Catchment Characterisation: Hydrology of The Barna River, Co Galway, Ireland.

NUI Galway
OÉ Gaillimh
Earth & Ocean Sciences
School of Natural Sciences

Seán Haughton[1], Tiernan Henry[1]

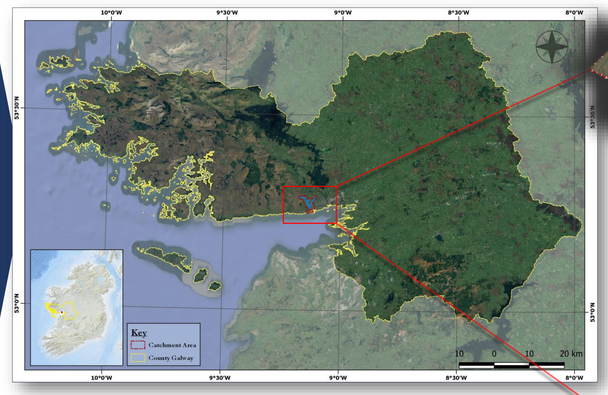
[1]*Department of Earth & Ocean Sciences, National University of Ireland, University Road, Galway, Ireland. Contact: s.haughton1@nuigalway.ie.*

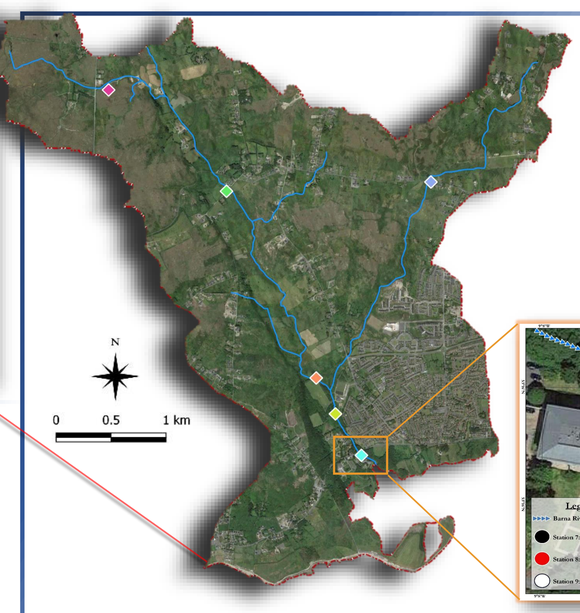
Introduction

The importance of streamflow measurements is prefaced by the reality that it is the only *true* integrated representation of an entire catchment area which can be plainly observed. Despite the evident value of flow measurements, there has been a shift within the hydrological community towards advancement of modelling techniques, leading to a decline in readily available streamflow data at the catchment scale. The spatio-temporal flow regime of the Barna catchment was assessed through a combination of field techniques and statistical analysis. The flow dynamics observed reflect the heterogenic nature of small catchments and the variability, intensity & duration of localised precipitation events. Analysis of discrete & continuous flow data also validate the impacts of anthropogenic pressures & underutilised land across the catchment area. This highlights the need for continued, effective hydrological monitoring in small catchments in tandem with advancements of modelling techniques.

1: Catchment Characteristics

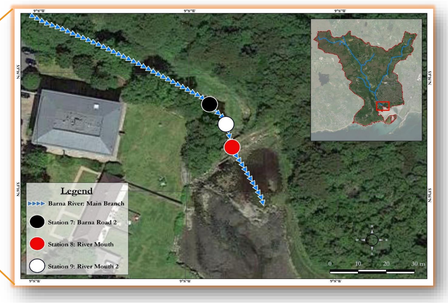
Site Location





Measurement Stations

- 1: Barna Road
- 2: Barna Woods
- 3: Keeraun
- 4: Corboley
- 5: Stream Cottage
- 6: Barna North



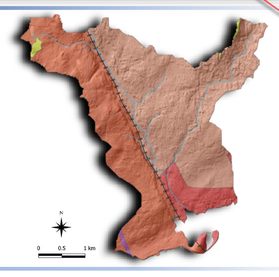
Geology

Granite Units

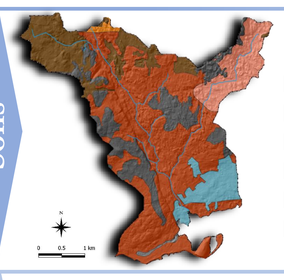
- Errisbeg Townland Granite
- Fine-grained foliated granite
- Murvey Granite
- Porphyritic-Megacrystic Granite
- Quartz porphyry and Felsite

Faults

- Barna Fault



Soils

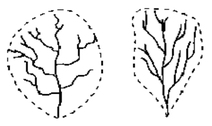


Soil Association

- 01_Bk: Peat (Blanket Bog)
- 1150b: Brown Earth
- 1150c: Brown Earth
- 410a: Lithosol (Peat)
- Bedrock
- Urban

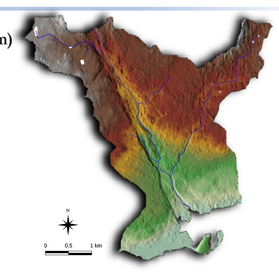
Geomorphology

Arterial Drainage Pattern:



a. dendritic b. parallel

Elevation (m)
0 10 20 30 40 50 60 70 80 90



- Catchment Area: 11.19km^2
- River Length: 13.09km
- Ungauged catchment: located 5km west of Galway City Centre
- 2 main tributaries: Western & Eastern Branch. 4 minor tributaries feed western branch with river discharge into Rusheen Bay.
- Urban land cover increase of 50% between 1995-2019 (Fig. 1).

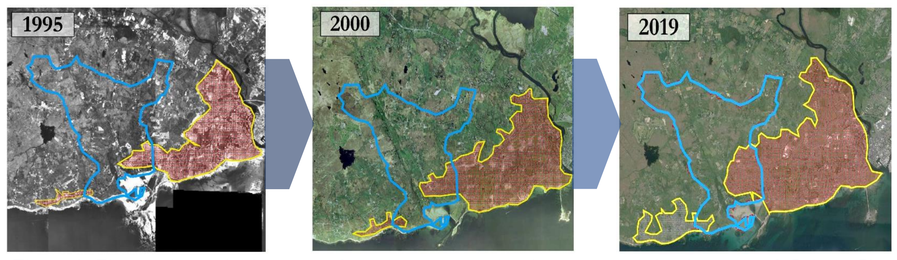


Figure 1: Time series aerial imagery of catchment area showing westward development of Galway City Suburbs and expansion of Barna village.

2: Precipitation

Catchment rainfall synthesis was derived using linear regression analysis between observed daily amounts recorded at gauge stations vs Met Éireann data recorded at Mace Head & Athenry automated weather stations. Analysis yielded an r^2 of 0.94 for observed amounts at catchment river mouth & base location in Salthill. (Fig. 2).

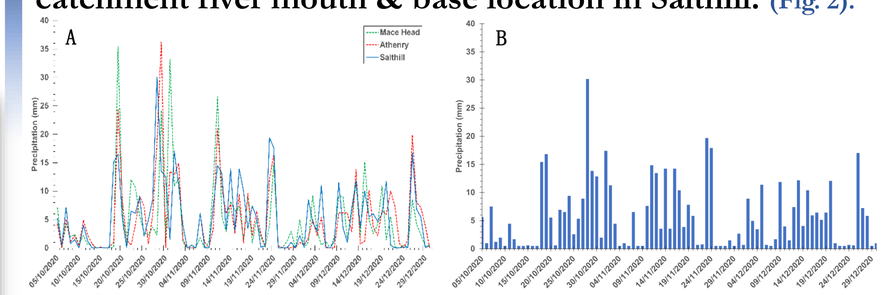


Figure 2: Precipitation observed from rain gauge & weather stations (A) during study period and final daily catchment rainfall synthesis (B)

3: Streamflow Dynamics

Detailed analysis of flow dynamics convey the heterogenic nature of the Barna Catchment. Pressures occurring at headwater locations have evident impacts downstream; facilitated by rainfall intensity & duration, channel geometry, nature of substrate (Mannings roughness coefficient *n*) and conditions of the surrounding land (Fig. 3).

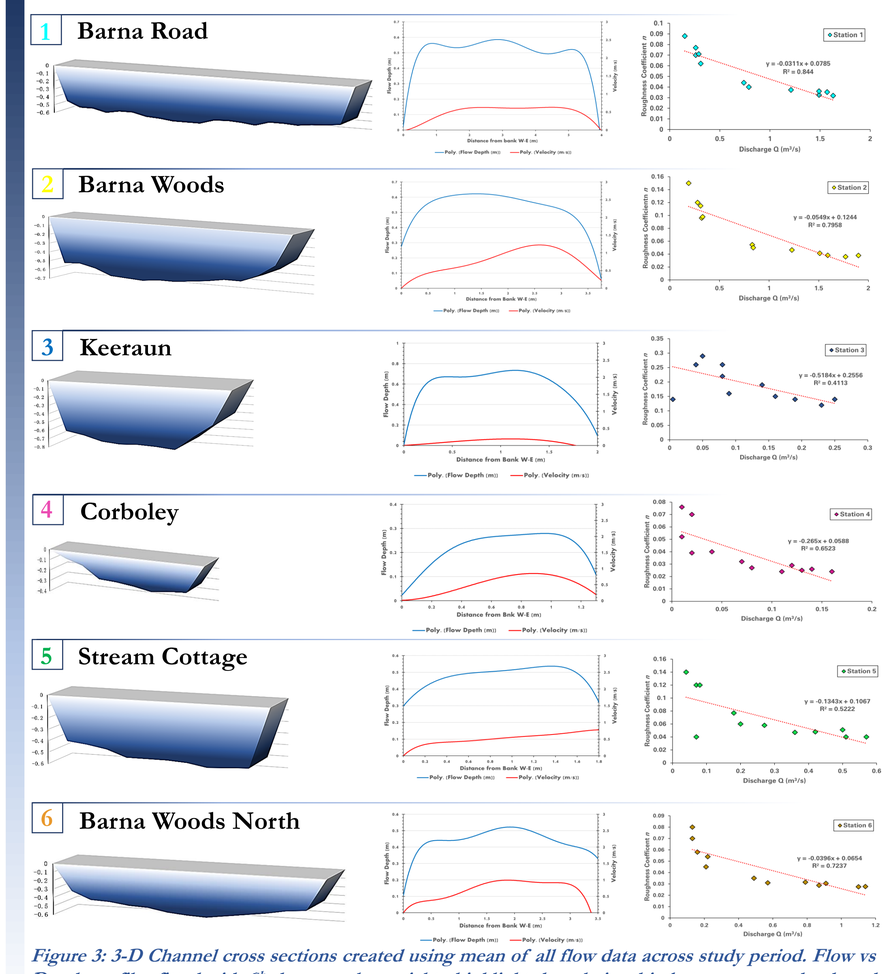


Figure 3: 3-D Channel cross sections created using mean of all flow data across study period. Flow vs Depth profiles fitted with 6th degree polynomial to highlight the relationship between water depth and flow velocity. This relationship is mediated by channel substrate. Variances in roughness coefficient values infer changeable substrate dependant upon flow magnitude and transport load. At low flows, substrate becomes primary resistant force compared with high flows which are dictated by gravity and flow velocity, the processes of which are generated at headwater locations.

4: Hydrology & Land Management

The flow dynamics of the Barna Catchment are intimately linked with the continuum of impermeable host bedrock, thin soil coverage and topography. Coupled with anthropogenic driven pressures, the Barna Catchment represents a dynamic and complex hydrological system. The primary findings of the Hydrology & associated impacts can be summarised as follows:

- Extremely flashy system with immediate response times; Rainfall expressed in streamflow within 4 – 8 hours (Fig. 4).
- Western Branch is the primary contributor to the overall flow regime. Eastern branch streamflow is heavily impacted by poor land management.
- Flash flooding is common in discrete zones throughout the catchment. Flooding events are predominantly coincident with closer proximity to urbanised areas and poorly managed land (*neglected* farmland) (Fig. 5).
- Increasing age profile of land owners across the region supports neglection of pastures which facilitate obstruction of natural flow regime.
- Barna Woodland Reserve acts as a key natural barrier to westward growth of Galway City Suburbs and is considered vital in terms of ecology & overall system health.
- Dry Weather Flows (Q_{50}) were not observed during this study.

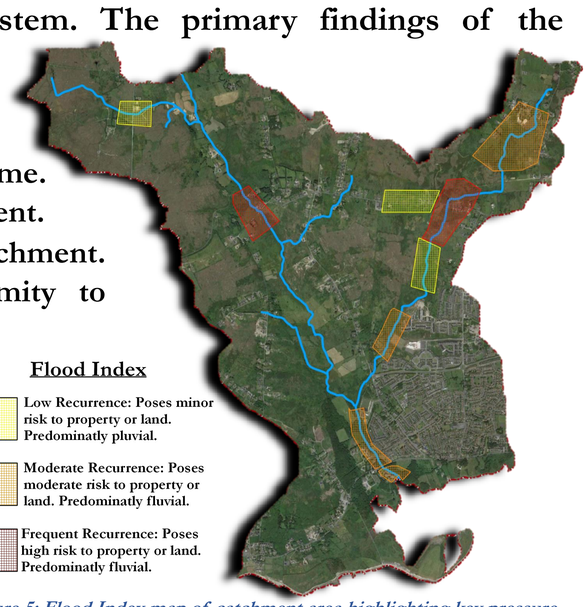


Figure 5: Flood Index map of catchment area highlighting key pressure points & probability along river system. Note Eastern branch flow regime heavily & regularly impacted by neglected land use upstream and increased urbanisation downstream.

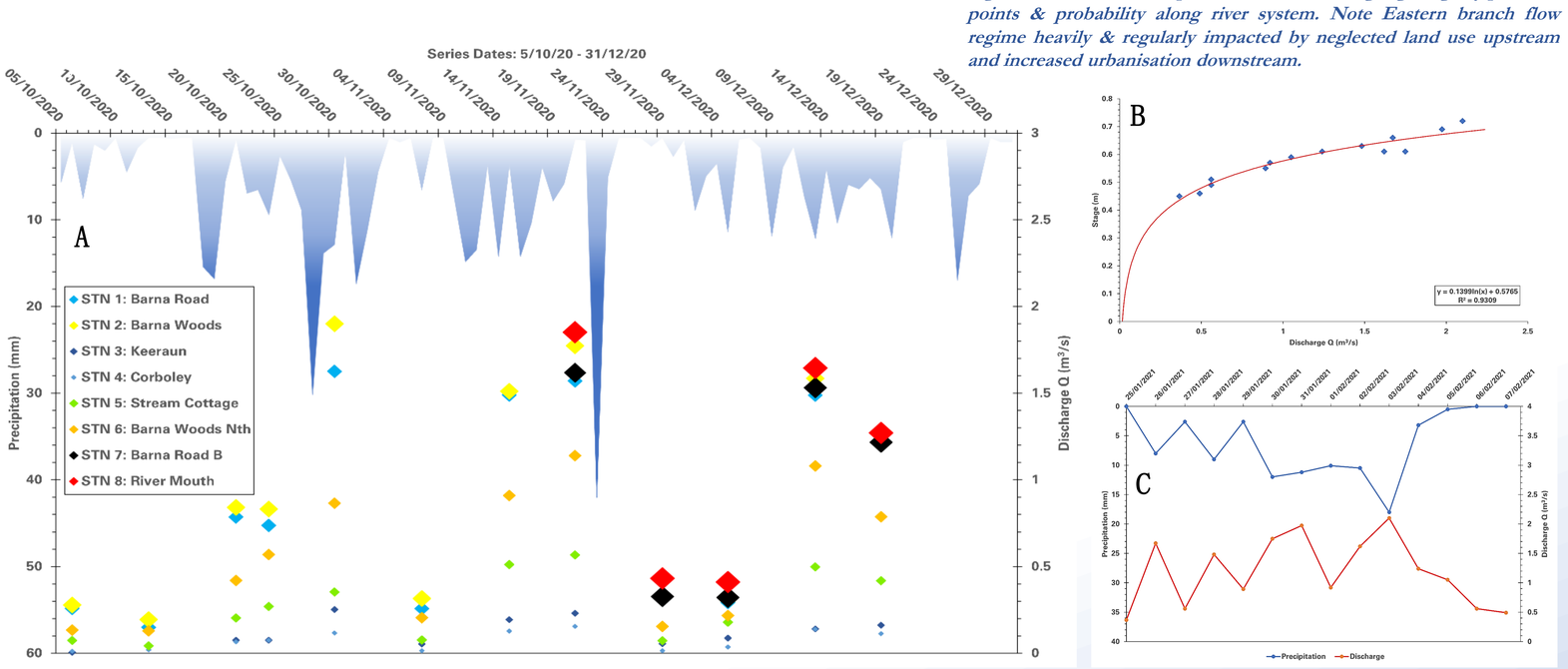


Figure 4: A; Runoff Hydrograph of discrete streamflow measurements for all stations across catchment area during study period. B; River rating curve derived from 14 day continuous discharge measurements at river mouth (station 9). C; Continuous daily hydrograph illustrating immediate system response to rainfall inputs measured over 14 day period.

5: Recommendations

- Installation of permanent rain gauge & staff gauge to improve stream network data.
- Water quality assessment to be considered in line with legislative requirements at key pressure points to assess ecological status of this river.
- Improved communication and outreach with local stakeholders to promote awareness of holistic & integrated catchment management practises.
- Further monitoring of flow regime to improve assessment accuracy & characterisation of this catchment

Acknowledgements

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Mapping metadata & permissions

1. Bedrock data: GSI 100k bedrock polygon data
2. Topography: DEM data supplied by OSI for academic use.
3. Soil data: Teagasc 250k soil association polygon data
4. Base map & Aerial Imagery: Google Satellite

References:

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