

# Tool Box of Solutions

## Eugene-Springfield Metro Waterways Study

Draft, May 2006

The toolbox is an interactive application designed to facilitate the decision-making process when choosing what type of project should be undertaken to improve waterway conditions. The toolbox process begins by identifying the **Issue/Factors** that needs to be addressed at a specific site. Staff and Technical Assistance Pool input along with public comment narrowed the scope to a list of seven core issues. These are listed in the farthest left column on the matrix.

The **Potential Tools** column lists the types of techniques that can be applied to address the issue of concern. There are many **Potential Tools** for each **Issue/Factor**. The **Potential Tools** were compiled and summarized from extensive research on waterway enhancement and restoration techniques in the region and around the country. Some of these tools are tried and true, while others are more innovative and do not yet have a well established rate of success.

After identifying the **Issue/Factor** and the **Potential Tools**, the toolbox includes a *Selection Features* section, which summarizes the most important considerations for each individual tool. There are eight columns in the *Selection Features* section.

1. The **Benefits** column indicates the type of benefit(s) the tool is likely to produce when implemented. Many of the tools produce multiple benefits. The benefits are broken into four major categories, which relate directly to the study's planning objectives and the categories used in the channel assessment methodology. These include:
  - **Physical** (bank stability, bed stability, sediment, flood conveyance)
  - **Water Quality** (absorption/filtration, aeration, shade/temperature, bank integrity)
  - **Natural Resource** (riparian width, riparian vegetation, terrestrial habitat, aquatic habitat structure, and wildlife corridor function)
  - **Social** (public access, facilities, community amenity)
2. The **Cost** column gives an indication of how much the tool will cost to implement. Although costs may vary significantly, this column gives project staff a base approximation to work from. In some cases, too many variables exist to develop a cost estimate (*Highly Variable*).
3. **Typical Scale of Application** gives a spatial definition for each tool by assigning one of five potential scales to each tool. A tool can be assigned Region, Watershed, Corridor, Segment, or Point Specific depending on its size and scope.
4. The **Life Span** column indicates how long a properly designed and constructed tool will last under normal conditions and maintenance. The Life Span can be **Long** (permanent solution), **Medium** (requires eventual replacement after many years), or **Short** (needs to be redone on an annual of bi-annual basis).
5. **Proven Effectiveness** is based upon the history of a tool, previous research, and case studies. This column explains where a tool is most effective and points out issues that may not be effectively addressed with the specific tool.
6. The **Maintenance Needs** column explains the ongoing operational and maintenance commitments that must be understood before implementing the tool.
7. **Permits Needed** gives a broad picture of what documentation must be obtained to implement a tool. There are three levels of permits needed: Local, State, and Federal.
8. The **Other** column describes any special considerations of each tool such as general advantages/disadvantages, access requirements, and other relevant information.

Metro Waterways Study – Tool Box – Final Draft May 2006

Issues/Factors	Potential Tools	Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
		- Physical - Water Quality - Natural Resource - Social	Estimated Range of Cost	- Region - Watershed - Corridor - Segment - Point Specific	- Long - Medium - Short	Short description of effectiveness	Short description of maintenance commitments	- Federal - State - Local	- Advantages - Disadvantages - Access Needs - Suitable Conditions
<b>Channel Stability</b> <ul style="list-style-type: none"> <li>Channel incision (bed scour)</li> <li>Bank erosion (slumping)</li> <li>Failing revetment (specifically along the McKenzie River)</li> <li>Flow Velocity (erosion, stability)</li> </ul>	<b>Soft Bank Stabilization - examples:</b> <ul style="list-style-type: none"> <li>Riparian vegetation enhancement</li> <li>Coir Fiber Logs</li> <li>Erosion control fabrics</li> <li>Soil lifts</li> <li>Live stakes</li> <li>Live fascines</li> <li>Brush mattresses</li> <li>Replace revetment with soft bank techniques</li> <li>Streambank shaping (see "channel widening" below)</li> </ul>	<ul style="list-style-type: none"> <li>Physical (bank stability, flood prevention, flow retention, energy dissipation)</li> <li>Water Quality (filtration, temperature, bank integrity)</li> <li>Natural Resource (terrestrial/aquatic habitat, native vegetation, wildlife corridor, sanctuary habitat)</li> <li>Social (community amenity)</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation enhancement: low when compared to other tools; can often be accomplished with volunteers</li> <li>\$1 - \$3/plant: live stakes</li> <li>\$5 - \$10/lf: revetment removal/replace with softbank techniques</li> <li>\$5 - \$30/lf: coil fiber; soil lifts; live fascines</li> <li>\$30 - \$50/lf: brush mattress</li> <li>\$1 - 5/sq yd: erosion fabric (installed)</li> </ul>	Point-specific; Segment; Corridor	Medium - Long	<ul style="list-style-type: none"> <li>Effective in stabilizing banks</li> <li>Not effective stabilizing channel bottom.</li> <li>Effective in retaining or restoring "naturalized" habitat and aesthetic appearance.</li> </ul>	<ul style="list-style-type: none"> <li>Vegetation enhancement: high maintenance first few seasons; annual monitoring</li> <li>Soil lifts, live stakes, brush mattress, coir logs: frequent inspections first few seasons, then annually.</li> <li>Live fascines: minimal</li> <li>Replace revetment: frequent monitoring first few years for structural integrity and vegetation survival.</li> </ul>	Federal, State, Local.	Vegetation enhancement: <ul style="list-style-type: none"> <li>Sun exposure important</li> <li>Heavy equipment not needed</li> <li>Invasive weed management</li> <li>Potential role for volunteer groups, watershed councils</li> <li>Success rate improves with use of native vegetation</li> </ul> Revetment removal: <ul style="list-style-type: none"> <li>Landowners may resist due to perceived increased risk of flooding</li> </ul>
	<b>Hard Bank Stabilization – examples:</b> <ul style="list-style-type: none"> <li>Boulder revetment</li> <li>Rootwad revetment</li> <li>Imbricated rip-rap</li> <li>A-Jacks</li> <li>Live cribwalls</li> </ul>	<ul style="list-style-type: none"> <li>Physical (bank stability, flood prevention, energy dissipation)</li> <li>Water Quality (bank integrity)</li> <li>Social (protect at-risk property)</li> </ul>	<ul style="list-style-type: none"> <li>\$20 - \$40/lf river bank: boulder revetment</li> <li>\$60 - \$90/lf: rip-rap; A-Jacks</li> <li>\$250 - \$350/lf: live cribwall</li> <li>\$50 - \$330/ea: rootwad revetment (onsite)</li> <li>\$250 - \$600/ea: rootwad revetment (off-site)</li> </ul>	Point-specific; Segment	Medium	In general, hard bank solutions are: <ul style="list-style-type: none"> <li>Effective in stabilizing banks, but not channel bottoms.</li> <li>If incision is an issue, other techniques should be used in conjunction with these.</li> </ul>	<ul style="list-style-type: none"> <li>Boulder: monitor after first big storms for stability;</li> <li>Rootwad: monitor initial years to detect scour;</li> <li>Rip-rap: monitor monthly first 6 months for stability</li> <li>A-jacks: minimal</li> <li>Cribwalls: monitor for vegetation and stability first growing season.</li> <li>Each requires on-going annual inspections</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>Applicable for wide variety of conditions.</li> <li>Requires toe protection, grade control if addressing incision.</li> <li>Requires heavy equipment.</li> <li>Can change flow dynamics resulting in potential upstream, downstream stability problems.</li> <li>Permit and T&amp;E requirements could preclude revetment option</li> </ul>
	<b>In-stream Grade Control &amp; Flow Deflection – examples:</b> <ul style="list-style-type: none"> <li>Gravel/Boulders (incision)</li> <li>Large wood (bank erosion, incision)</li> <li>Log, Rock, J-Rock Vanes (toe erosion)</li> <li>V-log drops (bank erosion, incision)</li> <li>Rock cross vane (bank erosion, incision)</li> <li>Step pools (incision, energy dissipater)</li> </ul>	<ul style="list-style-type: none"> <li>Physical (bed and bank stability, flow retention, energy dissipation)</li> <li>Natural Resource (aquatic habitat, sanctuary habitat)</li> <li>Water Quality (restoration)</li> </ul>	Costs vary depending on width/size, etc: <ul style="list-style-type: none"> <li>\$50 - \$300/lf: gravel/boulders,</li> <li>\$250 - \$800/ea: large wood</li> <li>\$400 - \$1400/ea: log/rock/J-rock vanes</li> <li>\$800 - \$2600/ea: V-log drops</li> <li>\$1200 - \$5,000/ea: rock cross vane</li> <li>\$800 - \$6000/lf: step pools</li> </ul>	Point-specific; Segment	Short to medium	<ul style="list-style-type: none"> <li>Gravel/boulders: short-term fix; effective only if properly sized for bed transport capacity</li> <li>Large wood: experimental</li> <li>V-logs: effective for small, low gradient streams with cobble/gravel bedload</li> <li>Step pools: effective if designed for all flow levels</li> <li>Vanes: effective in low gradient streams</li> <li>Cross vane: appropriate for low – moderate grades; avoid sand-bed streams</li> </ul>	<ul style="list-style-type: none"> <li>Gravel/boulders: Monitor after high flow events and repair as necessary</li> <li>Large wood: minimal</li> <li>V-logs: Monitor after high flow events, repair as needed.</li> <li>Step pools: minimal</li> <li>Vanes: monitor after large storms first year and check for stability. Most common problem is erosion at streambank</li> <li>Cross vane: minimal</li> </ul>	Federal, State, Local	

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
<b>(con't)</b> <b>Channel Stability</b> <ul style="list-style-type: none"> <li>Channel incision (bed scour)</li> <li>Bank erosion (slumping)</li> <li>Failing revetment (specifically along the McKenzie River)</li> <li>Flow Velocity (erosion, stability)</li> </ul>	<i>Channel widening, shaping, redesign, and introduction of new side channels</i>	<ul style="list-style-type: none"> <li>Physical (bed and bank stability, flood conveyance, flow retention)</li> <li>Water Quality (filtration, shade, bank integrity)</li> <li>Natural Resource (riparian width, aquatic/terrestrial habitat, sanctuary habitat)</li> <li>Social (community amenity)</li> </ul>	<ul style="list-style-type: none"> <li>\$250/lf (City of Eugene): construction costs</li> <li>Land acquisition costs can vary significantly</li> </ul>	Segment	Long	Very effective and for achieving other multiple objectives: <ul style="list-style-type: none"> <li>Water quality</li> <li>Habitat enhancement</li> <li>Aesthetic</li> </ul> Local experience with this tool has been very successful.	<ul style="list-style-type: none"> <li>Frequent monitoring of initial growing season to ensure adequate soil moisture for seed germination and growth. May need supplemental irrigation</li> <li>Streambanks should be monitored after first significant storm event for erosion and soil loss.</li> <li>Document "as-construct" channel design for baseline reference.</li> <li>Long-term monitoring to track overall performance and to identify and remedy invasive species.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>ESA issues, as applicable, can limit scope of project and timing of construction.</li> <li>Channel widening is dependent on the availability of adequate space</li> <li>Acquisition costs are a significant factor</li> <li>Requires extensive landowner collaboration.</li> </ul>
	<i>Parallel Pipes</i>	<ul style="list-style-type: none"> <li>Physical (bed, bank stability)</li> <li>Water Quality (bank stability)</li> <li>Natural Resources (aquatic habitat)</li> </ul>	<ul style="list-style-type: none"> <li>\$50 - \$300/lf, depending on pipe size</li> </ul>	Segment	Long	Very effective, particularly in steep, hillside headwater areas..	<ul style="list-style-type: none"> <li>Inlet clogging requires on-going maintenance</li> </ul>	Local	<ul style="list-style-type: none"> <li>Maintaining base flow and small storm flows to the repair stream is critical for maintaining in-stream habitat.</li> </ul>
	<i>Manage public access</i>	<ul style="list-style-type: none"> <li>Physical (bank stability)</li> <li>Natural Resource (terrestrial habitat)</li> <li>Social (access, facility)</li> </ul>	Trails: \$5 - \$10/lf	Corridor	Long	Effective in reducing damage to riparian areas and sediment loads due to erosion.	Trail/Trailhead maintenance		
	<i>Riparian protection ordinance</i>	<ul style="list-style-type: none"> <li>Physical (bank stability, sediment reduction, energy dissipation)</li> <li>Water Quality (shade, filtration, bank integrity)</li> <li>Natural Resource (habitat, wildlife corridor)</li> <li>Social (preserve community amenity)</li> </ul>	Primarily administrative costs for: <ul style="list-style-type: none"> <li>Initial ordinance preparation, public involvement processing, adoption</li> <li>On-going costs: development review, inspections, enforcement</li> </ul>	Region	Long		None		<ul style="list-style-type: none"> <li>Can be affected by local politics and potentially subject to Measure 37 claims.</li> <li>Successful implementation depends on effective development review, inspection, and enforcement programming.</li> </ul>
<b>Water Quality</b> <ul style="list-style-type: none"> <li>Pollutants of Concern (Temperature, Dissolved Oxygen, Nutrients, Bacteria, Turbidity, Toxics, Mercury)</li> <li>Water Quality Function Condition (riparian cover, shade cover; channel stability, dissolved oxygen)</li> <li>ESA Related (Oregon Chub, Spring Chinook)</li> </ul>	<i>Protect/Enhance Riparian Vegetation</i> — examples: <ul style="list-style-type: none"> <li>Protection Ordinance</li> <li>Acquisition</li> <li>Financial incentives</li> <li>Capital enhancement projects</li> </ul>	<ul style="list-style-type: none"> <li>Physical (bank stability, flow retention, energy dissipation)</li> <li>Water Quality (filtration, shade, bank stability, aeration)</li> <li>Natural Resource (terrestrial/aquatic habitat, sanctuary habitat)</li> <li>Social (community amenity)</li> </ul>	<ul style="list-style-type: none"> <li>Regulatory protection costs are relatively low when compared to other capital projects</li> <li>Acquisition protection measures are comparatively high especially within urban areas.</li> <li>Capital project costs are relatively low</li> </ul>	Segment, Corridor	Long	<ul style="list-style-type: none"> <li>Effective at controlling erosion, stabilizing banks; moderating temperature, filtering/uptaking pollutants.</li> </ul>	<ul style="list-style-type: none"> <li>Regulations require on-going development review, inspections, enforcement</li> <li>Enhancement requires monitoring and maintenance in initial years.</li> </ul>		<ul style="list-style-type: none"> <li>Regulations can be affected by local politics and potentially subject to Measure 37 claims.</li> <li>Enhancements can use volunteer groups.</li> </ul>
	<i>Vegetation Planting for Stream Shading</i>	<ul style="list-style-type: none"> <li>Physical (bed, bank stability)</li> <li>Water Quality (sediment, bank stability)</li> <li>Natural Resources (aquatic habitat)</li> </ul>		Segment	Long	<ul style="list-style-type: none"> <li>Generally effective for moderating temperature</li> </ul>	<ul style="list-style-type: none"> <li>Initial years following planting require more monitoring and maintenance.</li> </ul>		<ul style="list-style-type: none"> <li>Potential role for volunteer groups, watershed councils</li> </ul>

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
<p><b>(con't)</b> <b>Water Quality</b></p> <ul style="list-style-type: none"> <li>• Pollutants of Concern (Temperature, Dissolved Oxygen, Nutrients, Bacteria, Turbidity, Toxics, Mercury)</li> <li>• Water Quality Function Condition (riparian cover, shade cover; channel stability, dissolved oxygen)</li> <li>• ESA Related (Oregon Chub, Spring Chinook)</li> </ul>	<p><i>Protect/Enhance Forest Canopy – examples:</i></p> <ul style="list-style-type: none"> <li>• Protection ordinance for steep, hillside headwater areas</li> <li>• Acquisition</li> <li>• Financial incentives</li> <li>• Capital enhancement projects</li> </ul>	<ul style="list-style-type: none"> <li>• Water Quality (filtration, shade, flow retention)</li> <li>• Natural Resources (terrestrial habitat,)</li> <li>• Social (community amenity)</li> </ul>	<ul style="list-style-type: none"> <li>• Regulatory protection costs are relatively low when compared to other capital projects</li> <li>• Acquisition protection measures are comparatively high especially within urban areas</li> <li>• Incentives: tax credit; stormwater fee/sdc reduction</li> <li>• Capital project costs are relatively low</li> </ul>	Watershed		<ul style="list-style-type: none"> <li>• Effective at reducing runoff, erosion; filtering/uptaking pollutants; moderating temperature</li> </ul>	<ul style="list-style-type: none"> <li>• Regulations require on-going development review, inspections, enforcement</li> <li>• Enhancement requires monitoring and maintenance in initial years.</li> </ul>		<p>Regulations can be affected by local politics and potentially subject to Measure 37 claims.</p> <p>Enhancements can use volunteer groups.</p>
	<p><i>Implement Applicable NPDES Permit &amp; TMDL Stormwater Programming Requirements (Best Management Practices, Capital Projects, Illicit Discharges, Education Outreach, etc)</i></p>	<ul style="list-style-type: none"> <li>• Water Quality (pollutant prevention/reduction)</li> </ul>	<ul style="list-style-type: none"> <li>• Per applicable program budgets of each jurisdiction</li> </ul>	Region, Watershed, Corridor Segment	Long	Generally, most techniques, methods have proven effective and/or adapted overtime as experience grows.	Per programming requirements.	Federal, State, Local	
	<p><i>Create Base Flow Channel (ie within the existing concrete channel in Amazon Creek)</i></p>	<ul style="list-style-type: none"> <li>• Water Quality (temperature)</li> <li>• Natural Resource (aquatic habitat)</li> </ul>	\$400 - \$1400/lf for vanes or deflectors	Segment	Medium	Effective in urban streams that have widened channels and lateral instability. Effective in reducing erosion at the toe of the bank.	Inspect after large storms to check for stability.	Federal, State, Local	Not suitable in high gradient streams with highly mobile bedloads.
	<p><i>Channel widening, shaping, redesign, and introduction of new side channels (spread flow, filtration, more capacity for riparian vegetation)</i></p>	<ul style="list-style-type: none"> <li>• Physical (bed and bank stability, flood conveyance, flow retention, energy dissipation)</li> <li>• Water Quality (filtration, shade, bank integrity)</li> <li>• Natural Resource (riparian width, aquatic and terrestrial habitat, sanctuary habitat)</li> <li>• Social (community amenity)</li> </ul>	<ul style="list-style-type: none"> <li>• \$250/lf (City of Eugene): construction costs</li> <li>• Land acquisition costs can vary significantly</li> </ul>	Segment	Long	<p>Very effective and for achieving other multiple objectives:</p> <ul style="list-style-type: none"> <li>• Bank/channel stability</li> <li>• Habitat</li> </ul> <p>Local experience with this tool has been very successful.</p>	<ul style="list-style-type: none"> <li>• Frequent monitoring of initial growing season to ensure adequate soil moisture for seed germination and growth.</li> <li>• Streambanks should be monitored after first significant storm event for erosion and soil loss.</li> <li>• Document “as-built” design for baseline reference</li> <li>• Long-term monitoring to track performance and to identify any problems in early stages.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>• ESA issues, as applicable, can limit scope of project and timing of construction.</li> <li>• Channel widening is dependent on the availability of adequate space</li> <li>• Acquisition costs are a significant factor</li> </ul>
	<p><i>Animal Waste Management Program (feeding waterfowl, dog/pet waste) design:</i></p> <ul style="list-style-type: none"> <li>• Education</li> <li>• Inspection</li> <li>• Design</li> </ul>	<ul style="list-style-type: none"> <li>• Water Quality (pollutant removal)</li> <li>• Social (community amenity)</li> </ul>		Segment	Long				Potential role for volunteer groups, watershed councils
	<p><i>Education/Clean-up/stream adoption/waste collection programs</i></p>	<ul style="list-style-type: none"> <li>• Water Quality (pollutant removal)</li> <li>• Social (community amenity)</li> </ul>	Varies depending on donated time and materials	Region, Watershed	Long	Very effective in making the site more aesthetically pleasing.	<ul style="list-style-type: none"> <li>• Repeated clean-ups are much more effective.</li> <li>• Important to monitor for illegal dumping.</li> </ul>		<ul style="list-style-type: none"> <li>• Access to site is a major consideration.</li> <li>• Potential role for volunteer organization, watershed councils.</li> <li>• Safety of volunteers</li> </ul>

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
<b>Flooding</b> <ul style="list-style-type: none"> <li>Flows overtop bank</li> <li>Inadequate storm water conveyance</li> </ul>	<i>Channel widening</i> (increased flood storage capacity)	<ul style="list-style-type: none"> <li>Physical (bed and bank stability, flood conveyance)</li> <li>Water Quality (filtration, shade, bank integrity)</li> <li>Natural Resource (riparian width, aquatic and terrestrial habitat, vegetation, sanctuary habitat)</li> <li>Social (community amenity)</li> </ul>	Approximately \$250/lf (Based on City of Eugene experience)	Segment	Long	Effective in streams that are incising	<ul style="list-style-type: none"> <li>Intensive monitoring for the first two weeks and after large storm events.</li> <li>Immediate repair of any observed erosion.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>Costs increase based on access, sediment disposal options, and the need for specialized equipment.</li> <li>Requires extensive landowner collaboration.</li> </ul>
	<i>Parallel piped system</i> (peak flows)	<ul style="list-style-type: none"> <li>Physical (flood conveyance, bed and bank stability)</li> <li>Water Quality (bank integrity)</li> </ul>	\$50 to \$300/lf, depending on pipe size	Segment	Medium	Effective in reducing velocity and protecting sensitive areas. Many examples.	Inlet needs to be maintained to prevent clogging, but can be minimized with filters and stilling basins.	Local	<ul style="list-style-type: none"> <li>Fish passage or exclusion design will increase costs for monitoring and maintenance.</li> <li>Coordinate with USFW &amp; ODFW</li> </ul>
	<i>Reduce peak-flow runoff from new development:</i> <ul style="list-style-type: none"> <li>Stormwater development ordinance (detention, infiltration, reduced impervious surfaces)</li> <li>Forest canopy protection</li> </ul>	<ul style="list-style-type: none"> <li>Physical (storm conveyance)</li> <li>Water Quality (absorption/filtration)</li> <li>Natural Resources (terrestrial and aquatic habitats)</li> </ul>	Varies	Watershed, Corridor	Long	Most effective when used in headwater areas for reducing peak flows in lower reaches		Local	<ul style="list-style-type: none"> <li>Coordinate with USFW &amp; ODFW</li> </ul>
	<i>Reduce peak-flow from existing development:</i> <ul style="list-style-type: none"> <li>Construct capital projects (detention pond, retention pond)</li> </ul>	<ul style="list-style-type: none"> <li>Physical (flood conveyance)</li> <li>Water Quality (absorption/filtration)</li> <li>Natural Resource (aquatic habitat)</li> </ul>		Segment	Long		On-going silt removal required for detention, retention pond effectiveness	Local	<ul style="list-style-type: none"> <li>Coordinate with USFW &amp; ODFW</li> </ul>
	<i>Existing Levees:</i> <ul style="list-style-type: none"> <li>Repair to improve function</li> <li>Remove, relocate and connect to floodplain</li> </ul>	<ul style="list-style-type: none"> <li>Physical (flood conveyance, flow retention, energy dissipation)</li> <li>Natural Resources (riparian width, habitat diversity)</li> </ul>		Point Specific	Medium	Local experience (Dragon Fly Bend)		Federal, State, Local	
	<i>Restore/protect natural pervious areas</i> (flood plains, riparian zones, wetlands, steep slopes, forest canopy): <ul style="list-style-type: none"> <li>Regulatory requirements</li> <li>Acquisition</li> <li>Incentives</li> <li>Capital restoration/enhancement projects</li> </ul>	<ul style="list-style-type: none"> <li>Physical (flood conveyance)</li> <li>Water Quality (absorption/filtration)</li> <li>Natural Resource (preserves or enhances habitat)</li> </ul>	<ul style="list-style-type: none"> <li>Regulatory costs are relatively low when compared to capital projects</li> <li>Acquisitions are comparatively high especially within urban areas</li> <li>Incentives: tax credit; stormwater fee/sdc reduction</li> <li>Capital project costs are relatively low</li> </ul>	Watershed, Corridor	Long	All of these techniques are proven effective and are widely used to reduce peak flows and maintain flood elevations.			<ul style="list-style-type: none"> <li>Regulatory measures are politically sensitive and potentially subject to Measure 37 claims.</li> <li>Other tools require extensive landowner collaboration for privately owned areas.</li> </ul>
	<i>Acquire properties vulnerable to frequent flooding</i>	<ul style="list-style-type: none"> <li>Physical (flood conveyance)</li> <li>Water Quality (absorption, filtration)</li> <li>Natural Resources (riparian width, habitat diversity)</li> <li>Social (community amenity)</li> </ul>	Real estate costs are very high especially for scarce, river- front properties.	Corridor, Segment	Long	Very effective. Eliminates hit and miss efforts to protect adjacent, developed properties.			Depending on acreage needed, could affect buildable land supply and negatively impact revenues for certain taxing districts.
	<i>Update floodplain maps and zoning</i>	<ul style="list-style-type: none"> <li>Physical (flood avoidance: provides more reliable information for siting structures)</li> </ul>		Region, Watershed	Long	Maintain instream flows for habitat		State (ODWR)	

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
<b>Adequate Flow</b> <ul style="list-style-type: none"> <li>Water intake not functioning</li> <li>Water rights not secure</li> </ul>	<i>Secure water rights</i>	<ul style="list-style-type: none"> <li>Water quality (temperature)</li> <li>Natural Resource (aquatic habitat)</li> <li>Social (secures water for agricultural uses)</li> </ul>	Varies	Watershed	Long				
	<i>Re-construct water intake structure</i>	<ul style="list-style-type: none"> <li>Water quality (temperature)</li> <li>Natural Resource (aquatic habitat)</li> <li>Social (more efficient water distribution)</li> </ul>		Point Specific	Medium	Reduce intake velocities screen for fish exclusion. Long-term maintenance required.	Fish passage or exclusion will increase monitoring and maintenance costs	Federal, State, Local	<ul style="list-style-type: none"> <li>Potential land ownership issues</li> <li>Remote control of valve intake would improve effectiveness of this facility</li> </ul>
	<i>Establish connection with hyporheic zone</i>	<ul style="list-style-type: none"> <li>Water Quality (temperature)</li> </ul>		Corridor					
<b>In-Channel Habitat</b> <ul style="list-style-type: none"> <li>Barriers to fish passage</li> <li>Lack of channel diversity</li> <li>No side channels</li> <li>Lack of gravel recruitment</li> <li>Threatened and endangered species</li> </ul>	<i>Habitat features:</i> <ul style="list-style-type: none"> <li>Large wood</li> <li>Lunkers</li> <li>Boulders clusters</li> <li>Riparian canopy for stream shading</li> </ul>	<ul style="list-style-type: none"> <li>Natural Resource (aquatic habitat, sanctuary habitat)</li> <li>Water Quality (temperature)</li> </ul>	<ul style="list-style-type: none"> <li>\$60 - \$250/ea: Boulder Cluster</li> <li>\$360 - \$500/ea: Lunker</li> <li>\$20 to \$40/lf: Large wood</li> </ul>	Segment	Medium	Very effective in creating habitat features and adding complexity to channel	<ul style="list-style-type: none"> <li>Large Wood, Boulders, Lunkers:: size and placement should be recorded and checked annually for movement.</li> <li>Riparian Canopy: requires high maintenance initial years to ensure survival; 5-10 year monitoring.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>Can dramatically alter flow conditions and stream morphology.</li> <li>Safe boater passage required for toatable streams.</li> </ul>
	<i>Channel widening and introduction of side channels (spread flow)</i>	<ul style="list-style-type: none"> <li>Physical (bed and bank stability, flood conveyance, flow retention, energy dissipation)</li> <li>Water Quality (filtration, shade, bank integrity)</li> <li>Natural Resource (riparian width, aquatic/terrestrial habitat, sanctuary habitat)</li> <li>Social (community amenity)</li> </ul>	Approximately\$250/lf  (Based on City of Eugene experience)	Segment	Long	Very effective and for achieving other multiple objectives: <ul style="list-style-type: none"> <li>Bank stability</li> <li>Channel stability</li> <li>Water quality</li> <li>Aesthetic</li> </ul> Local experience with this tool has been very successful.	Vegetation Management	Federal, State, Local	<ul style="list-style-type: none"> <li>Requires extensive landowner collaboration</li> </ul>
	<i>In-stream stormwater pond</i>	<ul style="list-style-type: none"> <li>Physical (flood conveyance, flow retention, energy dissipation)</li> <li>Water Quality (absorption/filtration)</li> <li>Natural Resource (aquatic habitat, sanctuary habitat)</li> </ul>		Segment	Long	Most effective in headwaters area to reduce peak flows in downstream areas		Federal, State, Local	Coordinate with USFW & ODFW
	<i>Install gravel</i>	<ul style="list-style-type: none"> <li>Natural Resource (aquatic habitat)</li> </ul>	\$50-\$250/lf	Segment	Medium	Effective in encouraging spawning, but fish passage barriers are first priority.		Federal, State, Local	<ul style="list-style-type: none"> <li>Appropriate in shallow streams with mid-sized bedloads and few pools.</li> <li>Must be considered with fish passage improvements.</li> </ul>
	<i>Remove/modify culverts (daylighting)</i>	<ul style="list-style-type: none"> <li>Water Quality (filtration)</li> <li>Natural Resource (terrestrial and aquatic habitat, riparian width)</li> <li>Social (public access, community amenity, aesthetic)</li> </ul>	\$150 to \$350/lf	Segment	Long	Very effective in addressing habitat concerns and improving aesthetics. Many examples.	<ul style="list-style-type: none"> <li>Annual maintenance timed with fish migration.</li> <li>If associated with fish passage, long-term monitoring and maintenance required.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>Restores natural character</li> <li>Education important for gaining community support.</li> <li>Potential role for volunteer groups, watershed councils.</li> <li>Day-lighting highly dependent on adequate space and availability of land</li> </ul>

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
(con't) <b>In-Channel Habitat</b> <ul style="list-style-type: none"> <li>• Barriers to fish passage</li> <li>• Lack of channel diversity</li> <li>• No side channels</li> <li>• Lack of gravel recruitment</li> <li>• Threatened and endangered species</li> </ul>	<i>Restore wetlands</i>	<ul style="list-style-type: none"> <li>• Physical (flood storage)</li> <li>• Water Quality (absorption/filtration)</li> <li>• Natural Resource (terrestrial/aquatic habitat, sanctuary habitat)</li> <li>• Social (community amenity)</li> </ul>	\$50,000/acre	Segment or Corridor	Long	Highly effective in addressing multiple objectives. Many examples.	5-year monitoring (minimum) required	Federal, State, Local	<ul style="list-style-type: none"> <li>• Need to weigh potential issues with wetlands converting mercury to methylmercury which can then move into the food chain.</li> <li>• Potential role for volunteer groups, watershed councils.</li> </ul>
<b>Riparian (off-channel) Habitat</b> <ul style="list-style-type: none"> <li>• Lack of vegetation</li> <li>• Lack of habitat</li> <li>• Invasive species</li> <li>• Threatened and Endangered species</li> </ul>	<i>Riparian planting (native species) and invasive weed removal(off-channel)</i>	<ul style="list-style-type: none"> <li>• Physical (bank stability)</li> <li>• Water Quality (absorption/filtration, temp.)</li> <li>• Natural Resource (riparian width, terrestrial habitat, wildlife corridor function)</li> <li>• Social (community amenity)</li> </ul>	Varies, but generally low compared to other capital projects	Segment	Long	Effective for encouraging native habitat	Vegetation management; invasive weed control; landowner involvement.		Requires extensive landowner collaboration. Role for volunteer groups, watershed councils.
	<i>Channel widening and introduction of side channels (spread flow)</i>	<ul style="list-style-type: none"> <li>• Physical (bed and bank stability, flood conveyance)</li> <li>• Water Quality (filtration, shade, bank integrity)</li> <li>• Natural Resource (riparian width, aquatic and terrestrial habitat, vegetation)</li> <li>• Social (community amenity)</li> </ul>	Approximately\$250/lf (Based on City of Eugene experience)	Segment	Long	Very effective for achieving multiple objectives: <ul style="list-style-type: none"> <li>• Bank stability</li> <li>• Channel stability</li> <li>• Habitat enhancement</li> <li>• Aesthetic</li> </ul> Local experience with this tool has been very successful.	<ul style="list-style-type: none"> <li>• Vegetation Management</li> <li>• T &amp; E species requires on-going monitoring and adaptive management practice.</li> </ul>	Federal, State, Local	Requires extensive landowner collaboration.
	<i>Floodplain Restoration</i>	<ul style="list-style-type: none"> <li>• Physical (bank stability, flood control, conveyance)</li> <li>• Water Quality (filtration, bank integrity)</li> <li>• Natural Resource (riparian, aquatic and terrestrial habitat, vegetation)</li> <li>• Social (community amenity)</li> </ul>	Varies	Segment	Long	<ul style="list-style-type: none"> <li>• Very effective for restoring floodplain-related habitat.</li> <li>• Dragon fly Bend is a local example of a very successful restoration project.</li> </ul>	Requires rigorous initial management to ensure properly functioning condition.	Federal, State, Local	<ul style="list-style-type: none"> <li>• Ownership and land availability of issues.</li> </ul>
	<i>Removal of portions of concrete walled channel (one or both sides as conditions allow)</i>	<ul style="list-style-type: none"> <li>• Water Quality (filtration, temperature)</li> <li>• Natural Resource (riparian width, riparian vegetation, terrestrial/aquatic habitat, wildlife corridor function)</li> <li>• Social (public access, community amenity)</li> </ul>	\$750/lf (Upper Amazon Creek Enhancement Study – 2000)	Segment	Long	Effective at decreasing flow velocities	Would increase maintenance requirements, at least initially.	Federal, State, Local	<ul style="list-style-type: none"> <li>• Highly dependent on having adequate space.</li> <li>• Soil-based channel could increase erosion and bank stability problems to adjacent landowners</li> </ul>
	<i>Acquisition/protection of existing riparian habitats</i>	<ul style="list-style-type: none"> <li>• Natural Resource (preserves/improves existing habitat)</li> </ul>	Varies	Corridor or Watershed	Long				

		Selection Features							
		Benefits	Cost	Scale of Application	Life Span	Proven Effectiveness	Maintenance Needs	Permits Needed	Other
<b>Community Vitality/Public Access</b> <ul style="list-style-type: none"> <li>Waterway is visually unattractive</li> <li>Is not an amenity to adjacent properties</li> <li>No public access to waterway due to steep banks, lack of trails, or land not in public ownership</li> <li>Structures or obstructions in waterway prevents access by boat</li> <li>Trespass and illegal camping</li> <li>Headgate system ownership</li> </ul>	<i>Remove/modify culverts (daylighting) and fish passage barriers</i>	<ul style="list-style-type: none"> <li>Water Quality (filtration)</li> <li>Natural Resource (terrestrial and aquatic habitat, riparian width)</li> <li>Social (public access, community amenity)</li> </ul>	\$150 to \$350/lf	Segment	Long	Very effective in addressing habitat concerns and improving aesthetics. Many examples.	<ul style="list-style-type: none"> <li>Annual maintenance timed with fish migration.</li> <li>If associated with fish passage, long-term monitoring and maintenance required.</li> </ul>	Federal, State, Local	<ul style="list-style-type: none"> <li>Restores natural character to urban streams.</li> <li>Education is important to gain community support.</li> </ul>
	<i>Channel widening and introduction of side channels (spread flow)</i>	<ul style="list-style-type: none"> <li>Physical (bed and bank stability, flood conveyance)</li> <li>Water Quality (filtration, shade, bank integrity)</li> <li>Natural Resource (riparian width, aquatic and terrestrial habitat, vegetation)</li> <li>Social (community amenity)</li> </ul>	Approximately \$250/lf (Based on City of Eugene experience)	Segment	Long	A very effective tool to both strengthen the bank and stabilize the streambed	Vegetation Management	Federal, State, Local	
	<i>Develop multi-use path system/pedestrian bridges (on public lands or, in special cases, with private property owner agreement or with access easement)</i>	<ul style="list-style-type: none"> <li>Social (public access, community amenity)</li> </ul>	Path: \$75-125/lf Bridge example: 100 ft. long/12 ft. wide (\$100/sq. ft) = \$120,000	Corridor	Medium	Effective in managing access.	Periodic edge mowing	Federal, State, Local	<ul style="list-style-type: none"> <li>Potential social conflict with users and landowners.</li> <li>Pathways should be setback from top-of-bank to minimize potential damage due to bank failure</li> </ul>
	<i>Develop soft surfaced trails</i>	<ul style="list-style-type: none"> <li>Social (public access, community amenity)</li> </ul>	\$5-10/lf	Corridor	Short	<ul style="list-style-type: none"> <li>Effective in managing access.</li> <li>Successful examples are along Amazon Creek.</li> </ul>	Periodic edge mowing, resurfacing	Local	
	<i>Provide other recreational facilities</i>	<ul style="list-style-type: none"> <li>Social (facility, community amenity)</li> </ul>	Varies	Point or Segment	Medium			Local	
	<i>Interpretive displays/Outdoor classrooms</i>	<ul style="list-style-type: none"> <li>Social (facility, access, community amenity)</li> </ul>	Varies	Point-Specific	Medium			Local	
	<i>Acquire land for public use</i>	<ul style="list-style-type: none"> <li>Social (facility, access, community amenity)</li> </ul>	Varies	Watershed	Long				