Stormwater Retrofit Analysis and Recommendations for Juanita Creek Basin

King County Science Seminar
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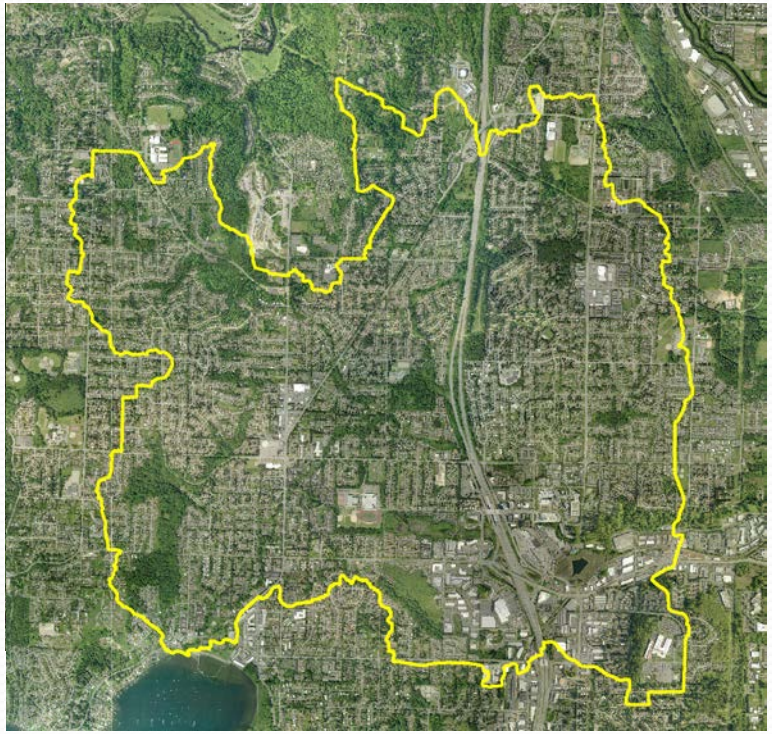
Partners/Team Members



King County

- Curt Crawford, Cheer leading P.I.
- Mark Wilgus, Puppet Master/Editor
- Jeff Burkey, Modeling Maestro
- Hans Berge, Stream Recon, ~~EPT~~
- David Batts, BMP Designs
- Dale Nelson, Pond Designs

Ecology

- Anne Dettelbach, Partner w/$
- Ed O'Brien, Partner

City of Kirkland

- Jenny Gaus, Partner, Stormwater mapping

Washington State DOT

- Bill Jordan, Networking Partner

Northwest Hydraulics Consultants

- David Hartley, Geomorphology, hydraulics, peer review

Stillwater Sciences/Cambria Sciences

- Derek Booth, Geomorphology, peer review

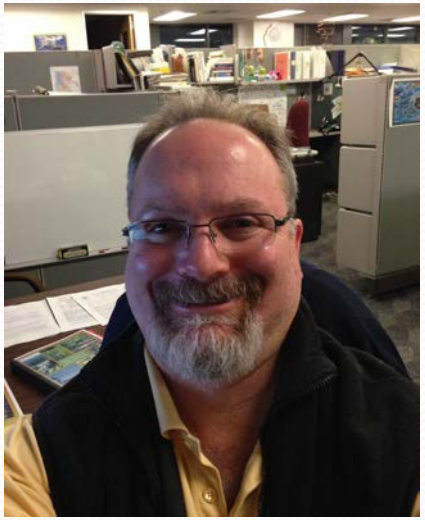
The Question

How much stormwater management is required to restore Juanita Creek to Beneficial Uses?

Begets one more Question

But how does one quantify Beneficial Uses in a way that encompasses complex environmental conditions?

We model it!



Framework of Study

- Define quantifiable metrics using *multiple lines of evidence* approach:
  - hydrology
  - biology
  - geomorphology
  - water quality
- Define Targets (Biology, WQ, Geomorphology)
- Define Scenarios (*evolutionary* process)
  - 7 mitigation scenarios (LEVEL2,LVL2WET,LID40,LID40+,LID80, ECY08,CISTERN)
  - Using Green and Gray
- Evaluate cost effectiveness of scenarios

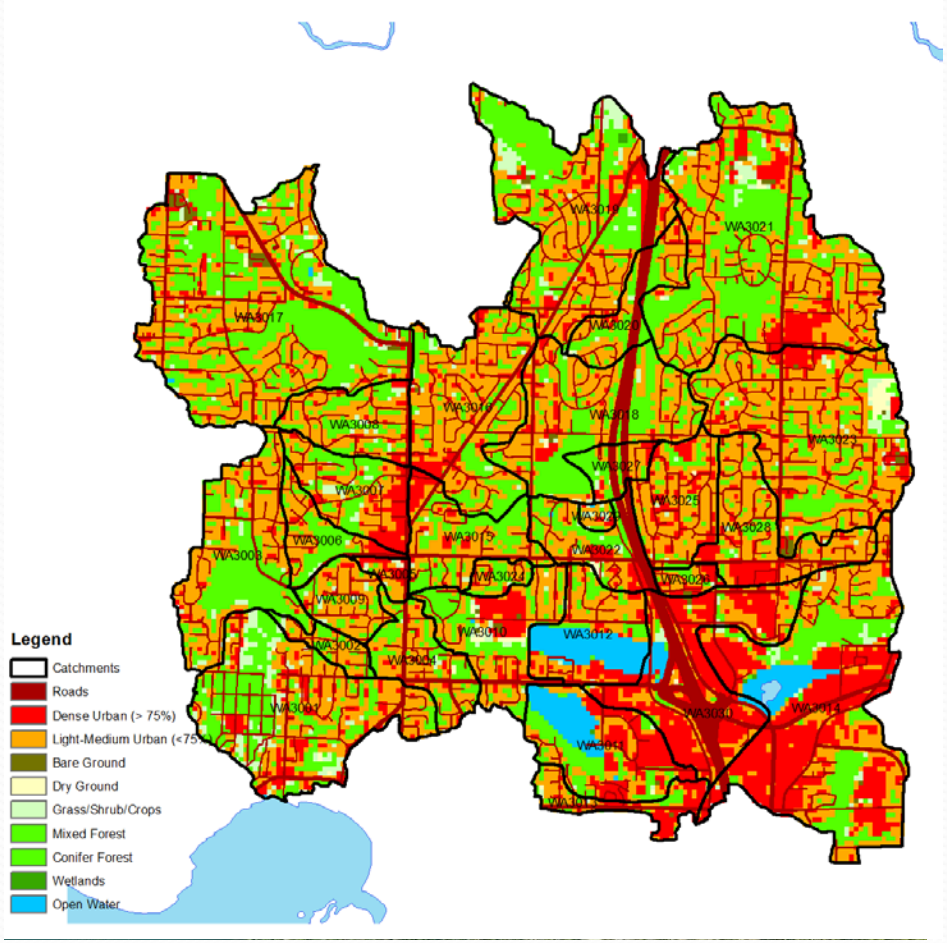
So we can:

- Provide basis for developing new guidelines better informed on resources needed restoring habitat to beneficial uses in highly urbanized areas…*we hope!*

Defining Targets

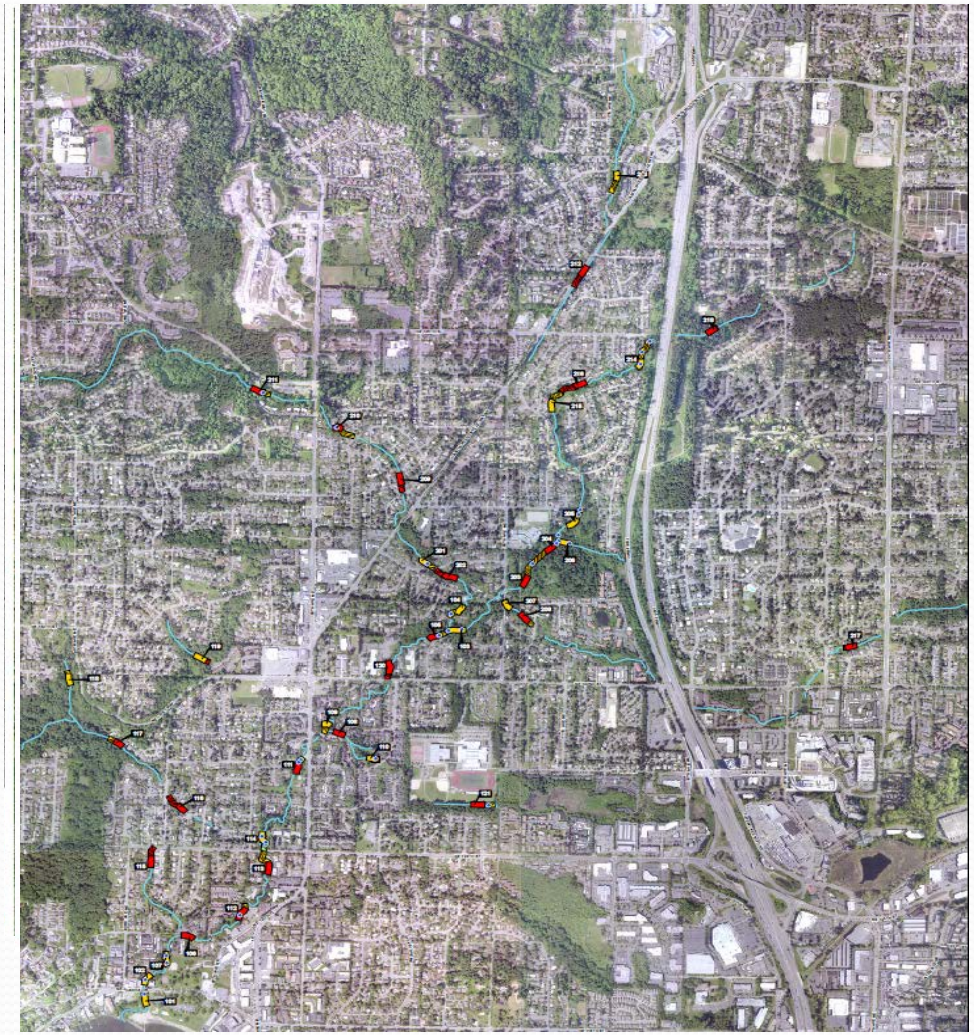
- BIBI
  - 35 (Karr et al., 2003)-minimum for salmonid viability
  - Relative to benchmark values
    - Fully forested, 65/10_{TIA}, and 1977 land use
- Water Quality
  - WAC173-201A
  - Annual loadings compared to benchmark values
- Gravel Disturbances
  - 1-3 per year (Doyle et al., 2000)

Juanita Creek Characterization



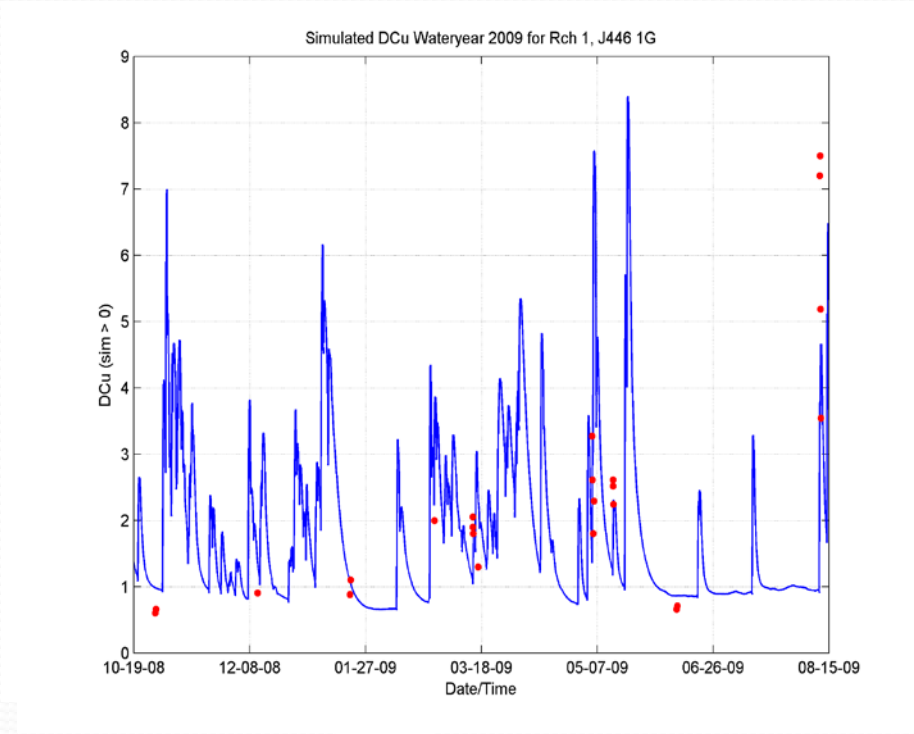
- 6.8 square miles
- 16 miles of stream
- 30 catchments
- 65% developed (2002)

Field Monitoring



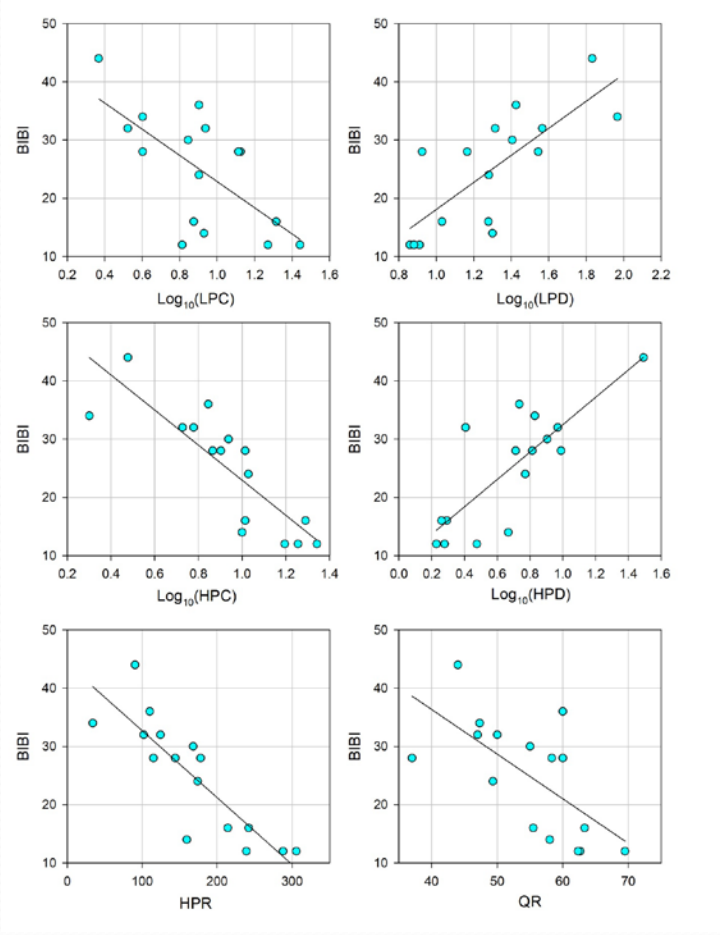
- Fully mapped stormwater network
- 8 water quality monitoring stations
- 6 continuous recording stream flow stations
- 7 storms 3 base sampling events
- 7 ~ 8 BIBI monitoring locations
- Channel substrate, slope, LWD, bank stability

What was modeled & Model Accuracy



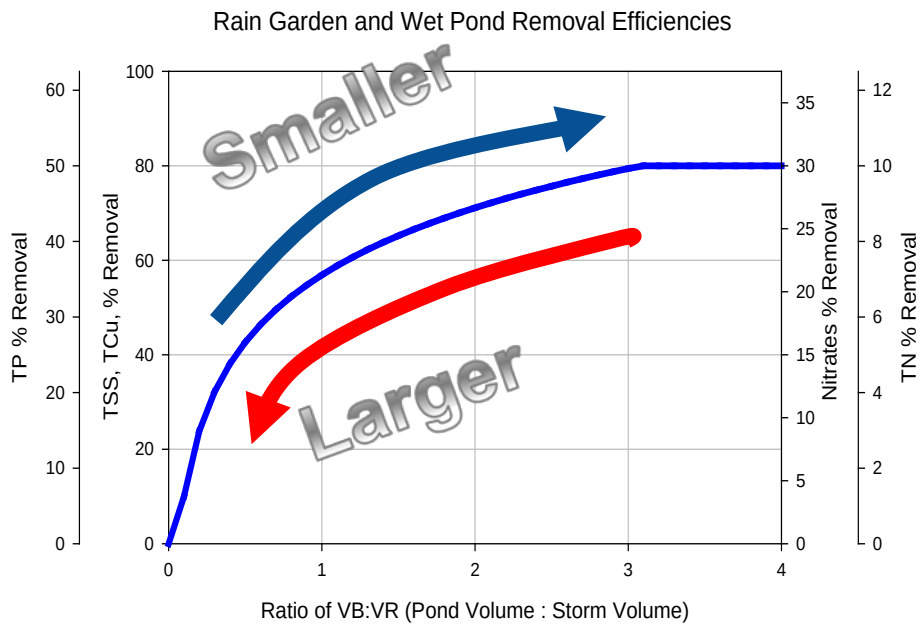
- Mean Daily
- Maximum Daily
- 15-min
- Suite of statistics
- Water Temperature
- TSS
- DO
- Fecals
- Total Copper
- Dissolved Copper
- Nutrients
  - -44%(NH3)
  - -10%(NN)
  - -8%(PO4)

Flashiness and BIBI



- Established Regressions correlating Flashiness Metrics to BIBI
- BIBI
  - Obs_{avg} ~ 14.4,
  - Sim_{avg} ~ 17,
  - RPD 18%
  - in same category

BMP/Facility Removal Efficacies



- Efficiency of treatment on outflows depends on the size of the pond relative to the storm

  Larger storms → less effective

- Infiltration is assumed to be 100-percent effective in treatment (nitrates pass through system)

Simulated BIBI scores

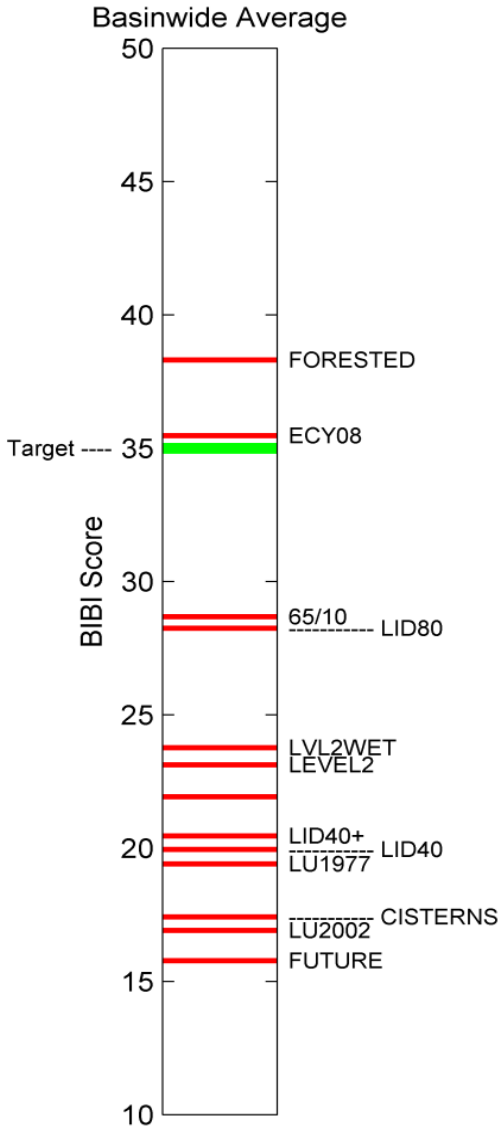
Catchment	FORESTED	65/10	LU1977	LU2002	FUTURE	LEVEL2	LID40	ECY08	LID40+	LID80	LVL2WET	CISTERNS
WA3001	39.8	30.6	21.1	18.7	17.1	24.2	21.4	36.2	22.1	29.7	24.6	18.7
WA3002	31.3	23.2	16.0	14.4	13.6	19.1	18.1	31.8	18.1	26.0	20.0	15.2
WA3003	31.4	24.2	16.6	14.7	13.7	19.8	18.0	35.0	18.0	26.1	20.1	15.4
WA3004	40.2	30.6	21.0	18.8	17.0	24.2	21.4	36.7	22.4	29.6	24.9	18.9
WA3005	35.4	25.6	14.9	14.1	13.6	19.4	18.3	30.2	18.3	26.3	20.4	15.2
WA3006	37.2	28.1	16.1	15.7	14.9	21.9	18.6	29.3	18.6	26.9	22.7	15.6
WA3007	34.7	24.3	14.6	13.8	13.6	18.3	18.4	30.6	18.4	26.6	19.2	15.2
WA3008	32.3	21.6	13.6	13.1	12.9	16.0	18.0	26.6	18.0	26.6	17.2	15.6
WA3009	38.0	28.4	17.1	15.2	14.7	18.3	19.1	29.6	19.1	27.2	19.9	15.6
WA3010	40.3	35.2	29.0	24.1	22.2	29.4	26.4	39.8	26.4	34.6	29.8	23.7
WA3011	40.3	29.7	26.8	15.7	14.6	23.1	18.4	35.2	18.4	27.8	23.7	16.2
WA3012	40.1	36.2	29.4	24.8	23.3	30.4	27.4	41.7	27.4	35.6	30.6	24.8
WA3013	39.4	30.6	19.1	15.9	15.4	26.3	19.6	36.9	19.6	28.3	27.2	17.0
WA3014	41.1	31.4	22.6	16.8	15.8	25.8	20.0	41.0	20.0	28.7	25.9	18.1
WA3015	40.3	29.6	19.1	17.0	15.8	22.9	19.4	36.1	20.9	28.3	23.3	17.2
WA3016	39.0	26.2	19.0	16.2	15.4	19.7	19.9	35.7	21.4	29.1	20.4	18.1
WA3017	40.6	27.8	21.1	16.3	15.4	20.8	19.1	38.9	21.0	28.2	21.2	17.2
WA3018	40.3	29.9	18.3	17.4	15.9	23.0	19.4	35.1	21.7	28.2	23.4	17.2
WA3019	38.8	29.2	18.9	16.6	15.0	22.6	19.6	32.7	19.6	27.6	22.9	16.0
WA3020	41.1	30.7	18.9	18.6	16.2	24.3	20.0	39.1	23.0	29.3	24.4	18.3
WA3021	41.0	30.8	19.3	18.9	16.3	24.4	20.4	40.8	23.8	29.7	24.7	18.7
WA3022	38.7	28.1	17.3	15.7	15.1	23.9	19.7	37.0	19.7	27.6	24.3	16.6
WA3023	40.4	27.7	17.1	15.9	15.3	24.0	19.3	40.4	19.3	27.4	24.7	16.4
WA3024	41.4	30.1	17.6	18.3	14.9	22.2	18.8	31.3	18.8	26.6	24.0	18.0
WA3025	40.2	27.4	16.3	15.2	14.8	24.0	19.1	36.3	19.1	27.2	24.7	16.1
WA3026	39.8	29.1	18.6	16.6	15.9	24.8	20.1	40.3	20.1	28.1	25.1	17.2
WA3027	35.3	26.3	14.4	14.1	12.4	22.7	16.3	26.4	16.3	24.7	22.9	12.8
WA3028	39.9	29.2	18.7	16.6	16.0	24.8	20.4	40.9	20.4	28.4	25.0	17.4
WA3029	30.0	27.3	29.8	21.9	21.2	27.6	24.0	31.1	24.0	28.8	29.6	23.4
WA3030	40.8	31.0	19.8	16.1	15.2	25.6	19.6	41.1	19.6	28.1	25.9	16.7
Average	38.3	28.7	19.4	16.9	15.8	23.1	20.0	35.5	20.5	28.2	23.8	17.4

Category	Very poor	10-17	Poor	18-27	Fair	28-37	Good	38-45	Excellent	46-50

Catchment	FORESTED	65/10	LU1977	LU2002	FUTURE	LEVEL2	LID40	ECY08	LID40+	LID80	LVL2WET	CISTERNS
WA3027	35.3	26.3	14.4	14.1	12.4	22.7	16.3	26.4	16.3	24.7	22.9	12.8
WA3028	39.9	29.2	18.7	16.6	16.0	24.8	20.4	40.9	20.4	28.4	25.0	17.4
WA3029	30.0	27.3	29.8	21.9	21.2	27.6	24.0	31.1	24.0	28.8	29.6	23.4
WA3030	40.8	31.0	19.8	16.1	15.2	25.6	19.6	41.1	19.6	28.1	25.9	16.7
Average	38.3	28.7	19.4	16.9	15.8	23.1	20.0	35.5	20.5	28.2	23.8	17.4

Category	Very poor	10-17	Poor	18-27	Fair	28-37	Good	38-45	Excellent	46-50

Basinwide Avg. BIBI Score



Arithmetic mean of predicted BIBI for all 9 flashiness metrics and all catchments

- Forested = 38
- Target = 35
- ECY08 = 36
- Next closest = 28
- KC Level 2 = 23

- Why is Forested only 38?
- Should predictions be scaled and how? 35/38?

Water Quality Targets

Parameter	Meet Forested Conditions Benchmark							
	LU2002	FUTURE	LID40	ECY08	LID40+	LID80	LVL2WET	CISTERN
Dissolved Copper	No	No	No*	Yes	No*	No*	No*	No
Water Temperature	No	No	No	Yes	Yes	Yes	No	Yes
Dissolved Oxygen	No	No	No	No	No	Yes	No	No
Fecal Coliforms	No	No	No	No	No	No	No	No

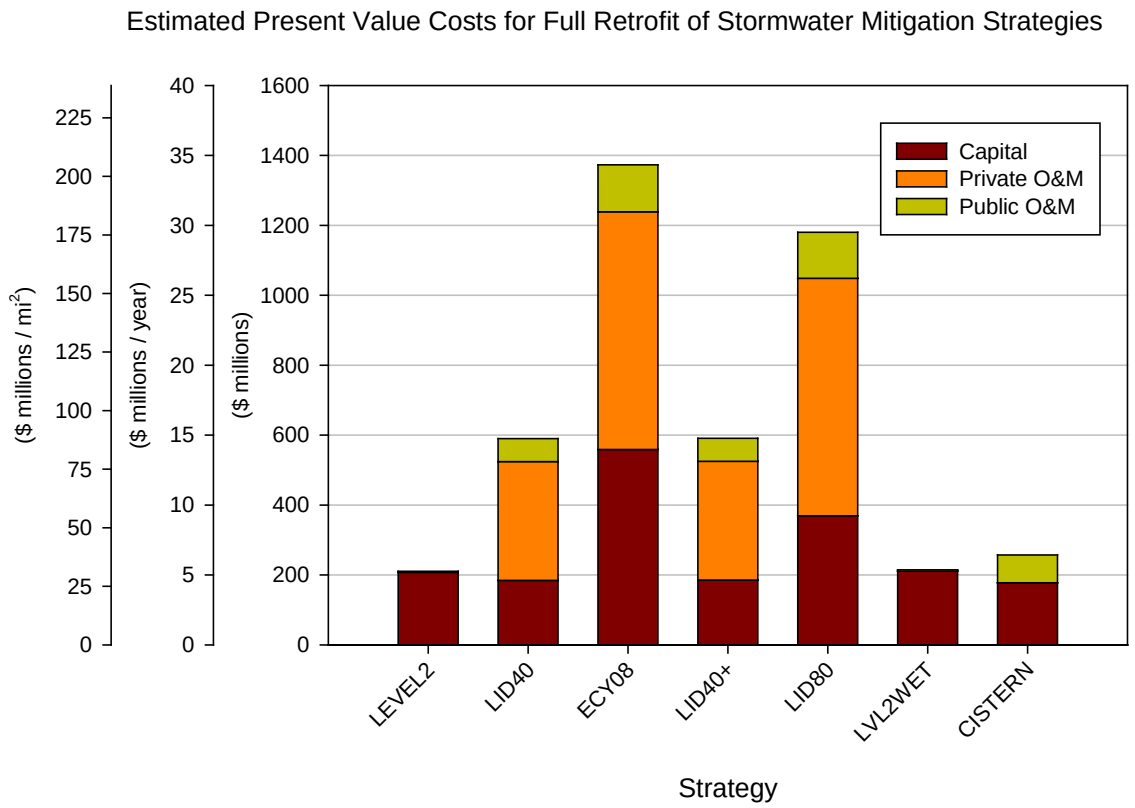
*Annual exceedances are significantly reduced from projected future conditions.

Parameter	Meets 65/10 Conditions Benchmark							
	LU2002	FUTURE	LID40	ECY08	LID40+	LID80	LVL2WET	CISTERN
Dissolved Copper	No	No	No*	Yes	No*	No*	No*	No
Water Temperature	No	No	No	Yes	Yes	Yes	No	Yes
Dissolved Oxygen	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Fecal Coliforms	No	No	No	No	No	No	No	No

*Annual exceedances are significantly reduced from projected future conditions.

Parameter	Meet 1977 Conditions Benchmark							
	LU2002	FUTURE	LID40	ECY08	LID40+	LID80	LVL2WET	CISTERN
Dissolved Copper	No	No	No*	Yes	No*	Yes	Yes	No
Water Temperature	No	No	Yes	Yes	Yes	Yes	No	Yes
Dissolved Oxygen	No	No	Yes	Yes	Yes	Yes	No	No
Fecal Coliforms	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

Scenario Costs

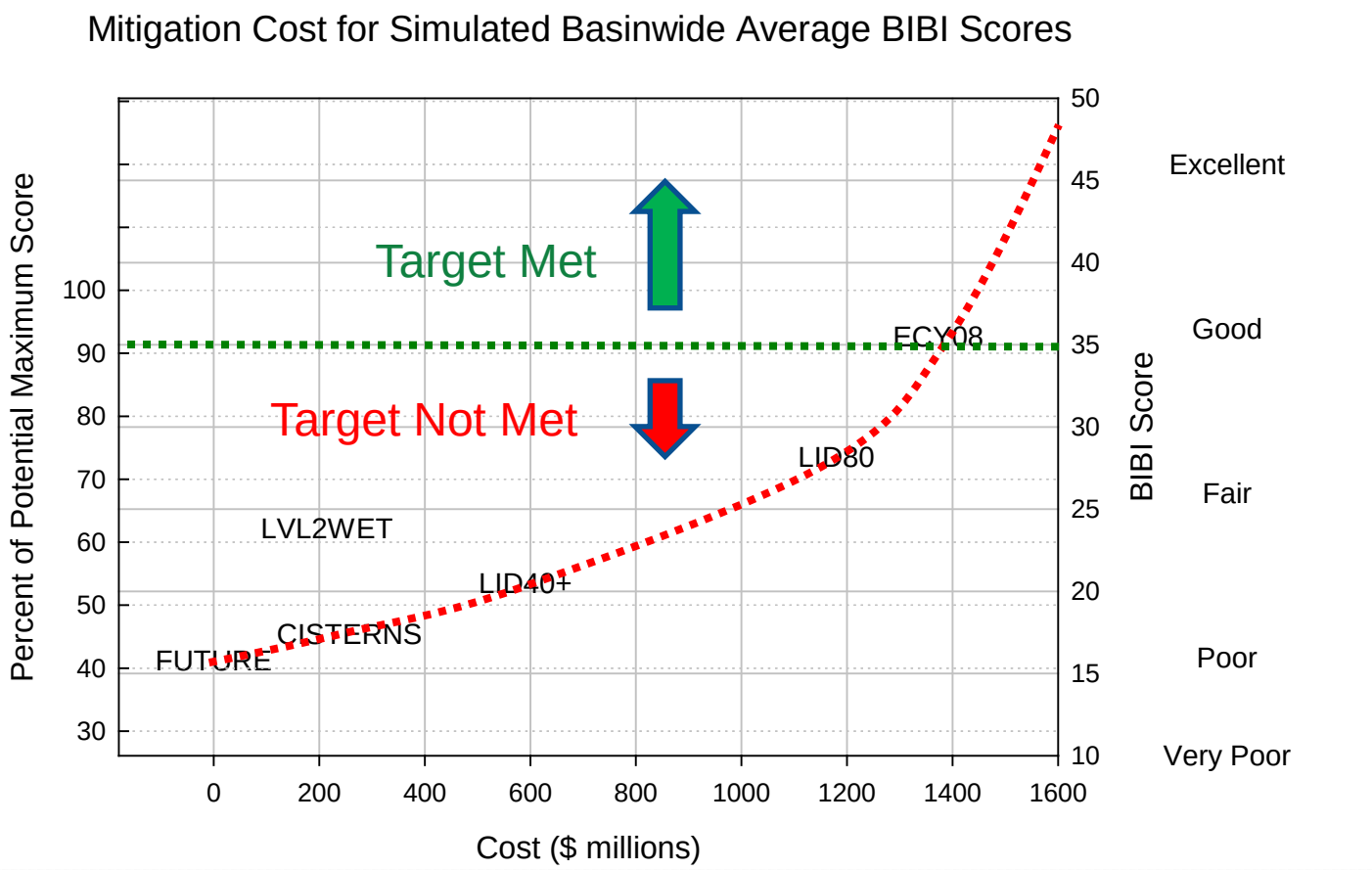


- 40-year horizon
- 2011 Present Value
- Includes all costs public and private

LEVEL2 =	$ 210
LID40 =	$ 590
ECY08 =	$1400
LID40+ =	$ 590
LID80 =	$1200
LVL2WET =	$ 210
CISTERN =	$ 260

Cost in millions of dollars

Cost Effectiveness – Example: BIBI



Note: LEVEL2 ≈ LEVEL2WET, LID40 ≈ LID40+

Caveats and Assumptions

- Regressions used for BIBI represent an average response, Juanita Creek is average (recall: obs = 14, sim = 17).
- No other limiting factors (e.g. lack of riparian vegetation, poor water quality, scarcity of large wood, bank instability, clean gravels, etc.)
- ‘If you build it, will they come?’
- Is any one or more of the nine hydrologic metrics better for predicting BIBI? Can one flashiness metric be a limiting factor?

Discussion

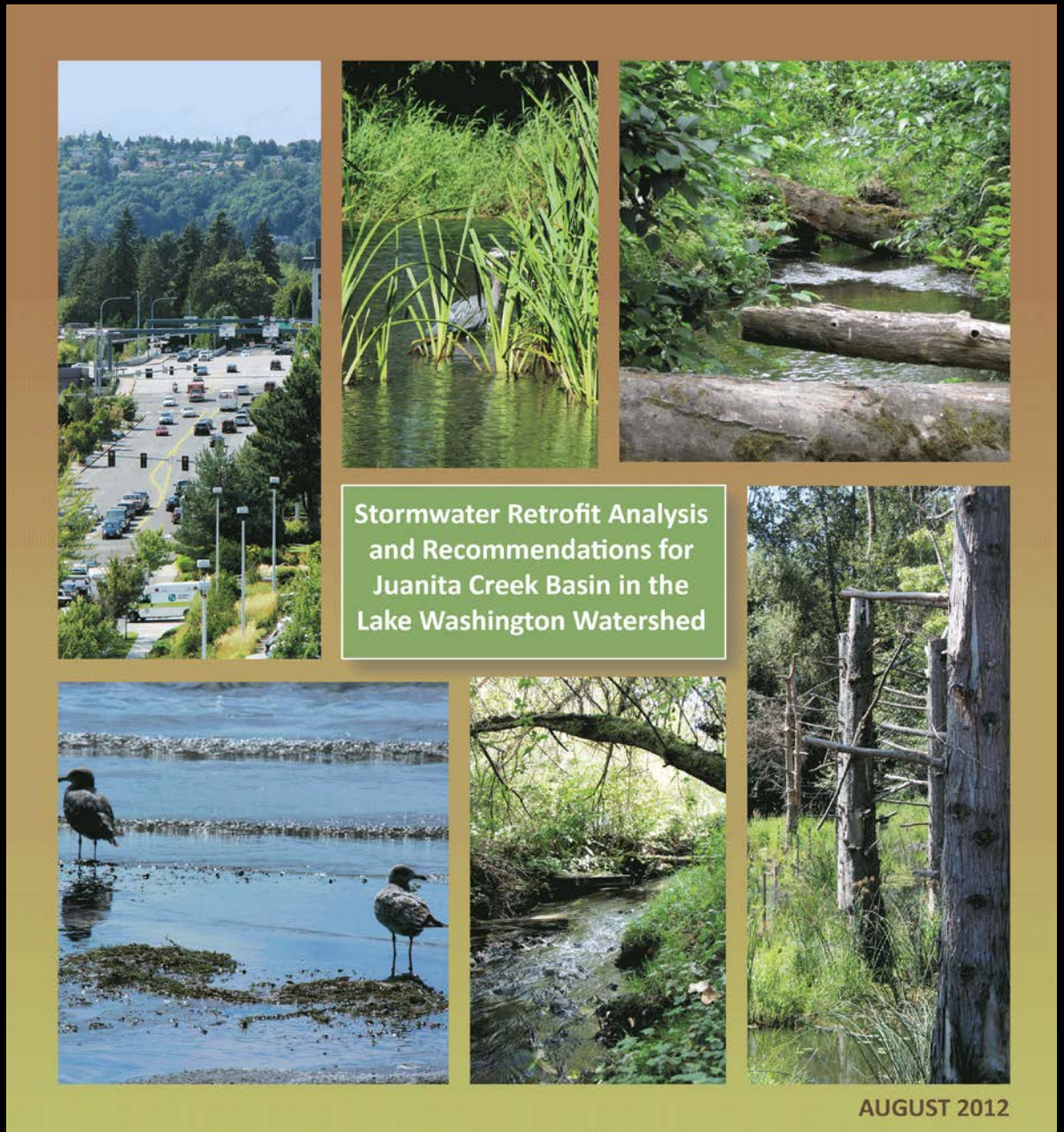
- Current stormwater standards fail to achieve flow and water quality conditions supportive of beneficial uses.
- ECY08 proposed stormwater standards was the only scenario meeting our targets.
- ECY08 is the new proposed standard in next NPDES stormwater permit.
- Predicted BIBI scores are possibly conservative (i.e., low)
  - suppressing factors may incl. water quality, riparian buffer, LWD, bank instability in original paired BIBI/hydrology data.
- Infiltration of stormwater runoff was instrumental in meeting the ECYO8 performance standard.
- The ECYO8 scenario was the most expensive scenario at approximately $200 mil/mile^2.
- Highly mitigative scenarios may result in two few gravel disturbances in already altered channels—therefore, channel modifications are necessary, but may be accomplished by natural processes over time.

Suggested Next Steps

- Implement in test sub-basin to study ‘on ground’ effectiveness of the proposed ECYO8 scenario.
- Improve BIBI/flashiness regressions

http://green.kingcounty.gov/WLR/Waterres/StreamsData/reports/JuanitaCreek2012.aspx

Questions?



Questions?