The role of groundwater in the degradation and restoration of raised bog ecosystems

Shane Regan

Department of Civil, Structural and Environmental Engineering
Trinity College Dublin

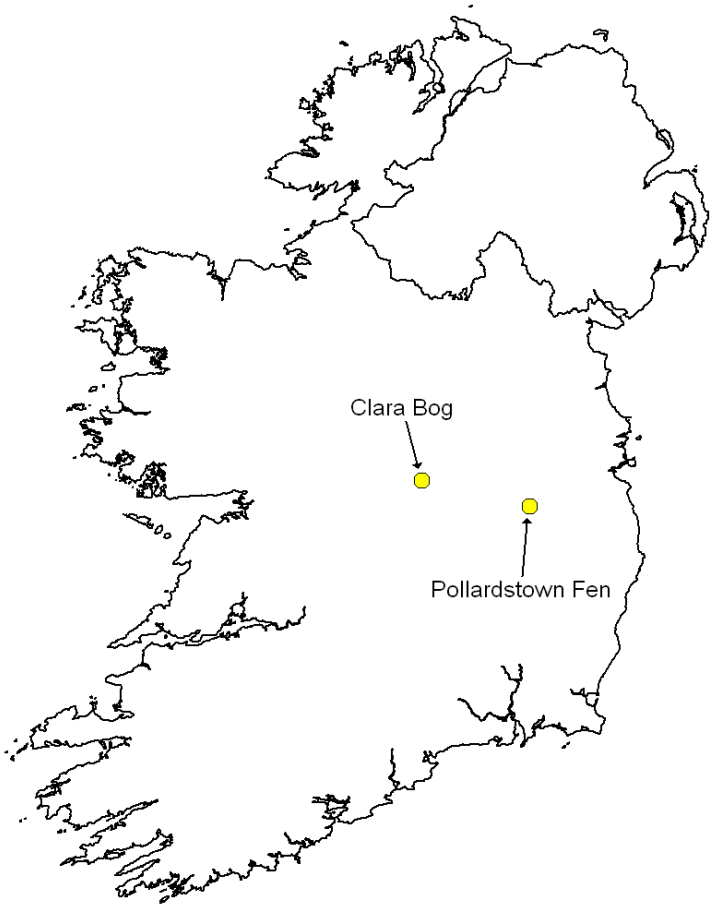
Supervisor: Paul Johnston

Introduction

- Aim:
  - To demonstrate that regional hydrology has a much greater role in the sustainability of a raised bog ecosystem than has previously been assumed
- Implication:
  - Restoration measures must take account of hydrogeological processes
  - Raised Bogs may be considered as GWTDEs under the WFD

Clara Bog

- Designated Special Area of conservation (SAC)
- Has been damaged in the past – it is now two bogs
- Irish-Dutch study 1989-1994 – ecohydrolgical advancements
- Still retains internationally important *soak* systems – rheotrophic drainage features
- Clara Bog West has undergone significant changes since the early 1990s – it is subsiding




Clara Bog West
Clara Bog East

NPWS Clara Bog Restoration Project

- Clara Bog West has subsided significantly - > 1.0 m in local areas and as far as 600 m from the bog margin towards its centre (< 20 years).

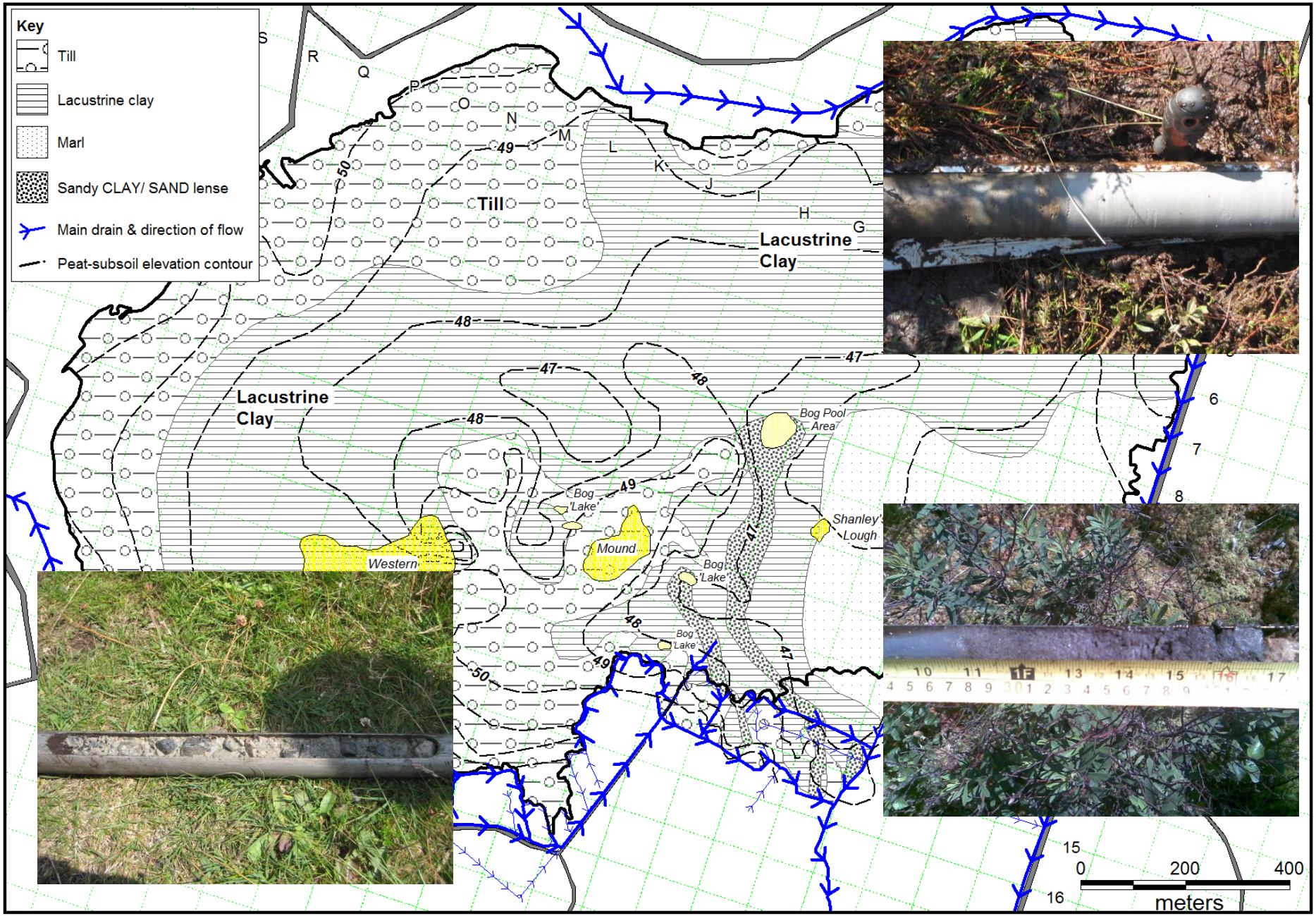
- Two main objectives of project:

1. To investigate and establish the key hydrological controls relating to the sustainability of Clara Bog West
2. To devise and design remediation measures to arrest the continuing deterioration in the morphology and hydroecology of the wetland


South
Western
Soak System
Western Mound
Shanely's Lough
Soak System

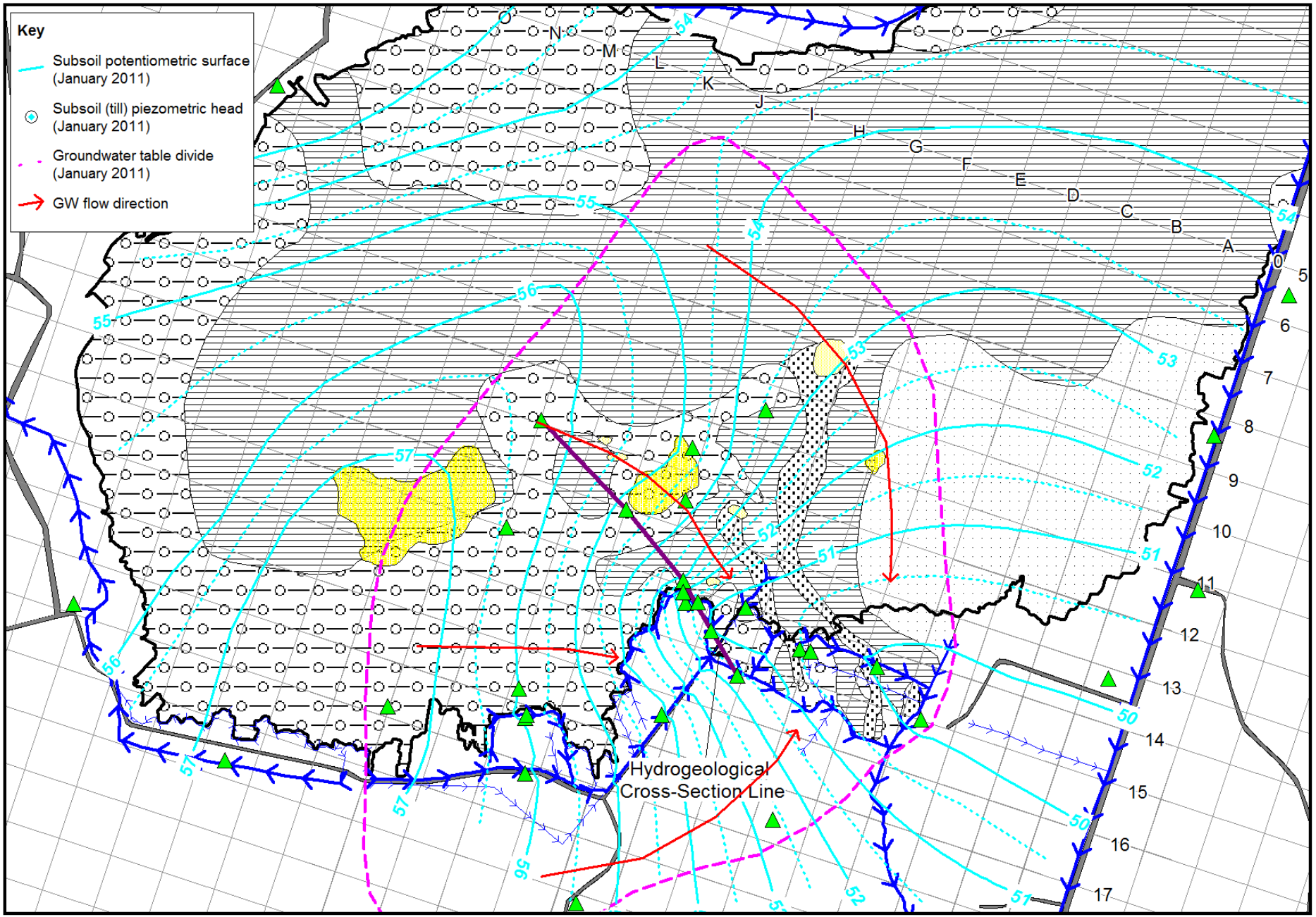
Geohydrological Framework

- Local geological framework and its material properties invariably control the movement of water in the subsurface
- Evaluate the hydraulic connectivity between wetland and underlying geological structure
- Essentially:
  1. The general geo-hydrological setting within which the wetland is situated
  2. Identifies the water supply mechanisms that sustain the wetland

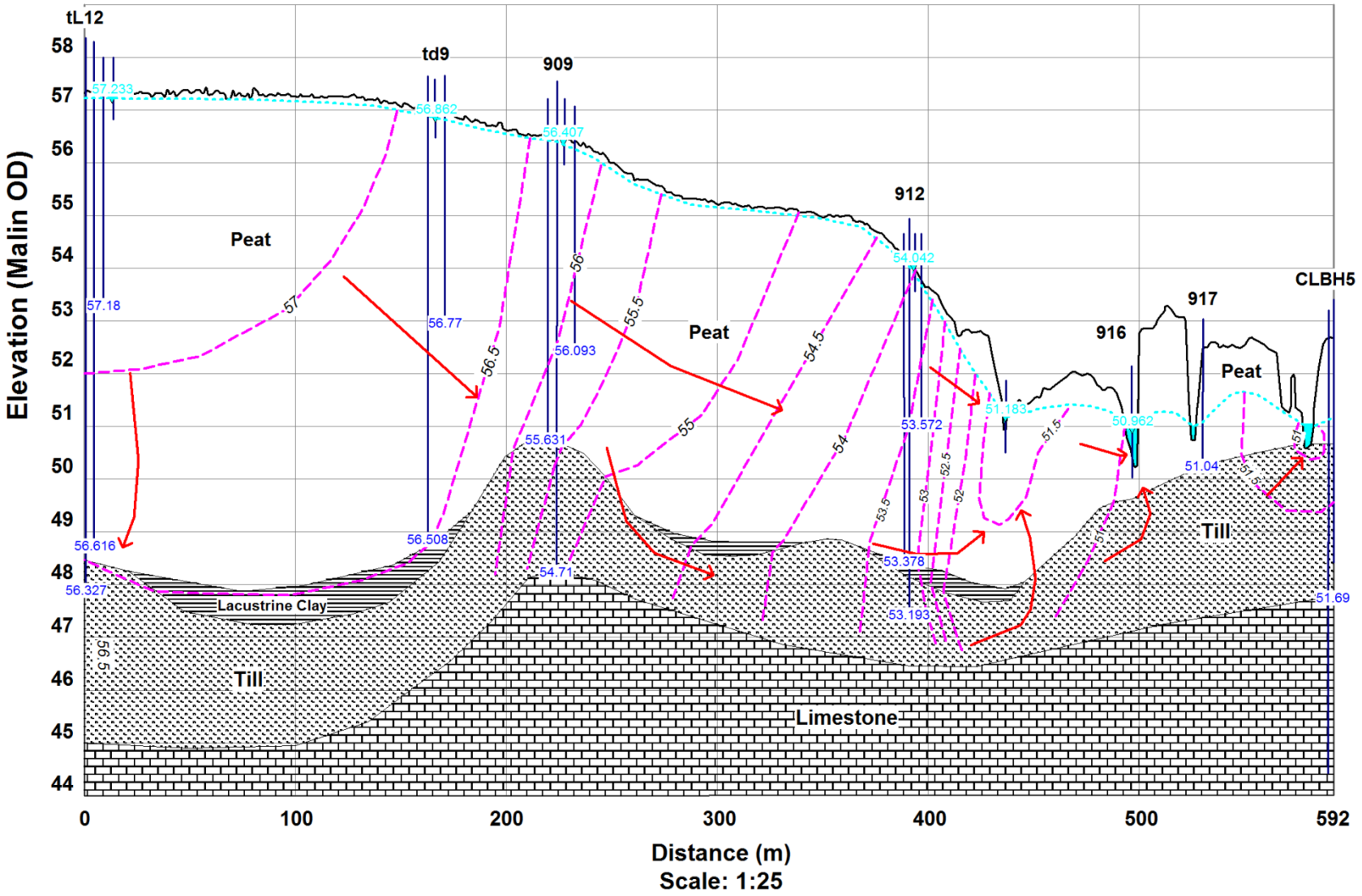

Key
Till
Lacustrine clay
Marl
Sandy CLAY/ SAND lense
Main drain & direction of flow
Peat-subsoil elevation contour
Till
Lacustrine Clay
Lacustrine Clay
Western
Bog Pool Area
Bog 'Lake'
Mound
Bog 'Lake'
Bog 'Lake'
Shanley's Lough
S
R
Q
P
O
N
M
L
K
J
I
H
G
49
50
48
47
6
7
8
15
0
200
400
16
meters

GW-SW Connection

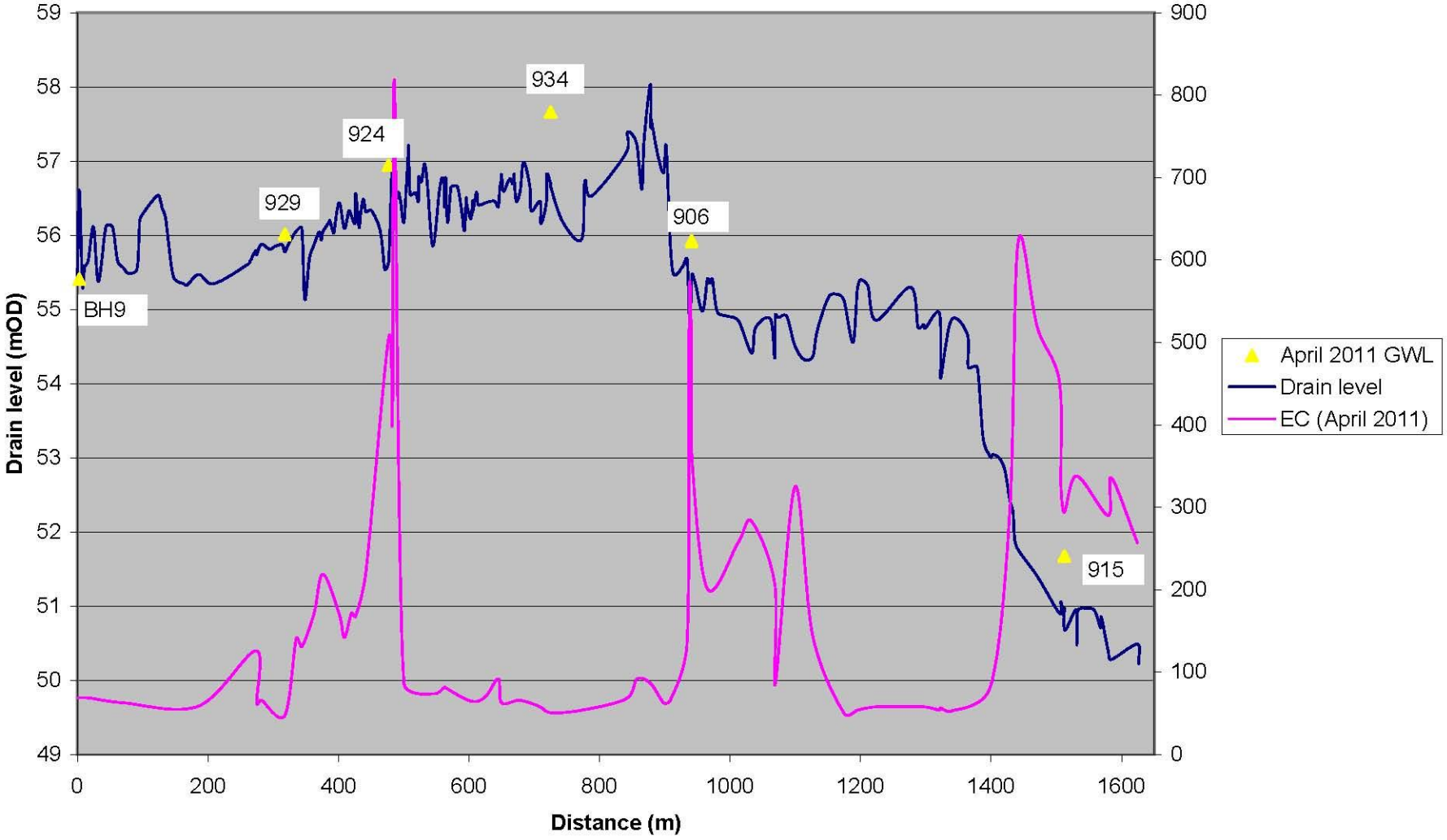
- Lacustrine clay a hydraulic barrier – downward seepage to groundwater is c. 10 mm/year
- Where absent, and peat sits directly on till mineral subsoil, a hydraulic connection between bog and RGWT exists - downward seepage from peat to groundwater > 50 mm/year
- Drains cut below RGWT
- Large tracts cut close, and into, till aquifer
- Upward hydraulic gradients
- Drains are now zones of groundwater discharge

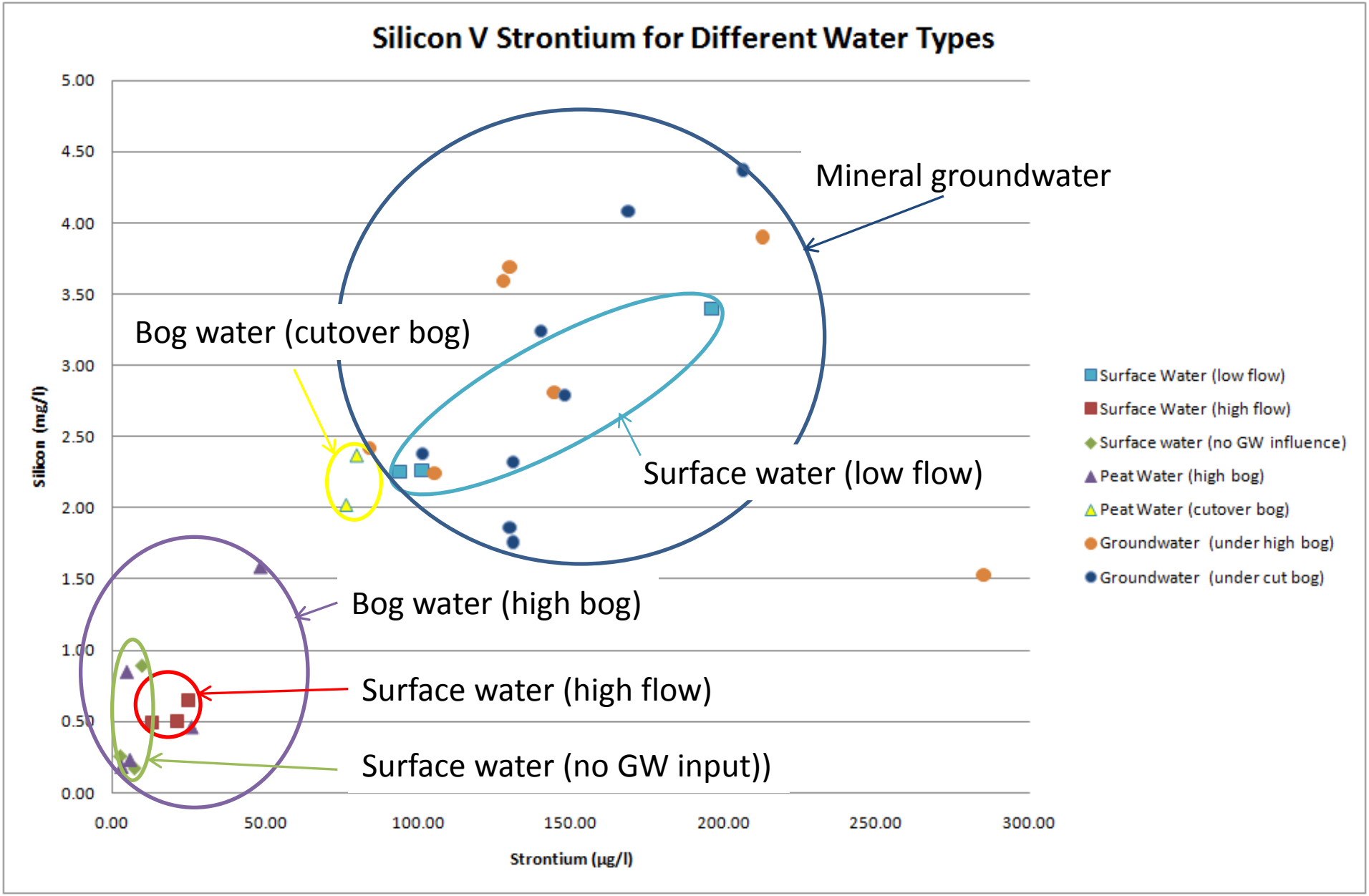

Key
Subsoil potentiometric surface (January 2011)
Subsoil (till) piezometric head (January 2011)
Groundwater table divide (January 2011)
GW flow direction
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
0
5
6
7
8
9
10
11
12
13
14
15
16
17
54
55
56
57
53
52
51
50
Hydrogeological Cross-Section Line

Hydrogeological Cross Section through Transect 3
January 2011



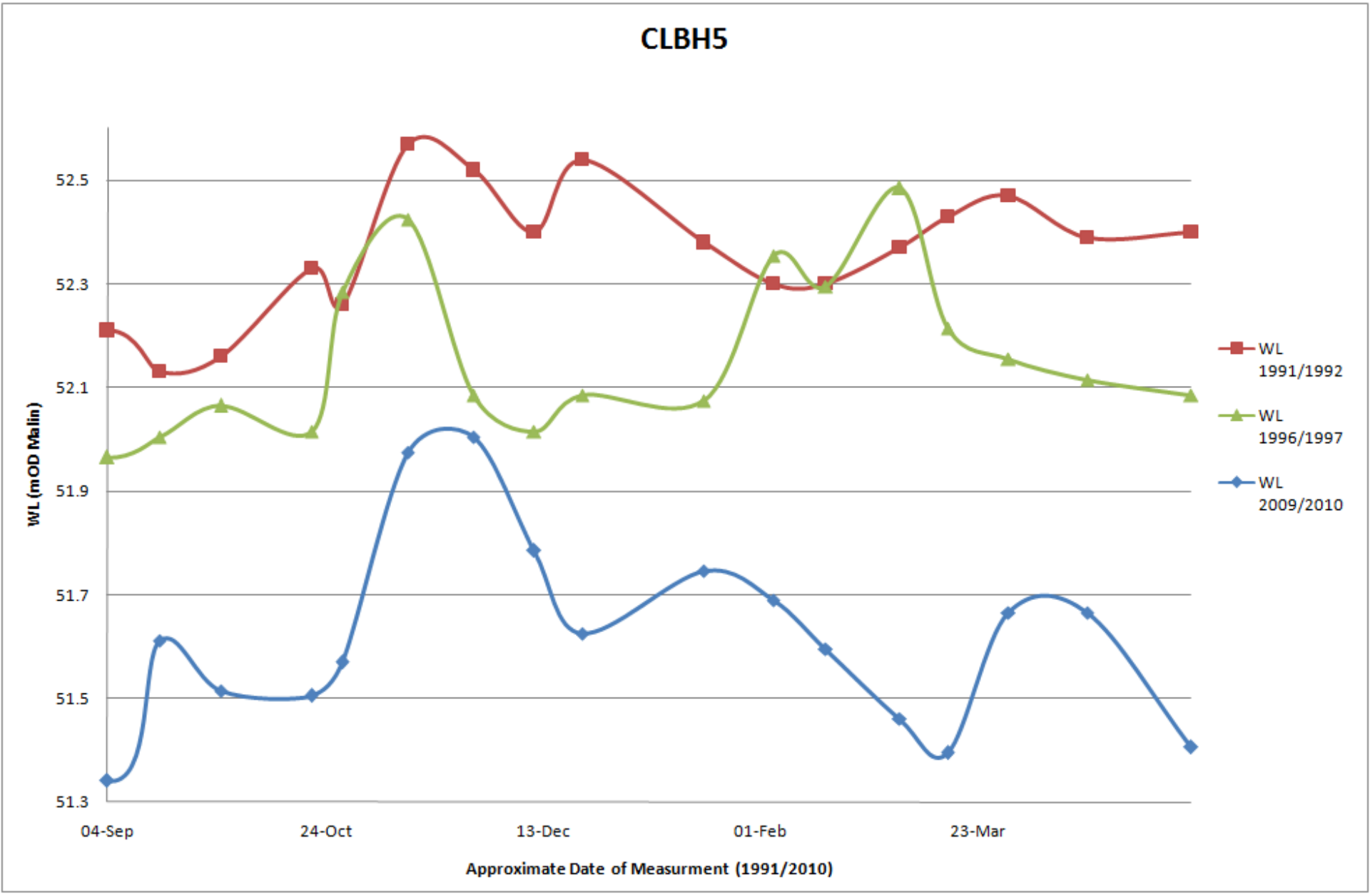
Drain profile, electrical conductivity & local groundwater level

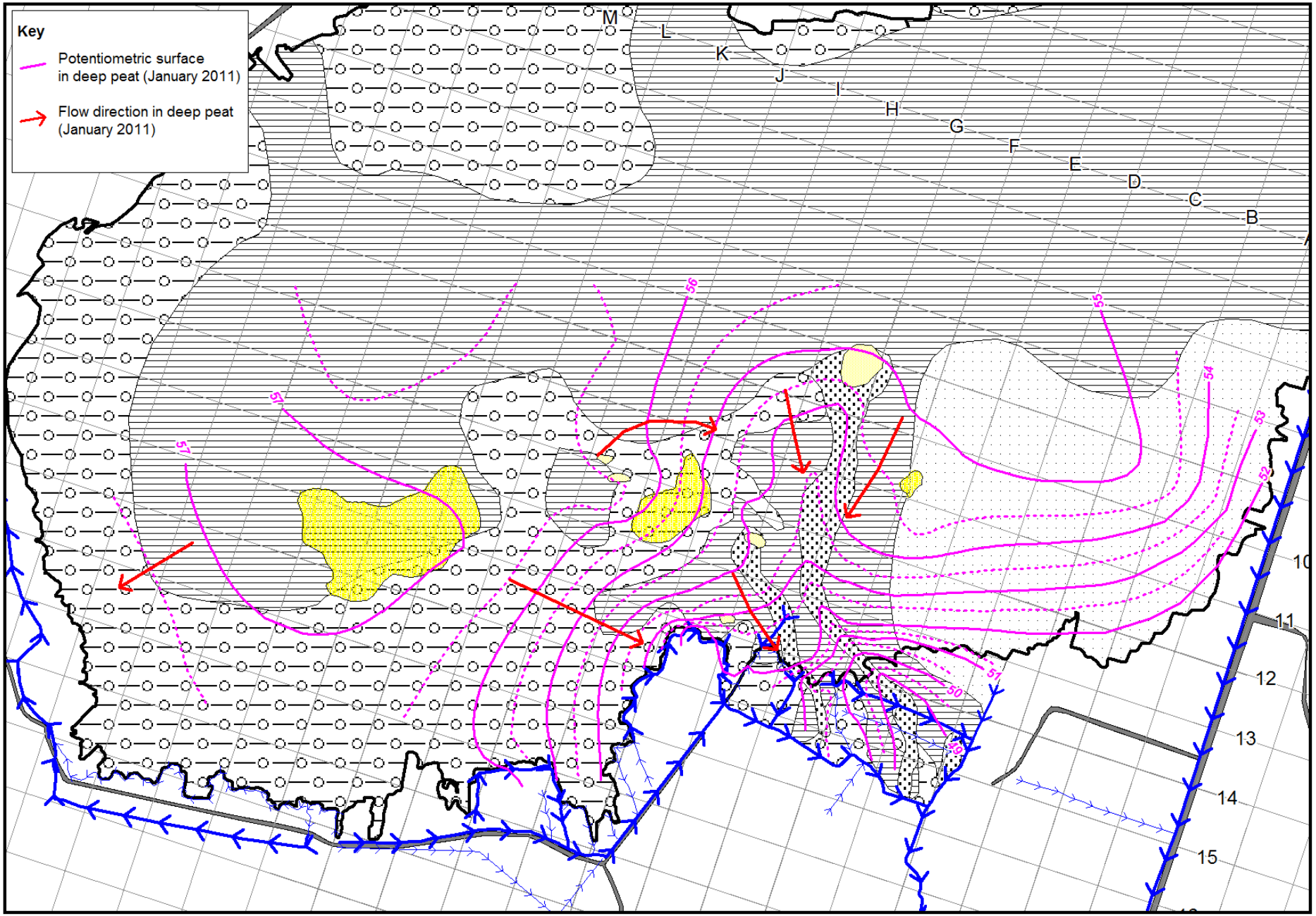


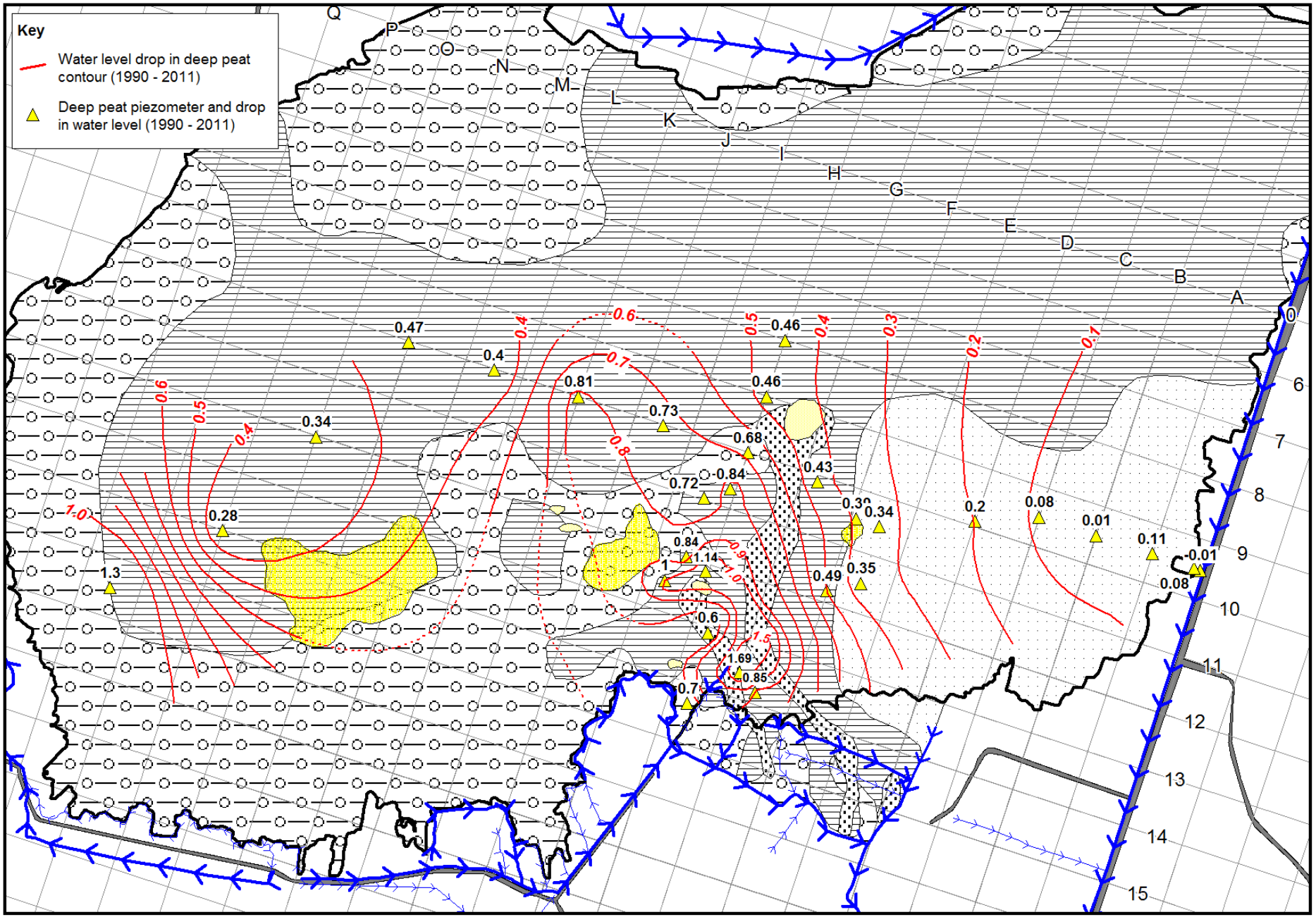

Silicon V Strontium for Different Water Types
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Silicon (mg/l)
0.00
50.00
100.00
150.00
200.00
250.00
300.00
Strontium (µg/l)
Mineral groundwater
Bog water (cutover bog)
Surface water (low flow)
Bog water (high bog)
Surface water (high flow)
Surface water (no GW input))
Surface Water (low flow)
Surface Water (high flow)
Surface water (no GW influence)
Peat Water (high bog)
Peat Water (cutover bog)
Groundwater (under high bog)
Groundwater (under cut bog)

Reduced GWL

- Regional groundwater has declined since the 1990s
- Coincident with peat and drain cutting
- Water level in peat profile has also reduced
- Two main drainage pathways:
  - Through till
  - Through sand lense/ palaeochannel

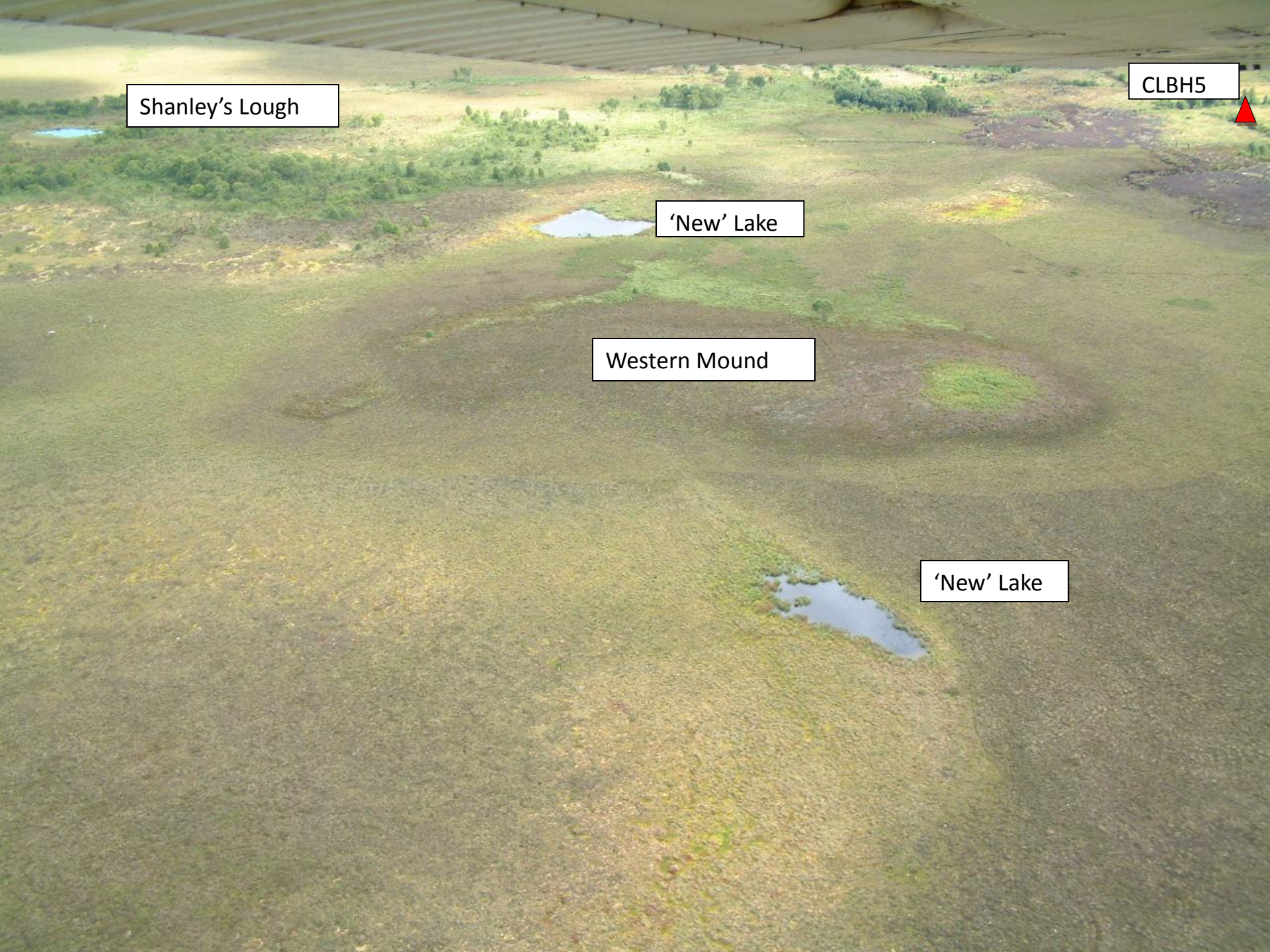

CLBH5
52.5
52.3
52.1
51.9
51.7
51.5
51.3
WL (mOD Malin)
04-Sep
24-Oct
13-Dec
01-Feb
23-Mar
Approximate Date of Measurment (1991/2010)
WL 1991/1992
WL 1996/1997
WL 2009/2010

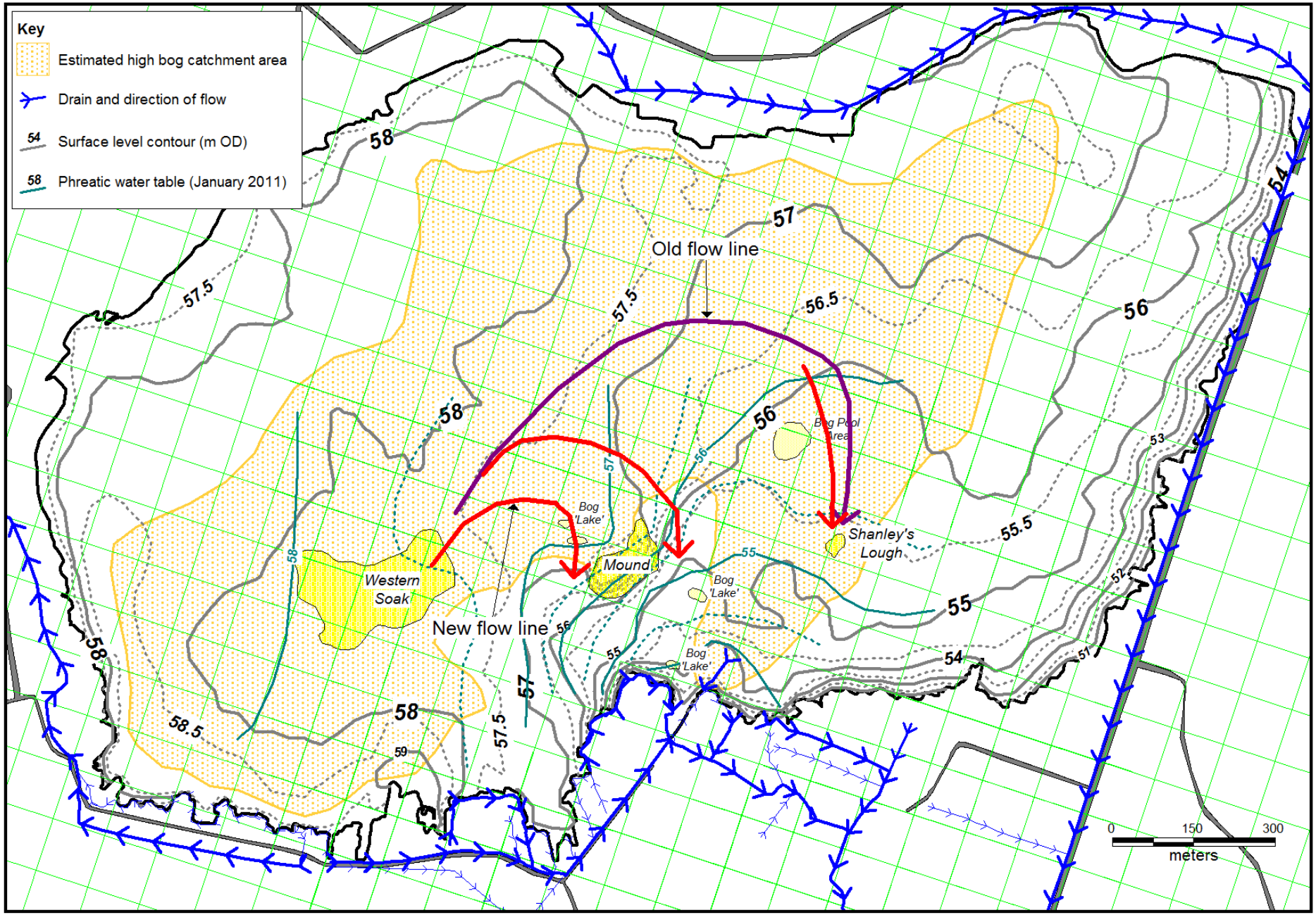

Key
Potentiometric surface in deep peat (January 2011)
Flow direction in deep peat (January 2011)
M
L
K
J
I
H
G
F
E
D
C
B
A
10
11
12
13
14
15
57
56
55
54
53
52
51
50
49

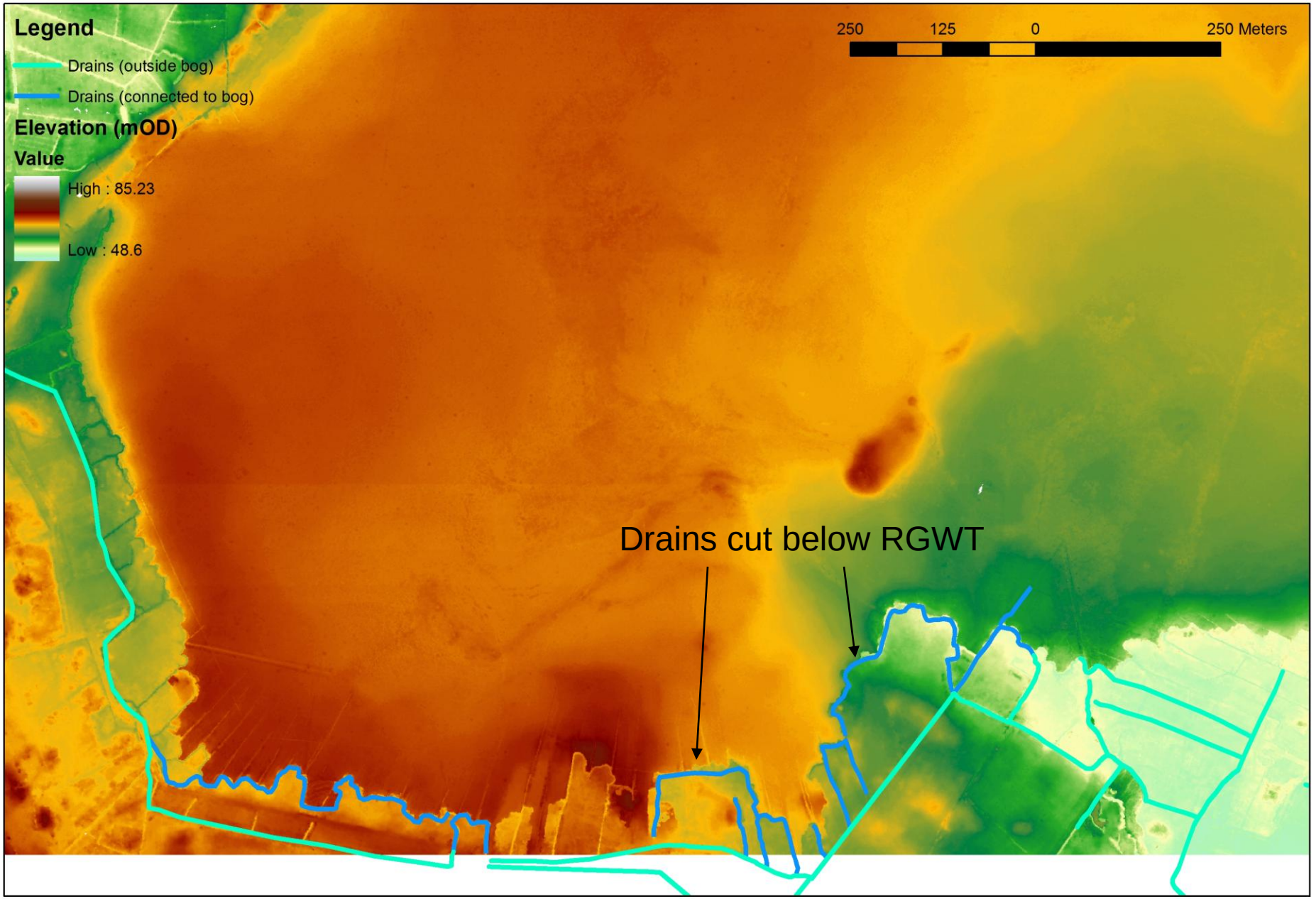

Key
Water level drop in deep peat contour (1990 - 2011)
Deep peat piezometer and drop in water level (1990 - 2011)
Q
P
O
N
M
L
K
J
I
H
G
F
E
D
C
B
A
0
6
7
8
9
10
11
12
13
14
15
0.47
0.4
0.81
0.46
0.46
0.34
0.73
0.68
0.43
0.72
-0.84
0.3
0.34
0.2
0.08
0.01
0.11
-0.01
0.08
0.28
1.3
0.84
1.14
1
0.49
0.35
0.6
1.69
0.85
0.7
0.6
0.5
0.4
0.7
0.8
0.9
1.0
1.5
0.3
0.2
0.1

Ecological Impact from Reduced RGWL?

- Reduced RGWL in till aquifer has induced vertical drainage at the base of peat
- Peat consolidating at its base
- As peat shrinks the bog subsides
- Surface level gradients increase on the bog surface preventing *Sphagnum* growth
- Long flow paths mainatining soak systems impacted
- Value of raised bog as an ecosystem severly compromised

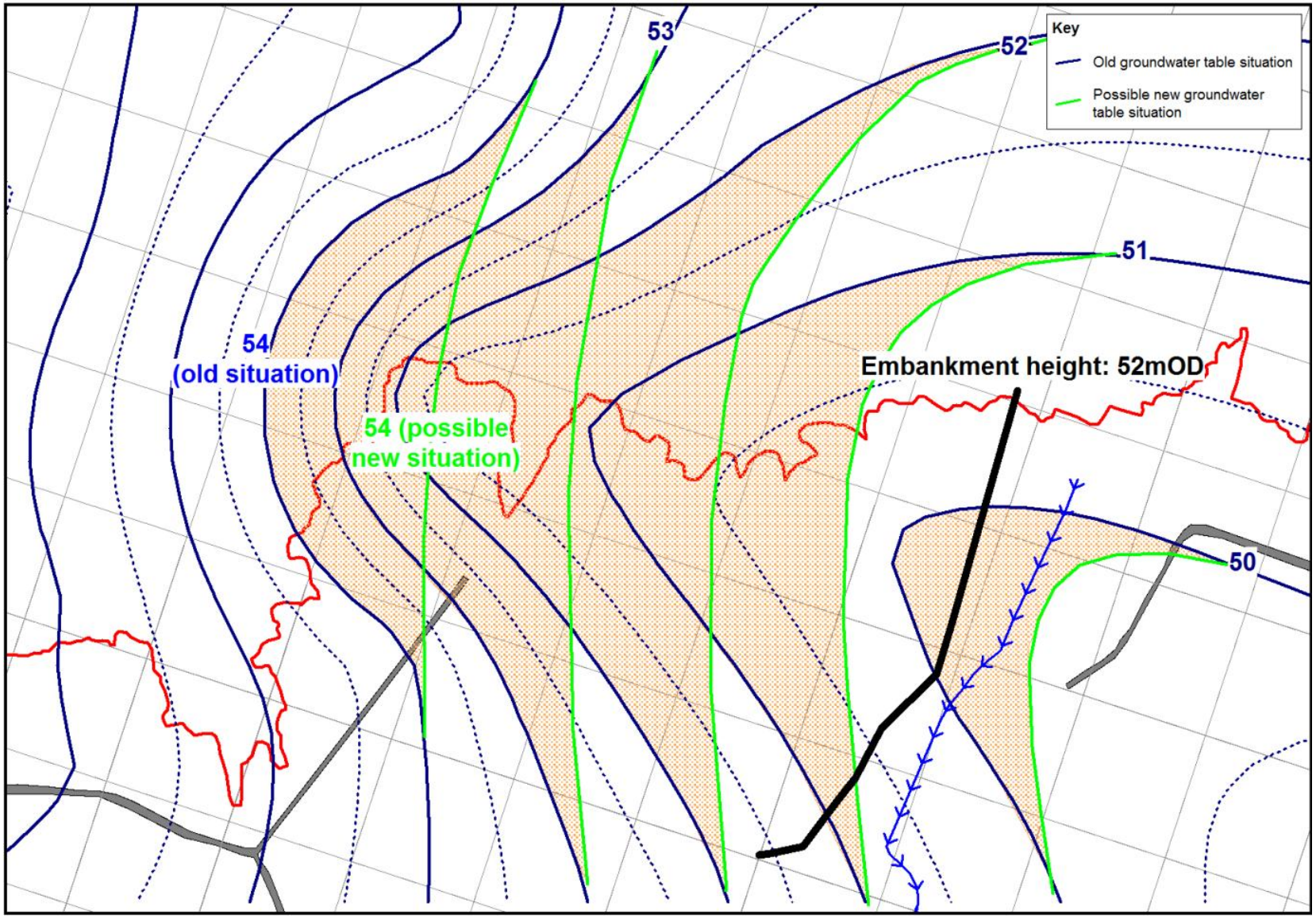

Shanley's Lough
CLBH5
'New' Lake
Western Mound
'New' Lake


Key
Estimated high bog catchment area
Drain and direction of flow
54 Surface level contour (m OD)
58 Phreatic water table (January 2011)
Old flow line
New flow line
Western Soak
Mound
Bog 'Lake'
Bog Pool Area
Shanley's Lough
58
57.5
57
56.5
56
55.5
55
54
53
52
51
58.5
59
0
150
300
meters


Legend
Drains (outside bog)
Drains (connected to bog)
Elevation (mOD)
Value
High : 85.23
Low : 48.6
250
125
0
250 Meters
Drains cut below RGWT

Restoration?

Slow down subsidence - raise the RGWT



Conclusion

- Clara Bog is not an isolated hydrological system
- GW is indirectly sustaining the ecosystem by:
  1. Preventing drainage
  2. Providing an upward pressure gradient
- Role of GW becomes apparent if the regional GWL is reduced
- If subsidence is to stop/ slow down the GWT must be raised and the natural dynamics maintained
- This situation is not unique to Clara and may apply to other raised bogs and therefore has key implications for restoration and for the role of raised bogs as GWTDEs under the WFD