A Northern Saskatchewan Case Study

IMPROVING FISH HABITAT SUITABILITY ASSESSMENTS

Amy Wiebe, Sauvelm McClean, Daniel Vicente, Jackie Lukey

Overview

- Habitat Suitability Indices (HSIs) for Riverine Fish
- Hydrodynamic Modelling
- Our Approach
  - Geographic Information Systems (GIS) Tools
  - Quantification of Habitat Types
  - Geo-referenced Map Products
- Case Study: Arctic Grayling in the Fond du Lac River, Saskatchewan

HSIs: Riverine Fish

- A method for classifying and comparing habitat types based on the preferences of the species and life stages of interest
  - Eggs, age-0, juvenile and adult fish
  - Spawning, rearing, foraging and overwintering habitat types

- Numerical indices of habitat suitability that exist on a continuous scale ranging from 0 to 1
  - 0 = unsuitable, 0.5 = moderate, 1 = highly suitable
  - Individual habitat variables (e.g., depth, velocity) at discreet spatial locations are assigned a suitability index (SI) value
  - Overall HSI values are calculated by combining the Sis assigned to the habitat variables:

E.g., Overall HSI = the minimum of SI_{Depth}, $SI_{Velocity}$, $SI_{Substrate}$

HSIs: Riverine Fish

- HSIs are a well-developed tool and have a number of applications:

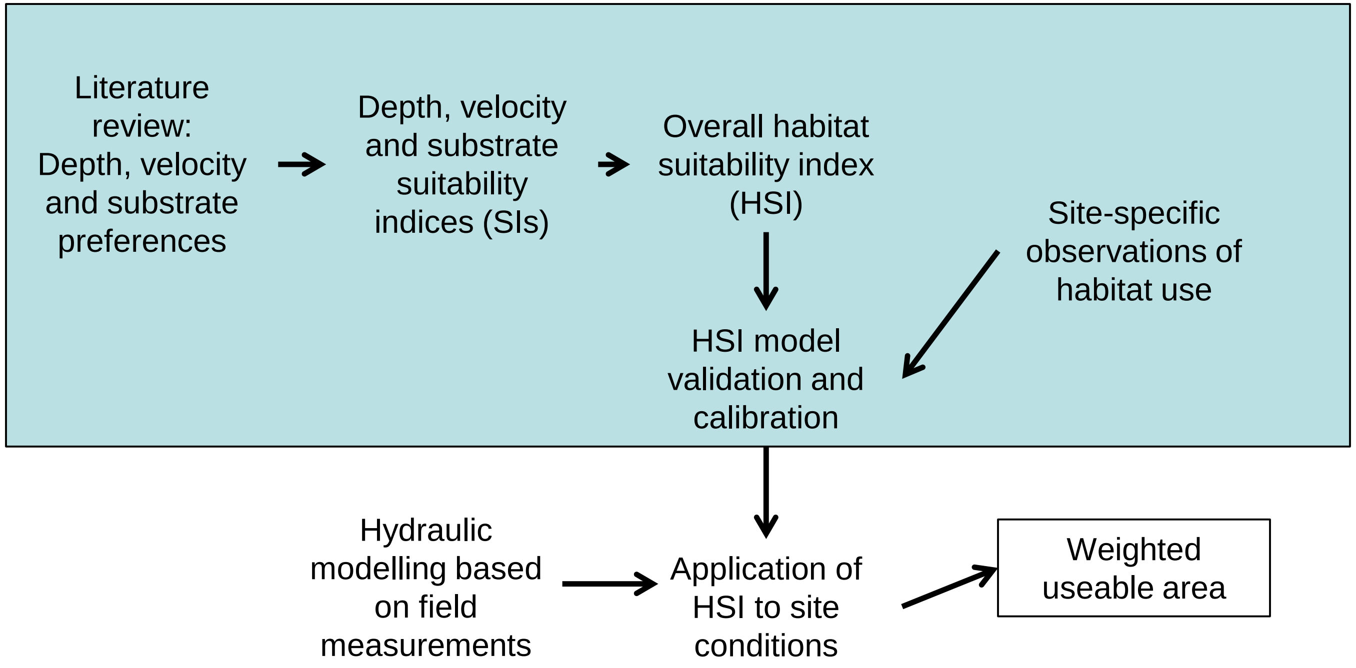
Channel diversions
Water withdrawal and discharge
In-water construction and infrastructure footprints
Habitat restoration efforts

Baseline programs
Environmental Impact Statements
Fisheries Offsetting
Monitoring

HSIs: Riverine Fish

- Literature Review
  - Habitat preferences of species and life stage of interest
    - Depths, velocities, substrates
  - Comparable environments

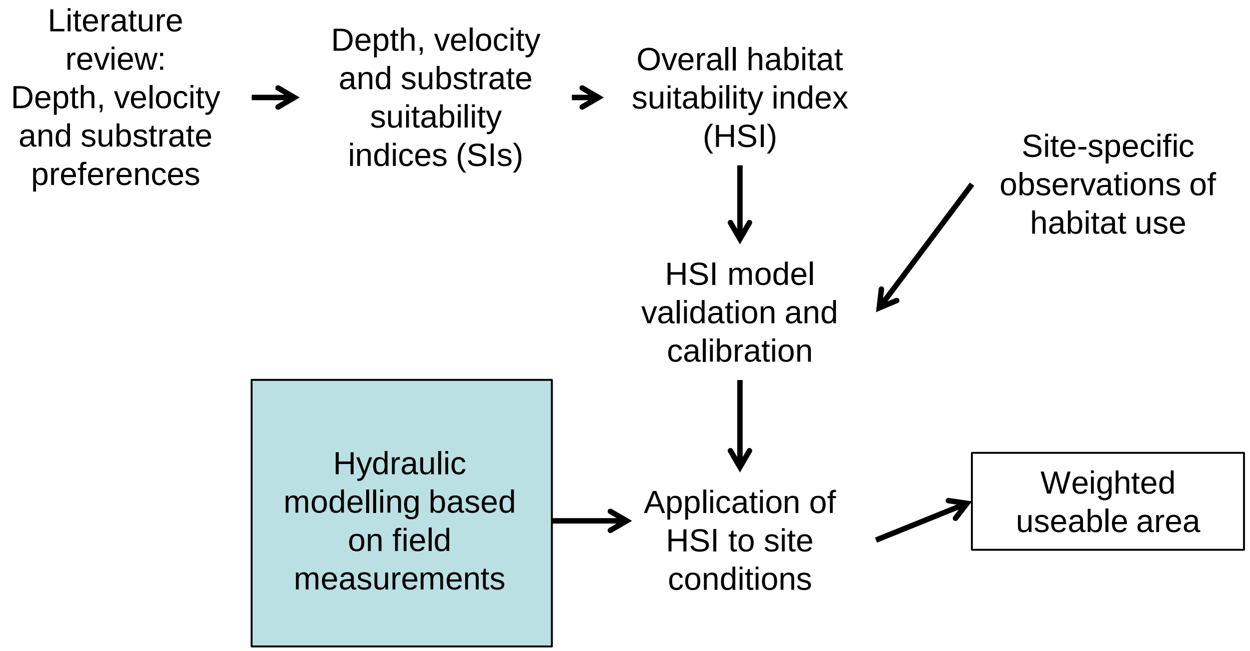
- Field Data
  - Measurements/observations of depth, velocity and substrate
  - Water levels and discharges
  - Fish use and fish capture data



Hydrodynamic Modelling

- Field Data
  - Bathymetric data
  - Water levels and discharges

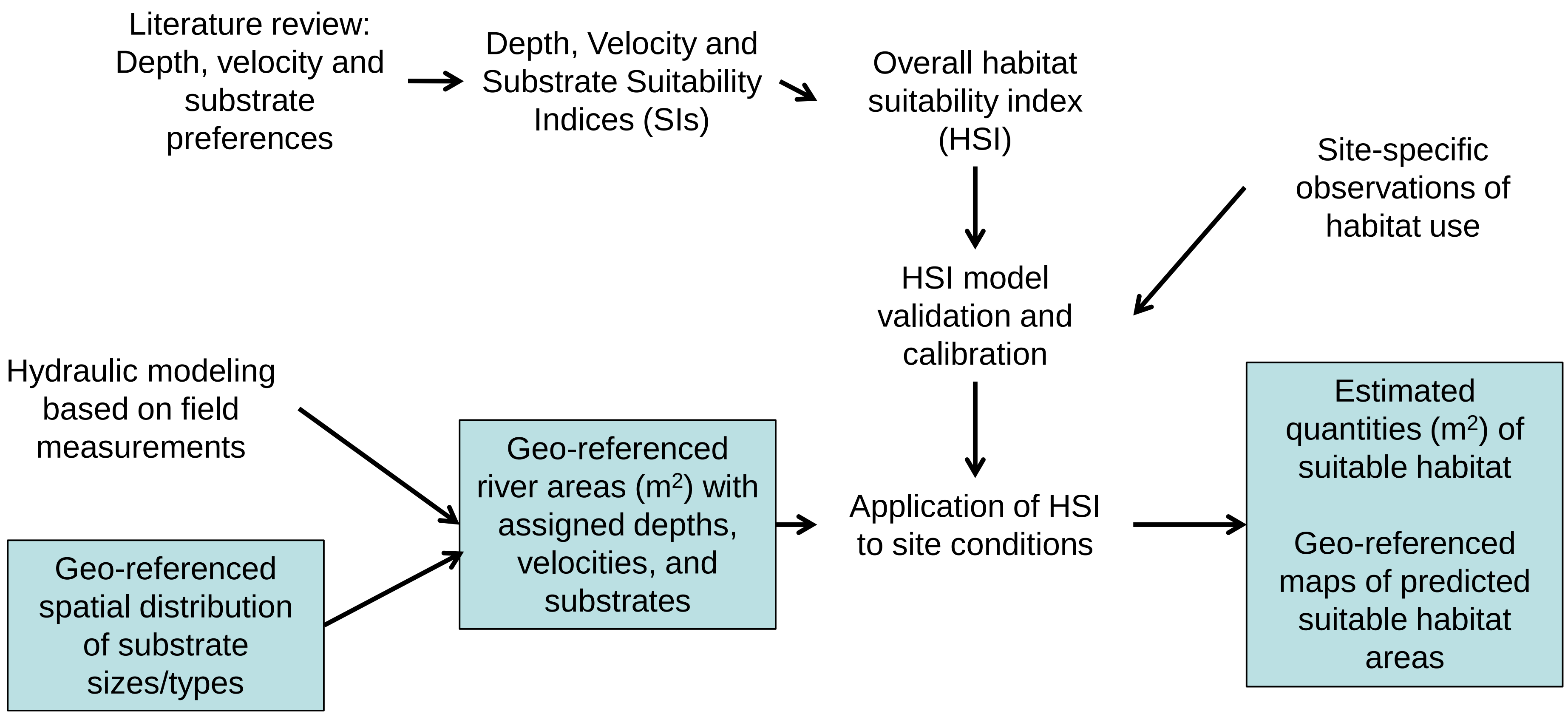
- Modelling: River2D
  - Depths and velocities at computational nodes
  - **Weighted useable area is computed for entire study reach**
    - Small areas of high quality habitat can have same WUA value as larger areas of poor habitat



Our Approach

Hydrodynamic Modelling Coupled with a Geographic Information Systems (GIS) Platform

Our Approach

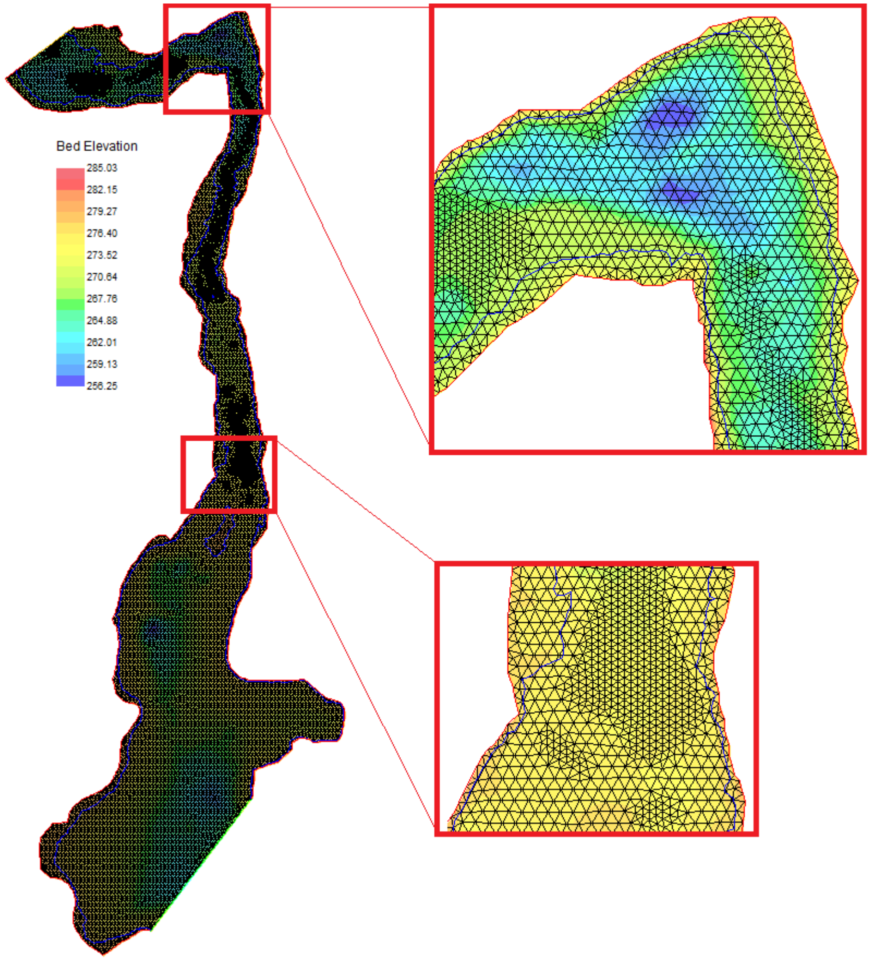


Our Approach

Our Approach	Weighted Useable Areas (WUAs) in River2D
▪ Allows for more thorough QA/QC and removal of suspicious/anomalous data points ▪ SIs and HSIs for multiple species and life stages can be assessed concurrently ▪ Areas (m^2) of unsuitable and suitable habitat can be compared quantitatively among flow scenarios ▪ Geo-referenced areas of unsuitable or suitable habitat can be mapped and compared to field data	▪ No QA/QC procedures to remove anomalous or suspicious data ▪ SIs and HSIs must be assessed separately for each species and life stage ▪ WUAs can be compared among flow scenarios ▪ Areas (m^2) of unsuitable versus suitable habitat cannot be quantified or compared ▪ WUA data is not geo-referenced, and cannot be mapped and compared to field data ▪ Small areas of good habitat can have same WUA as large areas of poor habitat

Our Approach

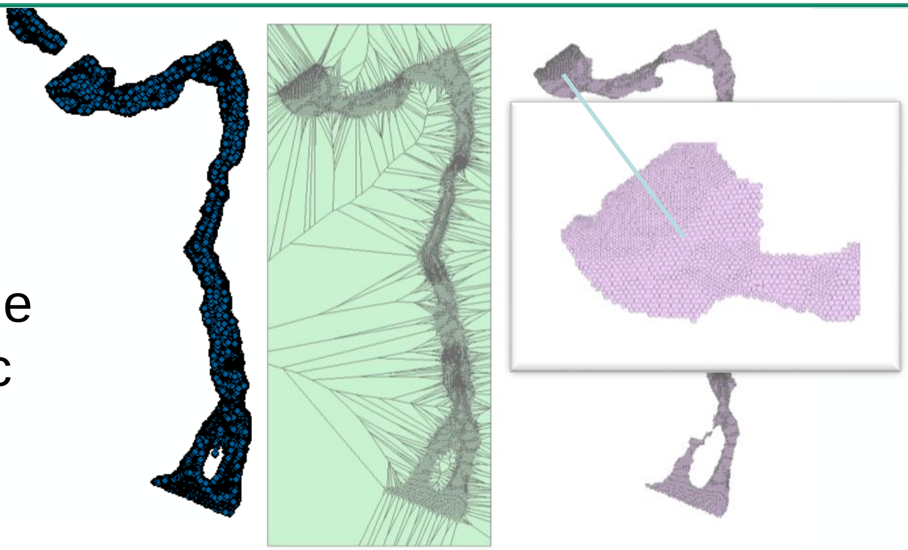
- River2D data are exported to a GIS platform
  - Each node in the mesh represents a geo-referenced depth/velocity pair



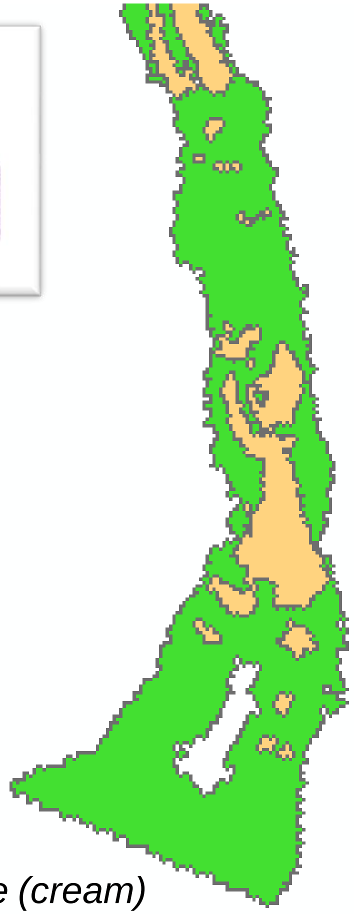
Sample computational mesh

Our Approach

- GIS
  - Each geo-referenced computational node (depth/velocity pair) in the hydrodynamic dataset is assigned a river area (m^2)
  - Spatial distributions of various substrate types are modelled based on hydrodynamic data and field measurements
    - Existing GIS substrate layer data can also be added



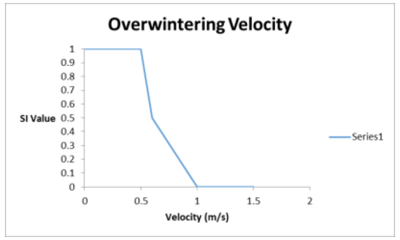
Thiessen polygon process for assigning areas (m^2) and controlling edge effects



Distributions of unsuitable (cream) and suitable (green) substrates

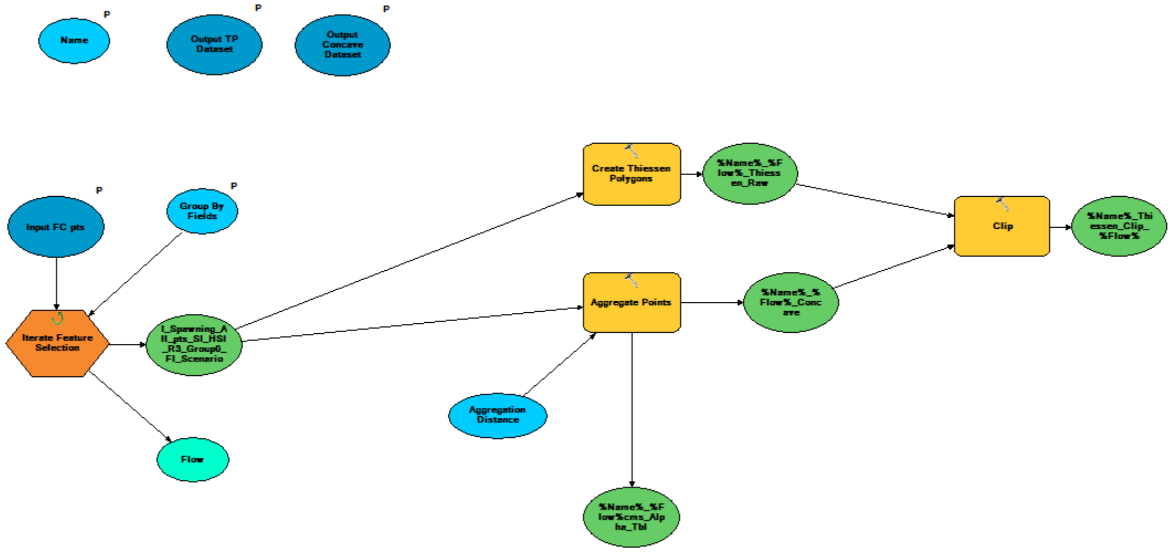
Our Approach

- Use Python (programming language) code with ArcPy (ArcGIS Python library and module)
- ArcGIS Model Builder for Thiessen Polygon output automation




```
def F1_Juv_V_SI(v): #Curve 1 for OW Velocity Juvenile
 SI = 0
 if v >= 0 and v <= 0.4999:
  SI = 1
 elif v >= 0.5 and v <= 0.5999:
  SI = (-4.995*v)+3.497
 elif v == 0.6:
  SI = 0.5
 elif v >= 0.6001 and v <= 0.9999:
  SI = (-1.25*v)+1.25
 elif v >= 1:
  SI = 0
 return SI
```

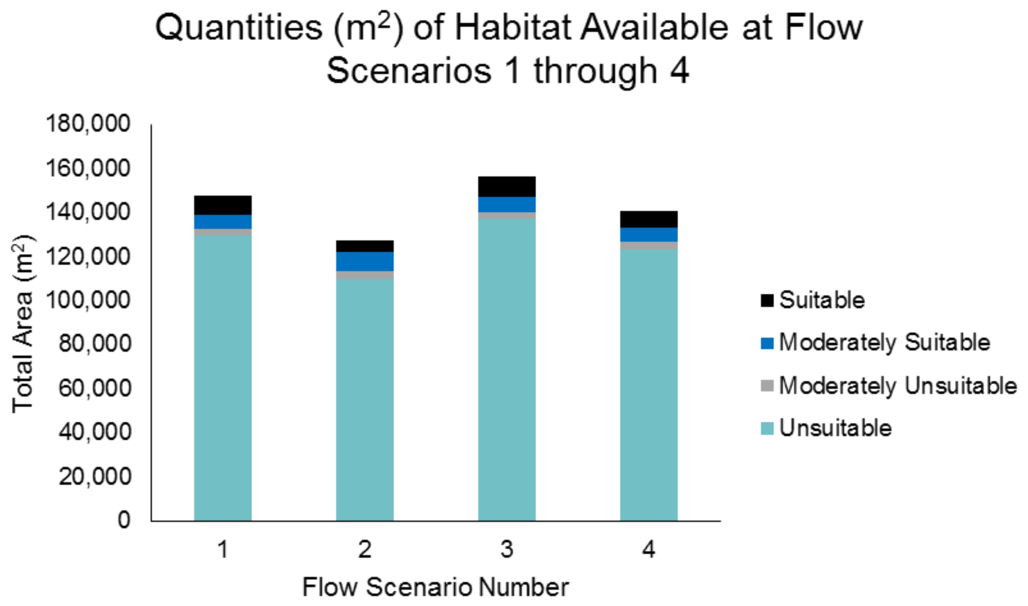
```
arcpy.AddMessage("Starting SI curve calculations...")
for field in fieldList_SI:
    try:
        if field.name[1:2] == "0":
            arcpy.AddMessage("Skipping F0 Case: " + field.name)
            pass
        else:
            #expression should be generated here to pass the depth and velocity values
            expression = "populate_SI('" + field.name + "',!" + str(depth) + "!,!" + str(velocity) + "!)"
            arcpy.AddMessage("Expression is: " + expression)

            arcpy.CalculateField_management(workingFC,field.name,expression,"PYTHON_9.3",codeblock_SI)
            arcpy.AddMessage(field.name + " Curve Value Calculation Complete")

    except Exception, e:
        import traceback
        map(arcpy.AddError, traceback.format_exc().split("\n"))
        arcpy.AddError(str(e))
```



Thiessen polygon output automation model

Our Approach

- GIS
  - HSI value for each portion of river area (m^2) calculated programmatically
    - Based on the combined depth, velocity and substrate suitabilities at each node
  - Areas classified into bins:
    - Range from unsuitable (HSI ≈0) to highly suitable (HSI ≈1)
    - Total area (m^2) assigned to each bin is quantified
  - Geo-referenced areas (m^2) of moderate to high suitability are mapped

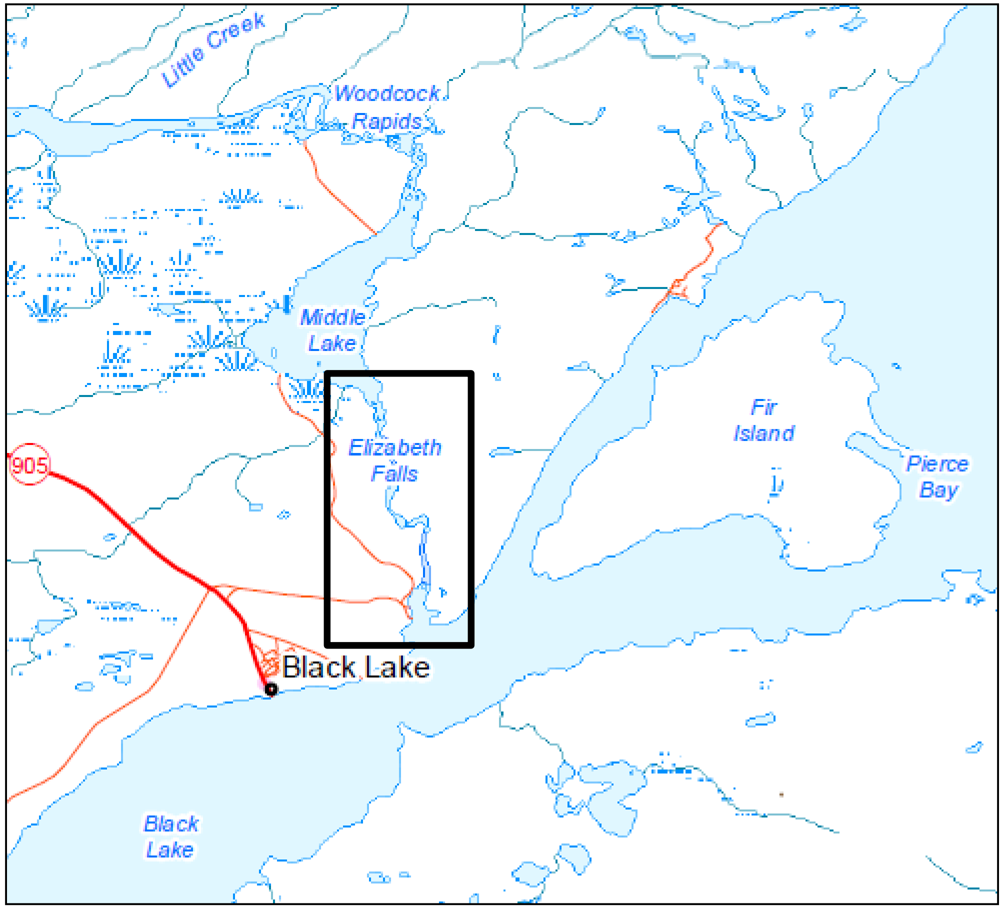


Northern Saskatchewan Case Study

Arctic Grayling (*Thymallus arcticus*) Spawning Habitat in the Fond du Lac River

Case Study: Spawning Arctic Grayling

- Study Area:
  - Fond du Lac River between Black Lake and Middle Lake, SK
  - Average annual discharge: 305 m^3/s
- Arctic grayling populations:
  - Support local recreational and Aboriginal fisheries
  - Spawn in the river (spring)
    - Quantity and quality of spawning habitat depends on flow conditions



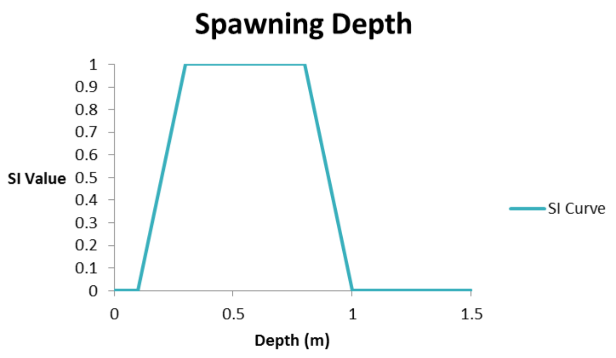
Golder Associates

Objective:

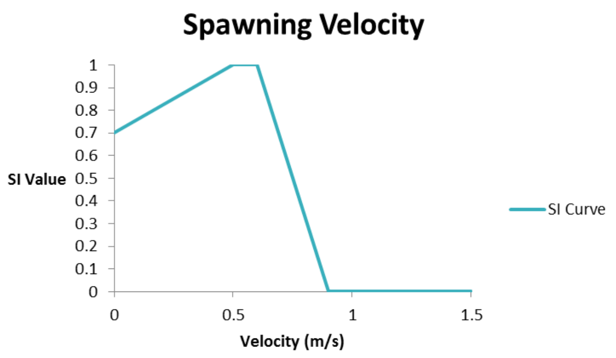
Determine the quantity, quality and location of spawning habitats available to Arctic grayling in the Fond du Lac River at low versus average spring flows

Case Study: Spawning Arctic Grayling

- Depth, velocity and substrate are key variables for assessing spawning habitat suitability for Arctic grayling
  - Literature review
  - Field-collected data
    - Validation and calibration



- River2D outputs
  - Geo-referenced distributions of depths and velocities
    - Low (302 m^3/s) and average (400 m^3/s) spring flows



Case Study: Spawning Arctic Grayling

- Portion of river area (m^2) assigned to each computational node
- Substrate distribution modelled based on hydrodynamic data and field measurements
- HSI value for each portion of river area (m^2) calculated programmatically
- Areas classified into bins and summed, based on assigned suitability
- Geo-referenced areas (m^2) of moderate to high suitability are mapped

Case Study: Spawning Arctic Grayling

- Quantities (m^2) of unsuitable and suitable habitat types available at a low versus average flow year?
  - 2.06 km section of river immediately downstream of Black Lake

Habitat Classification or Metric		Area (m^2)		% Change
		Average Spring Flow 400 m^3/s	Q10 Average Low Spring Flow 302 m^3/s	
0.0000-0.2500	Unsuitable	136,916	129,565	-5.4
0.2501-0.5000	Moderately Unsuitable	3,206	3,135	-2.2
0.5001-0.7500	Moderately Suitable	7,092	6,313	-11.0
0.7501-1.0000	Suitable	9,355	8,910	-4.8
Total Wetted Area of Assessment Section		16,447	15,222	-7.4

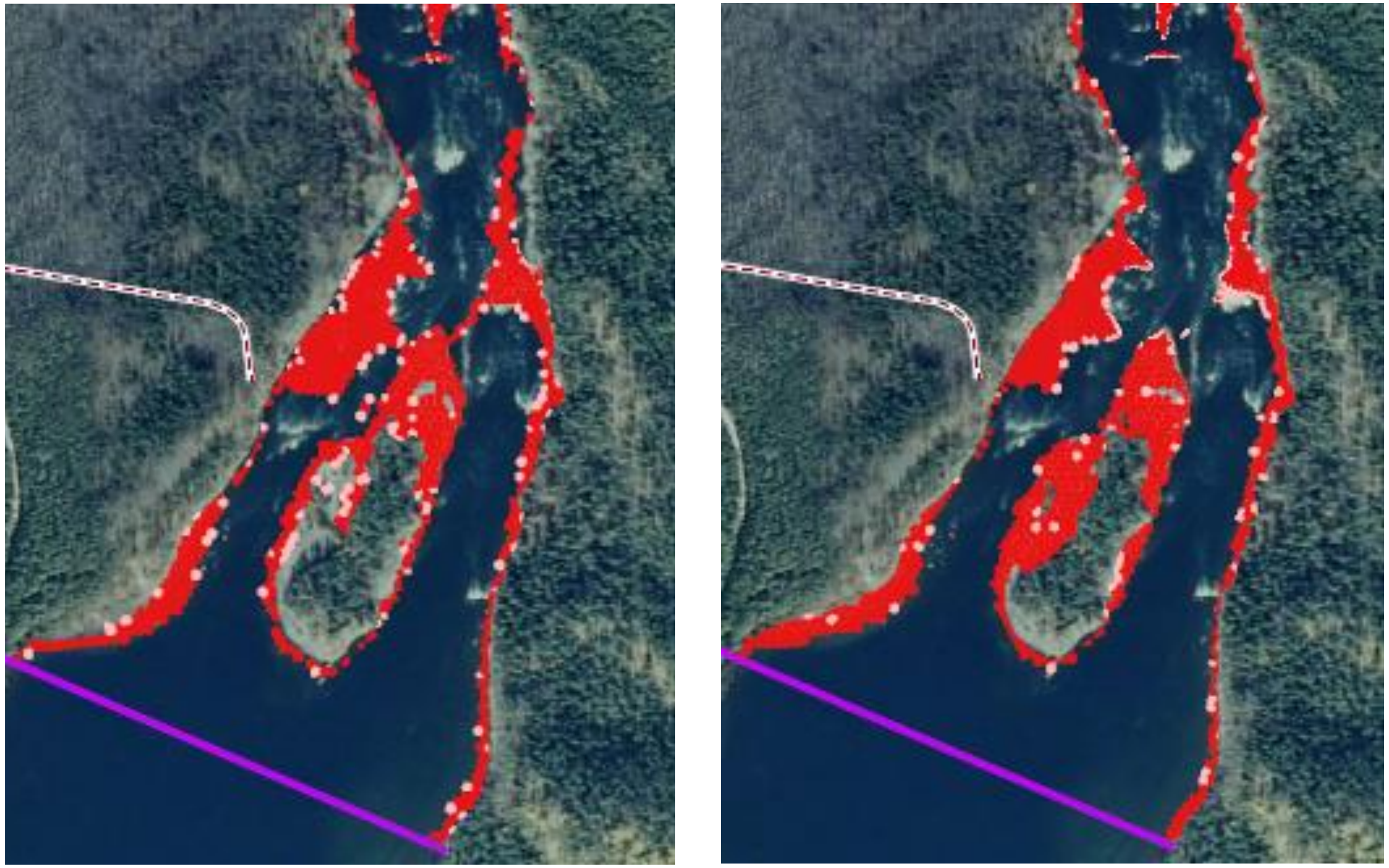
m^2 = square metres; m^3/s = cubic metres per second; % = percent

- Quantities (m^2) of moderately suitable (HSI = 0.5 to 0.75) habitat areas decrease the most when spring flows are reduced

Golder Associates

Case Study: Spawning Arctic Grayling

- Habitat variables: Distributions of moderately and highly suitable spawning depths

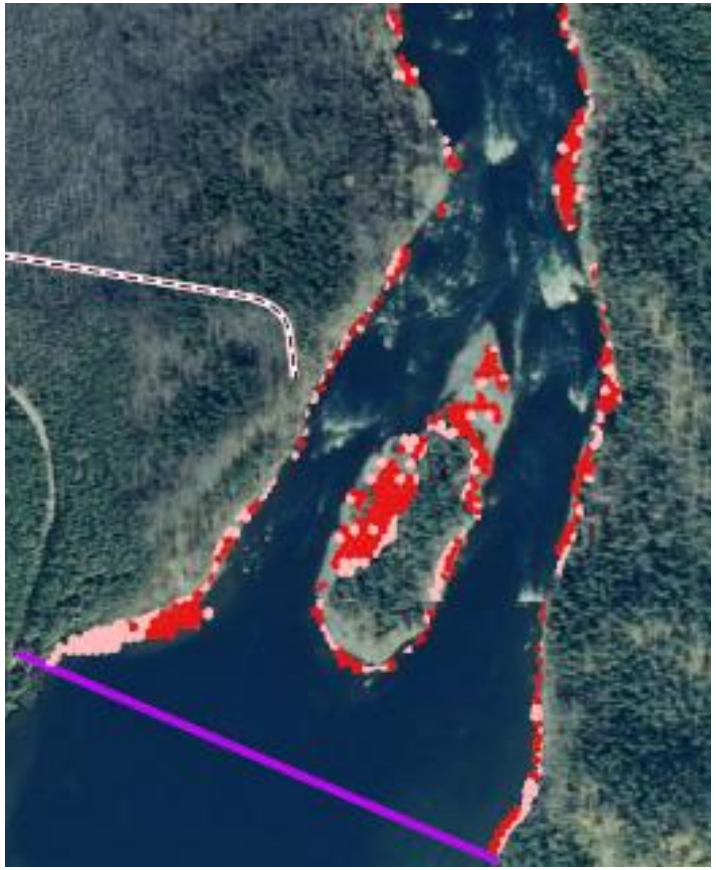


- Left panel: 302 m^3/s
- Right panel: 400 m^3/s
- Pink: Moderately suitable depths (SI = 0.5 to 0.75)
- Red: Highly suitable depths (SI = 0.75 to 1)
- Purple line = assessment area boundary

Golder Associates

Case Study: Spawning Arctic Grayling

- HSIs: Distributions of moderately and highly suitable spawning habitat areas



- Left panel: 302 m^3/s
- Right panel: 400 m^3/s
- Pink: Moderately suitable depths (SI = 0.5 to 0.75)
- Red: Highly suitable depths (SI = 0.75 to 1)
- Purple line = assessment area boundary

Summary

- HSIs and hydrodynamic models are valuable tools for assessing fish habitats in riverine environments

- Our approach improves on existing methods by:
  - Allowing for more thorough QA/QC
  - Supporting concurrent analyses for different flows, species, and life stages
    - Saves time and budget
  - Allowing for classification of habitat areas (m^2) and quantification of various habitat types
    - True habitat area (m^2) outputs support data interpretation better than an WUA index value
    - Allows for comparisons among flow scenarios
  - Producing geo-referenced results that can be mapped to support identification of critical habitat areas
    - Better spatial representation of data
    - Maps can be batch-processed for the variables and habitat types of interest
  - Can identify areas where fisheries offsetting could be considered
    - Areas where habitat is limited by a single variable that could be manipulated (e.g., modifying substrates)

Photo: Leah James