River Architect

The next generation stream design

https://riverarchitect.github.io

river.architect.program@gmail.com

Davis, CA | 2019

Highlights

Source: S. Schwindt

Source: Greg Pasternack @RiverSciLife

Motivation

State-of-the-Art stream design involves subjective and individual approaches that sometimes miss their objectives (ecological abundance and long-living)

Methods

Parametric and transparent design concepts

Product

Ecologically sustainable and long-living fluvial landscapes with economic assessment

Highlights

Lifespan & Design Mapping

Longevity assessments of single features

Morphology

Terrain modification to yield self-sustaining fluvial landscapes and mass movement assessments

Ecohydraulics

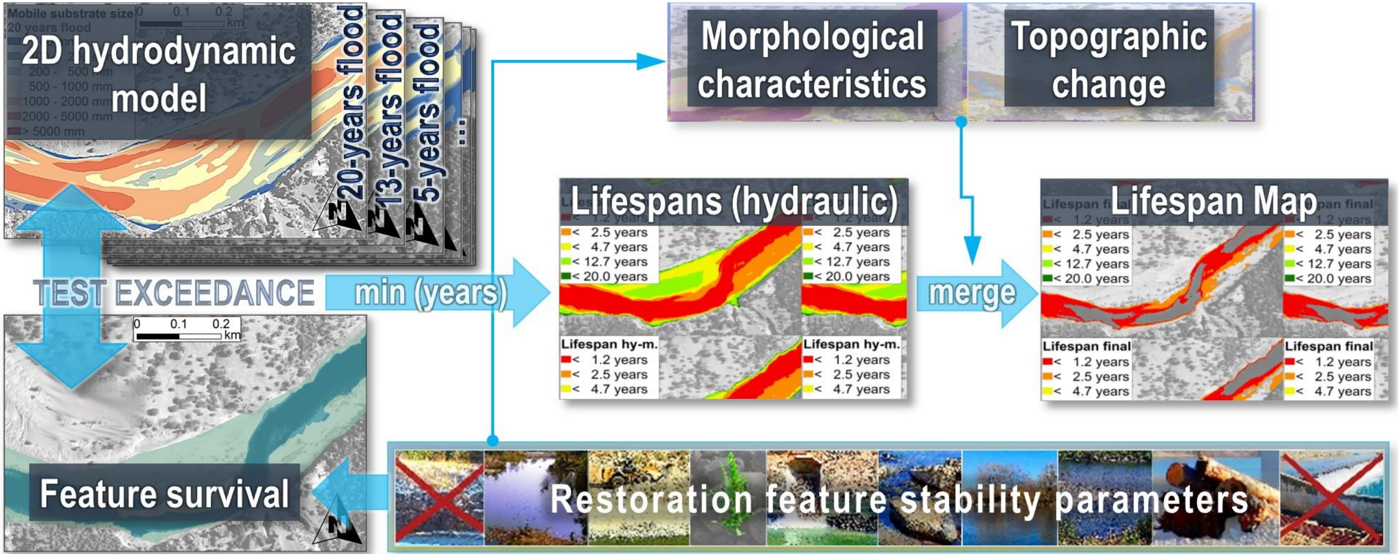
Habitat quality and connectivity assessment for target species and their lifestages

Project Maker

Presentation-ready wrap up of project costs and benefits

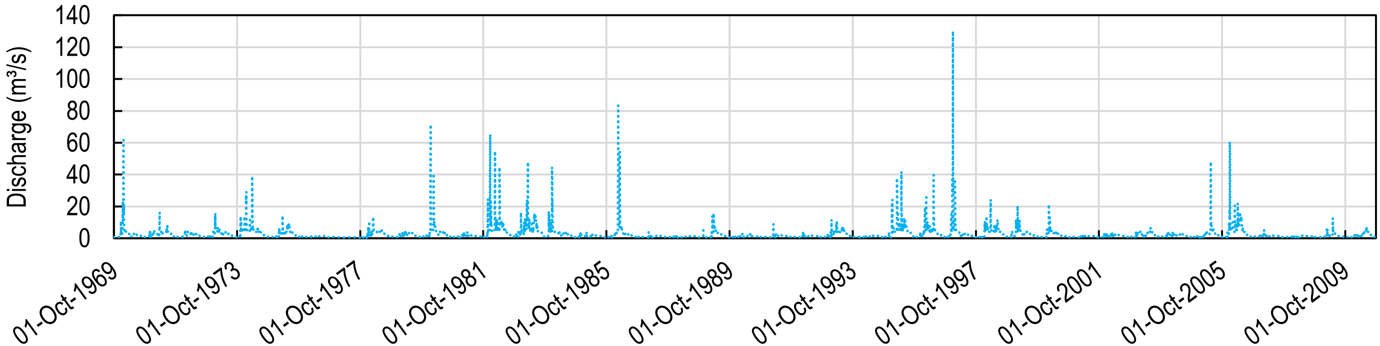
Lifespan & Design Mapping.

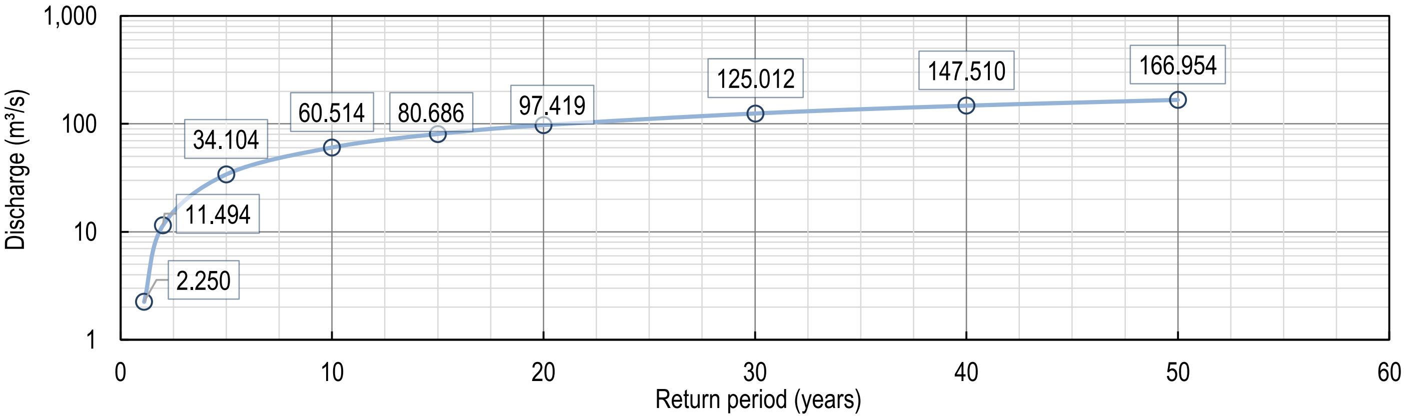
Lifespan mapping



Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Hydro-morphological parameters generate lifespan maps for stream restoration management. Journal of Environmental Management 232, 475-489. doi: 10.1016/j.jenvman.2018.11.010

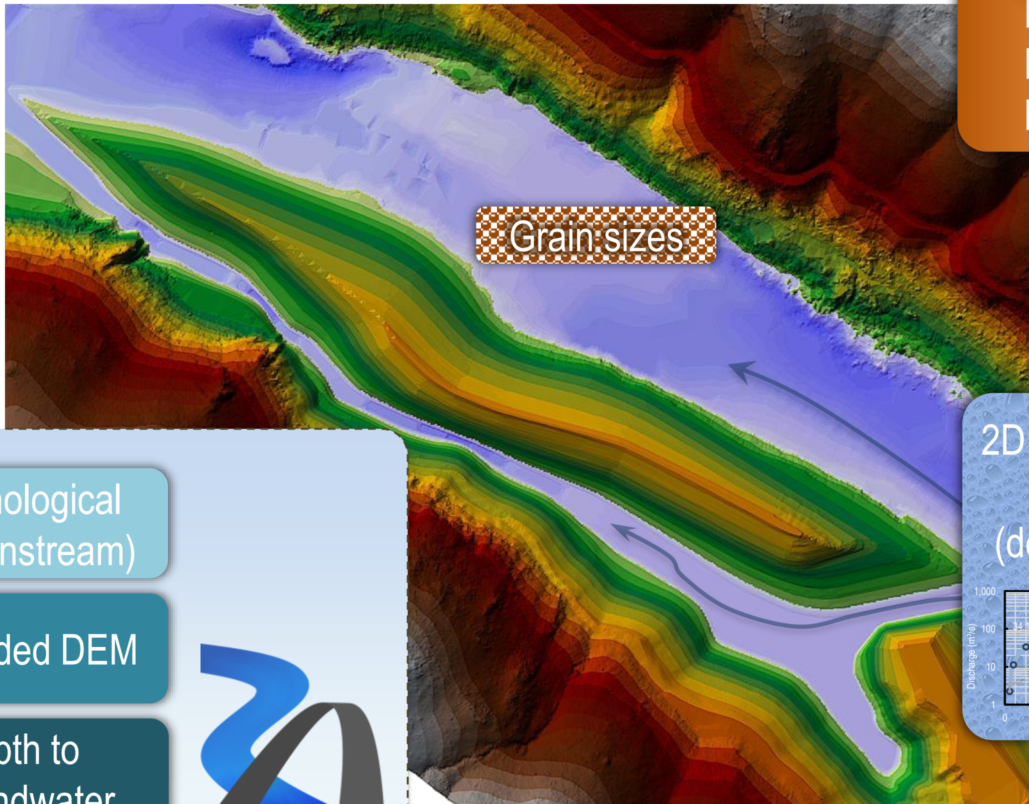
Lifespan mapping





Input
Flow data

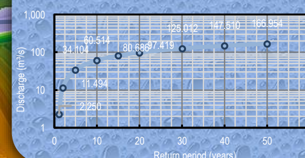
Lifespan mapping



Digital
Elevation
Model

Grain sizes

2D hydrodynamic modelling (depth, velocity)



Morphological Units (instream)

Detrended DEM

Depth to Groundwater

Features

► Stream design feature groups

GROUP 1: Berm setback, calm water zones, grading, side channels, bank scalloping

GROUP 2: Vegetation plantings & other (soil) bioengineering

GROUP 3 – Longitudinal connectivity: Sediment budget modification, flow regulation, lateral barrier removal (not yet fully considered in River Architect)

► Parametrization: Survival threshold values

Parameter (unit)	Depth to ground water (m)	Dim.less bed shear stress (--)	Froude number (--)	Flow depth (m)	Flow velocity (m/s)	TCD: Fill (m/year)	TCD: Erosion (m/year)
Grading	2 - 4	0.047	na	na	na	na	0.01
Etc.	…	…	…	…	…	…	…

Lifespan mapping

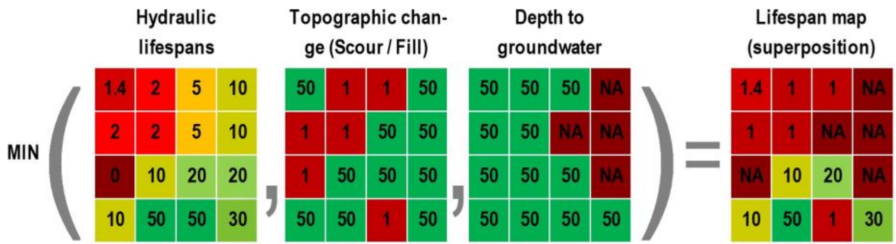
▶ Sustainability Criteria – Thresholds

	VEGETATION PLANTINGS				BIOENGINEERING (OTHER)		
Feature Name	Box Elder	Cottonwoo	White Alde	Willow	Streamwood	Angular boulders	Soil stabilization
Critical dimensionless bed shear str	0.047		0.047	0.100		0.047	
Depth to groundwater (min)	3.0	5.0	1.0	1.0			
Depth to groundwater (max)	6.0	10.0	5.0	5.0			12.0
Detrended DEM (min)							
Detrended DEM (max)							
Flow depth	1.0	2.1		2.1	3.4		
Flow velocity		3.0					
Froude number					1.0		
Grain size							
Design map frequency threshold					10.0	20.0	
Safety factor						1.3	
Terrain slope							0.20
Topographic change: fill rate		3.36					
Topographic change: scour rate		1.68	3.00	1.68		3.00	

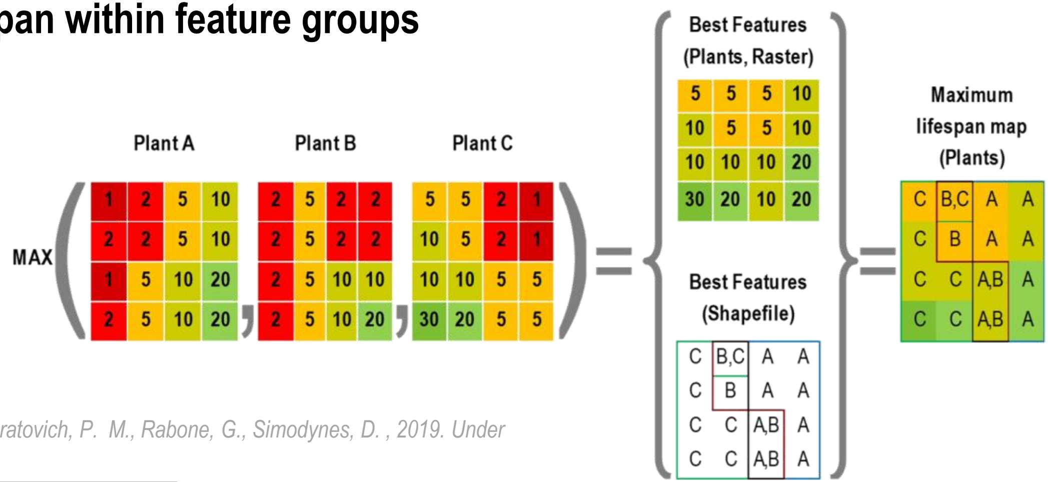
Source: https://github.com/RiverArchitect/program/blob/master/LifespanDesign/.templates/threshold_values.xlsx

Lifespan mapping

► Lifespan Calculation (Raster overlay)



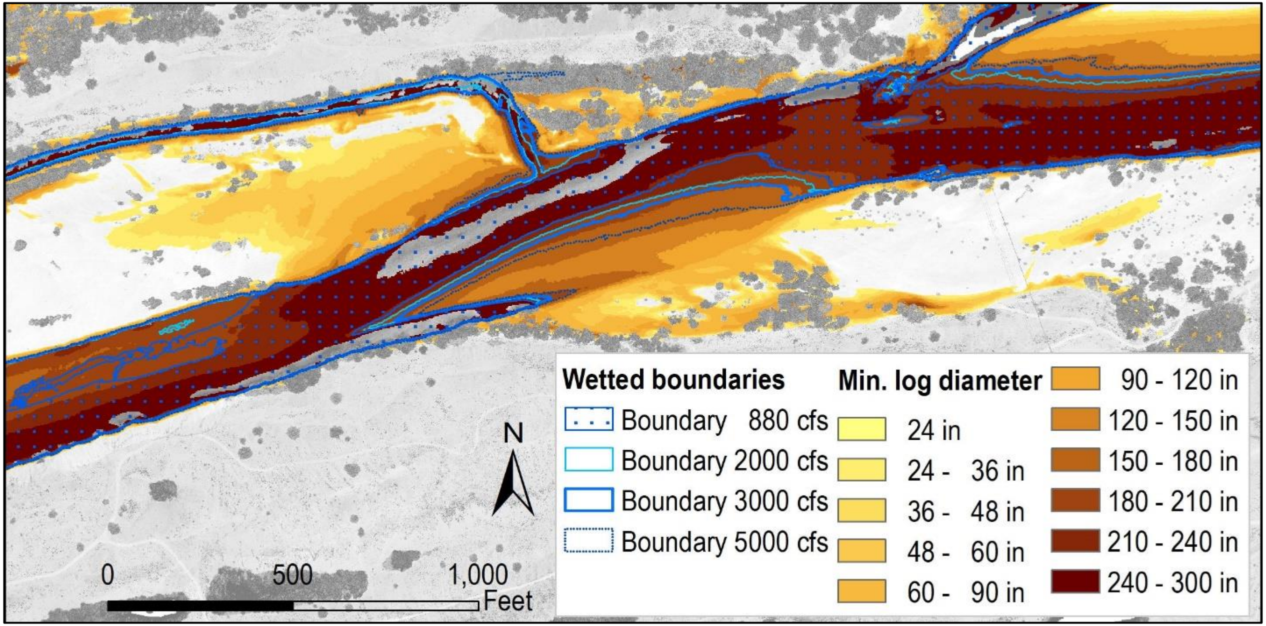
► Identify best lifespan within feature groups



Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Under preparation

Lifespan mapping

- Example: Identify stable log diameters for streamwood placement



Lifespan mapping

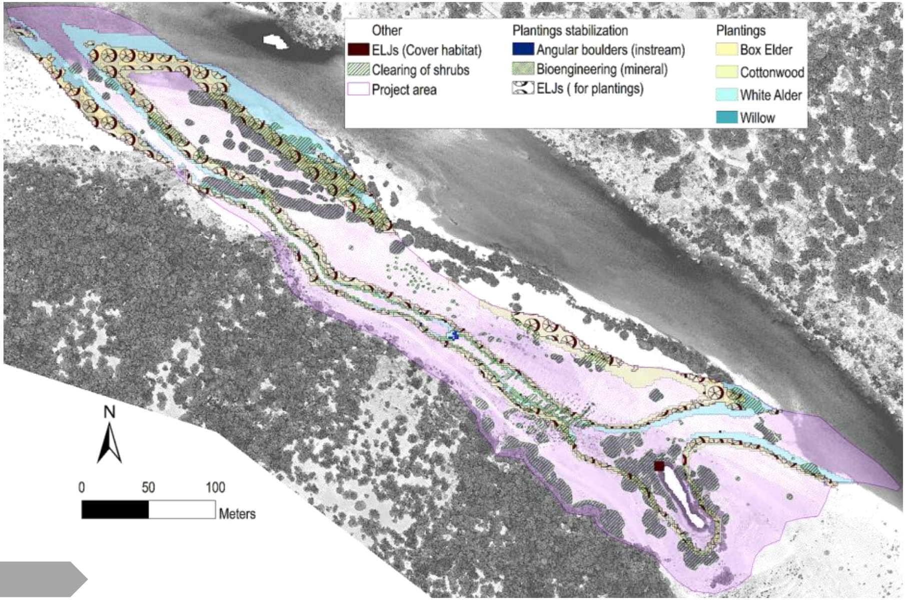
Result processing

- ▶ Use for planning terraforming actions: Manual action required

- ▶ Use for full-automated planning of vegetation plantings & other bioengineering features

- ▶ And more …

  … gravel augmentation
  … streamwood
  … mass movement



Morphology.

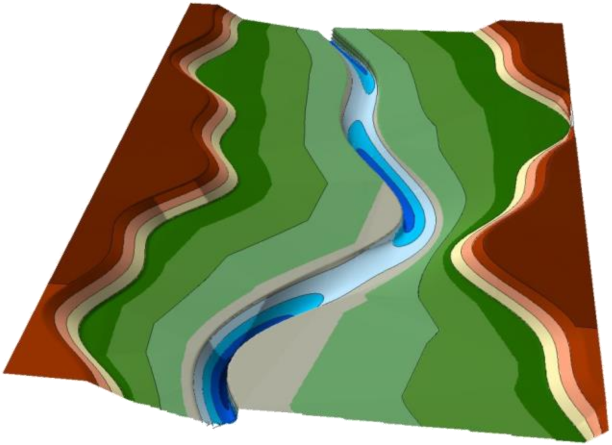
Morphology

Use Threshold-based terraforming or River Builder to design riverscapes

- Threshold-based terraforming: Grading or River widening
- River Builder
- Volumetric Terraforming assessment

… these routines procedualize
currently best available science

… we are developing new strategies
to improve procedural terraforming
based on physical boundary conditions

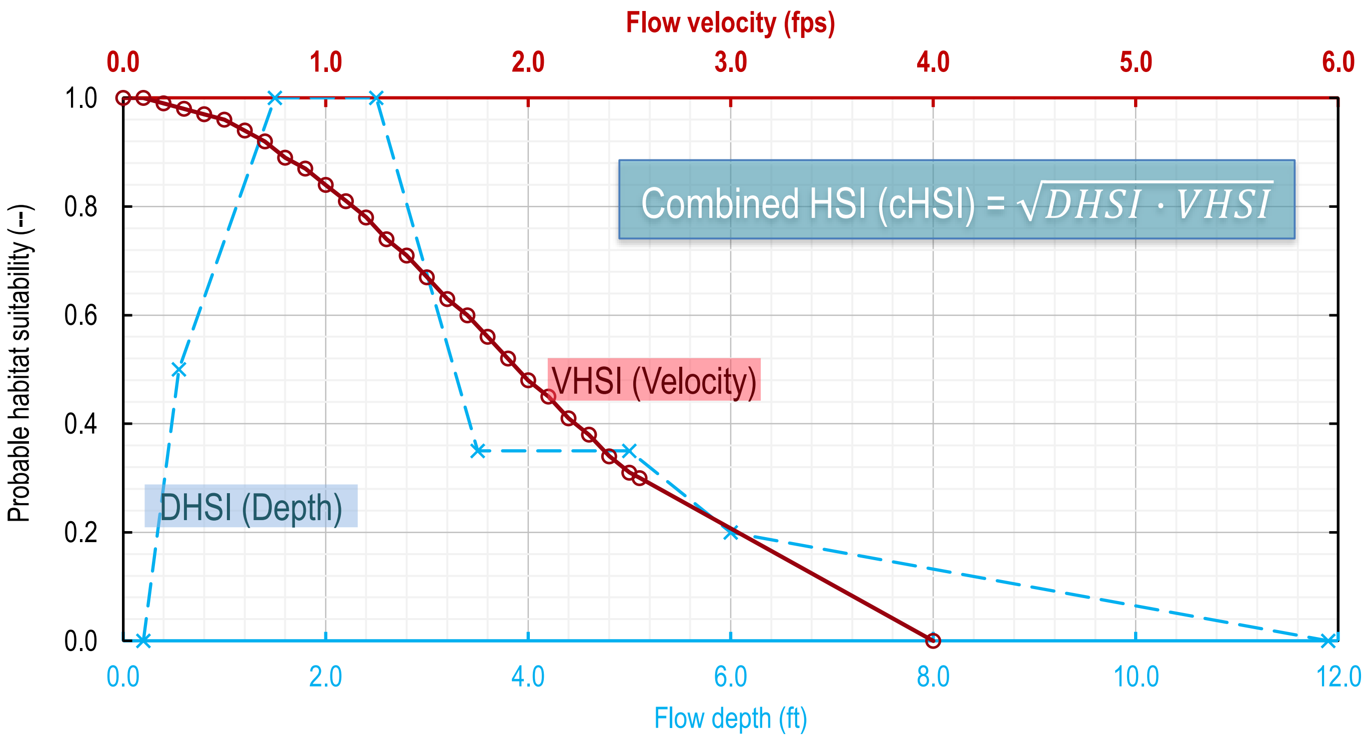


Synthetic river valley created with River Builder
(source: Gregory B. Pasternack)

Ecohydraulics.

Ecohydraulics

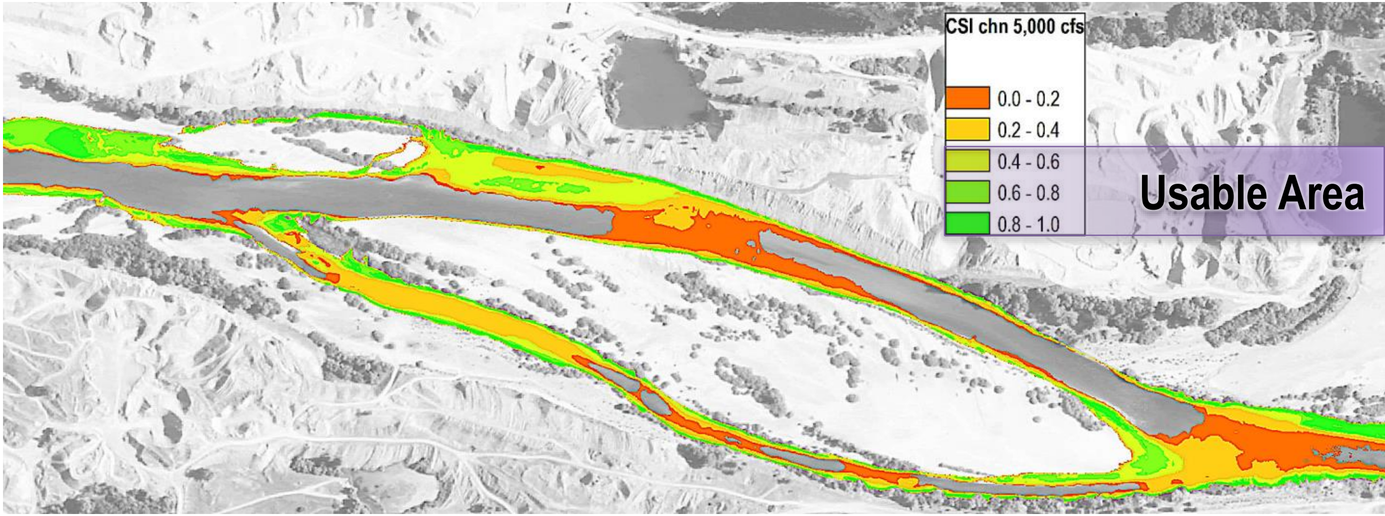
▶ Habitat assessment (1): Habitat Suitability Index (HSI) of juv. Chinook salm.



Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Under preparation.

Ecohydraulics : Habitat Enhancement

- Habitat assessment (2): composite Habitat Suitability Index (cHSI) map



- Repeat operation for multiple discharges (apply flow duration curve)
- Calculate usable habitat area (e.g., cHSI > $\theta = \ldots$)

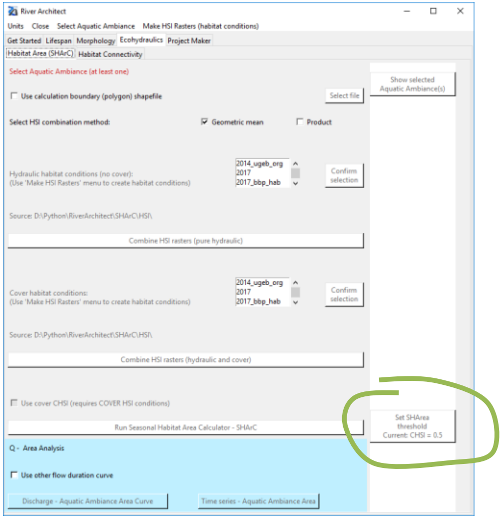
Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. under preparation

Ecohydraulics: Habitat Enhancement

- Fish preferences in River Architect

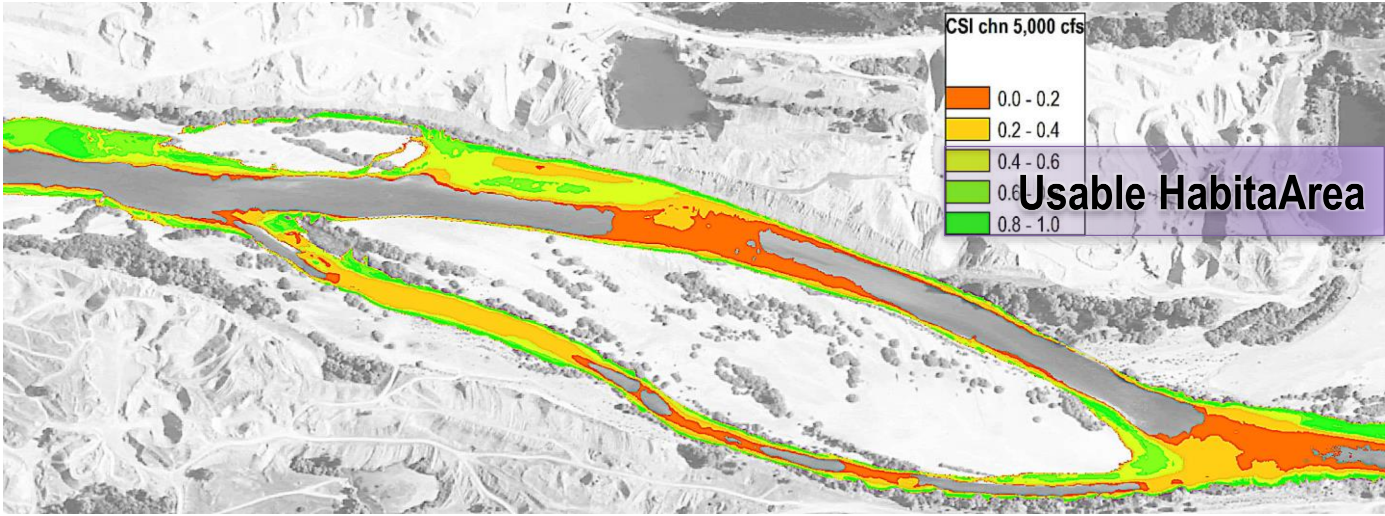
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		SET UNIT SYSTEM:	*U.S. customary*								u in (fps)		h in (ft)		D in (inch)		Rad. in (ft)			
2		Common name	Chinook Salmon								Rainbow / Steelhead Trout									
3		Genus	Oncorhynchus								Oncorhynchus									
4		Species	O. tshawytscha								O. mykiss									
5		Lifestages	spawning		fry		juvenile		adult		spawning		fry		juvenile		adult		spawning	
6		Season start		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct		1-Oct
7		Season end		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep		30-Sep
8			u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)	u	HSI (-)
9			0.22	0.00	0.00	1.00	0.00	1.00			0.06	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	
10			0.85	0.20	0.10	0.99	0.10	1.00			0.77	0.10	0.10	1.00	0.10	1.00	0.50	[illegible]		
11			1.30	0.52	0.20	0.95	0.20	0.99			1.00	0.20	0.20	0.99	0.20	[illegible]				

- Usable habitat is where $\theta = \ldots$



Ecohydraulics: Habitat Enhancement

- Habitat assessment (2): composite Habitat Suitability Index (cHSI) map



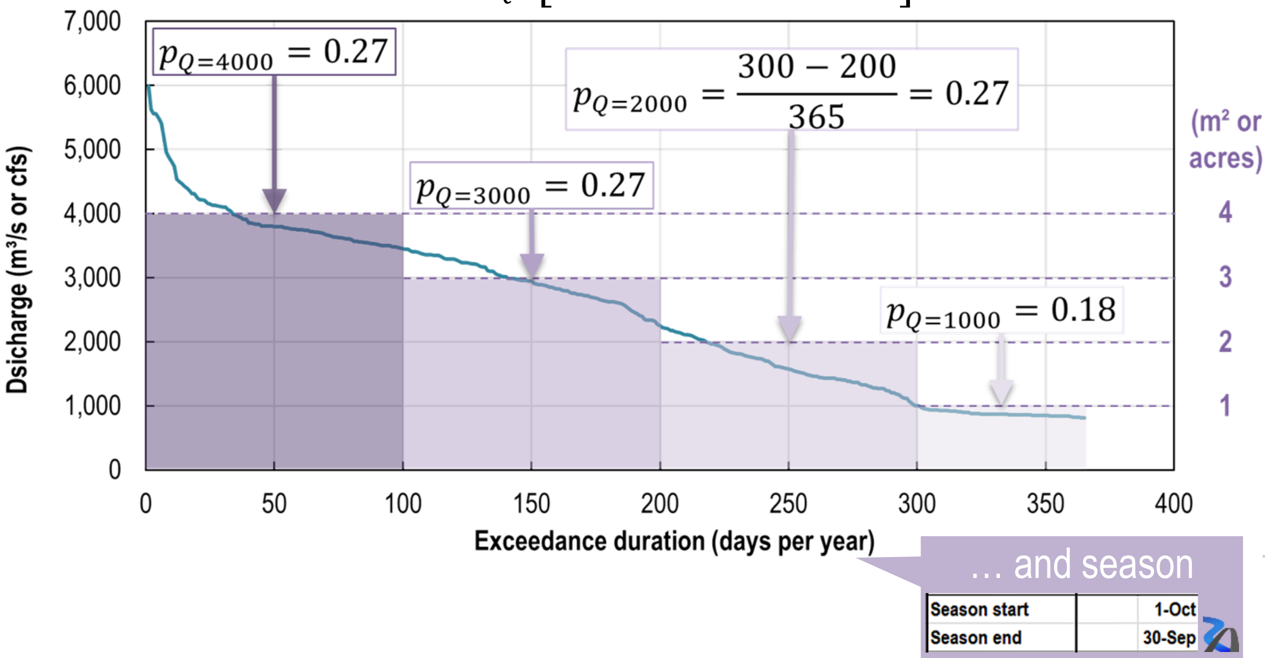
- Repeat operation for multiple discharges (apply flow duration curve)
- Calculate usable habitat area (e.g., cHSI > $\theta =$)
- Sum of usable areas for one discharge = SHArea
- Sum of multiple season-specific discharges = **S**easonal **H**abitat **Area**

Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Under preparation.

Ecohydraulics: Habitat Enhancement

- Habitat assessment (3): Calculate **S**easonal **H**abitat **Area** (***SHArea***)

$$\boldsymbol{SHArea} = \sum_{p_{Qi}}^{p_{Qn}} \left[\sum pixels(cHSI > \vartheta) \right] \cdot p_{Qk}$$

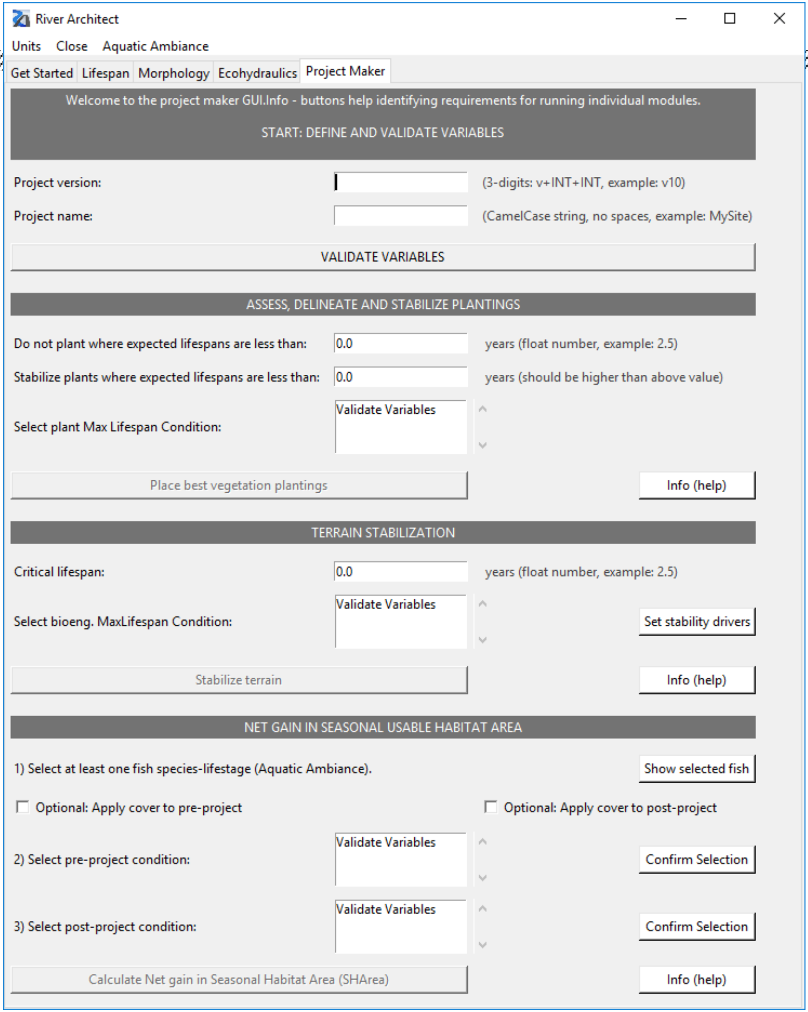


More: https://riverarchitect.github.io/RA_wiki/SHArC#herunSHArea

Project Maker (Cost-Benefit Analysis).

Project Maker

- Site-wise metrics
- Automated terraforming assessment
- Automated vegetation plant-ings & other bioengineering placement
- Automated cost assessment



Project Maker

Reach: REACH NAME Site: Site Name	Total costs: $4,576,446.64 Net gain in AUA (ac/yr): 2.5	Project return (US $ per ac net gain in AUA)	$1,816,541.54

Layer	Task	Costs per	Unit	Quantity	Total (US $)	Remarks	Literature Sources
Framework (terraforming)	Clearing (vegetation)	$ 220.00	acre	2.0	$441.41		LCH (2012)
	Excavate/fill alluvial material (includes transport)	$ 10.52	yd³	external	$1,411,446.10	Use terraforming_volumes sheet	CCC (2003) King et al. (1994) LCH (2012)
	Groin cavities	$ 1,200.00	piece		$0.00		Zeh (2007)
SUM (Terraforming)					$1,411,887.51		
Bioengineering (stabilization)	Anchoring (logs for plantings)	$ 80.00	yd'	6.0	$480.00	refers to log length	LCH (2012)
	Engineered log jam: log-wise (for plantings)	$ 775.00	log	0.7	$558.00	log length = 25 ft, Ø = 24 in	Cramer (2012) Virginia University (2004)
	Engineered log jam: root-wise	$ 49.88	rootwad		$0.00		King et al. (1994) Zeh (2007)
	Engineered log jam: complete	$38,750.00	piece		$0.00		Cramer (2012) Knutson (2015)
	Angular boulder placement (instream)	$ 130.00	yd²	175.0	$22,750.00		Zeh (2007) Cramer (2012)
SUM (Plant-stabilizing bioengineering)					$23,788.00		
	Ball method (small trees)	$ 210.00	piece		$0.00		Zeh (2007) Virginia University (2004)
	Container trees	$ 33.00	tree		$0.00		King et al. (1994)
	Rod method (Cottonwood)	$72,447.50	acre		$0.00	Cutting length = 7-12 ft, Ø = 6 in	
SUM (TOTAL CONSTRUCTION WORKS)					$3,389,960.47		
APPLICATION OF FEES & RATES							
CIVIL ENGINEERING							
Site (de-)mobilization (from total costs)		0.10	[-]	1.0	$338,996.05		LCH (2012)
Unexpected (from total costs)		0.10	[-]	1.0	$338,996.05		LCH (2012)
ENGINEERING FEES							
From total costs		0.15	[-]	1.0	$508,494.07		LCH (2012) Cramer (2012)
TOTAL COSTS					$4,576,446.64		

… Project key metrics

Projekt Maker | Output

download **https://sschwindt.github.io/RiverArchitect/**
docu **https://github.com/sschwindt/RiverArchitect/wiki**
maintenance S. Schwindt, K. Larrieu, G. Pasternack

Reference: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Under preparation