Optimization to Support Chesapeake Environmental Management: Most Protection at Least Cost

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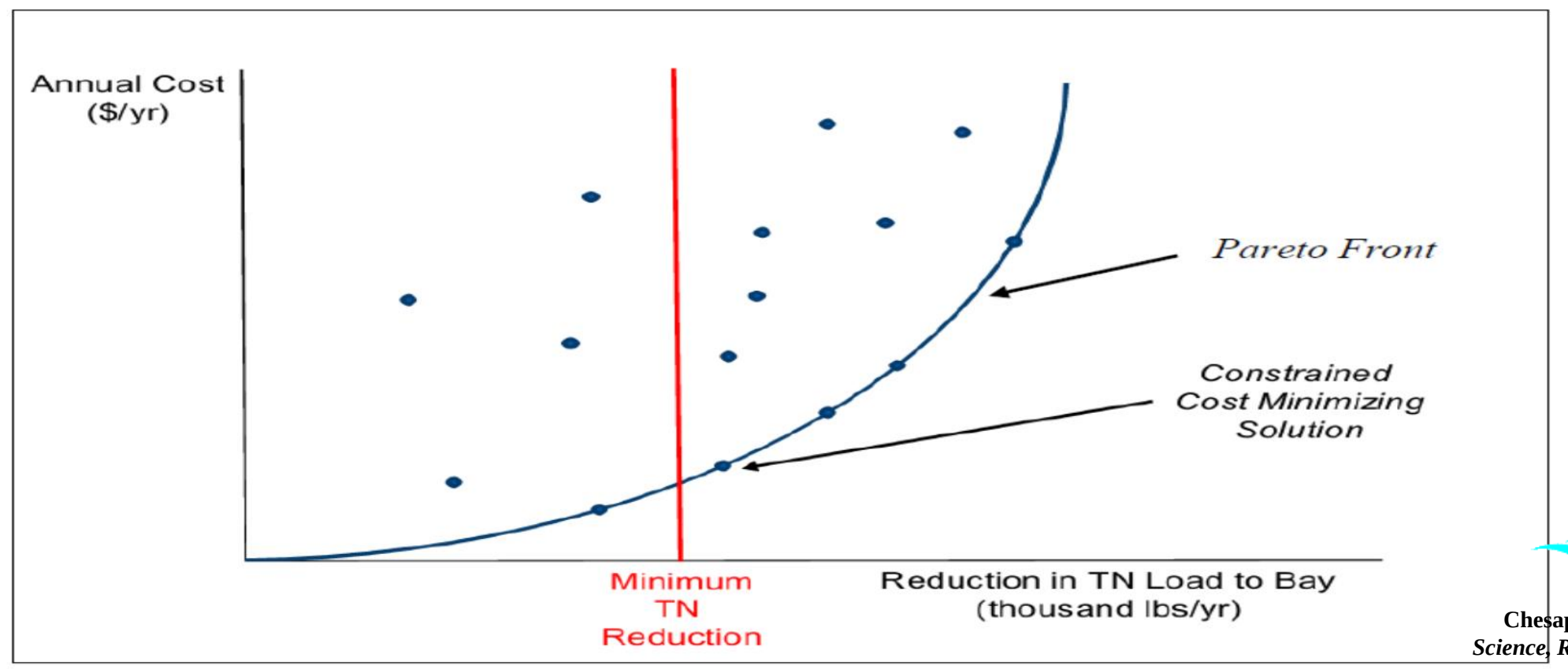
Lew Linker (EPA-CBP) and the CBPO Modeling Team
linker.lewis@epa.gov



Optimization Overview

Background of why were doing this: The 2016 STAC Workshop *Cracking the WIP: Designing an Optimization Engine to Guide Efficient Bay Implementation* recommended development of a least cost – most protection optimization tool for the CBP partnership based on the current CAST version at any given point in time.
https://www.chesapeake.org/pubs/373_Davis-Martin2017.pdf

There has been broad CBP partnership buy-in and support for the CBP Optimization. The work is supported by world-class Michigan State University optimization scientists and practitioners.

Optimization Overview

How long has the CBP been at it: A CBPO RFA (Request for Assistance) was let in 2019 in response to STAC Optimization workshop recommendations and the Cooperative Agreement w/ Michigan State University began in the second Quarter or 2020 for a six-year agreement.

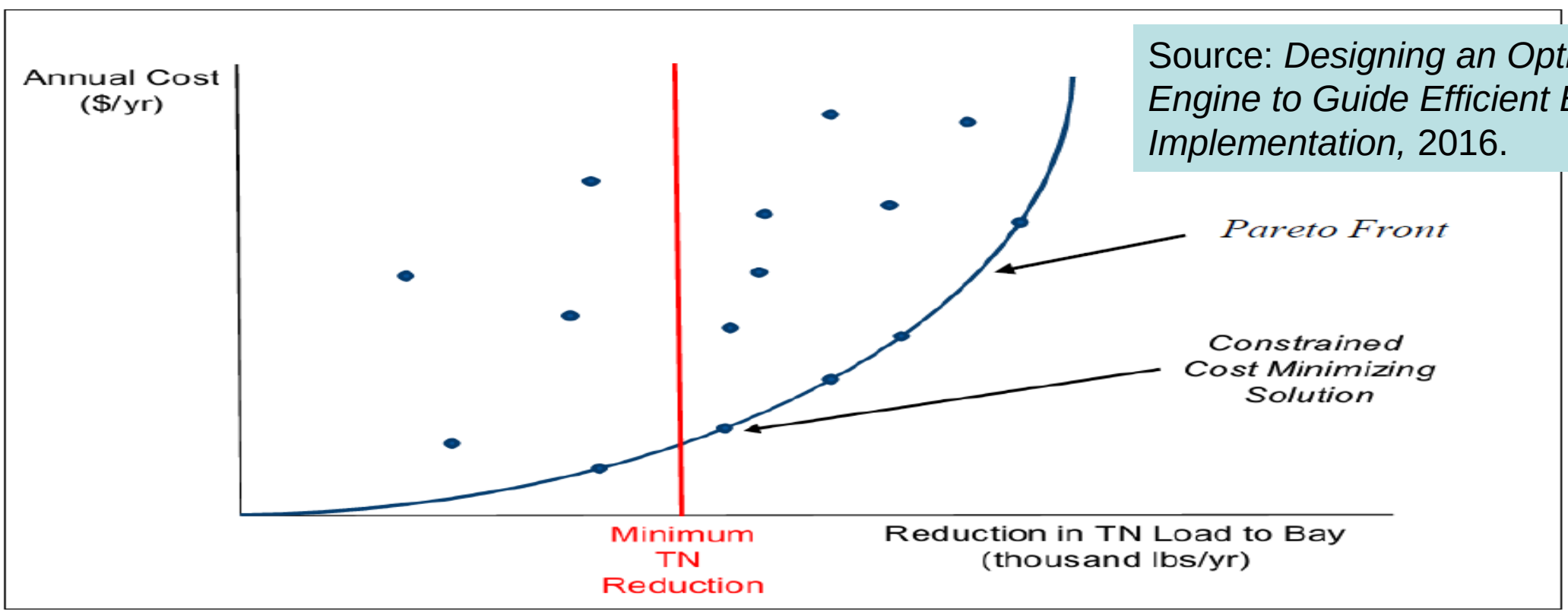
Who the expected users of this tool will be: All CBP partners at all scales including the whole watershed, State, and County scales could benefit from a planning tool that will allow a fast independent, user adjustable assessment of the “most nutrient or sediment reductions at least cost”.

From the 2016 STAC Workshop

"Adaptive management is highlighted in the Bay TMDL and watershed jurisdictions' WIPs as a key component of the Bay TMDL accountability framework. Optimization tools will provide a tangible and useable way to adapt implementation approaches based on new information. Small adjustments in optimization constraints, variables and objective trade-offs, based on new information or understanding, will produce an adapted nominally optimal implementation scenario that can guide program and policy changes."

Source: *Designing an Optimization Engine to Guide Efficient Bay Implementation*, 2016.

Minimize Cost – Maximize Nutrient Reduction

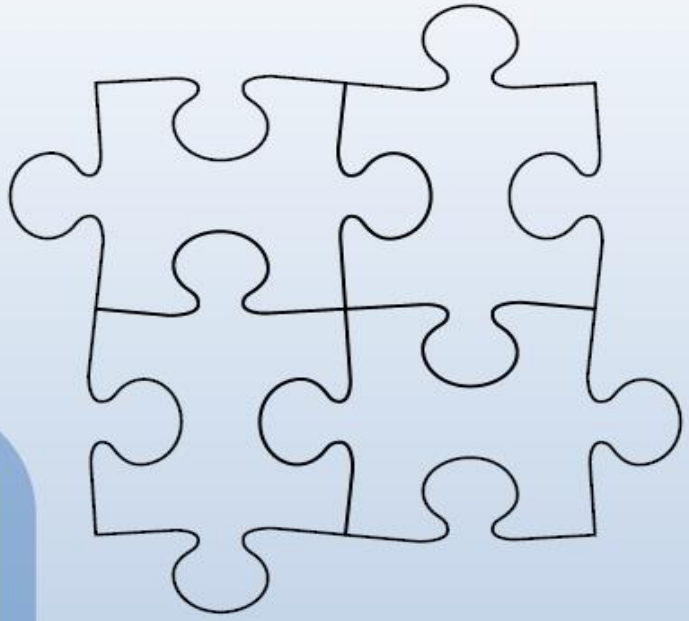


Source: *Designing an Optimization Engine to Guide Efficient Bay Implementation,* 2016.

In this example, the objective of the optimization problem is to minimize the total costs. The variables are all of the possible BMP types and extent of each that is used. The constraint is that the mix of BMPs in the solution must meet the TMDL load allocations. The optimization problem would be solved by evaluating multiple scenarios with different BMP combinations to determine their total cost and the resulting loads. Figure 1 represents the potential Pareto Front for cost minimizing scenarios and the solution that minimizes the total costs while also achieving the necessary load reduction.

The Essential CBP Optimization Problem

Beating the "Curse of Dimensionality"



- Due to the **large dimension of the problem**, there is **no off-the-shelf optimization algorithm** capable of handling this problem.

- Therefore, we developed a **customized optimization** approach **to speed up computational time and reduce the size of optimization variables** to make the problem solvable in a reasonable time frame.

The CBP Optimization Solution

Innovation through Optimization

The major problem we are facing is **the large number of optimization variables.** These variables originate from three major components:

- Type of BMPs
- BMP implementation location
- Size of BMPs

Innovization

By understanding **the common characteristics of the group of BMPs or locations of implementation**, we can reduce the number of BMPs and ultimately **reduce the total number of variables.**

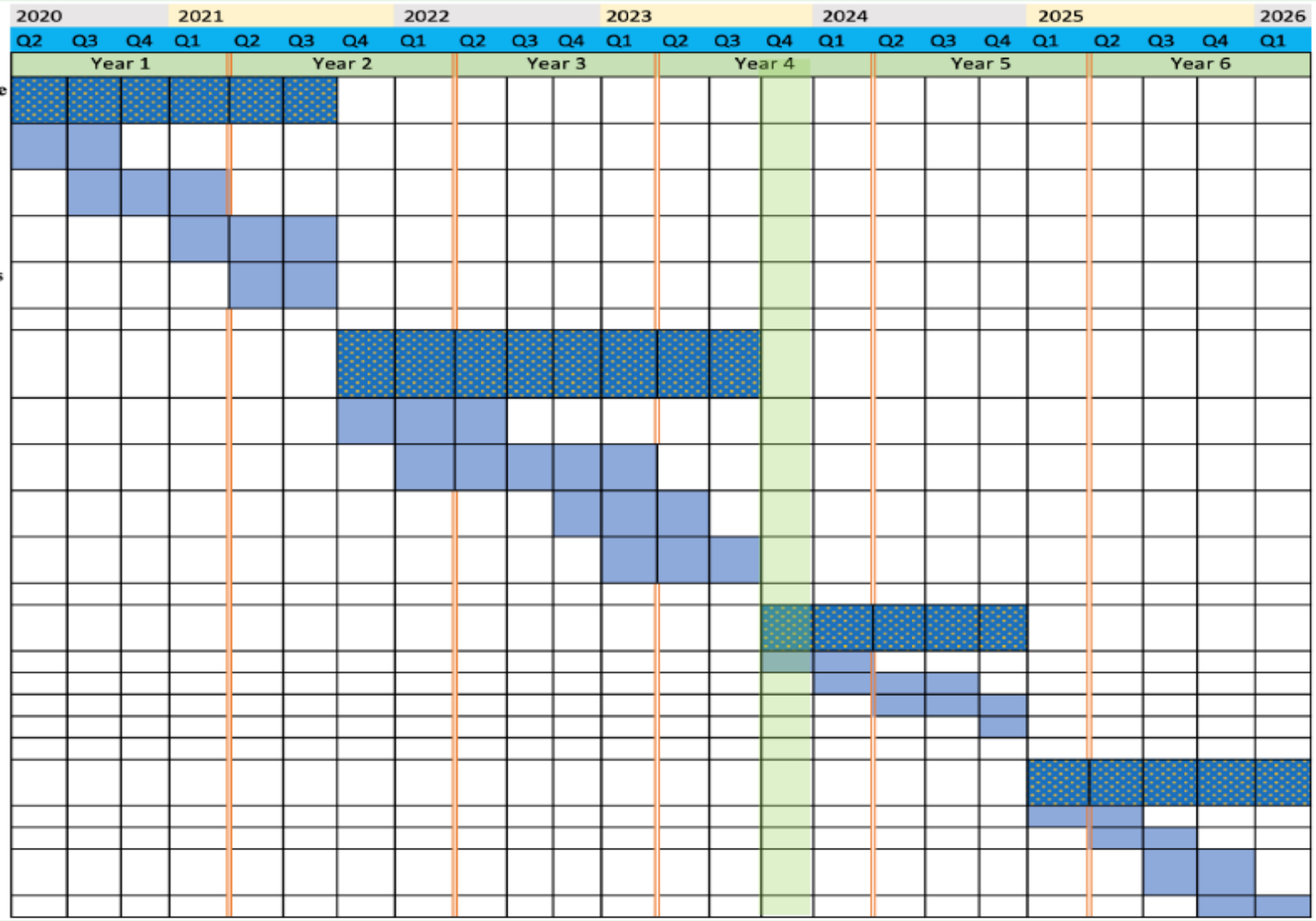
Innovization includes clustering techniques (principal component, Bayesian variable reduction and others), machine learning, and other artificial intelligence techniques.

How Optimization Fits In

Optimization will be a public domain web accessible tool that can be used by CBP State or Federal partners, and local jurisdictions for future implementation strategies of WIPs, milestones, and other future assessments.

Optimization Six-Year Timeline

Timeline of the Project



2024 Optimalization Webinars

In the coming weeks, the schedule of 2024 Optimization Webinars will be announced. The webinars will encourage discussion with CBP decision makers on the application of CBP Optimization with CAST.

The CBP Optimization will be fully operational in December 2025, allowing for full review and application in 2026 and beyond.

Objective:

* Raise awareness about our BMP optimization framework.

Features:

* Interactive show of the framework capabilities

Benefits:

* Enhanced decision-making
* Foster community collaborations