Development of Efficient Multi-Objective Optimization Procedures

Kalyanmoy Deb, Pouyan Nejadhashemi, Ritam Guha and Hoda Razavi

Agenda

- New Member Onboarding: Auden Garrard
- Revised Work Plan
- Assistance from CoreCAST team
- Conflict Resolution between Optimization WebApp and CAST
- Dashboard Updates
    - Replicating CAST UI Interface
- Live Demonstration of the dashboard
- Future Plans

About the New Member

Project Experience

- Front End Developer
- Auto-Owners Insurance

  Technologies:
  Node.js, Python, Java, COBOL, Django

- Recovery of Lost and Stolen IT Assets

  General Motors

  Technologies: PowerShell, JavaScript, C++,

Auden Garrard

He/Him

Education

Master in Computer Science
Michigan State University

Contact Information

garrardw@msu.edu

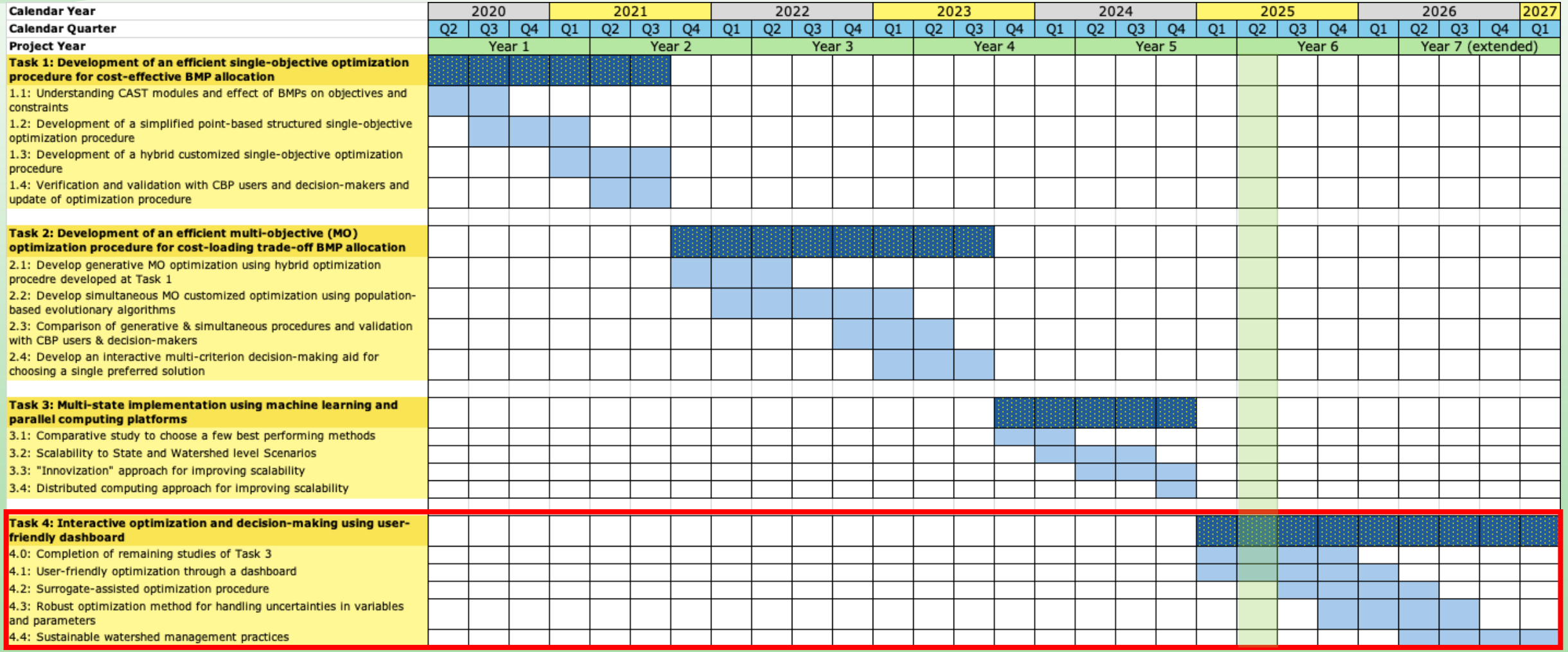
Personal Hobbies

- Rock climbing
- Kayaking
- Pottery

Revised Timeline of the Project

Original End Date: March 31, 2026

Proposed Extended End Date: March 31, 2027



Task 4: Interactive optimization and decision-making using user-friendly dashboard

4.0 Completion of remaining studies of Task 3

4.1 User-friendly optimization through a dashboard

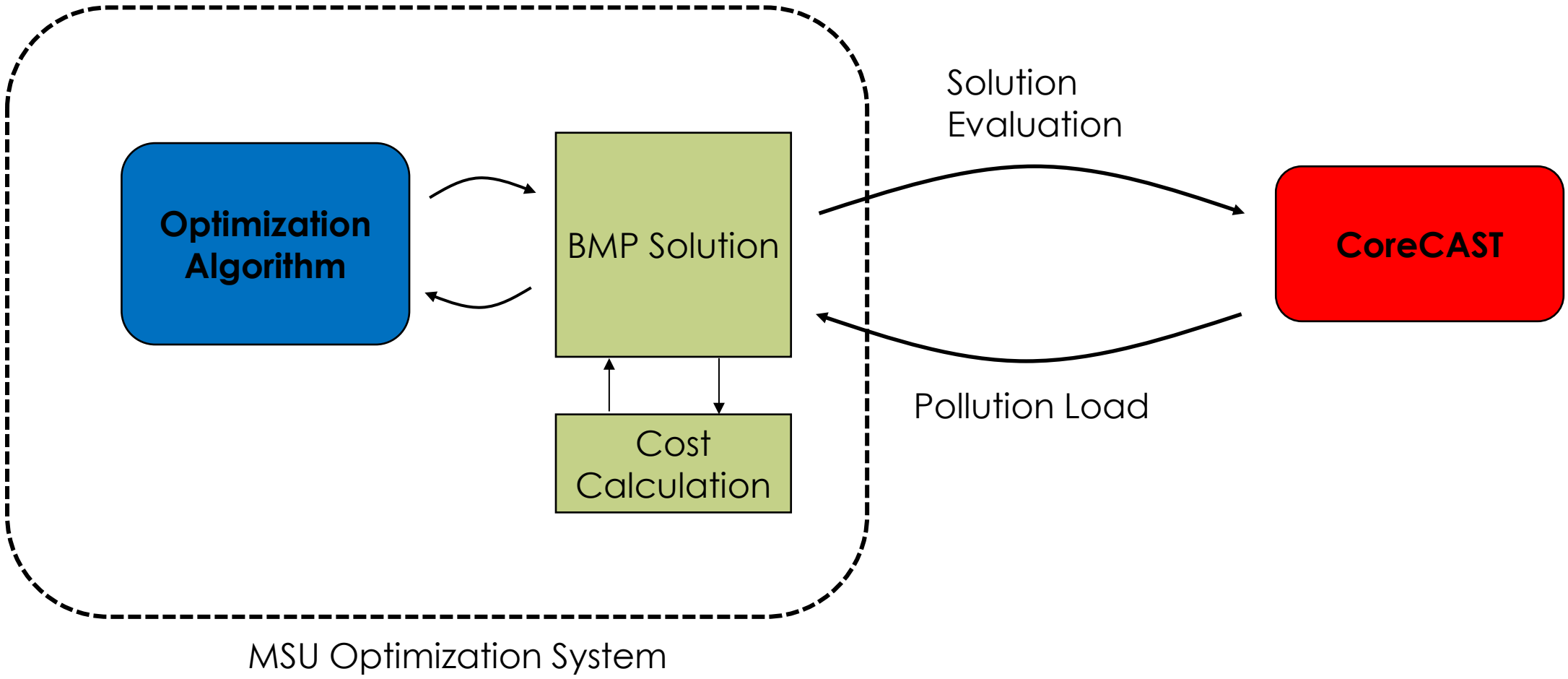
4.2. Surrogate-assisted optimization procedure

4.3 Robust optimization methods for handling uncertainty in variables and parameters

4.4 Sustainable watershed management practices

Timeline of the Project

Optimization Process Overview (Recap)



Assistance from the CoreCAST Team

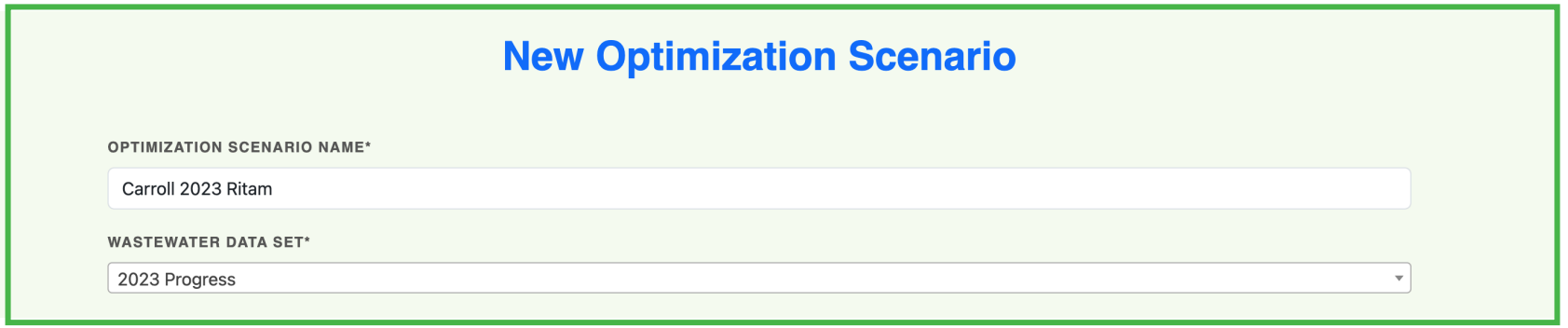
- Due to the transfer of project leadership from Gregorio to Ritam, we encountered **substantial challenges** in comprehending the system and its integration with CoreCAST.

- Thanks to the CoreCAST team, we have now received the following essential documents:
    1. **Documentation** on CoreCAST.
    2. A copy of the **database** used in CoreCAST.
    3. A detailed **validation** of our results.

- With this invaluable support, we have successfully **addressed several issues** in our web interface, which were previously caused by a lack of understanding of the CoreCAST system.

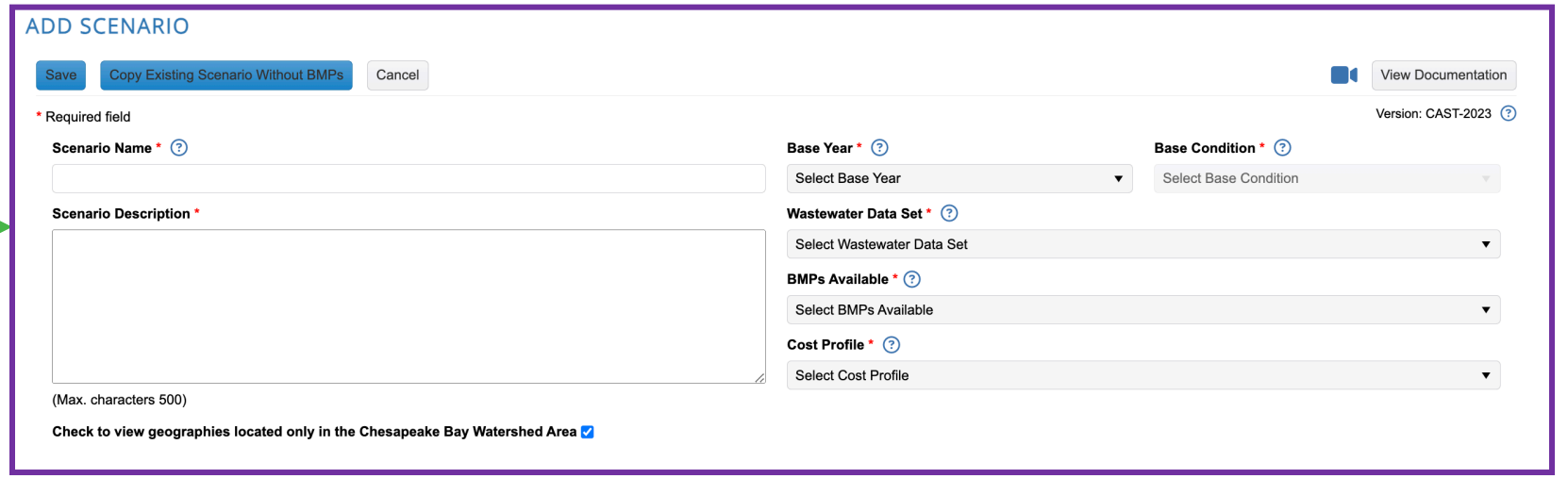
Previous Dashboard Inputs

Web App UI

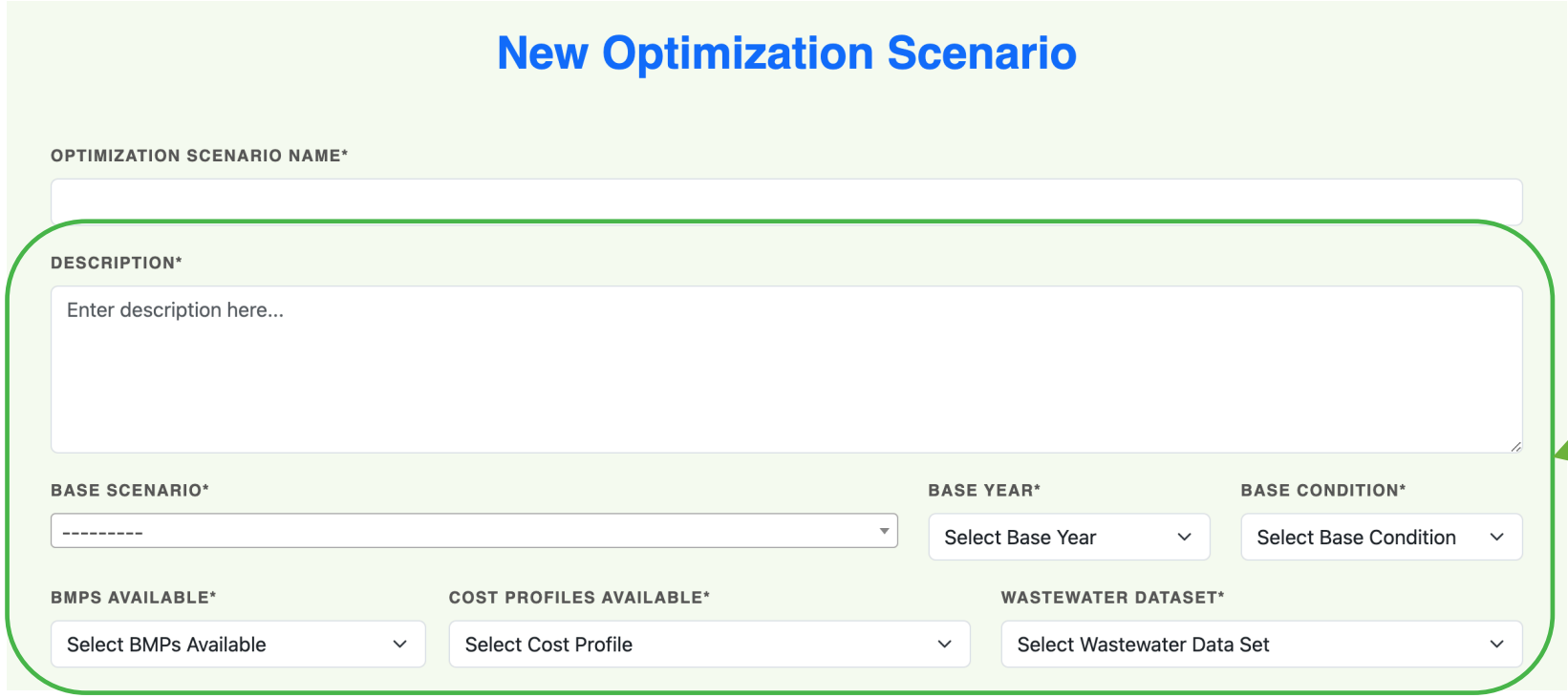


Not matching with CAST

CAST UI

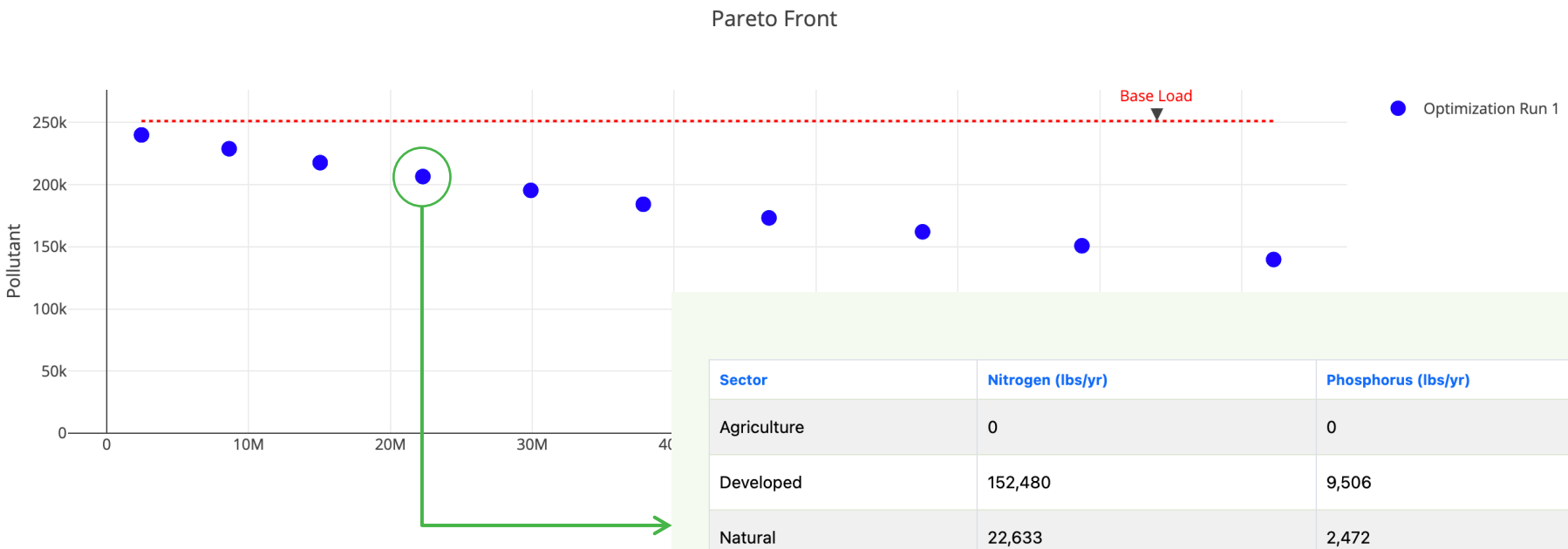


Current Dashboard Improvements



Added new options for the user inputs to remove any ambiguity with the CAST system

Optimization Run with Washington DC



Sector	Nitrogen (lbs/yr)	Phosphorus (lbs/yr)	Sediments (lbs/yr)
Agriculture	0	0	0
Developed	152,480	9,506	25,947,779
Natural	22,633	2,472	17,926,838
Septic	235	0	0
Total	206,523	18,611	44,736,900
Wastewater	31,175	6,633	862,283

Optimization Run with Washington DC

Sector	Nitrogen (lbs/yr)	Phosphorus (lbs/yr)	Sediments (lbs/yr)
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Natural	22,633	2,472	17,926,838
Septic	235	0	0
Total	206,523	18,611	44,736,900
Wastewater	31,175	6,633	862,283

Everything is matching except Wastewater in two sub-segments: **Industrial** and **Municipal** loads; And a small portion for developed

CAST Result Verification

Sector: Agriculture	0.00
Sector: Developed	152,450.14
Sector: Natural	22,632.79
Sector: Septic	235.42
Sector: Wastewater	
AgencyType: Non Federal	
Agency: Non-Federal	
Combined Sewer Overflow	31,174.86
Industrial Wastewater Treatment Plant	33,000.65
Municipal Wastewater Treatment Plant	1,316,067.67
	1,380,243.18
	1,380,243.18

Sector: Agriculture	0.00
Sector: Developed	9,504.43
Sector: Natural	2,472.05
Sector: Septic	0.00
Sector: Wastewater	
AgencyType: Non Federal	
Agency: Non-Federal	
Combined Sewer Overflow	6,632.95
Industrial Wastewater Treatment Plant	3,575.89
Municipal Wastewater Treatment Plant	44,359.74
	54,568.58

Sector: Agriculture	0.00
Sector: Developed	25,937,147.16
Sector: Natural	17,926,837.68
Sector: Septic	0.00
Sector: Wastewater	
AgencyType: Non Federal	
Agency: Non-Federal	
Combined Sewer Overflow	862,283.32
Industrial Wastewater Treatment Plant	272,925.09
Municipal Wastewater Treatment Plant	556,828.46
	1,692,036.87

Wastewater Mismatch Correction

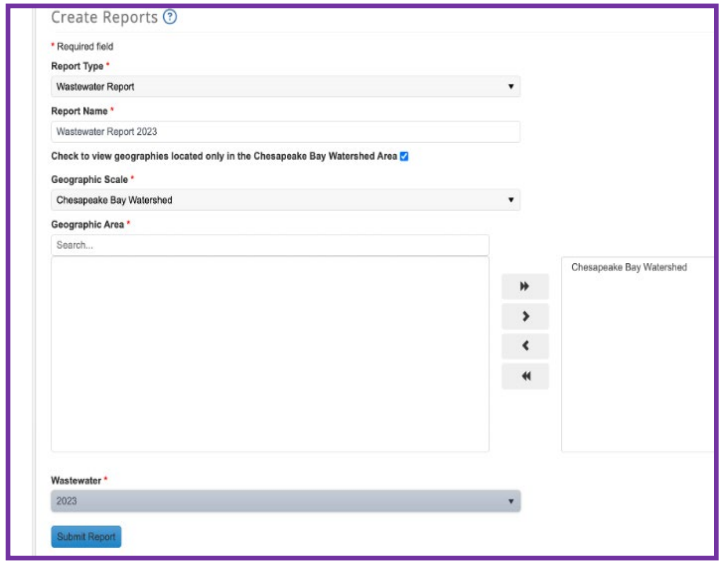
- We have identified that the two sub-segments of wastewater namely Industrial and Municipal Treatment Plant loads can be retrieved from Wastewater Reports:
    1. **Nitrogen Loads EOS**: No3LbsPerYearEos, Nh3LbsPerYearEos, OrgnLbsPerYearEos
    2. **Phosphorus Loads EOS**: Po4LbsPerYearEos, OrgpLbsPerYearEos
    3. **Sediments Loads EOS**: TssLbsPerYearEos

- We are in the process of obtaining the reports and integrating it to our web interface.

Wastewater is polluting more than what our system thinks!

Wastewater Mismatch Correction

CAST Reports Section



Match!

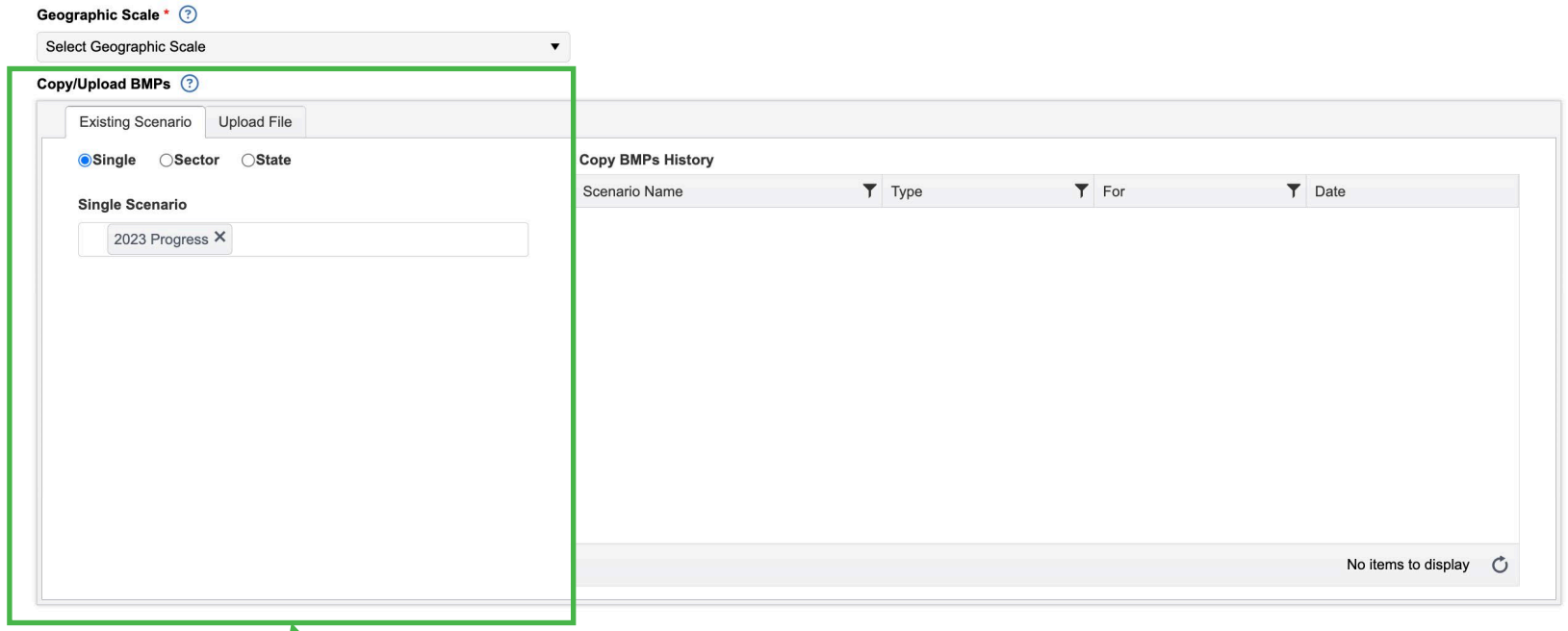
EOS Nitrogen	EOS Phosphorus	EOS Sediments	EOT Nitrogen	EOT Phosphorus	EOT Sediments
119071.8860	4747.7632	76731.9283	74980.9756	2992.3246	27398.6016
22543.8977	171.8241	42983.9054	263.7143	55.0644	23710.3483

Aggregations

WasteWate	Npdes	Facility	Outf	LandRiverSegment	Geography	Agency	LoadSource	Sign	FloAvgMillior	BodLbsPerY	DoLbsPerYe	No3LbsPerY	Nh3LbsPerYe	OrgnLbsPerY	Po4LbsP	OrgpLbs	TssLbsPerYe	NO3LbsPe	NH3LbsPer	ORGNLbsP	PO4LbsPerY	ORGPLbs	TSSLbsPerYear
2023	MD0022578	MANCHESTER WWTP	002	MD-N24013WU0_3021_3020(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	N	0.3222	11674.7340	0.0000	13851.2592	0.0000	0.0000	0.0000	0.0000	15001.7976	1738.8931	0.0000	0.0000	0.0000	0.0000	48.6034
2023	MDG766057	CARROLL COUNTY FAMILY YM	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0002	18.1820	3.0303	1.0303	0.0848	0.0970	0.0861	0.0352	9.0910	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MD0065927	RUNNYMEADE WWTP	001	MD-N24013PM1_3120_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	N	0.0019	35.2993	47.8545	0.0000	27.2440	0.0000	0.0000	0.0000	27.1505	0.0000	19.7136	0.0000	0.0000	0.0000	17.9857
2023	MDG766144	SOUTH CARROLL SWIM CLUB	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0002	18.1820	3.0303	1.0303	0.0848	0.0970	0.0861	0.0352	9.0910	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MDP121831	WATER DEPOT	001	MD-N24013PM1_3450_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MD0001881	BTR HAMPSTEAD, INC.-BLACK	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.2170	19826.5950	3304.4325	17820.2490	1467.5499	1677.2000	19.1700	7.8300	4503.9999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MD0024546	PHEASANT RIDGE WWTP	001	MD-N24013WM1_3882_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	N	0.0354	487.8486	812.0506	2711.9621	153.2796	83.0781	470.2674	113.4804	599.8585	1427.5690	80.6860	43.7321	214.2935	51.7112	165.1853
2023	MDG492472	S & G CONCRETE - FINKSBUR	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0010	0.0000	24.3401	4.4421	0.7302	0.9128	0.0204	0.0100	91.2754	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MDG490433	THOMAS, BENNETT & HUNTEF	001	MD-N24013PM1_3450_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0010	0.0000	24.3401	4.4421	0.7302	0.9128	0.0204	0.0100	91.2754	3.5275	0.5799	0.7248	0.0144	0.0071	62.2918
2023	MD0021512	FREEDOM DISTRICT WWTP	001	MD-N24013WM1_3882_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	Y	2.0243	7091.6907	47097.9902	9388.4351	518.0356	6516.9934	0.0000	608.1958	24514.8642	5128.9491	283.0054	3560.2661	0.0000	277.1453	6750.7497
2023	MDG344224	WALSH FUEL & SUPPLY CO,IN	001	MD-N24013PM2_2860_3040(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MD0024589	SOUTH CARROLL HIGH SCHO	001	MD-N24013WM1_3882_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	N	0.0054	25.9532	135.4949	325.6338	300.0502	9.2326	0.0000	2.6092	148.6450	90.3270	83.2304	2.5610	0.0000	0.2028	3.0747
2023	MDG912397	SHEETZ STORE # 132	001	MD-N24013PM3_3040_3340(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0025	228.2607	38.0434	32.3369	2.6630	3.0435	1.0804	0.4413	114.1303	21.8978	1.8033	2.0610	0.8055	0.3290	64.4877
2023	MD0000779	LEHIGH CEMENT COMPANY LI	001	MD-N24013PM1_3450_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.1400	12791.3519	2131.8919	28.9798	2.3866	2.7275	0.0000	0.0000	33727.7961	23.0135	1.8952	2.1660	0.0000	0.0000	23017.8547
2023	MDG499852	C. J. MILLER, LLC	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0010	0.0000	24.3401	4.4421	0.7302	0.9128	0.0204	0.0100	91.2754	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MD0022527	MOUNT AIRY WWTP	001	MD-N24013WM1_3882_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	Y	0.6536	5382.5892	14577.4628	1058.7626	550.9026	1069.8109	29.9366	169.0661	1990.0273	578.4073	300.9608	584.4431	13.6416	77.0408	548.0012
2023	MD0001384	CONGOLEUM CORPORATION	001	MD-N24013WM0_3881_3880(CBWS	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	Y	0.1195	807.0417	2279.7744	413.8601	76.8661	654.8738	29.6006	20.5699	3281.3356	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2023	MDG498000	MEDFORD QUARRY (REICHLI	001	MD-N24013PM1_3450_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Industrial Wastewater Treatment Plant	N	0.0010	0.0000	24.3401	4.4421	0.7302	0.9128	0.0204	0.0100	91.2754	3.3169	0.5453	0.6816	0.0144	0.0071	62.2918
2023	MD0022454	UNION BRIDGE WWTP	001	MD-N24013PM1_3450_3400(CBWS)	Carroll, MD (CBWS Portion Only)	Non-Federal	Municipal Wastewater Treatment Plant	N	0.1293	1554.1708	3156.0736	6618.7784	342.5110	258.9353	648.5850	66.0771	1151.6430	5256.1107	271.9952	205.6259	456.7233	46.5305	785.9497

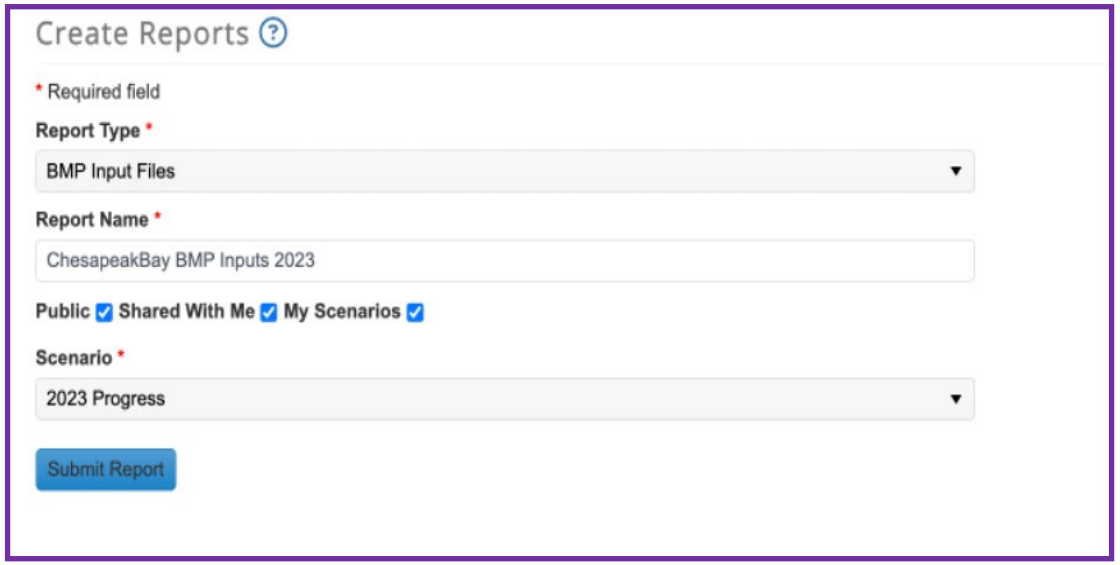
Base Progress Scenario Addition

- We also have identified a way to add the base scenario BMP implementations to the process by using the Reports.
- We are also in the process of obtaining the Progress reports and integrating it to our web interface.



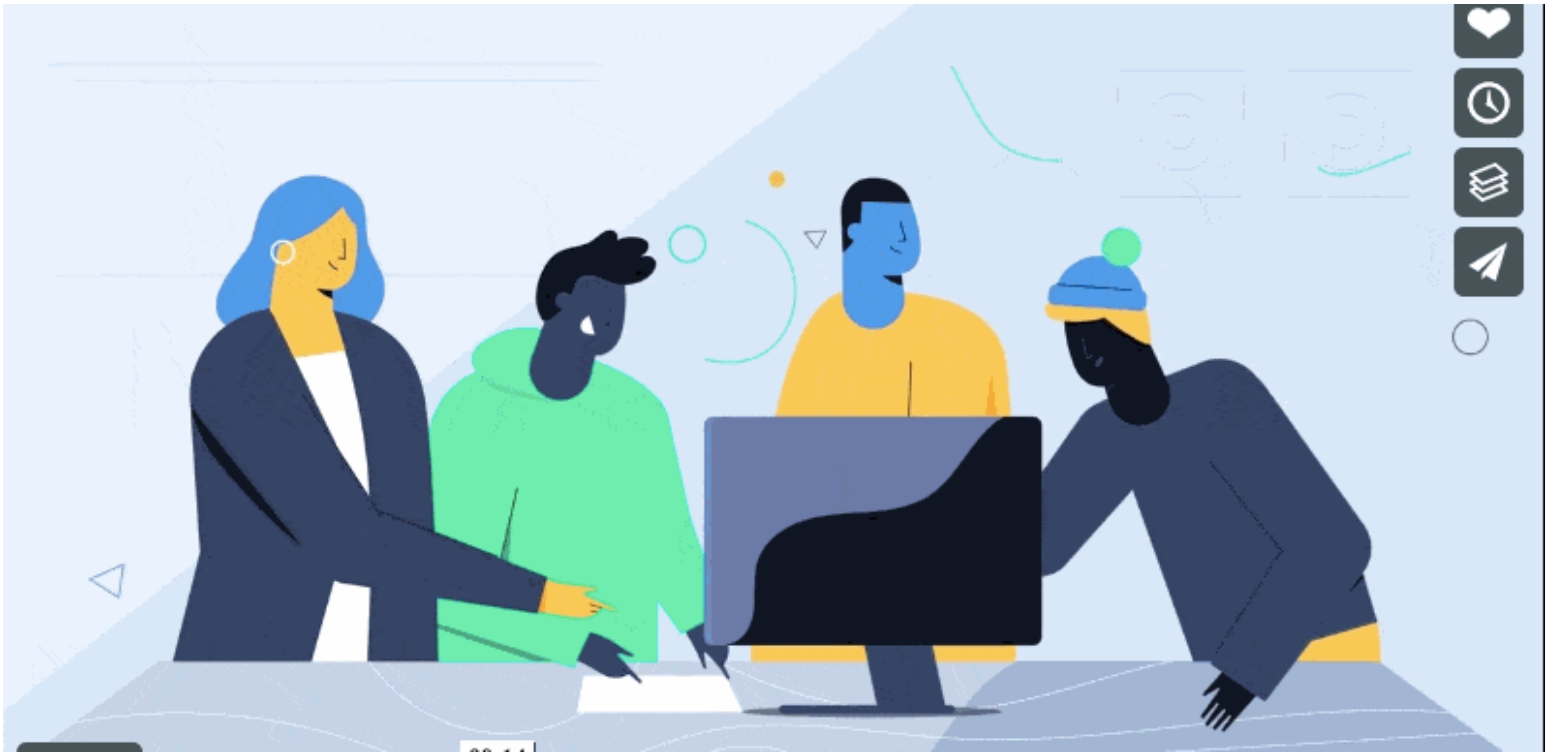
Adding this functionality;
Need to optimize on top of this

Base Progress Scenario Addition



StateUniqueIdentifier	AgencyCode	StateAbbreviation	BMPShortName	GeographyName	Lo
usnxv24010x1x62880	dod dc	bioretudab	dc	impervious	0.02500000037252903 acres
npsx2056x0x1	nps dc	bioretudab	dc	impervious	2.713406801223755 acres
npsx3786x0x1	nps dc	bioretudab	dc	impervious	4.655004501342773 acres
npsx3786x0x4	nps dc	bioretudab	dc	impervious	4.655004501342773 acres
npsx5535x1x2	nps dc	bioretudab	dc	impervious	0.014990816824138165 acres
six2100x0x1 si	dc	bioretudab	dc	impervious	0.04958677664399147 acres
six2100x0x2 si	dc	bioretudab	dc	impervious	0.04958677664399147 acres
arsx1155x0x2	ars dc	bioretudab	dc	ms4cssnonregulated	0.5 acres
arsx1155x0x3	ars dc	bioretudab	dc	ms4cssnonregulated	1 acres
usafx1070x0x1	dod dc	bioretudab	dc	ms4cssnonregulated	0.6727272868156433 acres
usnx365x0x1 dod	dc	bioretudab	dc	ms4cssnonregulated	0.32001835107803345 acres
usnx365x0x3 dod	dc	bioretudab	dc	ms4cssnonregulated	0.2700183689594269 acres
usnx950x0x1 dod	dc	bioretudab	dc	ms4cssnonregulated	0.657805323600769 acres

Live Demonstration



Link: https://coinlab.chesapeakebay.app/

Future Dashboard Improvements: Status Updates

Insert a status column

ID	Optimization Scenario Name	Wastewater Data Set	Counties	Date modified (EST)	Actions	Status
3	Carroll	2023 Progress	MD: [Carroll]	12/02/2024 6:22 p.m.		Completed
4	Kent	2023 Progress	DE: [Kent]	12/02/2024 7:08 p.m.		Initializing
5	Richmond	2023 Progress	VA: [Richmond]	12/02/2024 9:03 p.m.		Optimizing
6	Lancaster	2023 Progress	VA: [Lancaster]	12/02/2024 9:03 p.m.		Completed
7	Washington DC	2023 Progress	DC: [Washington]	12/02/2024 9:05 p.m.		Completed
16	Richmond 20 Iter	2023 Progress	VA: [Richmond]	12/11/2024 4 p.m.		Optimizing

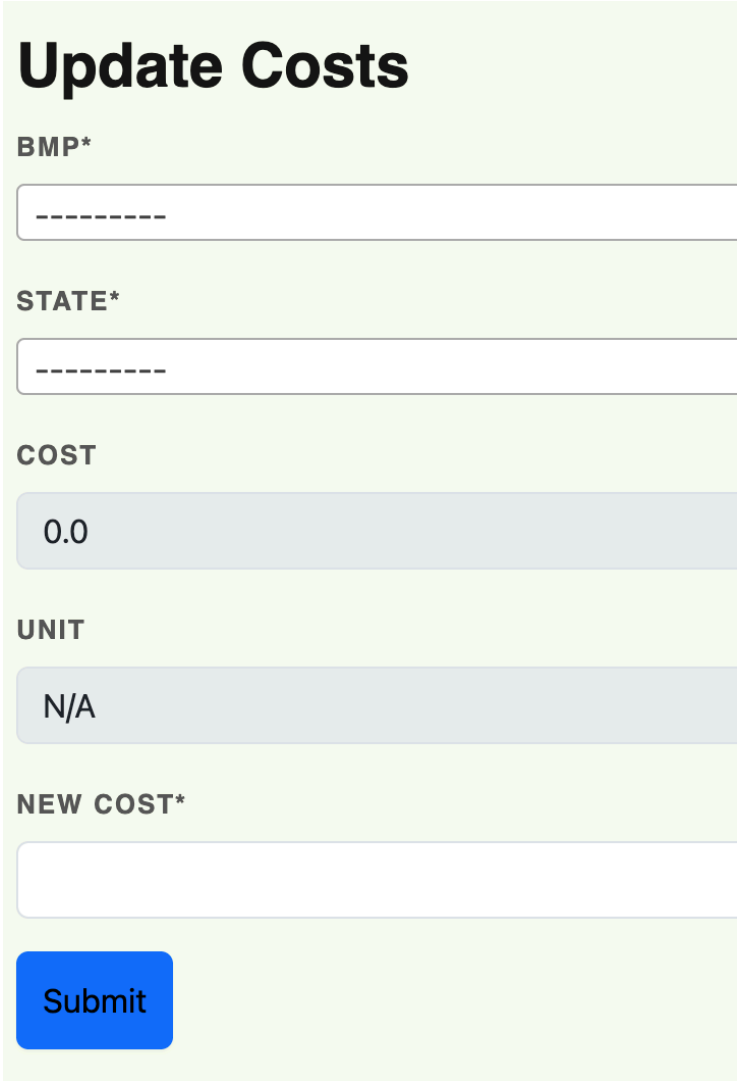
Will help the users keep track of what is going with each scenario: Optimizing/Fetching Base Scenario/Complete

Future Dashboard Improvements: Email Updates

- Will notify the users with two emails:
  - When Optimization starts
  - When Optimization completes

- When the optimization completes, the email might have a link to access the optimization results.

Future Dashboard Improvements: Cost Updates (Advanced Settings)



- Some of the cost information in the system might be old.
- If the user has updated cost information, the costs can be updated based on latest information

Future Improvements: Enable result sharing

Id	# Optimization Run	# Solutions	Actions
3	1	12	

Should help the user
Share the results of the Optimization with other users in the system

Future Improvements: Deleting Scenarios/Results

- Right now, only the admins can delete scenarios

Not needed anymore. The user should have the ability to delete it.

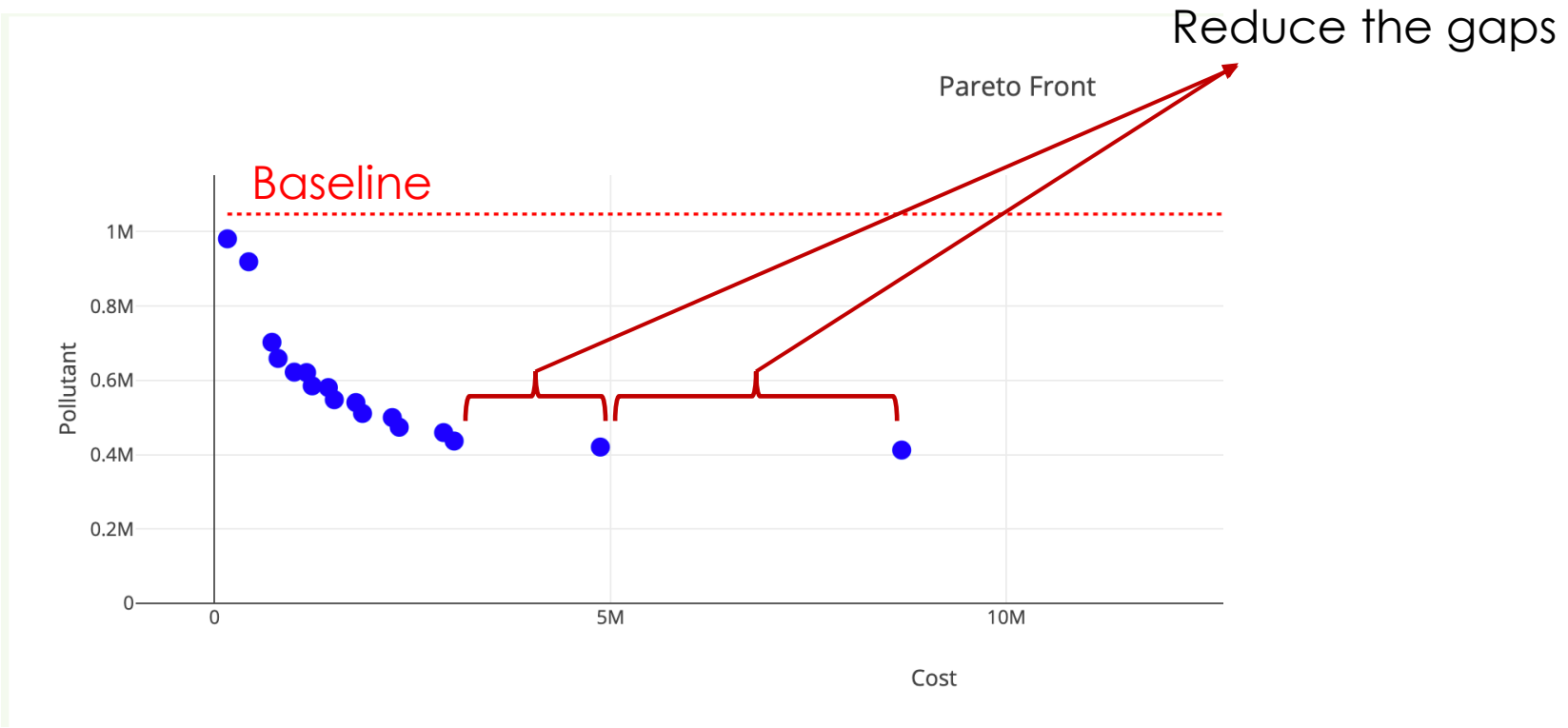
ID	Optimization Scenario Name	Wastewater Data Set	Counties	Date modified (EST)	Actions
3	Carroll	2023 Progress	MD: [Carroll]	12/02/2024 6:22 p.m.	
4	Kent	2023 Progress	DE: [Kent]	12/02/2024 7:08 p.m.	
5	Richmond	2023 Progress	VA: [Richmond]	12/02/2024 9:03 p.m.	
6	Lancaster	2023 Progress	VA: [Lancaster]	12/02/2024 9:03 p.m.	
7	Washington DC	2023 Progress	DC: [Washington]	12/02/2024 9:05 p.m.	
16	Richmond 20 Iter	2023 Progress	VA: [Richmond]	12/11/2024 4 p.m.	
17	Washington DC 20 Iter	2023 Progress	DC: [Washington]	12/11/2024 4:01 p.m.	
18	Lancaster 20 Iter	2023 Progress	VA: [Lancaster]	12/11/2024 4:01 p.m.	
19	Kent Iter 20	2023 Progress	DE: [Kent]	12/12/2024 10:35 a.m.	

Delete optimization results at will

Id	# Optimization Run	# Solutions	Actions
3	1	12	

Future Improvements: Improvement in Optimization Algorithm

- Spread is not uniform, we are improving the algorithm to make the solution distribution more uniform.



Future Plans

- Get the Optimization Code ready for demonstration during the webinar – First priority
- Scale-up study from one county to multiple counties to multiple states
  - Using "Innovization" (rule discovery) concept
  - Parallel CoreCAST evaluations of multiple solutions to speed up the optimization process
  - Surrogate-assisted optimization
  - Robust optimization

MICHIGAN STATE UNIVERSITY

Computational Optimization and Innovation

Thankyou