42nd International School of Hydraulics

FRESHWATER SYSTEM HEALTH: A HYDRAULIC PERSPECTIVE

MESOHYDRAULICS: MODELLING SPATIOTEMPORAL HYDRAULIC DISTRIBUTIONS

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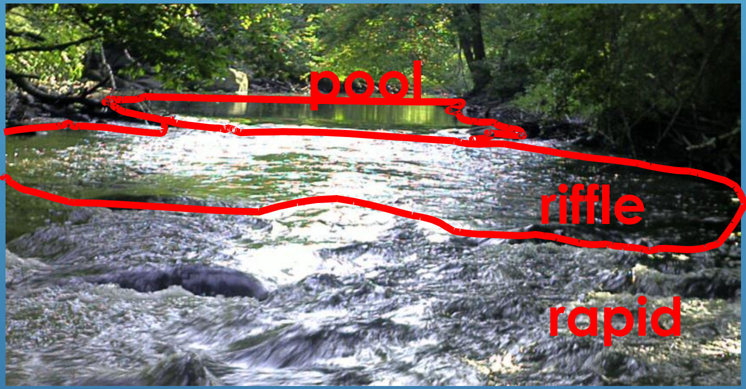
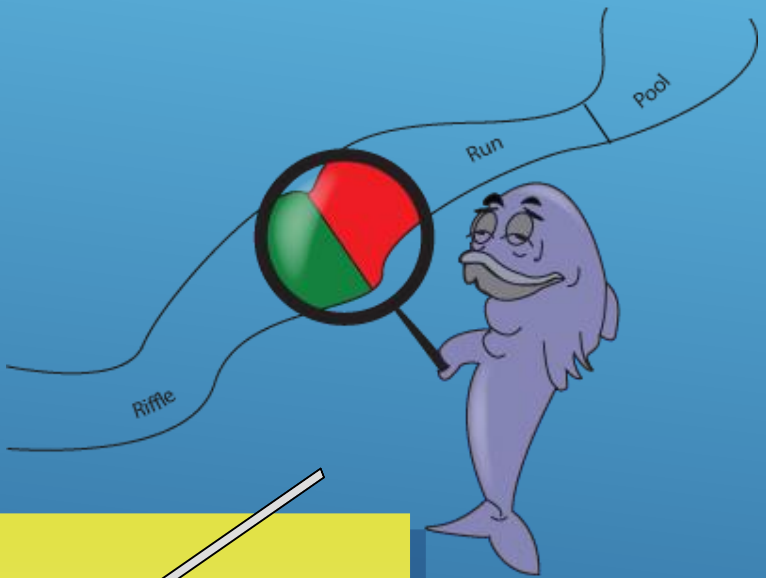
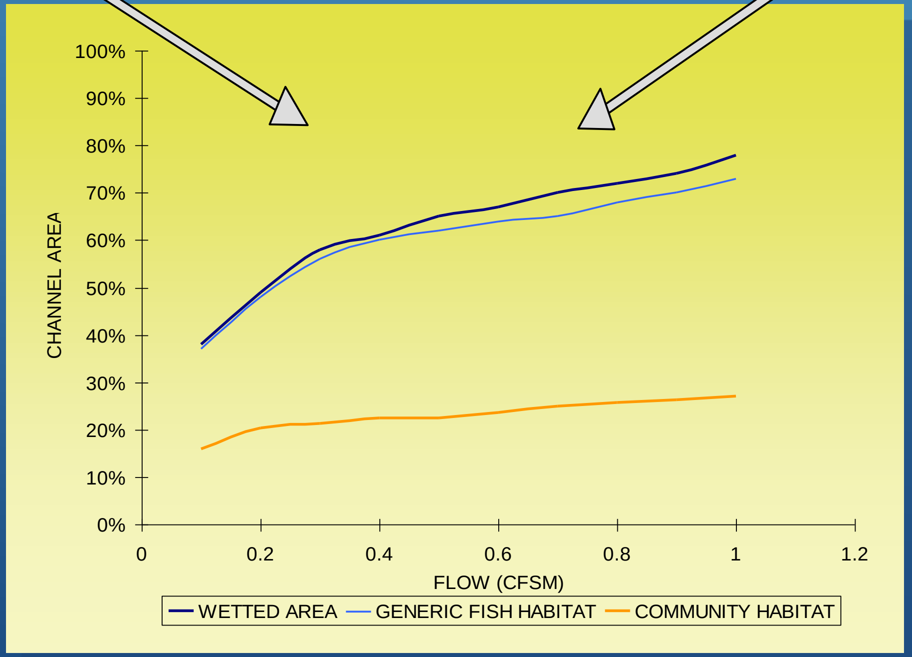
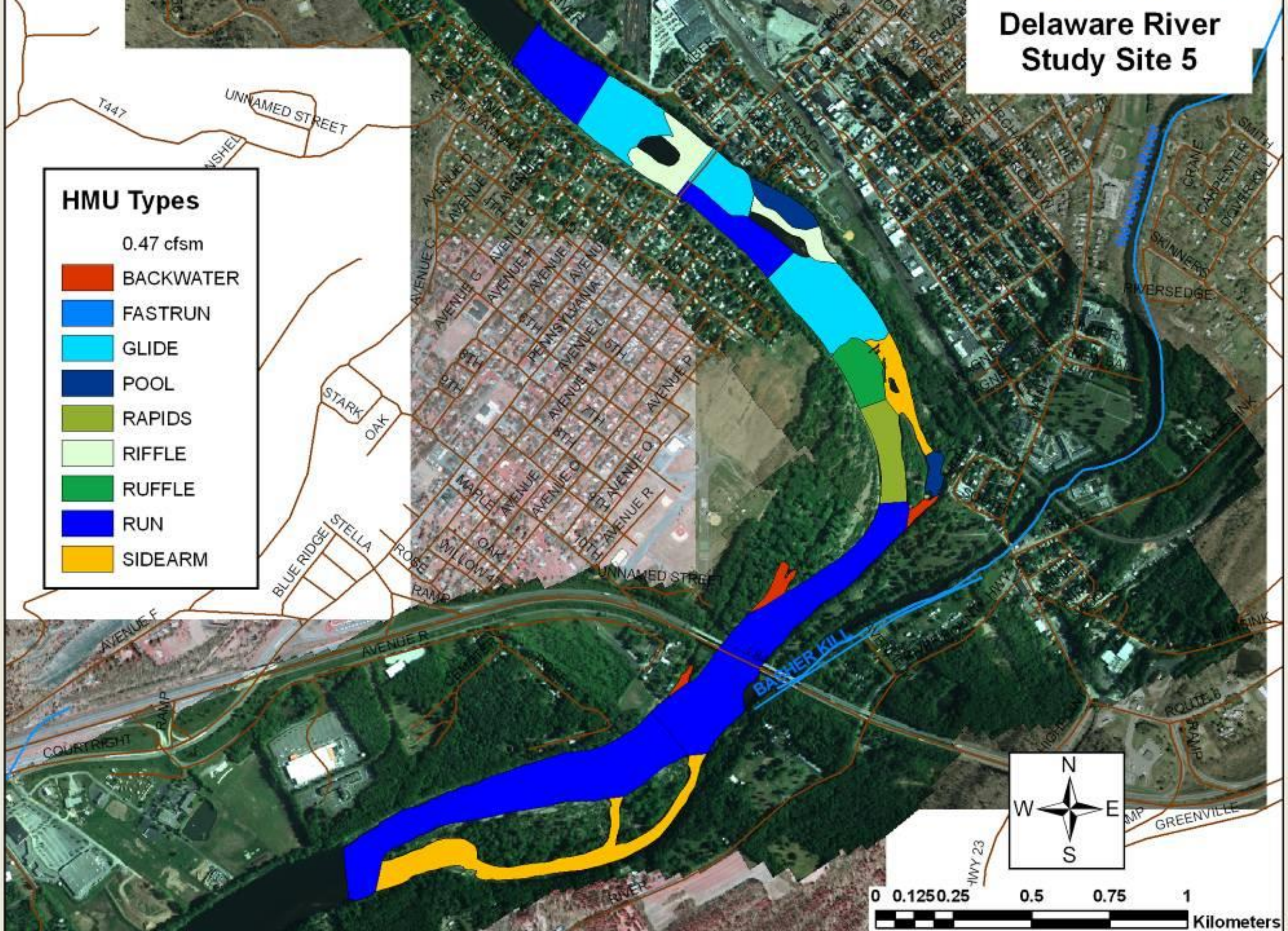
Ministerstwo Rolnictwa i Rozwoju Wsi

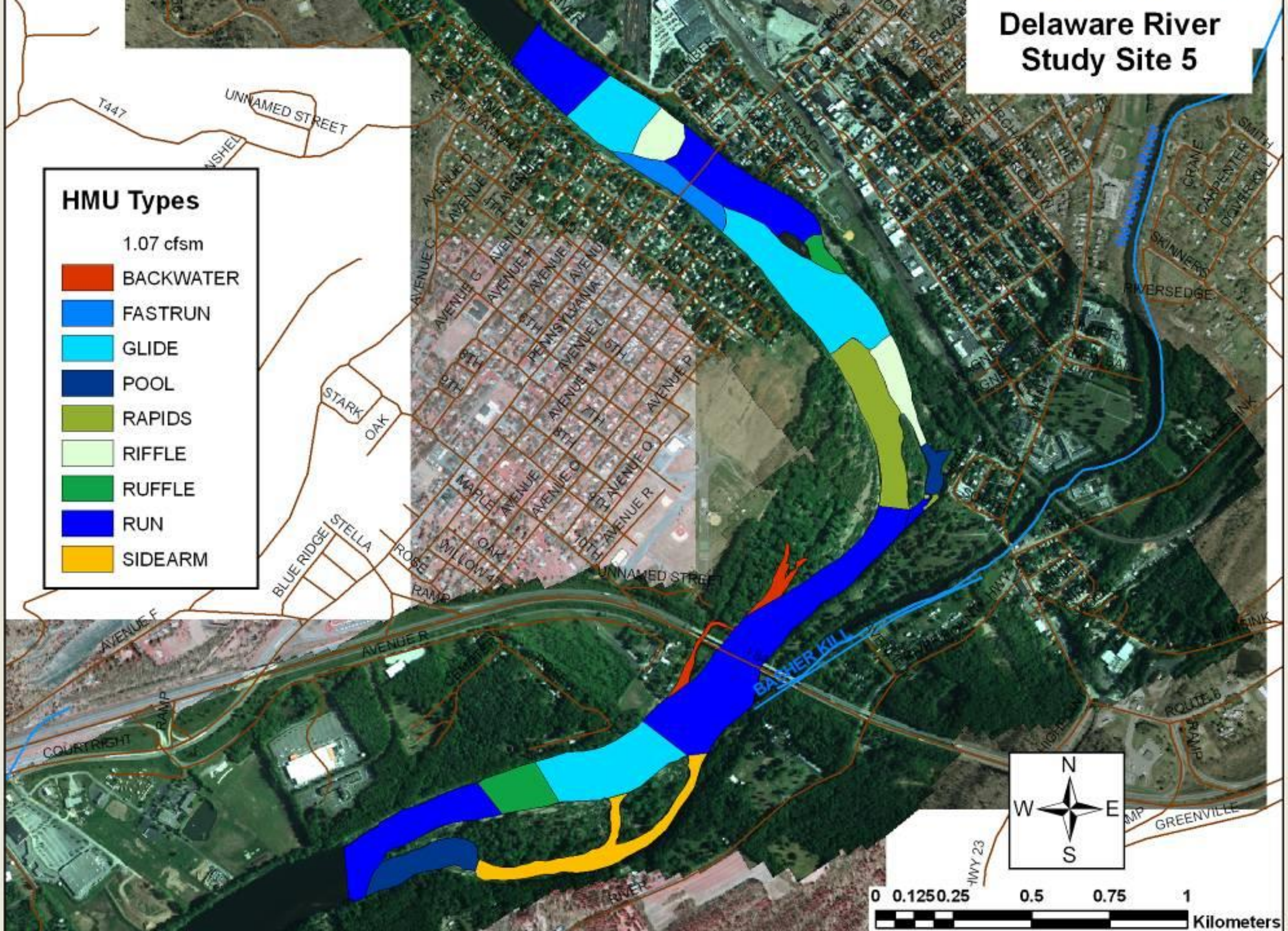
HABITAT MODELS: MESOHABSIM



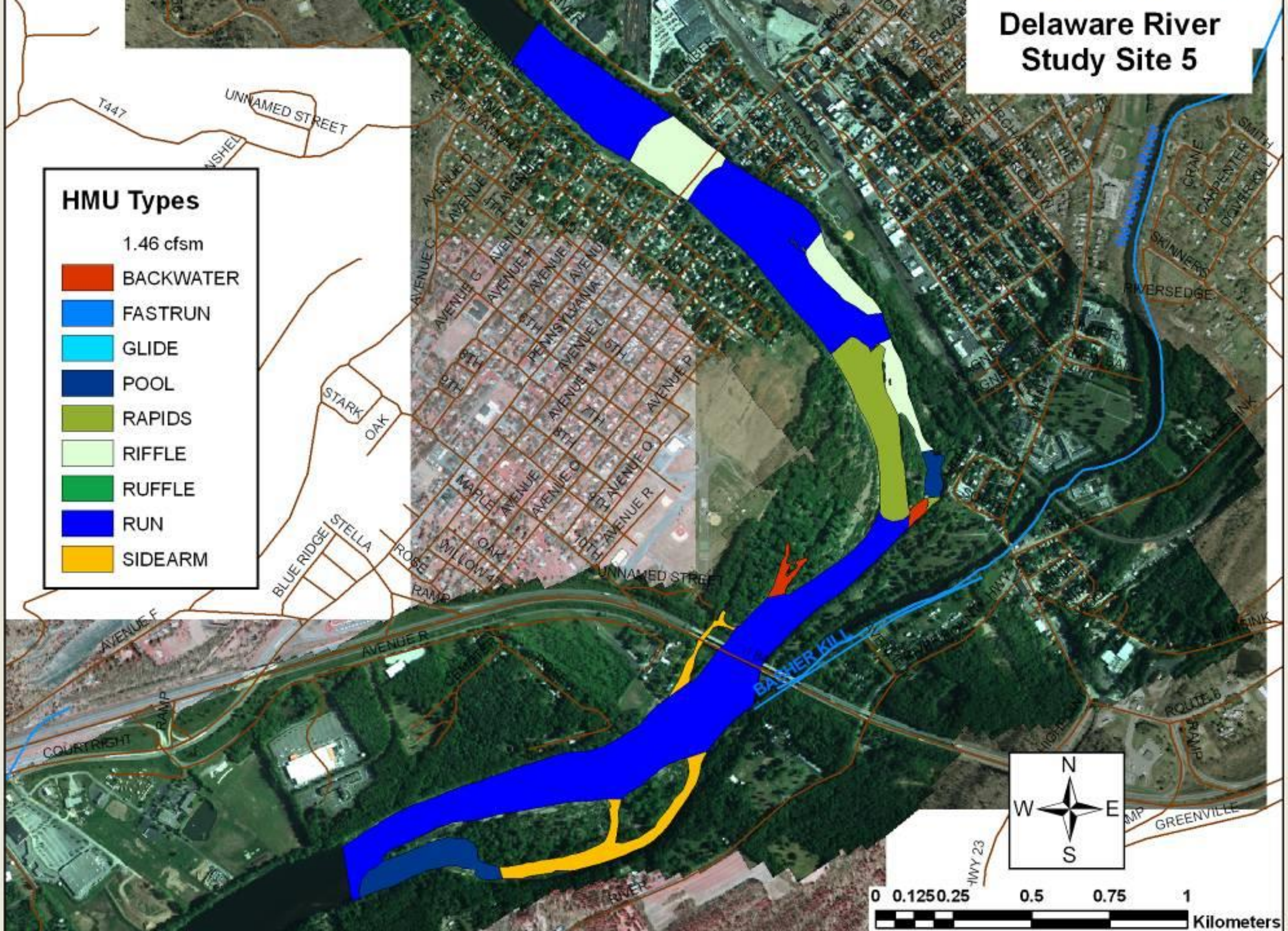





Delaware River
Study Site 5
HMU Types
0.47 cfsm
BACKWATER
FASTRUN
GLIDE
POOL
RAPIDS
RIFFLE
RUFFLE
RUN
SIDEARM
N
W
E
S
0 0.125 0.25 0.5 0.75 1
Kilometers



Delaware River
Study Site 5
HMU Types
1.07 cfsm
BACKWATER
FASTRUN
GLIDE
POOL
RAPIDS
RIFFLE
RUFFLE
RUN
SIDEARM
N
W
E
S
0 0.125 0.25 0.5 0.75 1
Kilometers

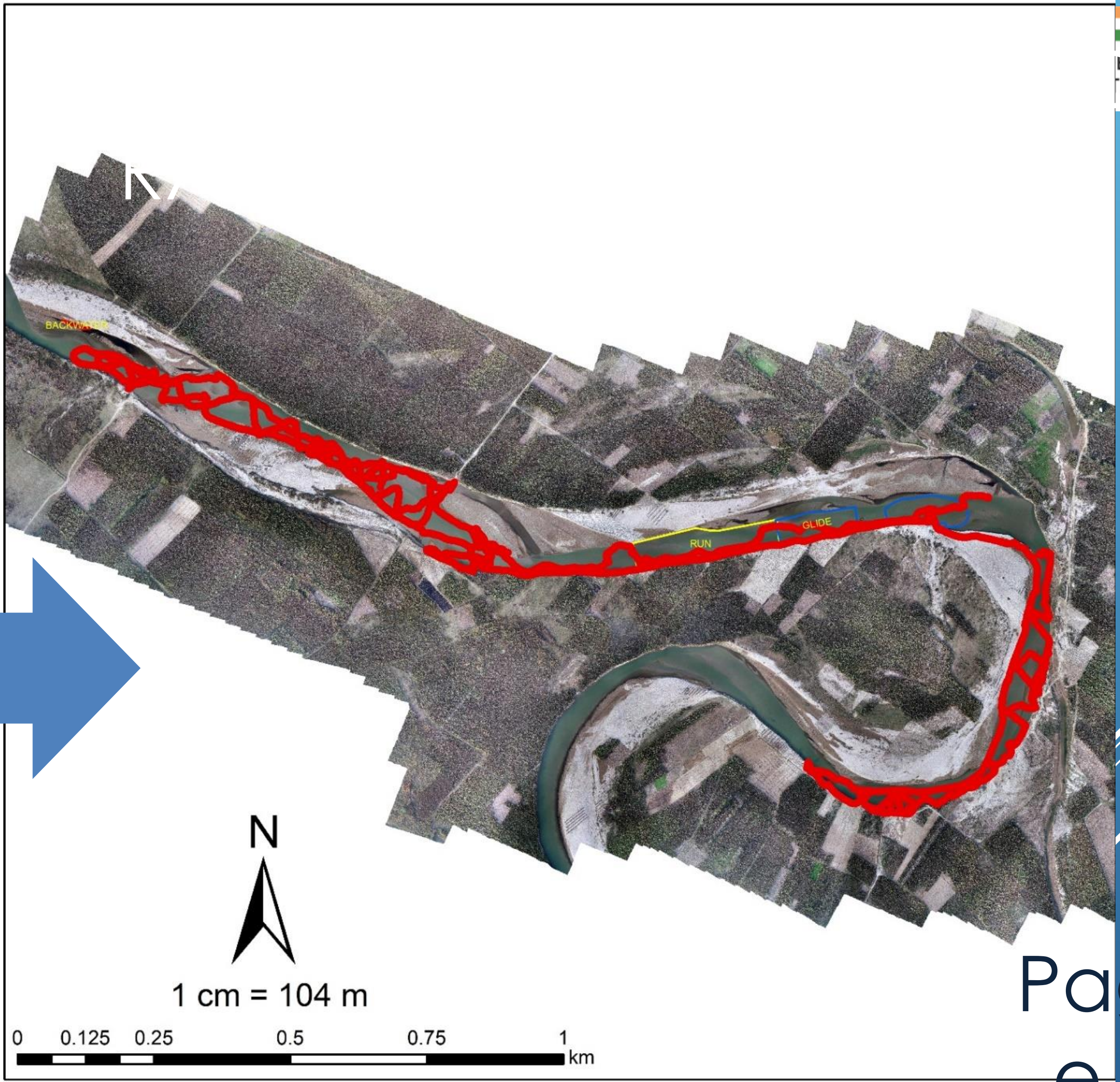

Delaware River
Study Site 5
HMU Types
1.46 cfsm
BACKWATER
FASTRUN
GLIDE
POOL
RAPIDS
RIFFLE
RUFFLE
RUN
SIDEARM
N
W
E
S
0 0.125 0.25 0.5 0.75 1
Kilometers

Co-funded by the European Union

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by giz

Hydraulic survey



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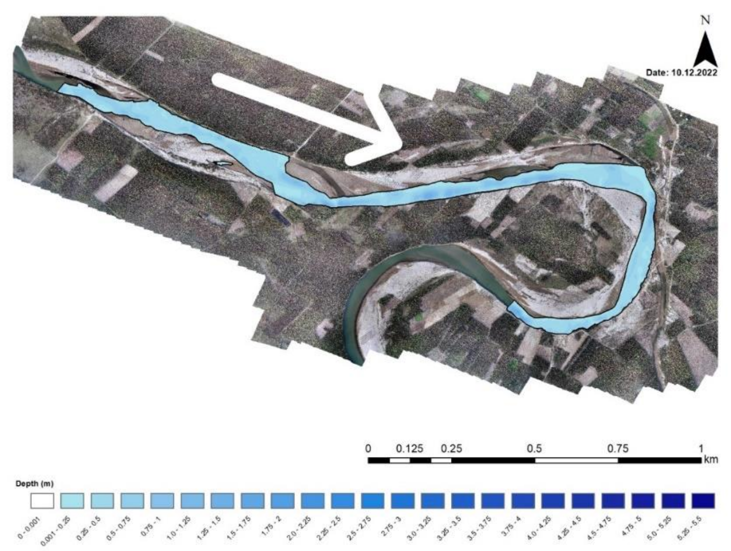
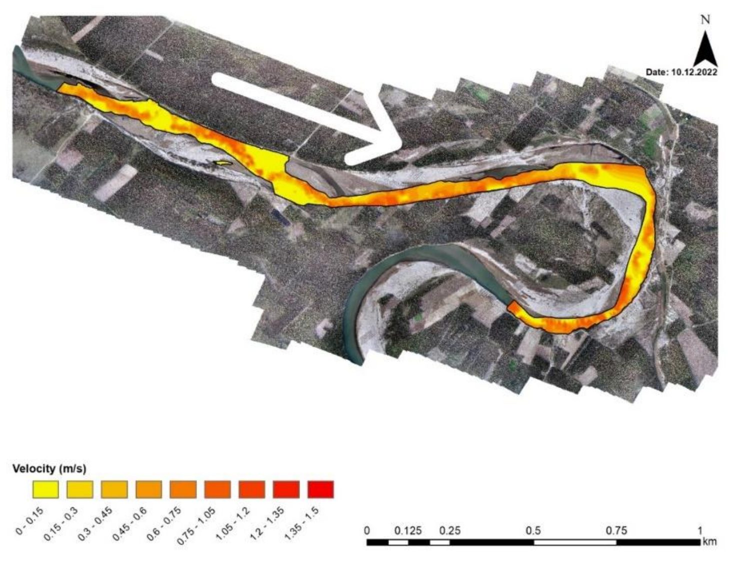
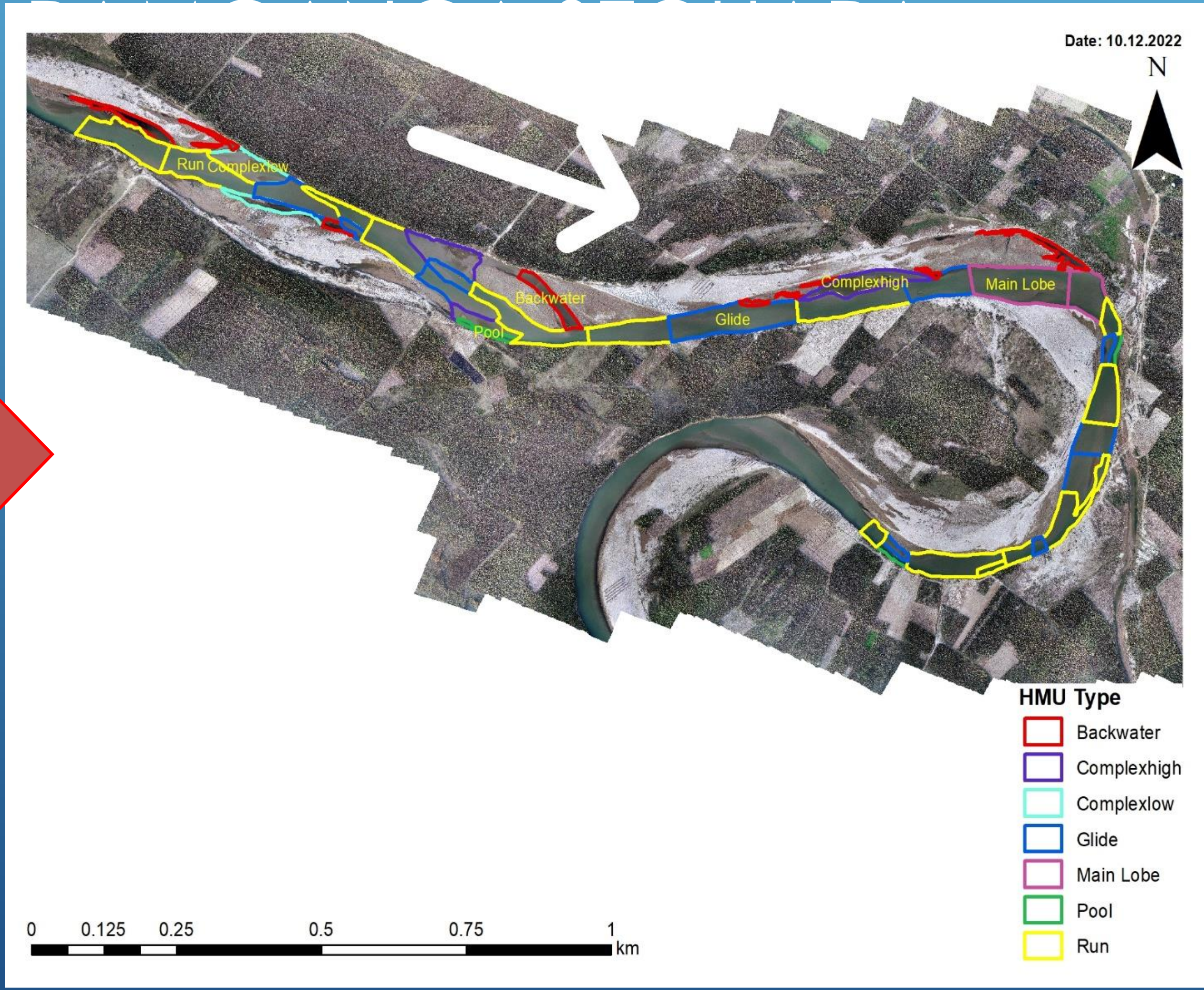
MAPPING HYDROMORPHOLOGIC UNITS

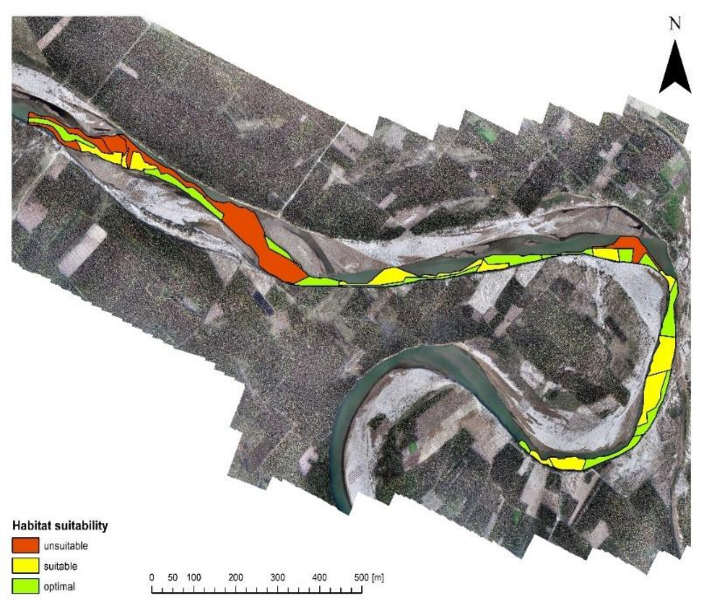




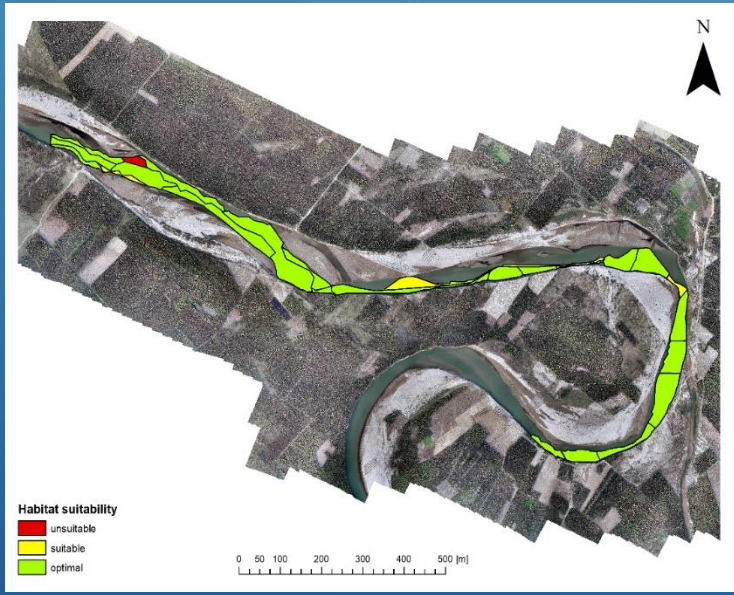


HMUS SUITABILITY FOR RHEOPHILIC WATER COLUMN SAND GRAVEL SPECIES OF THE RAMGANGA RIVER REACH AT SEOHARA.

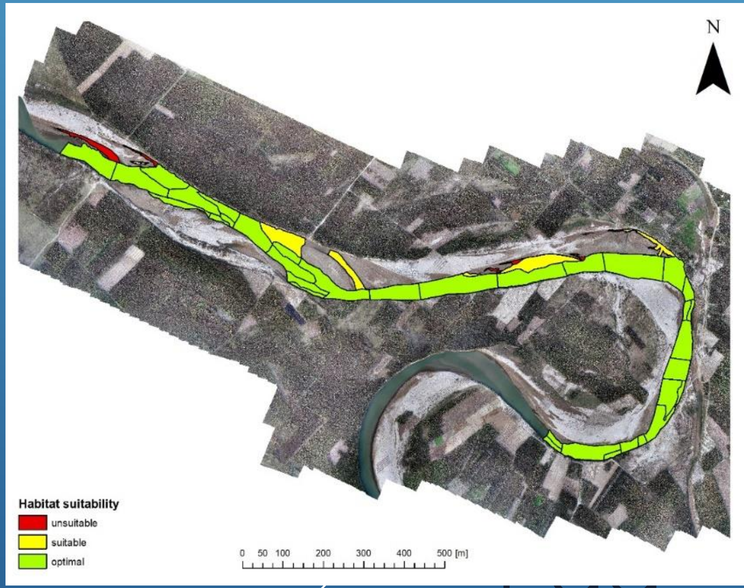
1.5 m^3s^{-1}



4.5 m^3s^{-1}



11 m^3s^{-1}



Alpine streams in Valle d'Aosta

Photos: Paolo Vezza

GOAL: REDUCED EFFORT OF HABITAT SURVEYS TO ONE MAPPING

- 0.5 m^{3}s^{-1}

1.5 m^{3}s^{-1}

2 m^{3}s^{-1}

BACKGROUND, CHALLENGES AND REASEARCH OBJECTIVES

Background

- MesoHABSIM habitat model → widely used in river management
- Hydromorphological unit (HMU) mapping across different flow conditions

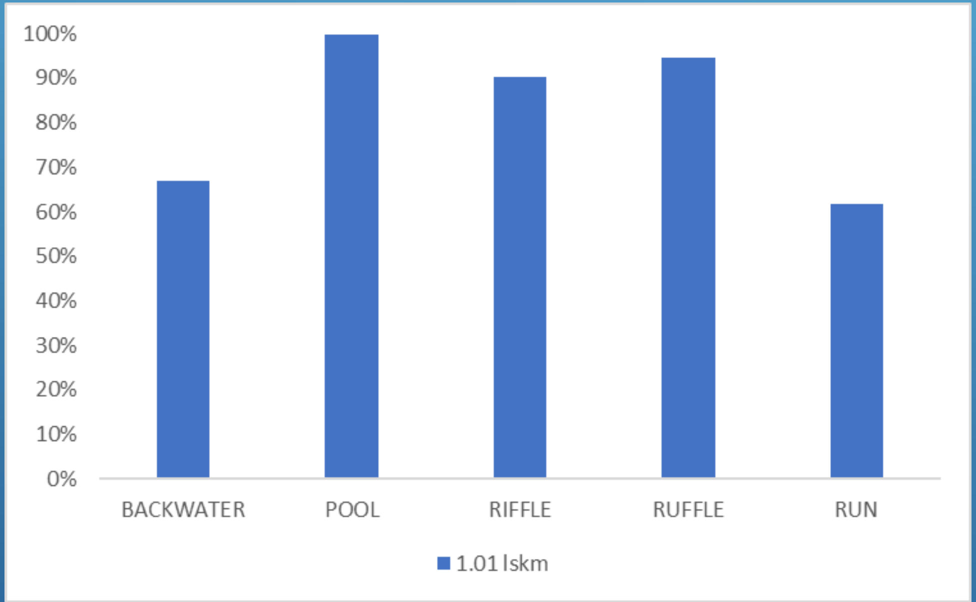
Challenges

- Complex and labour-intensivefieldwork

Research objective

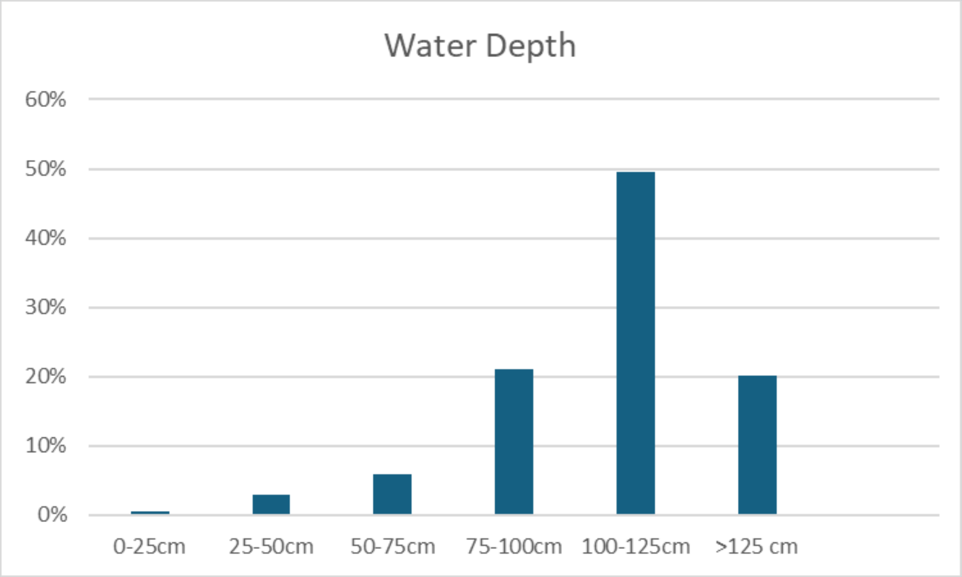
- Develop a statistical model to simulate HMU and hydraulic distributions for multiple flows by transferring change functions from one site to other sites

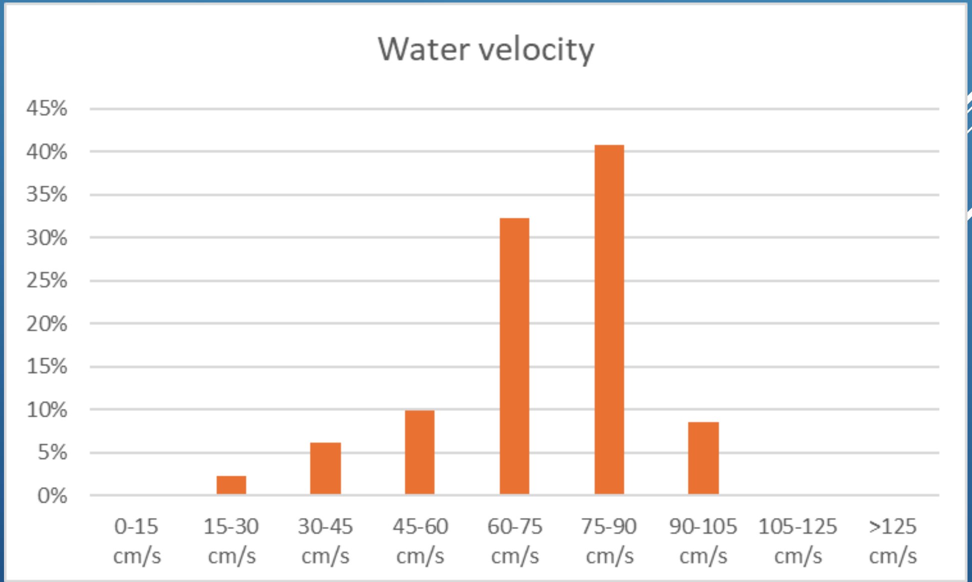
HMU



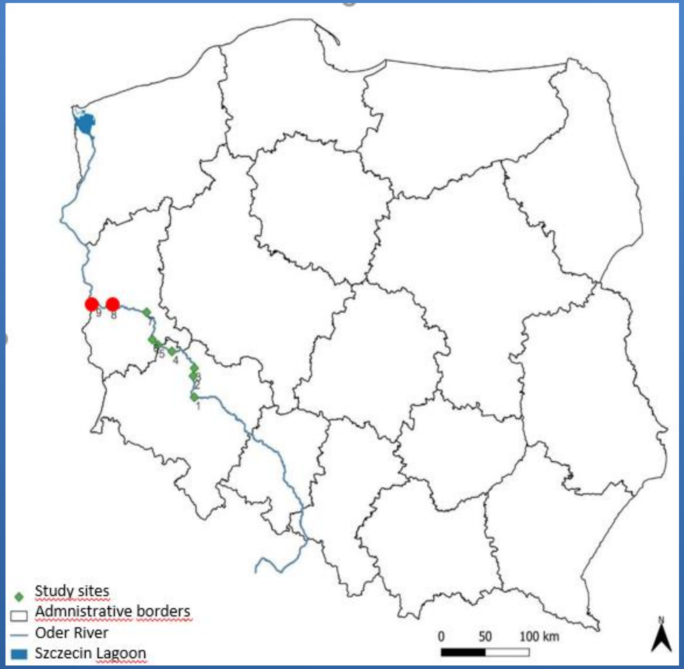
MODELLED PARAMETERS

Depth and velocity

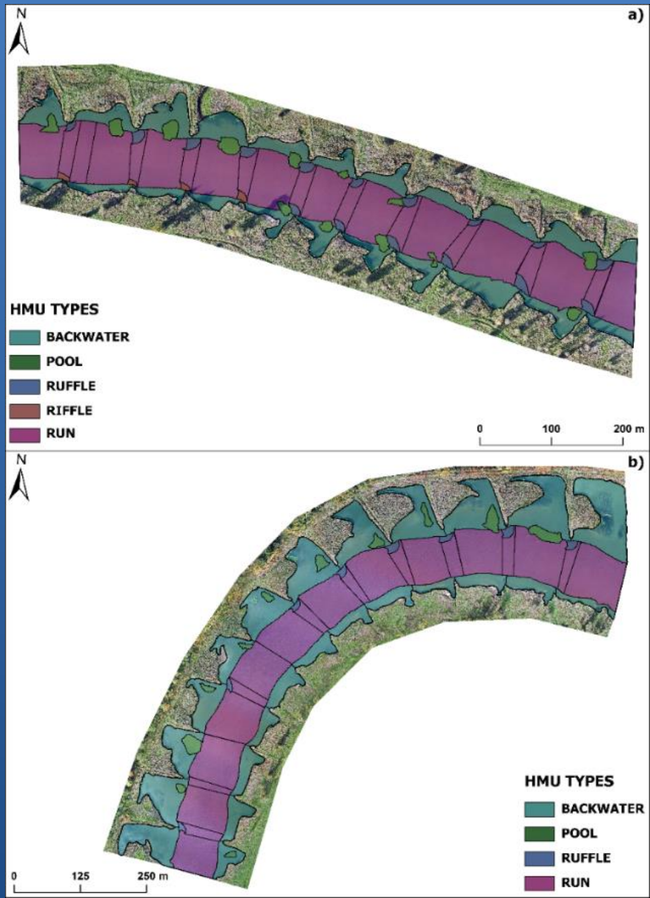




MODEL APPLICATION ON THE ODER RIVER

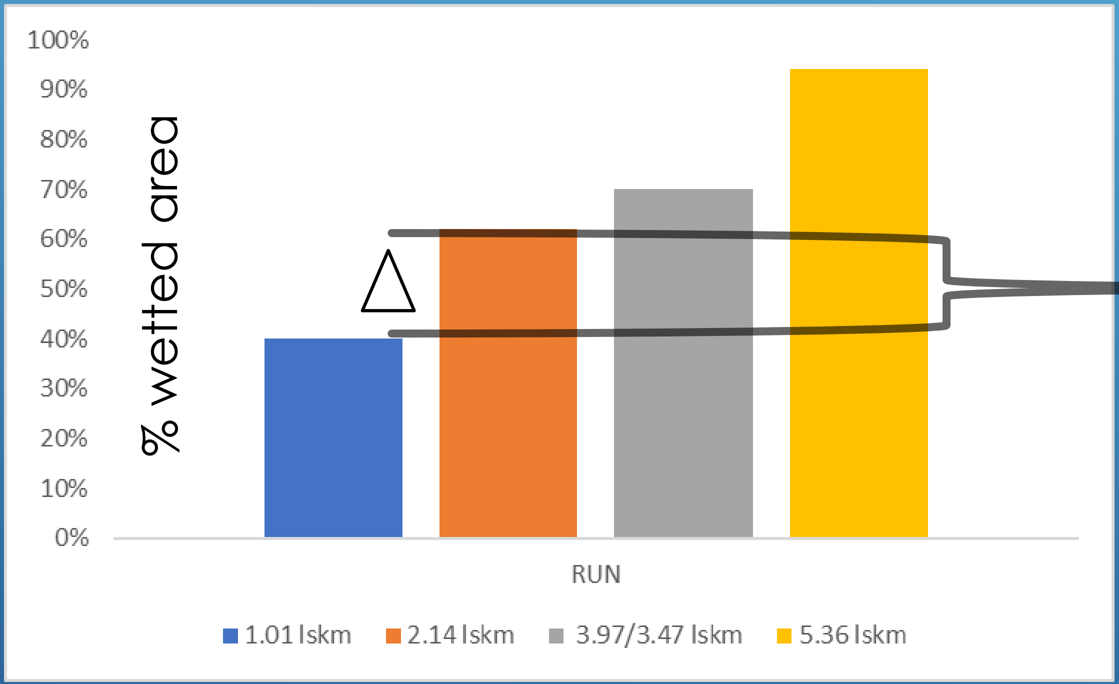


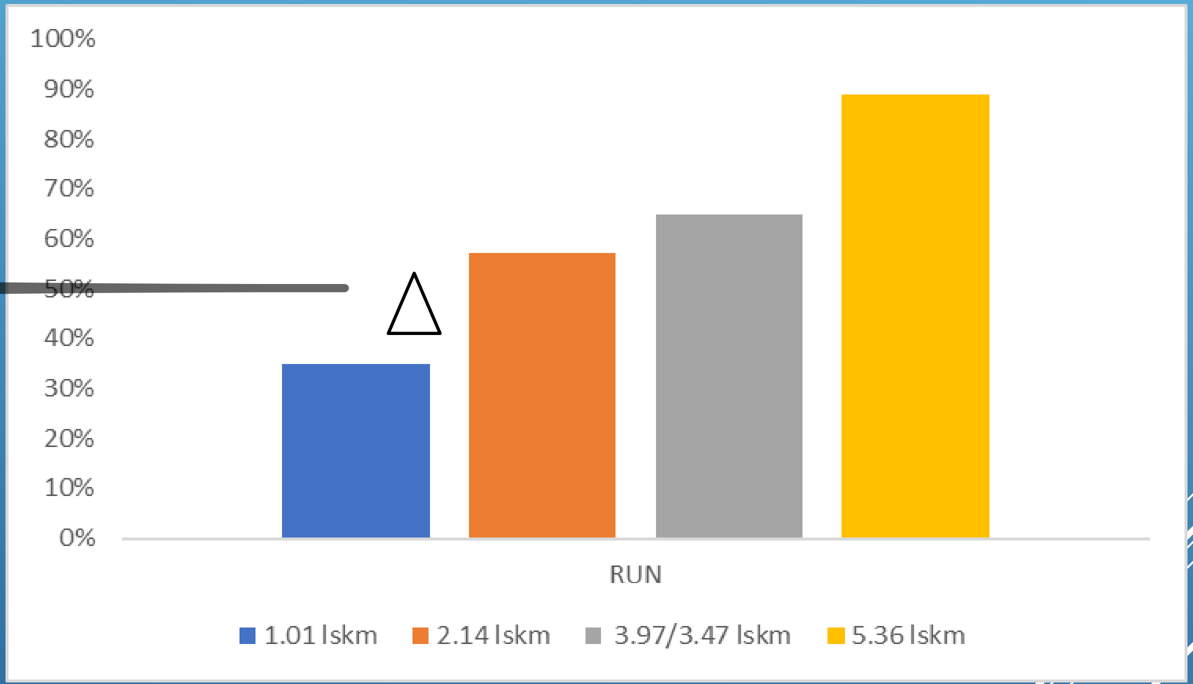
- Historic groynes present at both sites, built for bank stabilization
- 2017 Total number of sites mapped once = 9
- 2022 Two 1-km segments on the Oder River:
- Osiecznica: Straight channel with minimal meandering
- Szydłów: Morphologically diverse, meandering channel



- Flow at reference conditions:
  - Osiecznica: 185 m^3/s (3.97 $l/s/km^2$)
  - Szydłów: 162 m^3/s (3.47 $l/s/km^2$)
  - ADCP
  - Drone surveys
  - River2D → 1.07, 2.14, 3.47, 3.97, and 5.36 $l/s/km^2$

Source site (f) | Target site (g)





PRINCIPLE OF THE MODEL

$$g_i^0(q) = g_i(q_b) + f_i(q) - f_i(q_b).$$

Test feasibility of statistical model allowing to transfer quantitative HMU and hydraulic distribution to unmapped flows.

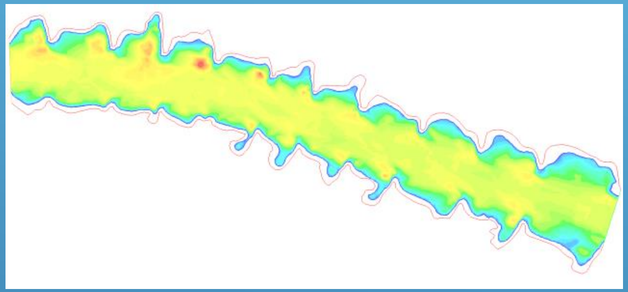
PROJECT OBJECTIVE

Osiecznica Site on Odra River

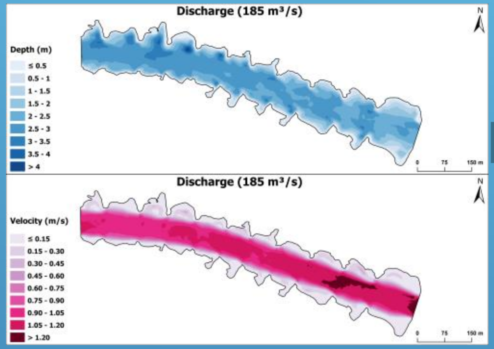
Szydłów Site on Odra River

1. Data collection

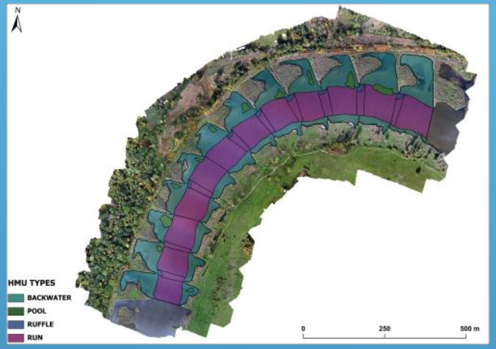
2. River2D Hydrodynamic simulation 4 flows



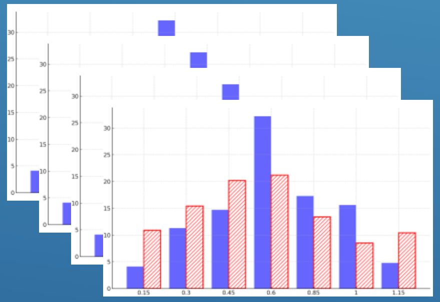
3. Depth and velocity maps @4 flows



4. HMU mapping @ 4 flows

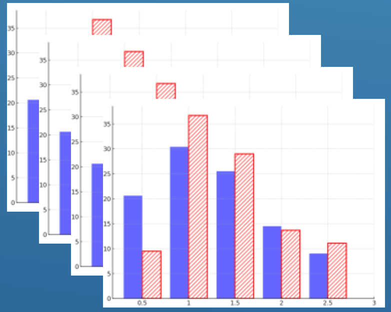


5. HMU, Depth and velocity distribution Site 1



$$g_i^0(q) = g_i(q_b) + f_i(q) - f_i(q_b).$$

6. HMU, Depth and velocity velocity distribution Site 2



7. Validation Mesohydraulics vs. River2D

Percent Model Affinity (Novak and Bode 1992)

Percent similarity = 100 – 0.5 (sum $|P_t - P_e|$)

MODEL PERFORMANCE TEST AND VALIDATION

PERCENT SIMILARITY = 100 – 0.5 (SUM $|P_T – P_E|$)

NOVAK AND BODEE 1992

Flow (l/s/km²)	Area (%)	<25 cm	25–50 cm	50–75 cm	75–100 cm	100–125 cm	>125 cm	<15 cm/s	15–30 cm/s	30–45 cm/s	45–60 cm/s	60–75 cm/s	75–90 cm/s	90–105 cm/s	>105 cm/s	Average (%)
1.07	66 %	93 %	87 %	64 %	90 %	84 %	95 %	98 %	89 %	91 %	99 %	94 %	97 %	81 %	22 %	83 %
2.14	92 %	99 %	92 %	95 %	81 %	94 %	89 %	100 %	95 %	86 %	89 %	92 %	96 %	93 %	89 %	89 %
3.97 / 3.47	97 %	100 %	100 %	100 %	98 %	98 %	100 %	100 %	97 %	97 %	98 %	99 %	100 %	100 %	100 %	99 %
5.36	84 %	100 %	100 %	50 %	93 %	97 %	92 %	97 %	94 %	86 %	82 %	95 %	69 %	89 %	99 %	88 %

MODEL PERFORMANCE TEST AND VALIDATION

Depth Distribution

- Highest accuracy at base flow (3.47 l/s/km²): 99.05%
- Lowest accuracy at low flow (1.01 l/s/km²): 83%
- Best HMU match: Pool (avg. 99.31%)
- Most inconsistent: Backwater (69.93%) and Run (79.08%)

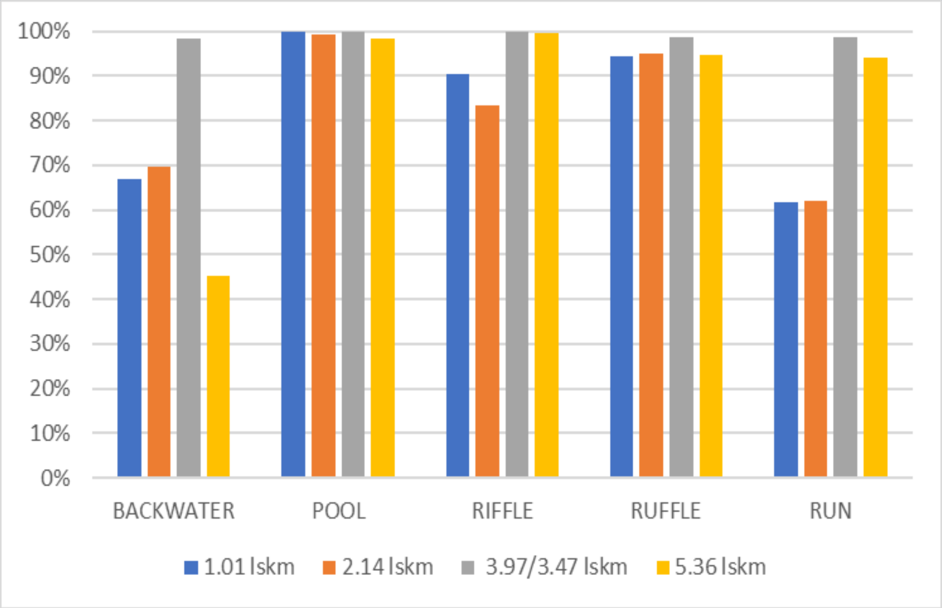
Velocity Distribution

- Best accuracy at 3.47 l/s/km²: 97.89%
- Lowest at 1.01 l/s/km²: 71.83%
- Best matching HMU: Backwater (95.02%)
- Least accurate: Run unit (70.96%)

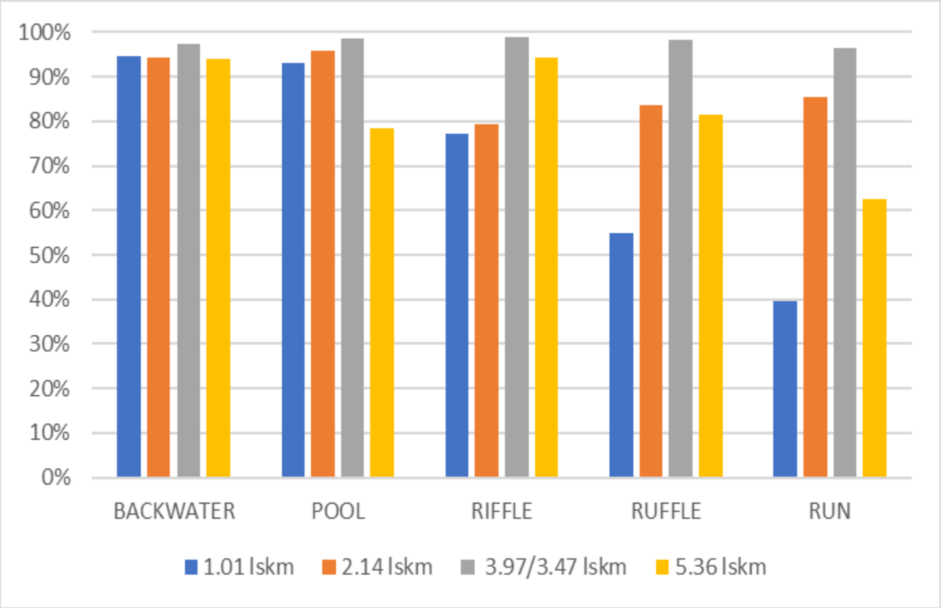
$$\text{PERCENT SIMILARITY} = 100 - 0.5\,(\text{SUM}\,|P_T - P_E|)$$

NOVAK AND BODEE 1992

Depth



Velocity



CONCLUSIONS

- MesoHydraulic model gave high accuracy (~90%) vs. River2D
- Best performance at base flows; less accurate at extremes
- Pool units are most stable; Run and Backwater more variable
- Morphology strongly influences model reliability
- Suitable for regulated rivers and flow assessments
- Future work: test on diverse rivers, improve extreme flow predictions


THANK YOU!