Comparing the Changes in Hydrology due to Different Development Regulations using Sub-Daily SWAT

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Study area
Study Watershed: Tributary to Gilleland Creek

4.99 km²
1233 acres
Elevation Data

Min Elev = 435 ft

Max Elev = 609 ft
Model Sub-basins
Site Slopes
Site Soils
City of Austin Ordinances: Land Use & Controls

- **Undeveloped [UND]**
- **Pre-Waterways Ordinances [Pre-ORD], <1974**
  - No controls
  - Limited creek easements, >320 ac.
- **Waterway Ordinance [WO], 1974-1986**
  - Detention only
  - Wider easements, >320 ac
- **Comprehensive Watershed Ordinance [CWO], 1986-present**
  - Detention and ½”+ sed-fil
  - Creek buffer and water quality transition zone, >320 ac
- **Watershed Protection Ordinance [WPO], proposed**
  - Detention and ½”+ sed-fil
  - Creek buffer, >64 ac (no WQTZ)
Undeveloped Land Use
Pre-Ord Land Use (<1974)
WO Land Use (~1974-86)
CWO Land Use (1986-present)
WPO Land Use (proposed)
HRU Distribution
Model Scenarios

Developed Conditions

- Irrigation and fertilizer on lawns and commercial; except high slopes
- Increased roughness & conductivity in channels
- 100% of developed residential & commercial land treated by BMPs; some land uses excluded.
- One large detention basin mid-basin (reach 9)
Detention Pond Location
Effects of Ordinances
Impacts on Flooding

Peak Flow Return Interval

- UND
- PRE
- WO
- CWO
- WPO

Peak Flow (cms) vs. Return Interval (yr)
Computation of shear

\[ \tau = \gamma_w \cdot D_H \cdot S_w \]

where,

- \( \tau \) = shear (Pa)
- \( \gamma_w \) = density of water (kg/m\(^3\))
- \( D_H \) = depth of water (m)
- \( S_w \) = channel slope (m/m)
Impacts on Erosion Potential

Gilleland Trib Cross-Section
Reach 20
Impacts on Erosion Potential

Channel and Total Shear

Excess Shear (Pa)

Flow Rate (cms)

- total shear
- channel shear
Computation of critical shear

\[ \tau_c = \Theta_c (S_g - 1) \cdot \gamma_w \cdot d_{50} \]

where,

- \( \tau_c \) = critical shear (Pa)
- \( \gamma_w \) = density of water (kg/m\(^3\))
- \( S_g \) = specific gravity of soil, 2.65
- \( d_{50} \) = median particle diameter (m)
- \( \theta_c \) = critical Shield’s parameter, 0.047

ES was defined as:

\[ ES = \sum (\tau - \tau_c) \text{ for all } \tau > \tau_c \]
Impacts on Erosion Potential

Critical Shear Flow Rate

Flow Rate (cms)

Median Particle Diameter, $d_{50}$ (mm)
Impacts on Erosion Potential

Average Annual Excess Shear

Excess Shear (Pa)

UND
Pre
WO
CWO
WPO
Impacts on Aquatic Life

Changes in hydrology affect aquatic life in two ways

- Changes in the wet-dry cycle interrupting species life cycles
- Increased variability affecting habitat
Impacts on Aquatic Life

![Graph showing low flow events in different scenarios](image-url)
Impacts on Aquatic Life (cont.)

Low Flow Conditions

- $T_{dry}$
- BF

Fraction

Scenario: UND, Pre, WO, CWO, WPO
Impacts on Aquatic Life (cont.)

Mean Daily Flow Duration Curve

- UND
- PRE
- WO
- CWO
- WPO
Impacts on Aquatic Life (cont.)

Flow Peak and Variability

- $q_{peak}$
- std dev

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Peak Flow Rate (cms)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UND</td>
<td>30</td>
<td>0.2</td>
</tr>
<tr>
<td>Pre</td>
<td>70</td>
<td>0.6</td>
</tr>
<tr>
<td>WO</td>
<td>70</td>
<td>0.6</td>
</tr>
<tr>
<td>CWO</td>
<td>40</td>
<td>0.4</td>
</tr>
<tr>
<td>WPO</td>
<td>40</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Impacts on Aquatic Life (cont.)
Impacts on Aquatic Life (cont.)

**Average Daily Change**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Rise (cms)</th>
<th>Fall (cms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UND</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Pre</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>WO</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>CWO</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>WPO</td>
<td>0.10</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Conclusions

- Development prior to regulations had negative impacts on flooding, erosion and aquatic life potential.
- Detention designed for large design rainfall events will not address the increased frequency of higher flow rates.
- Flood detention alone will not address issues of erosion and aquatic life (and may be detrimental).
- Austin regulations since CWO implementation have been beneficial with respect to flooding, erosion and aquatic life potential.