Perspectives on the Design of Step-Pool Stream Channel Segments

Mike Burke, Shawn Chartrand and Andy Collison
Motivation:

- Share perspectives and observations on step-pool design that have informed our efforts (and may provide insights to others)
Outline:

- Step Pool Definition
- Application Context
- Introduce Case Studies
- Pre-Design Considerations
- Design Example
Step-pool definitions

Building Blocks: Slope, Geology, Substrate

Step-pool stream segment: 2 or more step-pool units
Application Context: *Why Step-pools?*

- **Restoration:** means to conserve functional attributes in specific settings
Application Context: Why Step-pools?

- Attractive as a stabilization tool that has ‘natural’ attributes,

- Yet has characteristics of more structural approaches.
Application Context: *Where?*

- *Restoration* – where we would expect step-pools to form
- *Stabilization* - Structural and stability characteristics have led to application in ‘non-native’ context

*Constructed step-pool reach*
Restoration Case Study: *Carmel River (Dam Removal)*

- 125 sq. mi. at project
- 2500 foot reach, most at 3-5% (average of 2.5%)
- Marquee drainage for Steelhead recovery
- To be constructed 2013-15
Stabilization Case Study: *E. Fork Alamo Creek*

- 2 sq. mi. watershed, intermittent
- *Fine-grained watershed (project near bottom)*
- 600 foot segment, slope varies 3% to 5%
- *Bounded by infrastructure*
- *Constructed 2001*
Pre-Design Considerations: *Expectations*

- Compare 2 case studies – *influence of expectations on design and sustainability*
- Channel Reorganization
- Bank Deformation
- Substrate Mobility
Pre-Design Considerations: *Expectations*

✓ *Channel Reorganization*

➢ *Bank Deformation*

➢ *Substrate Mobility*

<table>
<thead>
<tr>
<th>Restoration: Carmel</th>
<th>Stabilization: Alamo</th>
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<tbody>
<tr>
<td>Q 25 – Q 50</td>
<td><em>Rigid (&gt;Q 100)</em></td>
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Pre-Design Considerations: *Expectations*

- *Channel Reorganization*
- ✓ *Bank Deformation*
- *Substrate Mobility*

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<td>Q 5 – Q 10</td>
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Pre-Design Considerations: *Expectations*

- **Channel Reorganization**
- **Bank Deformation**
- **Substrate Mobility**

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<th>Element</th>
<th>Restoration: Carmel</th>
<th>Stabilization: Alamo</th>
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<tbody>
<tr>
<td>Key Boulders</td>
<td>Q25 – Q50</td>
<td>Q100 or greater</td>
</tr>
<tr>
<td>Small Boulder/Cobble</td>
<td>Q2 – Q5</td>
<td>Q50 – Q100</td>
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<tr>
<td>‘Fines’ (gravel and smaller)</td>
<td>Annual</td>
<td>Annual</td>
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**Resupply**

**No Supply**
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<th>Element</th>
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<tbody>
<tr>
<td>Reorganization</td>
<td>Q 25 – Q 50</td>
<td>Never (&gt;Q 100)</td>
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<tr>
<td>Bank Deformation</td>
<td>Q 5 – Q 10</td>
<td>Q 100</td>
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<td>Q 25 – Q 50</td>
<td>Q100 or greater</td>
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<tr>
<td>Small Boulder/Cobble</td>
<td>Q 2 – Q 5 year event</td>
<td>Very rarely</td>
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<td>‘Fines’ (gravel and smaller)</td>
<td>Annual to Biennial</td>
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**Maintenance Requirements**

- **Lower**
- **Higher**
Carmel Design: *Deliberative Design Process*

**Step-pool Geometry Development Approach**

1. **Field Reconnaissance**
   - Measure naturally occurring step-pools

2. **Data Validation**
   - Compare to broader data set
   - Refinement balances channel capacity, fish passage, boulder stability, and geometric diversity
   - Repeat Steps 1-4 as needed

3. **Preliminary Geometries**
   - Through scaling relationships given slope range and step drop

4. **Model Validation**
   - Preliminary step-pool geometries modeled to validate fish passage, conveyance and boulder stability results

5. **Layout**
   - Based on refined geometry
Carmel Design: *Reconnaissance Highlights*

- **Morphology:** variable within slope range
Carmel Design: *Reconnaissance Highlights*

- Morphology: variable within slope range
- Role of the valley: reinforce morphology & resupply substrate
Carmel Design: *Reconnaissance Highlights*

- Morphology: variable within slope range
- Role of the valley: reinforce morphology & resupply substrate
  - Overbanks: relic features, meter substrate
Carmel Design: Preliminary Geometry

- **Maximum Resistance** (Abrahams et al. 1995)
  \[
  1 < \frac{\frac{H_s}{\lambda_s}}{S} < 2
  \]
  - Focus on profile
  - Focus on single value (1.5)

- **Geometric Scaling** (Chartrand et al. 2011)
  - Three dimensions
  - Linkage to Energy
  - Promote Variability
Carmel Design: *Iteration to Balance Goals*

- Gaps in criteria and directly applicable methods?
Carmel Design: Layout based on balanced design
Summary Points

- Physiographic and geologic setting matter
- Expectations influence design and maintenance challenges
- Step-pool streams adjust along a trajectory dictated by hillslopes and fluvial processes
- The design of step-pool stream corridors to meet multiple objectives requires a nuanced, balanced approach
Further Reading


Acknowledgements

• California American Water
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