Integrating Surveying Strategies for Microtopography: Insights for Flood and Water Quality Management

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Introduction

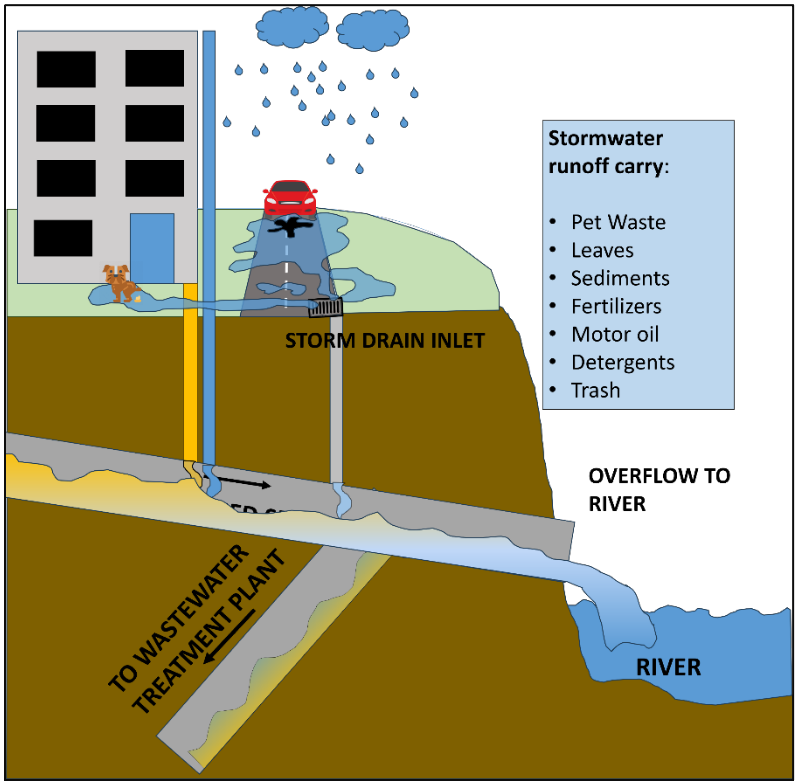
Currently

Around **325,000** properties in England are at high risk of surface water flooding

NO ACTION !

By 2055

Additional **230,000** properties in England are at high risk of surface water flooding



Combined sewer drainage system carrying both stormwater and sewage, discharging excess flows into rivers during heavy rainfall

- Extreme weather events, exacerbated by climate change, along with increased urbanisation are raising the frequency and severity of surface water flooding.
- Floods carry pollutants into streams, rivers, and lakes, degrading water quality.
- Surface water flow path and pollutant pathways are is significantly influenced by microtopography (feature like road kerbs, drainage gullies, walls). (Aronica & Lanza, 2005)

Understanding Microtopography

- Microtopography refers to small terrain variations in the order of 10 cm

- To capture features such as road kerbs, drainage gullies, vegetated embankments, walls, and steps that significantly influence runoff flow path and direction require fine topographic data as small as 10cm

- Better knowledge about the microtopographic features would help improve flood risk assessment and management

- Different technologies have already been used to map microtopography.

Objective and Scope of Research

- This study explores how advanced surveying strategies can characterise microtopographic features that influence surface water flow paths
- Goal: Compare the accuracy of the elevation data obtained from the two widely used surveying strategies to determines if they can be used interchangeably or feature specific
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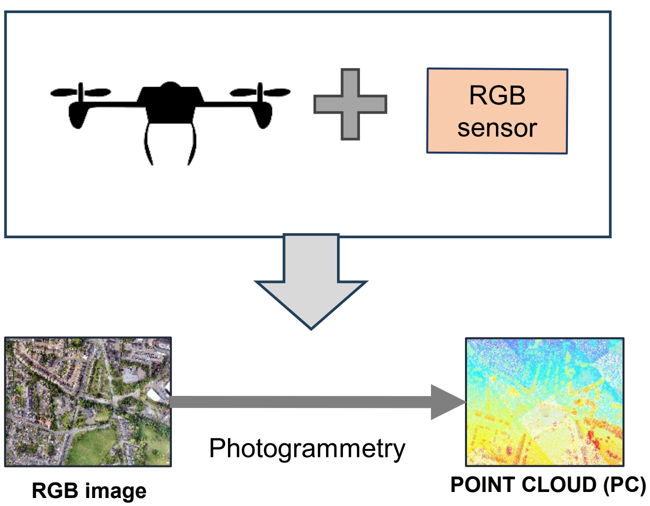
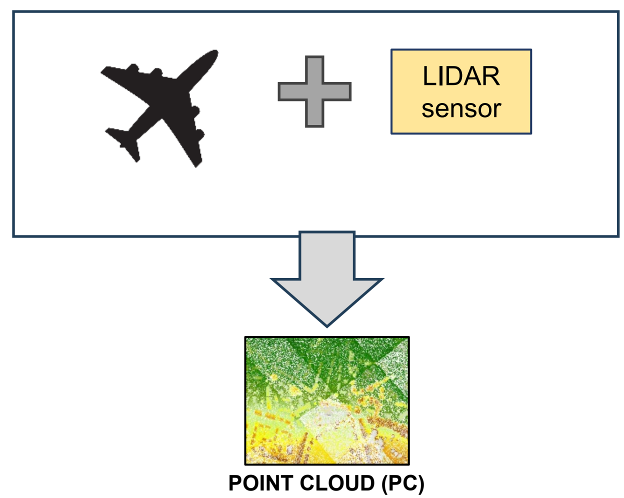
Point cloud data by Photogrammetry technique extracted from Aerial images from UAS (Unmanned Aerial Systems)



Point cloud data captured by LiDAR (Light Detection and Ranging) technique from Manned Aircraft



Study Area

Case Study: Cockermouth, Cumbria, UK

- Cockermouth, a flood-prone town in Cumbria, UK, was selected for its diverse terrain and history of severe flooding.

- This area provided an ideal testing ground for evaluating UAS and LiDAR effectiveness

Data Collection

- The total surveyed area was 4.71 km^2

UAS-RGB data

- Platform: Sirius Pro UAS with a 9DOF IMU
- Sensor: Sony Alpha ILCE 6300 PRO camera
- Flight altitude: 125m
- GPS was a GNSS-RTK- L1/L2 and GLONASS with a planimetric accuracy of 0.01 cm and altimetric accuracy of 0.015 cm
- Ground Sampling Distance: 2.23cm/pixel
- Survey strategy will be referred to as S1

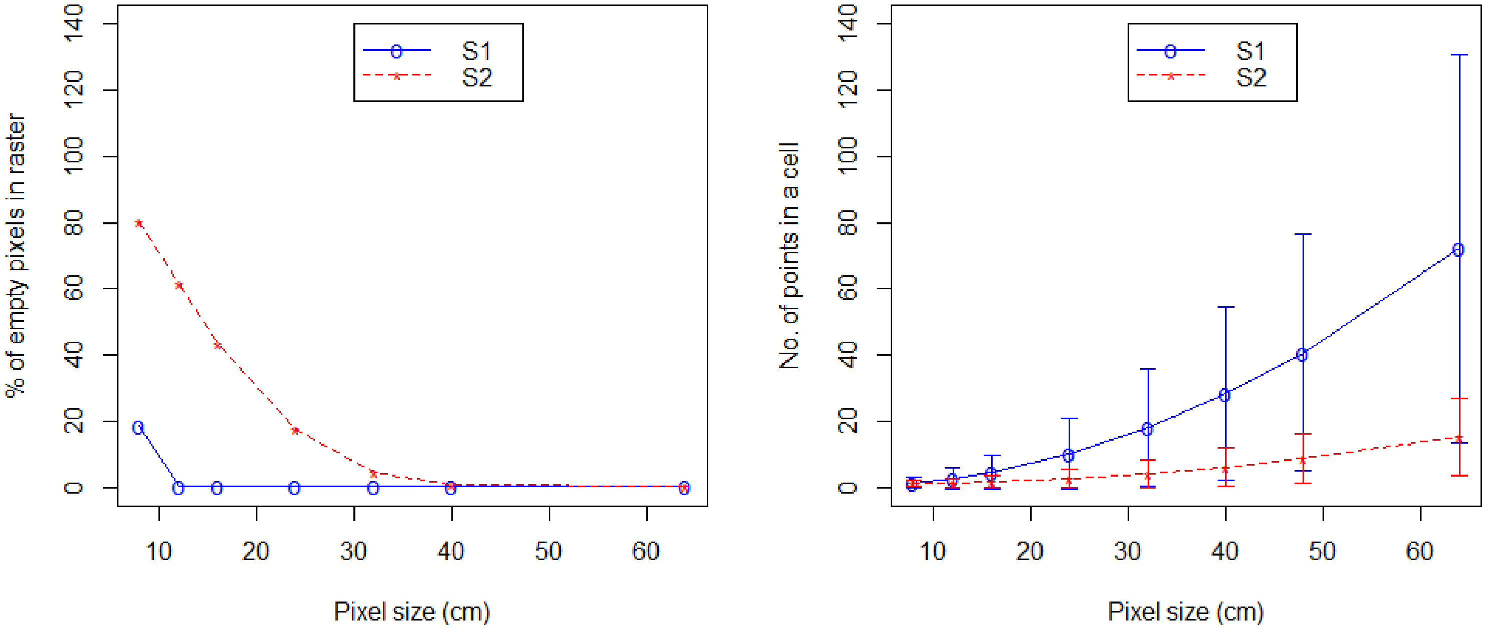
LiDAR data

- Platform: Partenavia P68 Aircraft
- Sensor: Teledyne Optech Galaxy topographic laser(18ppm)
- Flight altitude: 610m
- The centre of each LiDAR exposure had associated GPS (Trimble Applanix L1/L2 Card within the position and orientation module Rover Receiver incorporated into the Optech Galaxy system
- Flying speed ranged between 56 m s^{-1} and 76 m s^{-1}
- Survey strategy will be referred to as S2

Ground truth data

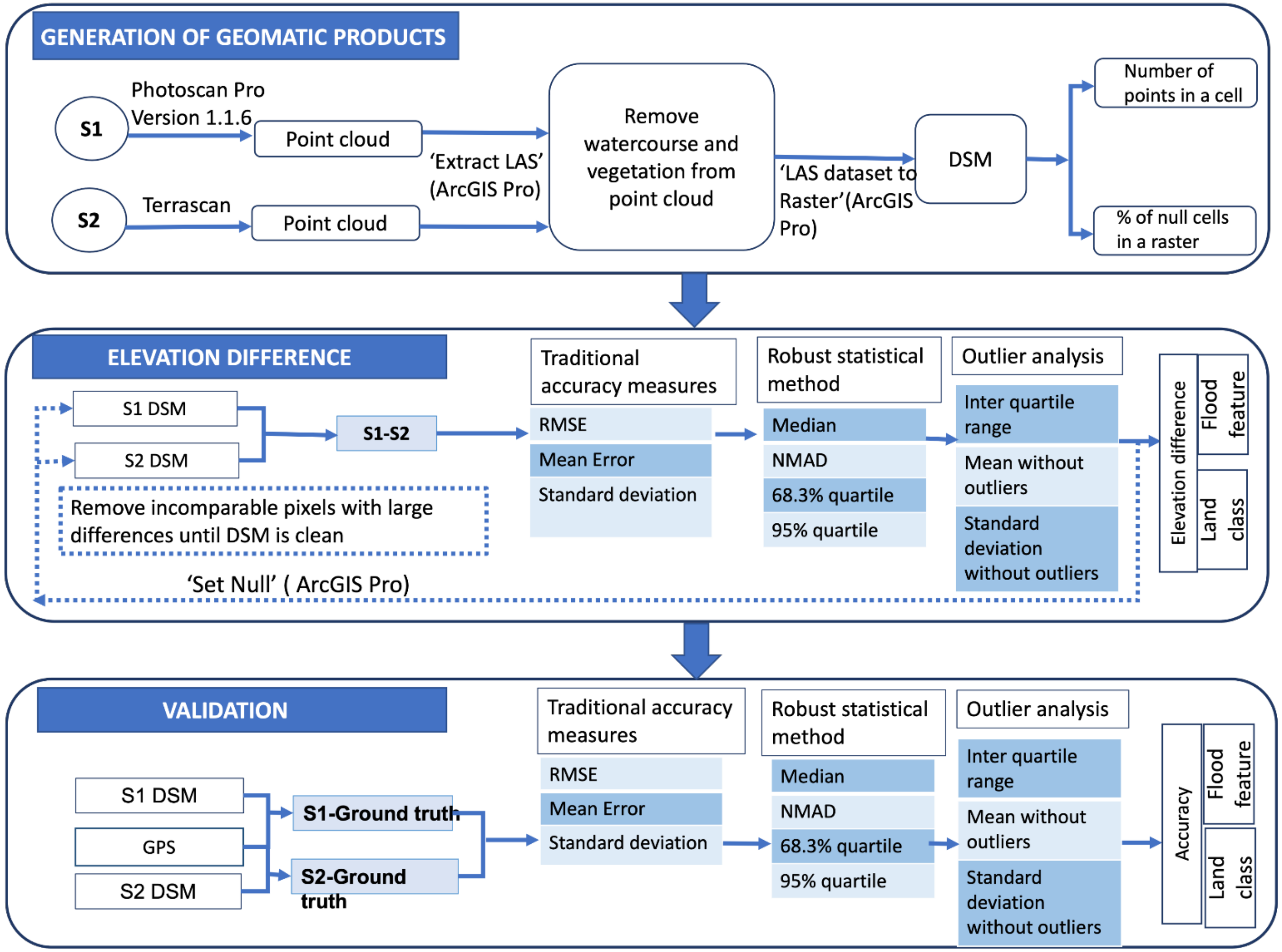
- Topcon Hiper V RTK Network RTK GPS
- 20 ground control points (GCPs) and 20 checkpoints (XPs)
- Planimetric accuracy : 15 mm Altimetric accuracy : 30 mm
- Additional 2,031 RTK GPS measurements was taken at walls, floodgates, drainage points, vegetated crests, roads and grassland areas

Data exploration



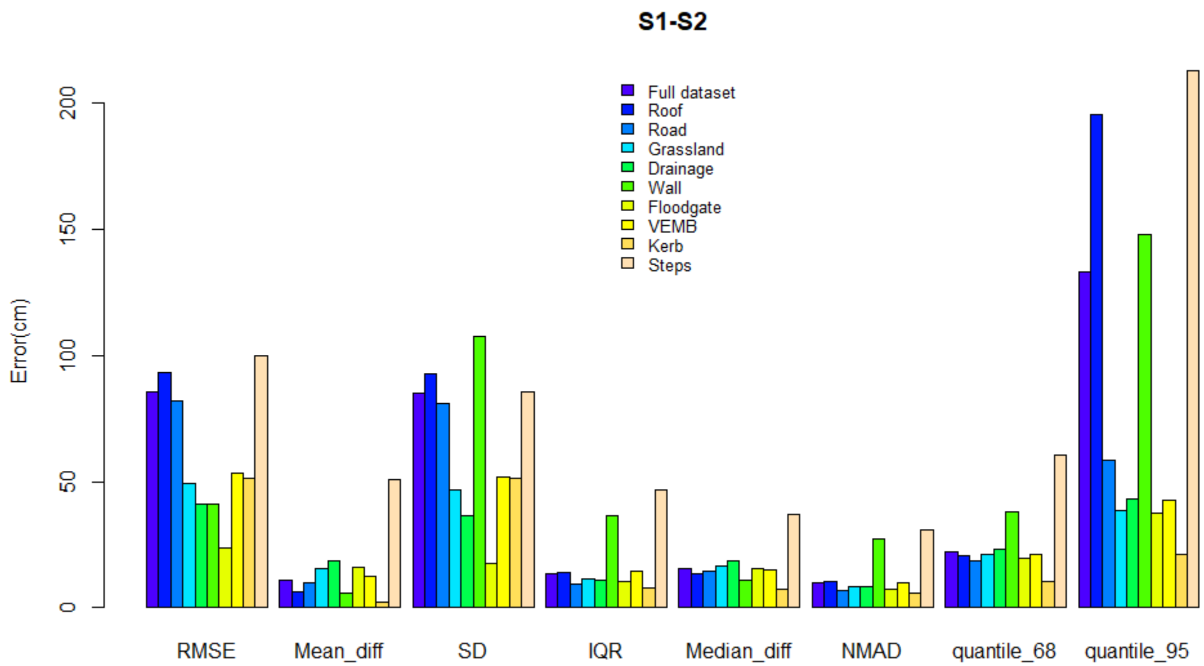
- Average point cloud spacing of S1- 8cm
- Average point cloud spacing of S2- 16cm

Data Analysis



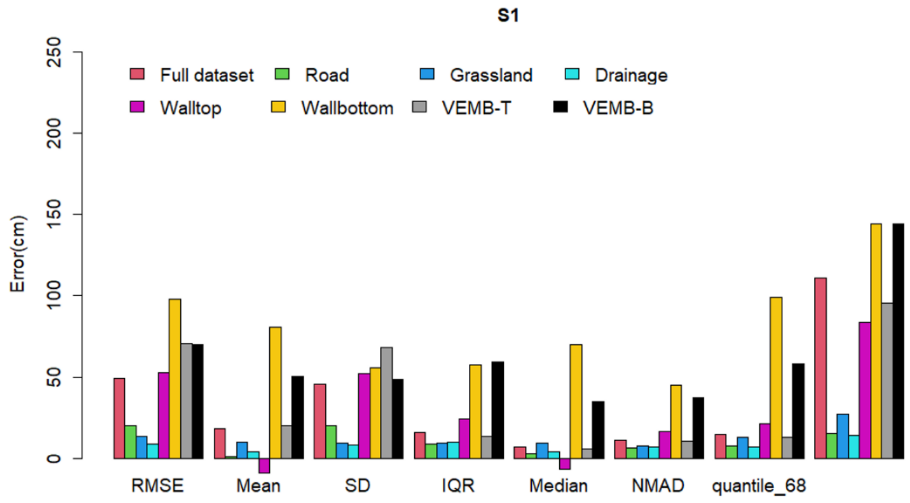
Key Findings: Elevation Difference

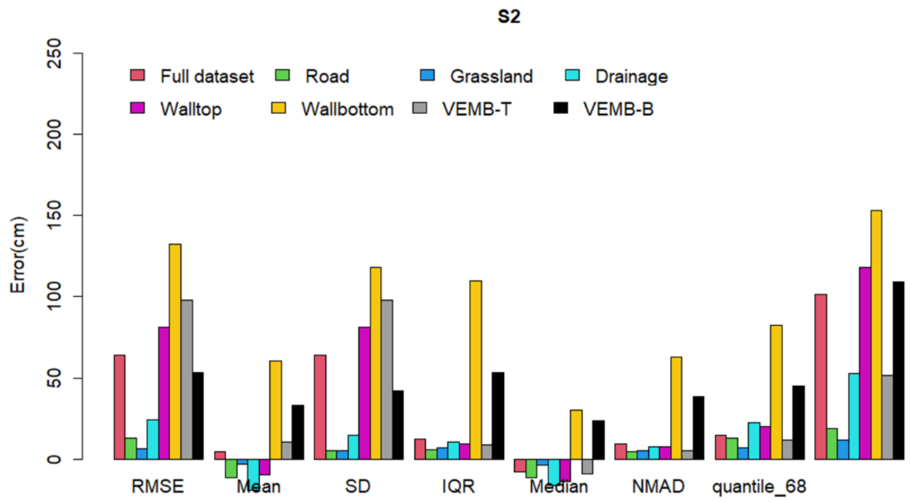
- The median of the elevation difference of the overall dataset was 15cm
- The median of the elevation difference at different land classes and microtopographic features ranges between 11 cm and 37 cm, except kerb (8cm).
- The outliers identified fell on the edge of the roofs, shrubs, as well as hedgerows and narrow bridges



Key Findings: Elevation Accuracy

- The accuracy of overall dataset of both S1 and S2 are similar and less than 10cm
- S1 accuracy: 3 cm to 70 cm,
- S2 accuracy: 4 cm to 30 cm
- Based on median accuracy, S1 excels in capturing fine details on road, drainage gullies, road kerbs, top of wall and vegetated embankment while S2 is better on grassland.
- For both strategies, outliers were identified on uneven surfaces, vegetated areas, bridges and shadows of tall structures

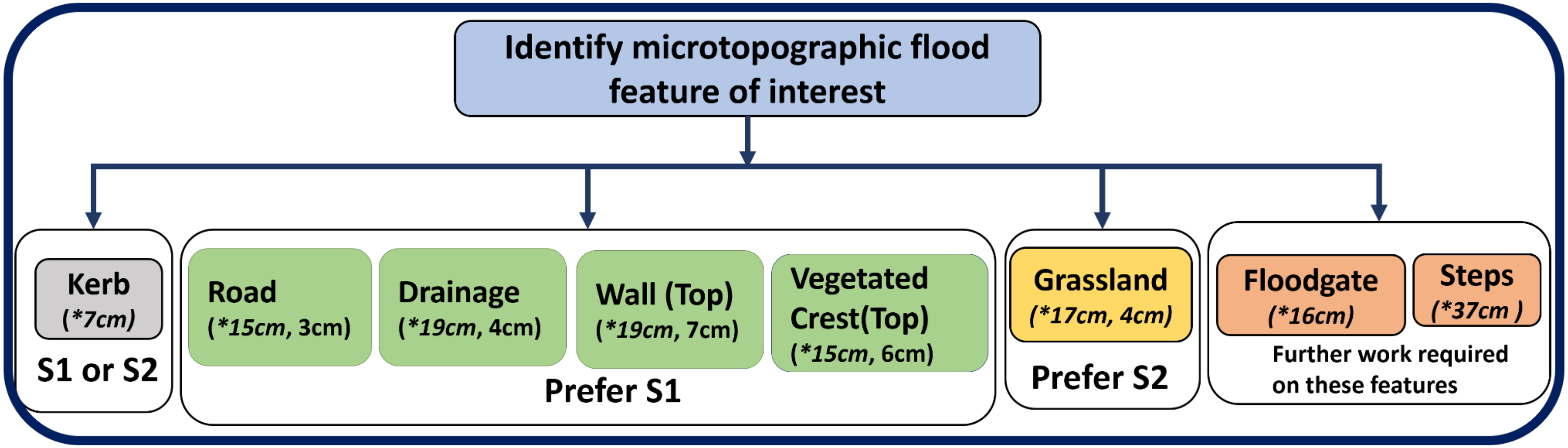




Decision Framework

Choosing Between UAS-RGB (S1) and Manned Aircraft LiDAR (S2)

- **Framework goal:** Determines if S1 and S2 can be used interchangeably or feature specific
- **Decision criteria:** Driven by the features of interest, their accuracies and error-threshold.
- **Benefit:** Guides practitioners in choosing the appropriate surveying strategy based on the accuracy.
- **Limitation:** The study is carried out only on limited flood features, and the inclusion of other relevant flood features should be further explored, and the framework is limited to a single criterion of accuracy and elevation difference between the two survey strategies.



Survey decision framework for S1 and S2 for the characterisation of microtopographic features. Values in brackets show the (*) median elevation difference between S1 and S2 and the elevation accuracy

Contribution to Flood and Water Quality Management

- **Identifying High Flood Risk Areas**: High-resolution microtopographic detail contributes to identifying localized flooding zones, aiding targeted flood mitigation.

- **Managing Drainage Assets:** Microtopography insights enhance understanding of the effectiveness of existing urban drainage systems

- **Improving Water Quality Management:** Understanding microtopography reveals pollutant sources and pathways, enabling actions to prevent contamination.

- **Sustainable Drainage Systems (SuDS):** Microtopographic insights also helps in identifying runoff accumulation areas and aids better planning of SuDS to store, filter and release runoff, thus reducing contamination

The Role of AI in Surveying and Water Management

Improving Water Quality Through Precise Flood Mapping

- Extracting flood features of interest from image could help in mapping the features of interest and deploying survey teams accordingly or monitoring infrastructure

Example of storm drains extracted from UAS RGB images

Conclusion

Key Takeaways

- The median of elevation difference of the two survey strategies is greater than 15cm on most features and the accuracy also varies at different flood features.
- UAS-RGB and Manned Aircraft LiDAR survey cannot always be used interchangeably for microtopographic detail but integrating 2 datasets would improve accuracy of elevation data of microtopographic features.
- Integrating AI with these survey strategies could potentially offer a powerful tool to enhance surveying and infrastructure monitoring for flood and water quality management.

Questions