Precise Determination of Salt Impacted Soil on an Oilfield Site using 3D Salt Imaging in Combination with Dual Tube Soil Sampling

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KiNiLau Physics Inc.

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Site

- Northern Alberta pipeline break
- Complicated stratigraphy
- Prior subsurface investigations for several years

Tools

3 tools applied strategically,
in 1 day.

Tools

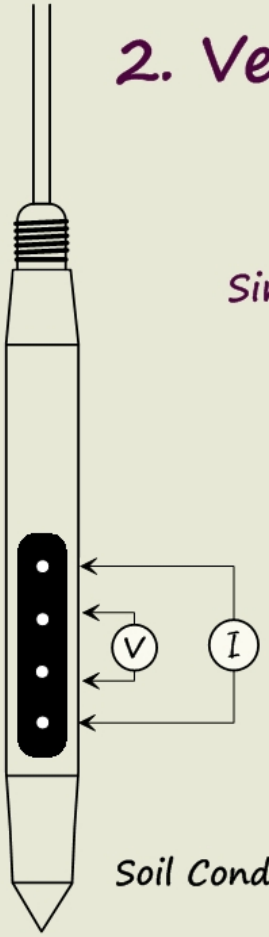
1. Lateral Conductivity

(Geonics EM31)

Tools

2. Vertical Conductivity

(Geoprobe SC400)



Similar technology to analytical meters:

- Calibration constant in NaCl solution
- Infield calibration across resistors
- System linearity to 10 dS/m
- Numerical normalization to 25°C

(Heimovaara, 1995)

but,

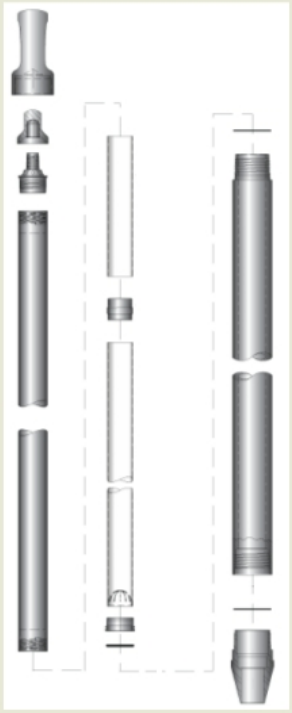
NO moisture normalization

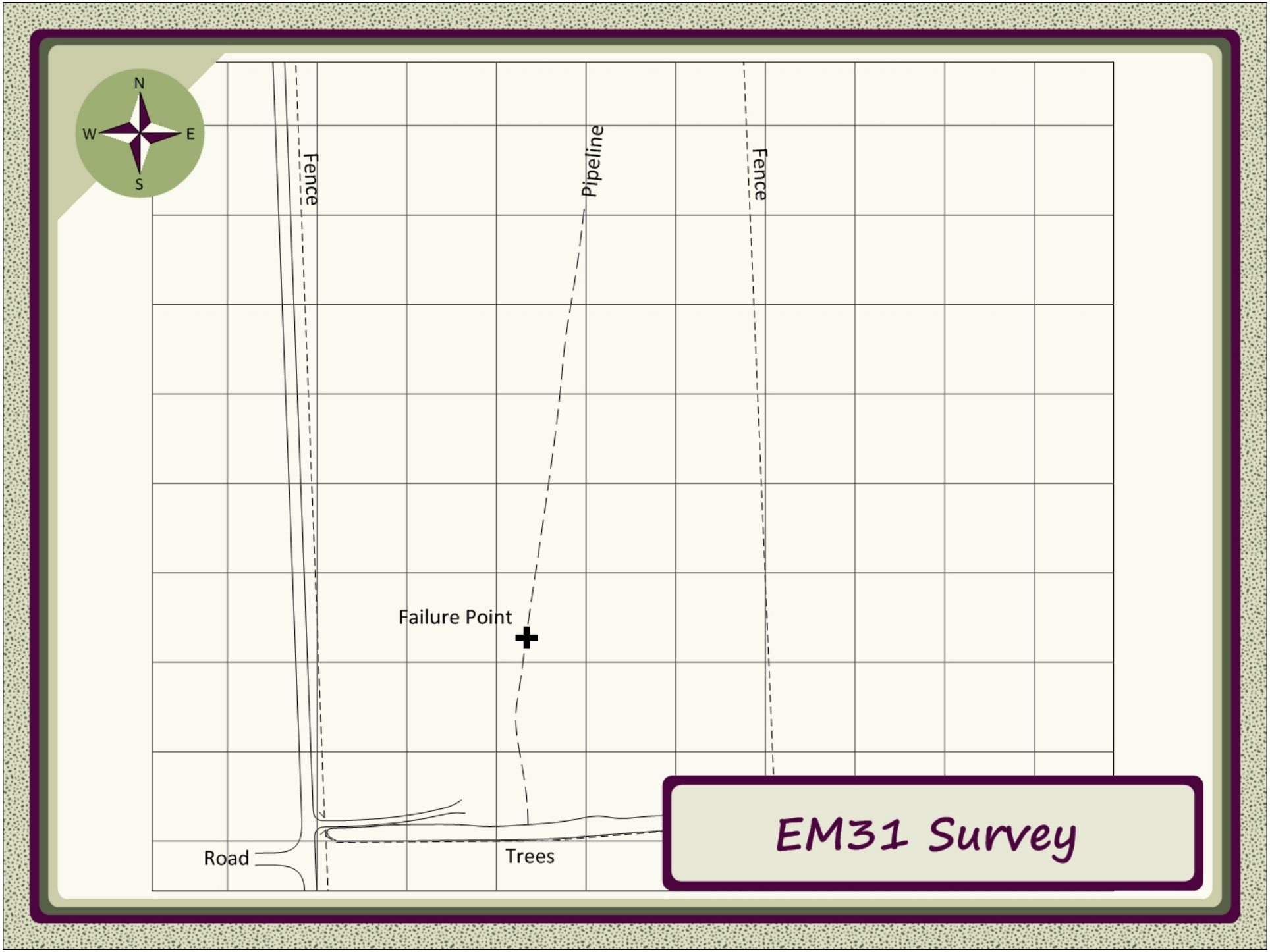
$$\text{Soil Conductivity} = \frac{I}{V}$$

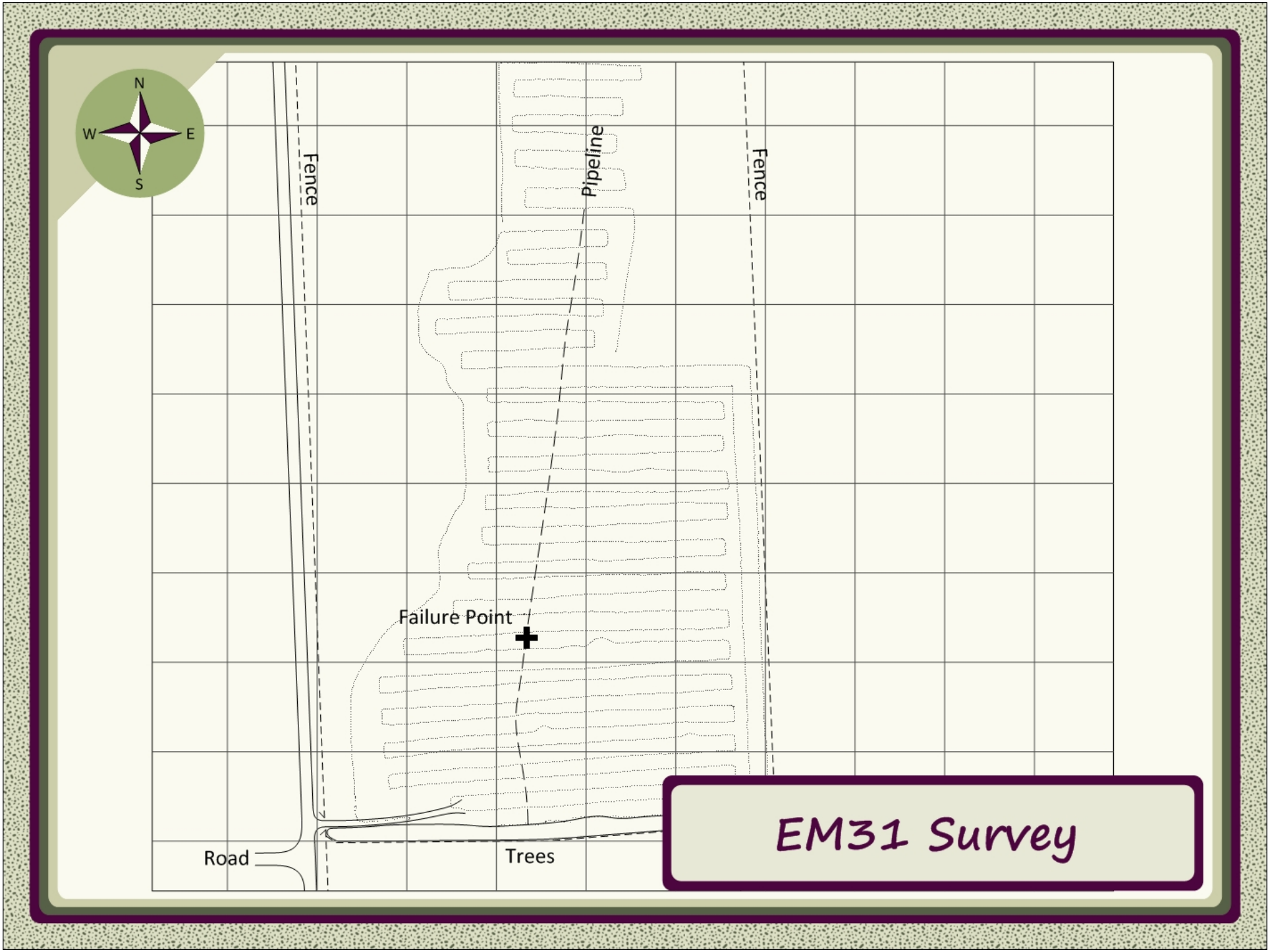
Tools

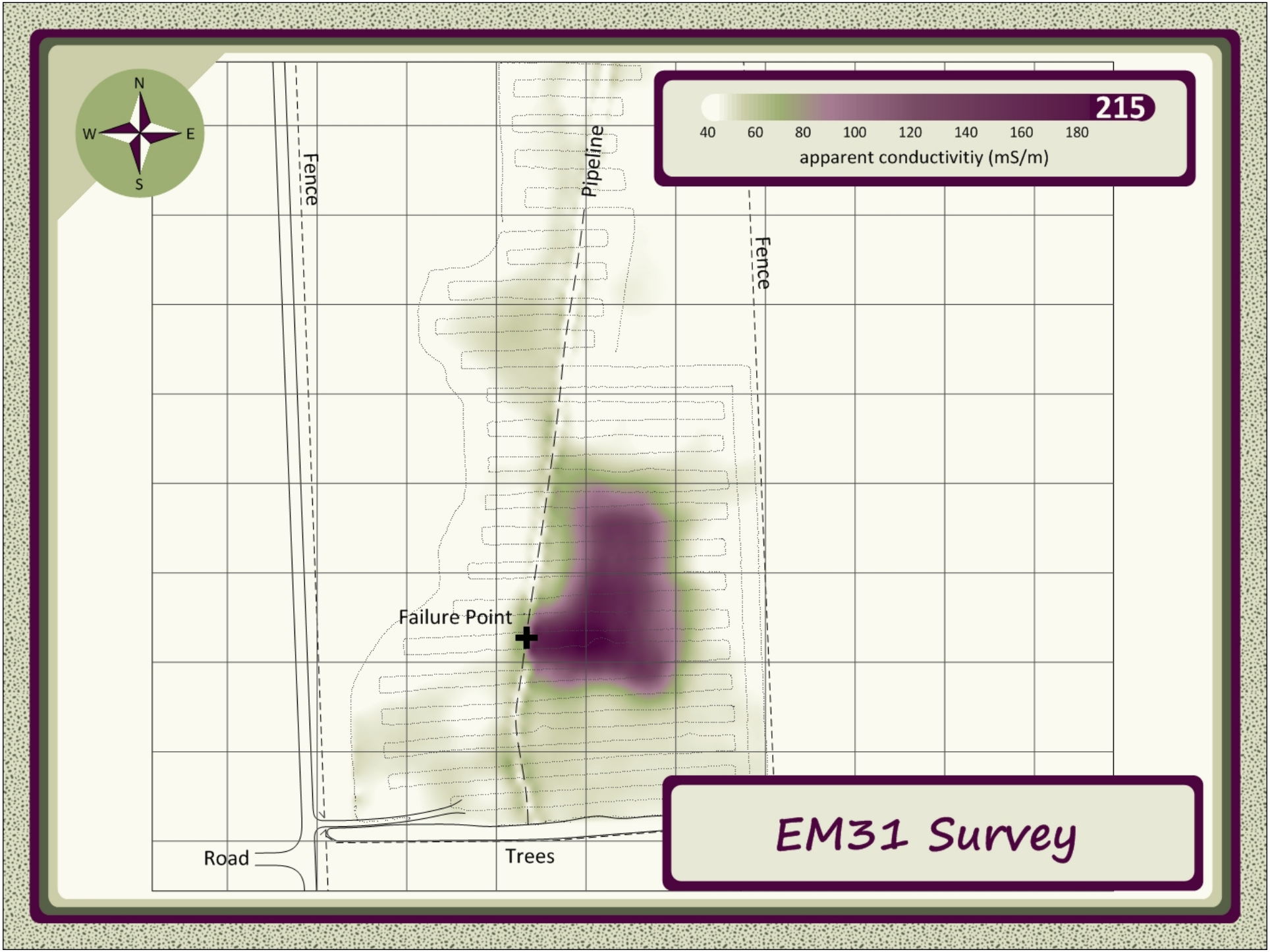
3. Targeted Core

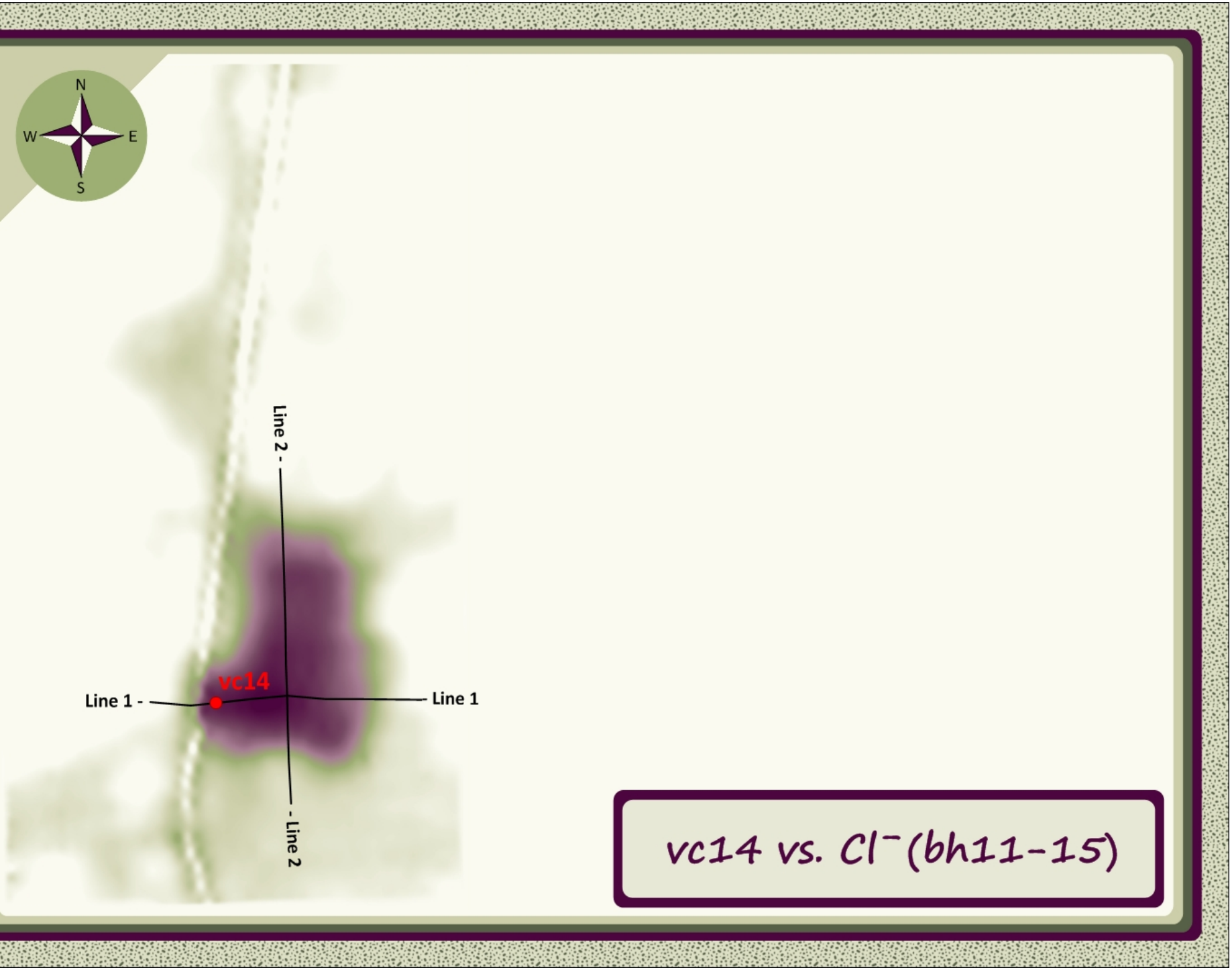
(Geoprobe Dual Tube Soil Sampler)



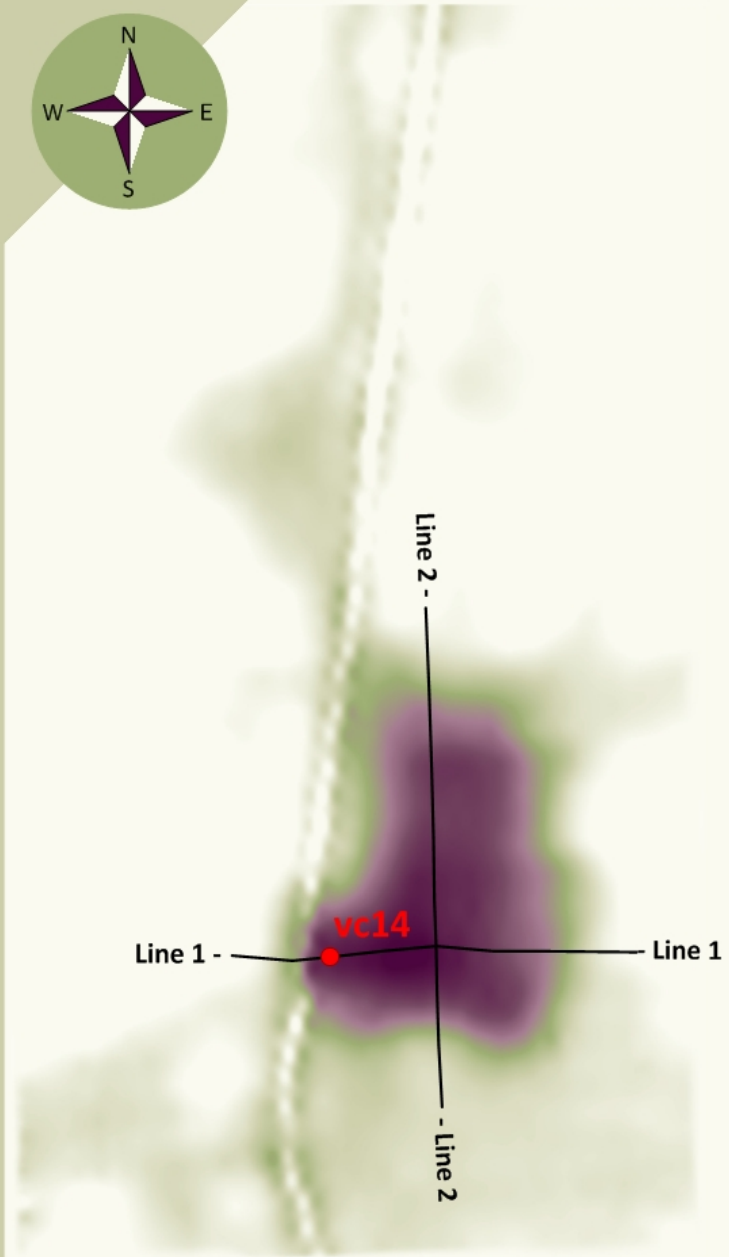

N
W
E
S
Fence
Pipeline
Fence
Failure Point
Road
Trees
EM31 Survey

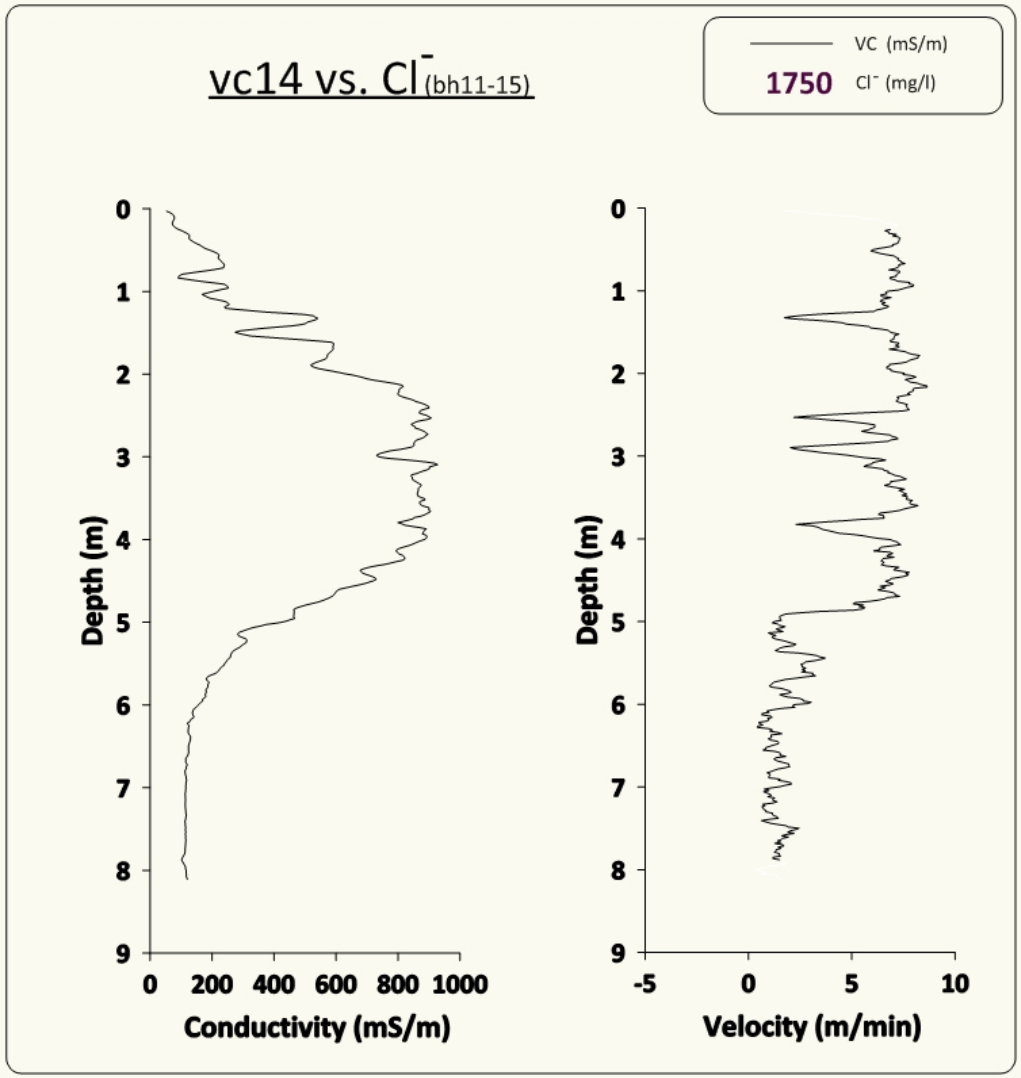

N
W
E
S
Fence
Pipeline
Fence
Failure Point
Road
Trees
EM31 Survey


N
W
E
S
215
40
60
80
100
120
140
160
180
apparent conductivitiy (mS/m)
Fence
Pipeline
Fence
Failure Point
Road
Trees
EM31 Survey

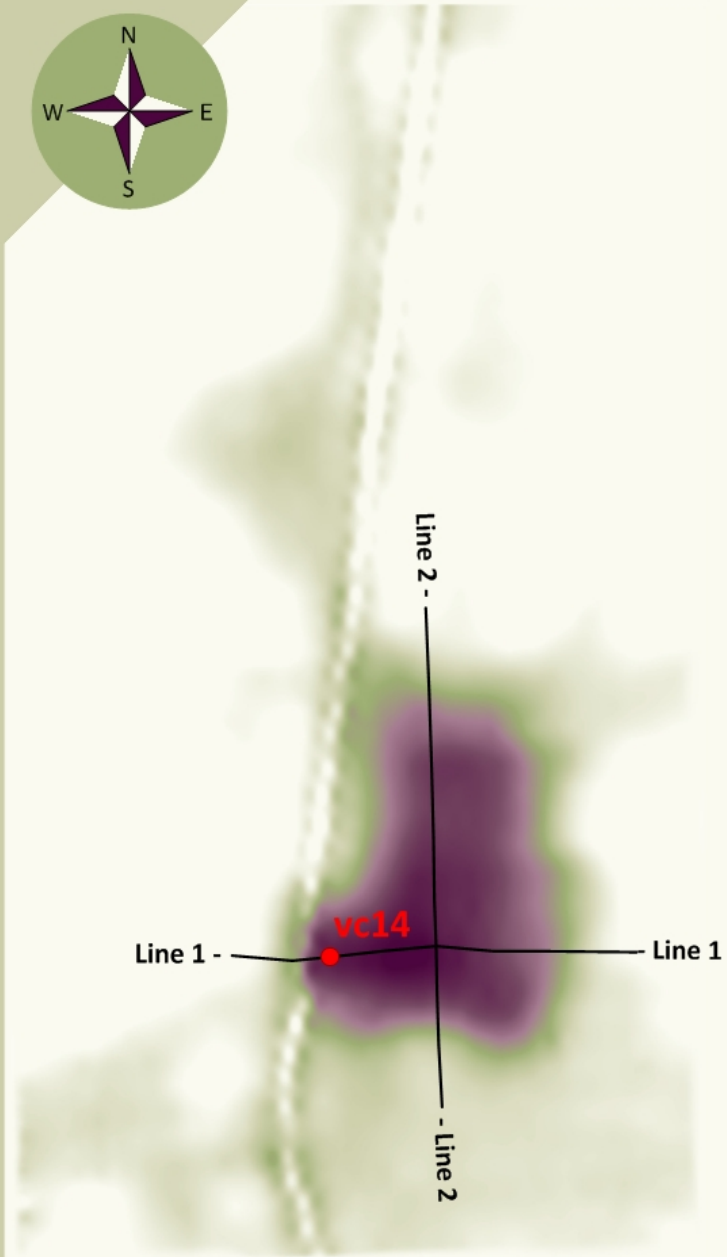


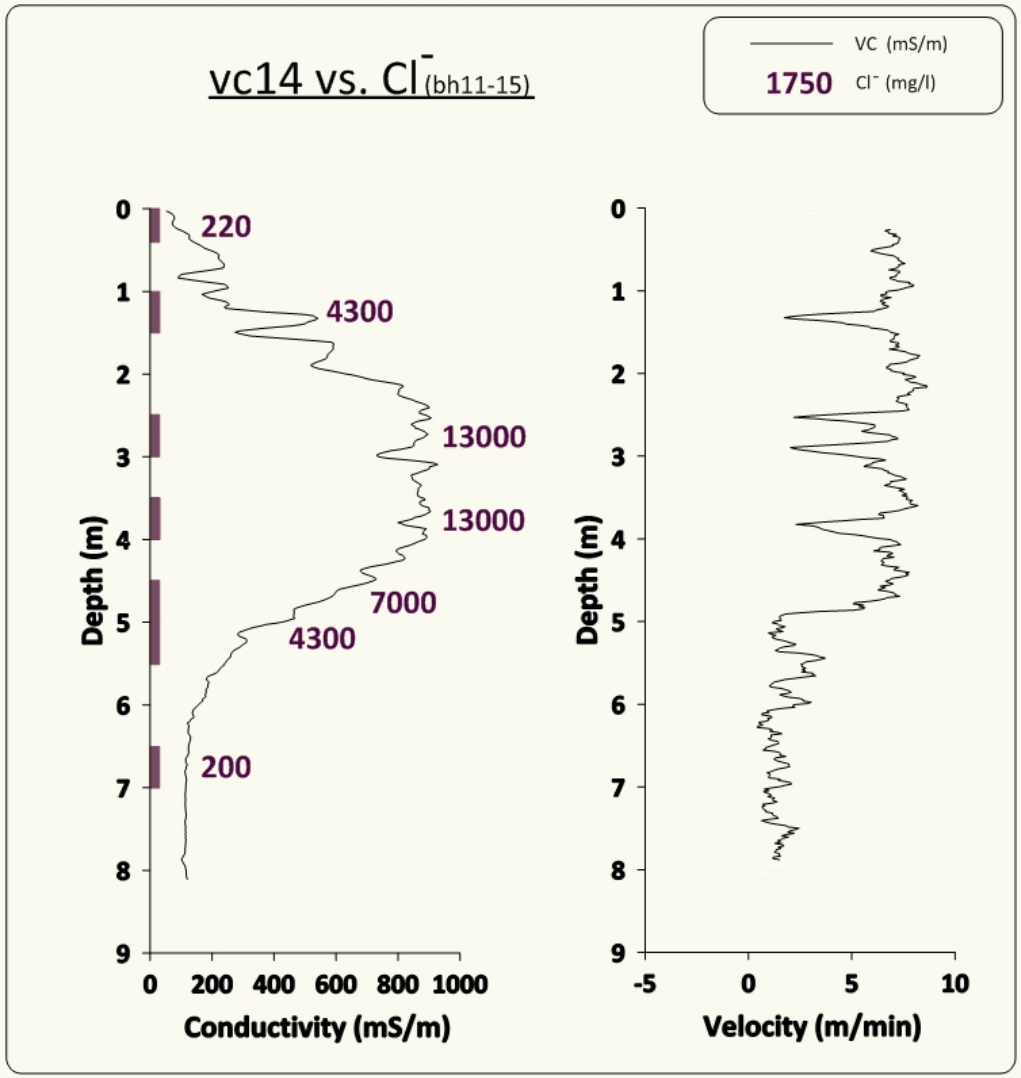
vc14 vs. Cl^- (bh11-15)



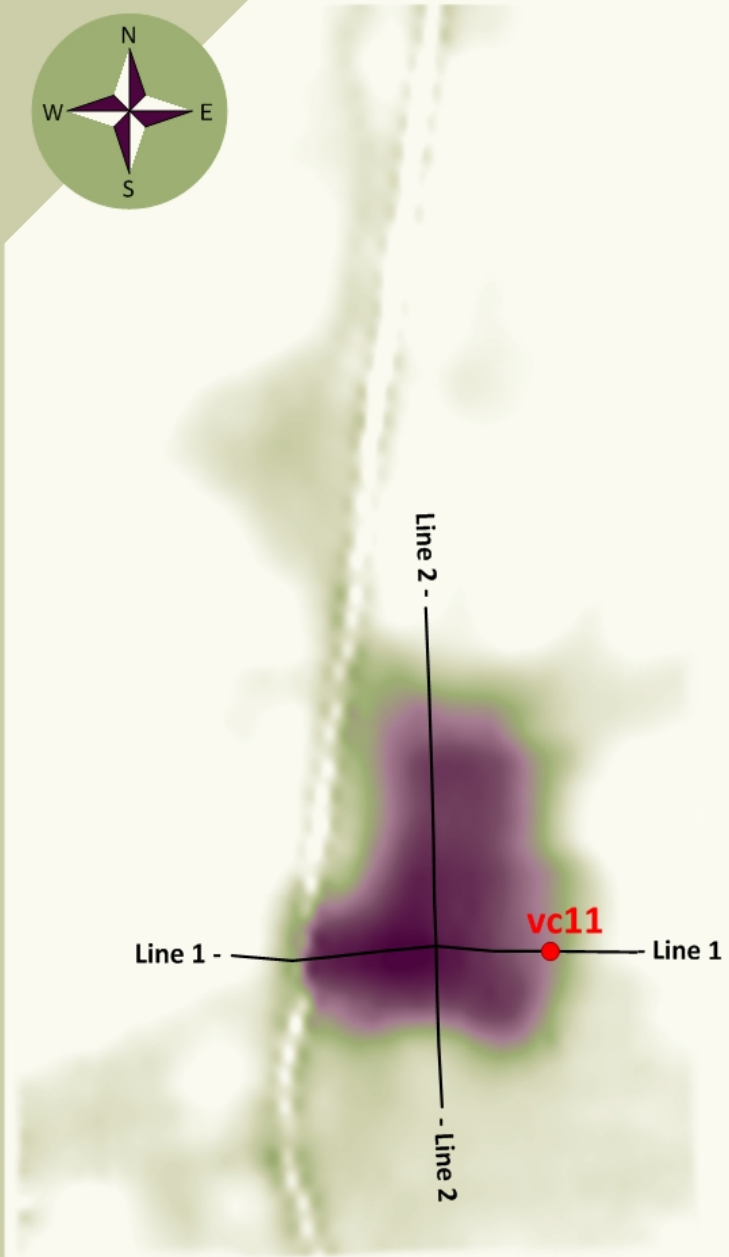


vc14 vs. Cl⁻(bh11-15)

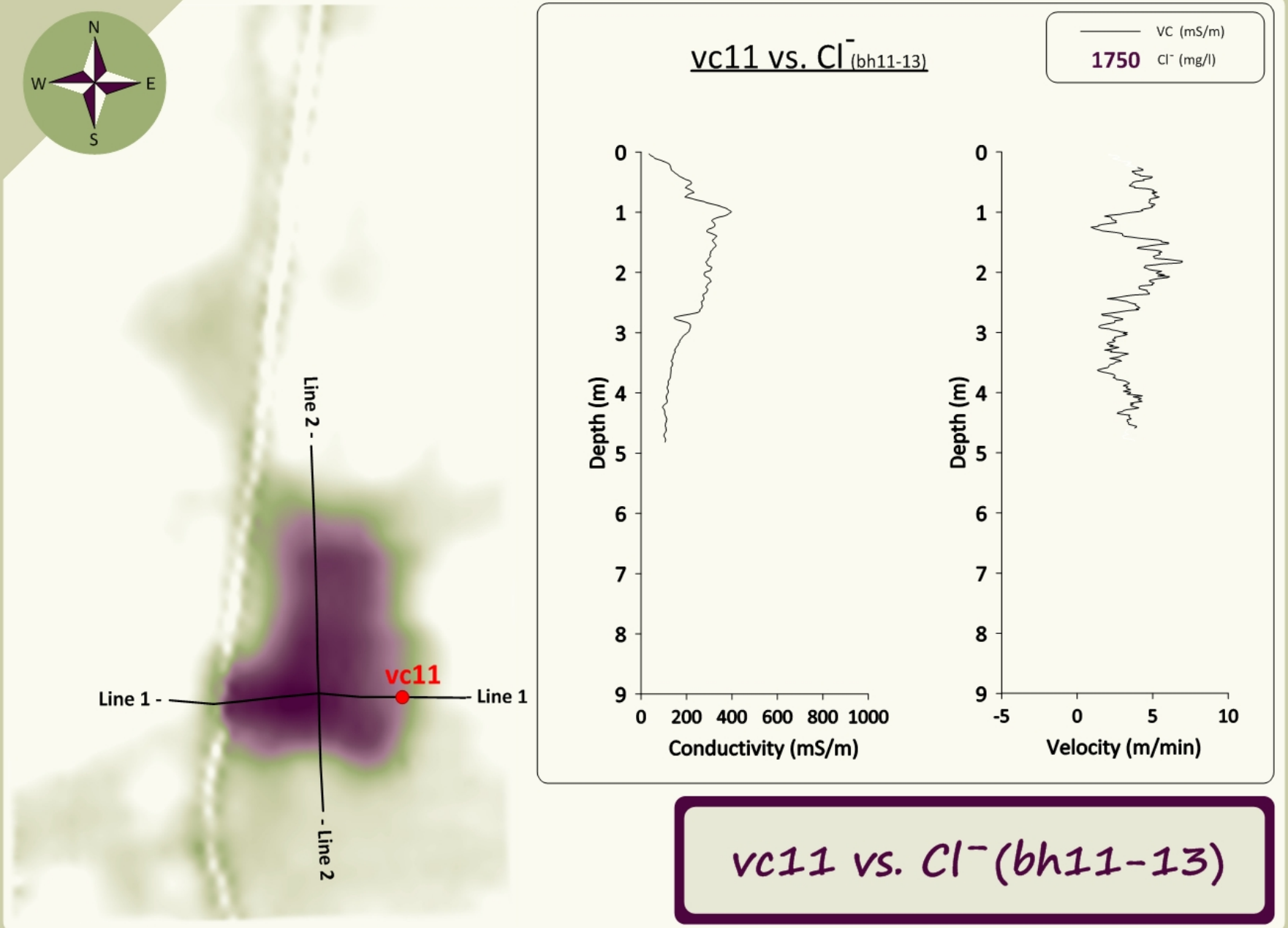


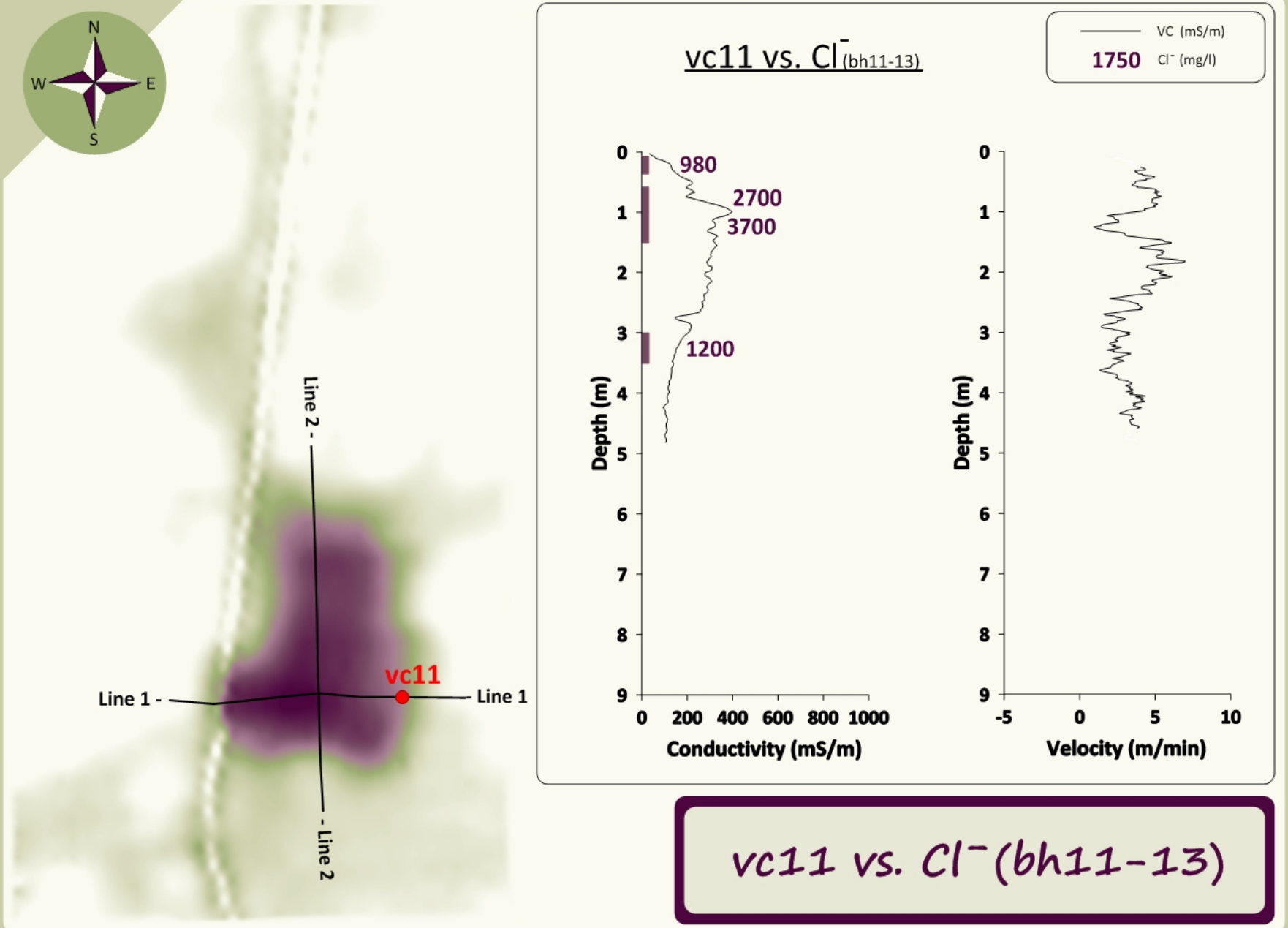


vc14 vs. Cl⁻(bh11-15)

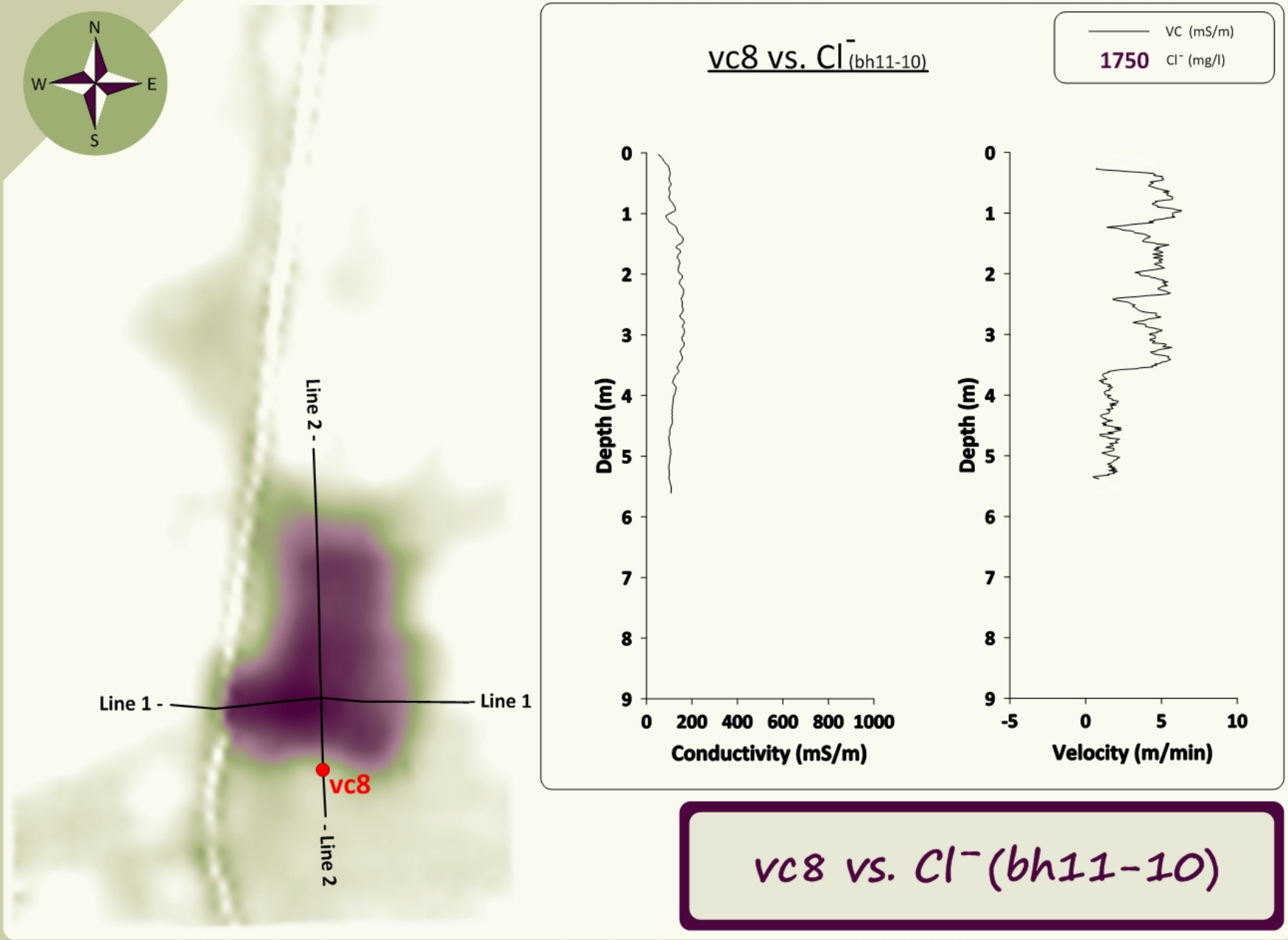


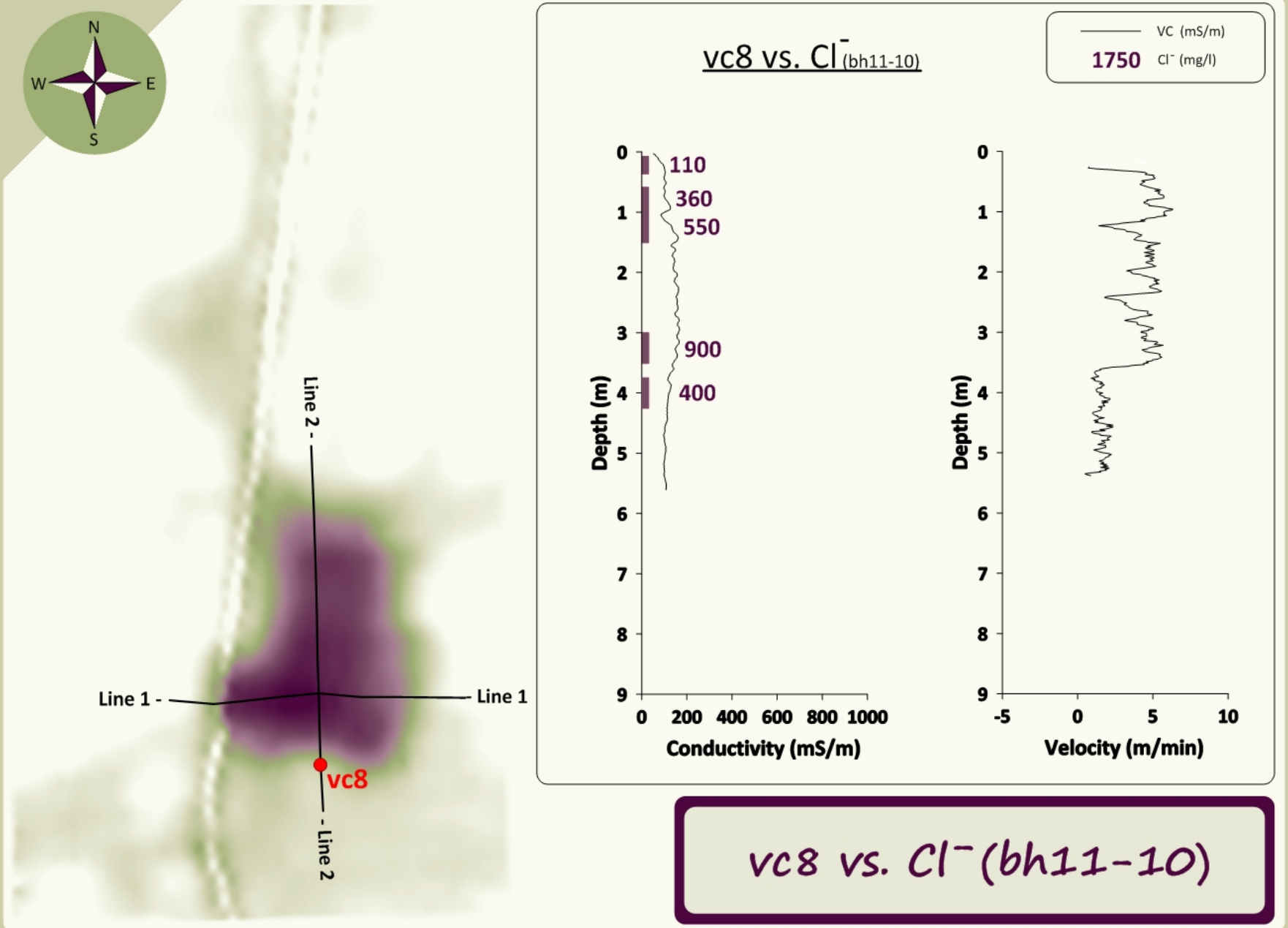
vc11 vs. Cl^- (bh11-13)

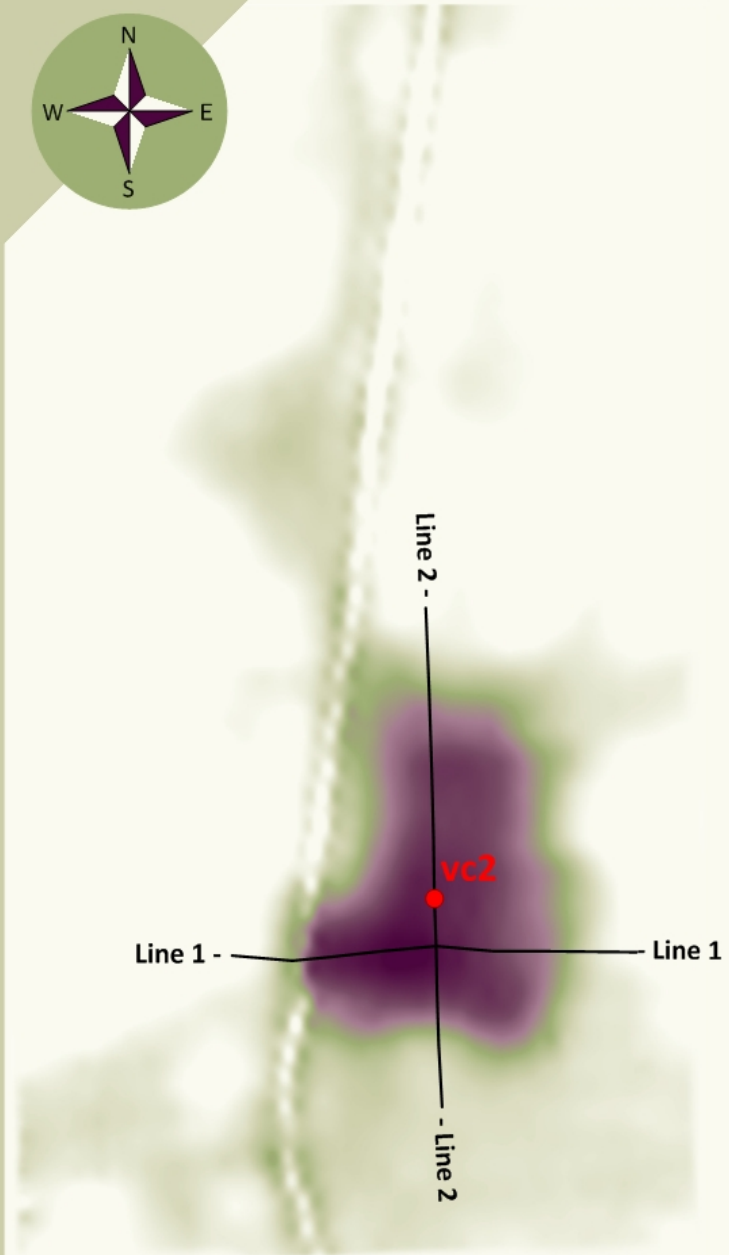

N
W
E
S
Line 2
Line 1
vc11
Line 1
Line 2
vc11 vs. Cl⁻ (bh11-13)
VC (mS/m)
1750
Cl⁻ (mg/l)
Depth (m)
0
1
2
3
4
5
6
7
8
9
0 200 400 600 800 1000
Conductivity (mS/m)
-5 0 5 10
Velocity (m/min)
vc11 vs. Cl⁻ (bh11-13)


N
W
E
S
Line 2 -
- Line 2
Line 1 -
Line 1
vc11
vc11 vs. Cl⁻(bh11-13)
VC (mS/m)
1750 Cl⁻ (mg/l)
980
2700
3700
1200
Depth (m)
0 1 2 3 4 5 6 7 8 9
0 200 400 600 800 1000
Conductivity (mS/m)
-5 0 5 10
Velocity (m/min)
vc11 vs. Cl⁻(bh11-13)

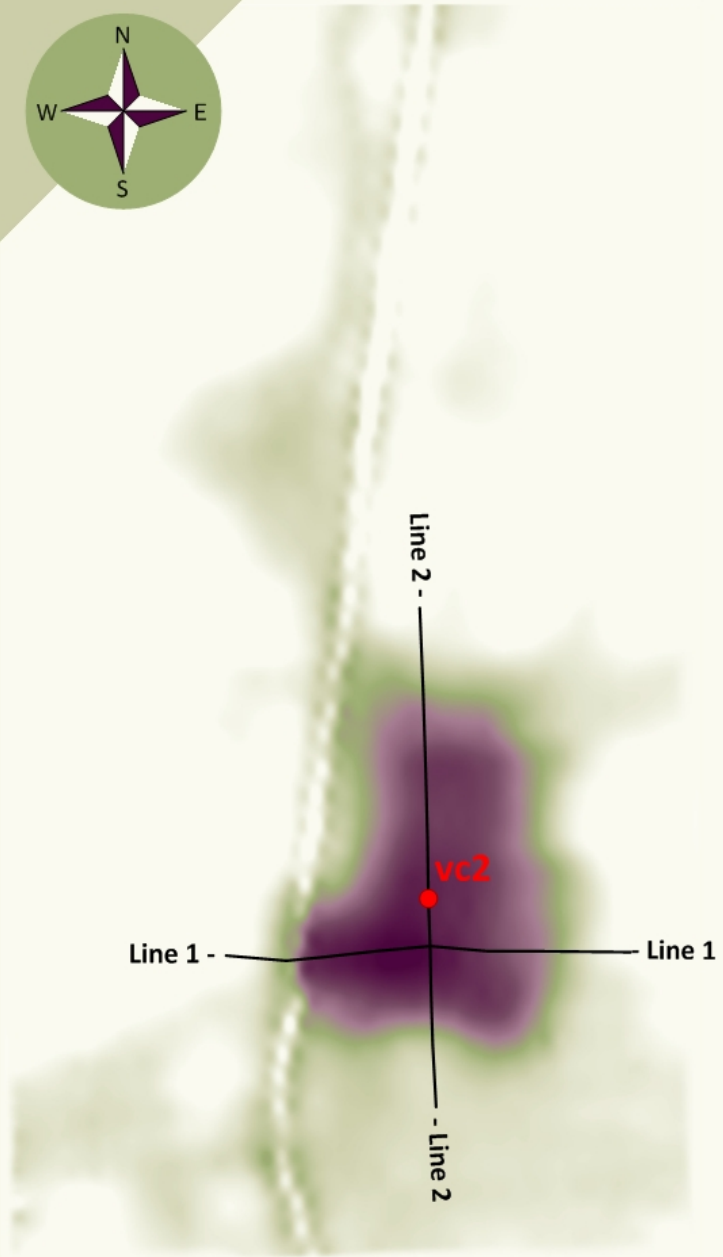

N
W
E
S
Line 2 -
Line 1 -
Line 1
vc8
- Line 2
vc8 vs. Cl⁻ (bh11-10)

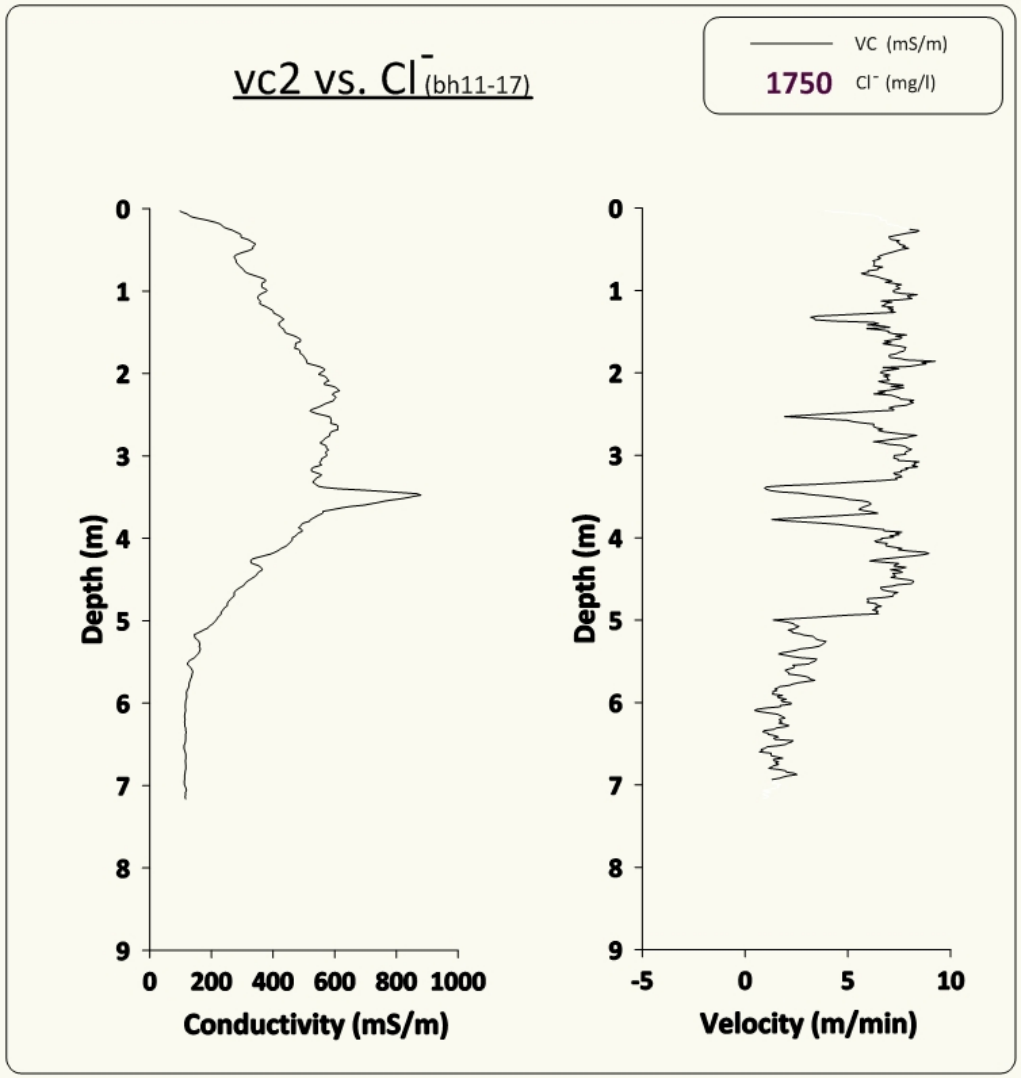

N
W
E
S
Line 2
Line 1
Line 1
vc8
Line 2
vc8 vs. Cl⁻ (bh11-10)
VC (mS/m)
1750
Cl⁻ (mg/l)
Depth (m)
0
1
2
3
4
5
6
7
8
9
0
200
400
600
800
1000
Conductivity (mS/m)
Depth (m)
-5
0
5
10
Velocity (m/min)
vc8 vs. Cl⁻ (bh11-10)


N
W
E
S
Line 2
Line 1
Line 1
vc8
Line 2
vc8 vs. Cl⁻ (bh11-10)
VC (mS/m)
1750
Cl⁻ (mg/l)
110
360
550
900
400
Depth (m)
0 1 2 3 4 5 6 7 8 9
0 200 400 600 800 1000
Conductivity (mS/m)
Depth (m)
0 1 2 3 4 5 6 7 8 9
-5 0 5 10
Velocity (m/min)
vc8 vs. Cl⁻ (bh11-10)

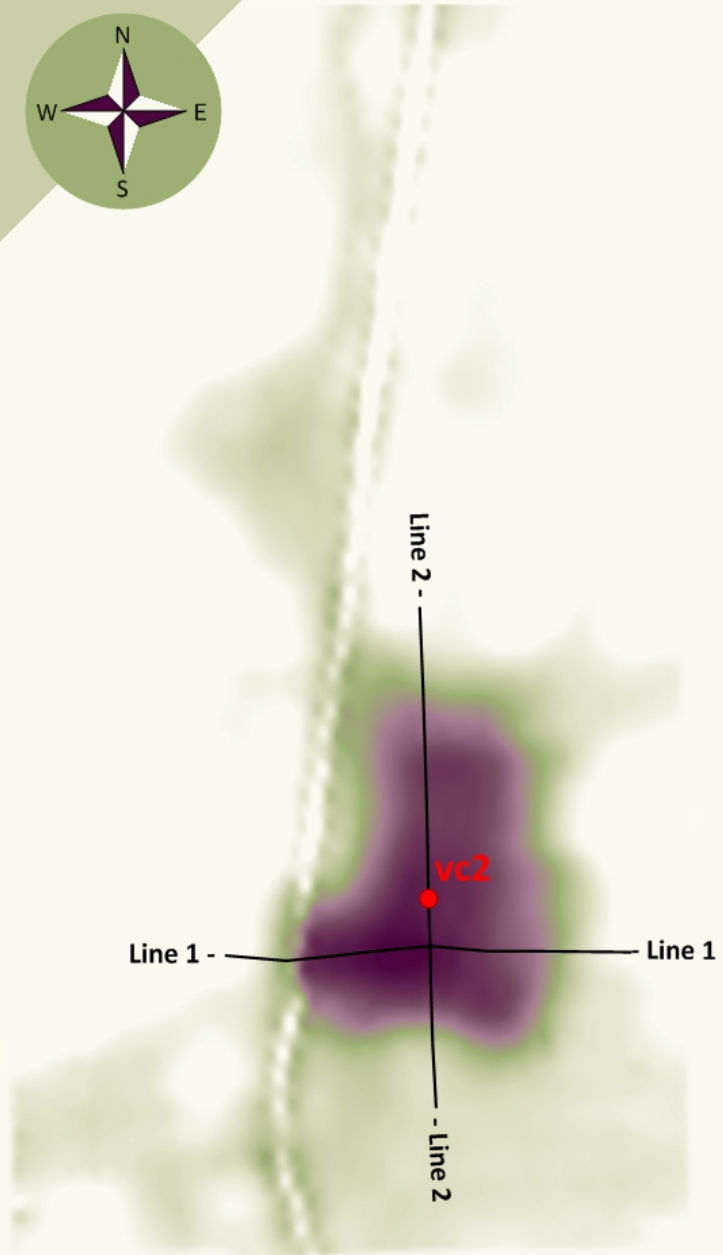


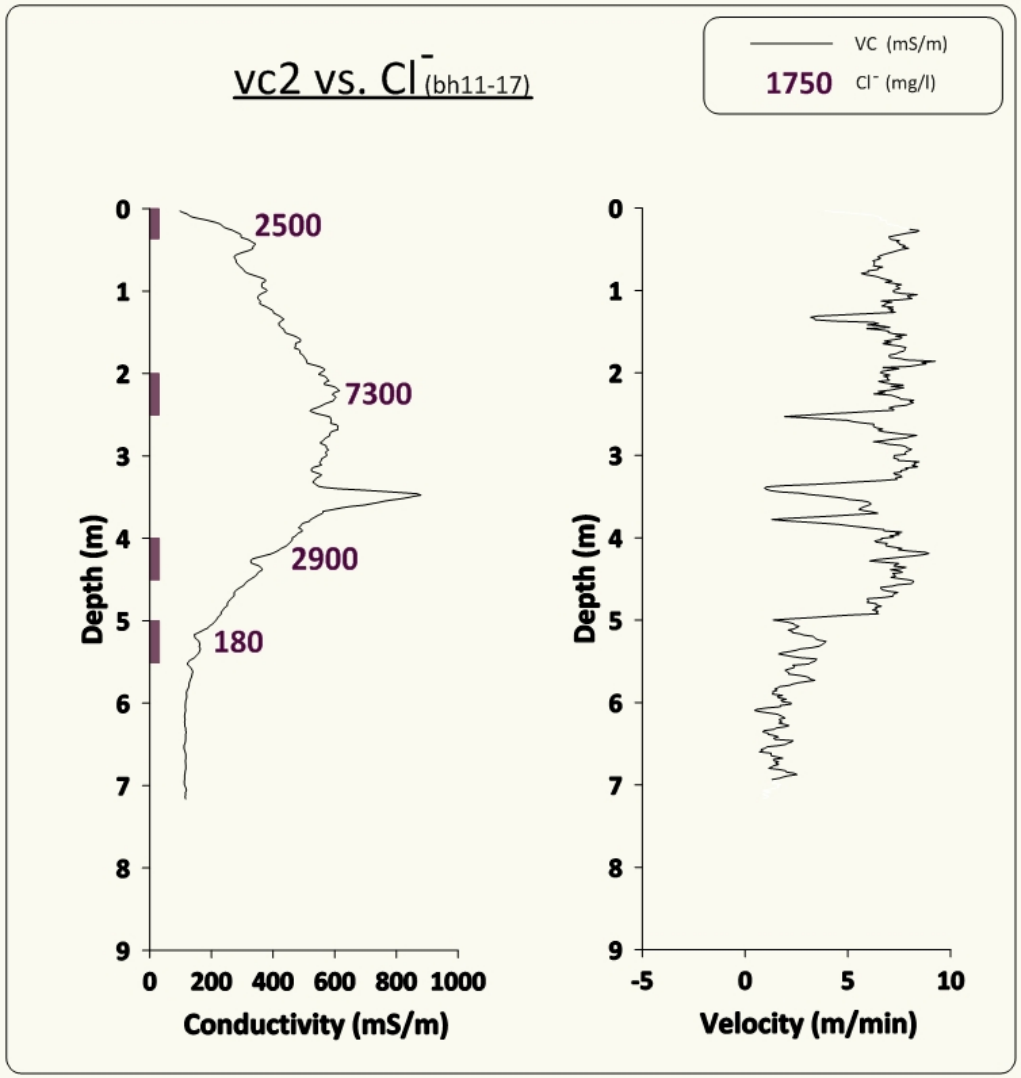
vc2 vs. Cl^- (bh11-17)



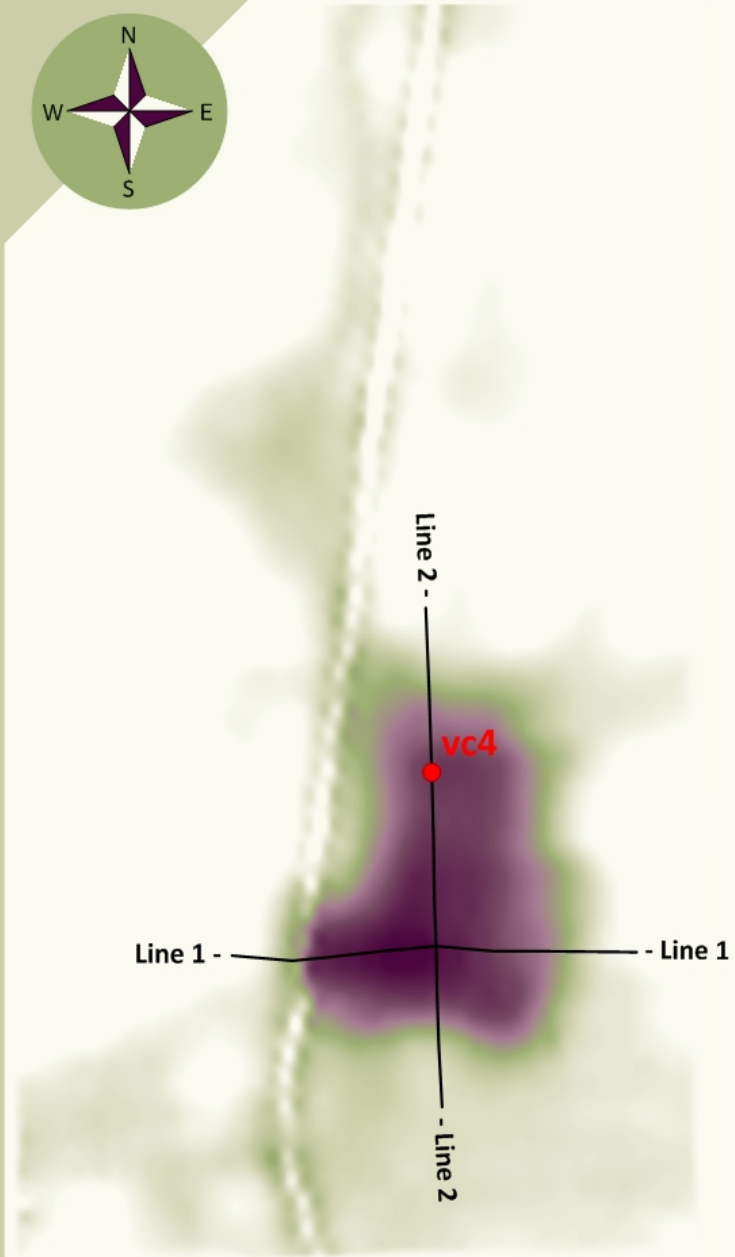


vc2 vs. Cl⁻ (bh11-17)

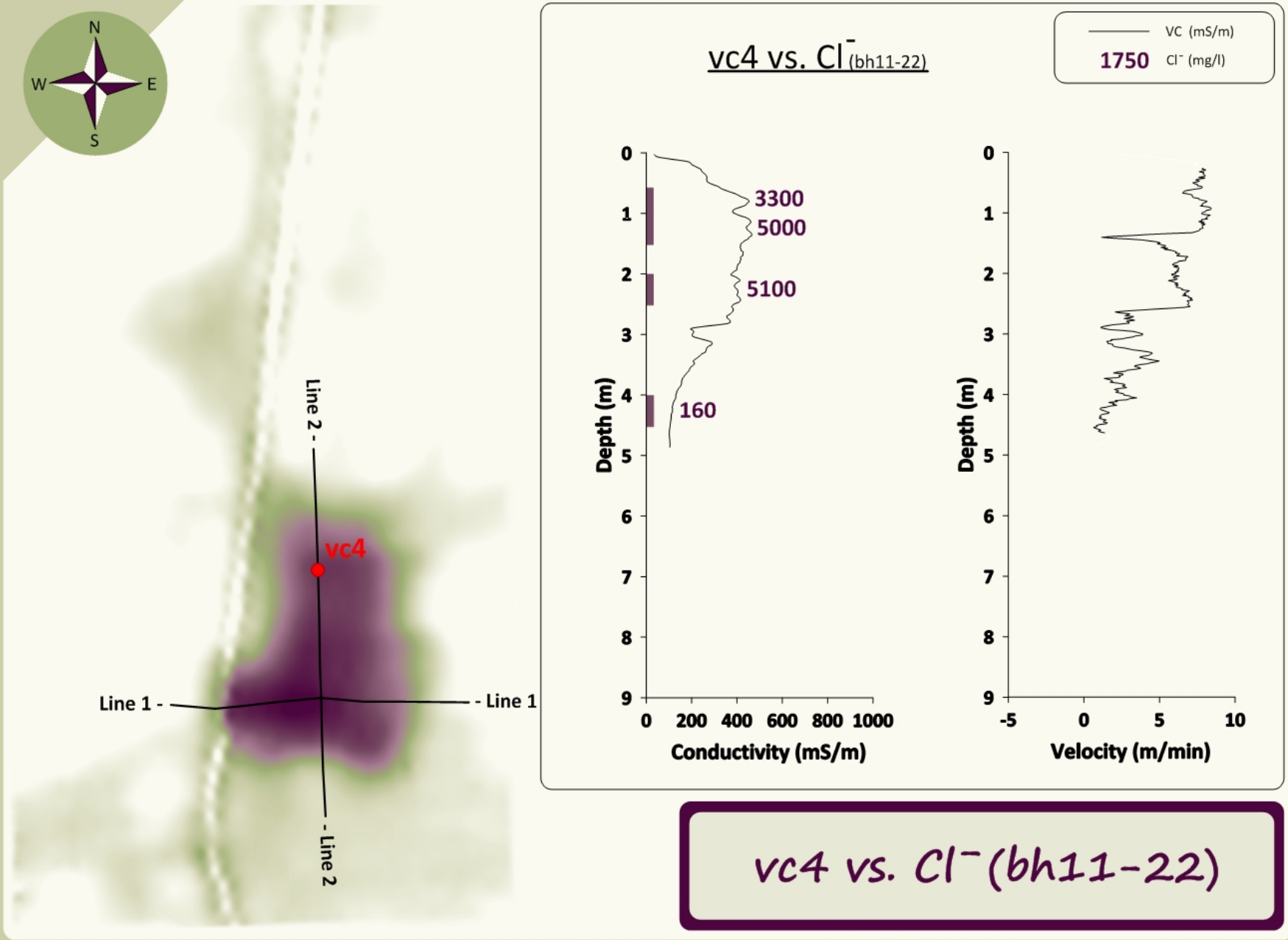




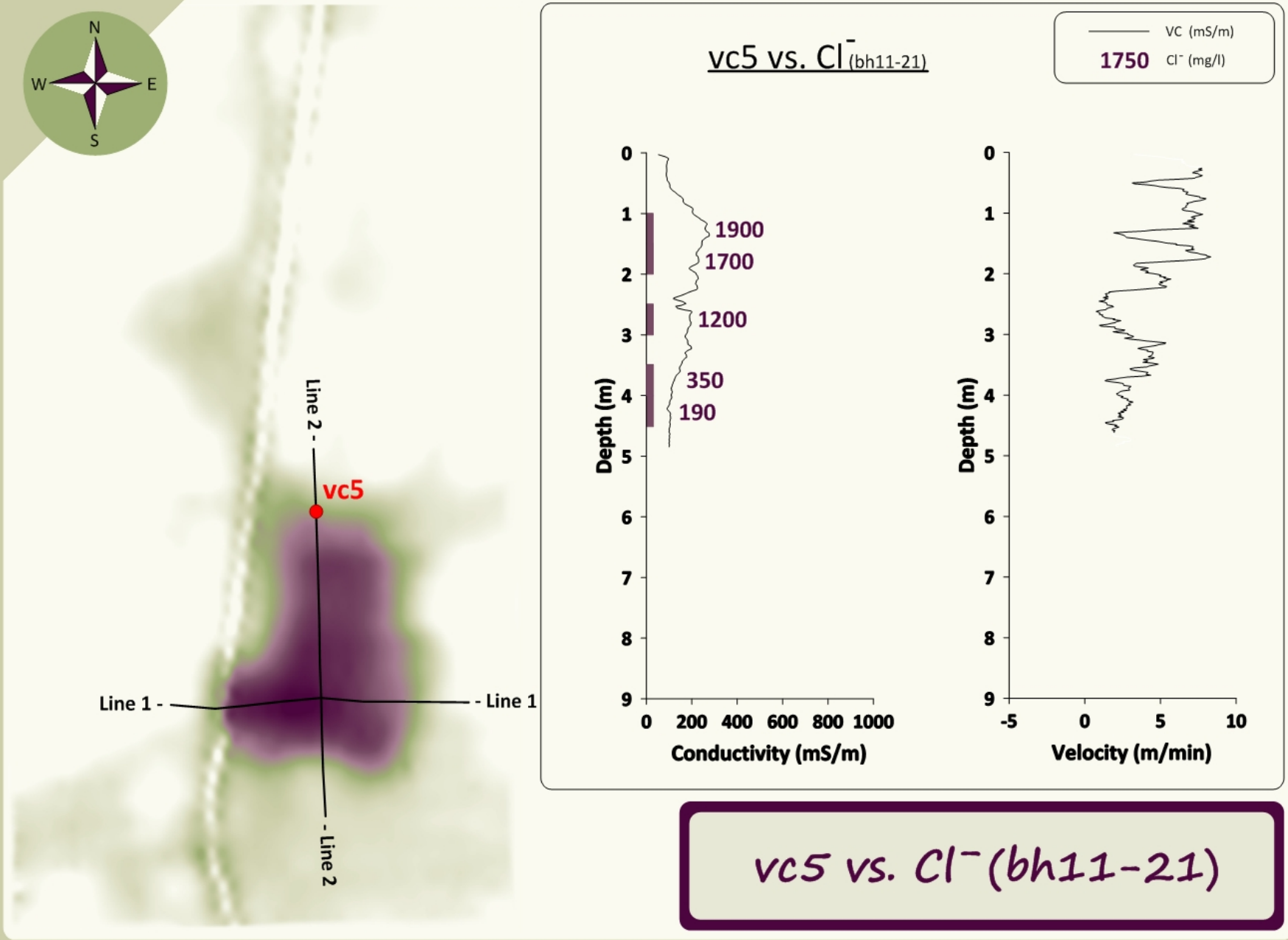
vc2 vs. Cl⁻ (bh11-17)



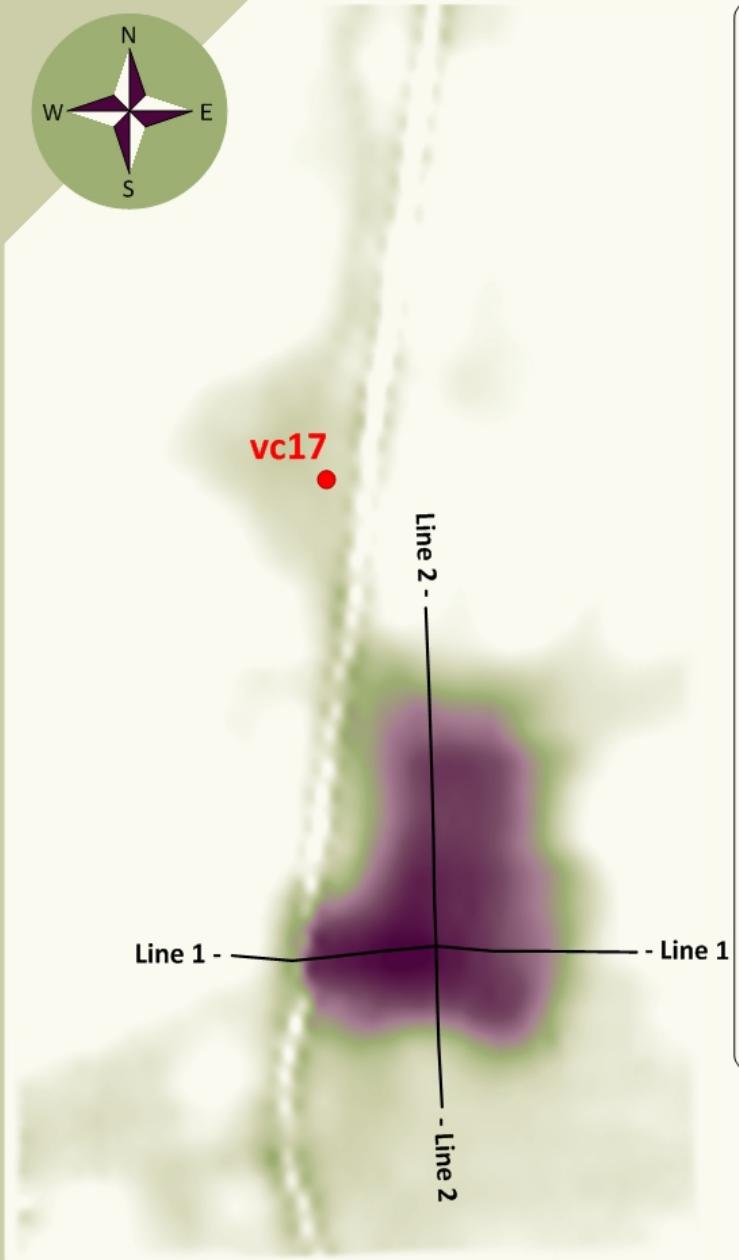
vc4 vs. Cl^- (bh11-22)

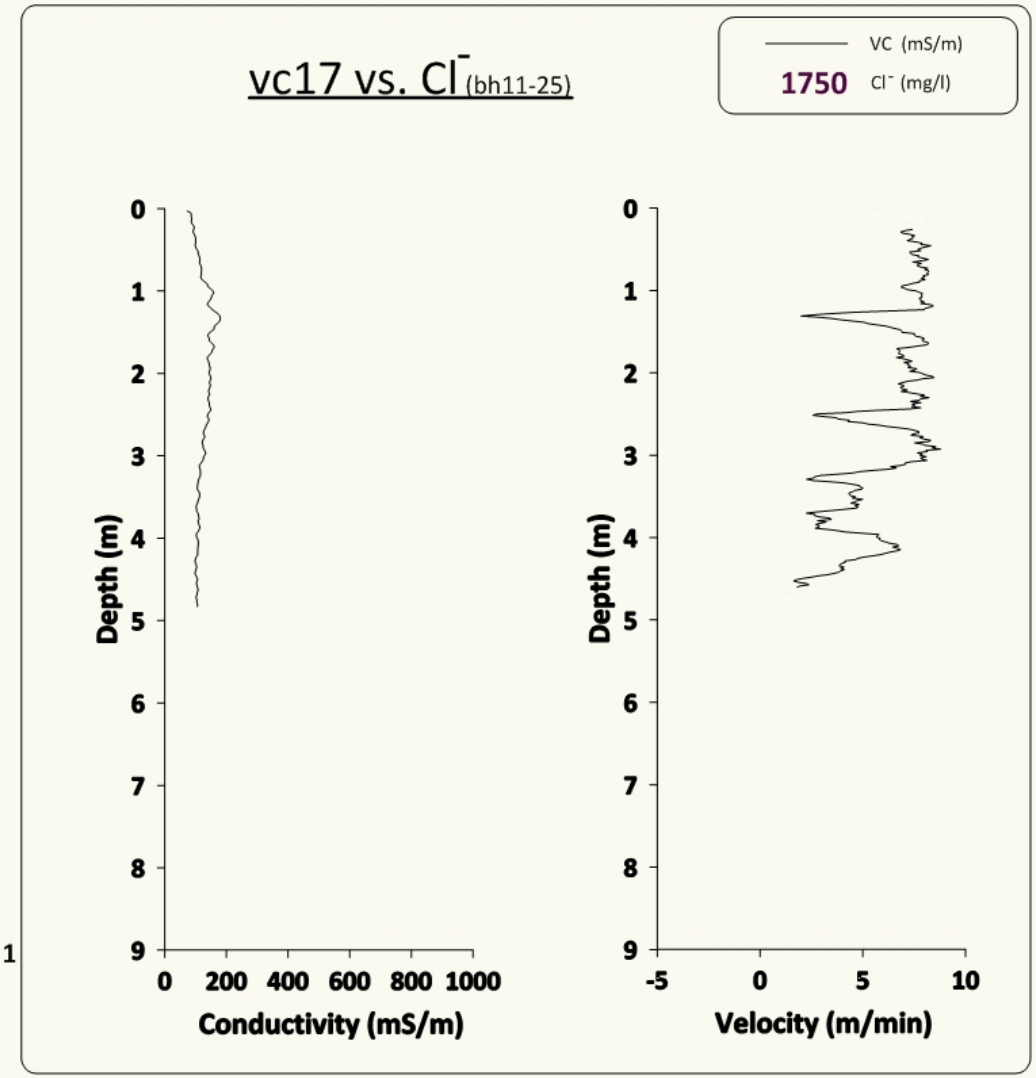

N
W
E
S
Line 2 -
vc4
Line 1 -
- Line 1
- Line 2
vc4 vs. Cl⁻ (bh11-22)
VC (mS/m)
1750 Cl⁻ (mg/l)
3300
5000
5100
160
Depth (m)
0 1 2 3 4 5 6 7 8 9
0 200 400 600 800 1000
Conductivity (mS/m)
-5 0 5 10
Velocity (m/min)
vc4 vs. Cl⁻ (bh11-22)


N
W
E
S
Line 2 -
vc5
Line 1 -
- Line 1
- Line 2
vc5 vs. Cl⁻ (bh11-21)

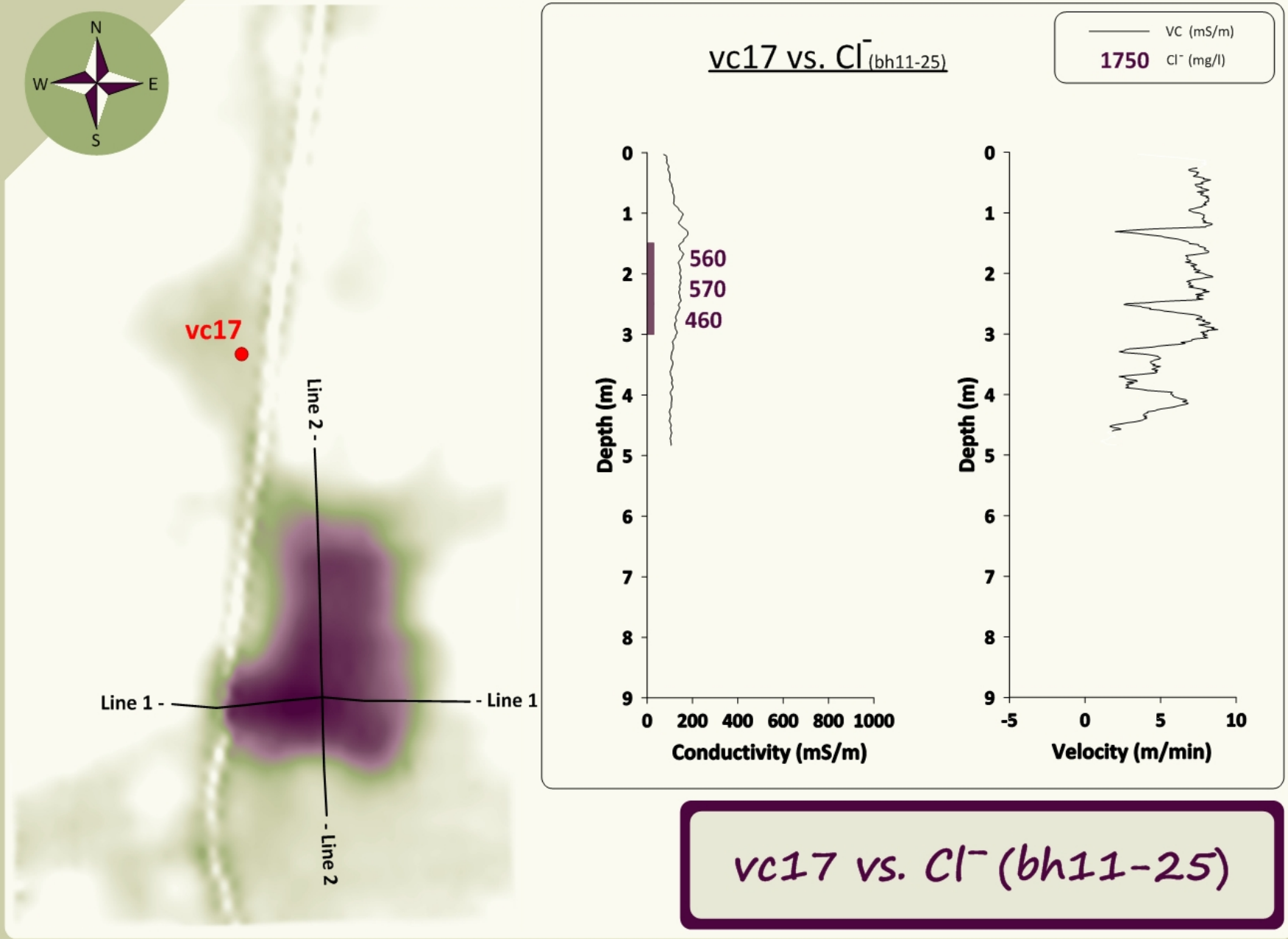

N
W
E
S
Line 2 -
vc5
Line 1 -
- Line 1
- Line 2
vc5 vs. Cl⁻ (bh11-21)
VC (mS/m)
1750 Cl⁻ (mg/l)
Depth (m)
0
1
2
3
4
5
6
7
8
9
1900
1700
1200
350
190
0 200 400 600 800 1000
Conductivity (mS/m)
-5 0 5 10
Velocity (m/min)
vc5 vs. Cl⁻ (bh11-21)


N
W
E
S
vc17
Line 2 -
Line 1 -
- Line 1
- Line 2
vc17 vs. Cl⁻ (bh11-25)

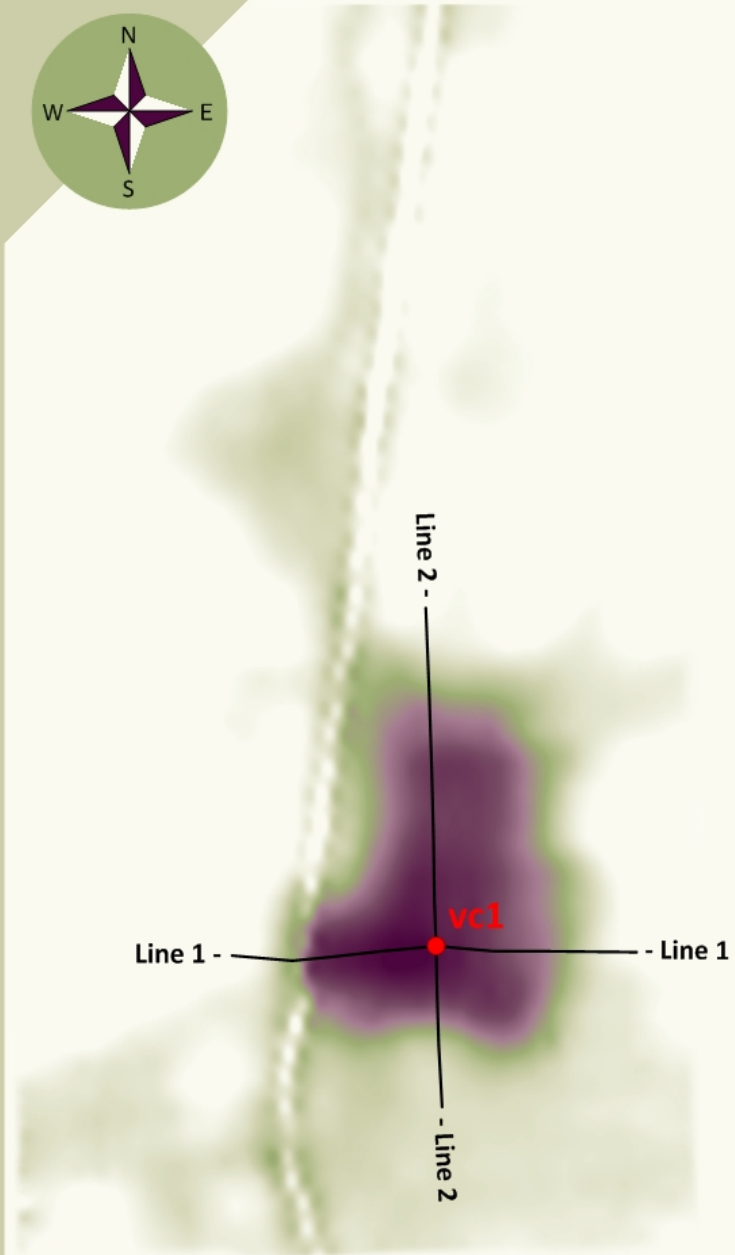




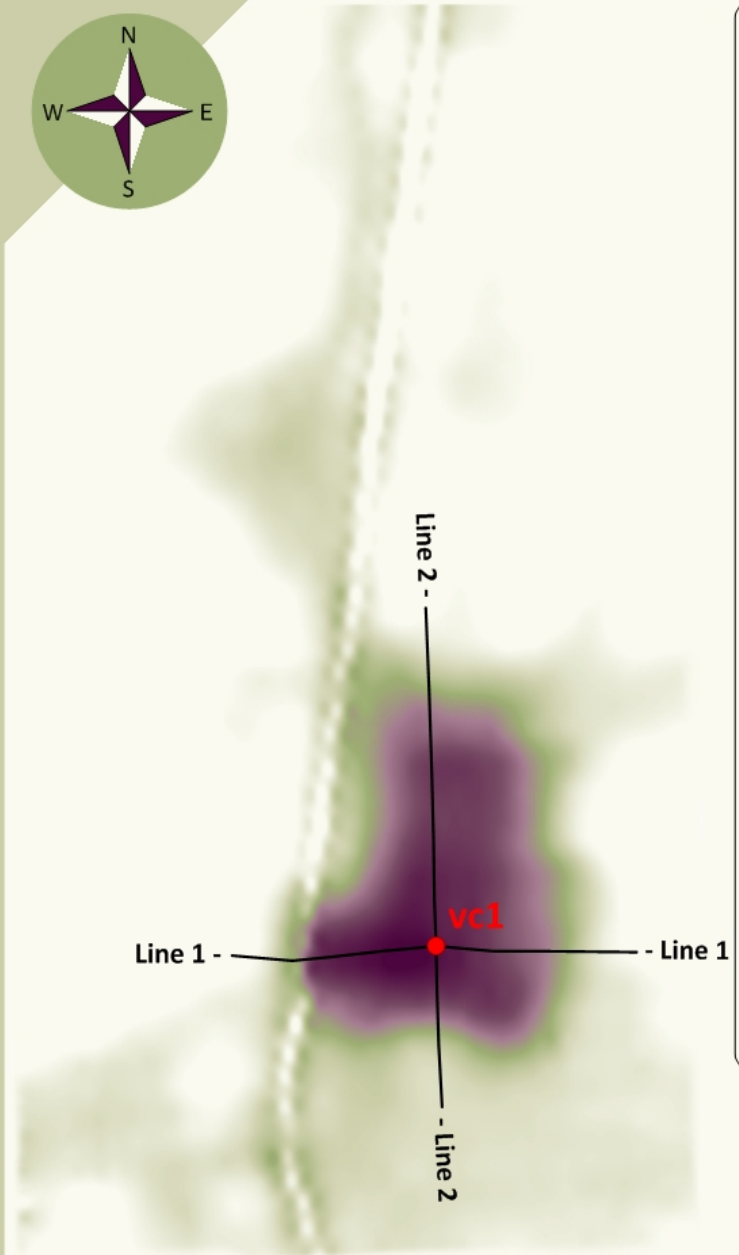
vc17 vs. Cl⁻ (bh11-25)

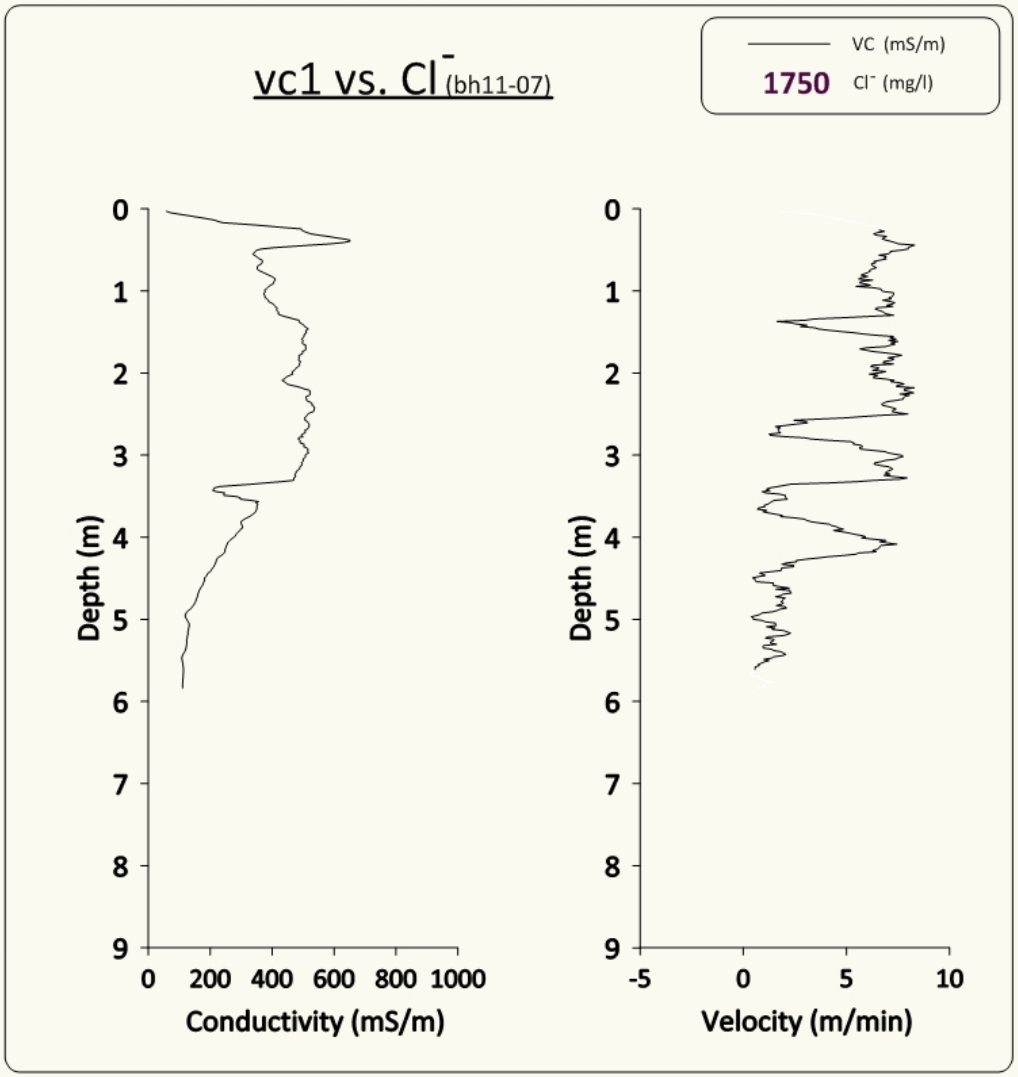


vc17 vs. Cl⁻ (bh11-25)

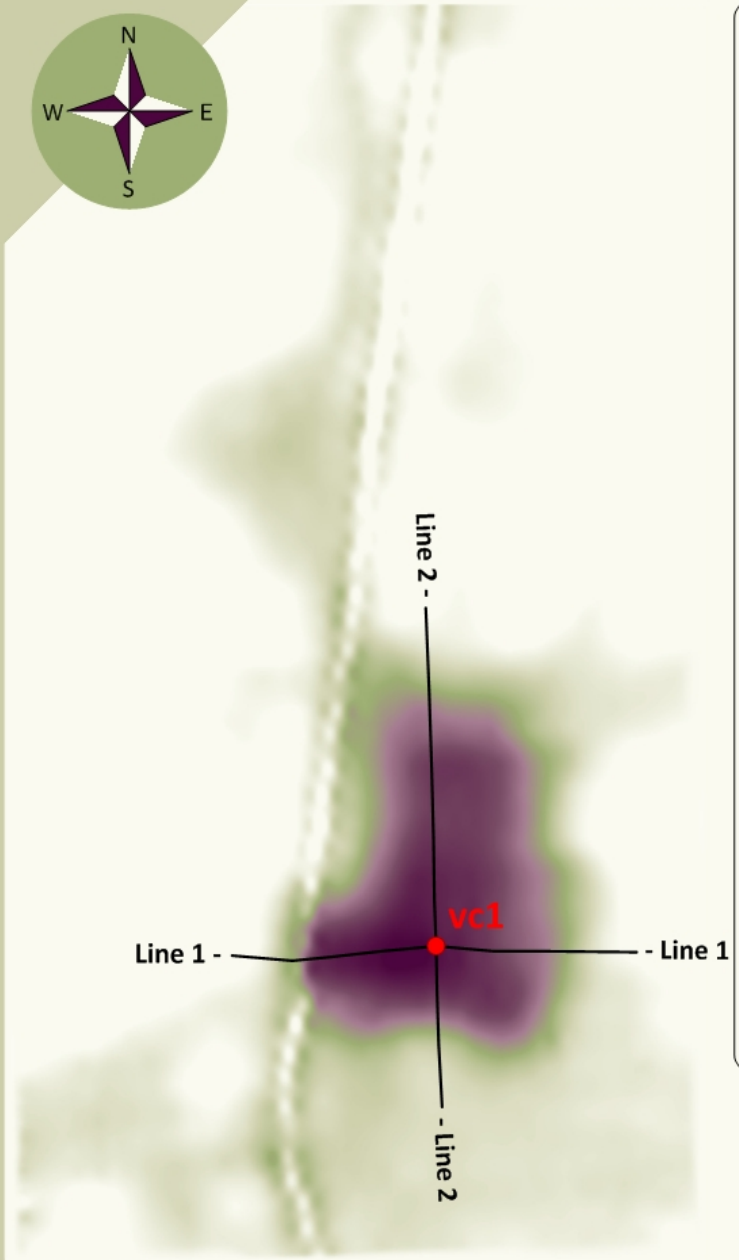


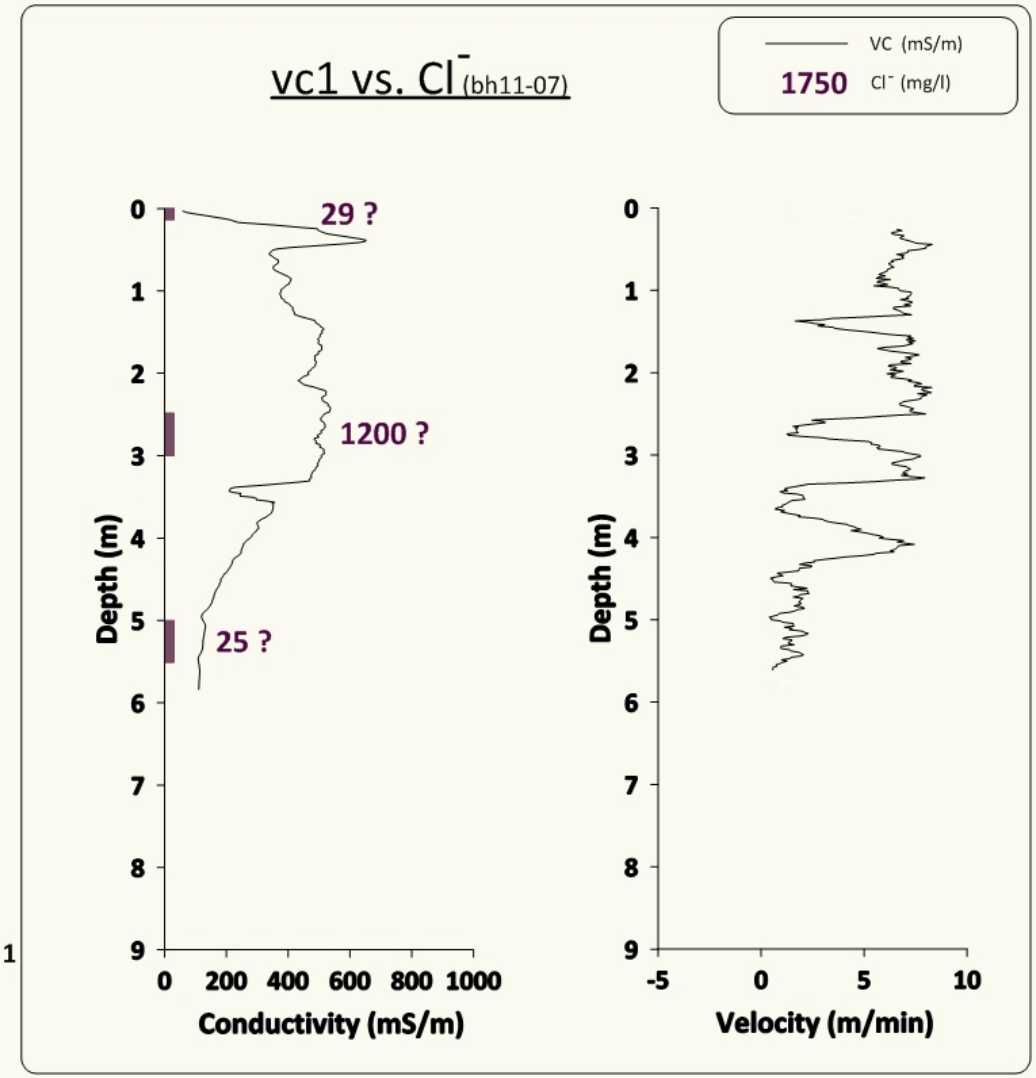
vc1 vs. Cl^- (bh11-07)



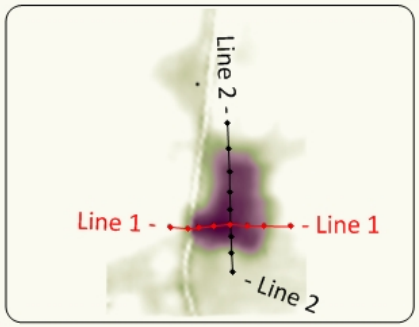


vc1 vs. Cl^- (bh11-07)



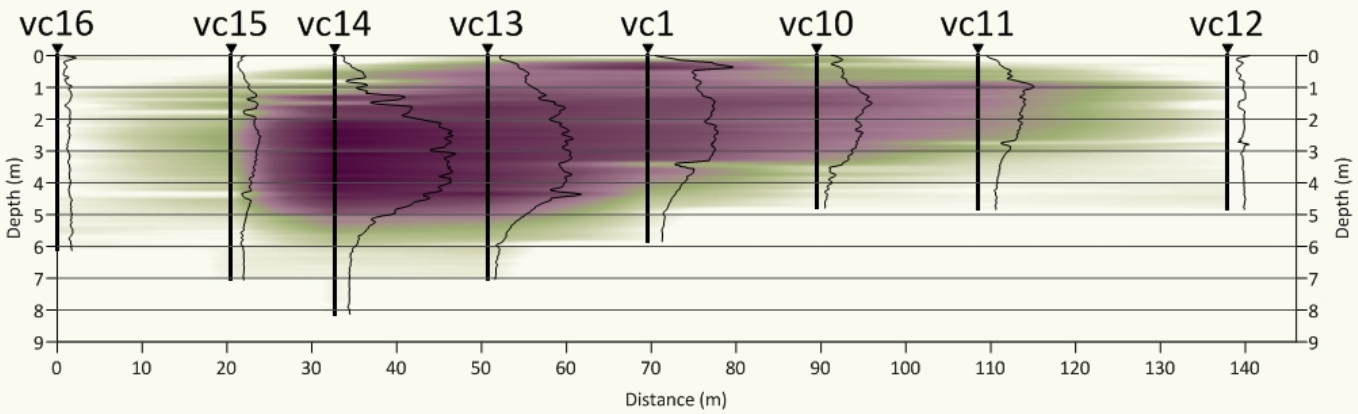


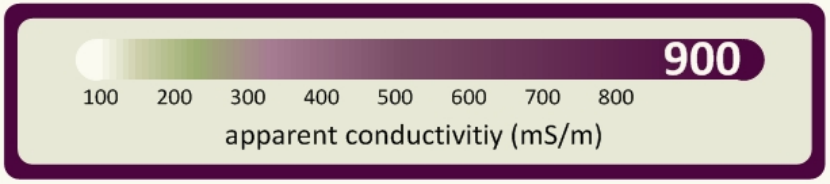
vc1 vs. Cl⁻ (bh11-07)



Line 1

(west) (east)





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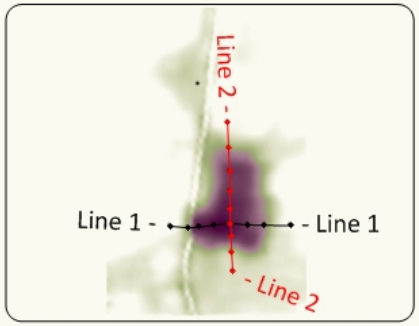
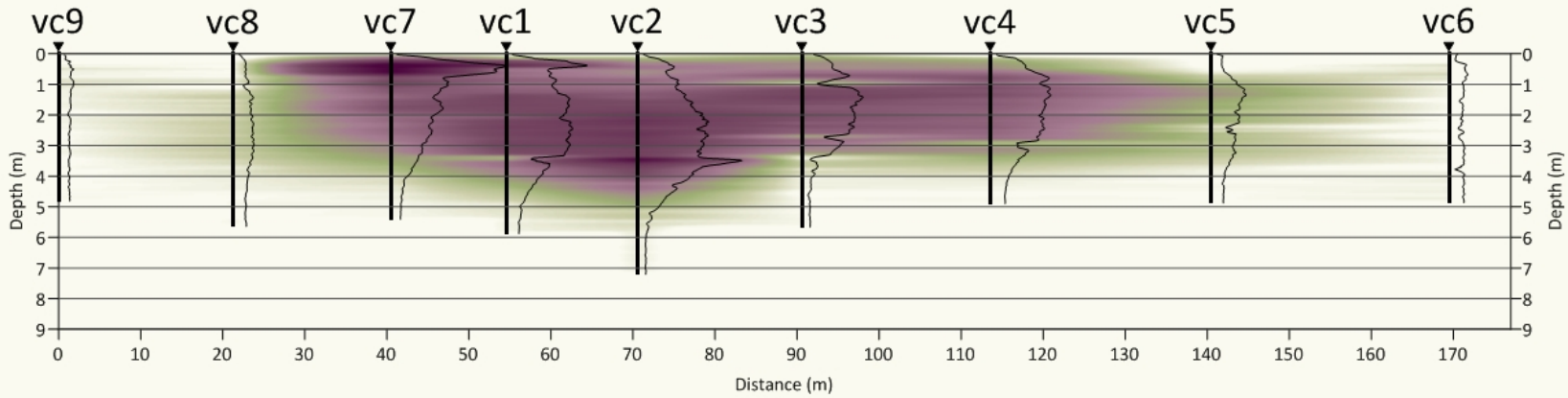
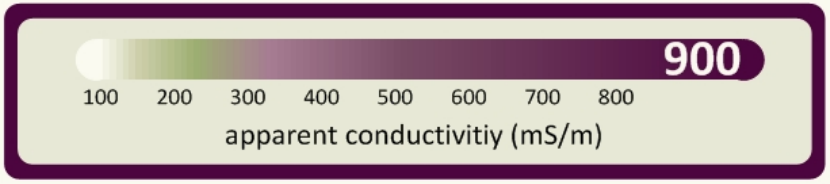


Line 2

(south) (north)





Summary

step1. Lateral conductivity delineation

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Summary

step1. Lateral conductivity delineation

step2. Use Step 1 to target precise VC traces

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Summary

step1. Lateral conductivity delineation

step2. Use Step 1 to target precise VC traces

step3. Use Step 2 to target reliable soil samples

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Summary

step1. Lateral conductivity delineation

step2. Use Step 1 to target precise VC traces

step3. Use Step 2 to target reliable soil samples

step4. Consultant establishes geostatistical confidence between VC Traces & Cl^- by considering:

i) analytics ii) geology iii) PV Traces ...

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Summary

step1. Lateral conductivity delineation

step2. Use Step 1 to target precise VC traces

step3. Use Step 2 to target reliable soil samples

step4. Consultant establishes geostatistical confidence between VC Traces & Cl^- by considering:

i) analytics ii) geology iii) PV Traces ...

step5. Based on confidence level: 'trust VC Traces'

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Thank you.

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Discussion

... how we deal with subsurface salts.

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Discussion

... how we deal with subsurface salts.

Certification

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Discussion

... how we deal with subsurface salts.

Office: Detailed Approaches
(Tier 1/2, Risk Management, SST)

Certification

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Discussion

... how we deal with subsurface salts.

Field: Detailed Sampling Techniques
(QA/QC, Sampling Protocol, Chain of Custody)

Office: Detailed Approaches
(Tier 1/2, Risk Management, SST)

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Discussion

... how we deal with subsurface salts.

Field: Detailed Sampling Techniques
(QA/QC, Sampling Protocol, Chain of Custody)

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Certification

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Discussion

... how we deal with subsurface salts.

Solid Stem Auger

Field: Detailed Sampling Techniques
(QA/QC, Sampling Protocol, Chain of Custody)

Office: Detailed Approaches
(Tier 1/2, Risk Management, SST)

Certification

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Discussion

... how we deal with subsurface salts.

Solid Stem Auger & Pacing/Uncorrected GPS

Field: Detailed Sampling Techniques
(QA/QC, Sampling Protocol, Chain of Custody)

Office: Detailed Approaches
(Tier 1/2, Risk Management, SST)

Certification

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Thank you.

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