# Using Watercraft Inspection Data to Improve Aquatic Invasive Species Management
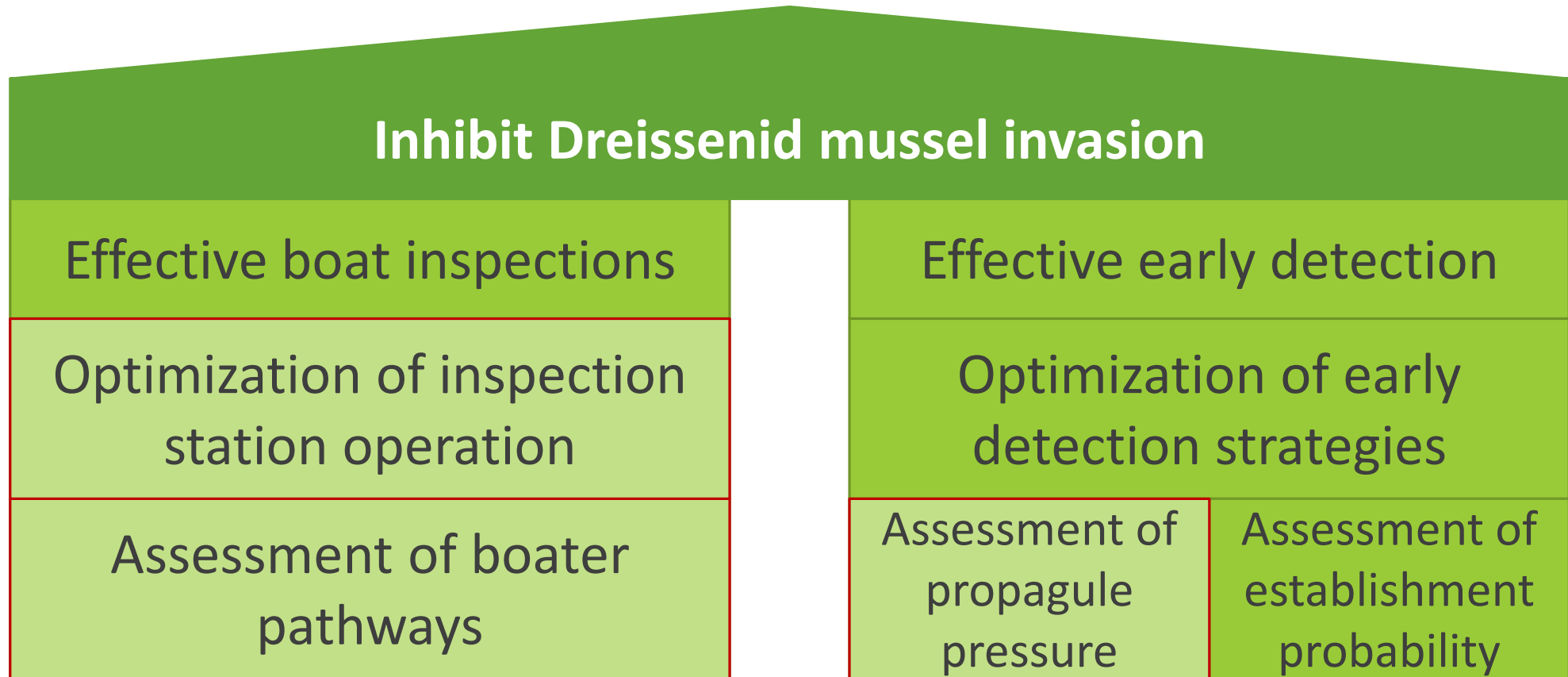
SAMUEL FISCHER, MARTINA BECK, MATTHIAS HERBORG, MARK LEWIS
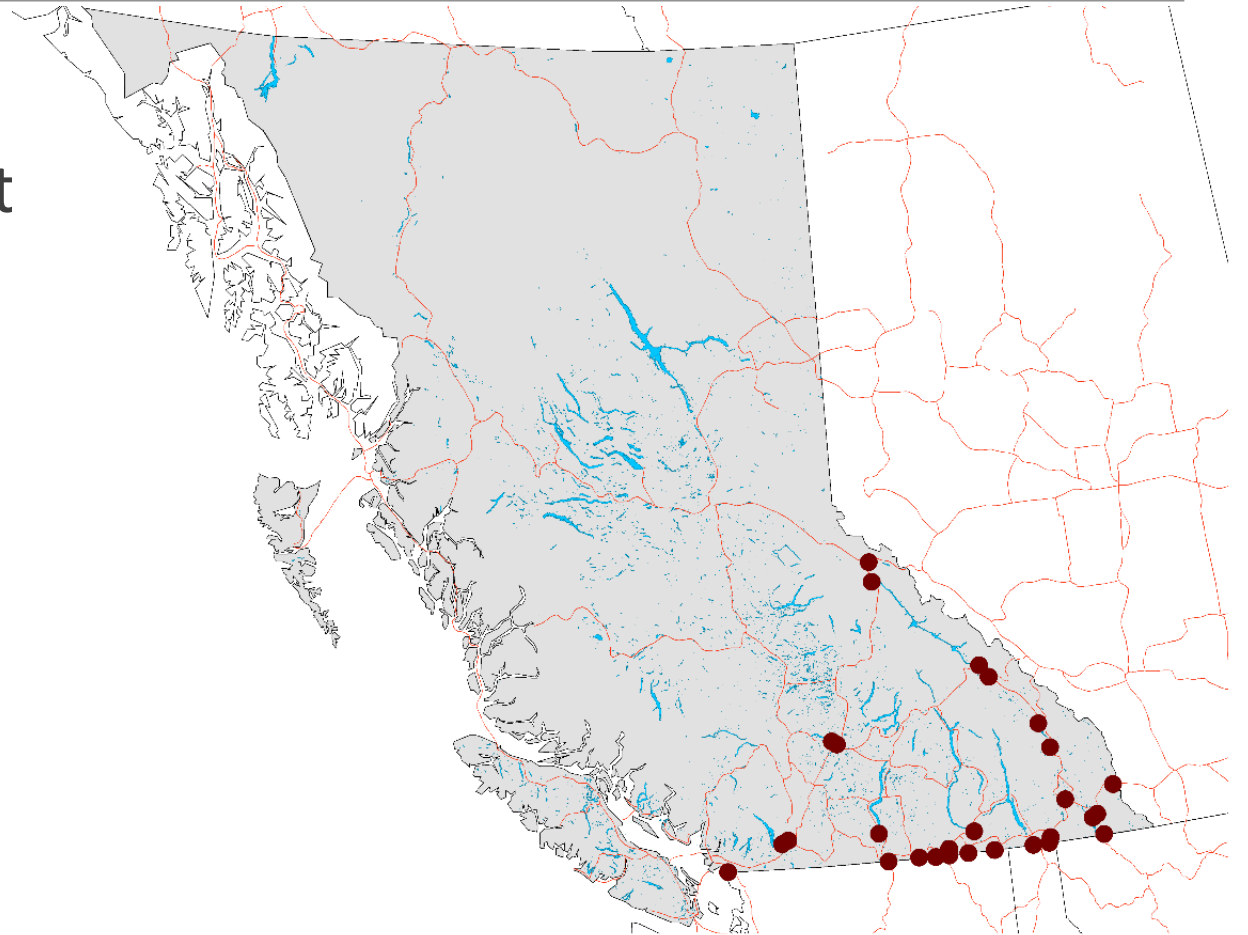
# Motivation

# Available Data

- Survey data from watercraft inspection stations

- Further data on lakes, provinces and states

# Available Data

| Inspection location | Shift start time | Shift End time | Observa-tion time | From jurisdiction | To lake | Boat type |
|---|---|---|---|---|---|---|
| Golden | 8 AM | 2 PM | 10:31 AM | Calgary | Lake Okanagan | Canoe |
| | | | 12:10 PM | Edmonton | Shuswap Lake | Car Topper |
| | | | 1:44 PM | Ontario | Shuswap Lake | Cabin Cruiser |
| Laidlaw | 12 PM | 6 PM | 12:42 PM | Seattle | Lake Okanagan | Wakeboard |
| | | | 3:28 PM | California | Christina Lake | Bassboat |

# Available Data
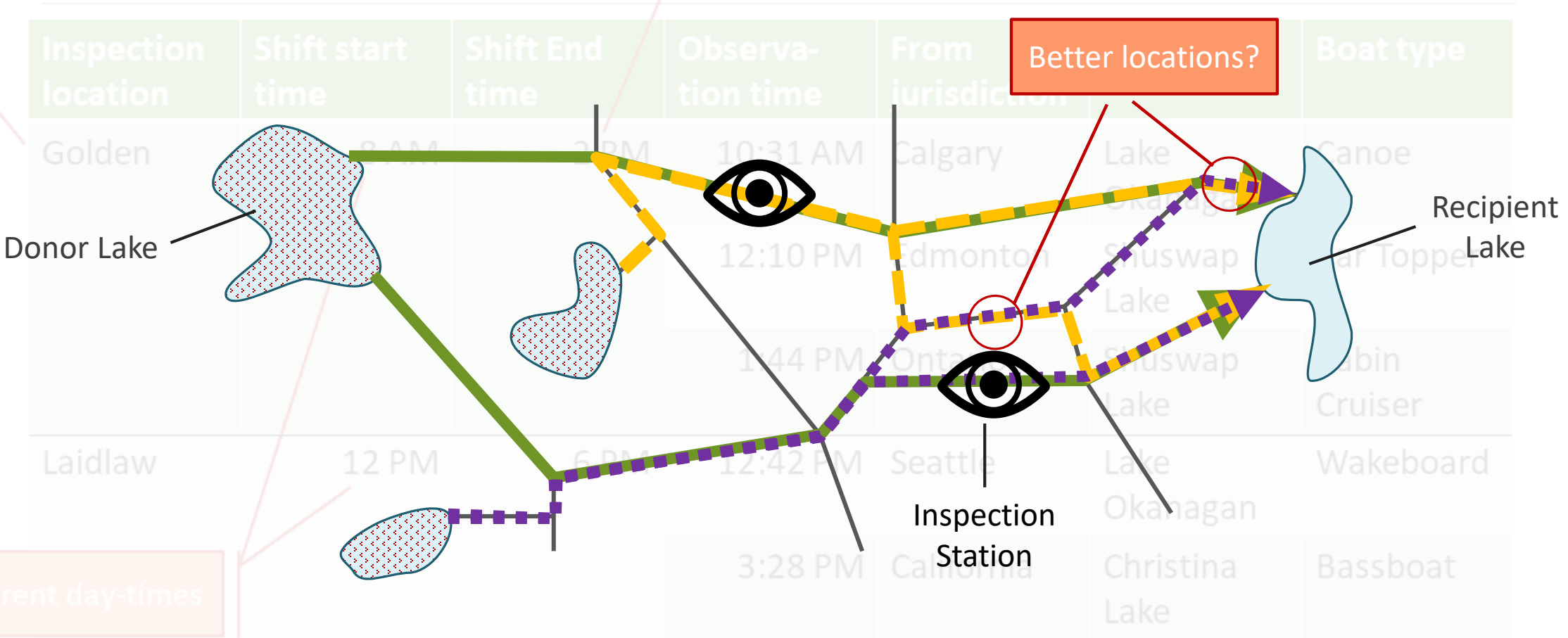
# Challenges

1. Extrapolate part-day observations on full day
   o Need temporal traffic distribution

2. Extrapolate boater flow along single road to full boater flow; Estimate traffic at untested locations

# Daily Traffic Distribution
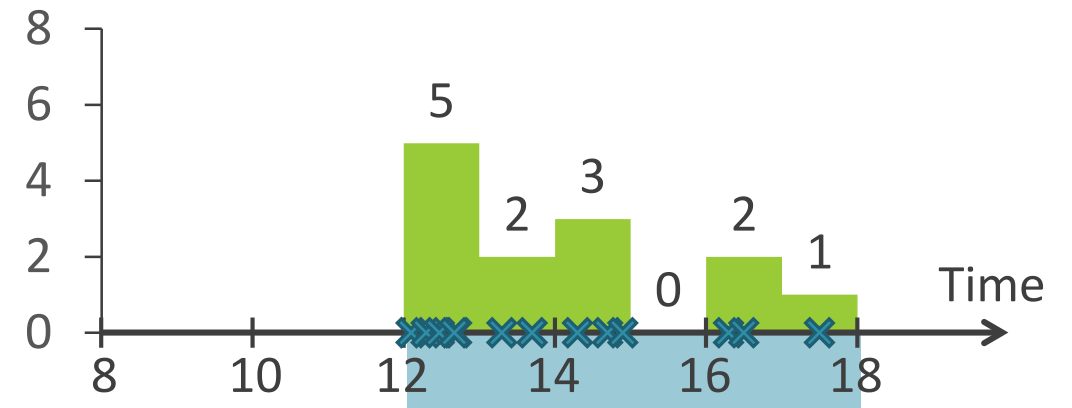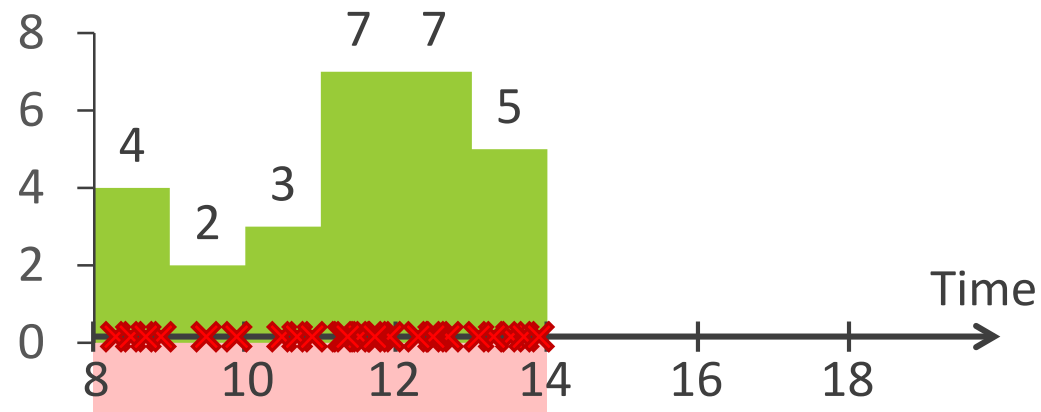
Histogram approach

# Daily Traffic Distribution

Histogram approach

# Daily Traffic Distribution

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# Daily Traffic Distribution

Probabilistic approach

# Challenges

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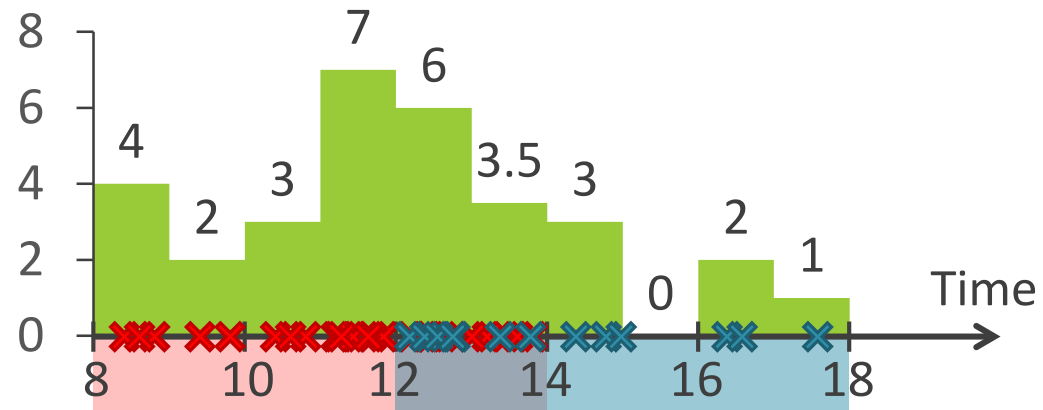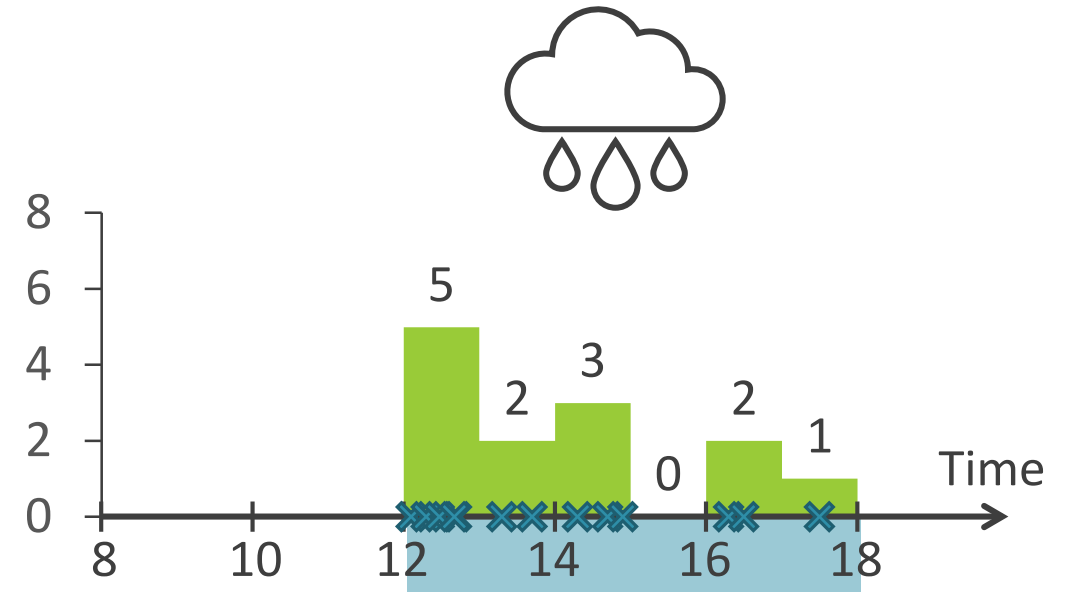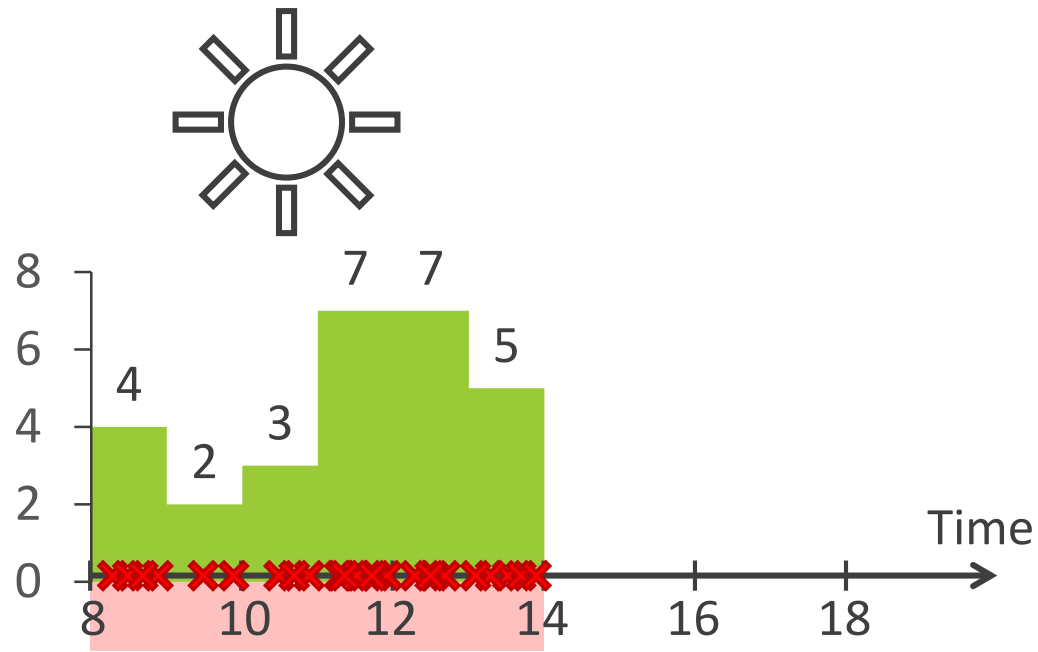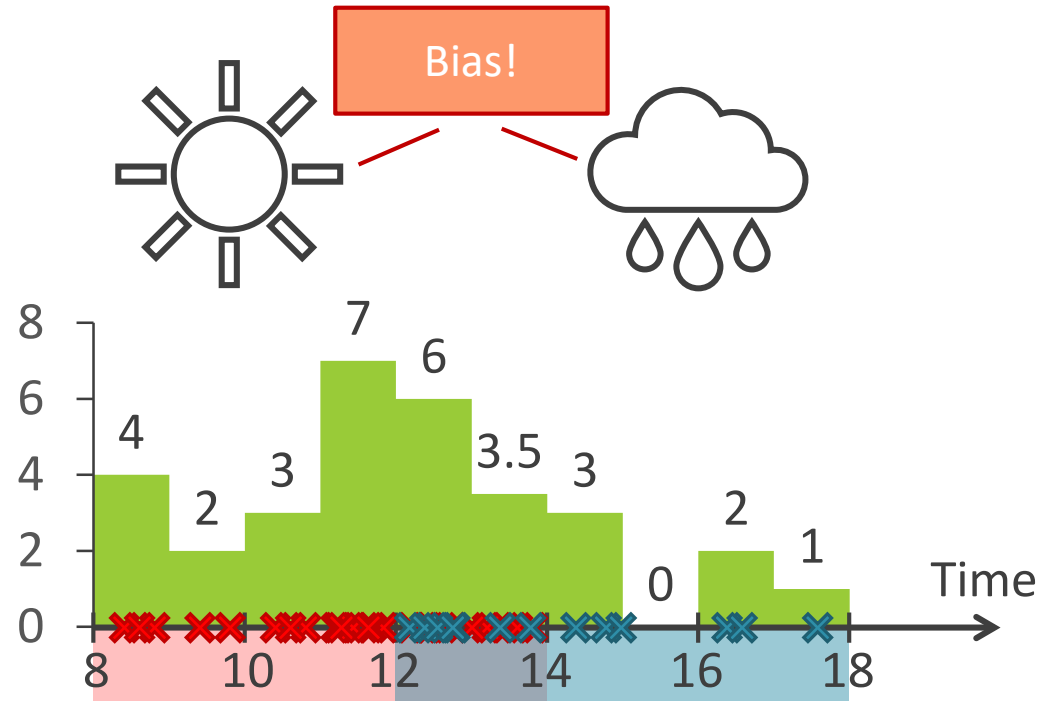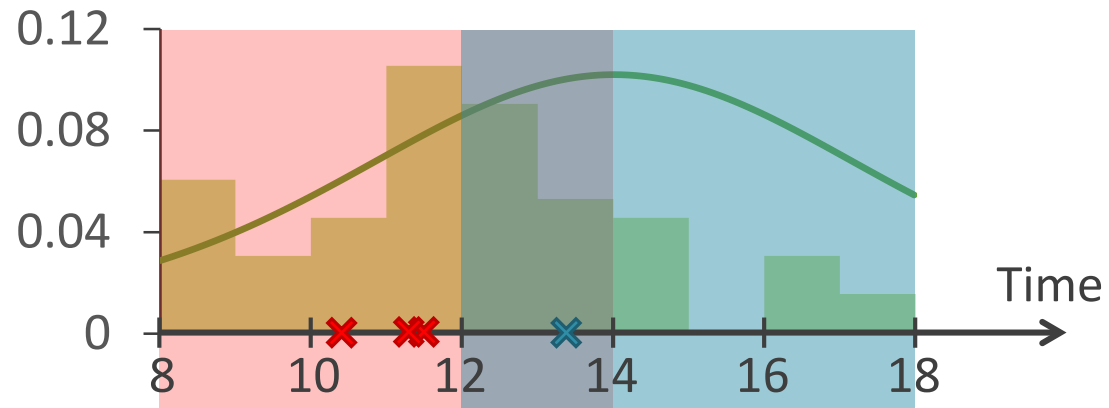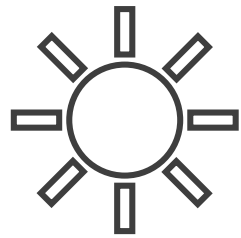   o Need road choice model

# Route Model
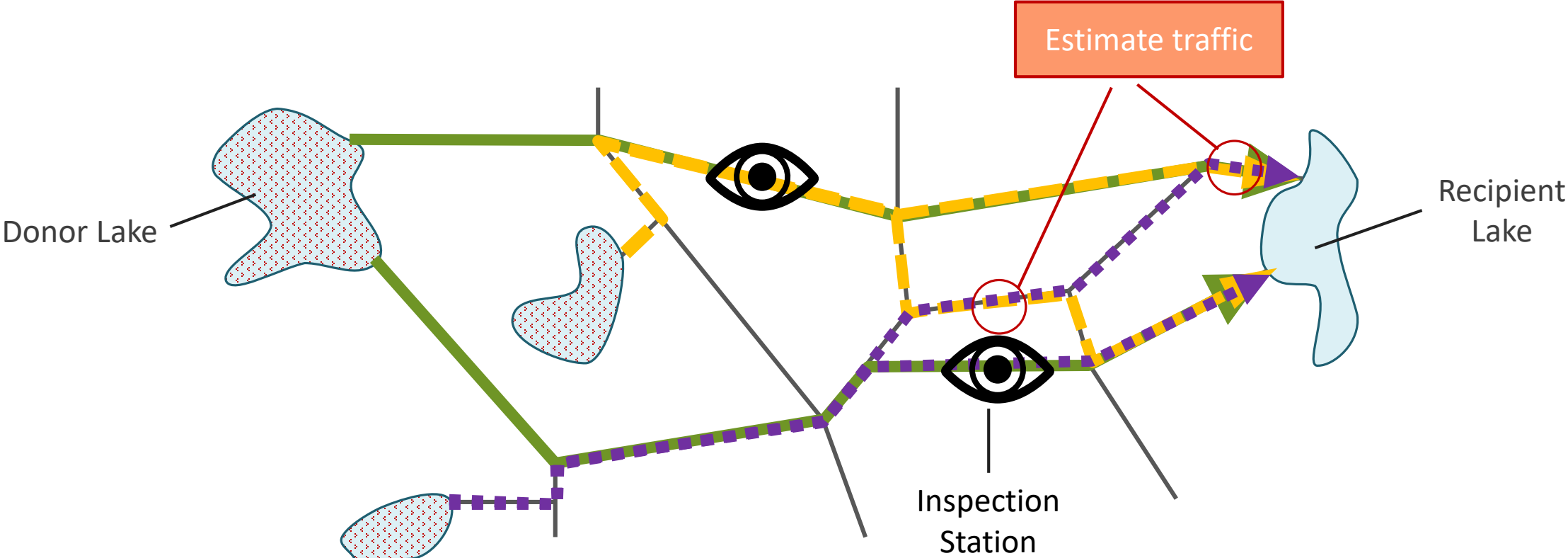
# Route Model

- Assumption:     Most boaters travel on routes that "make sense"
                            Rest: "randomly"

- Routes that "make sense":

  o   Not much longer than shortest route

  o   Locally optimal



Weighted according to length

Reference:      Abraham, I., Delling, D., Goldberg, A. V., & Werneck, R. F. (2013). Journal of Experimental Algorithmics (JEA), 18, 1-3.

# Hierarchical Process

Different route

| Go |
|---|

| Choose route |
|---|

| Choose time |
|---|
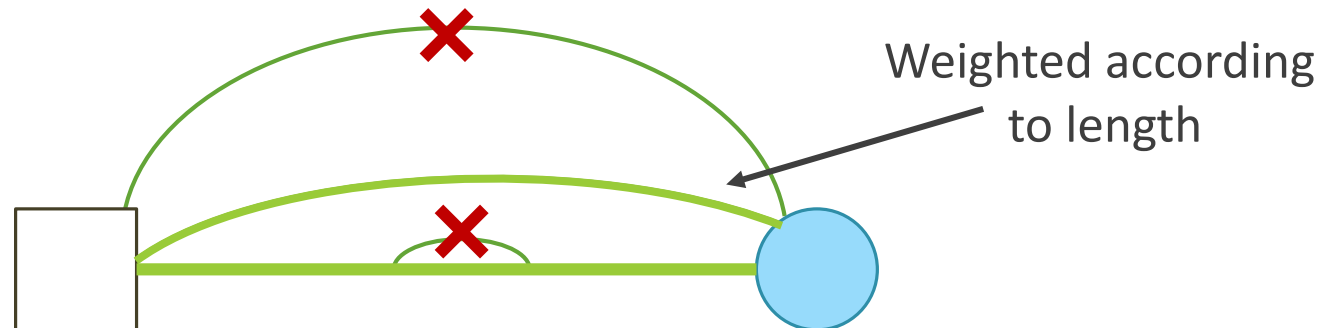
Be observed in inspection shift
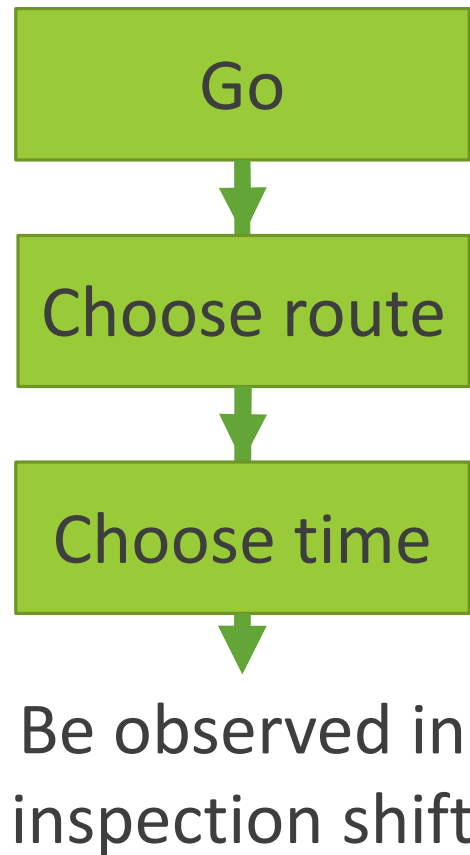
6 boaters go from A to B

4 out of 6 boaters choose route via our inspection location

2 out of 4 boaters pass during inspection shift

Observed

2 boaters are observed

Different time

# Hierarchical Process

Go

Choose route

Choose time

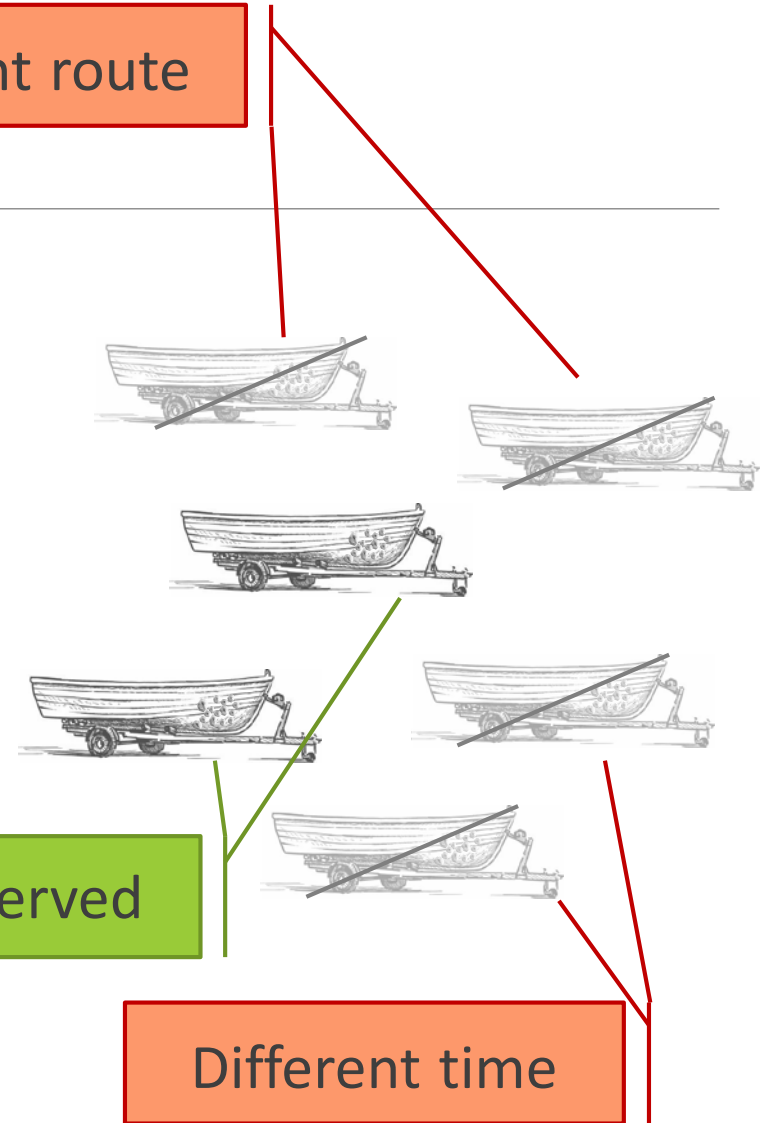Be observed in inspection shift

Gravity model

Route model

Time model

$N$ boaters go from A to B

$M$ out of $N$ boaters choose route via our inspection location

$L$ out of $M$ boaters pass during inspection shift

$L$ boaters are observed

# Stochastic Gravity Model

- Goal: Estimate traffic from each donor to each recipient

- Assumption: Number of travelling boaters randomly distributed

- Mean flow: Given by a "gravity model"

  - $mean\_flow_{ij} = c \dfrac{\#boaters_i \cdot attractivity_j}{distance_{ij}^{\gamma}}$

  - $i$: Infested jurisdiction

  - $j$: Lake

  - $c, \gamma$: Constants

**Reference:** Potapov, A., Muirhead, J. R., Lele, S. R., & Lewis, M. A. (2011). Ecological Modelling, 222(4), 964-972.

# Hierarchical Process

Go

Choose route

Choose time

Be observed in inspection shift

Gravity model

Route model

Time model

Estimates / Data

$N$ boaters go from A to B

$M$ out of $N$ boaters choose route via our inspection location

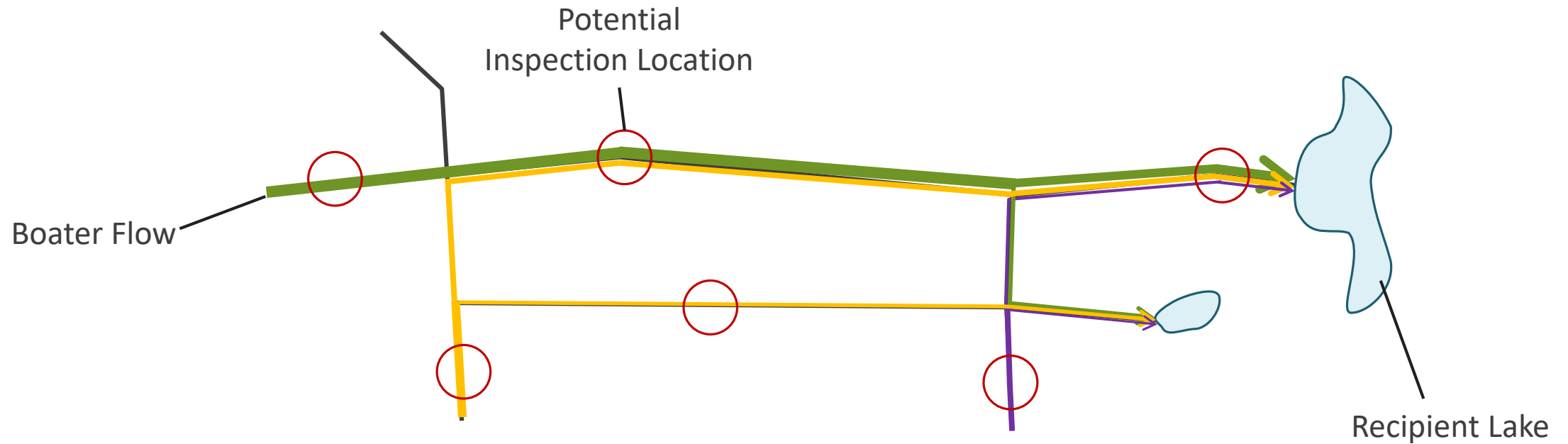$L$ out of $M$ boaters pass during inspection shift

$L$ boaters are observed

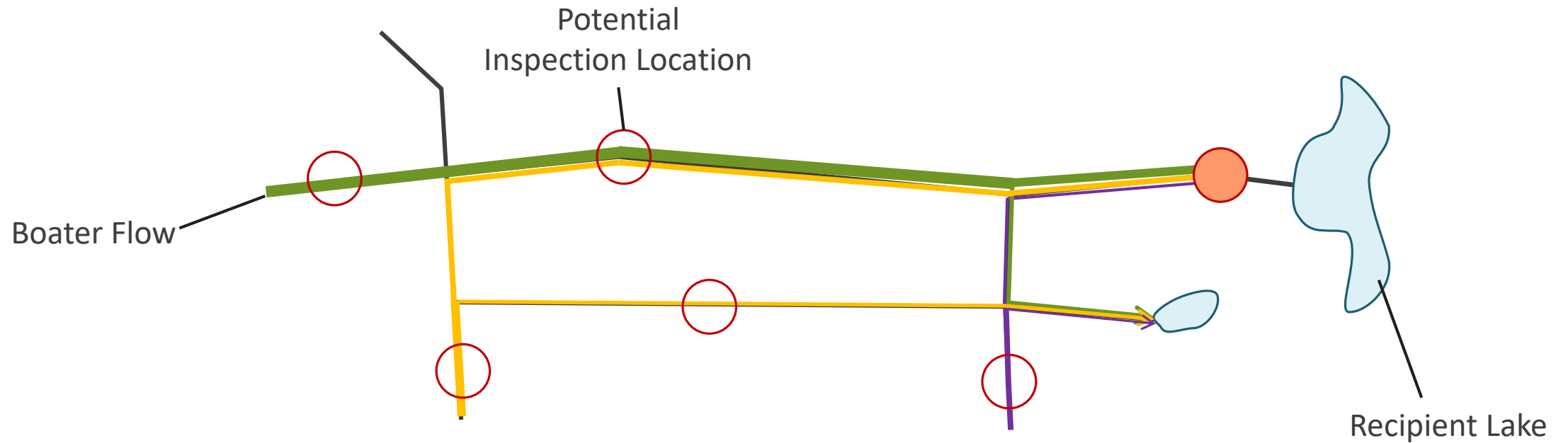Can be fitted to different boat types

# Results

- Our results are still under review and therefore not available to the public at this time. Thank you for your understanding.
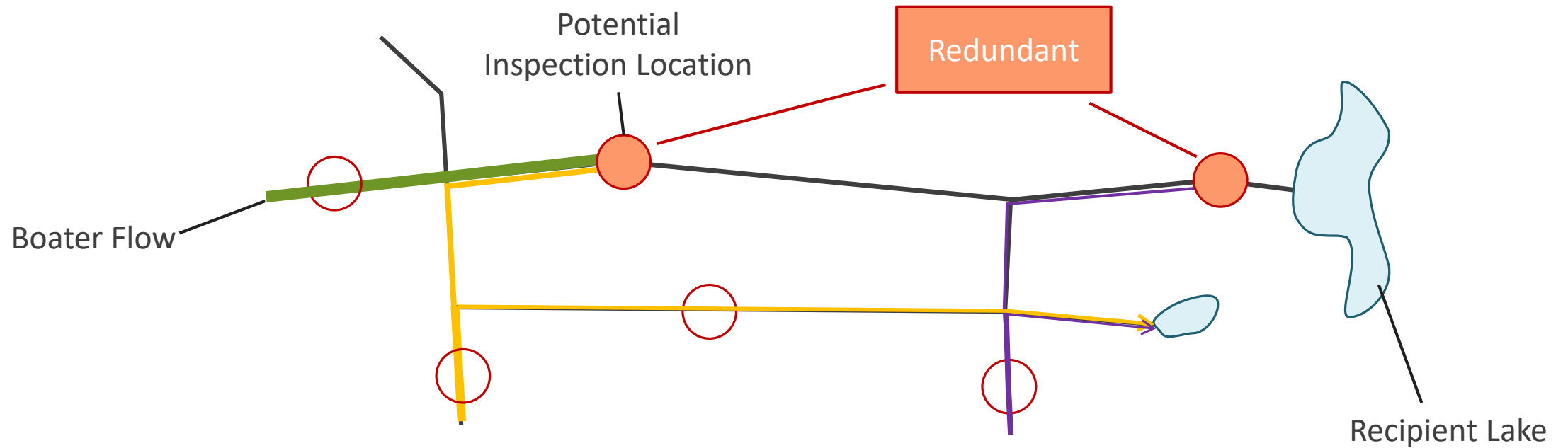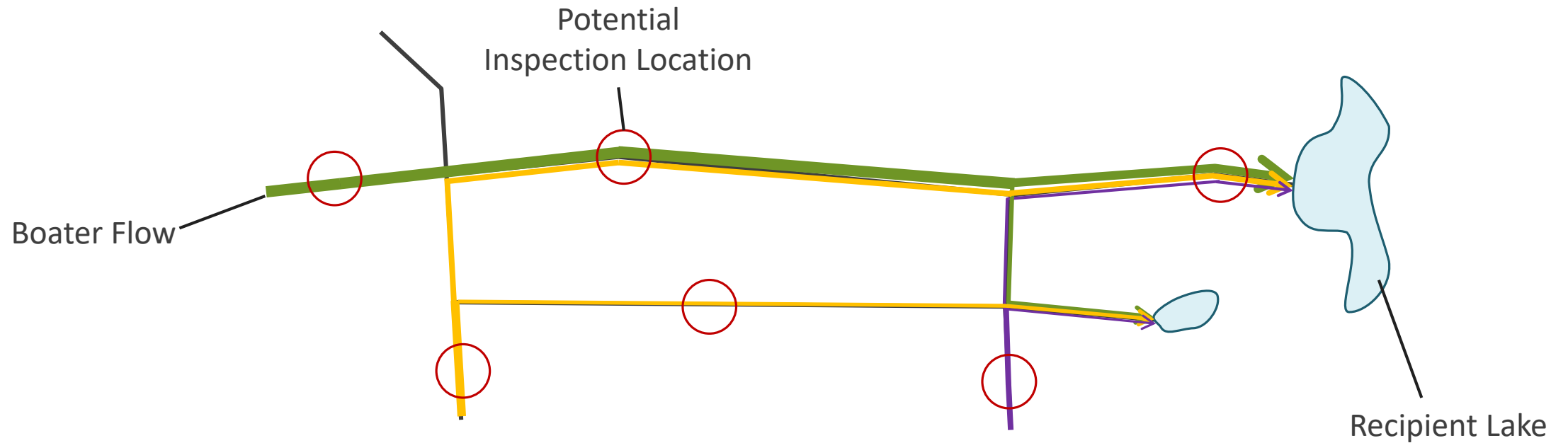
# Optimizing Inspection Station Placement



Boater Flow

Potential Inspection Location

Recipient Lake

# Optimizing Inspection Station Placement



Potential Inspection Location

Boater Flow

Recipient Lake

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Potential Inspection Location

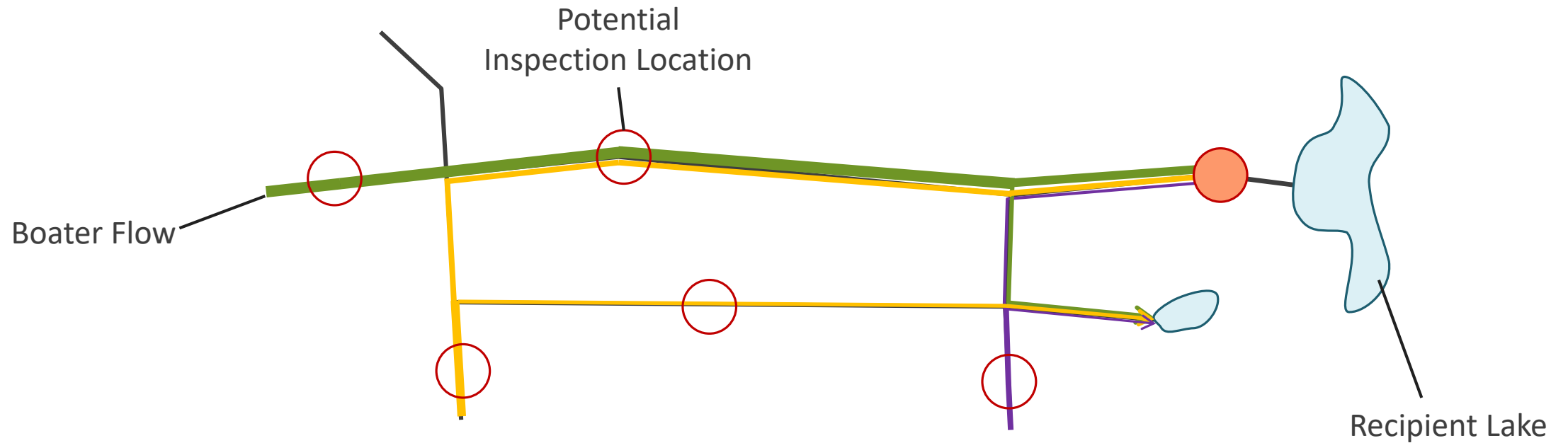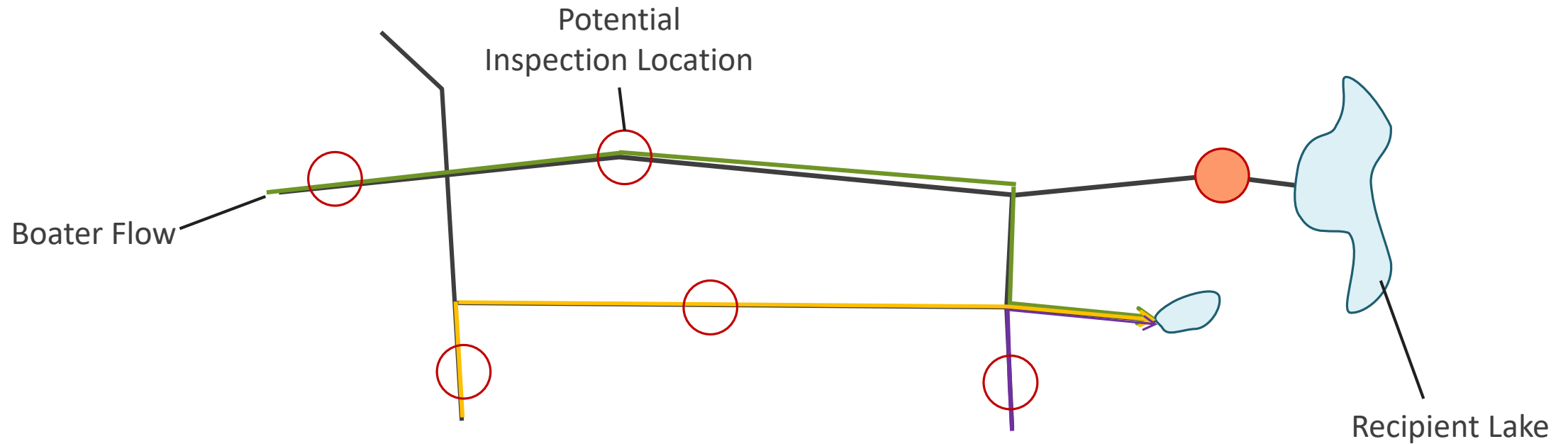Boater Flow

Recipient Lake

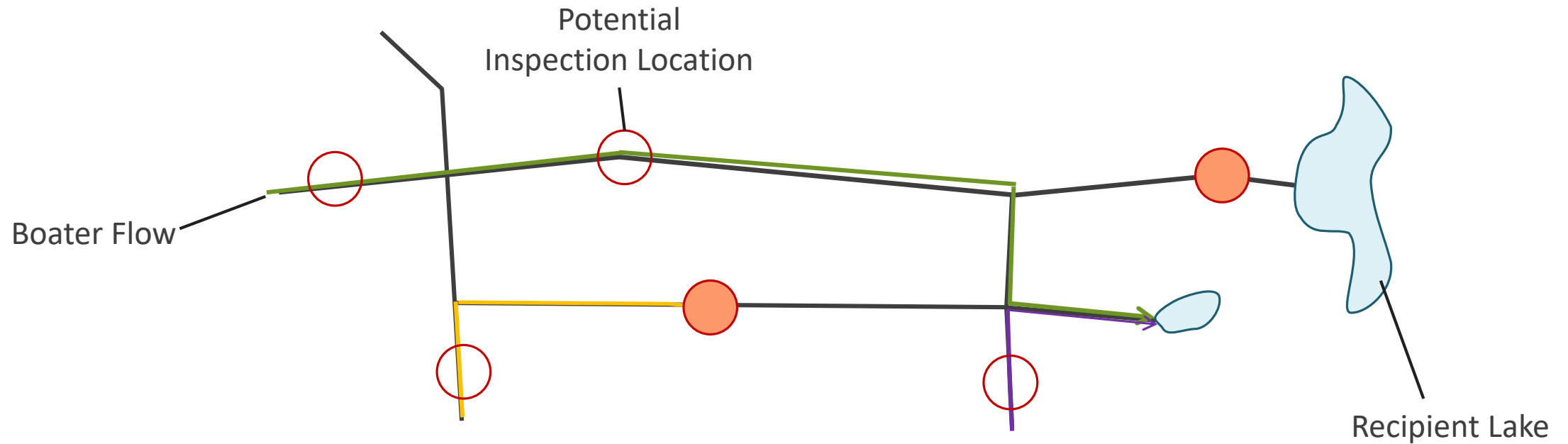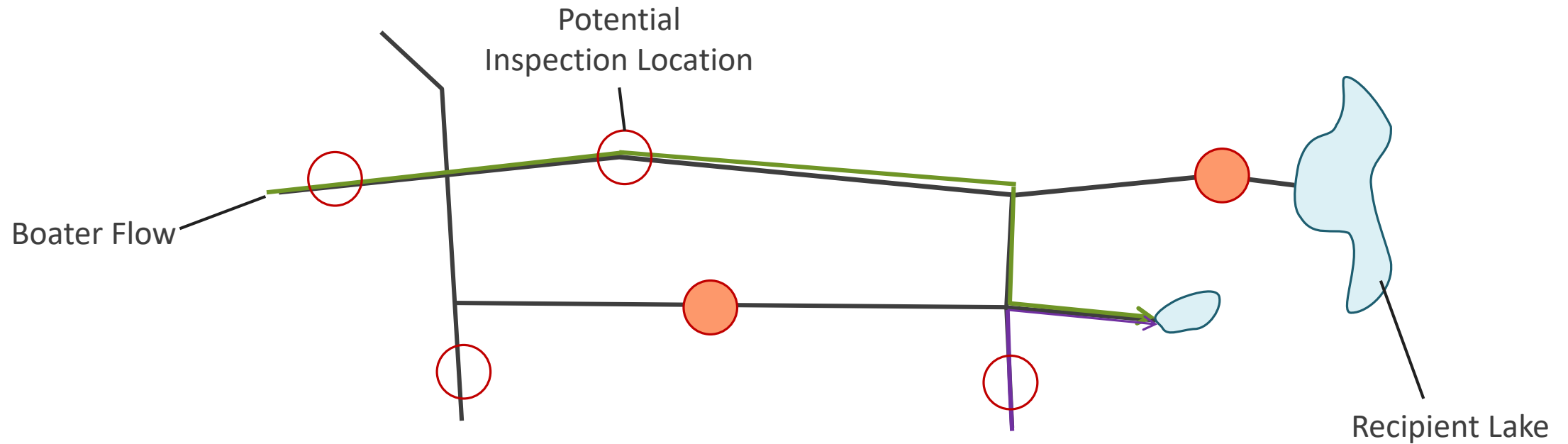# Optimizing Inspection Station Placement

# Optimizing Inspection Station Placement

# Optimizing Inspection Station Placement



Potential Inspection Location

Boater Flow

Recipient Lake

# Optimizing Inspection Station Placement



Potential Inspection Location

Not perfect

Boater Flow

Recipient Lake
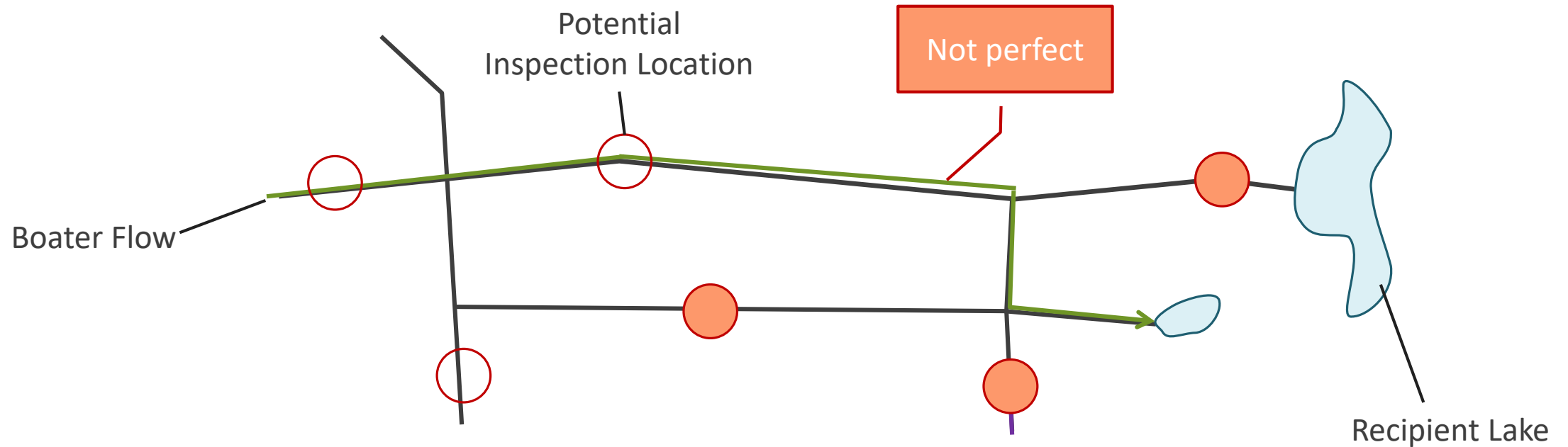
Note: Step requires route model!

# Optimizing Inspection Station Placement



Potential Inspection Location

Boater Flow

Recipient Lake

# Optimizing Inspection Station Placement



Potential Inspection Location

Useless

Boater Flow

Recipient Lake
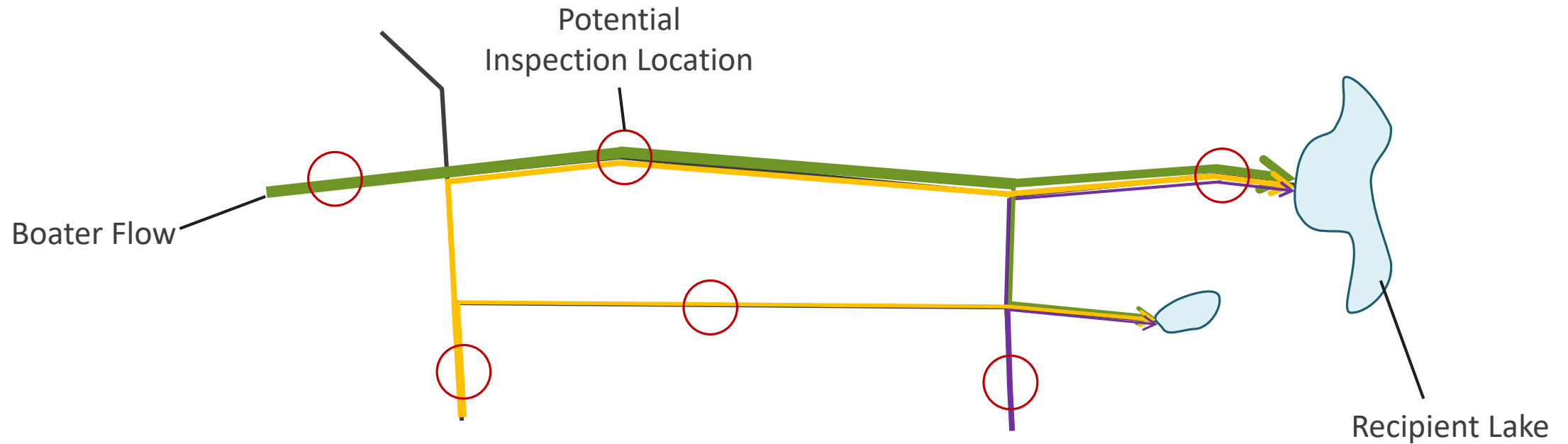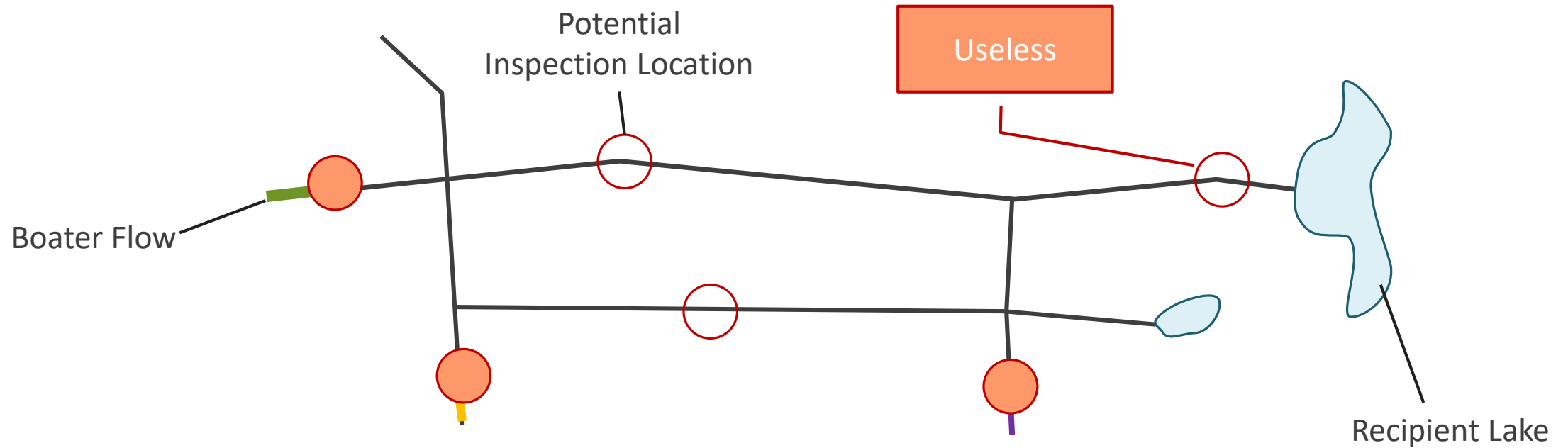
Linear programming with rounding

# Results

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# Extension: Optimizing Operating Times

Constraints:

- Sum of costs for
  - operated locations
  - operated shifts

  is below the budget constraint

- Stations are operated in shifts of given lengths

# Extension: Optimizing Operating Times

Main idea:

- Solve inspection station placement problem for multiple time intervals

Results:

- Not presentable yet

# Discussion

- The presented approach gives valuable information on
  - When and where to operate inspection stations
  - Invasion risk (propagule inflow)
  - Scenarios of interest

- Results should be combined with sanity and reason

- More details can be included

# Acknowledgements

- Collaborators in presented research:
  - Martina Beck
  - Matthias Herborg
  - Mark Lewis

- Funding sources for presented research: