




# **Puget Sound Stormwater – What's all the Shouting About?**

## **Landscape Level Stormwater Solutions**

**William E. Derry, January, 2008**



# **Puget Sound Stormwater – What's all the Shouting About?**

- **PSP recommendations for stormwater, October 2006, page 43 of Appendix A:**  
**"The strategies listed are not likely to be sufficient to achieve ecosystem goals."**



# **Puget Sound Stormwater – What's all the Shouting About?**

- **Ecology's Stormwater Management Manual for Western WA: "land development as practiced today is incompatible with the achievement of sustainable ecosystems."**



# **Known with a High Degree of Certainty**

- **Ecosystems are more complex:**
    - than we know and
    - more complex than we know how to think
- \*paraphrased from Jack Ward Thomas

# Known with a High Degree of Certainty

- Puget Sound and tributary streams are degraded and declining – populations crashing
- Human population growth is unrestrained and will continue
- Puget Sound will continue to decline even without growth
- The majority of lowlands in the Puget Sound Basin has been deforested and converted to other human uses

idge Island

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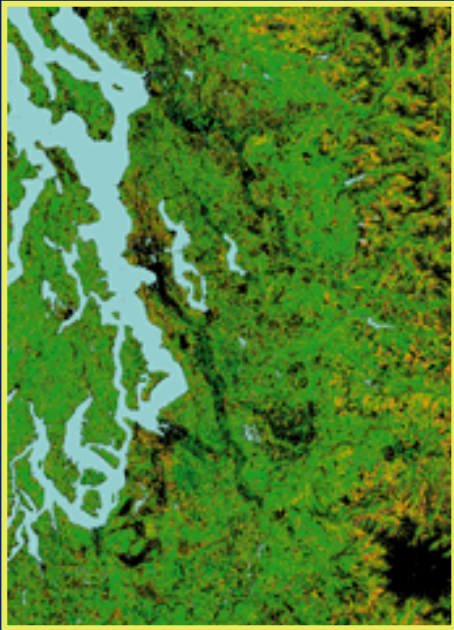
© 2007 Google™

Pointer 47°47'17.80" N 122°00'14.56" W elev 49 ft

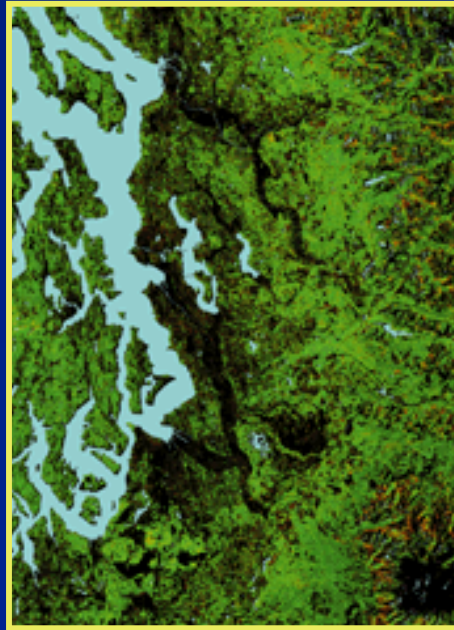
Streaming 100%

Eye alt 44.18 m

# Puget Sound Satellite Images Showing Forest Losses



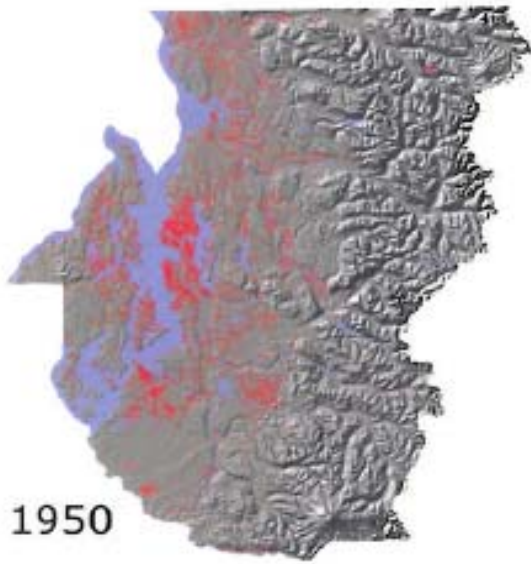
1972



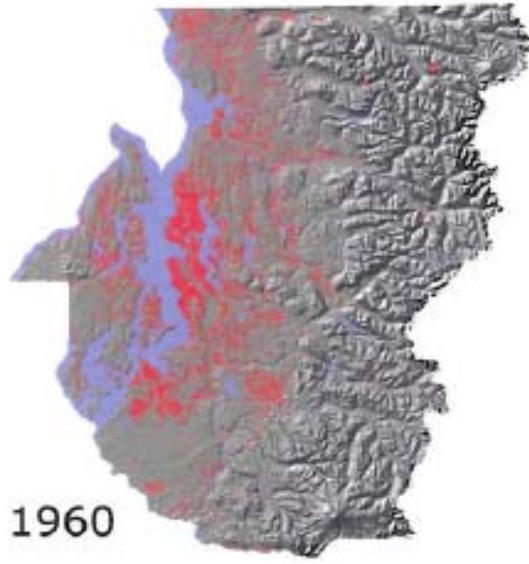
1986



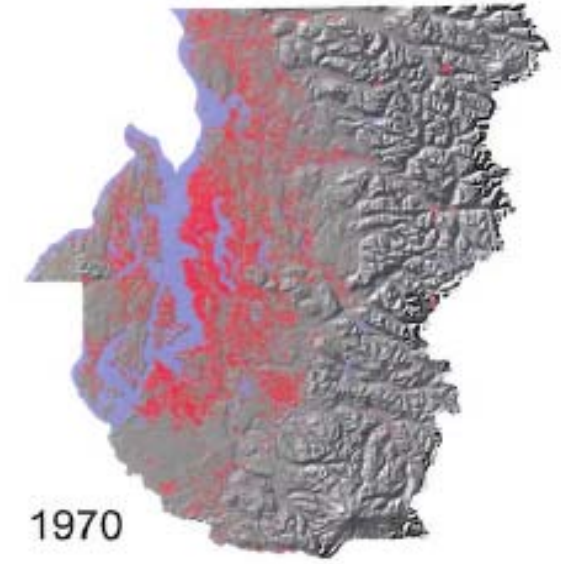
1996



1950



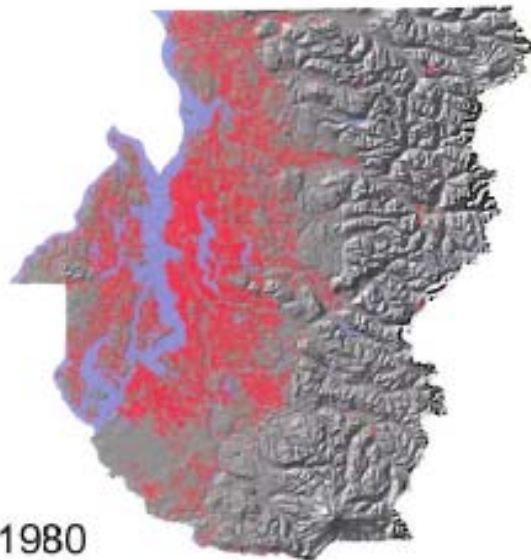
1960



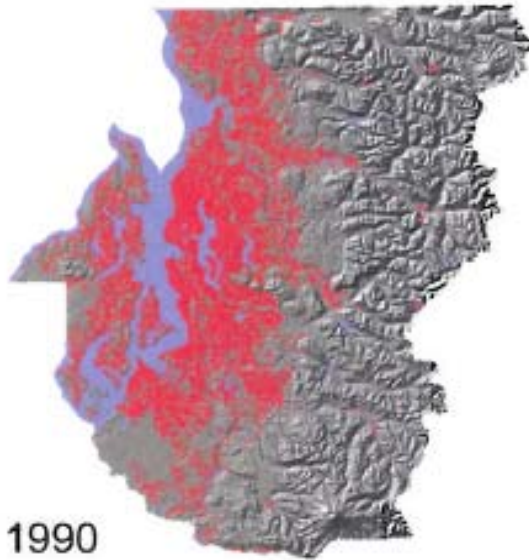
1970

## Developed Land

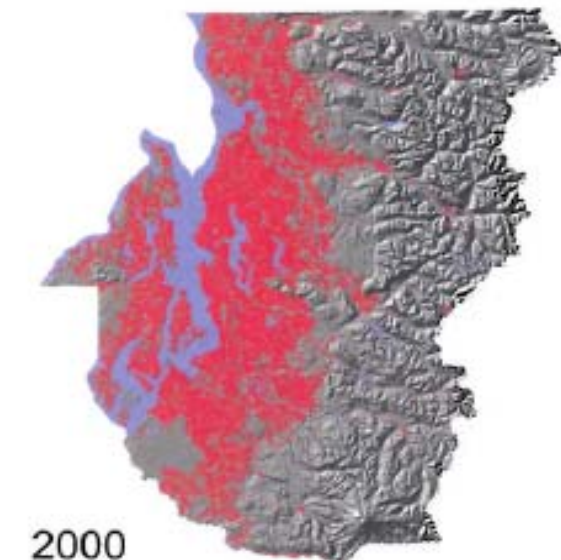
(Source: UW Urban Ecology Research Lab 2005)



1980

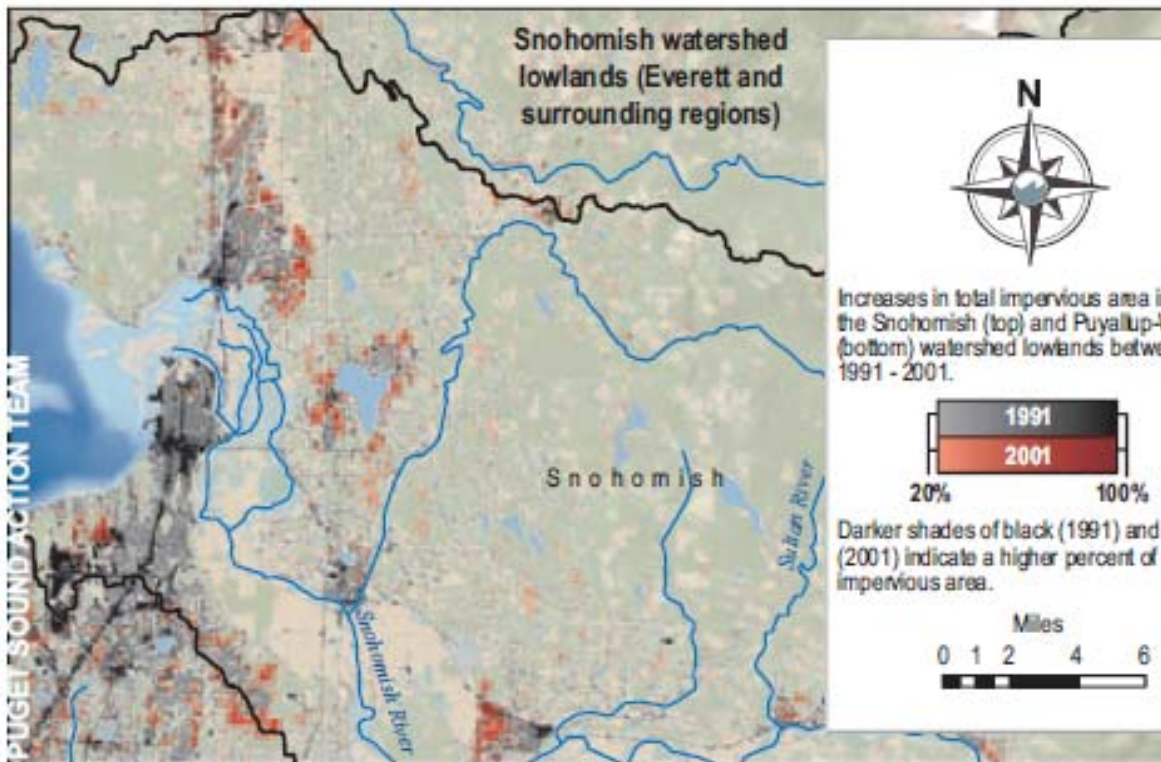
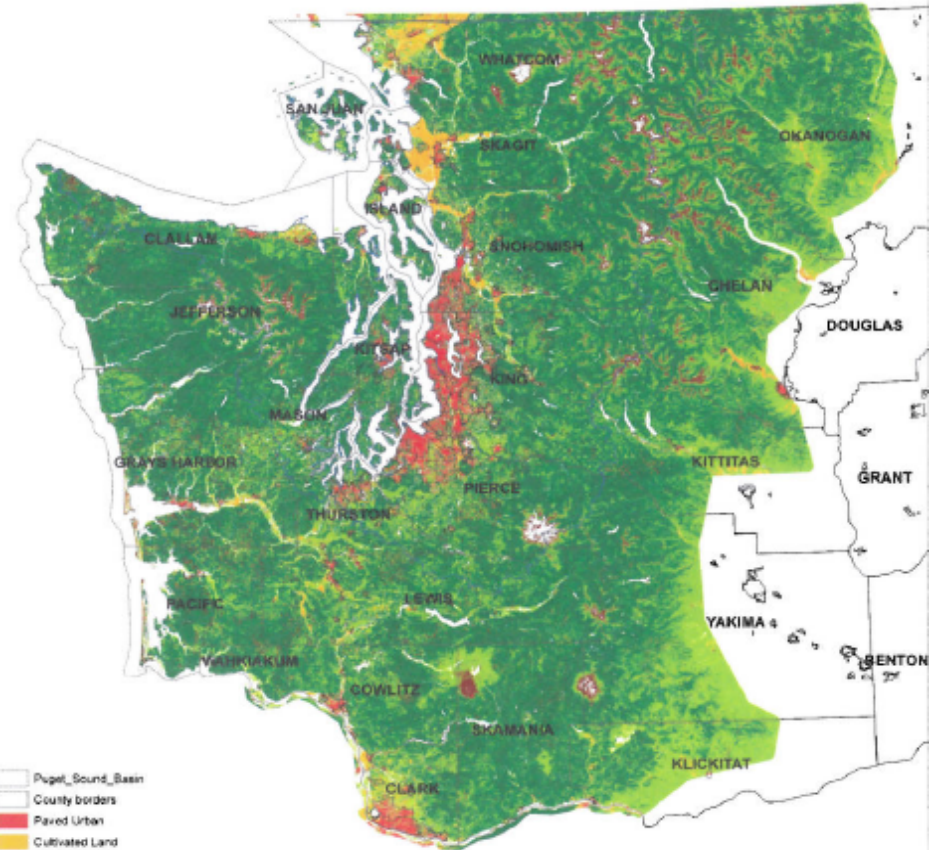


1990



2000

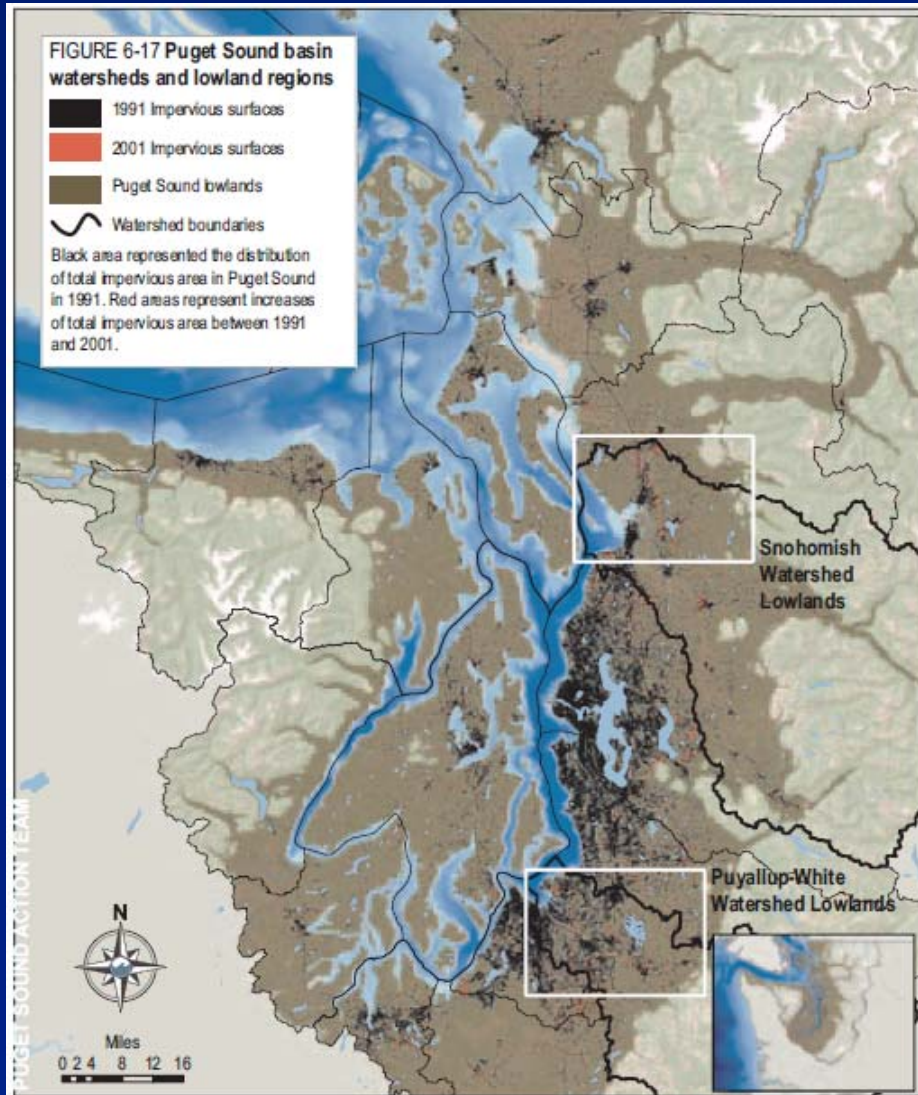
# Total Impervious Surface and Developed Land



(Source: UW Urban Ecology Research Lab 2005)

PUGET SOUND ACTION TEAM

# Known with a High Degree of Certainty




- **Removing forest and creating impervious area and drainage systems alters stream hydrology and delivers pollutants to streams and Puget Sound**
- **Altered stream hydrology degrades stream habitat**
- **Stormwater contaminants include:**
  - heavy metals (esp. cu, zn)
  - oil and grease
  - TSS
  - nutrients
  - phthalates
  - pesticides
- **Available technologies can not eliminate these contaminants**

# Known with a High Degree of Certainty

## Road systems

- remove forest cover and soils
- add impervious surface (65%) and increase runoff
- generate pollutants
- associated drainage systems remove water from soils and rapidly deliver runoff and pollutants to streams
- destroy stream and riparian habitat
- culverts create fish blockages





**There is no science and no historic example to support the concept that stormwater management practices can sustain hydrologic regimes and water quality to the extent needed to protect, let alone, restore aquatic resources of Puget Sound or its streams in developed areas.**



## Therefore

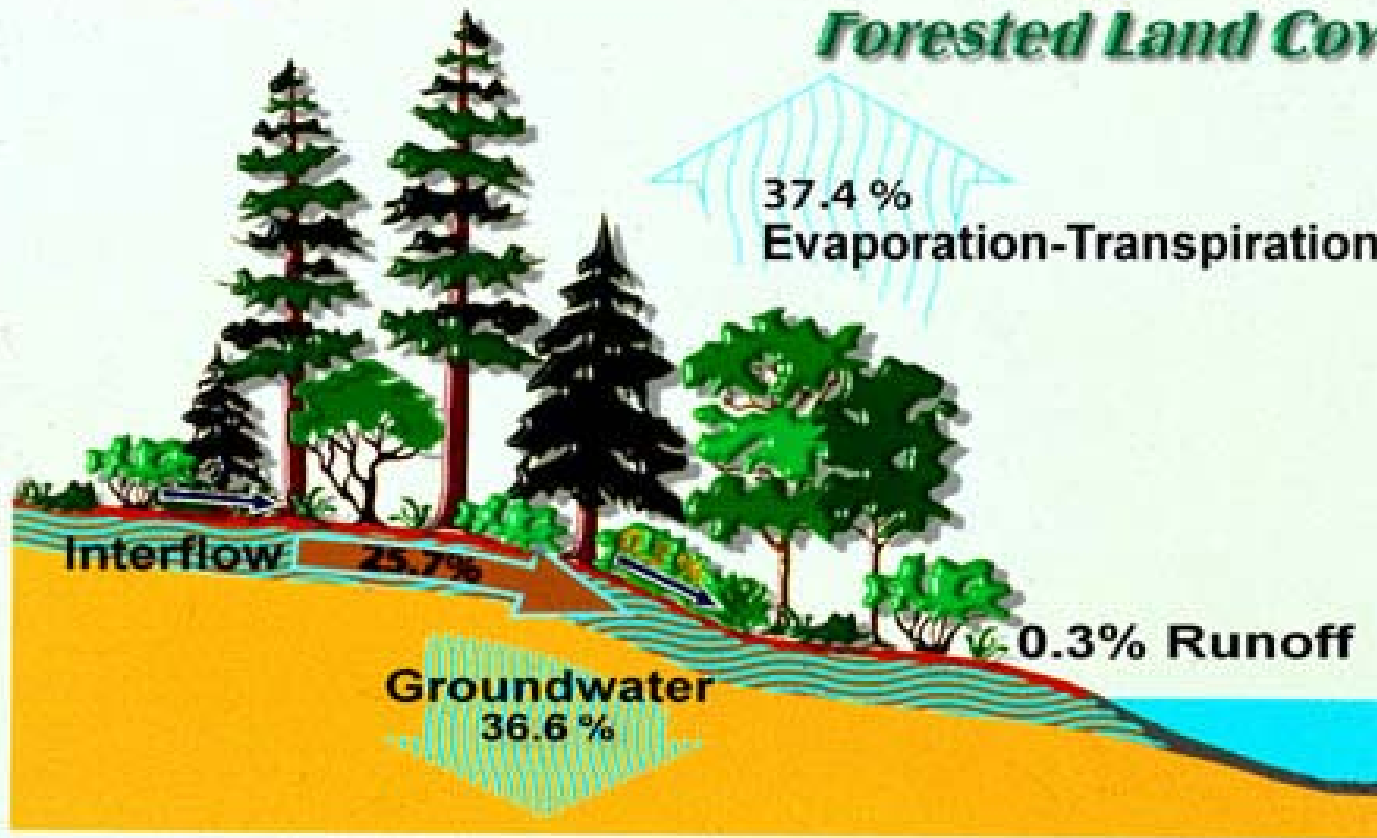
- **Refinements to current practices won't be enough**
- **Changes in lifestyles, land use, and regulations are needed**
- **More public education and funding needed.**



# Background Science

# Typical Annual Water Budget

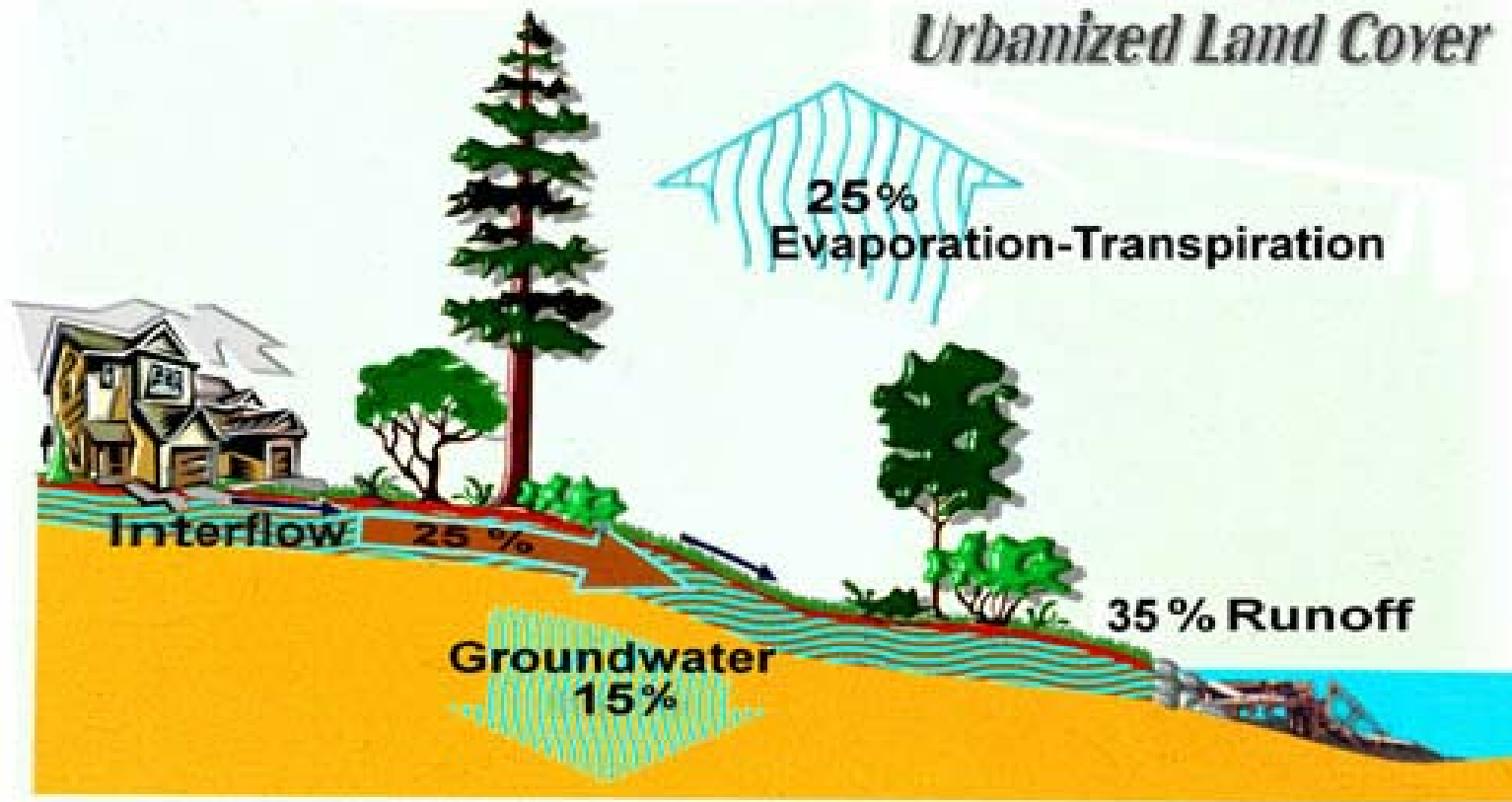
## *Forested Land Cover*



From Chris May

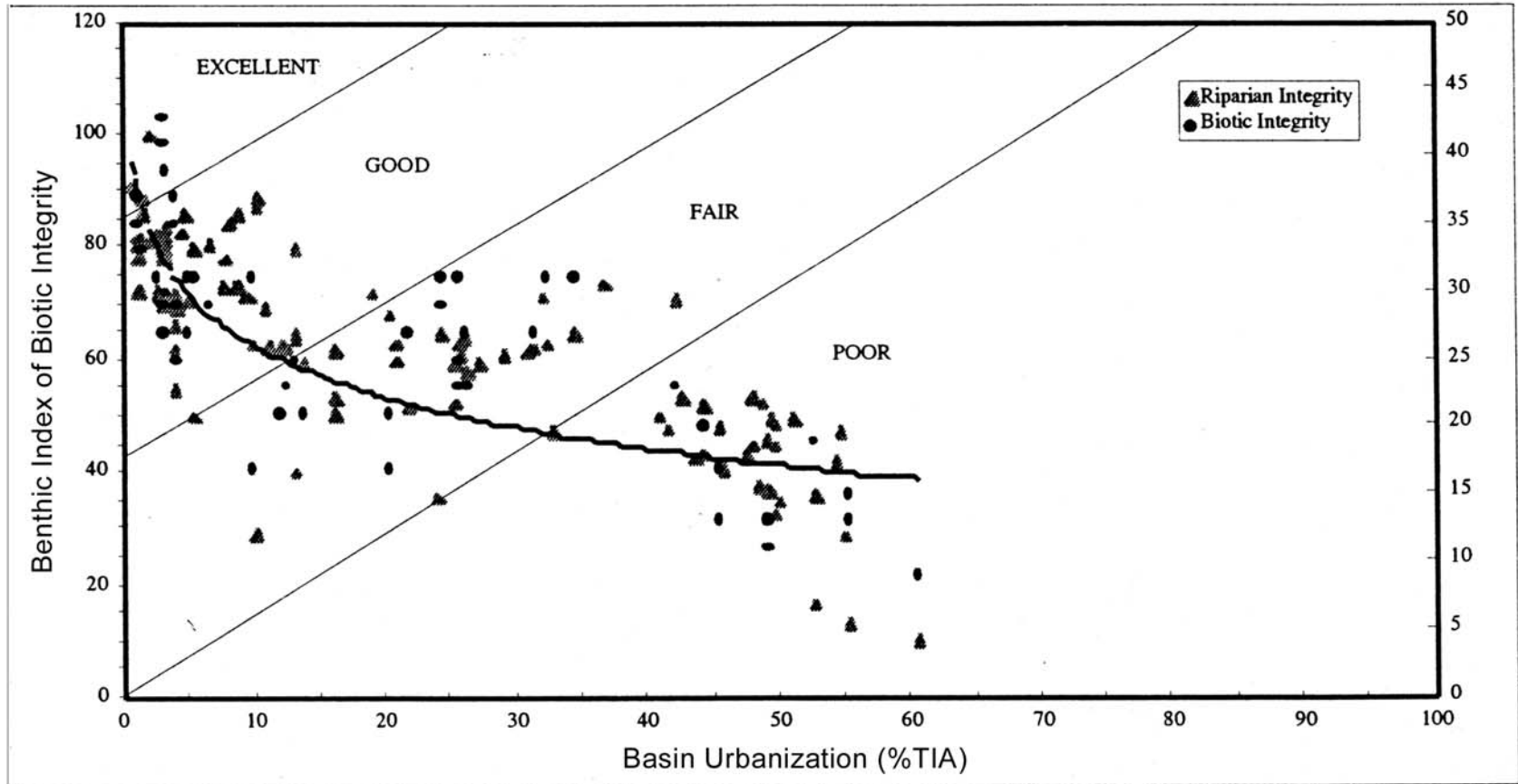
# Typical Annual Water Budget

*Urbanized Land Cover*



From Chris May

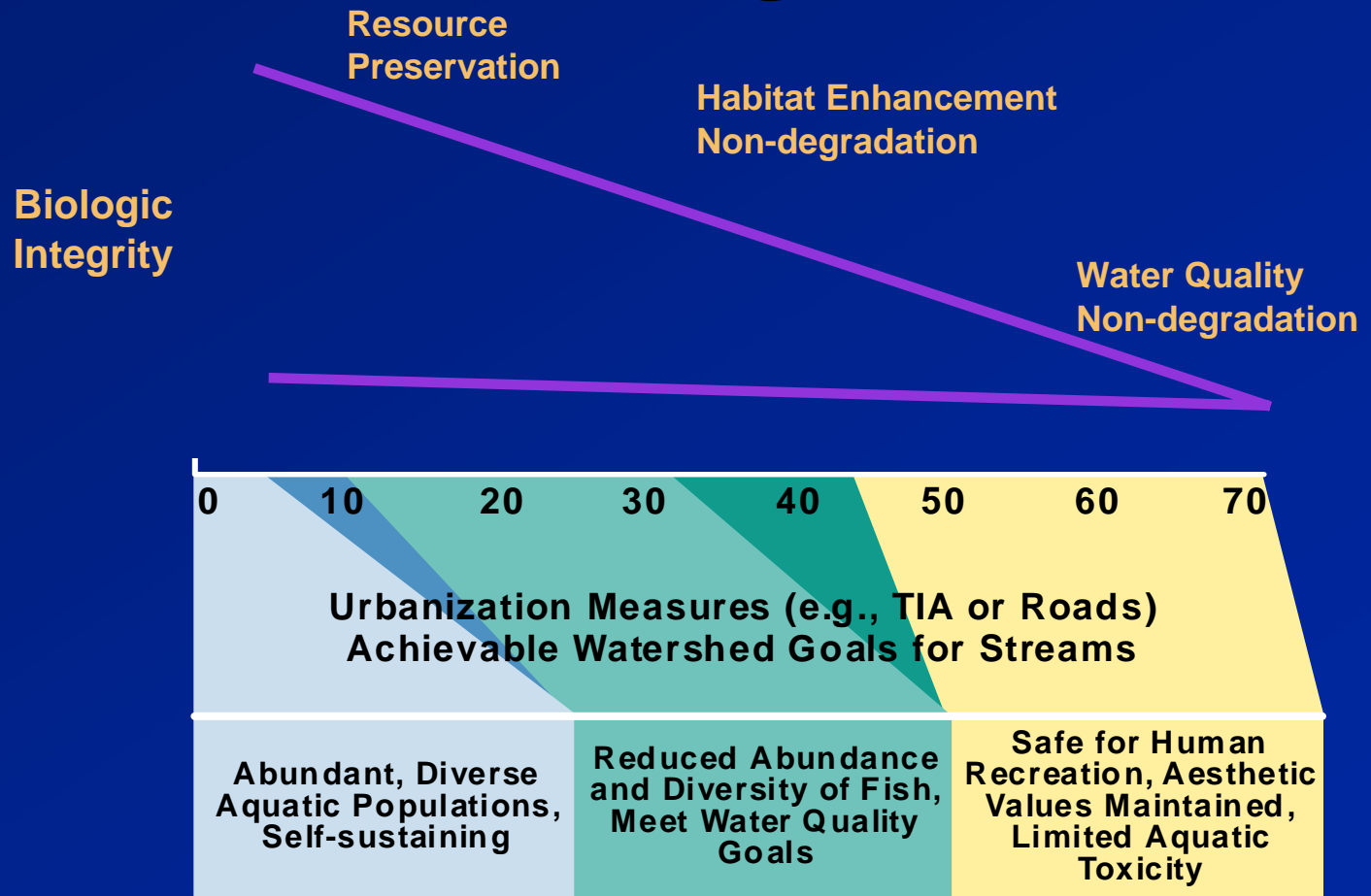
# B-IBI and Urbanization



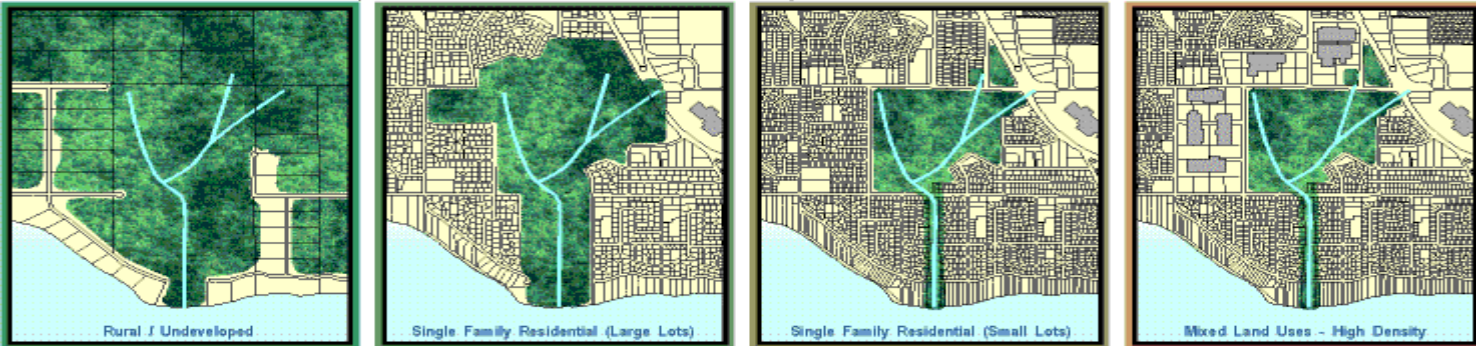
FiFigure 5-10

Source: Chris May, Jim Karr

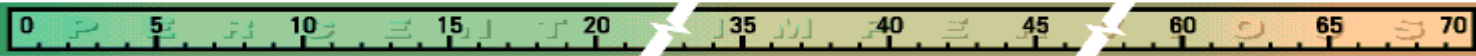
# Impacts of Urbanization on Streams: Implications for Management Goals



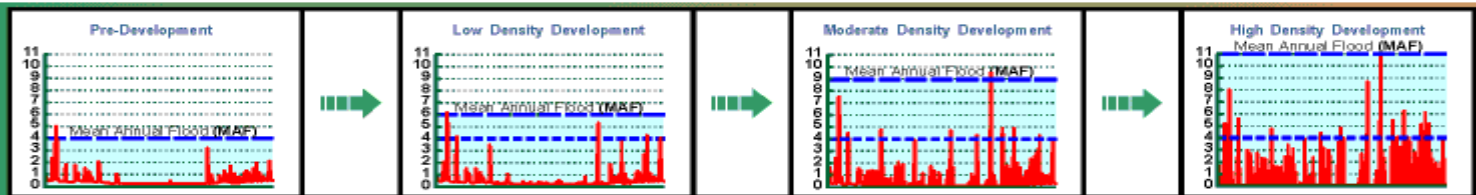
INCREASING URBANIZATION (NO BEST MANAGEMENT PRACTICES)



PROPORTION OF IMPERVIOUS LAND AREA (%)



EFFECT ON TYPICAL YEAR HYDROGRAPH



EFFECT ON WATERCOURSE EROSION



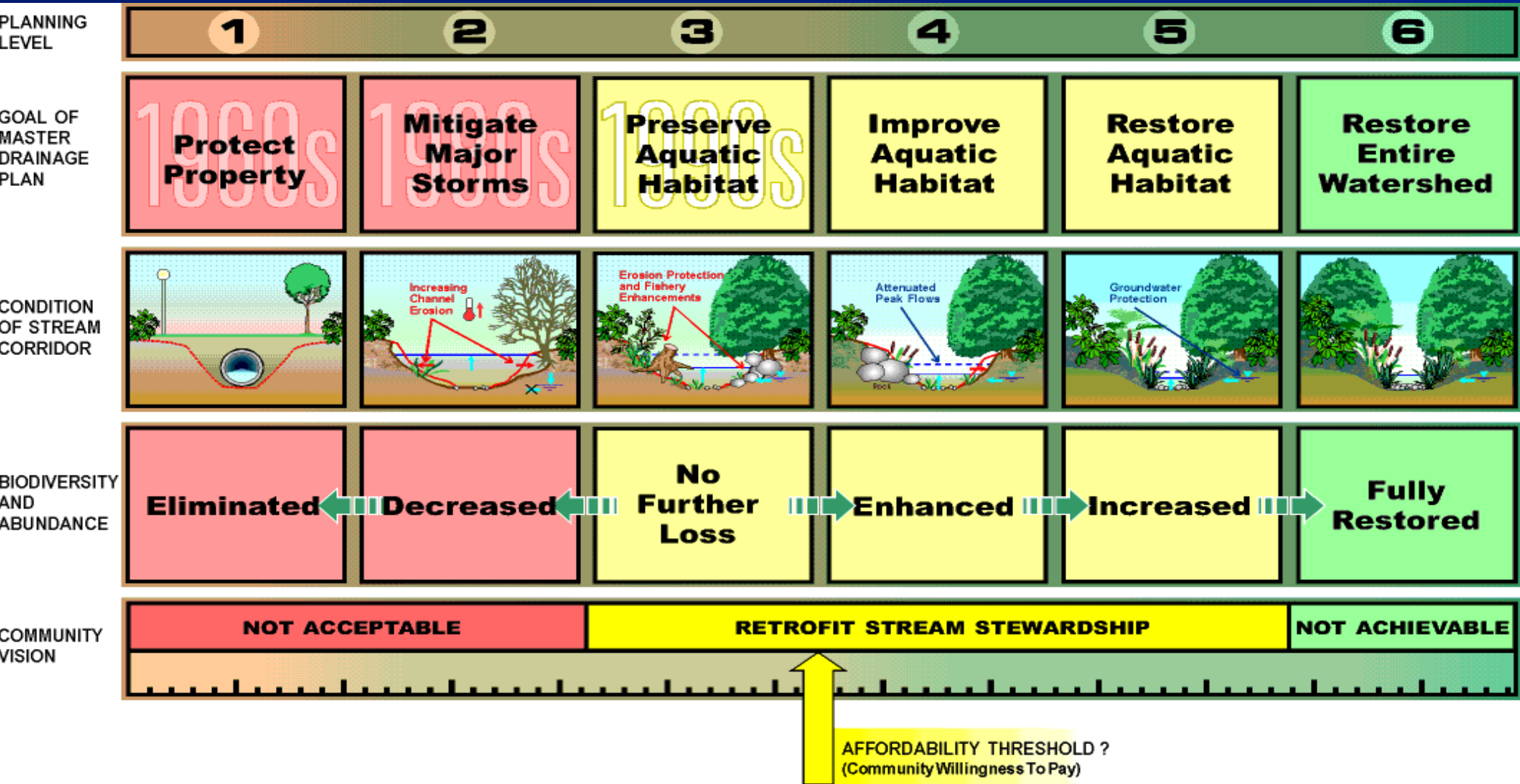
NUMBER OF STORM EVENTS AT OR ABOVE PREDEVELOPMENT MEAN ANNUAL FLOOD




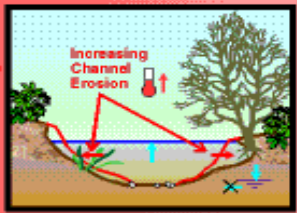

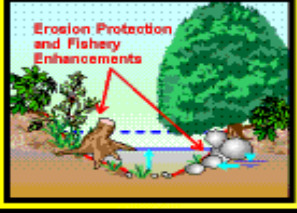


RATIO OF MEAN ANNUAL FLOOD TO WINTER BASE FLOW



Source: CH2M HILL



Source: CH2M HILL

Planning Level	Sustainability Continuum	Guiding Philosophy versus Resulting Condition of Stream Corridor	Key Management Objectives	Synopsis of Selected Management Strategies	Cost Implications
2	 <p><b>NO SALMON?</b> (eventually?)</p>	<p>PROTECT PROPERTY, MITIGATE MAJOR STORMS AND DEVELOPMENT IMPACTS</p> 	<ul style="list-style-type: none"> <li>▶ Provide storm drainage collection and removal.</li> <li>▶ Comply with Land Development Guidelines.</li> <li>▶ Size detention facilities for infrequently occurring storms.</li> <li>▶ Maintain and expand "Leave Strips" along creek banks.</li> <li>▶ Provide public information.</li> </ul>	<ul style="list-style-type: none"> <li>▶ <b>Purpose of Detention Facilities:</b> Maintain predevelopment runoff conditions.</li> <li>▶ <b>Purpose of Leave Strips:</b> Protect biodiversity and abundance.</li> </ul> <p><b>Caution:</b></p> <ul style="list-style-type: none"> <li>● Watersource erosion and sedimentation can be expected to continue because of the increased frequency of minor storm events.</li> <li>● Land-use changes outside the Leave Strips have environmental consequences within the creek corridor.</li> </ul>	<ul style="list-style-type: none"> <li>▶ Requires land purchases and construction of new ponds.</li> <li>▶ Require that developers dedicate expanded Leave Strips.</li> <li>▶ May eventually require comprehensive channel stabilization program.</li> </ul>
3	 <p><b>HATCHERY FISH</b> (and Some Wild fish)</p>	<p>PROTECT PROPERTY, MITIGATE FREQUENT STORMS, AND PRESERVE EXISTING AQUATIC HABITAT</p> 	<ul style="list-style-type: none"> <li>▶ Comply with "No-Net-Loss" requirements (habitat, water quality and quantity).</li> <li>▶ Expand and construct new detention facilities for frequently occurring storms.</li> <li>▶ Construct peak flow bypasses in sensitive areas.</li> <li>▶ Hold watershed impervious percentage at existing level.</li> <li>▶ Add public education.</li> </ul>	<ul style="list-style-type: none"> <li>▶ <b>Hydrotechnical Component of Stormwater Management Strategy:</b> Utilize the main stem for flood conveyance. Stabilize tributaries by reducing the frequency of threshold runoff events that trigger erosion.</li> <li>▶ <b>Environmental Component of Stormwater Management Strategy:</b> Utilize the downstream floodplain for habitat creation and other beneficial uses.</li> </ul>	<ul style="list-style-type: none"> <li>▶ The major cost item would be the Floodplain Habitat Creation Project.</li> <li>▶ Requires more land to construct larger ponds. (may also result in lost development opportunities).</li> <li>▶ Impervious area limitations result in higher on-site development costs.</li> </ul>
4	 <p><b>WILD FISH</b> (Self-Sustaining)</p>	<p>PROTECT PROPERTY, MITIGATE FREQUENT STORMS, AND IMPROVE AQUATIC HABITAT</p> 	<ul style="list-style-type: none"> <li>▶ Add sediment settling for pollutant removal.</li> <li>▶ Turn habitat problems into restoration opportunities.</li> <li>▶ Recharge groundwater and supplement baseflow.</li> <li>▶ Reduce the percentage of impervious area.</li> <li>▶ Construct large scale flow diversions.</li> <li>▶ Expand public education.</li> </ul>	<ul style="list-style-type: none"> <li>▶ Transfer peak flows from City Centre to the river and treat prior to discharge.</li> <li>▶ Ensure the land redevelopment strategy results in a high level of habitat and water quality protection.</li> <li>▶ Provide off-channel rearing at selected locations along the main stem.</li> <li>▶ Implement an Impervious Area Reduction Program selectively in conjunction with land redevelopment.</li> </ul>	<ul style="list-style-type: none"> <li>▶ The options for the City Centre are a tunneled diversion, a large scale regional detention facility, or major on-site facilities.</li> <li>▶ An Impervious Area Reduction Program would be a major and challenging undertaking.</li> <li>▶ Habitat-driven strategies would limit redevelopment opportunities.</li> </ul>

Source: CH2M HILL

# So What Are the Solutions?

- Put the forest back

Thank you. Any Questions?

idge Island

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Image © 2007 DigitalGlobe

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Pointer 47°47'17.80" N 122°00'14.56" W elev 49 ft

Streaming 100%

Eye alt 44.18 m



# So What Are the Solutions?

- 1. Discuss population and immigration**
- 2. Manage land use better**
  - Address at 3 scales (watershed, community, site)
  - No expansion of UGA
- 3. Protect and restore habitat**
  - Protect the best (forested) watersheds
  - No net loss of forest cover
  - Mandatory restoration of forest
  - Preserve and restore buffers
- 4. Change new development practices**
  - Zero discharge
  - Channel into existing urban areas



# So What Are the Solutions?

- 5. Mandatory retrofit of developed areas**
- 6. Prohibit toxics in consumer products**
- 7. Limit Roads**
  - No extension or expansion of road capacity for SOVs in urban areas
  - Require pervious pavement
  - Reduce width for residential streets
- 8. Independent assessment of restoration and progress toward restoring fishable, swimmable in each jurisdiction**
- 9. Fund regional monitoring**
- 10. Send money**

# Solution 1. Discuss population and immigration

- Population growth is unrestrained and will continue
- US birth rate near replacement level
- Economic growth is not dependent on population growth

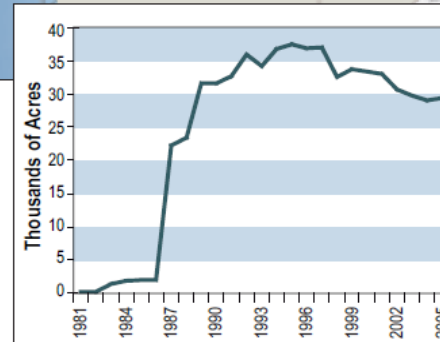
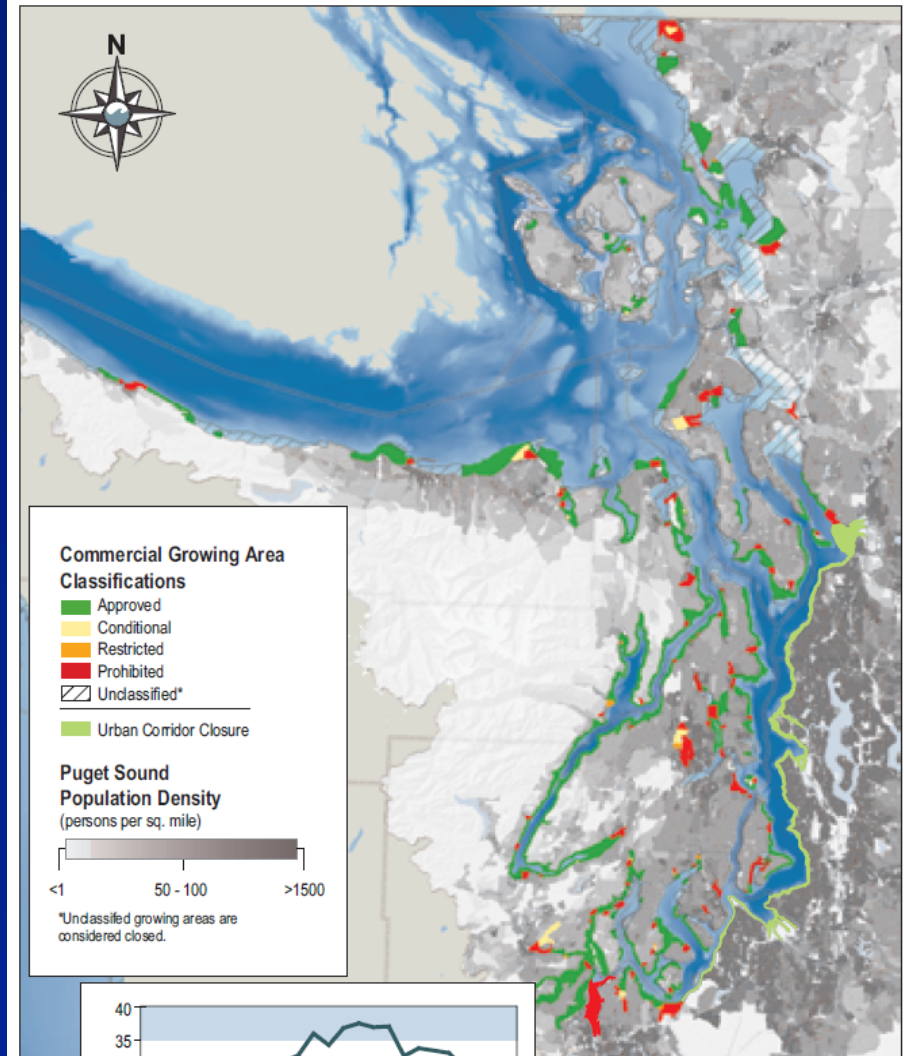


Figure 5-27. Population density and shellfish classification in Puget Sound and surrounding watersheds. Areas of Puget Sound with the lowest population densities tend to have the highest classified shellfish growing areas. (Source: PSAT)



# **Solution 2. Manage land use better**

- **Must Approach Solutions at 3 Scales**
  - Watershed: protect the best
  - Community: increase densities, livable, sustainable, retain trees
  - Site: infiltrate, retain trees
- **No expansion of UGA**

# Watershed Scale

Where is the best  
habitat?

Where do we  
channel growth?





# Watershed Scale

- **First, protect the best**
  - **Where are best resources?**
  - **What is needed to protect them?**
    - **regulations?**
    - **purchase?**
    - **funding**
    - **governance?**
- **Channel growth away from best habitat**
  - **inside UGA**
  - **limit road extensions**

An aerial photograph of a suburban community. The image shows a dense residential area with a grid-like street pattern. A major highway interchange is visible in the lower right quadrant. There are several green spaces, including a large park area in the center and a golf course in the upper left. The overall scene is a mix of built-up areas and natural greenery.

# Community Scale

Walkable?

Sustainable?

Livable?

# **Community Scale: Inside Urban Growth Boundary**



- **Accommodate higher densities (11/acre)**
  - **livable communities**
  - **sustainable communities**
  - **3,500 sq. ft. lots**
- **Reduce dependency on automobiles**
  - **walkable communities**
  - **transit oriented**

# Transit Oriented Development

- **All Residences within 5 minute walk of Transit and Shops**
  - **need higher densities to support transit**
- **Reduce auto dependency “carchitecture”**
  - **current design standard is 100 year party**
  - **65% of urban TIA is car habitat**
- **Mixed-use neighborhoods**



# Mixed Dwelling Types

- **Mother-in-law apartments**
- **Different family types and incomes**
- **Retain single-family look and feel**



# Lighter, Greener, Cheaper, Smarter Infrastructure



- **Curbs are evil**
- **No pipes, keep it on the surface**
- **Use open space for surface water treatment, storage, infiltration**
- **Reduce Costs**
  - roads**
  - detention**
  - utilities**
  - maintenance**

# Site Scale

- Reduce TIA
- Infiltrate
- Rooftop gardens
- No curbs, no pipes, keep it on the surface



# What is LID?

## Put it in the ground or re-use it

### GROUNDWATER RECHARGE FACILITY

In-situ soils should have a high infiltration rate (at least 1"/hr).  
Soil filter depth should be at least 2.5'.

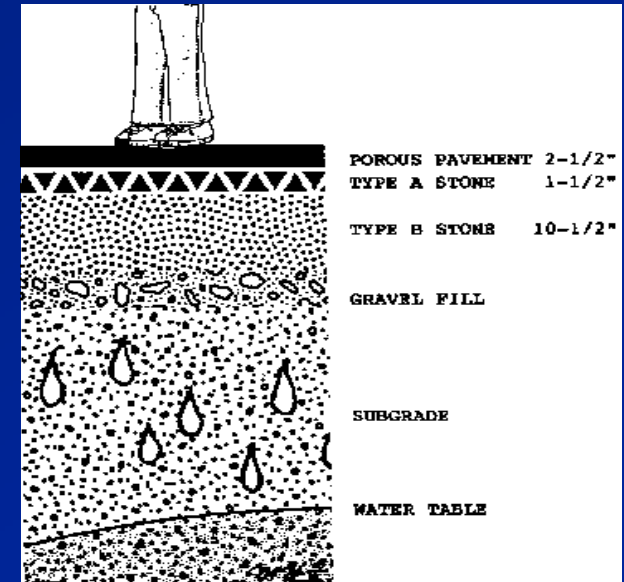
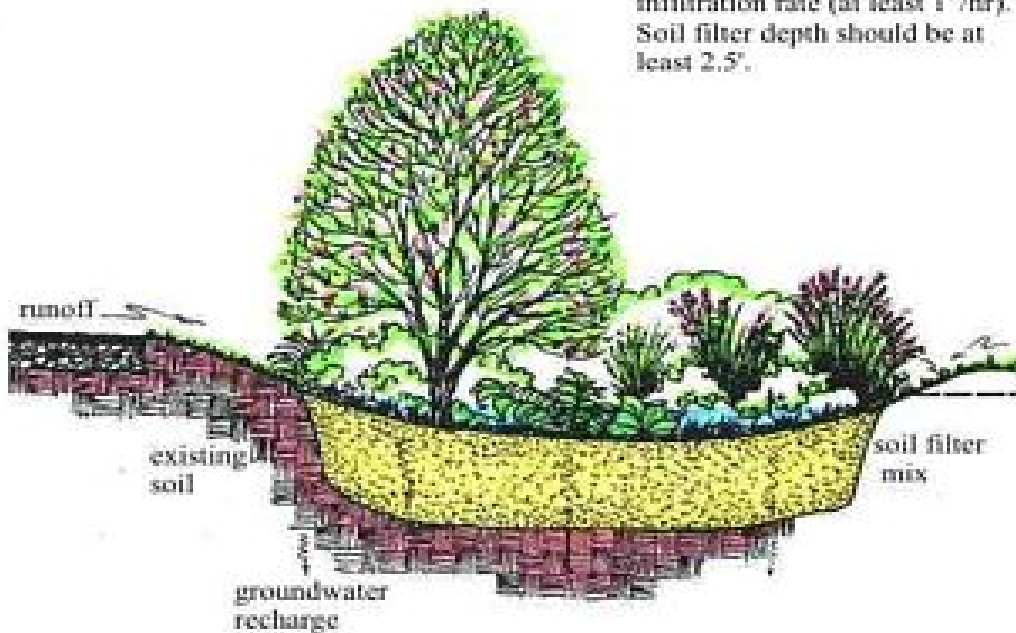


Figure 3.1 – Pervious Pavement Section, NRDC

# Low Impact Development BMPs

- **Bioretention/Bioswales**
- **Green Roofs**
- **Rain Harvesting**
- **Permeable Pavers**
- **Imperviousness Minimization**
- **Infiltration Devices**
- **Hydrodynamic Devices**

Bioswales



Green Roofs



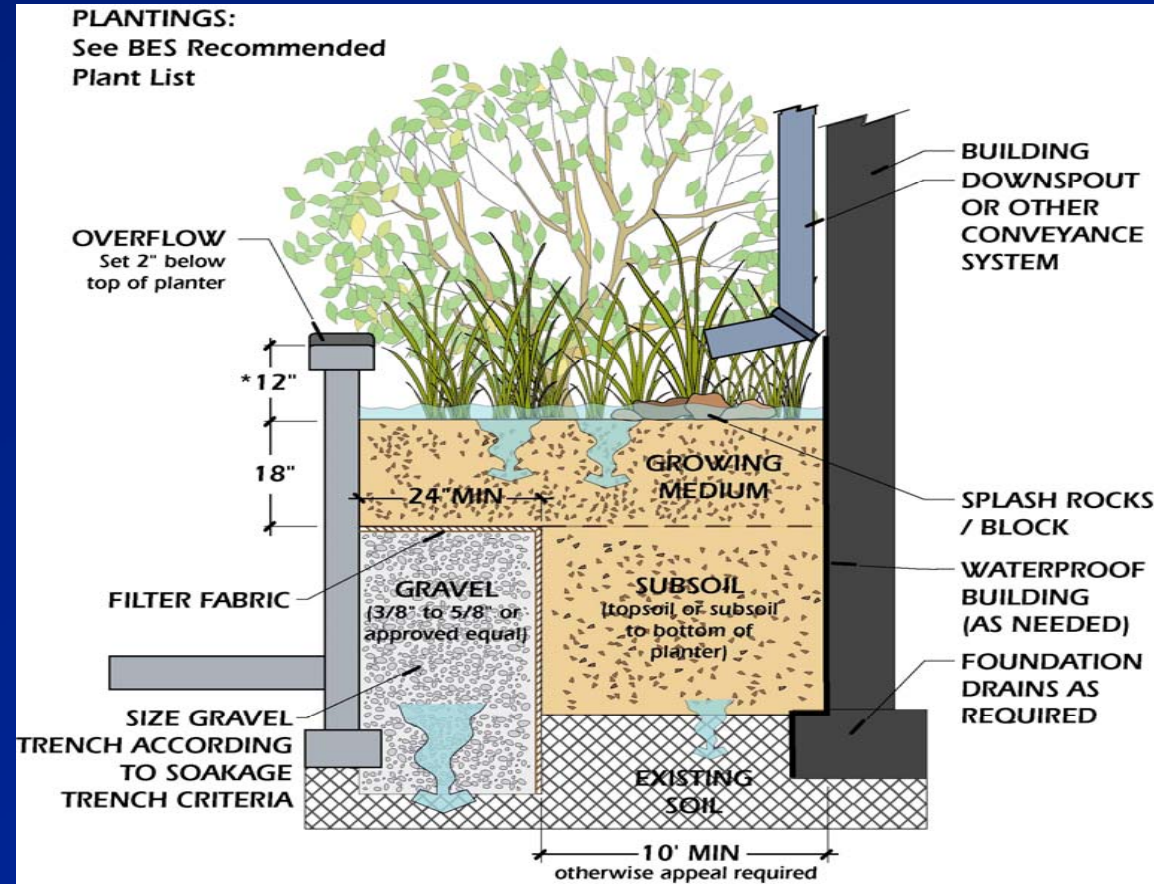
Permeable Pavers



Bioretention

# Site Scale - Residential

- Cisterns
- Redirecting Downspouts
- Collect and re-use



\*Water reservoir depth may be reduced if planter surface area is increased.

## Infiltration Planter



## **Solution 3. Protect and restore habitat**

- **Protect the best (forested) watersheds**
- **No net loss of forest cover**
- **Restore forest**
- **Preserve and restore buffers**



# **Example: Olympia Aquatic Habitat Evaluation and Management Report**

- **Applied research to Olympia creeks and wetlands**
- **Develops feasible management goals**
- **Prioritizes highest value aquatic habitat**
- **Identifies science based management tools**

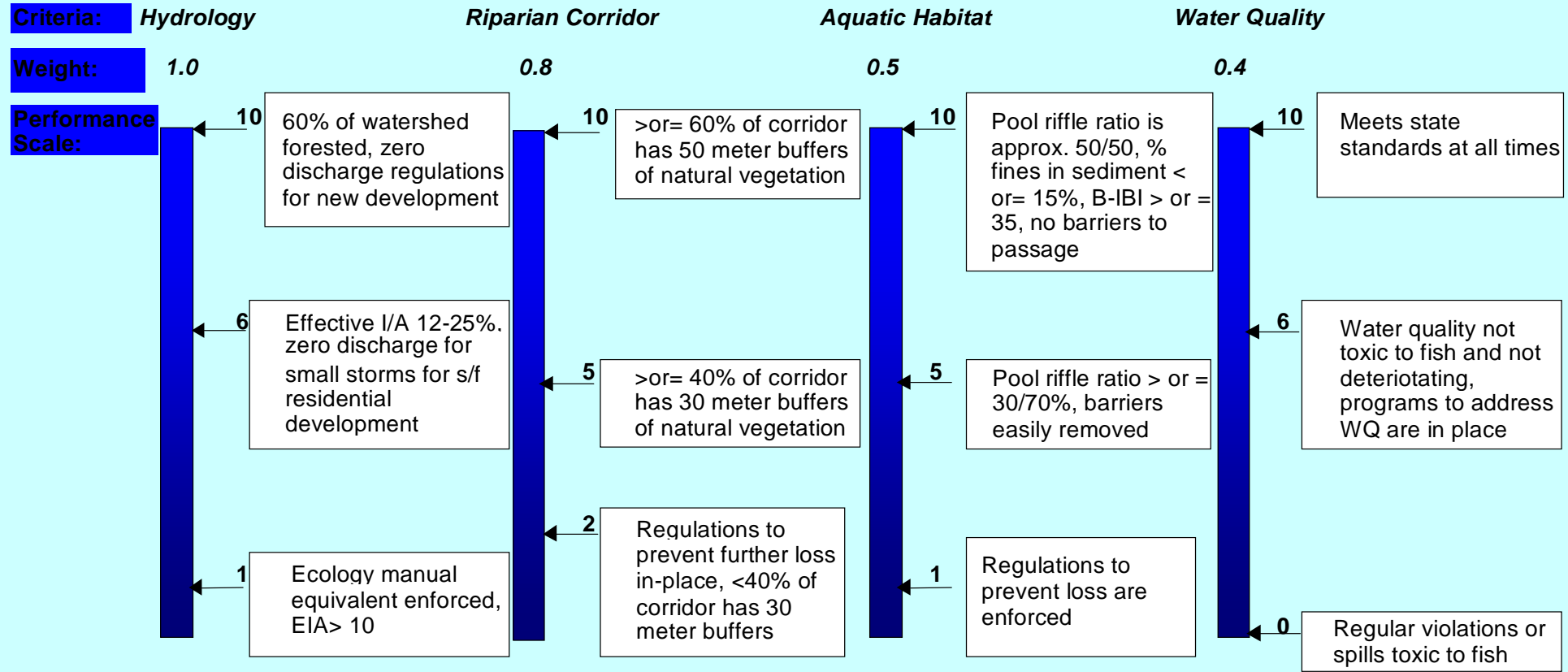


# Sustainable Olympia?

- **Ranked Watersheds**
- **Purpose: Id. Achievable Goals**
- **Different Standards for individual watersheds**
  - **Cat. 1: Zero EIA, transfer development densities**
  - **Cat. 2: Maintain existing regs. Increase densities**













# Olympia Streams Rating and Weighting Criteria



# Olympia Ranking of Watersheds

How well the existing watershed conditions meet the four criteria

Decision: Rank Watersheds		
Watersheds	Value	Decision Scores
Green Cove Creek	0.89	
Percival Creek	0.71	
Ellis Creek	0.51	
Woodard Creek	0.44	
Chambers/Ward/Hewitt	0.34	
Mission Creek	0.33	
Schneider Creek	0.27	
Indian/Moxlie Creeks	0.16	
East Bay/West Bay	0.16	
Capitol Lake	0.10	



# **Mandatory Restoration of Forest and Riparian Corridors**

- **Restore forest 2%/ year required of counties?**
- **Determine appropriate mandatory tree cover for cities**
- **Restore riparian buffers 2%/year cities and counties?**
- **Allow Transfer of Development Rights for private developers**



# **Solution 4. New Development: Consistent Regional Regulations**

- **Zero discharge**
- **Outside UGA:**
  - **limit TIA to 10%**
  - **retain 65% forest cover**
  - **clustering, relax height limits**
- **Narrow residential streets, eliminate curbs**
- **No net loss of forest**
- **No net loss of riparian or shoreline buffers**



## **Solution 4. New development: Consistent Regional Regulations (cont.)**

- **Urban areas: higher densities**
  - **maximum rather than minimum lot sizes**
  - **sustainable development, livable communities concepts**
- **Require treatment**
- **Require infiltration**
  - **100% up to 2 year storm**
  - **consider down-gradient slope stability**

# Solution 5. Mandatory stormwater retrofit for treatment and flow control



- 5%/year would take 20 years – that's beyond the 2020 goal for Puget Sound

# King County Concept to Retrofit Seattle Center



Source: Seattle PI, October, 2007

# SEA Streets Retrofit Example



SEA Streets - After Construction  
2nd Ave NW - NW 117th St to NW 120th St

- 60' row
- 40' infiltration
- flat
- soils amended <6'
- homeowner maintenance
- City project, high cost
- no utility conflicts
- >\$600,000/block



# Venema Creek Catchment Proposed Natural Drainage System Layout



## LEGEND

- Project Boundary
- One-Layer Bioretention Swale
- Two-Layer Bioretention Swale
- Two-Layer Bioretention Swale with Weir
- Driveway or Walkway with Traditional Pipe
- Driveway, Walkway, or Roadway with Buried Infiltration
- Flow Splitter
- Sidewalk
- Ditch

Scale: 1" = 40'

# Mandatory Retrofit



# Solution 6. Prohibit toxics in consumer products

- Phthalates
- Dissolved
  - Copper
  - Zinc
  - Phosphorous
- Plastic packaging, brake linings, tires, galvanizing, detergents, fertilizers, oil, pipes, roofs
- **Even our best technologies can't remove these well...**



Contech Stormfilter

# **Solution 7. Limit Roads**



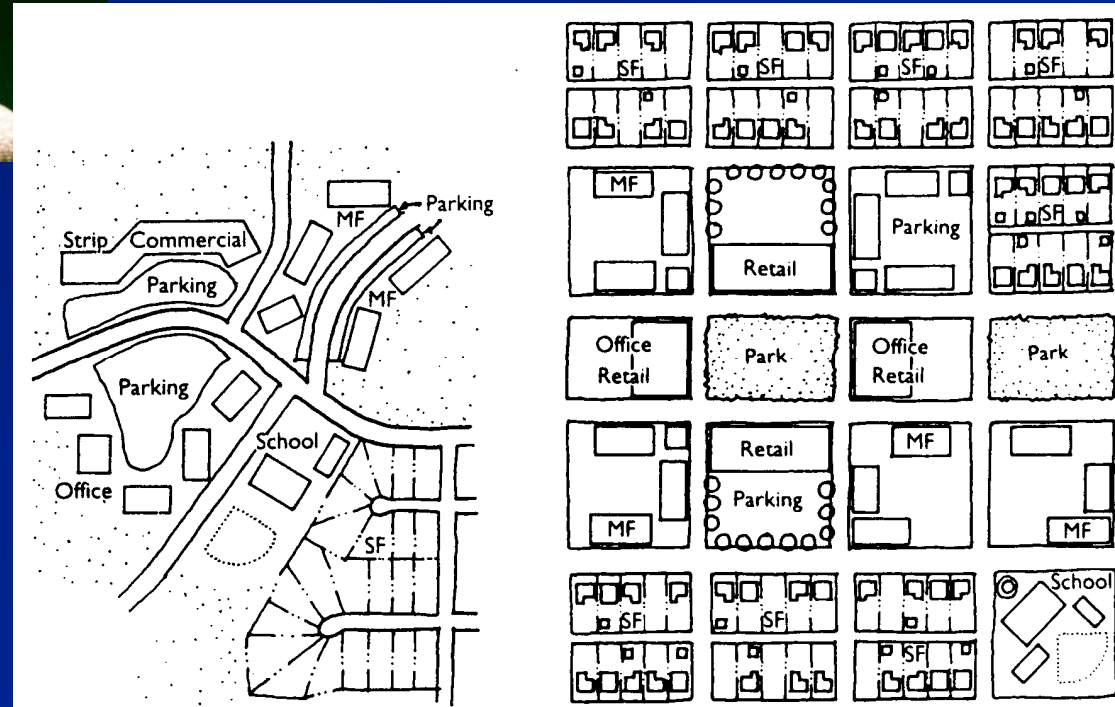
- **Limit Road Extensions**
- **Require full mitigation of all direct and indirect impacts including growth, transportation, air pollution, fish habitat, energy**
- **Serve existing needs only**
- **Require pervious pavement**
- **Reduce width**



# Solution 7. Limit Roads

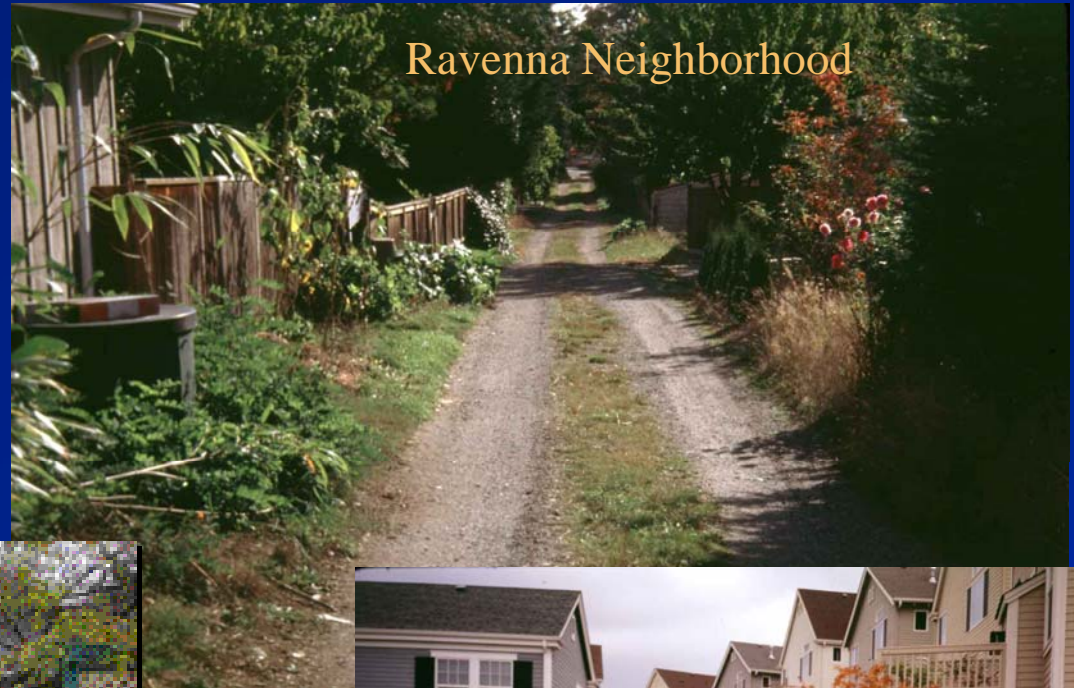
## Grid System for Streets

- Narrow Streets
- Reduced speeds, reduce congestion
- Easy fire access
- Walkable



# Car Storage and Services in Alley

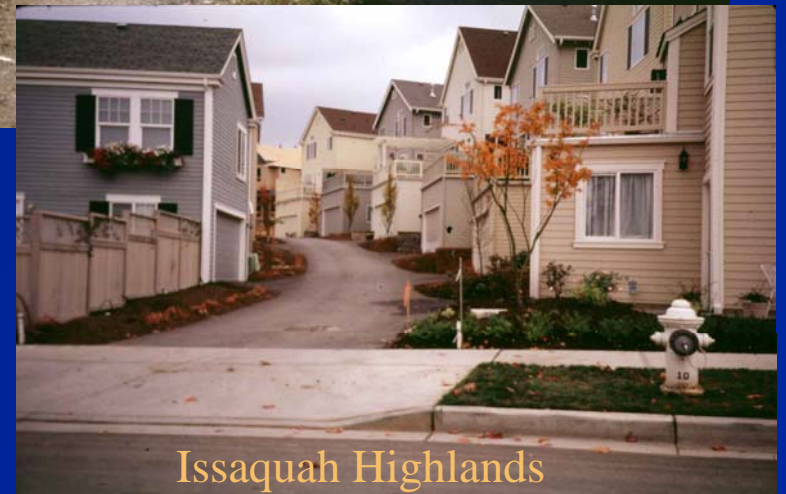
- Prohibit on street parking
- More pleasant street, porches, trees
- Private back yards



Ravenna Neighborhood



Vancouver BC Retrofit



Issaquah Highlands



**Solution 8. Independent assessment  
of restoration and progress  
toward restoring fishable,  
swimmable in each jurisdiction**

**Solution 9. Fund regional monitoring**

**Solution 10. Send money**



# SMURRF Today

- Treatment Plant
- **Capital Cost - \$6.2 Million**
- Reuse Distribution System
- **Initial System Capital Cost - \$2.5 Million**

# Thank You

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