

The logo for River Architect features a stylized blue 'R' and a dark grey 'A' that overlap. The background is an underwater scene with a fish and some green plants.

River Architect

The next generation stream design

<https://sschwindt.github.io/RiverArchitect/>

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 (ecol. relevance / lifespan)

Methods

Parametric and transparent design concepts

Product

Ecologically sustainable and long-living fluvial landscapes with economic assessment

Highlights

Lifespan & Design

Longevity assessments of single features

Best Lifespans

Identification of best features for habitat enhancement

Modify Terrain

Simple terrain modification and mass movement assessments

Habitat Evaluation

Habitat quality assessment for target species and their lifestages

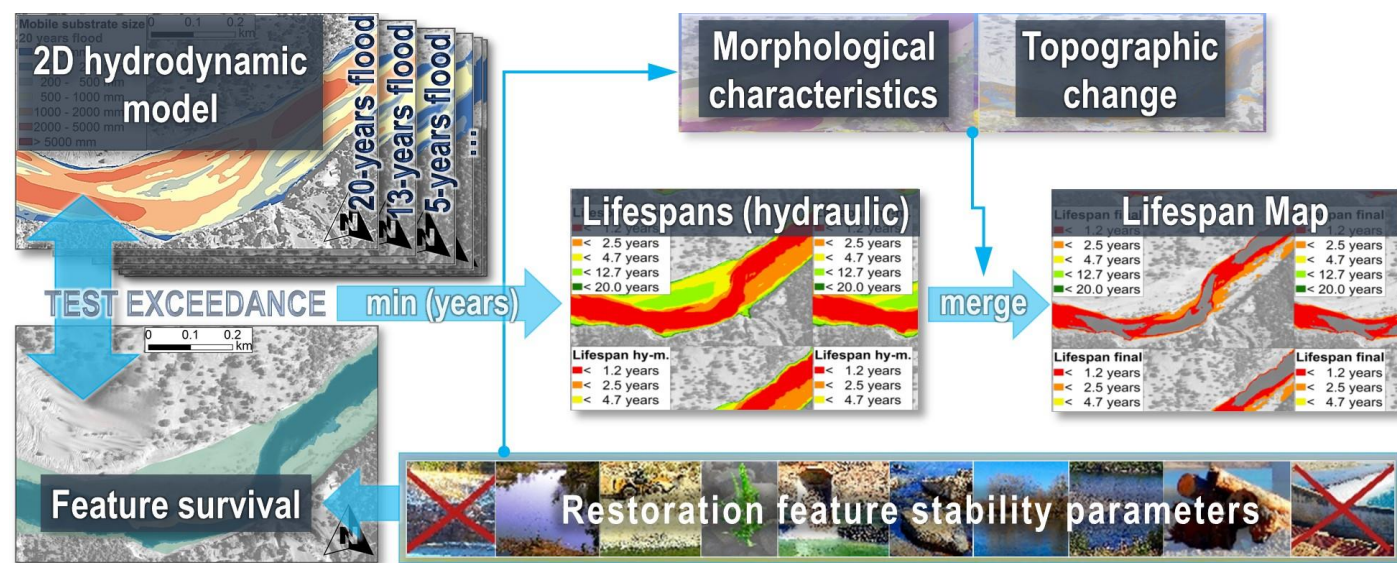
Project Maker

Shovel-ready wrap up of project costs and benefits

More is under development ...

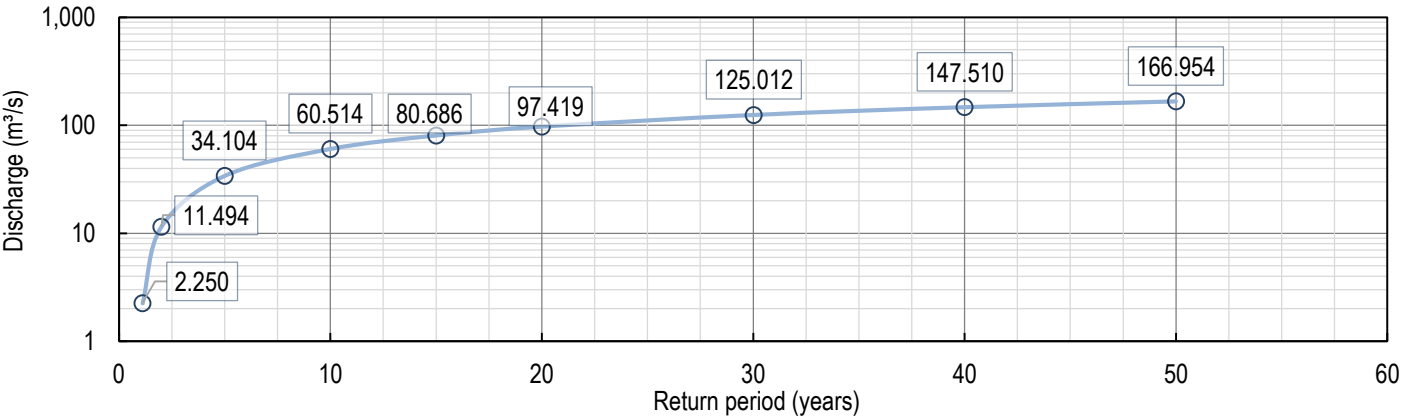
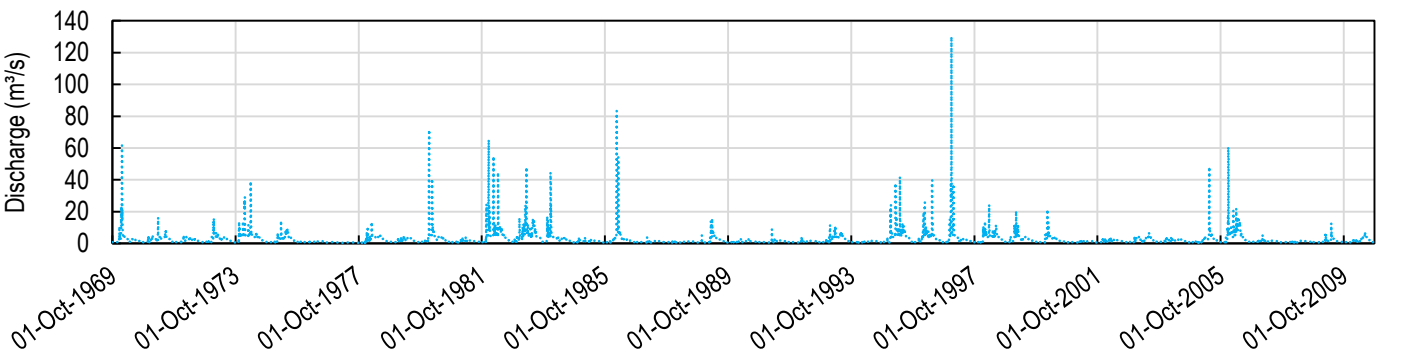
 **Lifespan Mapping.**

Lifespan mapping

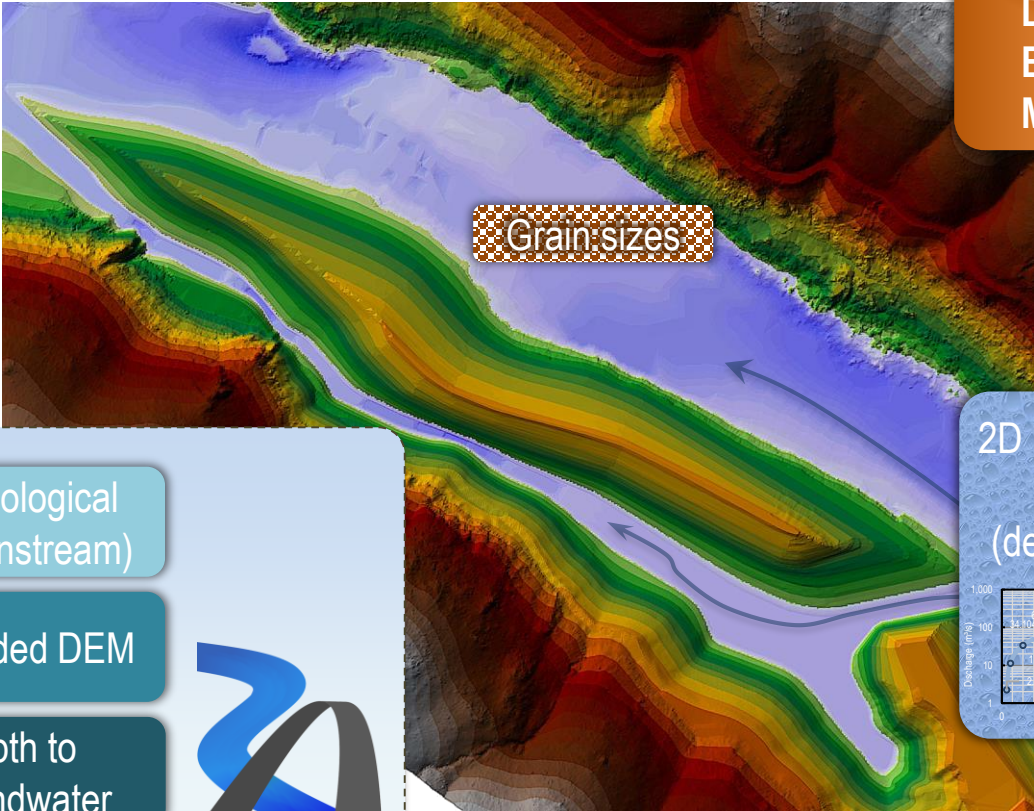


Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. Hydro-morphological parameters generate lifespan maps for stream restoration management. *Journal of Environmental Management* 232, 475-489. doi: 10.1016/j.jenvman.2018.11.010

Lifespan mapping

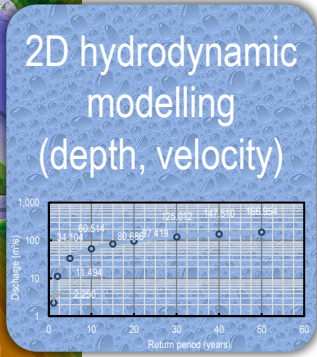


Lifespan mapping



Digital
Elevation
Model

- Morphological Units (instream)
- Detrended DEM
- Depth to Groundwater



Input

Rasters

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

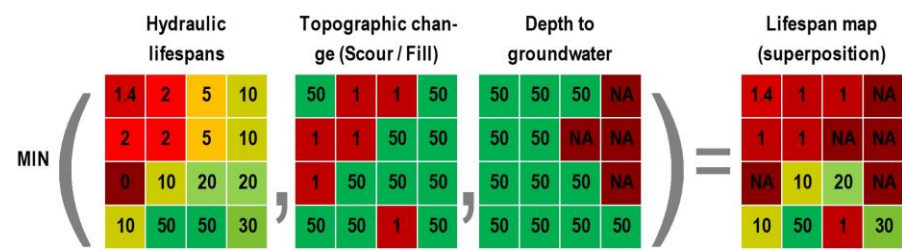
► Sustainability Criteria – Thresholds

	VEGETATION PLANTINGS				BIOENGINEERING (OTHER)		
Feature Name	Box Elder	Cottonwood	White Alder	Willow	Streamwood	Angular boulders	Soil stabilization
Critical dimensionless bed shear stress	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	

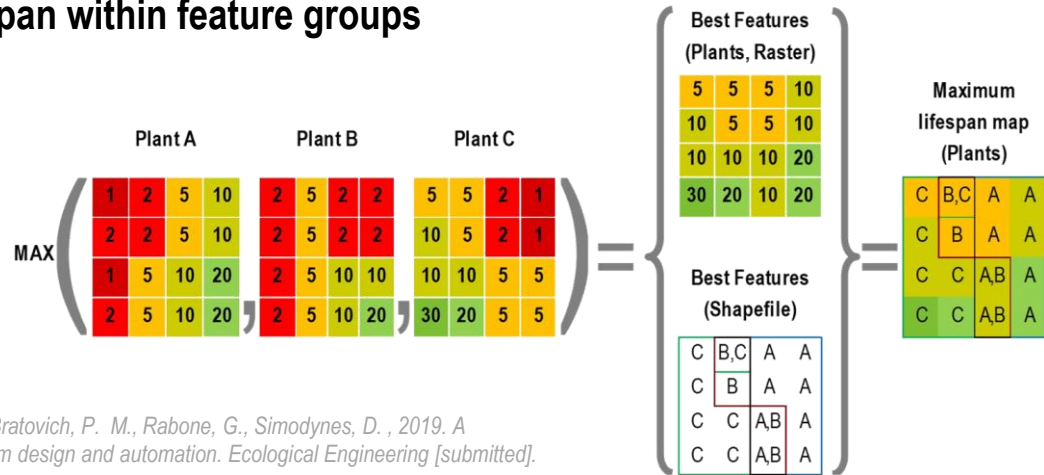
Source: https://github.com/sschwindt/RiverArchitect_development/blob/master/LifespanDesign/templates/threshold_values.xlsx

Lifespan mapping

► Lifespan Calculation (Raster overlay)



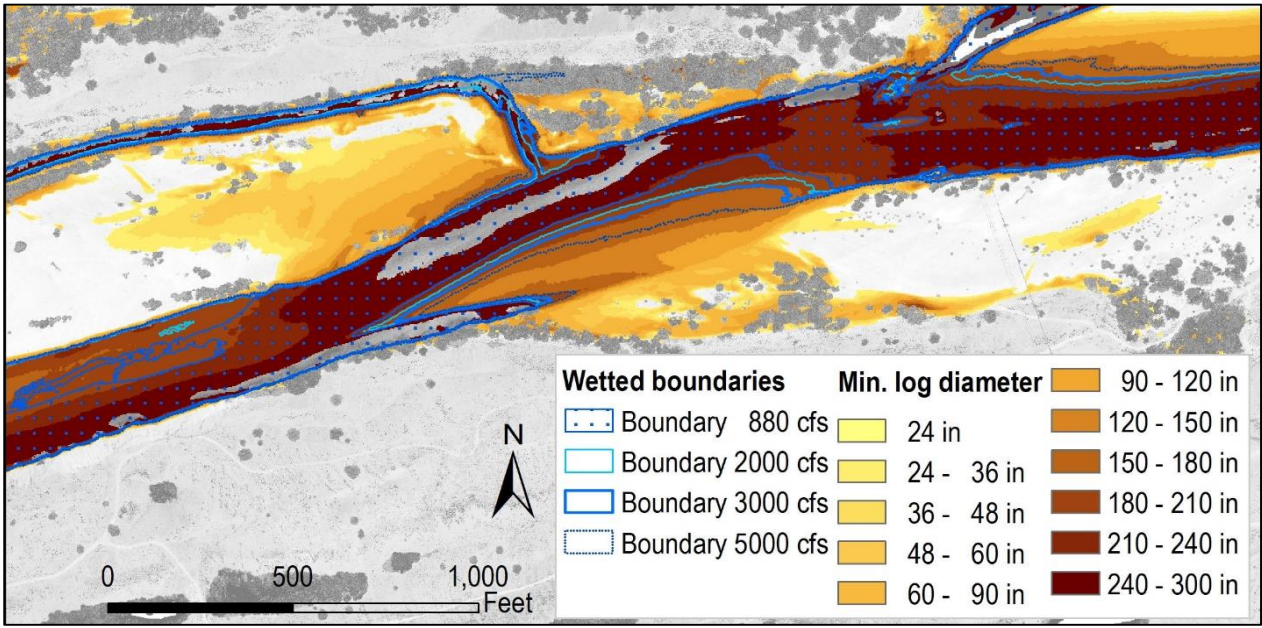
► Identify best lifespan within feature groups



Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].

Lifespan mapping

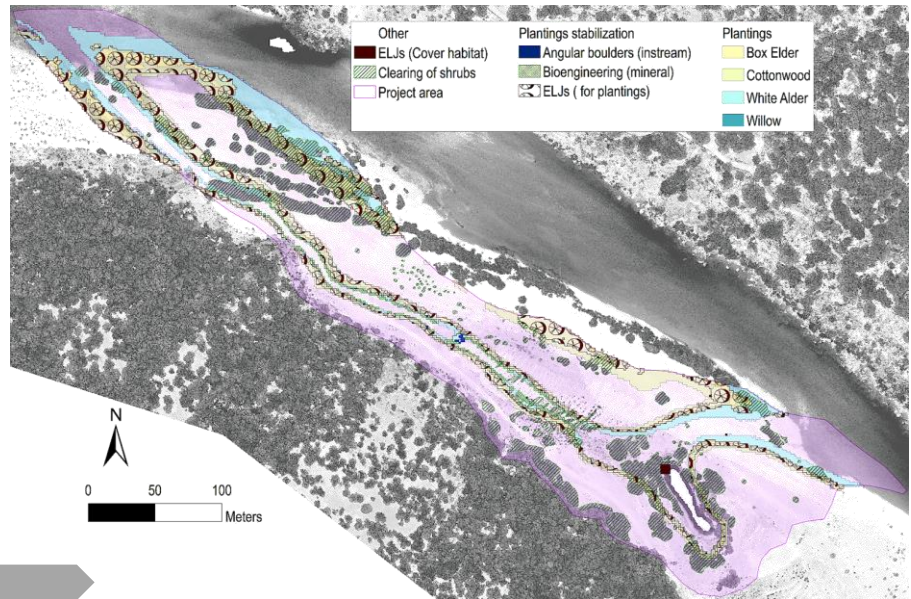
► Example: Identify stable log diameters for streamwood placement



Lifespan mapping

Result processing

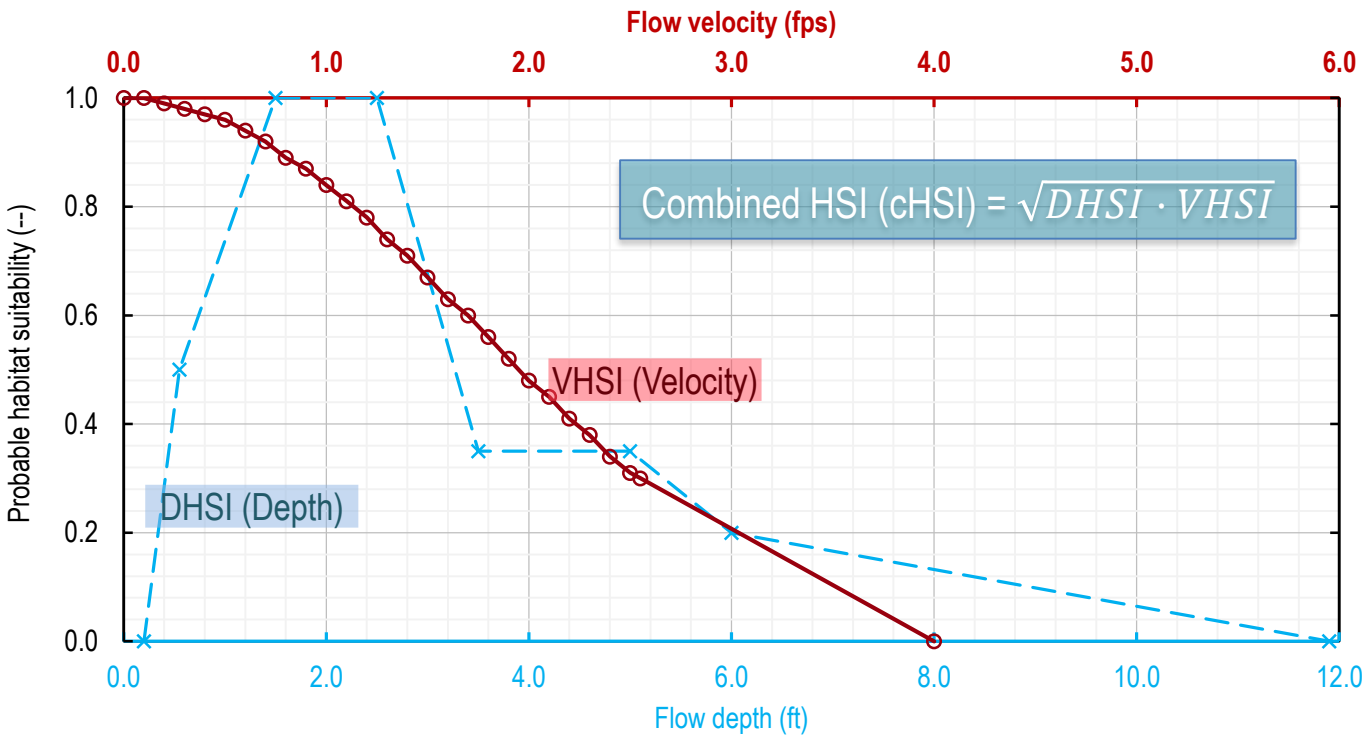
- ▶ Use for planning terraforming actions: Manual action required
- ▶ Use for full-automated planning of vegetation plantings & other bioengineering features
- ▶ And more ...
 - ... gravel augmentation
 - ... streamwood
 - ... mass movement



Fisheries Benefits.

Habitat Enhancement

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

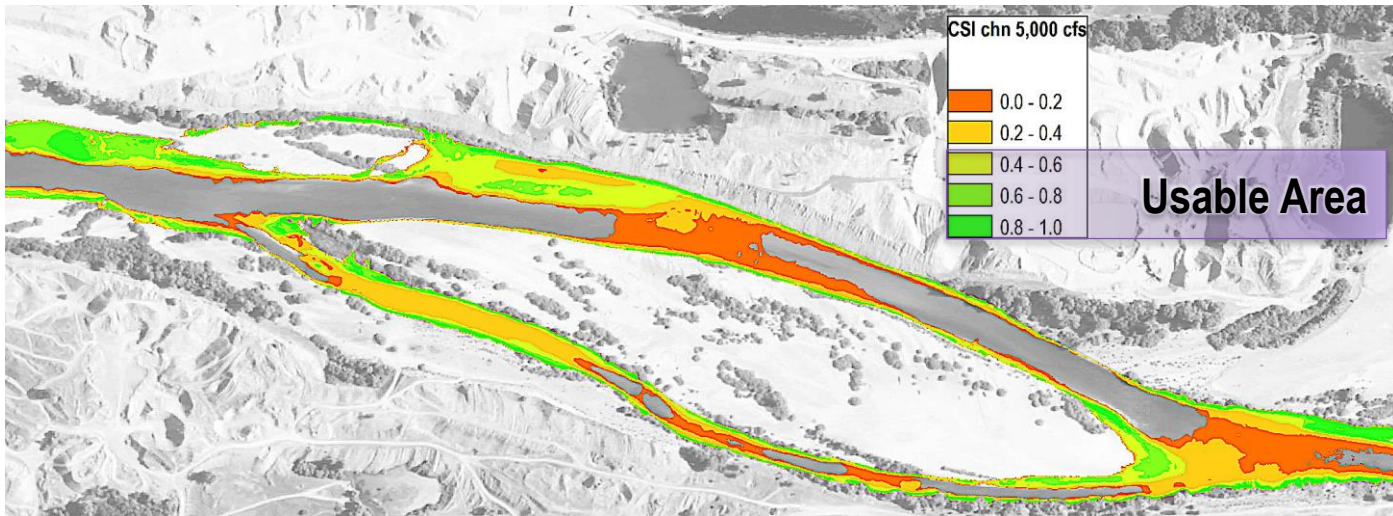


Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D. , 2019. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].



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., $\text{cHSI} > \theta = \dots$)

Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D., 2019. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].

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	0.50		
11			1.30	0.52	0.20	0.95	0.20	0.99			1.00	0.20	0.20	0.99	0.20	0.99				

► Usable habitat is where $\theta = \dots$

River Architect

1) Set fish 2) Make HSI rasters (habitat conditions) Units Close

Lifespan Design Max Lifespan Modify Terrain Habitat Evaluation Eco Morphology Project Maker

☐ Use calculation boundary (rectangular polygon) shapefile

3) Select HSI combination method: ☒ Geometric mean ☐ Product

4a) Available hydraulic habitat conditions: 2008 2008_rrr_lyr10 2017_ugeb_org

Source: D:\Python\RiverArchitect\HabitatEvaluation\HSI\

5a) Combine HSI rasters (pure hydraulic)

4b) Available cover habitat conditions: 2008 2008_rrr_lyr10 2017_ugeb_org

Source: D:\Python\RiverArchitect\HabitatEvaluation\HSI\

5b) Combine HSI rasters (hydraulic and cover)

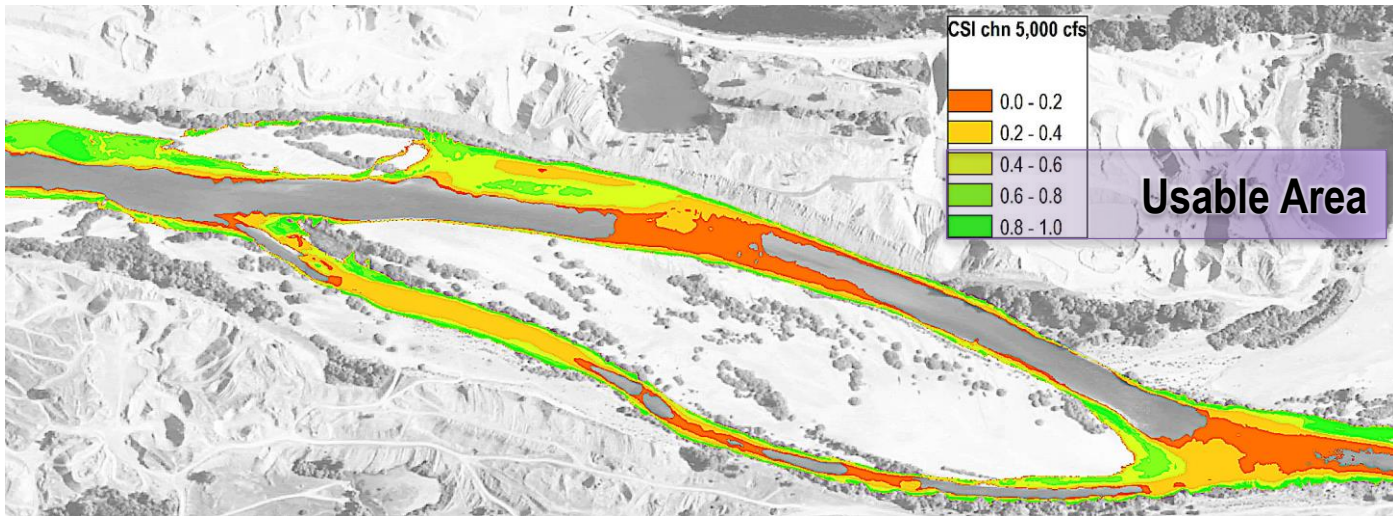
☐ Use cover CHSI (requires that 5b was executed)

6) Calculate Weighted Usable habitat Area (WUA)

Set WUA threshold
Current: CHSI = 0.4

Habitat Enhancement

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



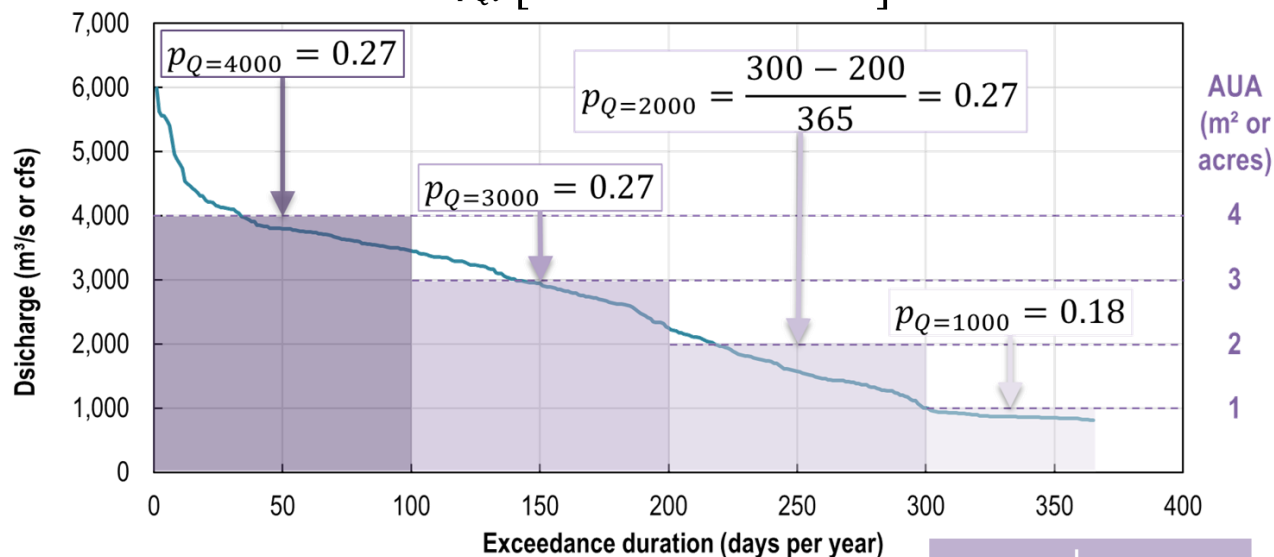
- Repeat operation for multiple discharges (apply flow duration curve)
- Calculate usable habitat area (e.g., $\text{cHSI} > \theta = 0.5$)
- Sum of usable areas for one discharge = WUA
- Sum of multiple discharges = **Annualized Usable Area (AUA)**

Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D., 2019. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].

Habitat Enhancement

► Habitat assessment (3): Calculate Annualized Usable Area (*AUA*)

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



... and season

Season start	1-Oct
Season end	30-Sep

More: <https://github.com/sschwindt/RiverArchitect/wiki/HabitatEvaluation#herunaua>

Source: Schwindt, S., Pasternack G. B., Bratovich, P. M., Rabone, G., Simodynes, D., 2019. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].



Project Maker (Cost-Benefit Analysis).

Project Maker

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

River Architect

Set fish Units Close

Lifespan Design Max Lifespan Modify Terrain Habitat Evaluation Eco Morphology **Project Maker**

Welcome to the project maker GUI. Info - buttons help identifying requirements for running individual modules.

START: DEFINE AND VALIDATE VARIABLES

Project version: (3-digits: v+INT+INT, example: v10)

Reach: (3-characters: RRR, example: TBR)

Site name: (CamelCase string, no spaces, example: MySite)

Site short name: (3-characters: stn, example: sit)

Critical plantings lifespan: years (float number, example: 2.5)
(for plant stabilization)

Change path to RiverArchitect package (skip this if current is ok)

Current: D:\Python\RiverArchitect\

VALIDATE VARIABLES

ASSESS AND DELINEATE PLANTINGS

Select plant Max.Lifespan map folder: Validate Variables No validation required for selection.

VEGETATION PLANTINGS STABILIZATION

Select bioeng. Max.Lifespan Raster folder: Validate Variables No validation required for selection.

NET GAIN IN WEIGHTED USABLE AREA

1) Select at least one fish species-lifestage from the Set fish menu.

☐ Optional: Apply cover to pre-project ☐ Optional: Apply cover to post-project

2) Select pre-project condition: Validate Variables

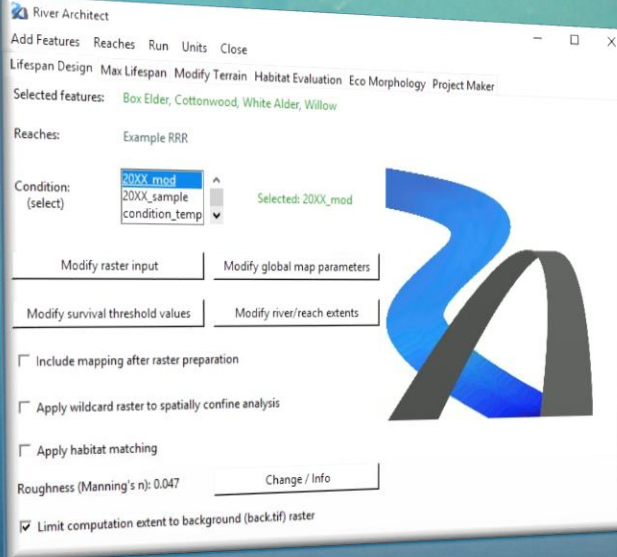
3) Select post-project condition: Validate Variables

Project Maker

Reach: REACH NAME	Total costs: \$4,576,446.64	Project return
Site: Site Name	Net gain in AUA (aclyr): 2.5	(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)
	Groin cavities	\$ 1,200.00	piece		\$0.00		LCH (2012) 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		
Bioengineering (planting)	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)
	Plant method (C. rubra/rostrata)	\$10,447.50	piece		\$0.00	Cutting length = 7-12 ft, Ø = 6 in	King et al. (2012)
SUM (TOTAL CONSTRUCTION WORKS)					\$3,389,960.47		
APPLICATION OF FEES & RATES							
CIVIL ENGINEERING							
Site (de-)mobilization (from total costs)		0.10	[H]	1.0	\$338,996.05		LCH (2012)
Unexpected (from total costs)		0.10	[H]	1.0	\$338,996.05		LCH (2012)
ENGINEERING FEES							
From total costs		0.15	[H]	1.0	\$508,494.07		LCH (2012) Cramer (2012)
TOTAL COSTS					\$4,576,446.64		

... Project key metrics



River Architect

A Python-based tool set for stream design, river restoration, and eco-hydraulic assessments.

[View on GitHub](#)

[Wiki](#)

[Download .zip](#)

[Download sample data](#)

River Architect

River Architect is a Python3-based open-source package that supports stream designers with a set of GUI modules (the last stable Python2 version can be downloaded [here](#) with sample data). The current core functionalities are:

- Lifespan mapping of stream design features according to Schwindt et al. (2019) with the LifespanDesign and MaxLifespan modules.
- Calculate terraforming activities (mass differences and simple terrain modifications) with the ModifyTerrain module.

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. A concept for ecologically sustainable stream design and automation. Ecological Engineering [submitted].