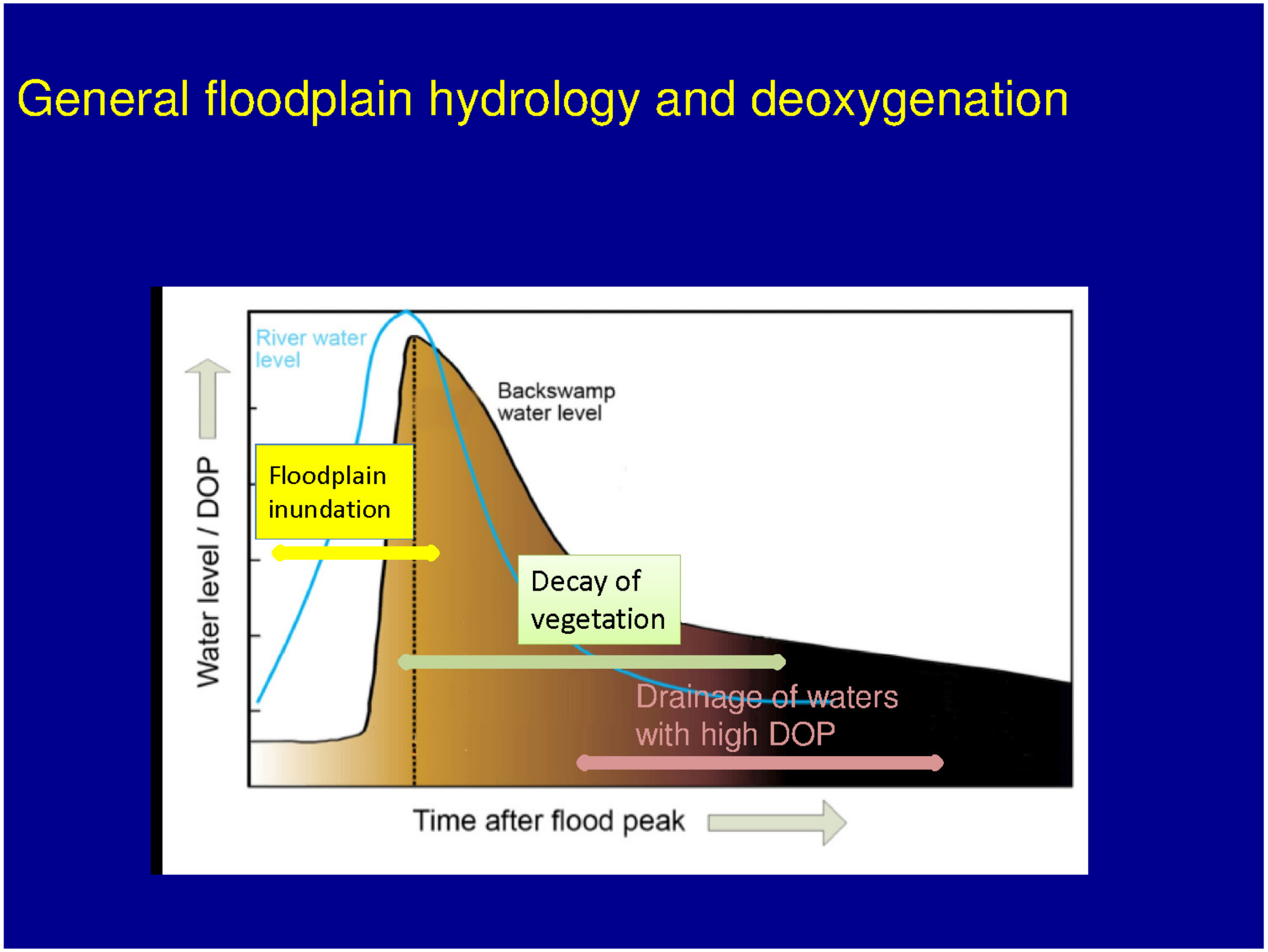
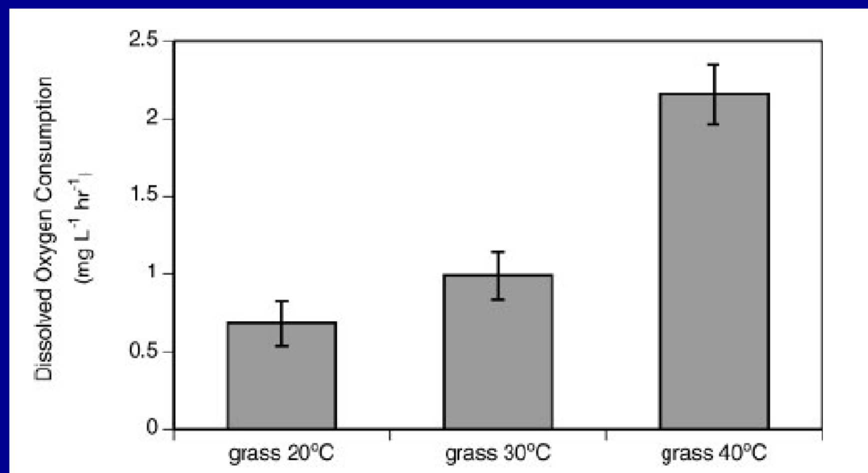

General floodplain hydrology and deoxygenation
River water level
Backswamp water level
Floodplain inundation
Decay of vegetation
Drainage of waters with high DOP
Water level / DOP
Time after flood peak

Deoxygenation potential (DOP)

- Mainly due to accumulation of partially decomposed organic materials in backswamps during inundation
- Build up of DOP in backswamps influenced by factors that include:
  - Temperature
  - Vegetation type
  - Soil type
  - Time

Development of DOP in Richmond has strong temperature dependence



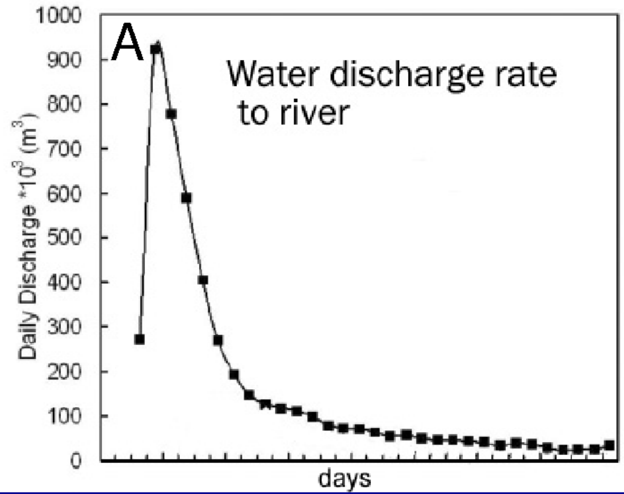
(Eyre, Kerr and Sullivan 2006)

Hence deoxygenation more likely in summer

Deoxygenation pollution

Two characteristics of sub-catchments are key determinants of DO pollution into rivers:

1. Discharge rate of water into river from sub-catchment over time (Fig. A)



Deoxygenation pollution

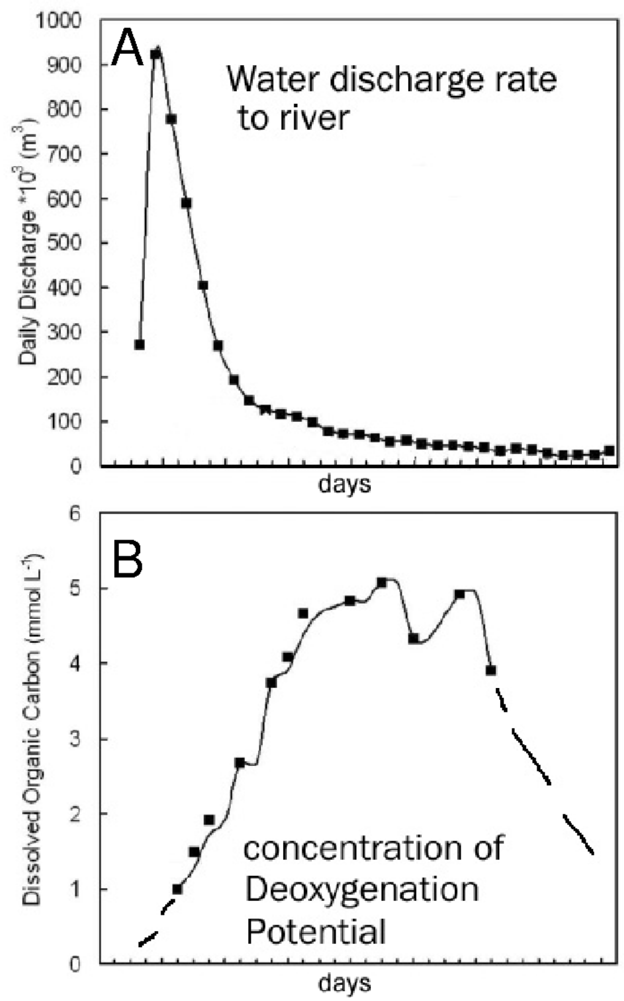
Two characteristics of sub-catchments are key determinants of DO pollution into rivers:

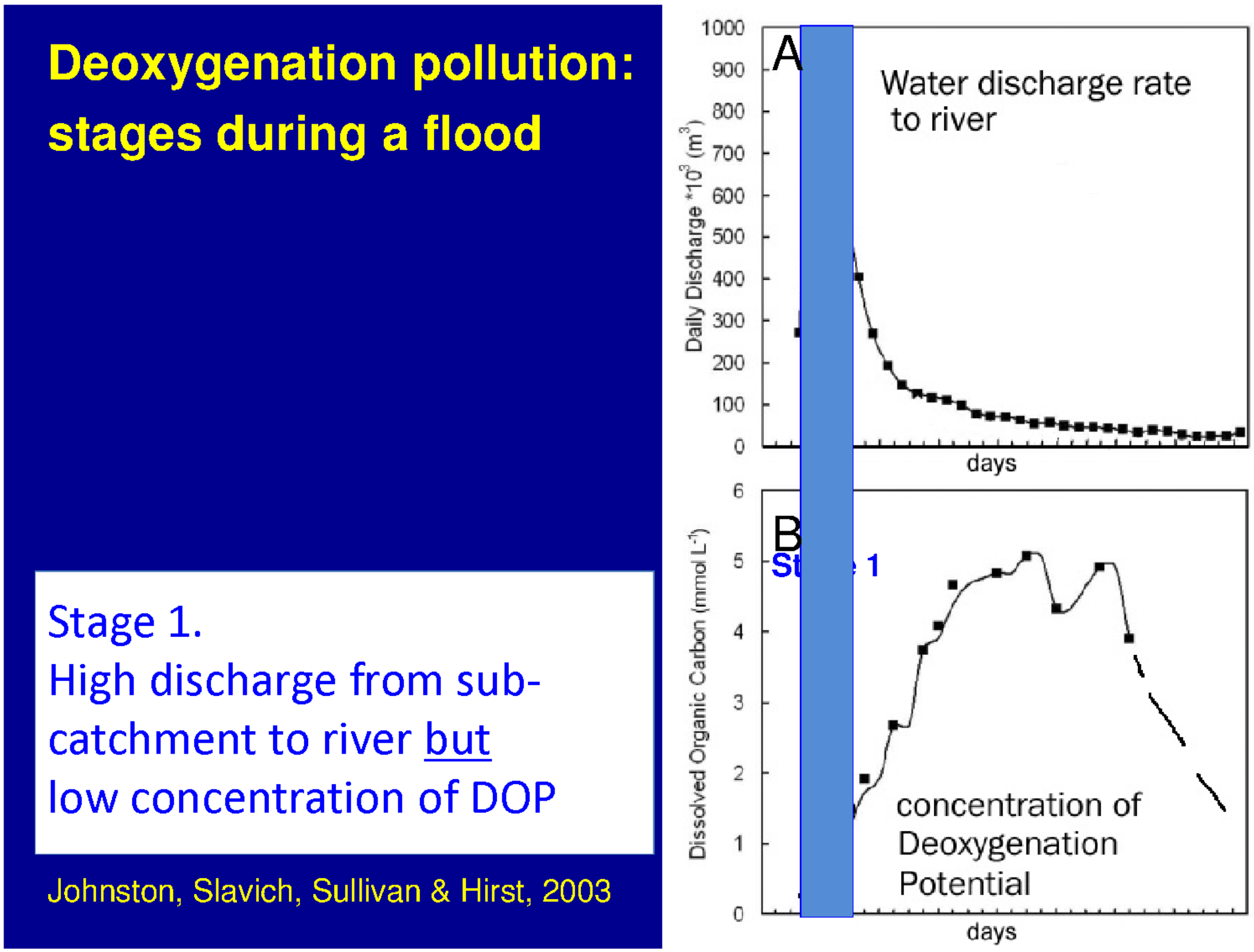
1. Discharge rate of water into river from sub-catchment over time (Fig. A)

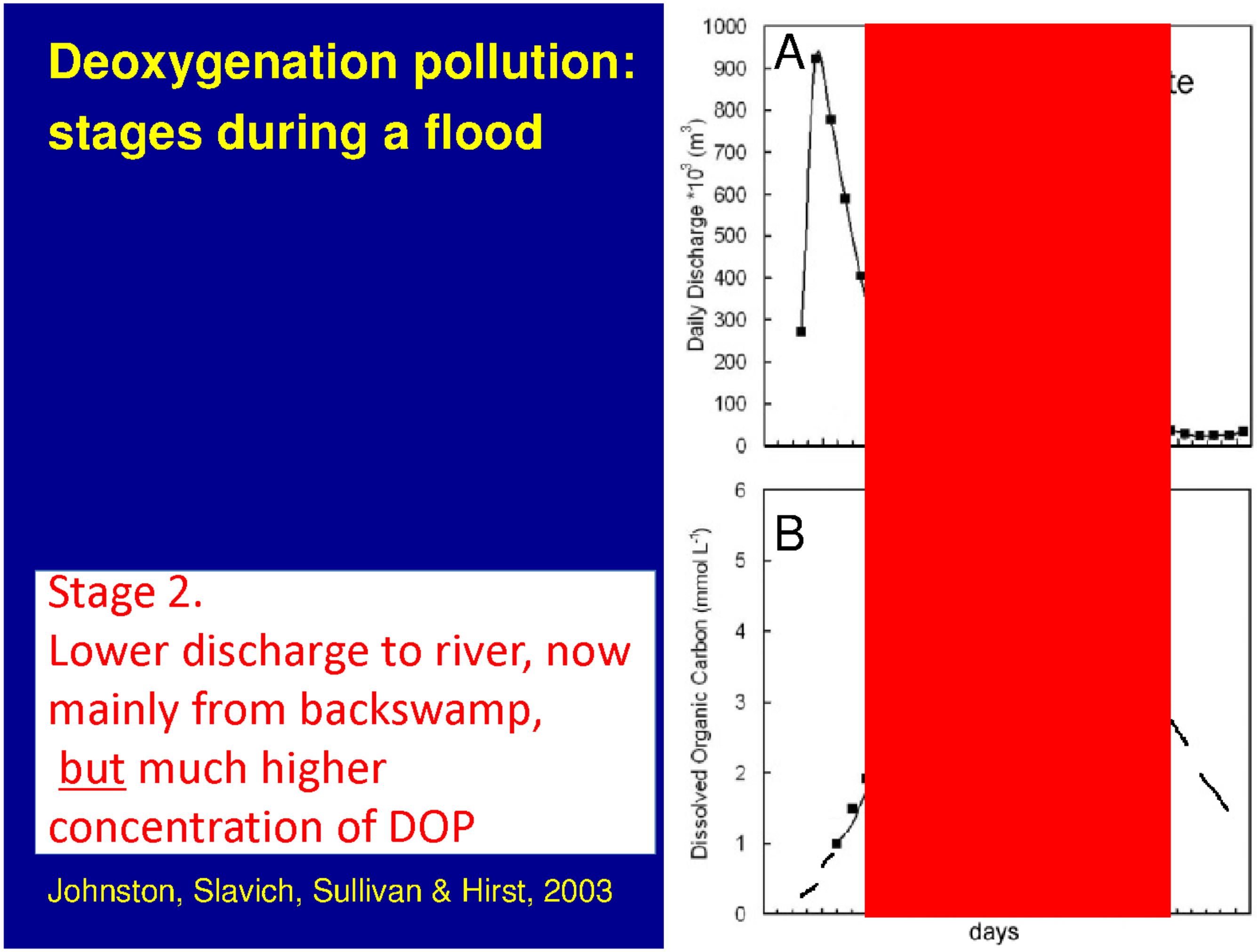
and

2. DO potential over time of water flowing from sub-catchment to river (Fig. B)

Johnston, Slavich, Sullivan & Hirst, 2003



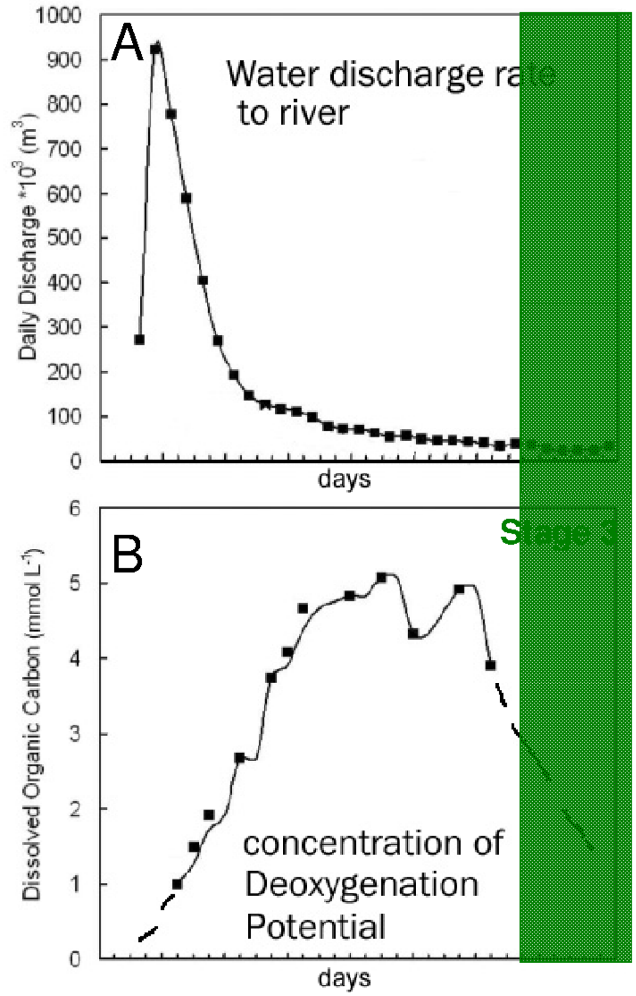

Deoxygenation pollution:
stages during a flood
Stage 1.
High discharge from sub-catchment to river but
low concentration of DOP
Johnston, Slavich, Sullivan & Hirst, 2003
A
Water discharge rate to river
Daily Discharge *10^3 (m^3)
days
B
Dissolved Organic Carbon (mmol L^-1)
concentration of Deoxygenation Potential
days


Deoxygenation pollution: stages during a flood
Stage 2.
Lower discharge to river, now mainly from backswamp,
but much higher concentration of DOP
Johnston, Slavich, Sullivan & Hirst, 2003
A
Daily Discharge *10^3 (m^3)
B
Dissolved Organic Carbon (mmol L^{-1})
days

Deoxygenation pollution: stages during a flood

Stage 3.
Low discharge from backswamp to river and low concentration of DOP

Johnston, Slavich, Sullivan & Hirst, 2003

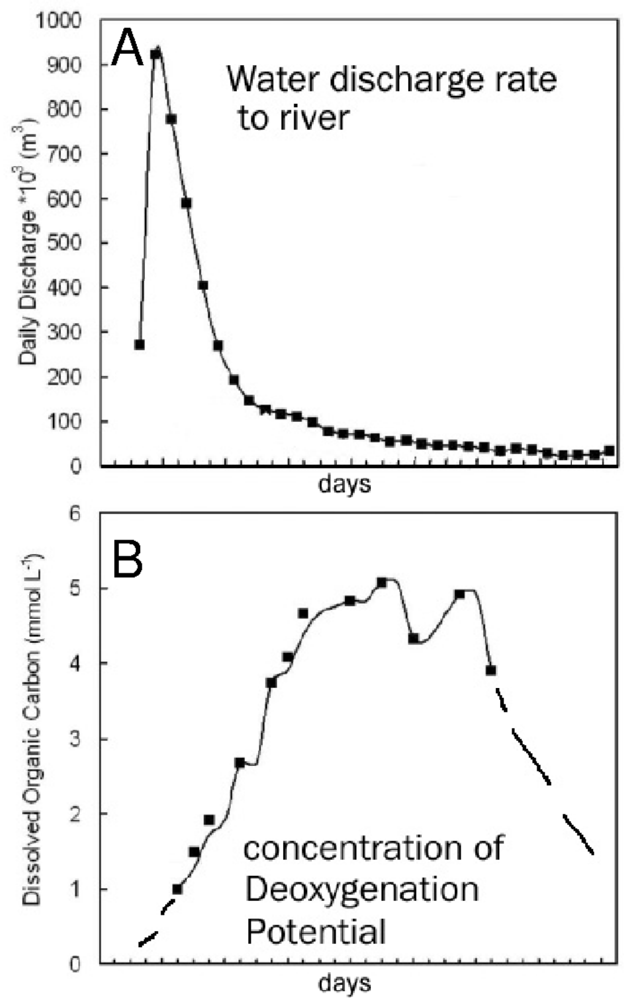


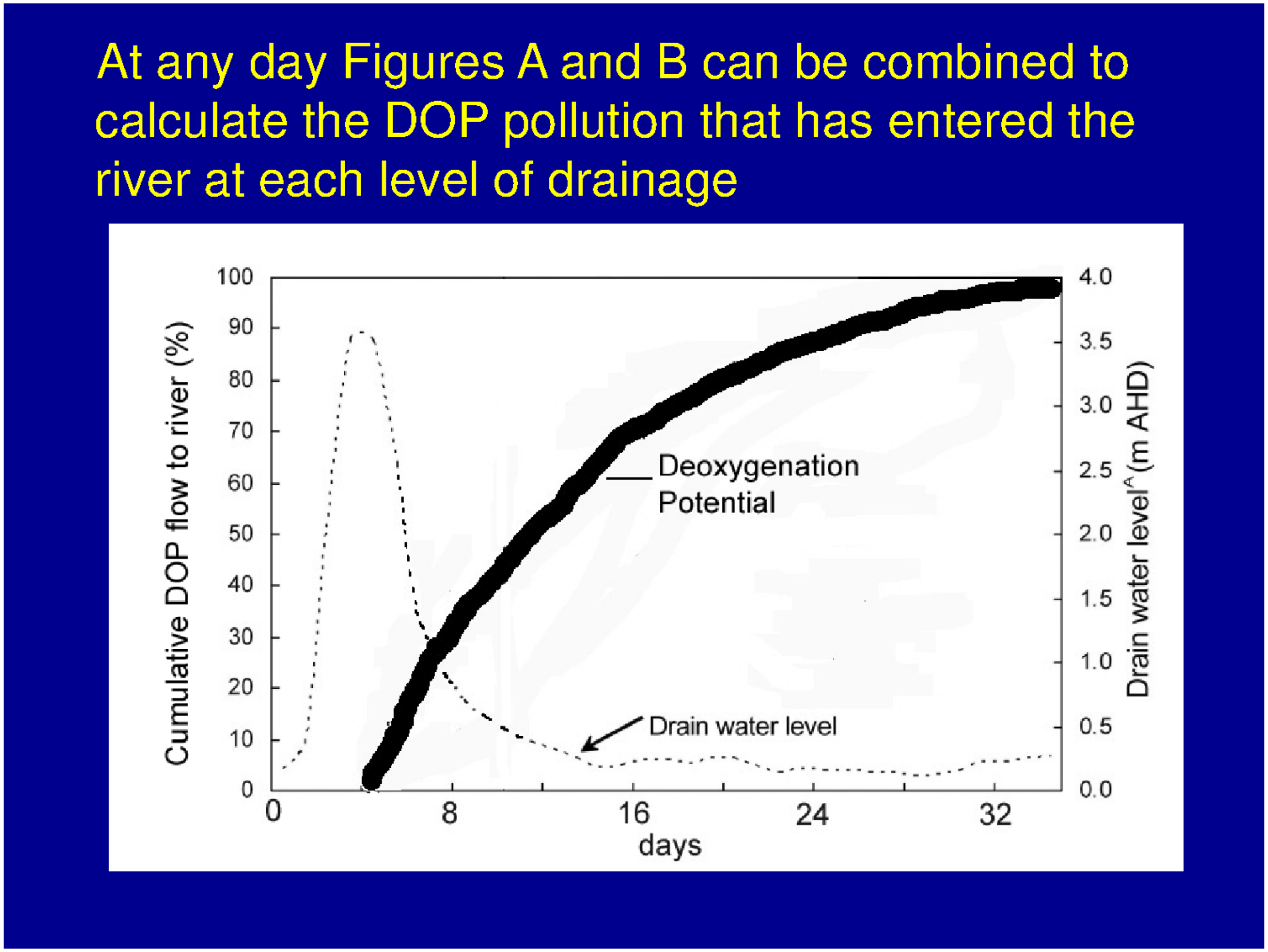
Deoxygenation pollution discharge into river at any time

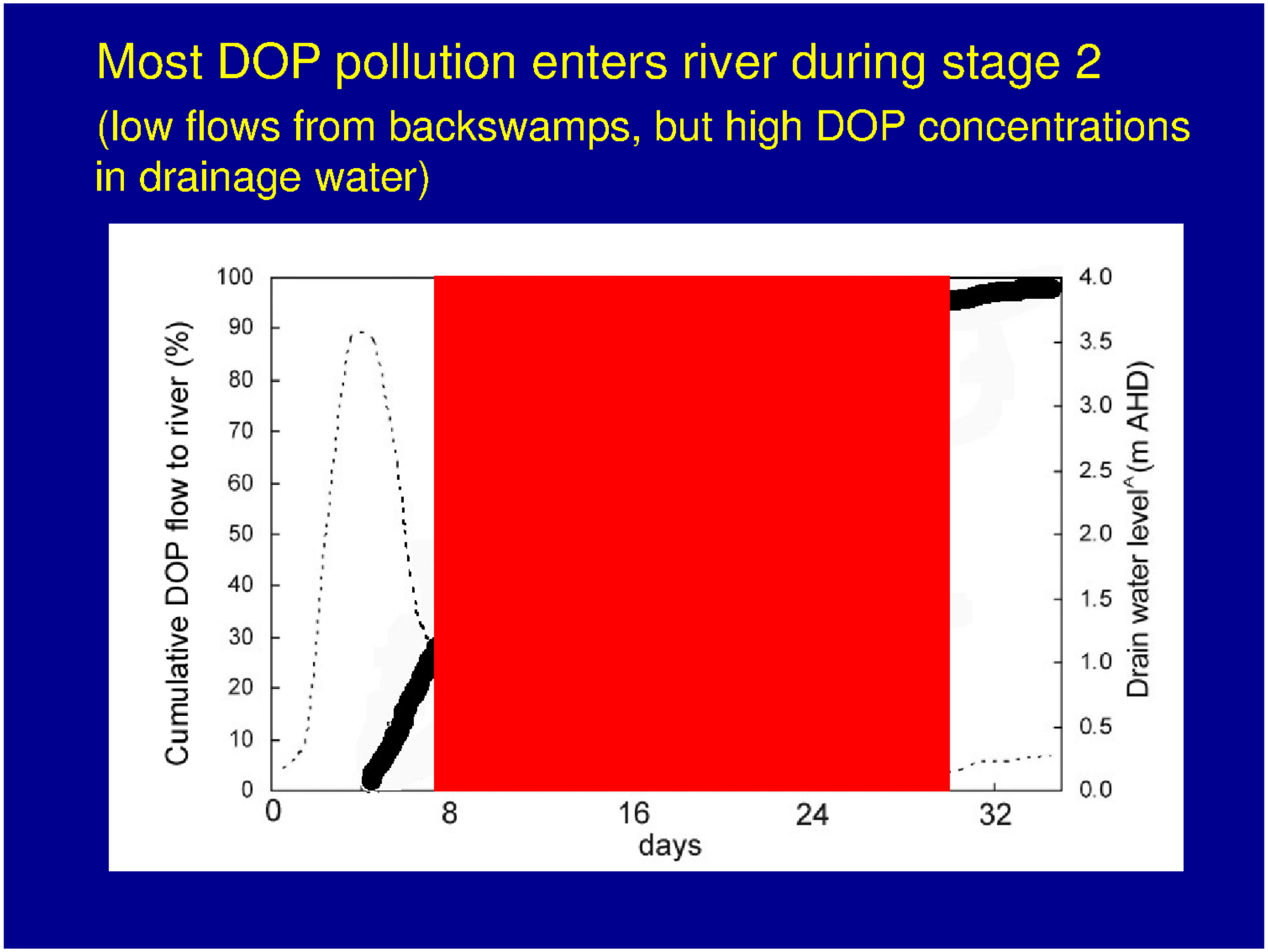
=

discharge rate
(from Fig. A)
X
concentration of DOP
(from Fig. B)

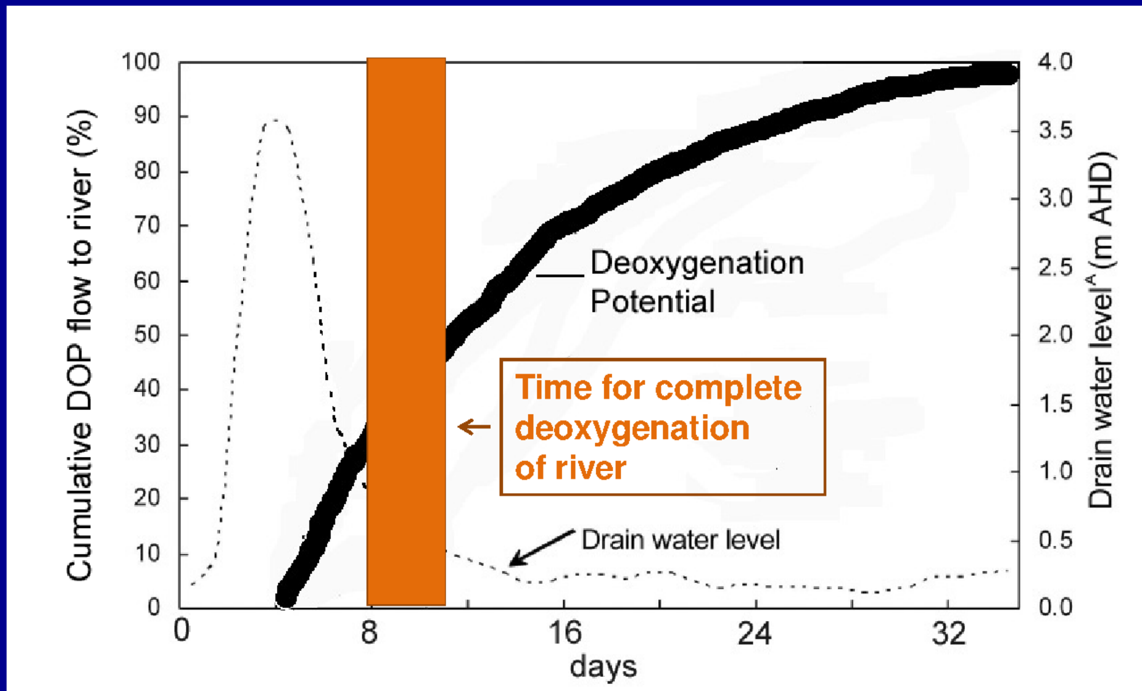
Johnston, Slavich, Sullivan & Hirst, 2003

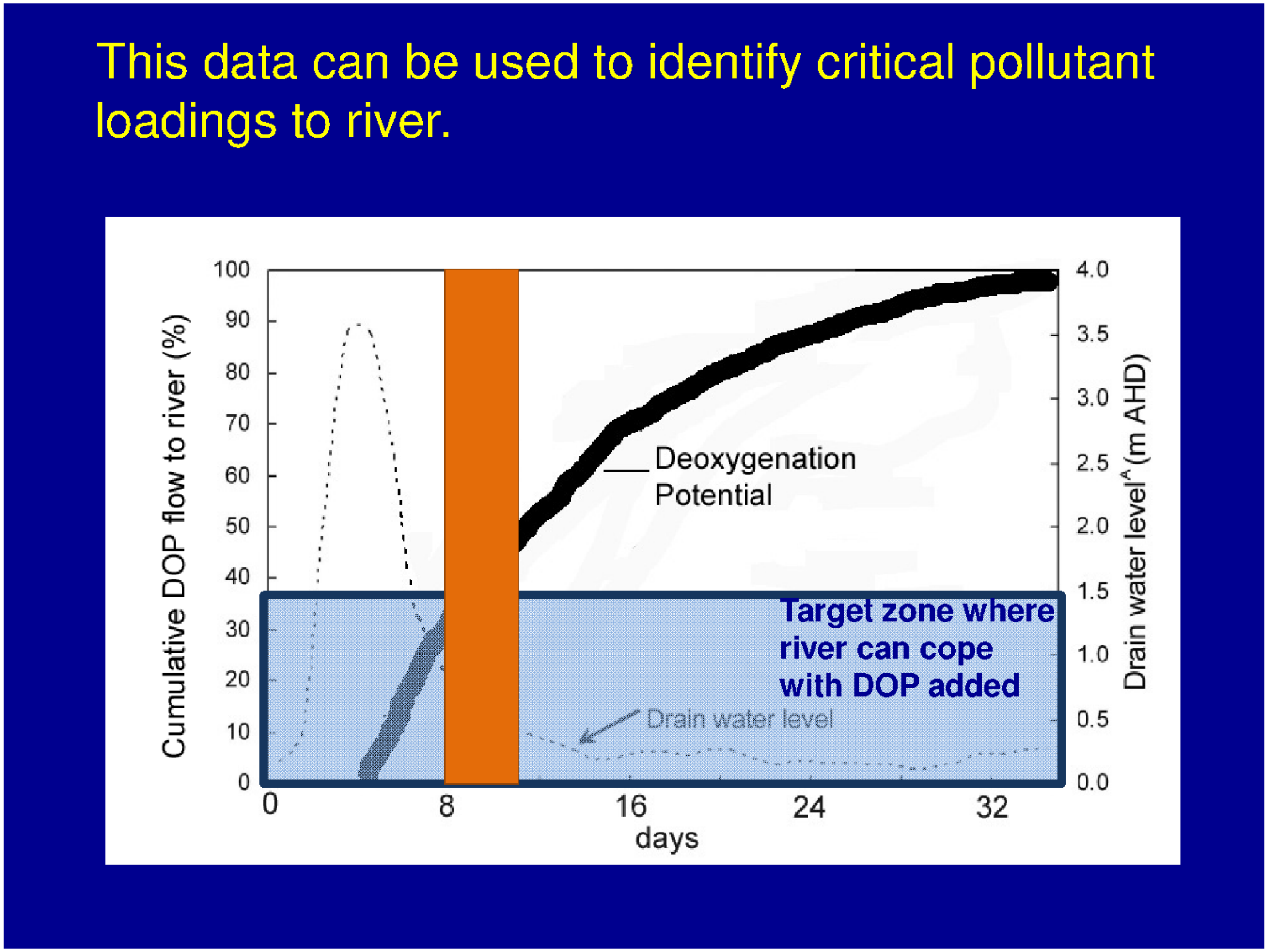



At any day Figures A and B can be combined to calculate the DOP pollution that has entered the river at each level of drainage
Cumulative DOP flow to river (%)
100
90
80
70
60
50
40
30
20
10
0
0
8
16
24
32
days
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Drain water level^ (m AHD)
Deoxygenation Potential
Drain water level


Most DOP pollution enters river during stage 2
(low flows from backswamps, but high DOP concentrations in drainage water)
Cumulative DOP flow to river (%)
Drain water level^ (m AHD)
days
0
8
16
24
32
100
90
80
70
60
50
40
30
20
10
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

This data can be used to identify critical pollutant loadings to river.




This data can be used to identify critical pollutant loadings to river.
Cumulative DOP flow to river (%)
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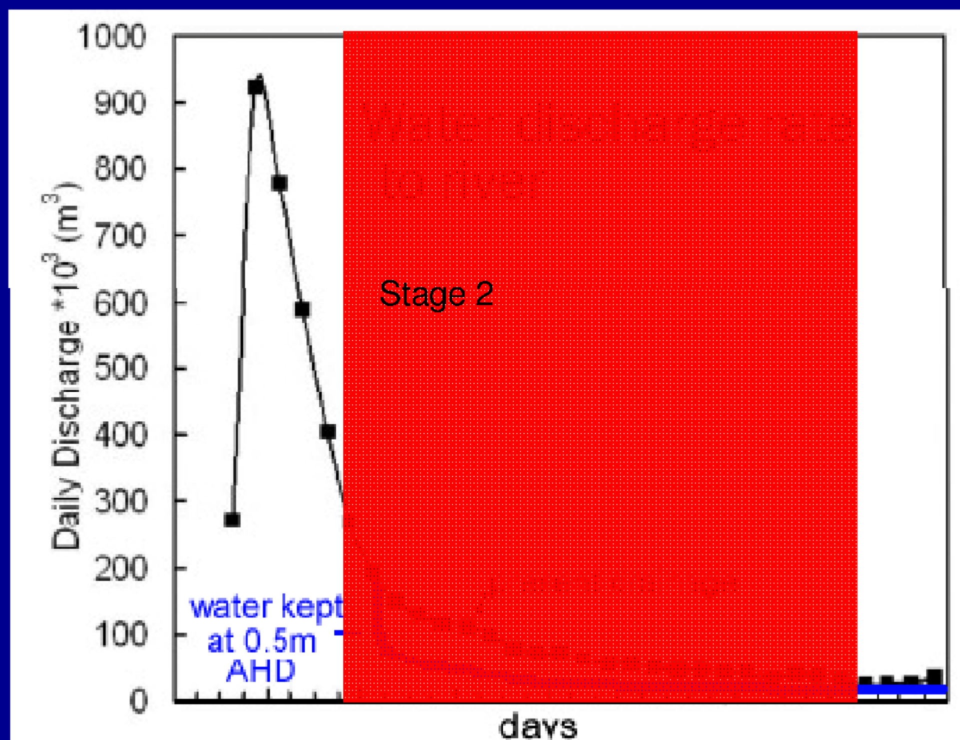
90
80
70
60
50
40
30
20
10
0
Drain water level^ (m AHD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
8
16
24
32
days
Deoxygenation Potential
Target zone where river can cope with DOP added
Drain water level

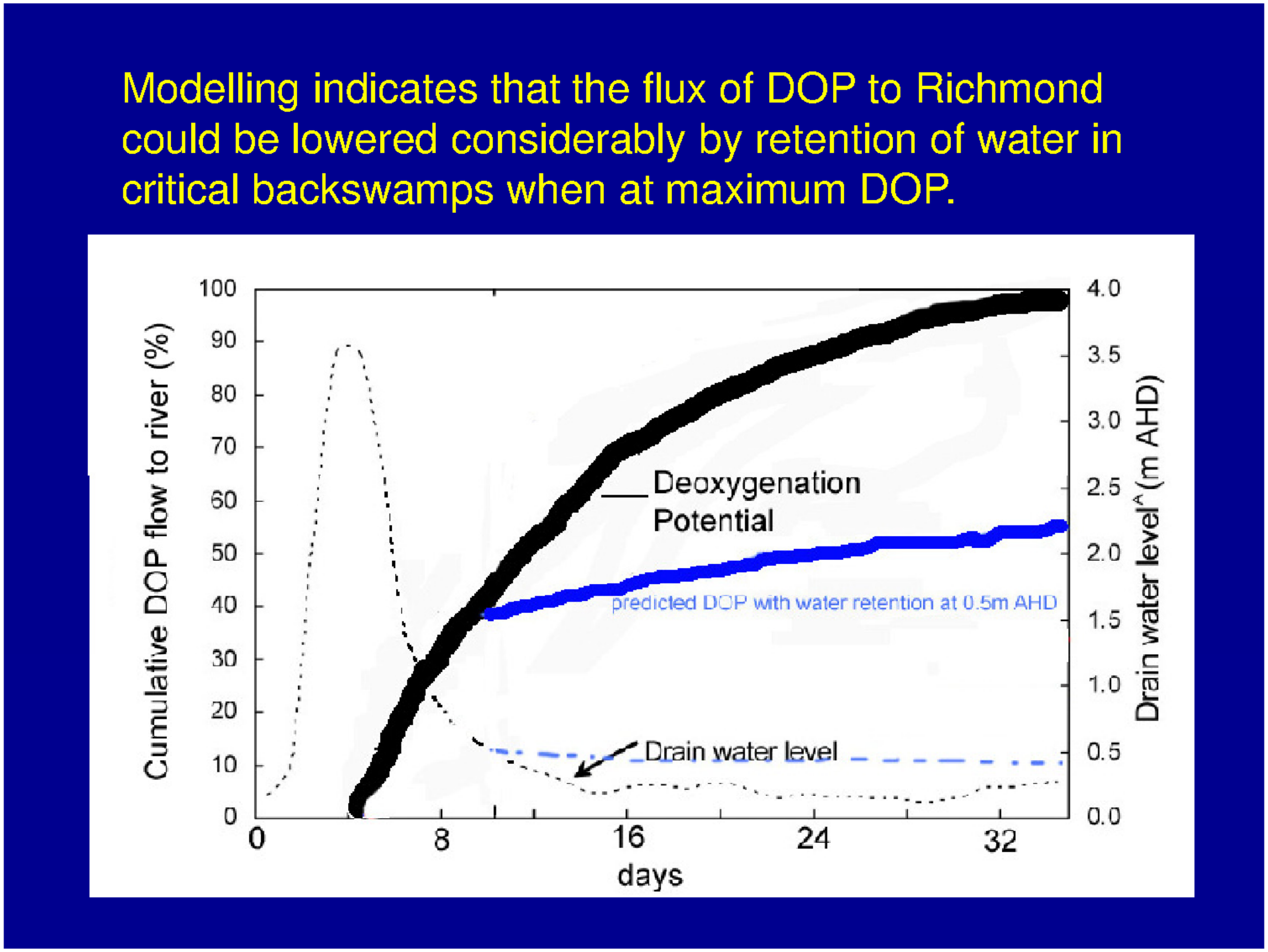
What are the management options available to reduce DOP pollution into Richmond?

General strategies

- *Decrease amount of DOP produced in the three critical backswamps*
- *Retain as much DOP in these backswamps as practical until they 'burn out'.*

DOP pollution in river could be reduced considerably by holding back the worst quality (i.e. highest DOP) water in the critical backswamps during stage 2.




Modelling indicates that the flux of DOP to Richmond could be lowered considerably by retention of water in critical backswamps when at maximum DOP.
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100
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10
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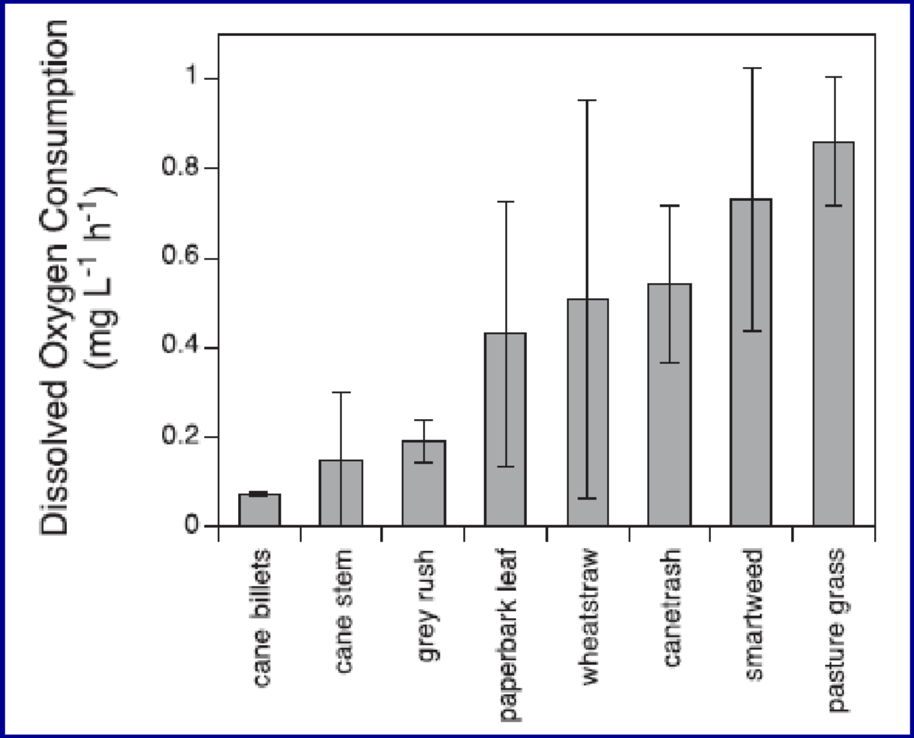
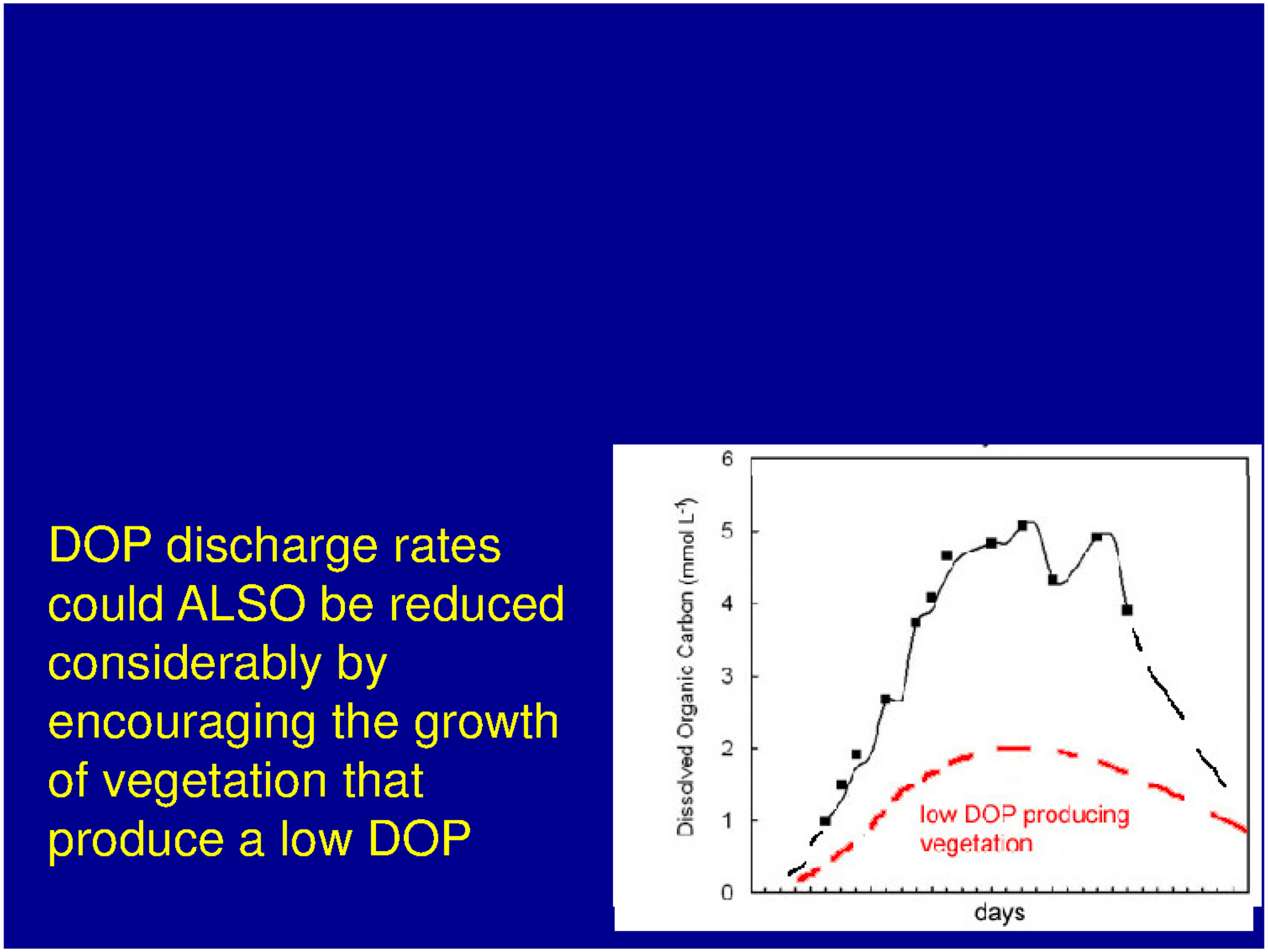
0
8
16
24
32
days
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Drain water level^ (m AHD)
Deoxygenation Potential
predicted DOP with water retention at 0.5m AHD
Drain water level

- Development of DOP strongly influenced by vegetation type

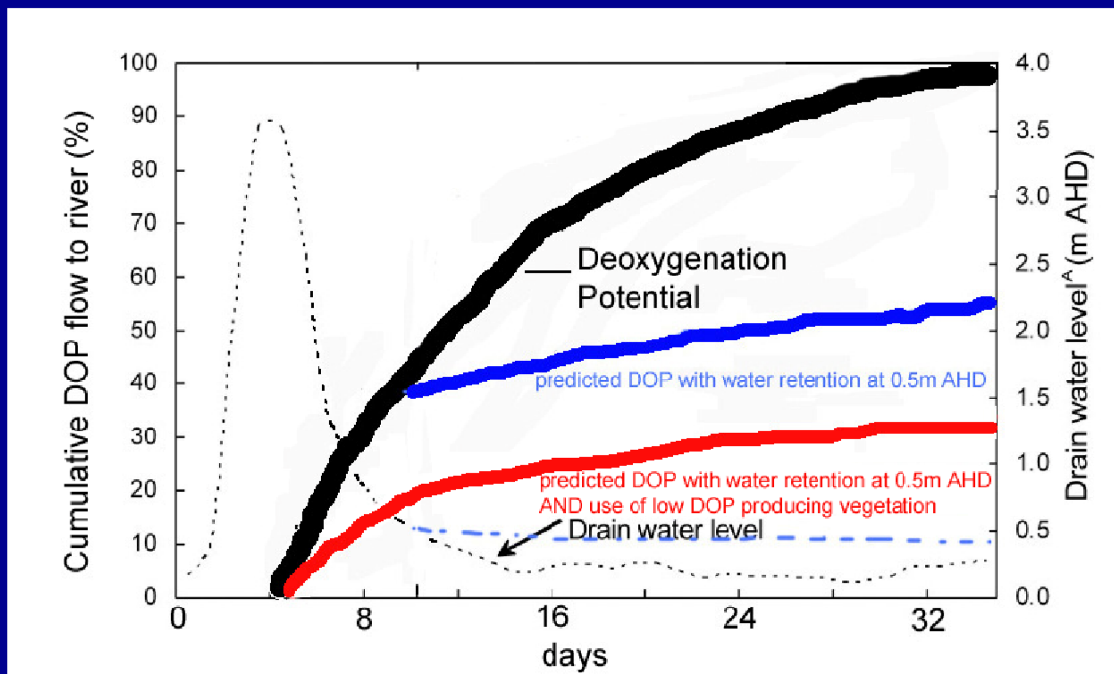


(Eyre, Kerr and Sullivan 2006)


DOP discharge rates could ALSO be reduced considerably by encouraging the growth of vegetation that produce a low DOP
Dissolved Organic Carbon (mmol L-1)
6
5
4
3
2
1
0
days
low DOP producing vegetation

Modelling indicates that the flux of DOP to Richmond could be lowered considerably by both:

1) retention of water in back swamps when at maximum DOP, and
2) encouraging low DOP-producing vegetation in major DOP source areas.



General strategies

- *Decrease amount of DOP produced in the three critical backswamps*
- *Retain as much DOP in these backswamps as practical until they 'burn out'.*

- **Key questions / information gaps**
  - What locations in the upper- to mid-estuary produce the highest rates of DOP?

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- **Key questions / information gaps**
  - What locations in the upper- to mid-estuary produce the highest rates of DOP?
  - What are the vegetation changes that are beneficial in reducing DOP & practically possible?
  - What are the water drainage characteristics of the major sub-catchments? (e.g. flow rates of drainage water vs water height on floodplain)
  - What are effects of longer-ponded backswamps on e.g. mosquitos, grazing?

What we believe is required to enable management of deoxygenation in the Richmond.

1) Produce a map of DOP across the mid- and upper-estuary of the Richmond (esp. of backswamps).

This will enable rational prioritisation of land for management.

What we believe is required to enable management of deoxygenation in the Richmond.

2) Identify DOP production characteristics of the major floodplain vegetation under summer inundation.

This will allow us to target the types of vegetation that should be encouraged to grow in high priority areas.

What we believe is required to enable management of deoxygenation in the Richmond.

3. Produce drainage hydrology characteristics for each of the three major backswamp areas.

This will allow us to determine the amount of DOP pollution at each drainage level.

What we believe is required to enable management of deoxygenation in the Richmond.

4. The data above, along with DEM, will enable accurate prediction of how much water/area of backswamp would be required to remain wet, and for how long, in order to stop varying amounts of DOP entering the Richmond during summer floods.

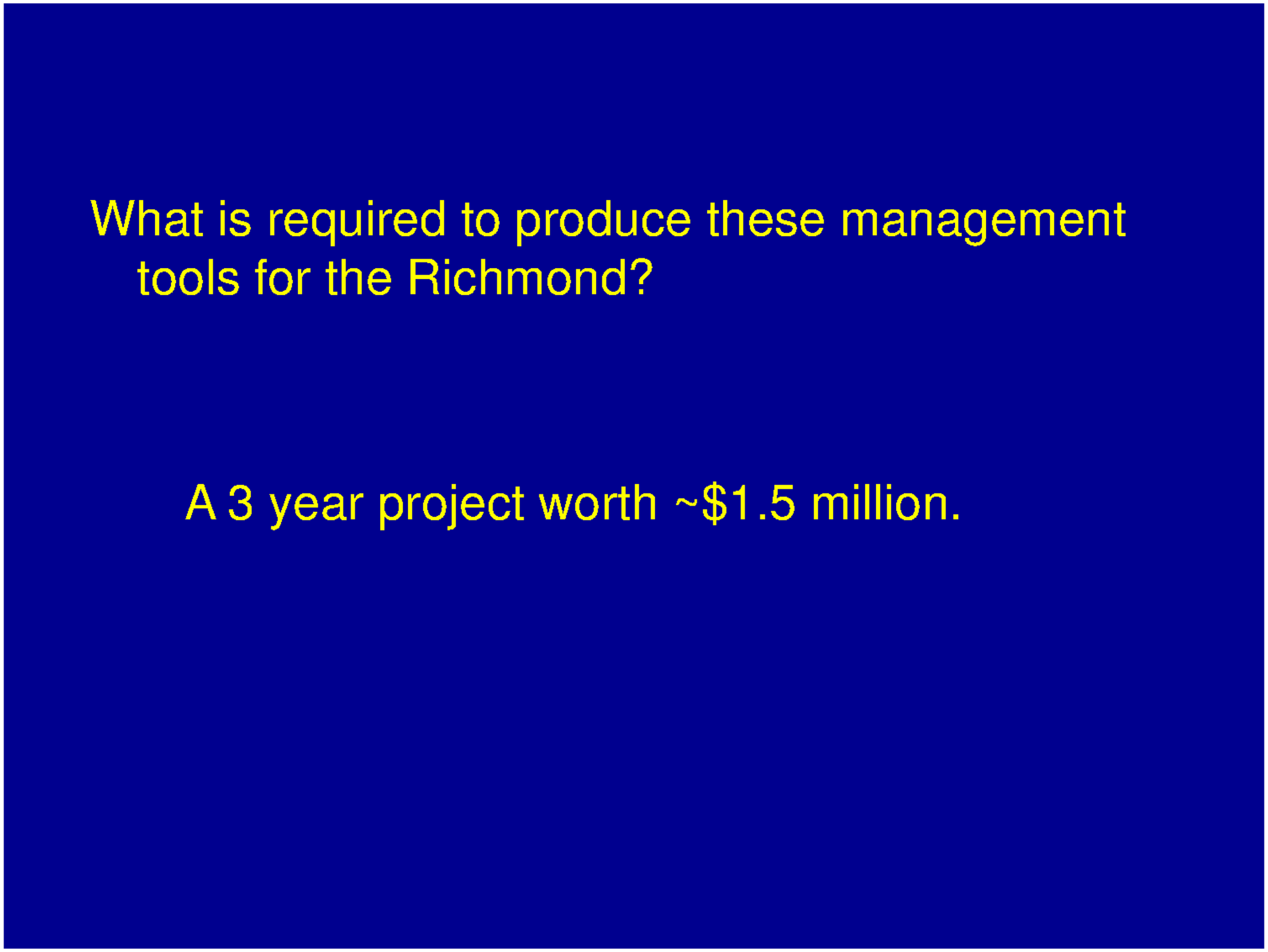
This data will enable formulation of ‘bang for buck’ scenarios for the Richmond.

e.g. If we were to manage 500 ha of backswamp:

- What is the location(s) of the 500 ha that would produce the most beneficial decrease in DOP pollution?
- What would this cost?
- How much improvement in lowering DOP pollution entering the river would we get during summer floods? etc.

<u>or</u>

* If we were to manage all 2,400 ha of backswamp in Richmond < 0m AHD, ……etc etc.


What is required to produce these management tools for the Richmond?
A 3 year project worth ~$1.5 million.

We (SCU, Monash University and RRCC) have been recently successful in obtaining a Commonwealth government funded ARC Linkage grant specifically for this project.

The Commonwealth have pledged to provide $325,000 in cash for this project.

For this $1.5 million project, Southern Cross University is also pledged to provide $600k.

Personnel ($400k)

- Professor Leigh Sullivan,
- Professor Richard Bush,
- Associate Professor Andrew Rose,
- Associate Professor Ed Burton,
- Associate Professor Scott Johnston.

Analytical and field costs ($200k)

For this $1.5 million project, Monash University is also pledged to provide $60k in kind.

Personnel

- Dr Vanessa Wong

For this $1.5 million project, RRCC is pledged to Provide the remaining $360k in cash and $180k in kind.

Personnel ($90k) in kind

- Michael Wood

Data (DEM data) ($90k) in kind

$360k ($120k pa for 3 years) cash

(for Research Assistant and towards analytical expenses)

The $360,000 in cash from the RRCC is required to start this project.

This $360,000 contribution will effectively be leveraged up to $1,500,000 for the total cost of this project aimed at producing these management tools for the Richmond River.