A geophysical study of palaeochannels on the Somerset Levels coastal plain and wetland to explore river landscape evolution.

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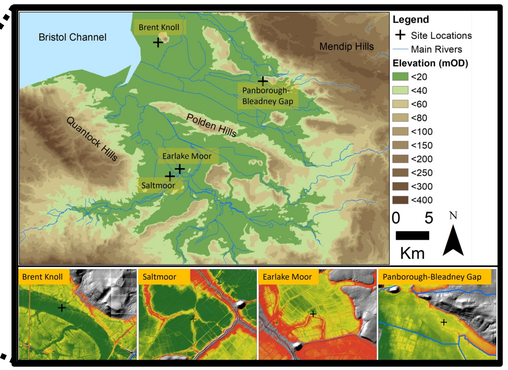
Introduction

The way we manage floods is changing. From traditional hard engineering to soft nature-based measures, flood risk management could benefit from an understanding of the natural processes and features preserved within palaeochannels, which have otherwise been hidden by a legacy of engineering and land management on the river and floodplain. This study presents field tests of geophysical surveying methods on palaeochannels to explore their uses for understanding river landscape evolution and palaeohydrology.

Study area

Figure: Somerset highlighted on map of England



The Somerset Levels in southwest England form a landscape marked by a long legacy of both 'natural' and anthropogenic influences that have driven flood risk presented by its rivers and coastline. Historical attempts to drain this region are represented in the intricate network of natural, augmented, and artificial channels. Landscape stratigraphy dominated by clays and silts, with interbedded peat and sand, representing the phases of marine transgression and regression. Underlain by Pleistocene gravel.

Objectives

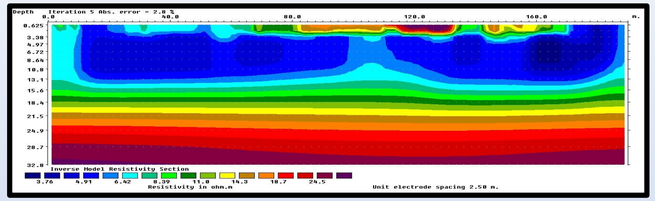
1. Conduct geophysical surveying field tests on wetland palaeochannels to explore uses in landscape evolution interpretation:
   a. Electrical resistivity tomography
   b. Ground penetrating radar
   c. Seismic refraction tomography

2. Reconstruct palaeohydrology using Manning's equation.

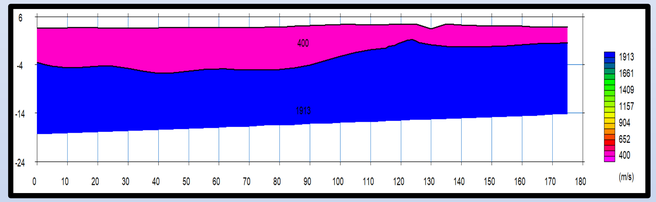
Four palaeochannel systems have been chosen to survey representing both tidally dominated and inland freshwater conditions:
1) a large tidal creek system within predominantly clay sediment;
2) an inland river system traversing a peat wetland which was the former course of a major drainage network before intentional diversion;
3) two systems at the transition between tidal and freshwater influence.

WORKFLOW CASE STUDY: SALTMOOR

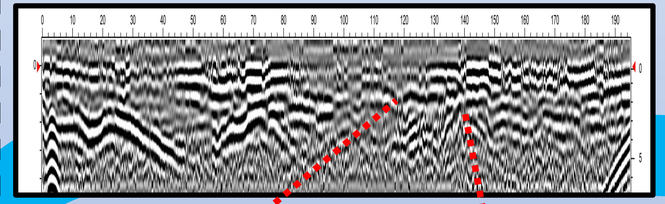
1. Geophysical methods



The **electrical resistivity tomography** survey clearly identifies the channel fill and overbank sediment structures. Channel fill presents as high resistivity measurements, decreasing across floodplain. Low resistivity measurements below attributed to high clay content.



The **seismic refraction tomography** survey identified a larger basin geometry that contextualises the palaeochannel within the subsurface structure. Increasing velocities indicate greater compaction of the underlying sediment, contrasting with the loose channel belt sediment.



70 MHz **ground penetrating radar** survey identified further erosional surfaces possibly indicating multiple channels or lateral migration. The high resolution of the shallow signals delineated the channel fill. Signal attenuates at 4-5m due to high clay content.

Site description

Saltmoor is a low-lying area of farmland in the floodplain of the confluence of two major rivers near their tidal extent. The palaeochannel was part of the former drainage system which was artificially rerouted to open land up for agriculture. The sediment is dominated by silt, clay, and peat.

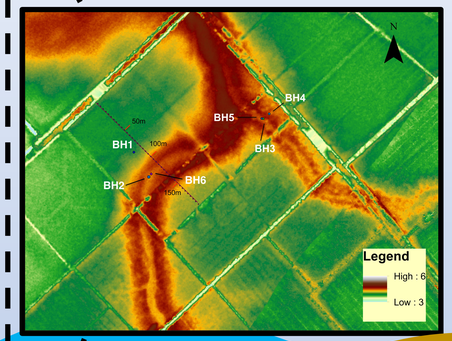
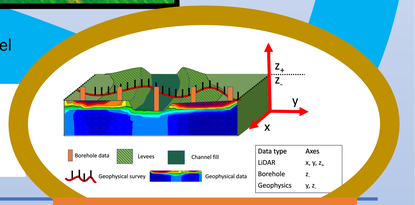


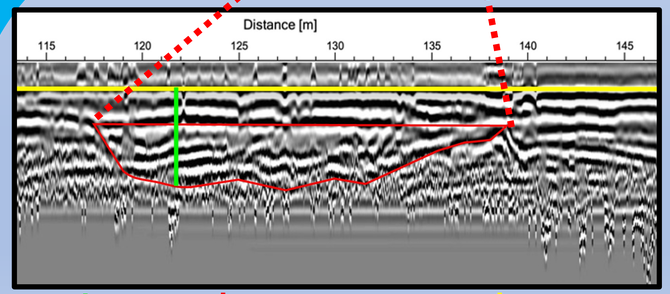
Figure: LiDAR map of Saltmoor palaeochannel

Surveying profile lines were designed perpendicular to the channel axis as derived from LiDAR imagery and positioned to intersect secondary sediment coring data.

Integration of geophysical, sediment, and topographic LiDAR data aids three-dimensional interpretation.



Data integration



Borehole | Channel fill perimeter | Surface

2. Palaeohydrology

Estimated discharge of palaeochannel: 8.3 – 27.7 cumecs.

Discharge of modern river (Tone): 16.9 cumecs

1. Clean, straight, full stage, no rifts or deep pools	0.03
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.04
4. Same as 3 but some weeds and stones	0.045
5. Same as 4, lower stages, more ineffective slopes and sections	0.048
6. Same as 4, but more stones	0.05
7. Sluggish reaches, weedy, deep pools	0.07
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.1

Manning's Equation: $Q = dWn^{-1}R^{\frac{2}{3}}S^{\frac{1}{2}}$

Q discharge, d depth, W width, n manning's roughness coefficient, R hydraulic radius, S slope.

Manning's coefficient (n) estimates from Chow (1959) represent roughness conditions in-channel. These values are not known for the palaeochannel.

Chow, V.T., 1959, Open-channel hydraulics: New York, McGraw-Hill Book Co., 680 p.

Findings

1. **Geophysics**
   - Combination of geophysical surveying methods successfully identified major features of the buried palaeochannel, including potential phases of channel development (migration, avulsion) following a major diversion project.
   - Inner sedimentary interfaces (laminations and interbedded peat) were not identified with confidence.
2. **Palaeohydrology**
   - Palaeohydrological reconstruction suggests bankfull flow rate is similar to modern day river, depending on roughness.