Catchment Scale Processes and River Restoration

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3 Main Catchment Elements

**Hydrology**
Energy associated with the flow of water affects the system

**Sedimentology**
Relationship between silt, sand and gravel size/position to hydrological regime

**River Processes**
Adjustment in shape and size of the river and topographical changes in the floodplain in relation to climatic conditions and geology

**DRIVERS** = Natural and Anthropogenic
Affect the relationship between river and floodplain features, habitats and their quality
Definition: River and Floodplain Processes...

The study of sediment sources, fluxes and storages within the river channel over short, medium and longer timescales and; of the resultant floodplain morphology (Sear and Newson, 1993). The pattern is determined by the hydrological regime in a natural system.

Helps to identify appropriate mitigation measure.
Catchments

- Streams receive water from their drainage basin
- Discharge: related to catchment area plus other influences
Discharge

- Discharge (cubic m/s). It has a magnitude-frequency relationship – both the very high and very low flows are rarer, the middle size flow more common.
- Small flow is exceeded a lot of the time, a given high flow is rarely exceeded.
- Important because impact on how much sediment and associated pollutants will move in the system and where they will be transported to within the context of the catchment characteristic.
Types of Flow to the River

• **Base or steady flow:** Slower route: rate depends on geology and landuse and flows through rather than over land.

• **Flashy or overland:** Catchments respond very quickly: depends on geology and human intervention.

Affects how quickly sediment, water and pollutants enter the river. Impact on aquatic habitat distribution and quality. Impacted by human intervention in the catchment.
Effects of Hydrology

• Catchments receive inputs (precipitation)
• Transformed to outputs (streamflow and evaporation)
• Input = output (allow for storage)
• Output is continuous.
• Inputs (precipitation) are discrete (i.e. separated by time/space).

Note:
– Visible and invisible inputs (e.g. seepage)
– Some river flow in summer maybe sustained by the flow of groundwater
... what characteristics can you see?
Mechanisms of Sediment Movement
Understanding connectivity in the sediment transfer system

Where are the sediment ‘sources’, ‘transfers’ and ‘sinks’?.. Helps to identify risk
Gradient or long profile (the energy curve)

Catchments naturally saucer shaped

- Steeper at the top - lots of energy but less catchment area so less discharge.
- Middle reaches - less gradient, more discharge from larger catchment.
- Lower reaches - lower gradient but highest discharge.

So where you are in the catchment effects erosion/deposition characteristics.
Summary of Controls

INDEPENDANT AND DEPENDANT CONTROLS OF CHANNEL FORM

Driving variables
- Inflow Discharge Hydrograph
- Inflow Sediment Hydrograph

Boundary characteristics
- Valley, slope and topography
- Bed and bank materials
- Riparian vegetation

Channel form
- Cross-sectional geometry (width, depth, maximum depth)
- Long profile (channel slope)
- Planform

Wash load
Bed material load
Human Intervention and Disruption to Natural Sediment Sources
The Case of Realignment

Figure 5a. Degradation in straightened river channels (after Parker and Andres, 1976)
The effect of a sediment pulse from upstream

Erosion and Sedimentation in the middle course

a) Lateral channel shift

b) Increase in sediment supply
Adjustment to Disturbances

CONTROL VARIABLE (CV)
RESPONSE VARIABLE (RV)

Disturbance

Reaction time

Relaxation time

Adjusted to new condition

TIME
Minimising Risk and Uncertainty: Understanding the Catchment Context
Hydrology/Hydraulics
Relevance to River Restoration?

- River restoration can change the shape, size and slope of river reaches
- Has impact on the amount of water a channel carries
- Flood levels might change
- The flow characteristics might change – velocities, flow spilt down channel and on floodplain

Need to understand hydrology (how much water coming through the catchment) and impact on sediment movement to inform flood risk management and habitats
Hydrological components affecting streamflow

• Catchment characteristics
• Rainfall
The Purpose of Hydraulics Studies?

• Determine the level/depth and extent of the water, and the velocities in the channel and floodplain under normal and flood conditions:
  – Experience/anecdotal evidence of what has happened previously
  – Or.. Models... complexity used depends on what you need to know! (Risk of increase water levels)
Hydraulics – Base Calculation (Mannings)

\[ \bar{v} = \frac{R^{2/3} s^{1/2}}{n} \]

Where
\( \bar{v} = \) Mean flow velocity (m/s)
\( R = \) Hydraulic radius
\( s = \) Channel gradient (energy slope)
\( n = \) Manning’s roughness coefficient
How Does this Help us in Restoration Design?

• Water levels within, upstream and downstream reach (flood, channel forming, normal)
• Some models = flood routes, flood flow rates and direction, flood storage
• Helps geomorphology design (v profile and Q)
• Enables assessment of the impact on 3rd parties from works and provides required assurances
## Comparison of Drainage and Restoration – impact on Hydraulics

<table>
<thead>
<tr>
<th>Aim</th>
<th>Drainage</th>
<th>Restoration</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>To drain away stormwater quicker, reduce water and flood levels</td>
<td>Restore more natural channel geomorphology, flows and features. Reconnect channel and floodplains</td>
</tr>
<tr>
<td>Impact on velocity and flow</td>
<td>increased flow velocity, increased discharge</td>
<td>More variable velocity, more natural flows, less flow in channel</td>
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<tr>
<td>Impact on Roughness Coefficient</td>
<td>Reduced roughness (less vegetation, bed features and regular channel shape)</td>
<td>Restore more natural roughness or increase roughness</td>
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<tr>
<td>Impact on Slope</td>
<td>Increased (steeper) slope</td>
<td>Restore ‘natural’ bed profile considering sediment continuity</td>
</tr>
<tr>
<td>Impact on Hydraulic Radius</td>
<td>Increased (larger) channel width &amp; depth area</td>
<td>Change channel dimensions to provide self sustaining in channel features</td>
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after Ashworth and Ferguson (1986)
What do we Want to Achieve?

Full of native wildlife
Water low in pollution
Natural structure and connectivity
Sufficient water flow

From RRC’s PRAGMO document (Judy England)
River Habitats