Beta-2

Scenario Optimization Tool for CAST

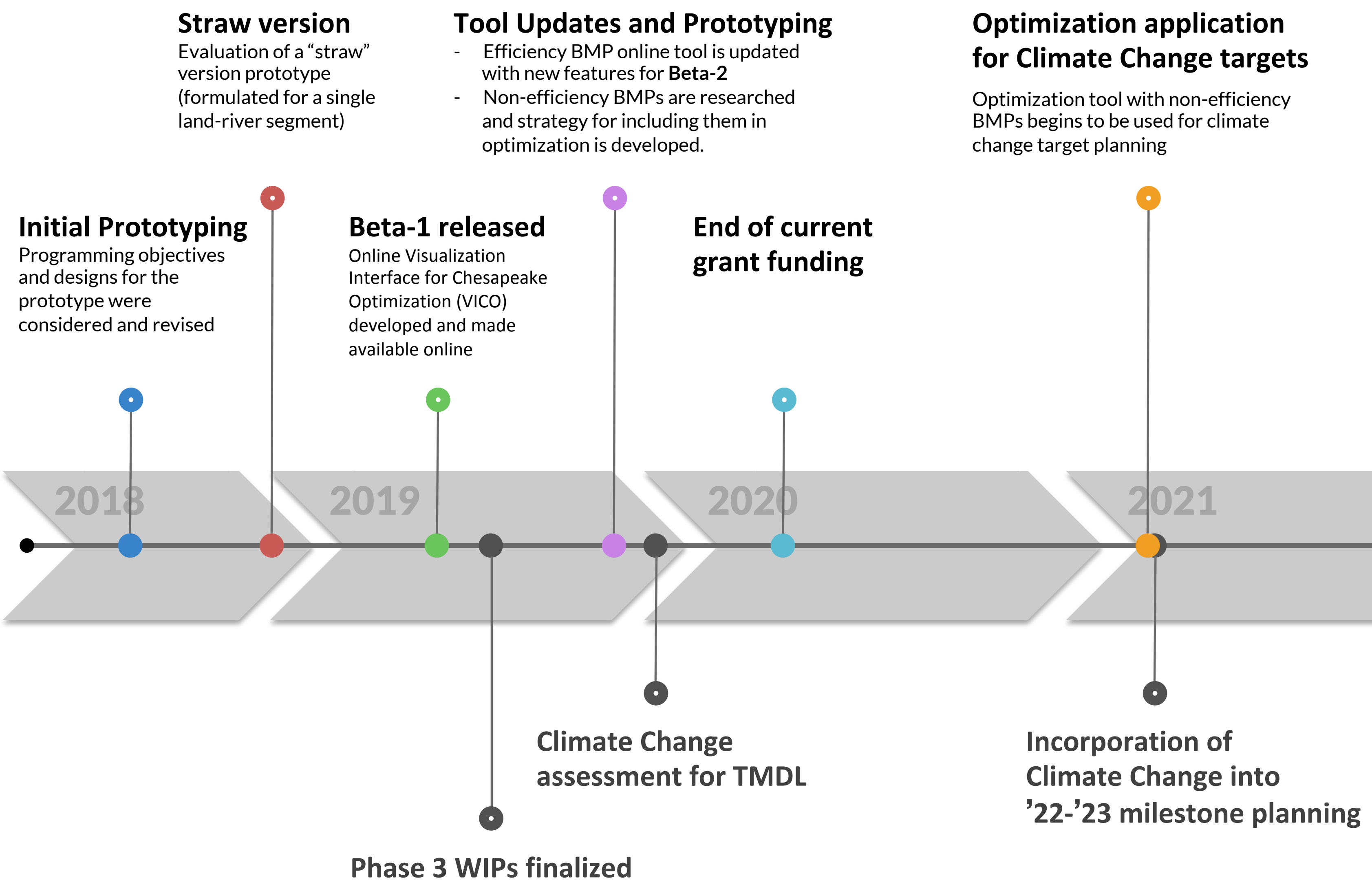
(the time-averaged Phase 6 watershed model)

8 October 2019 – Modeling Workgroup Quarterly Meeting

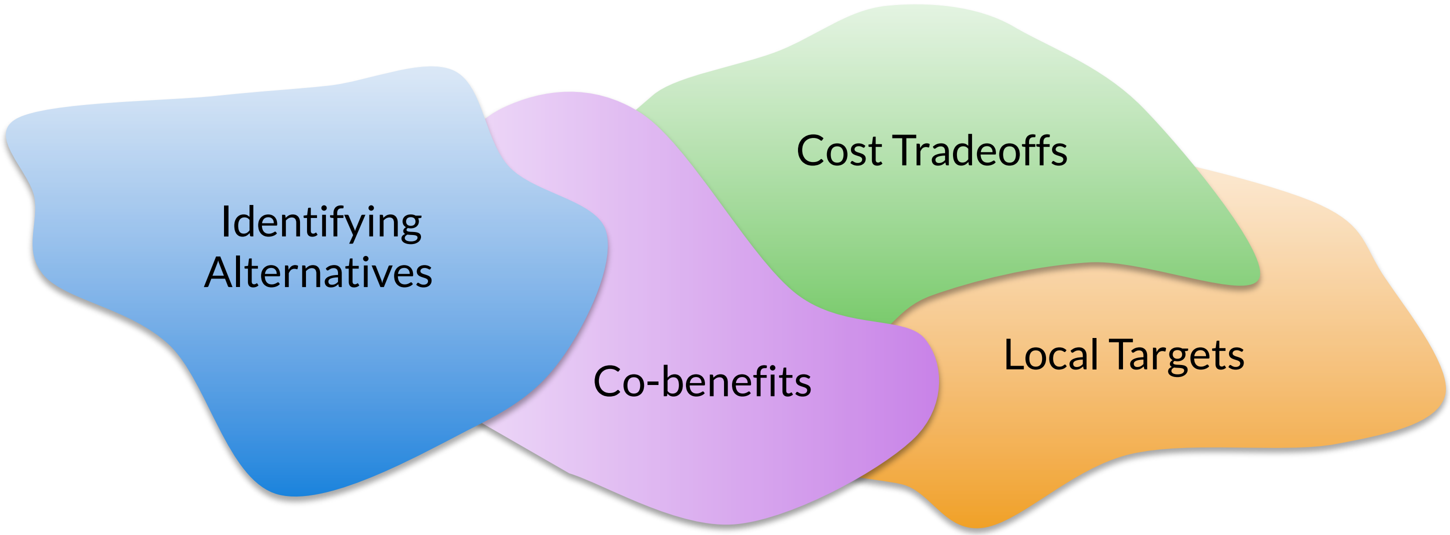
Danny Kaufman, Kevin Asplen, and the CBPO Modeling Team

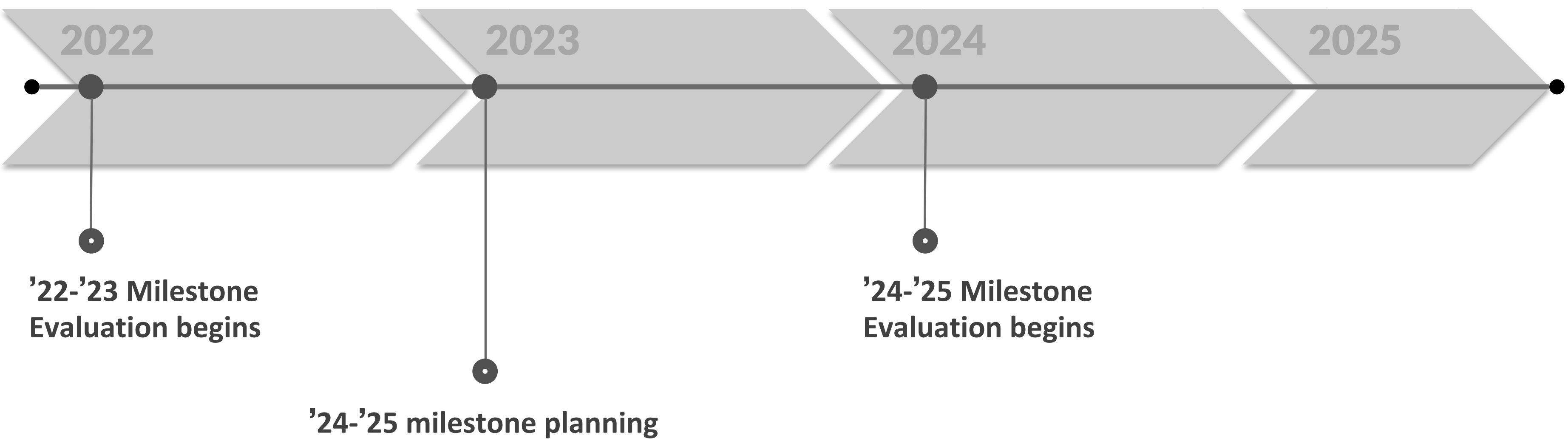
Project Goal: Investigate, develop, test, and implement an optimization system for the Chesapeake Assessment Scenario Tool (CAST) that will facilitate identification of more cost-effective and otherwise optimal approaches to pollutant load reduction for non-federal CBP partners.

Optimization Development Timeline (2018-2021)



Optimization Development Timeline (2022-2025)





Outline

Optimization challenge ("The Wall") update

Online tool updates

Ongoing development & planned updates

Optimization challenge

CAST
(Chesapeake Assessment Scenario Tool)

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Nutrient & Sediment
Load Reductions
(with least cost $)

Optimization challenge

Best Management Practices (BMPs)

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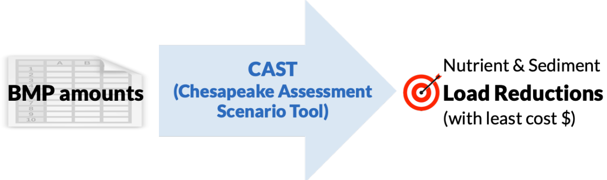
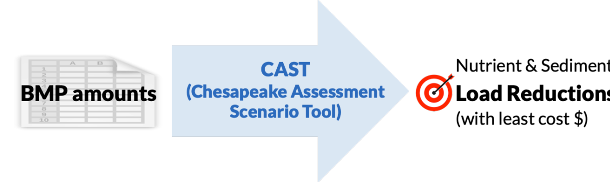


Approximately 300 BMP varieties in CAST

Optimization challenge



Approximately 300 BMP varieties in CAST

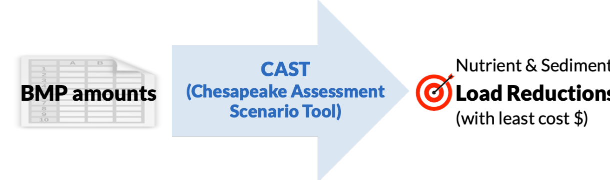
non-efficiency BMPs
~120

For example:
Animal waste storage,
Feed additives,
Riparian buffers

efficiency BMPs
~180

For example:
Cover crops,
Infiltration practices,
Barnyard runoff control

Optimization challenge



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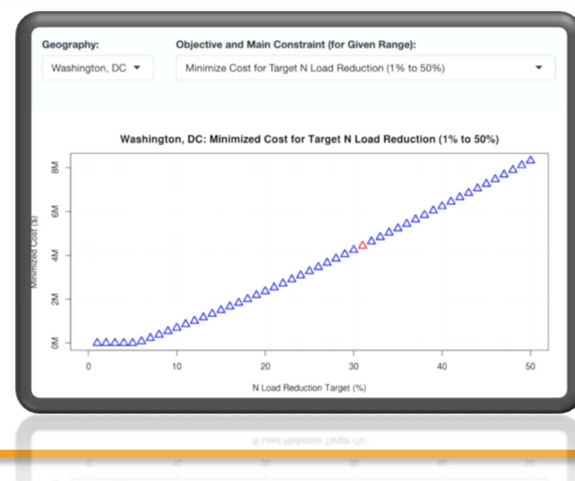
$$\prod_{G^B \in \mathcal{G}_u^B} \left(1 - \sum_{b \in G^B} \frac{\eta_{u,b}}{\alpha_u} X_{u,b}\right)$$

Current basis for online tool



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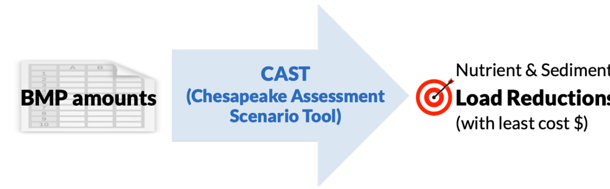

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What optimization approach will be effective?

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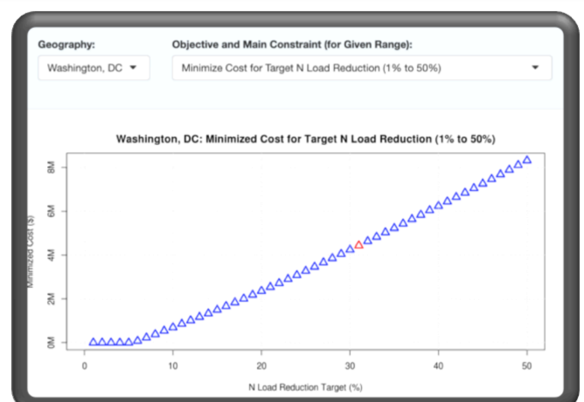

“The Wall” – what optimization approach will be effective?

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3+ approaches

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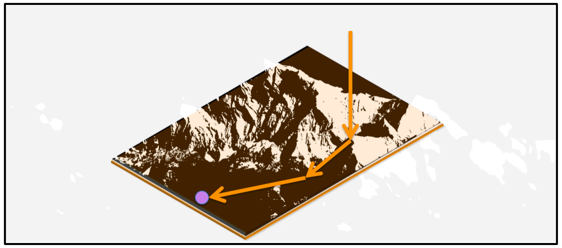
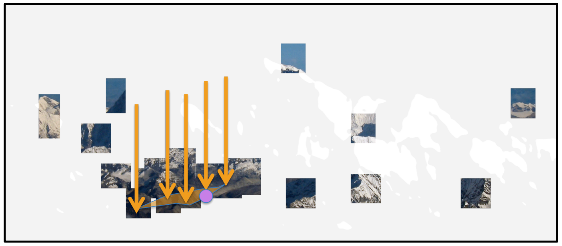
3+ approaches

A) "Exact"



B) Surrogate modeling

C) Heuristic



"The Wall" – what optimization approach will be effective?

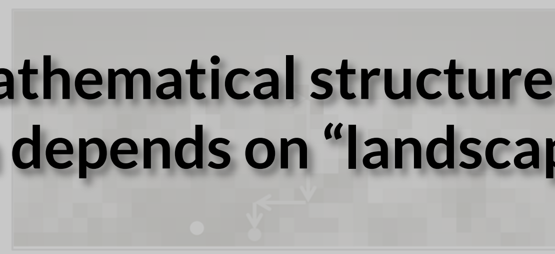
3+ approaches

A) "Exact"

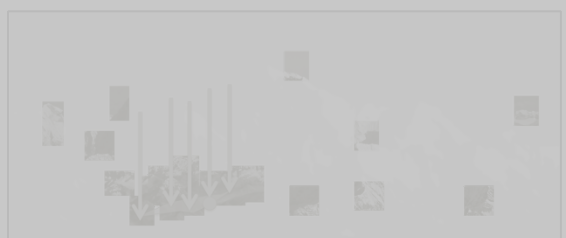
To decide... to get over "the wall":

- **evaluate mathematical structure (approach depends on "landscape")**
- **prototype**

B) Surrogate modeling



C) Heuristic



"The Wall" – what optimization approach will be effective?

Evaluating the mathematical structure of the CAST load function...

$$\mathcal{L} = \sum_{s\in S^*}\left[\sum_{h\in H}\left(\sum_{u\in U_N}\left(\left[\bar{\mathcal{L}}_u^w + \sum_{t\in T}\left(\left(I_{u,t,k(s)} - \bar{I}_{u,t}\right) * \sigma_{u,t}\right)\right] * \theta^*{}_{s,h,u} * \alpha_{s,h,u} * \psi_{s,h,u}^{LW} * \psi_{s,h,u}^{SR} * \zeta_{s,h}^{stb}\right) * \psi_{s,h,u}^{RB} + \sum_{u\in U_D}\left(\mathcal{L}_{s,u} * \psi_{s,u}\right)\right] + \sum_{s\in S^*}\sum_{h\in H}\mathcal{L}_{s,h,sho}$$

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1) We are revealing the problem Landscape

- High dimensional
- Non-linear
- Non-convex
- Generally non-separable

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1) We are revealing the problem Landscape

- High dimensional
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2) We are composing a report:

- Elucidation of the CAST mathematical structure
- Optimization models and algorithmic approaches

Outline

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At the Modeling Workgroup quarterly in April, we had the first Beta release of a working, publicly available optimization tool

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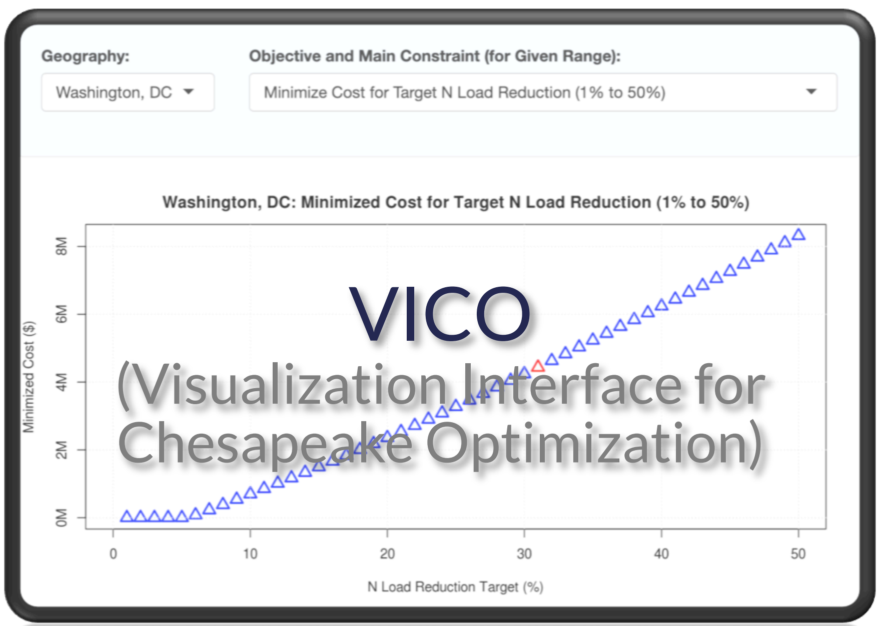

Load reduction and cost tradeoffs for counties in watershed

Acres of efficiency BMPs to achieve load reduction at near least-cost

39,400 solutions (cost, load, BMPs)

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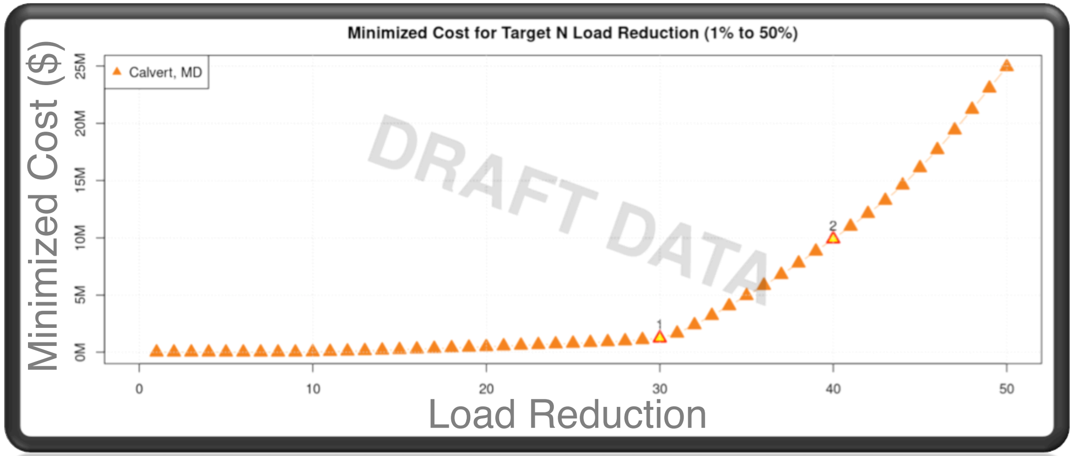
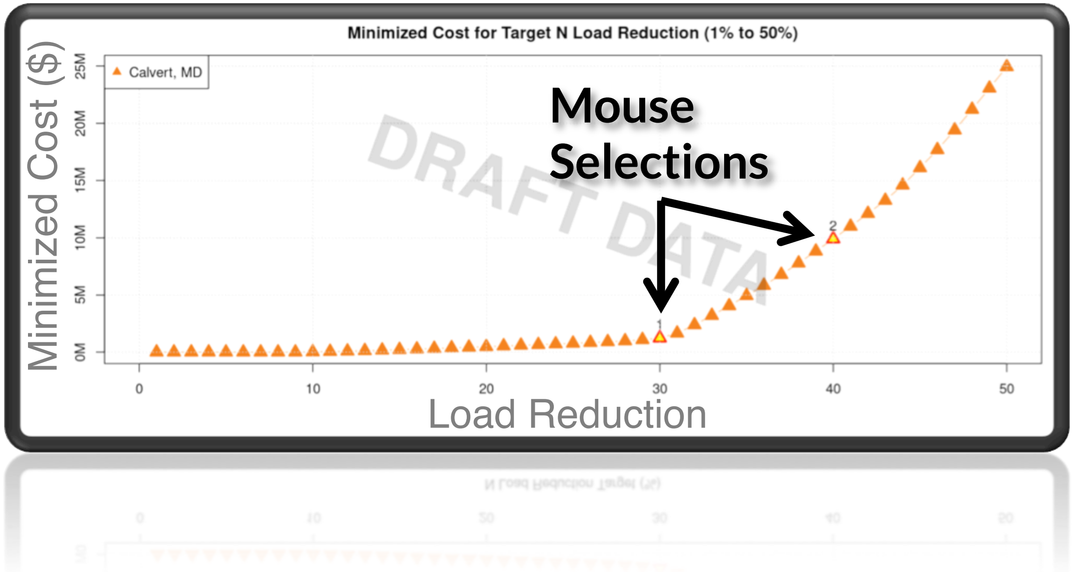
Where do things stand now?

Visualization Interface



Cost vs. Load tradeoff
for a given county

Visualization Interface



Allows comparisons

- between two points on the same county curve

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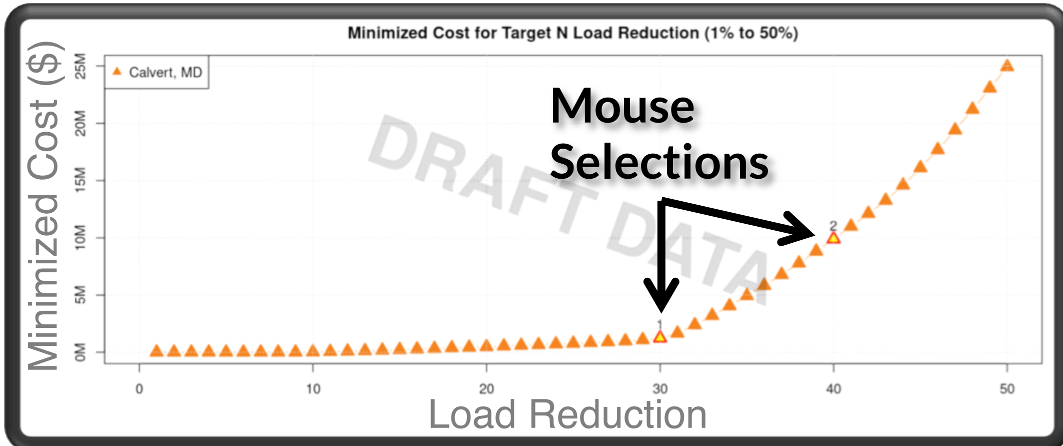

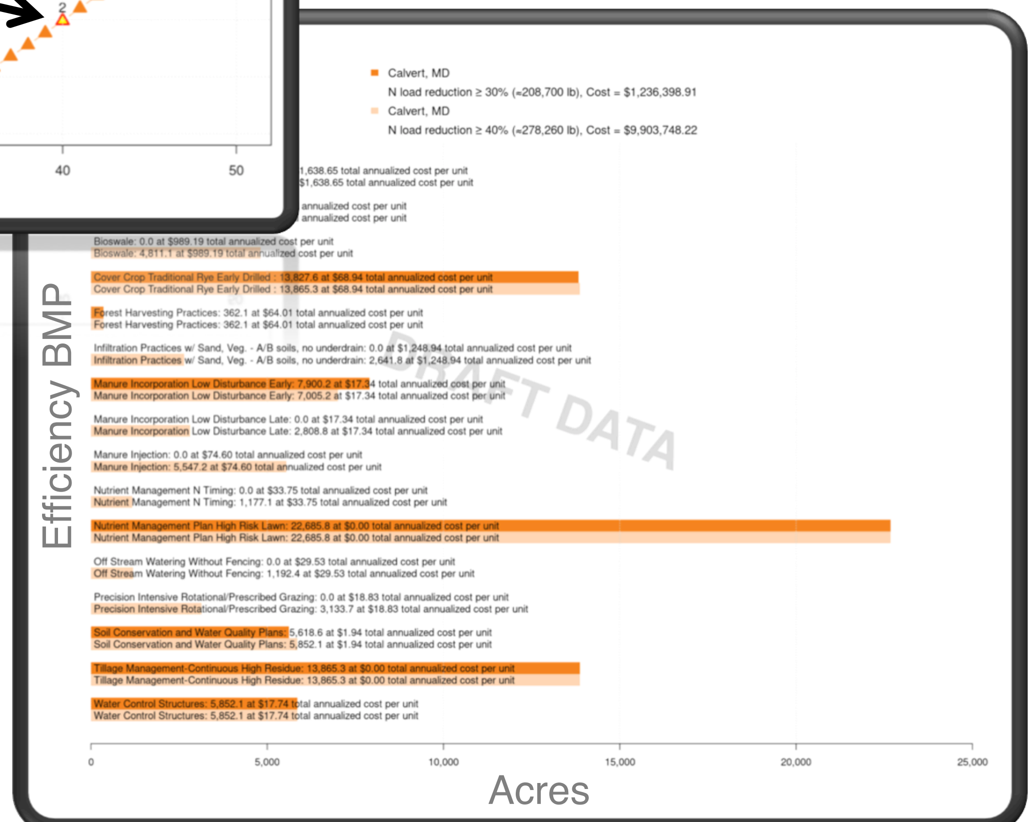

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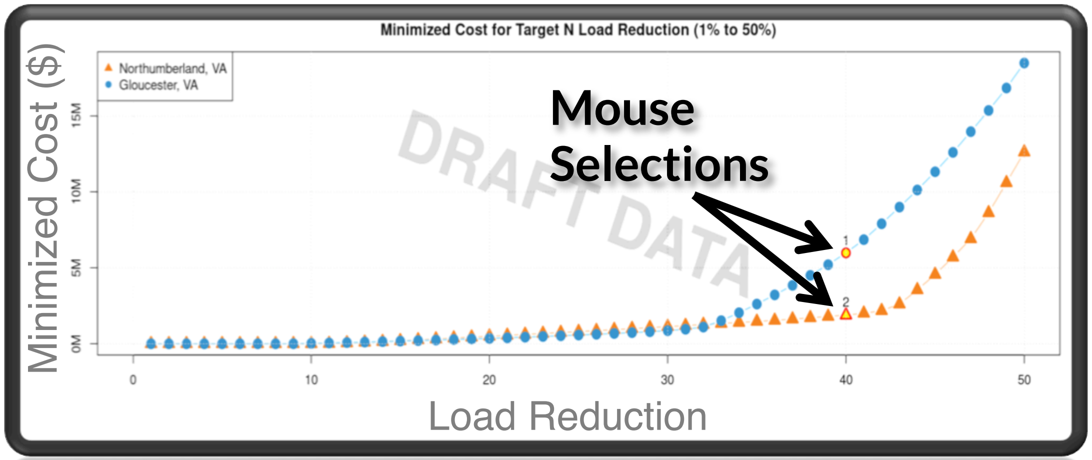

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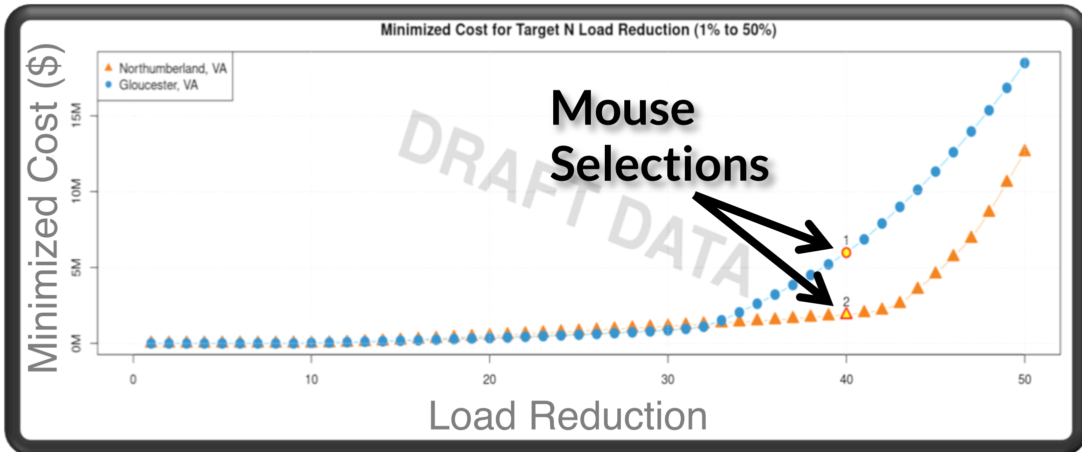

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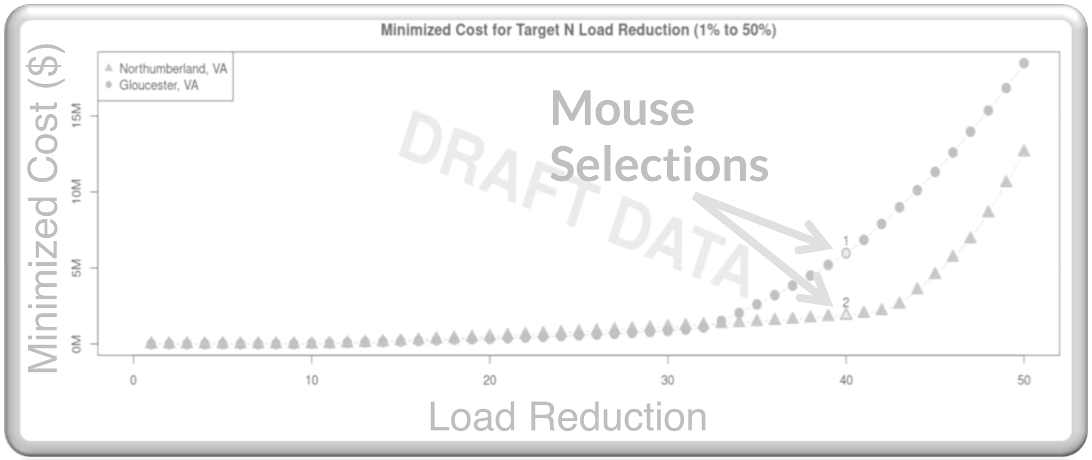

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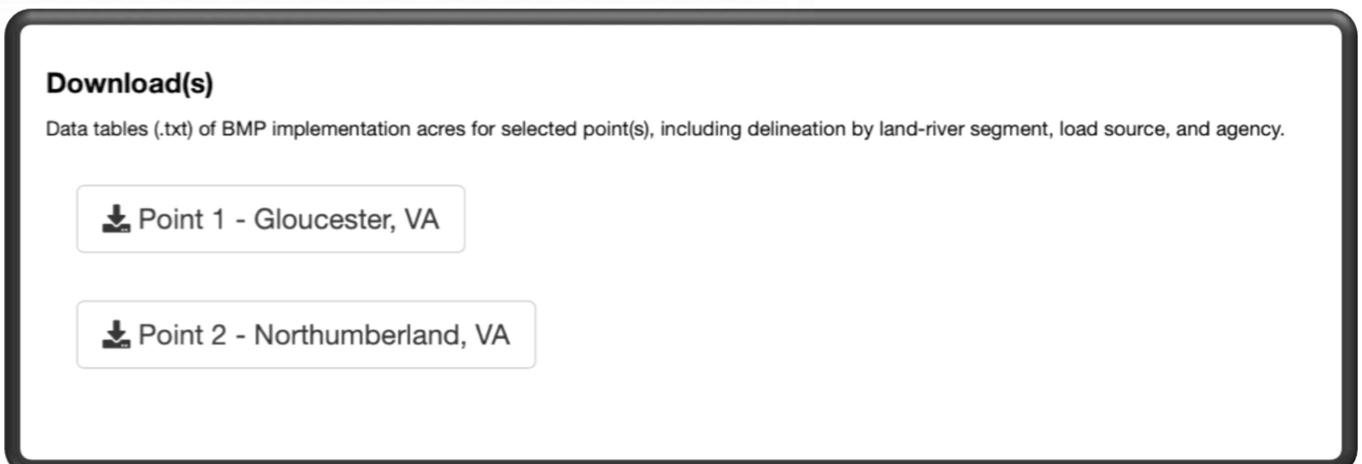
Downloadable BMP input file(s) for selected point(s)



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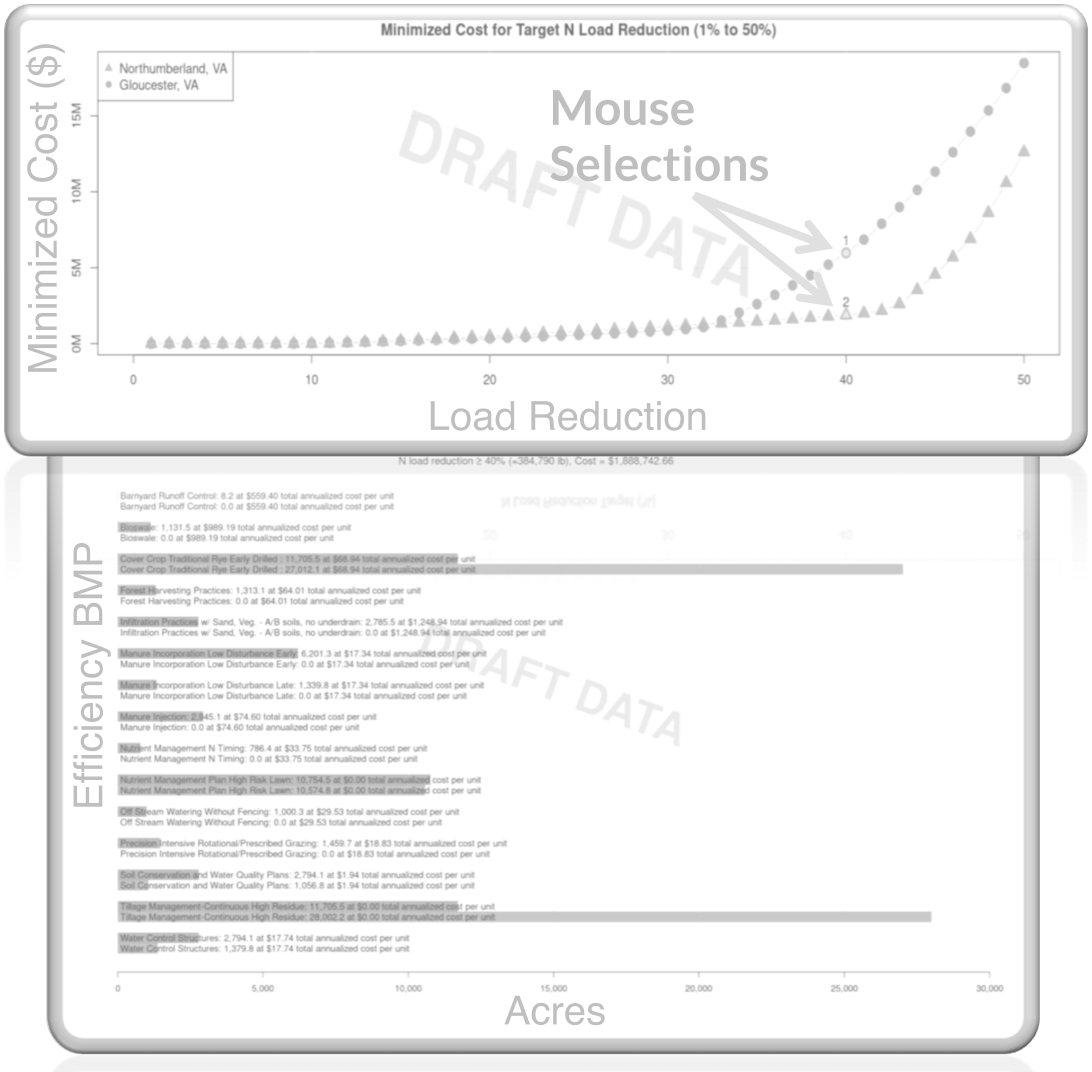

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- Load reduction in pounds in addition to percentages
- Fixed an issue when switching data points
- Other graphical improvements

Optimization Engine

Using updated CAST source data

Outputting additional table as CAST-formatted BMP inputs

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In the next week or so:

- Fixing issue with mapping between load source groups and load sources available for BMP implementation
- Including delineations between federal and non-federal agency acres, as in CAST

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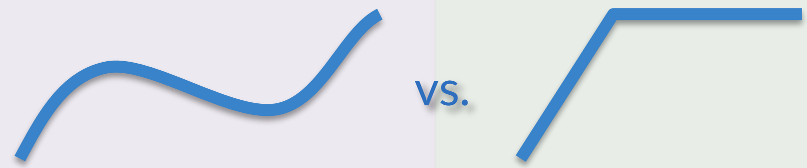
Ongoing development

1. Efficiency BMP representation:



Nonlinear	**Linear**
• same load calculation as in CAST	• solve faster • facilitate more solution exploration

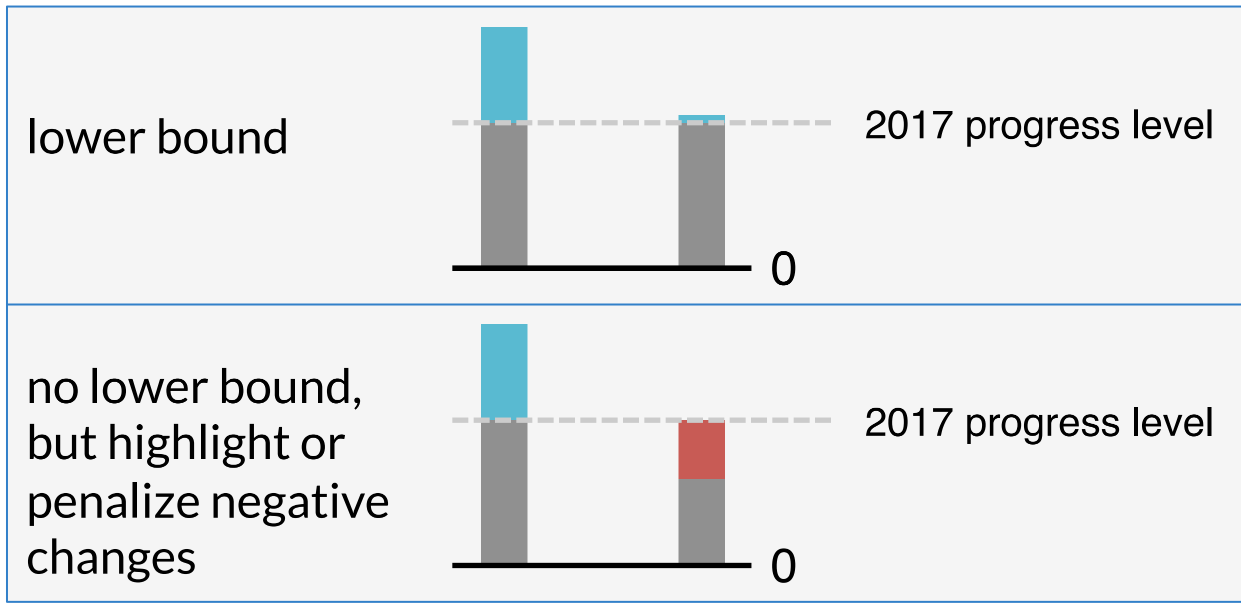
2. Land conversion BMP model

3. Larger geographies

Planned updates for January

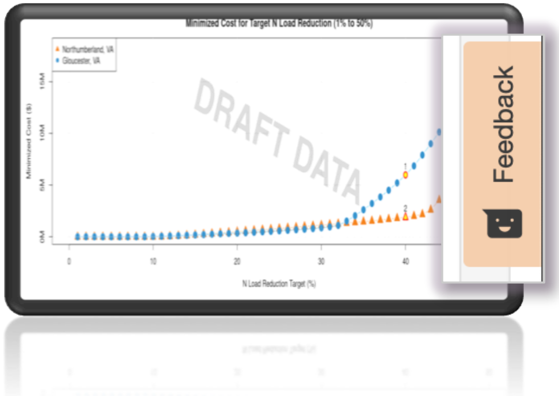
1. Base loads and BMPs other than 2010 no-action (e.g. 2017 progress)

How to handle existing BMP acres?



2. Structural software improvements

Will continue to be shaped by feedback



Check it out!

https://shiny-apps.chesapeakebay.net/vico/

...and email me (Danny), at:

dkaufman@chesapeakebay.net

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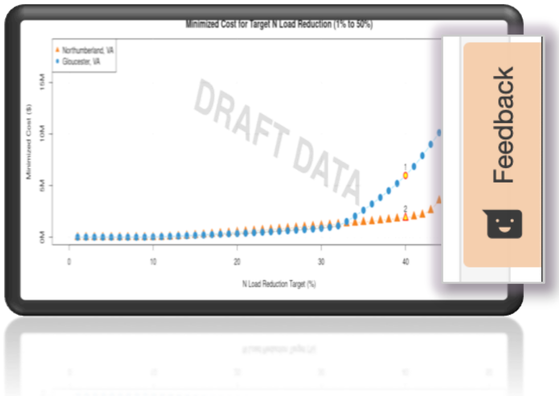

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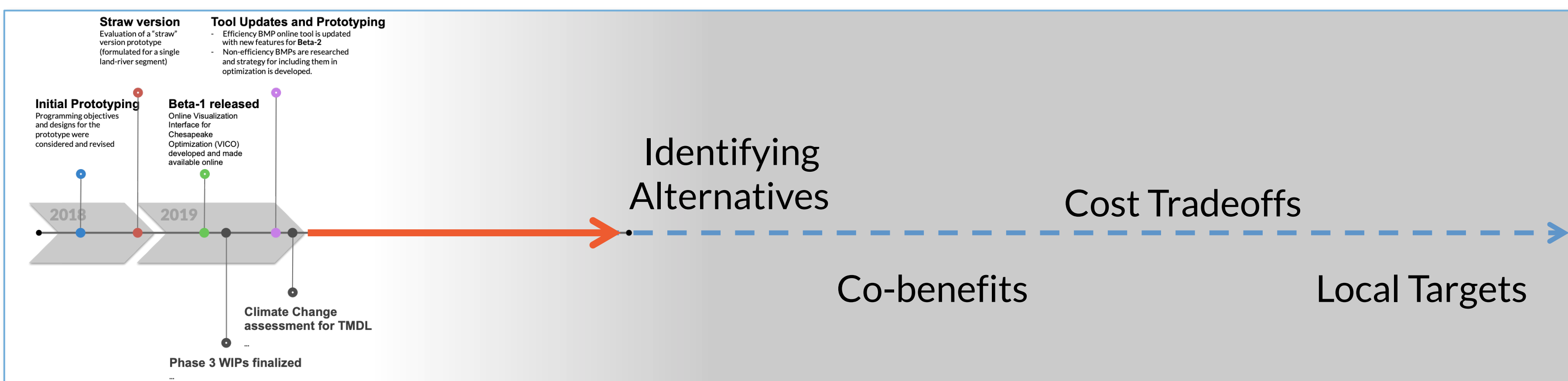
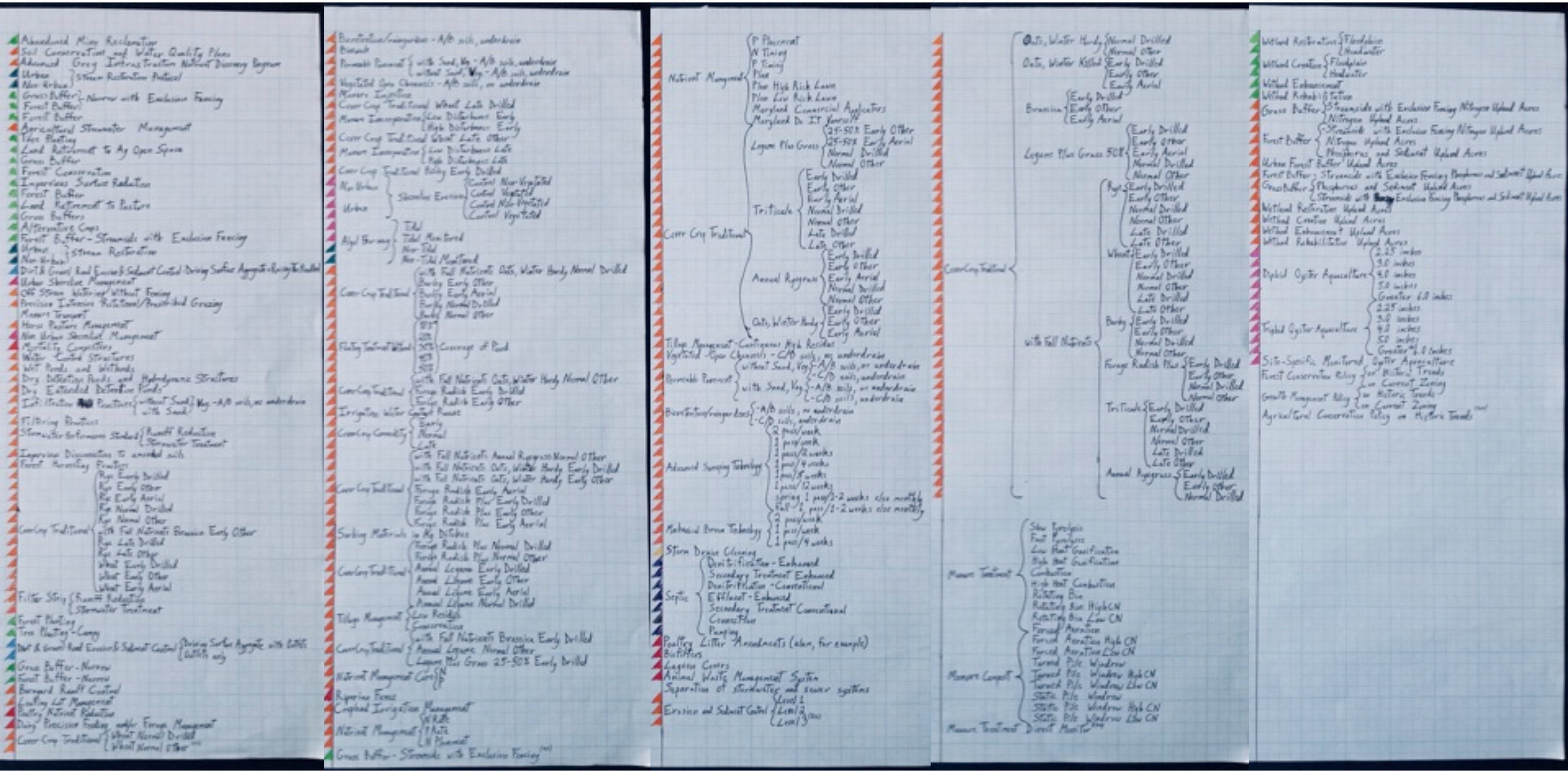


Best Management Practices (BMPs)



Orange - Efficiency

Light blue – dirt and gravel

Green – Land use change

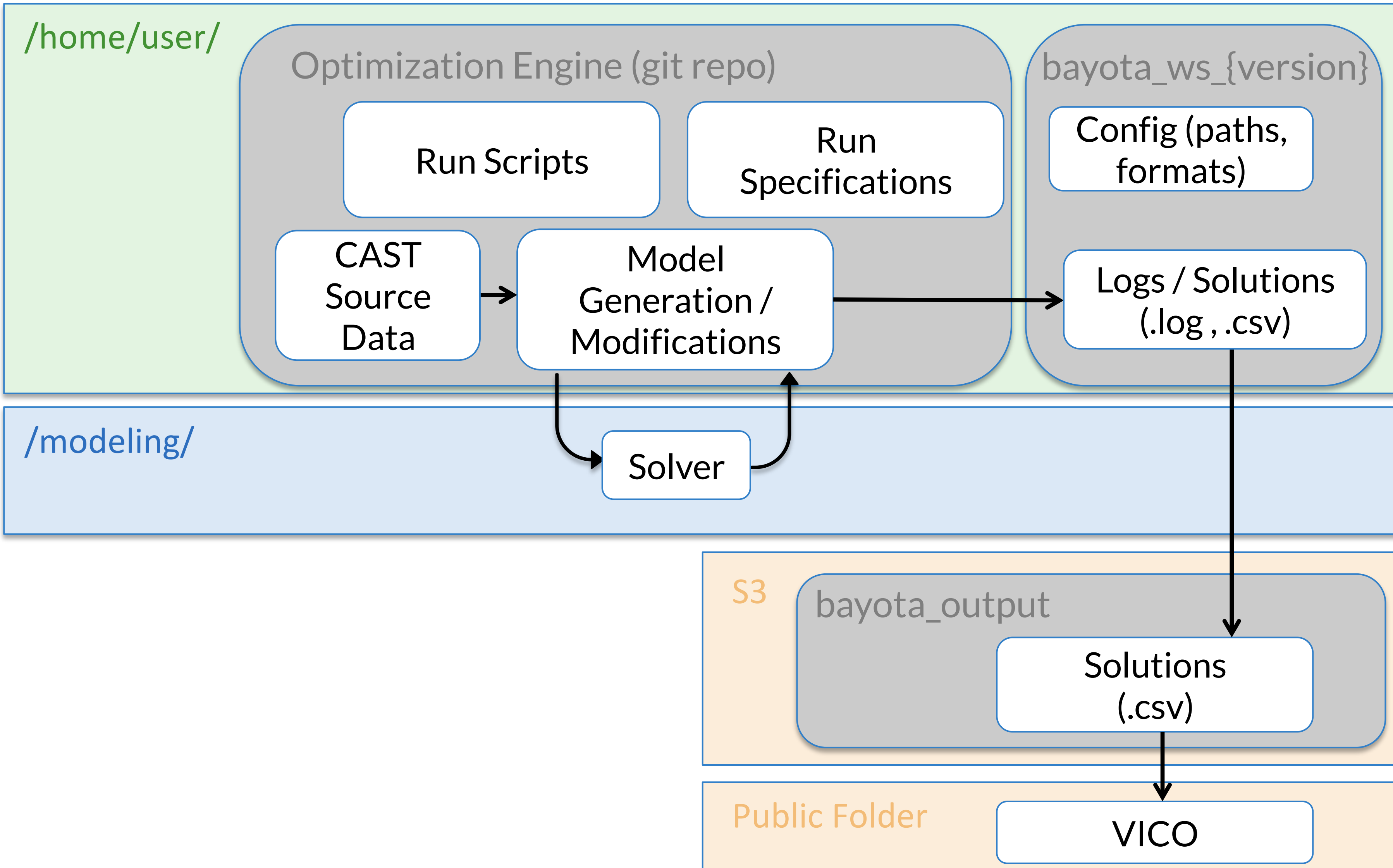
Pink – shore

Yellow – Load reduction

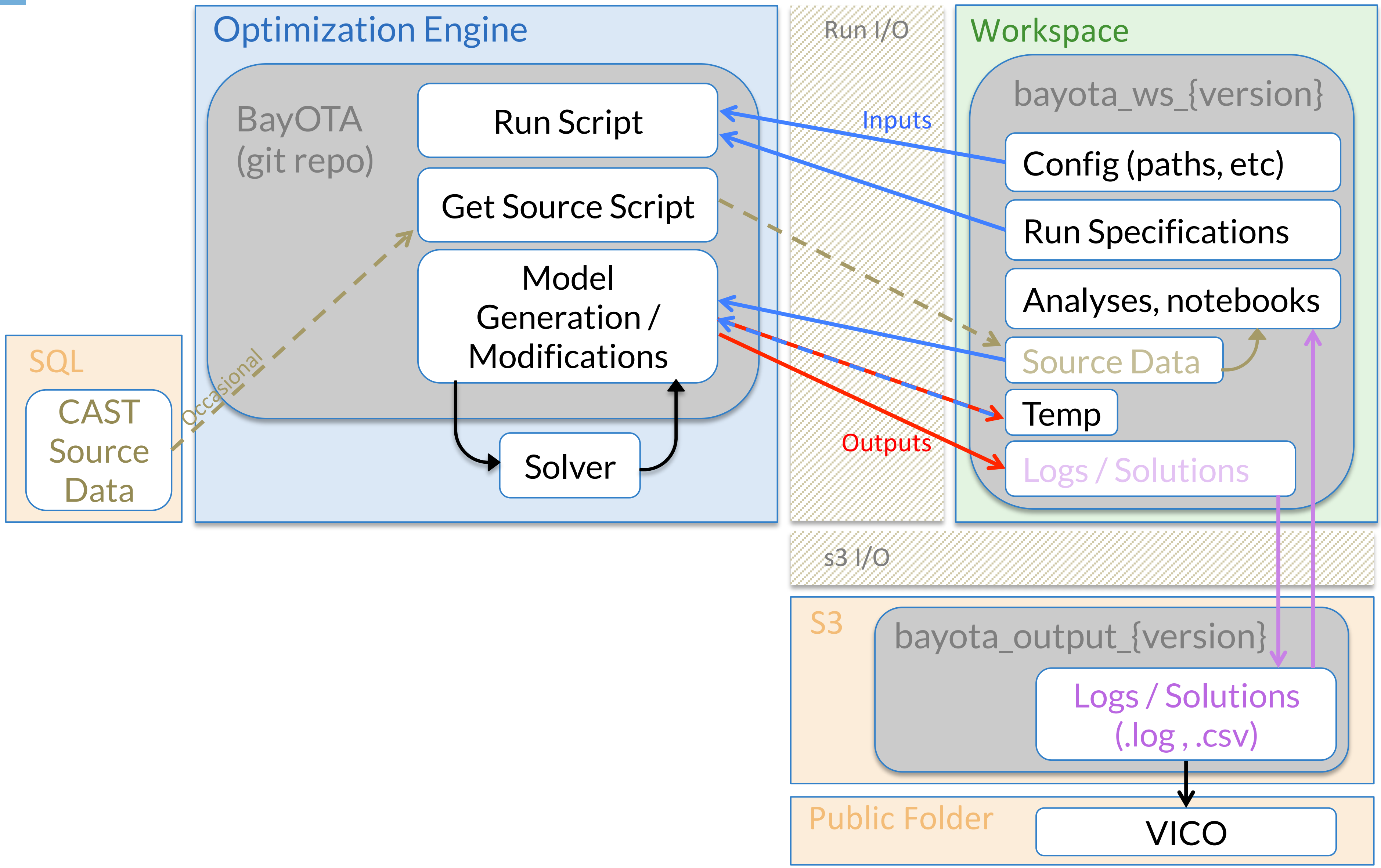
Red - animal

Teal – stream

Beta-1 Version components



Beta-2 Version components



Planned version components