RESILIENTMASS ACTION TEAM (RMAT)

CLIMATE RESILIENCE DESIGN STANDARDS & GUIDANCE

USER GUIDE

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VERSION 1.4

CONTRACT NUMBER:
ENV 19 CC 02
OWNER:
Massachusetts Executive Office of Energy and Environmental Affairs (EEA)
IN PARTNERSHIP WITH:
Massachusetts Emergency Management Agency (MEMA)
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1. Climate Resilience Design Standards Tool

1.1. How to Use this Document

This User Guide walks users through the Climate Resilience Design Standards Tool Version 1.4 ("the Tool"). Visuals and screenshots are used to show standard pages, key features and functions, and text descriptions provide overviews of actions at each step in the process.

1.2. Introduction to the Tool

The focus of the Climate Resilience Design Standards and Guidance project is to integrate best available statewide climate change projections and hazards data to inform early/conceptual planning and design of infrastructure, buildings, and natural resource assets in Massachusetts in conjunction with traditional engineering assessments, feasibility analyses, and cost-benefit analyses. These resources are intended to help incorporate climate resilience into the State's capital planning process and grant-making for local capital projects, through:

- **Climate Resilience Design Standards Tool (the Tool)**: an interactive web-tool that provides a preliminary climate hazard exposure and risk screening and recommended climate resilience design standards for projects with physical assets; and,
- **Climate Resilience Design Guidance**: guidance, best practices, and forms to support implementation of climate resilience design standards.

The Climate Resilience Design Standards Tool and Guidance are accessible at [https://resilient.mass.gov/rmat_home/designstandards/].

Purpose

This is a planning tool developed to support Massachusetts agencies and municipalities in integrating statewide climate change data and methodologies into the planning and design of projects with physical assets. This Tool was developed by the Executive Office of Energy and Environmental Affairs (EOEEA) in partnership with state agencies through the Commonwealth's ResilientMass Action Team (RMAT) and the Weston & Sampson and BSC Group consultant teams.

The Tool utilizes best available information that exists at the time of the latest update and is subject to revisions as more detailed data, new science, and/or new or evolving climate parameters become available. The Tool relies on limited user provided information to supplement statewide datasets. The beta version of the Tool was released in April 2021, Version 1.0 released in February 2022, Version 1.1 released in April 2022, Version 1.2 released in July 2022, Version 1.3 released in March 2023, and Version 1.4 released in December 2024, which supersedes previous versions. *Note: no supporting documentation was conducted for Version 1.3.*

Limitations

Users of this Tool will see a splash screen upon entering the Tool that requires users acknowledge the following important qualifications by clicking "I agree to the above terms and conditions."

- The data and content on this website are for informational purposes only and do not constitute and should not be construed as legal, financial, professional, or any other type of advice or counsel.
- This Tool is recommended to be used to inform planning and early design processes for projects with physical assets. Outputs provided through this Tool may be used as a reference point or basis-of-discussion in planning, early design, and/or evaluation of projects. The Tool does not replace location specific engineering calculations and analyses, existing code and regulatory requirements, risk and vulnerability assessments, or cost-benefit analyses.

The Tool does not take the place of statutory regulations or requirements, and does not replace detailed risk and vulnerability assessments, engineering calculations and alternatives analyses, or cost-benefit analyses.

- EOEEA and its partners do not guarantee or warrant that any information submitted by individuals using the Tool is correct and disclaim any liability for any loss or damage resulting from reliance on any such information.
- EOEEA and its partners make no representations or guarantees that the Tool will always be safe, secure, or error-free, or that it will function without disruptions, delays, or imperfections.
- Appropriate regulatory agencies should be contacted regarding existing practices, regulatory requirements, or codes.
- This Tool, associated data, and any related materials contained therein are provided "as is," without warranty of any kind, either express or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement. The entire risk of the use of and reliance upon the Tool, associated data, and any related materials shall be with the user.

Please direct any questions or comments on this Tool to **climatescience@mass.gov**.

User Roles

There are three primary users. Each type of user has different capabilities and roles within the Tool, as described below.

- **Reporter:** Can create new projects, edit, and view their own projects. Can share their projects with other Tool users. This is the default user type.
  For example, this user may be a municipal staff member submitting a project as part of a state grant application.
- **Viewer:** Can view all submitted projects, including inputs and outputs.
  For example, this user may be a State grant administrator.
- **Administrator:** Can view and edit all projects in the Tool. Administrators are limited to select EEA staff.
  For example, this user may be an EEA IT staff member.

This Guide provides step-by-step guidance for the 'Reporter' user role, unless otherwise noted.

Note: Some users may have multiple roles.

1.3. Key Tool Pages

The Tool has six main pages: Start Here, Locate Project, Project Inputs, Project Output, View Report, and Submit Project. Information provided by users via the Locate Project and Project Inputs pages generate Project Outputs. The View Report page includes a Project Report specific to a user's individual project, summarizing inputs and outputs from the Tool. The Tool workflow is captured in Figure 1.

Figure 1. Climate Resilience Design Standards Tool Reporting Workflow – Completed

Start Here (1st page in the Tool)

When users login to the Tool, they will immediately be taken to the Start Here page. The Tool's Start Here page introduces the Tool and provides additional documents and resources for users to review as needed. This page includes key additional resources, such as Tutorials, Guidance and Forms, and Supporting Documents. Tutorials include this User Guide and several how-to videos. The display and functionality are described further in Section 2.2 of this User Guide.

The Tool also provides Climate Resilience Design Guidance ("the Guidance") and best practices, Forms, and other supporting documents.

- **Guidance & Forms**: The **Guidance** are intended to be overarching climate resilience principles that are not specific to project/asset type or climate parameters. The Guidance provides general considerations for users to consider while implementing the Standards. This Guidance is illustrated through specific best practices, which will include case studies and/or existing published resources that exemplify the Guidance. A series of optional **Forms** walk users through Guidance considerations and serve to document design and decision making throughout the process. These forms include the following:
    - **Site Suitability Form**
    - **Regional Coordination Form**
    - **Flexible Adaptation Pathways Form**
- **Supporting Documents:** The other supporting documents provided by the Tool include the **Glossary of Terminology** (for industry and Tool-specific definitions), **Versioning History** (for a description of the four Tool "versions" released), **Massachusetts Coast Flood Risk Model (MC-FRM) Frequently Asked Questions** (provided by Woods Hole Group), and **Section Documents** (documents that provide the content and underlying relationships that are the foundation for the Tool inputs and outputs).

Locate Project (2nd page in the Tool)

The Tool's Locate Project page allows users to view and draw the location of their project by creating a GIS-based polygon. The project polygon should be inclusive of as many assets included in the project footprint – in many cases, this may be done by including the whole property. The display and functionality are described further in Section 2.3 of this User Guide.

Project Inputs (3rd page in the Tool)

One this page, the Tool prompts users to input additional details related to the project's location, and the project's physical asset(s)[1] ("Project Inputs"). The inputs are structured into four (4) steps: (1) questions regarding core project details; (2) questions regarding overall project ecosystem service benefits; (3) questions regarding overall project climate hazard exposure; and (4) questions related to individual physical asset(s) within the project. These inputs are captured through radio buttons, drop-down menu responses, and select automated spatial queries. The display and functionality are described further in Section 2.4 of this User Guide.

Project Outputs (4th page in the Tool)

The Tool relies on limited user provided information to supplement statewide datasets. The Tool has an **Overall Project Scores Output** and **Preliminary Asset Climate Risk Ratings and Recommended Design Standards Output**. The project outputs are intended to support project development and capital planning. *This does not replace a formal risk and vulnerability assessment*.

The **Overall Project Scores Output** provides:

- an evaluation of whether or not the project polygon is located within a mapped **Environmental Justice (EJ) population** neighborhood (census block group);
- an **Ecosystem Services Benefits Score** for the overall project;
- a **Preliminary Climate Hazard Exposure Rating** for the overall project for each climate parameter: sea level rise/storm surge, extreme precipitation (stormwater and riverine flooding), and extreme heat.

The **Preliminary Asset Climate Risk Ratings and Recommended Design Standards Output** provides:

- a **Preliminary Climate Risk Rating** for each building and infrastructure asset within the overall project for each climate parameter: sea level rise/storm surge, extreme precipitation (stormwater and riverine flooding), and extreme heat.
- **Recommended Climate Resilience Design Standards** ("the Standards") for each asset for each climate parameter: sea level rise/storm surge, extreme precipitation (stormwater and riverine flooding), and extreme heat. The objective of the Standards is to provide a consistent basis-of-discussion for assets across various projects in the Commonwealth. Standards include recommended intermediate and/or target planning horizons, return period or percentile, and applicable design criteria that may be affected by climate change.

[1] In the Tool, an Asset is defined as a major physical component of a project. It is further organized by an Asset Category: building/facility, infrastructure, or natural resources.

Users may also provide **Optional Report Comments** in response to reviewing these outputs on how this information may be incorporated into the project; for example, measures that will be taken to adapt the site and/or assets to climate change for any of the climate parameters assessed (sea level rise/storm surge, extreme precipitation (stormwater or riverine flooding), extreme heat). This text can be updated until the project is submitted, and will be included on the Project Report.

View Report (5th page in the Tool)

The Tool further provides users with the opportunity to review and download a PDF of their Project Report in the View Report page. Here, users may view a summary of the project and asset outputs, informed by Project Inputs. Users are not required to submit their project to download their report, but submission may be required by some grant-making programs or state processes.

Submit Report (6th page in the Tool)

On this page, users will have the option to submit their Project Report. This is available only once all Project Inputs have been entered, and is recommended for after Project Inputs have been reviewed and final edits have been made. Edits to Project Inputs and modifications to the map and name are not possible after submitting the project. Once the project has been submitted, it is viewable by State Agency administrators and is considered a public record. Users have the option to “clone” or “copy” a project. This action creates an entirely new project, with the same Project Inputs and, subsequently, the same Project Outputs. For more details on this process, refer to Section 2.7 of this User Guide.

2. Tool Functionality and Features

2.1. General Functionality

The Climate Resilience Design Standards Tool and Guidance are **accessible at resilient.mass.gov**.

The direct link to the Tool is **accessible at** [https://resilient.mass.gov/rmat_home/designstandards/].

Login

Navigate to the Tool link, provided above, to begin login. First time state users should request account set-up by emailing climatescience@mass.gov. MassDOT users (emails with @dot.state.ma.us) should expect a potential delay is account set-up due to extra IT steps. External users can proceed by clicking on the blue log-in/register button.

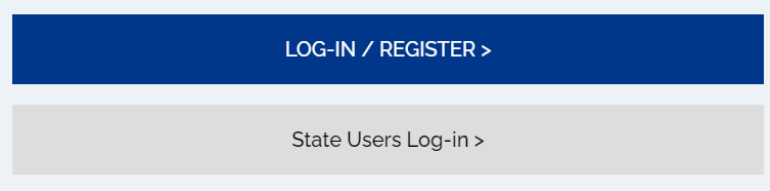


Figure 2. User login differences.

Here, external (non-state) users can create an account, retrieve a password, activate a user, and update a user profile. The dashboard outlook for this login page is shown in Figure 3, below.

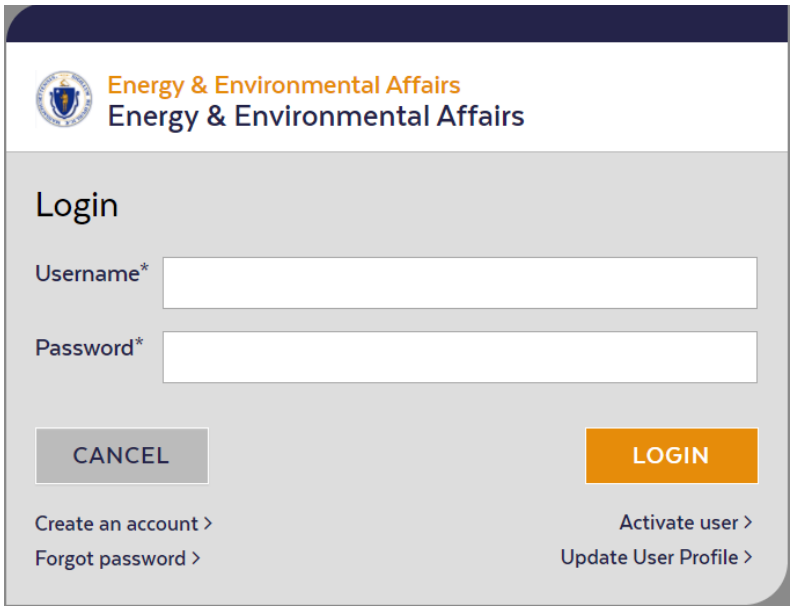


Figure 3. Login dashboard for the Tool.

Tip: Troubleshooting!

For public (non-state) user accounts, Username is not an email. Usernames cannot contain special characters (e.g., "@"). You need to remember your Username to retrieve passwords using the login dashboard above.

If users have trouble creating a log-in or accessing their account, please email questions to climatescience@mass.gov.

Project Pages

There are six main navigation pages in the Tool: Start Here, Locate Project, Project Inputs, Project Output, View Report, and Submit Project. These pages can be found across the top of the display.

The remainder of this User Guide will proceed along the Tool process, moving through each page view and its associated functionality.

2.2. Page: Start Here

On this page, users are introduced to an overview of the Tool and can review Tool resources in the tabs at the bottom of the screen. In this display, users can search for an existing project, create a new project, and review resources.

Search

To search for an existing project that has already been created, locate the “Project Search” box on the left side of the screen under “Project Name” and proceed with entering a search word for the project name. Reporters may only search and view results for projects they have created, while Viewers and Administrators can search and view all projects. Results will populate with relevant projects. Advanced query options, including location, creator, last edit date, estimated capital cost, grant program, project scoring, and asset scoring are possible. Select the “Search” button once complete. Refer to Figure 4, below.

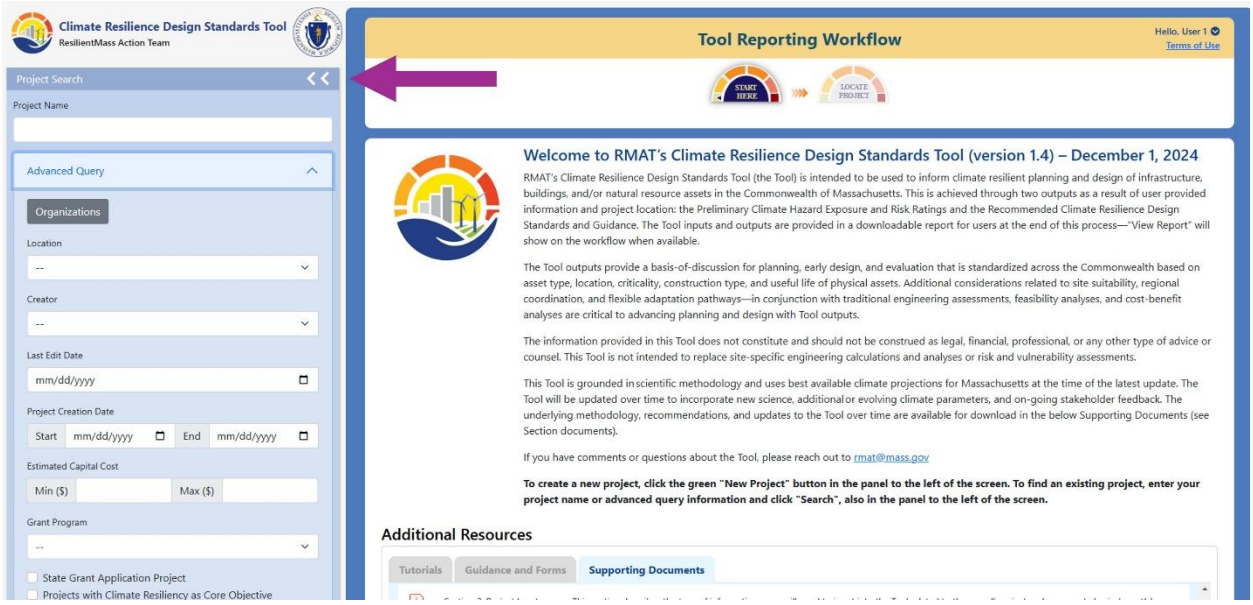


Figure 4. Project Search Box.

New Project

To create a new project within the Tool, select the green “New Project” button. Refer to Figure 5 and User Guide Section 2.3 for a review of this process, below.

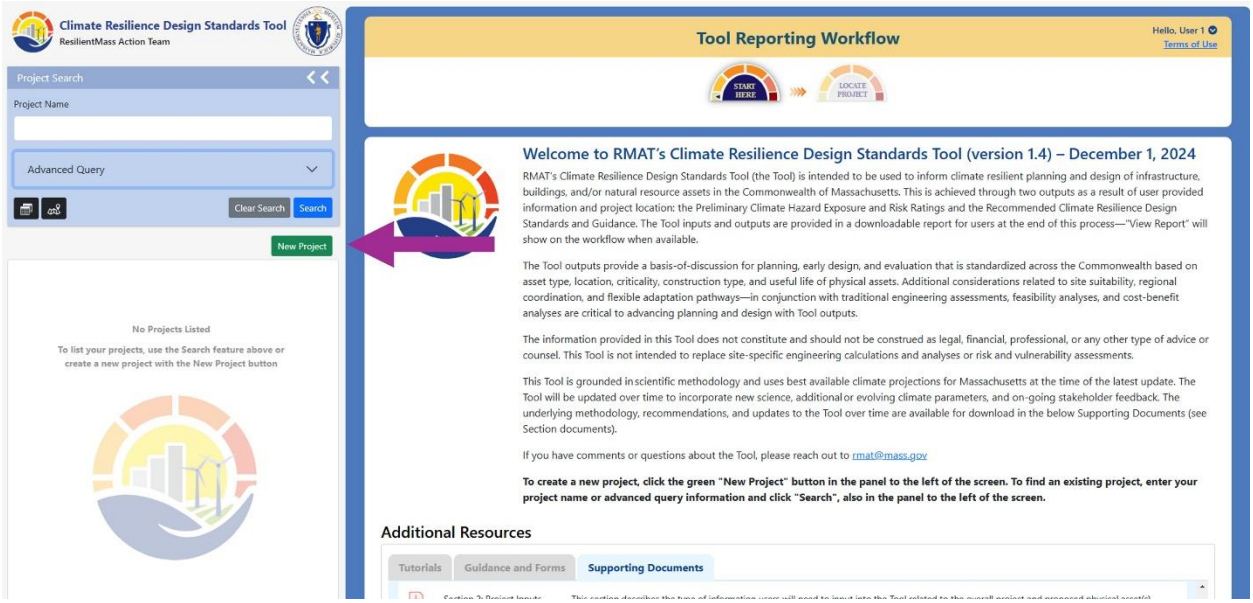


Figure 5. New project button location.

Additional resources are composed of three tabs. The **Tutorials** tab includes the user guide and how-to videos.

Additional Resources

The **Supporting Documents** tab include the **Glossary of Terminology** (for industry and Tool-specific definitions), **Tool Versioning History** (for a description of the four Tool “versions” released), **MC-FRM Frequently Asked Questions** (provided by Woods Hole Group), and **Section Documents** (documents that provide the content and underlying relationships that are the foundation for the Tool inputs and outputs). The purpose of these documents is to further aid the user in understanding the Tool’s functionality and outputs.

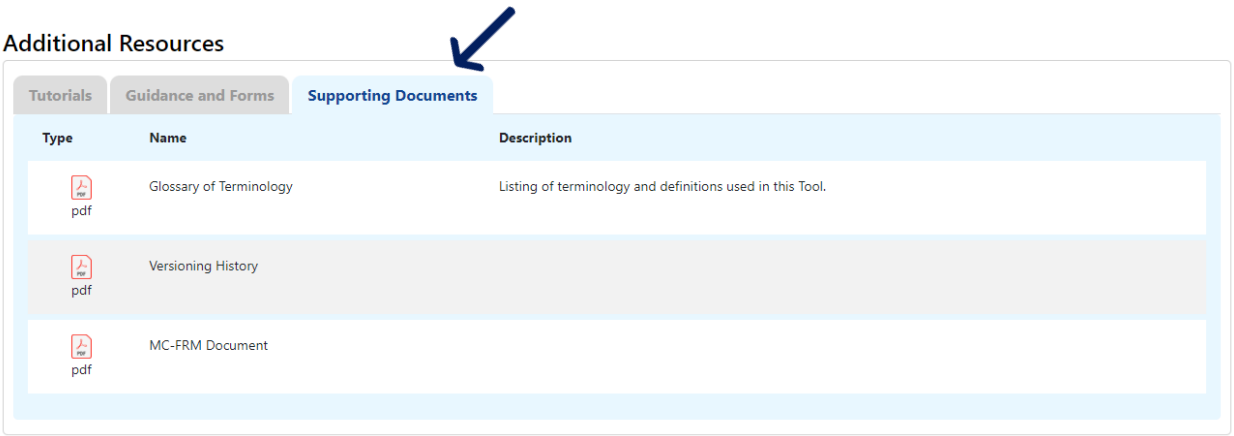


Figure 6. Supporting Documents tab with downloadable Section documents for user reference.

The **Guidance and Forms** tab includes four downloadable documents: one for all of the Guidance and Best Practices, and one for each of the three recommended Forms.

Guidance

These are supplemental resources that provide principles and best practices for implementing the Standards. The Guidance constitute design principles related to site suitability, flexible adaptation strategies and regional coordination that are illustrated through forms and specific "best practices," which may include case studies and/or existing published resources that exemplify the Guidance.

Site Suitability Form

Optional form aimed at evaluating how geographic location, existing conditions, and asset placement impact the sites' ability to serve its intended function, before, during, and after climate impacts.

Regional Coordination Form

Optional form aimed at guiding considerations of how coordination and collaboration across regions, as well as State Agencies and jurisdictions, can help strengthen resilient designs and implementation.

Flexible Adaptation Pathways Form

Optional form aimed at evaluating project design strategies that are able to adapt over time and respond to changing climate conditions, while encouraging climate mitigation, prioritizing nature-based solutions, and preparing for current and future operations and maintenance needs.

Selection of these Guidance and Forms is shown in Figure 7, below.

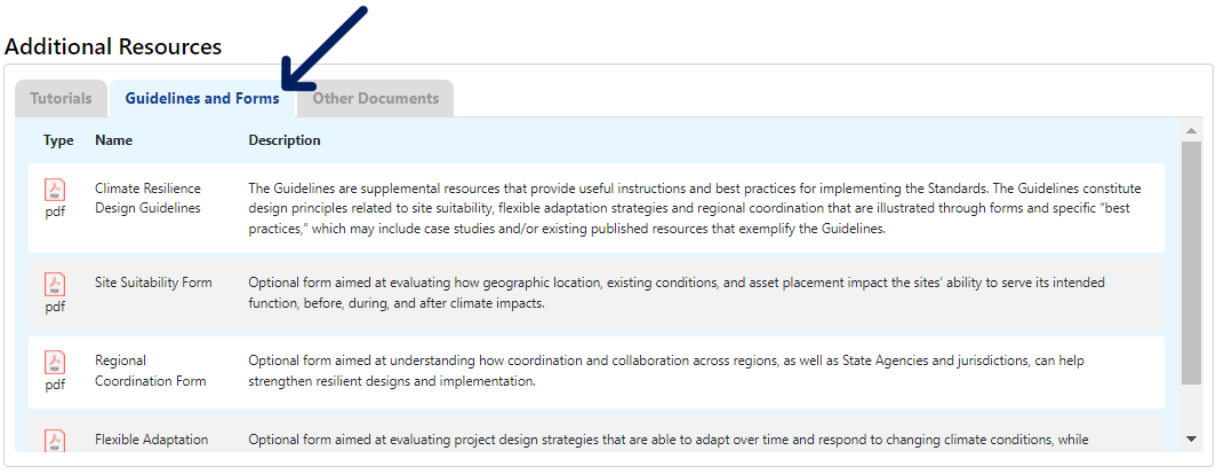


Figure 7. Downloadable content related to the Climate Resilience Design Guidance and Forms.

2.3. Page: Locate Project

Upon creating a new project, users will be prompted to enter a project name in the Locate Project page. From here, the Tool will walk users through the process of creating a project polygon on the map.

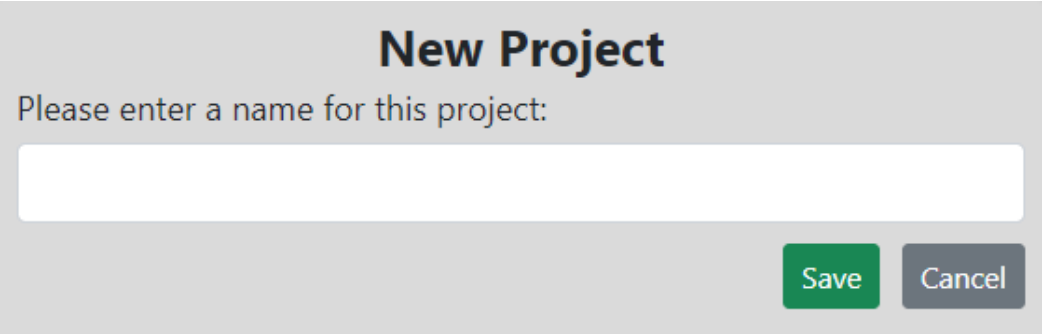


Figure 8. Enter a name for the new project.

Draw a Project Polygon

This step involves drawing the location of the new project on the map. It is the first step to begin establishing Project Inputs in the Tool. This project polygon will be used to determine project exposure to climate parameters, hence it is important the polygon encompasses the extent of all (on-site) physical assets of the project.

Follow the instructions on the left-side of the screen to draw the project polygon, as shown in Figure 9. Select the “Polygon” button shown in Figure 10, located in the top right corner of the map, to begin drawing the project polygon. The drawn polygon is now a feature. Refer to Figures 9 through 12, below. Frequently Asked Questions are also available on the left side of the screen, shown in the bottom of Figure 9.

Tip: Watch the how-to video! Avoid confusion by clicking on the “Show me how” button (shown in Figure 9) to watch a short video on how to draw the project polygon. This video also walks users through basic mapping features, polygon basics, freehand polygon sketching, how to edit an existing polygon, editing using the snapping feature, using MassGIS parcels, multiple selection of MassGIS parcels, and importing GIS data to create a polygon.

Tip: Avoid bad polygons! Avoid creating polygons that loop back onto themselves. This generates separate and distinct polygons. If this is accidently generated, please "Delete” the polygons and redraw.

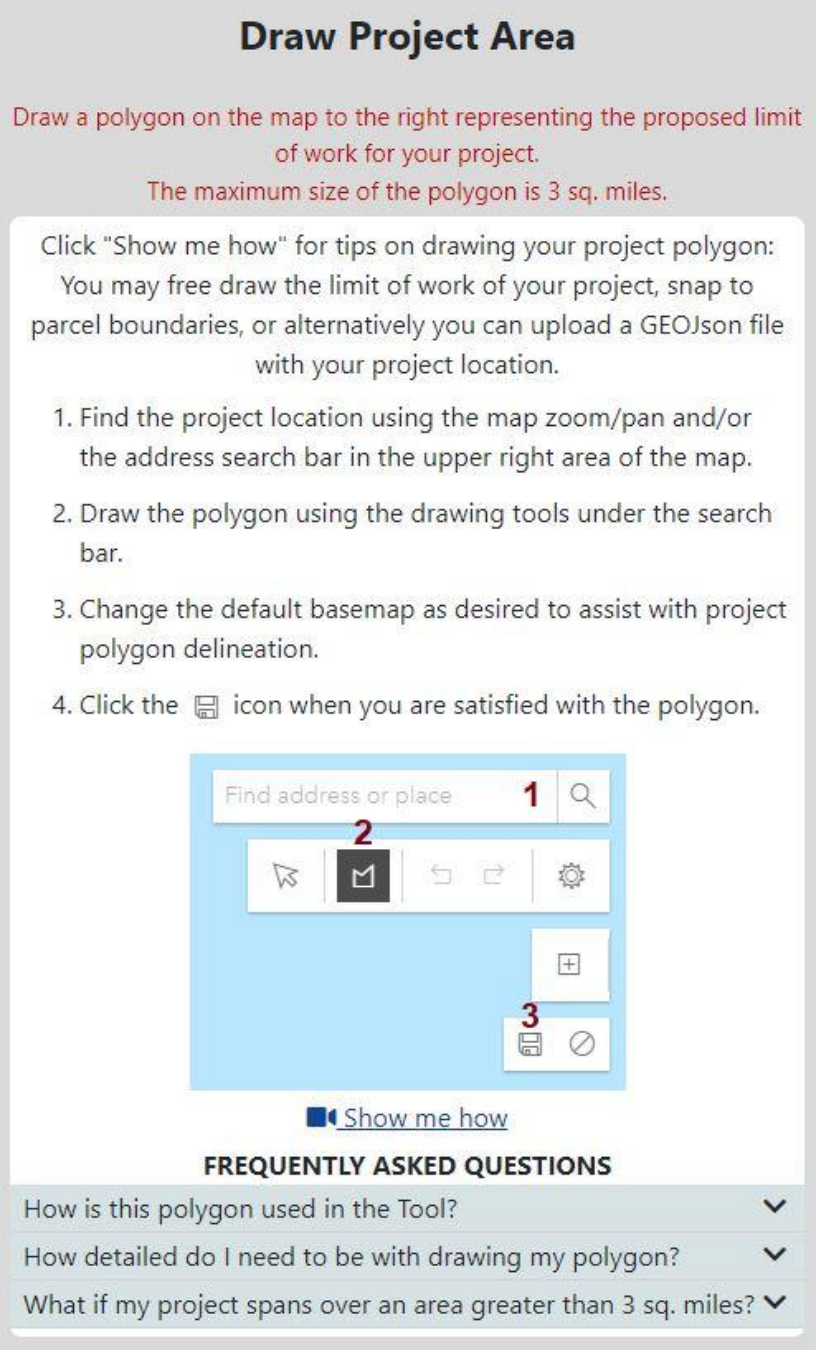


Figure 9. Draw Project Area (polygon) instructions.

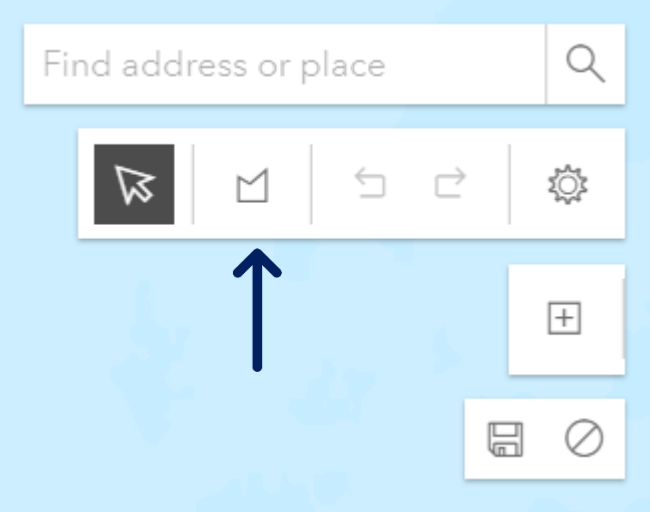


Figure 10. “Draw a polygon” button.

Figure 11. Example of a complete project polygon, saved.

Note: Polygon size must be under 3 square miles! If drawn over this limit, users will receive the error shown in Figure 12, below.

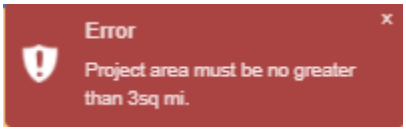


Figure 12. 3 Square Mile Limit Error

Note: Even if polygon size meets the 3 square mile threshold, the overall length/geometry of the polygon cannot span a large geographic area. If drawn polygons are over too large of an area, users will receive the error show in Figure 13, below.

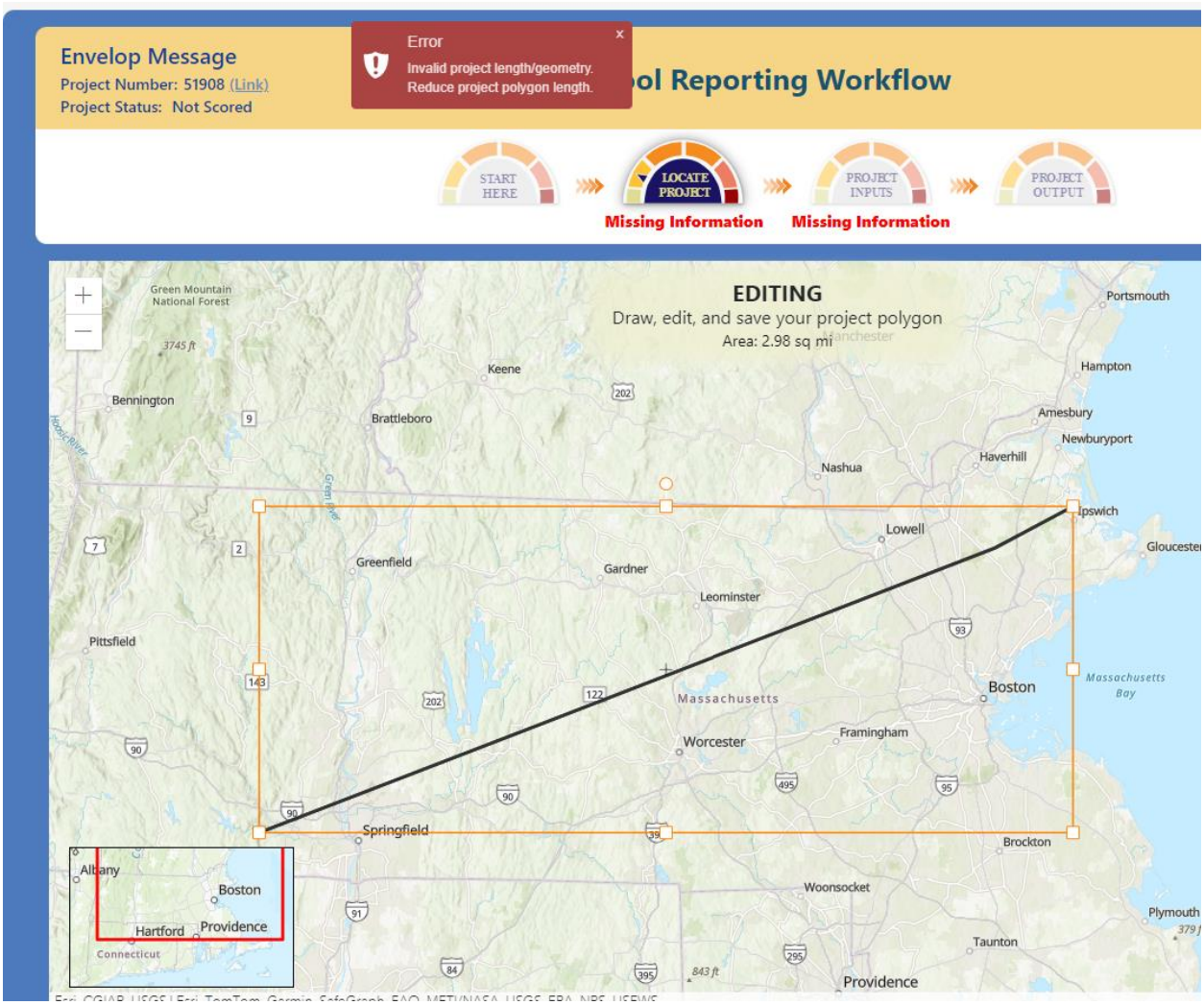


Figure 13. Invalid Geometry Error

MassGIS Parcel Map Use

Select the “plus” button to begin selecting MassGIS parcels as the outline of your project polygon, shown in Figure 14. This feature allows users to select multiple adjacent property parcels to create a conglomerate project polygon. This feature is useful if the user seeks to match the project polygon exactly to existing property parcels. The result of this process is shown in Figure 14.

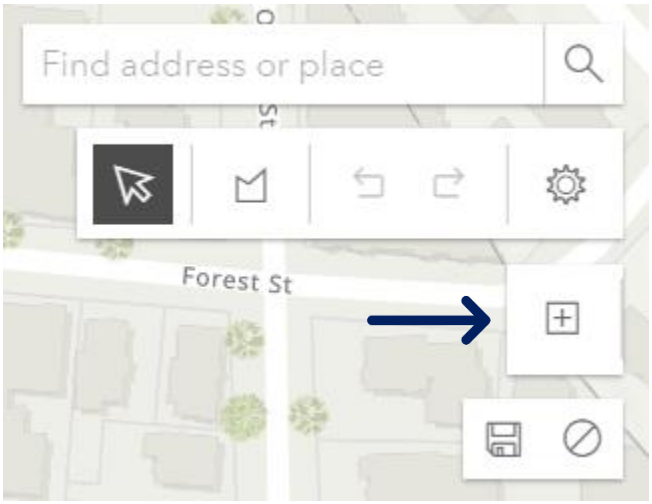


Figure 14. "Add Parcel Polygon" feature button.

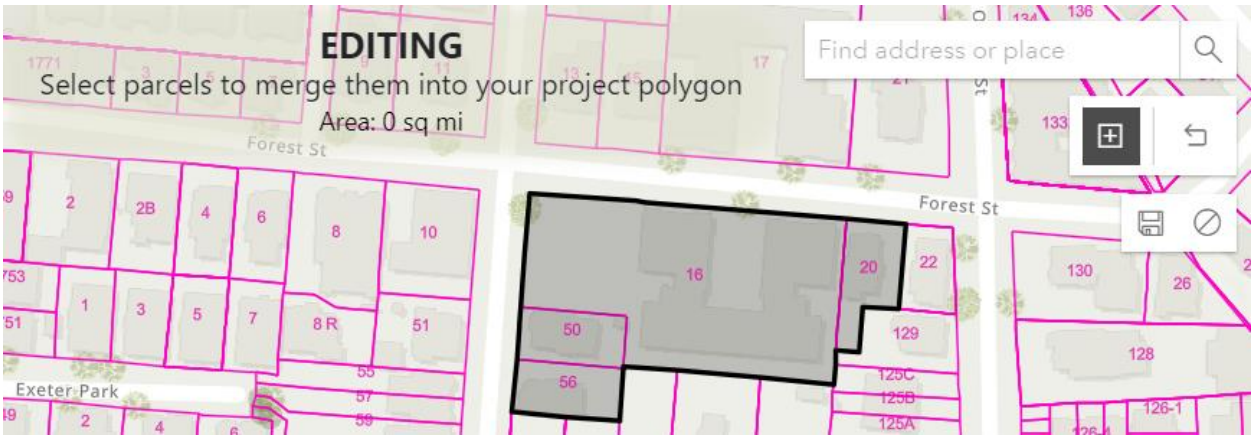


Figure 15. Completed use of the parcel polygon addition feature.

Save or Cancel the Project Polygon

Once the drawn polygon is complete, users can “Save” or “Cancel” their drawing using the buttons shown in Figure 16, below. Note that on this display, users can “Find address or place” to search the map, use the arrow pointer to select polygon objects, or “Undo” and “Redo” actions. **Users should further be aware that they will not receive Project Outputs unless their project polygon has been saved.** Also, once saved, any edits to the project polygon will result in rescoring of the Project Outputs.

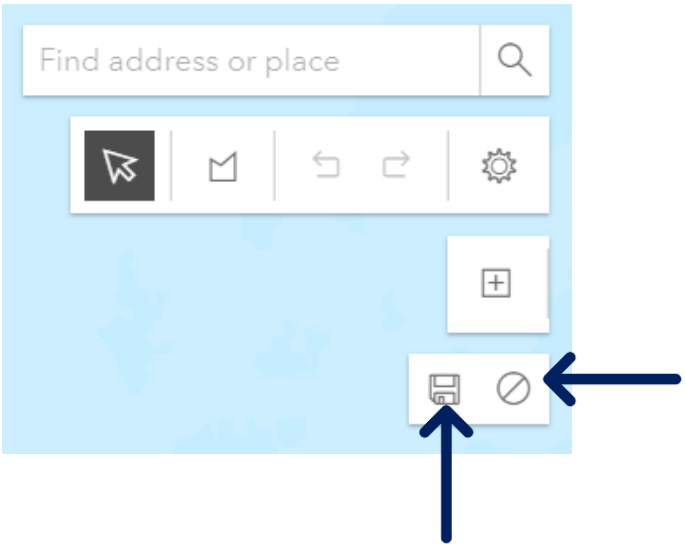


Figure 16. “Save” or “Cancel” a drawn polygon.

Edit the Project Polygon

To edit the project polygon once it has been saved, click on the project name in the Project panel on the left side of the screen. Viewing the project polygon on the Locate Project Page, click on the polygon and select “Edit.” The project polygon can now be edited, moved, and resized, as shown in Figure 17. Double-click on the polygon feature already formed to edit the polygon’s vertices. “Delete” polygons using the trash icon (above the “Save” button at the top right corner).

Tip: Don’t forget to Save any changes made in Edit mode!

Figure 17. Example polygon in editing form.

Viewing a Project Polygon

When returning to an existing project highlighted under “Results”, selecting a project in the left projects panel will automatically zoom to the project polygon, as shown in Figure 18, below.

Figure 18. Example completed project polygon.

2.4. Page: Project Inputs

Once the user has completed drawing and editing the project polygon, they move to the “Project Inputs” view, shown in Figure 19. This page, to the right of the “Locate Project” page, directs the user through inputting required information. The Tool prompts the user to input details related to the overall project and the project’s physical asset(s).

This page is broken down into four different steps to provide required information for output generation:

- Step 1: Core Project Information
- Step 2: Project Ecosystem Services Benefit
- Step 3: Project Climate Hazard Exposure
- Step 4: Project Asset(s)

Each “Step” is a series of questions to select or toggle for responses. The Tool then uses these inputs, including the project polygon drawn by the user, to generate the Project Outputs.

Figure 19. Project Inputs page view.

Step 1: Core Project Information

The first set of inputs required for a project consists of the Core Project Information. To complete these questions, click on the question, the space next to the question, or the pencil icon, and either a drop-down, fill-in-the-blank, or pre-populated answer choice will appear. After selecting or responding, click the “Save” button for each question to lock in the answer. Answers can be modified and resaved as needed using the “Save” button. The steps to complete this process are illustrated in Figures 20 through 22, below.

Note: Don’t forget to click Save after each question! Don’t forget this step--all questions are required. Unanswered questions will appear in red, while completed saved responses will appear in black.

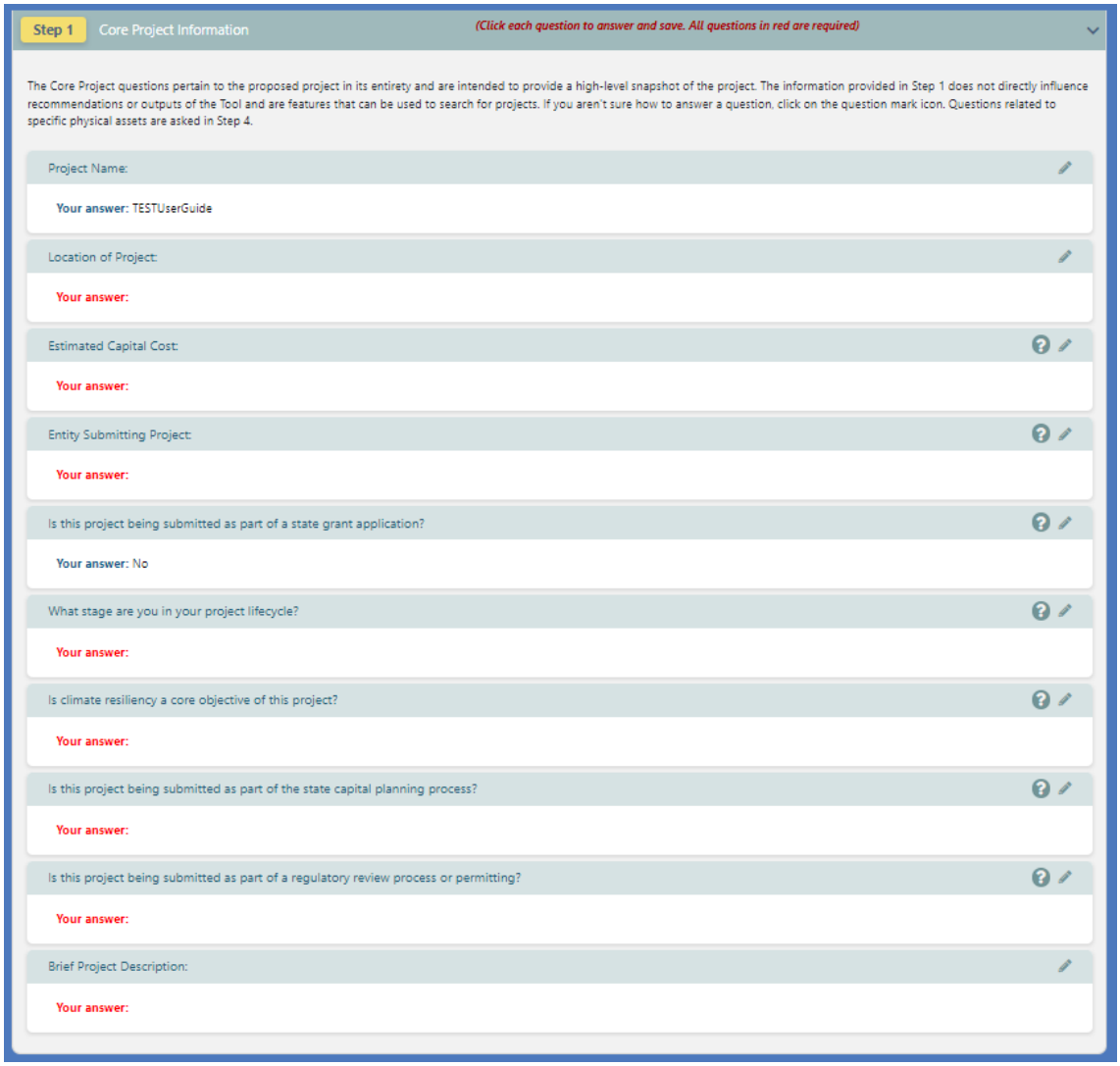


Figure 20. Example unanswered questions in Step 1.

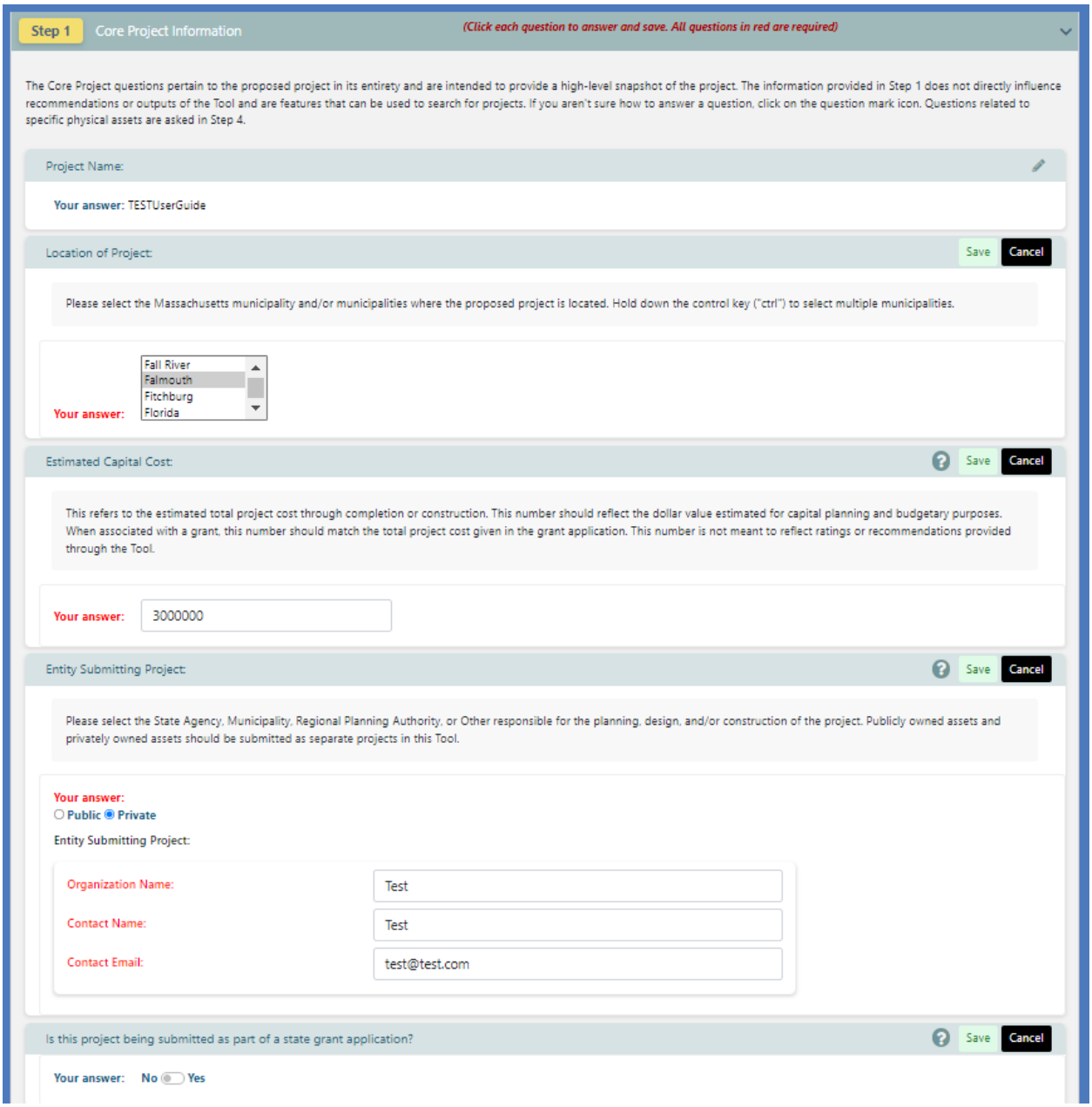


Figure 21. Example inputs before saving of Step 1 questions.

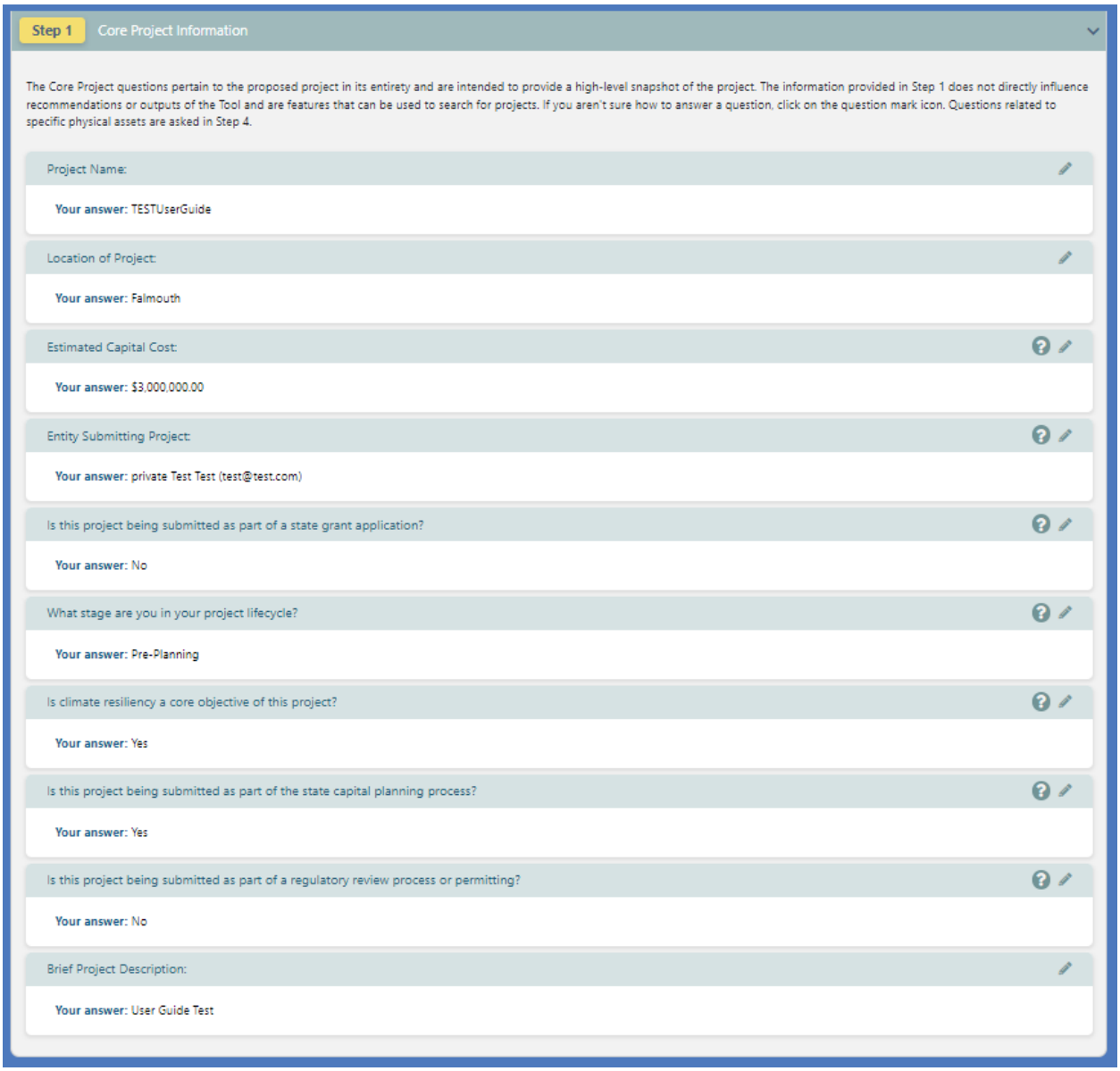


Figure 22. Example responses to Step 1 questions upon saving.

Certain questions, as indicated, may display a question mark icon for further details or definitions. Clicking on the icon will reveal this more detailed information. An example is shown below in Figure 23.

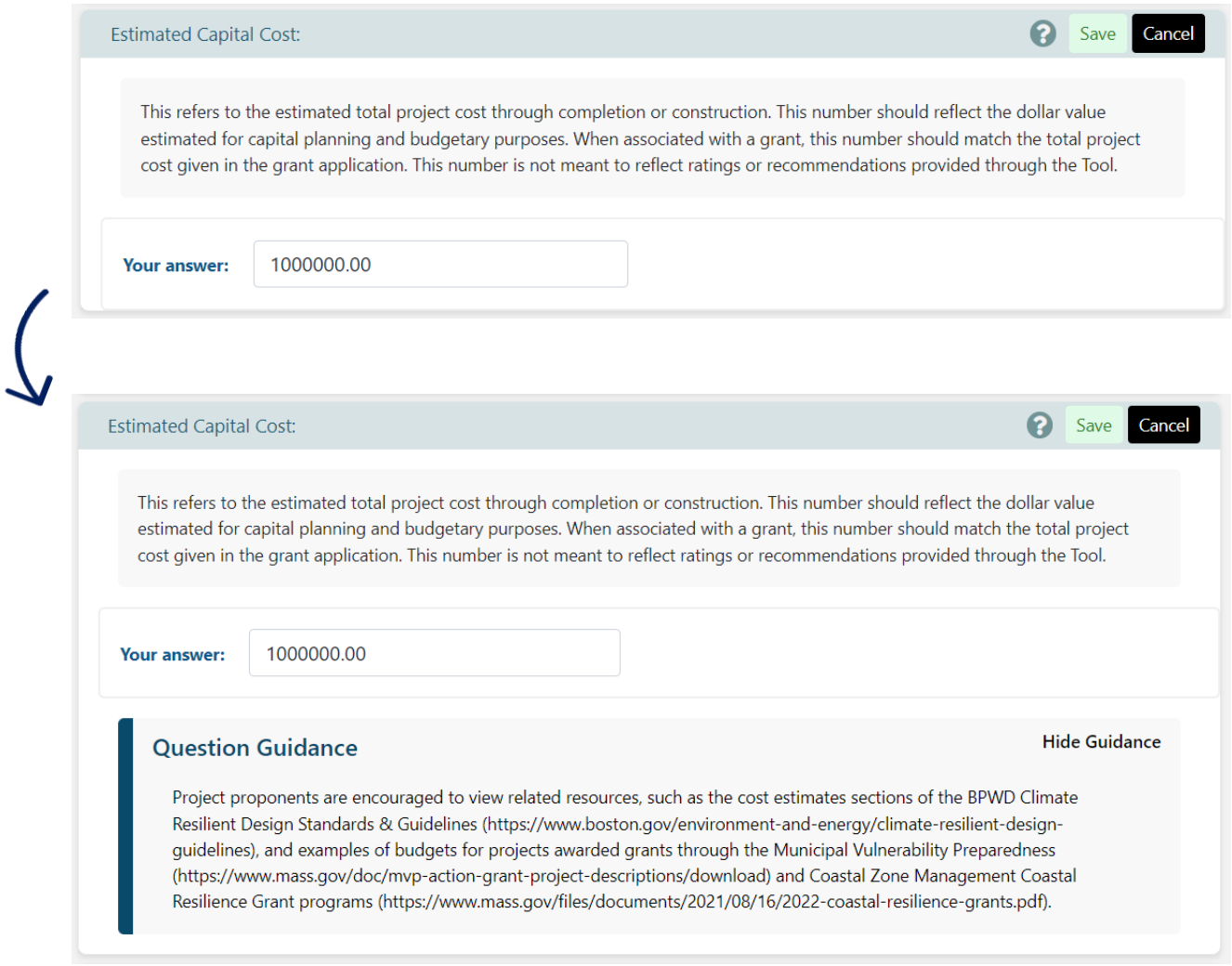


Figure 23. Example selection of the question mark icon for a question in Step 1.

Step 2: Project Ecosystem Services Benefits

In order to provide a preliminary assessment of the ecosystem services that an overall project provides, a series of project ecosystem benefits questions must be completed, as shown in Figure 24. Responses to these questions come in a Yes/No/Maybe toggle, and definitions are provided through the question mark icon on the right side of the question. Be sure not to forget the first question, "Is the primary purpose of this project ecological restoration?"

Note: The ecosystem service questions should be answered by considering the overall project, *not specific to an asset*.

Figure 24. Example of an (unsaved) ecosystem service benefits scoring page of Step 2.

Step 3: Project Exposure Questions

In order to provide a preliminary assessment of a project's exposure to climate hazard parameters (sea level rise/storm surge, extreme precipitation, and extreme heat), users must answer questions regarding the history of on-site flooding, impervious areas, and trees. Additional information icons are available to assist users in answering the project exposure questions. Additional details about a project's exposure to climate parameters are assessed geospatially by the Tool, based on project polygon location, as drawn by the user. The sequence of steps and example expanded information are shown below in Figures 25 through 27.

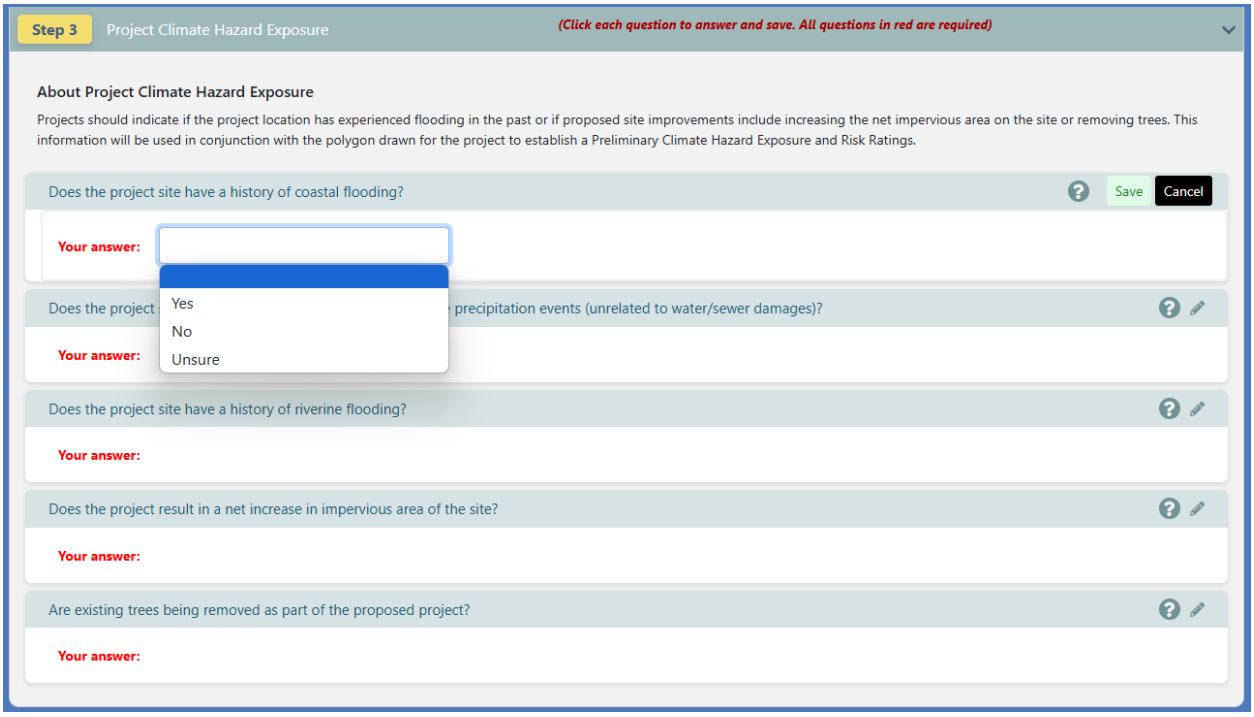


Figure 25. Example drop-down options for Step 3 questions.

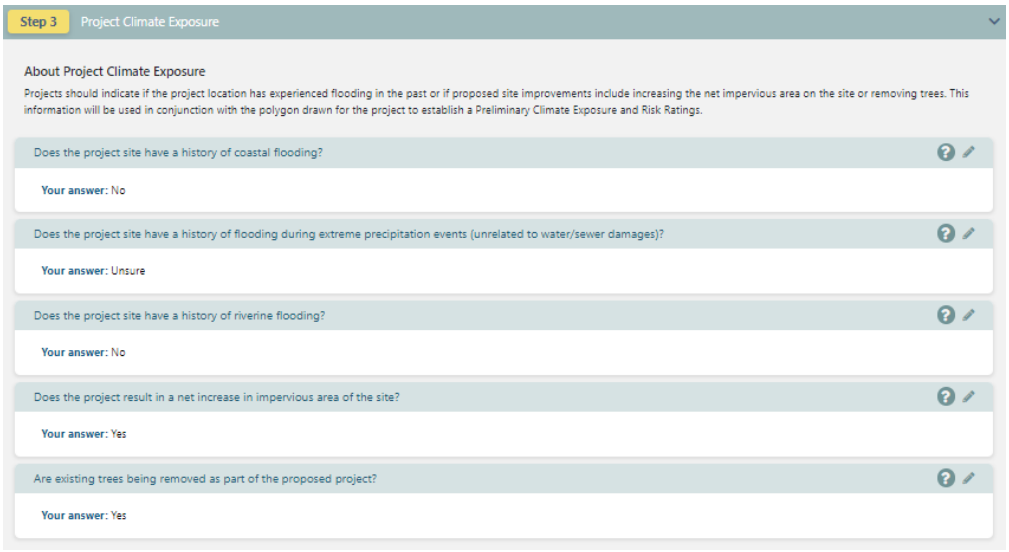


Figure 26. Example responses to Step 3 project exposure questions.

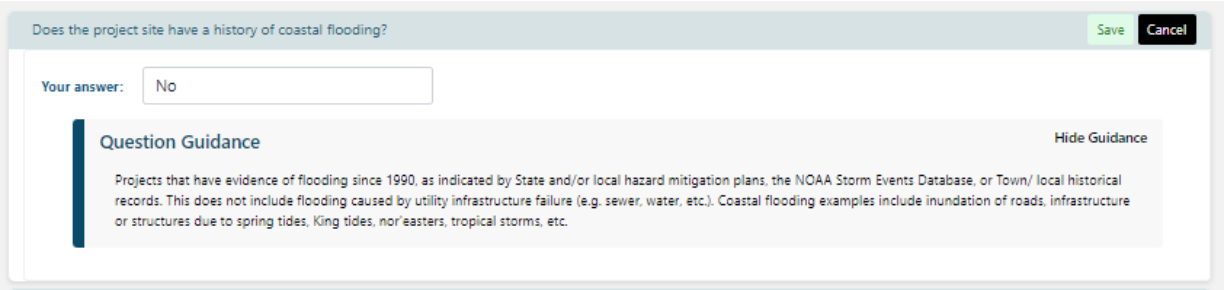


Figure 27. Example expanded information icon for a Step 3 question.

Step 4: Project Assets

An asset is defined as a major physical component of a project, organized into an Asset Category: building/facility, infrastructure, or natural resources. In this section, users are prompted to identify all major physical assets present in the project, and answer questions related to each asset. To add an asset, the user should select the “Add” button under the three main Asset Categories, as shown in Figure 28. The user may add multiple assets under each Asset Category, as necessary. For example, a park improvement project may include assets such as a berm for a flood control structure as an *infrastructure* asset, a salt marsh as a *natural resources* asset, and a park maintenance facility as a *building/facility* asset.

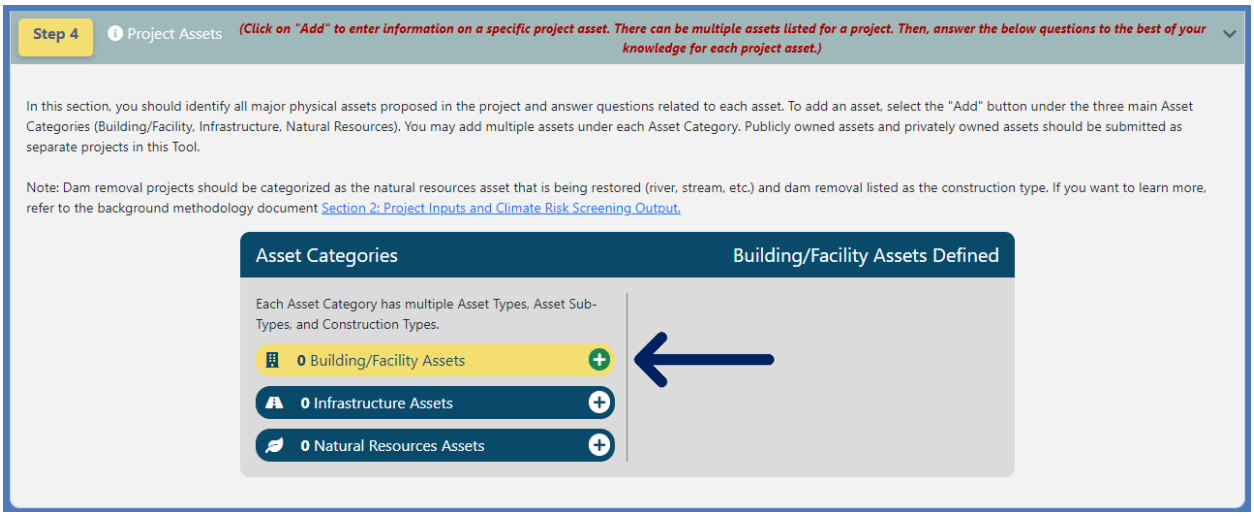


Figure 28. Button location to add a Building/Facility asset.

Upon selecting the “Add” button, users must fill out asset information to create an asset. Asset Type, Sub-Type, and Construction Type are all radio boxes for users to select based on what is most representative of the individual asset.

Construction Year refers to the year in which construction is expected to start on the asset.

Useful Life refers to the estimated number of years before the project will require significant reconstruction or renovation to continue performing its normal function(s). This differs from the design life, which is typically shorter. Typical Useful Life estimates for Buildings/Facilities and Infrastructure assets are shown in the figures below, which are available as guidance through the Tool.

Please reference the **Glossary of Terminology**, located on the Start Here page, for further information regarding this terminology.

Typical Useful Life	General Project Types	Typical Building/Facilities Elements
0 to 20 years	Temporary assets or assets with rapidly replaced components	• Temporary building structures • Storage Facilities • Developing Technology components (e.g. telecommunications equipment, batteries, solar photovoltaics, fuel cells, etc.)
20 to 40 years	Facility improvements and assets with a regular replacement cycle	• Electrical, HVAC, and mechanical components • Most building retrofits (substantial improvements) • Outdoor recreational facilities (e.g. ballfields, courts, playgrounds) • At-site energy equipment (e.g. fuel tanks, conduits, emergency generators) • Infrastructural mechanical components (e.g. compressors, lifts, pumps)
40 to 60 years	Long-lived buildings and infrastructure	• Most building new construction • On-site energy generation or co-generation plants • Water treatment facilities
60 to 80 years	Assets that are very unlikely to be relocated	• Major infrastructure facilities (e.g. wastewater treatment plants) • Most monumental building foundations

Figure 29. Typical Useful Life estimates for Building/Facilities assets.

Typical Useful Life	General Project Types	Typical Infrastructure Elements
0 to 20 years	Temporary assets or assets with rapidly replaced components	• Green infrastructure • • Interim and Deployable Flood Barriers • Asphalt pavement, pavers, and other right-of-way finishing • Street furniture • Developing Technology components (e.g. telecommunications equipment, fuel cells, etc.) • Septic systems • Outdoor lighting • Landscaping
20 to 40 years	Facility improvements and assets with a regular replacement cycle	• Concrete paving and public plazas • High voltage transformers • Infrastructural mechanical components (e.g. compressors, lifts, pumps) • Stormwater surface detention systems (e.g. detention pond systems) • Plastic culverts or storm drains • Roundabouts • Landfills
40 to 60 years	Long-lived buildings and infrastructure	• Bridges • Culverts (metal) • Seawalls/Bulkheads • Marinas/Ports • Transmission lines • Rail Tracks
60 to 80 years	Assets that are very unlikely to be relocated	• Reservoirs and Dams • Drinking water distribution systems • Subgrade sewer systems • Subgrade stormwater systems (e.g. conveyance, outfalls, etc.) • Tunnels • Culverts (concrete, HDPE, PVC)

Figure 30. Typical Useful Life estimates for Infrastructure assets.

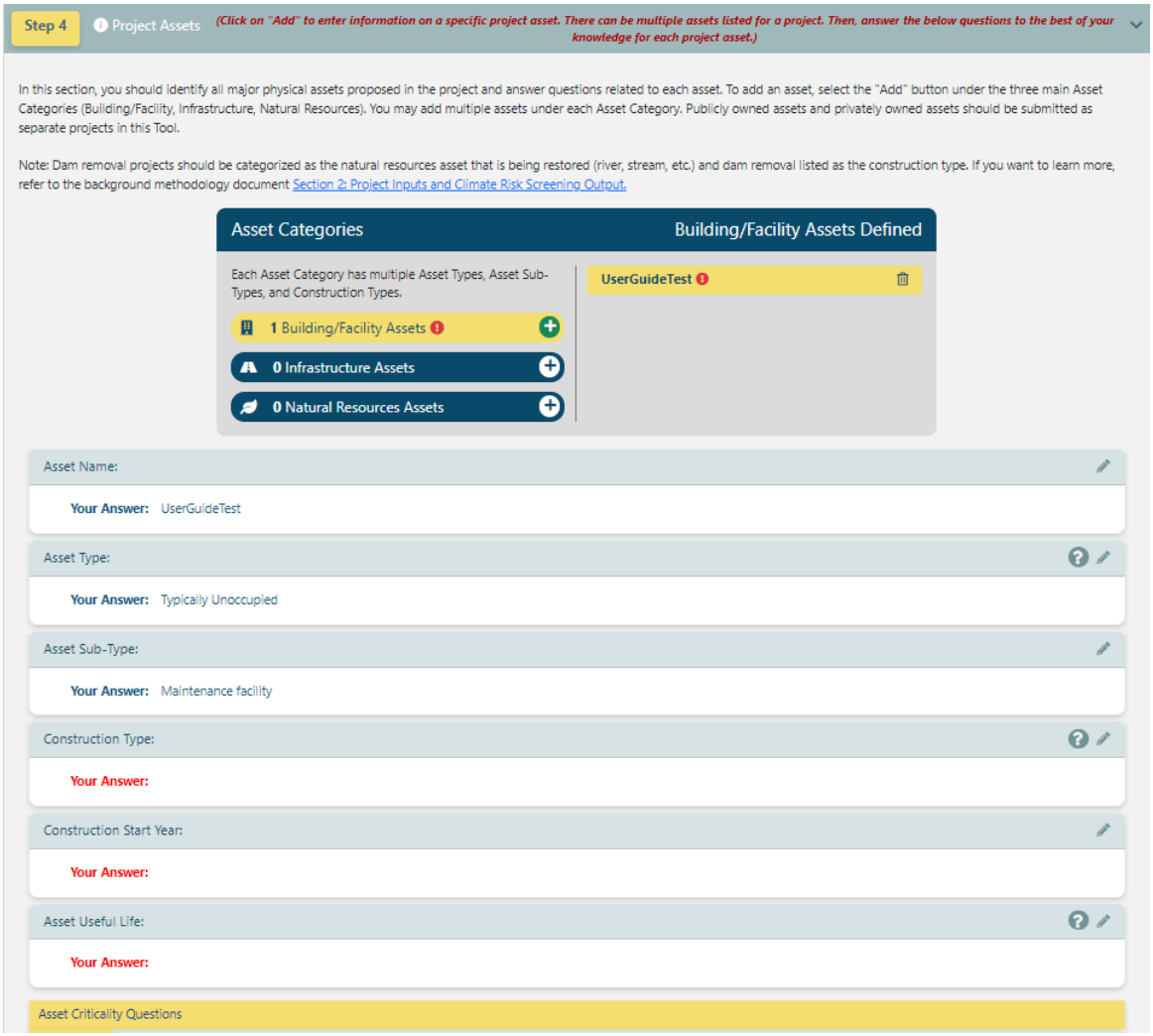


Figure 31. Example of incomplete asset inputs.

Note: Natural Resources assets will identify the monitoring frequency (years) of their asset, rather than the useful life.

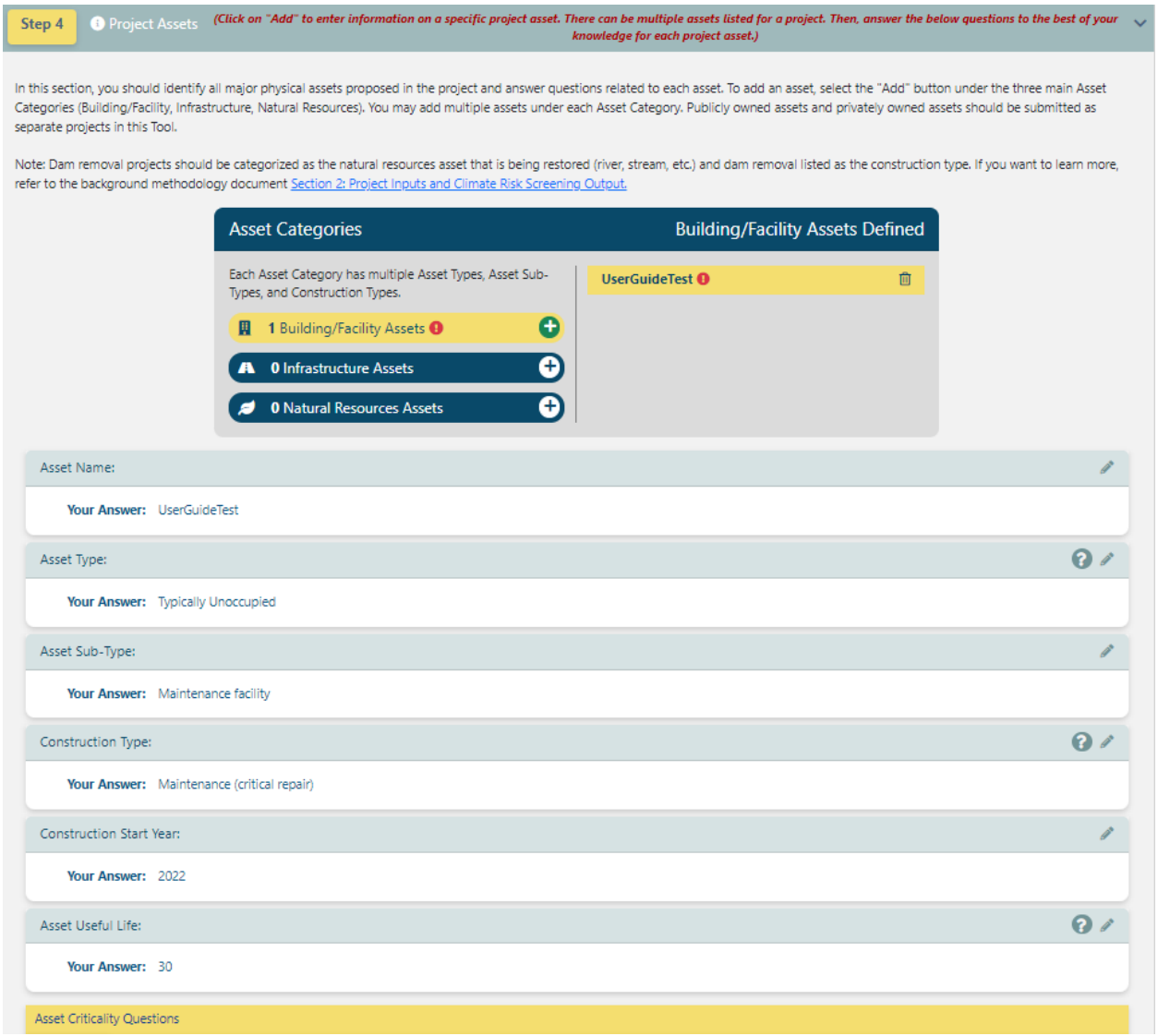


Figure 32. Example of completed asset inputs.

If an asset was added erroneously, the user can “Delete” the asset using the trash can icon in the upper right corner. This action is shown in Figure 33, below.

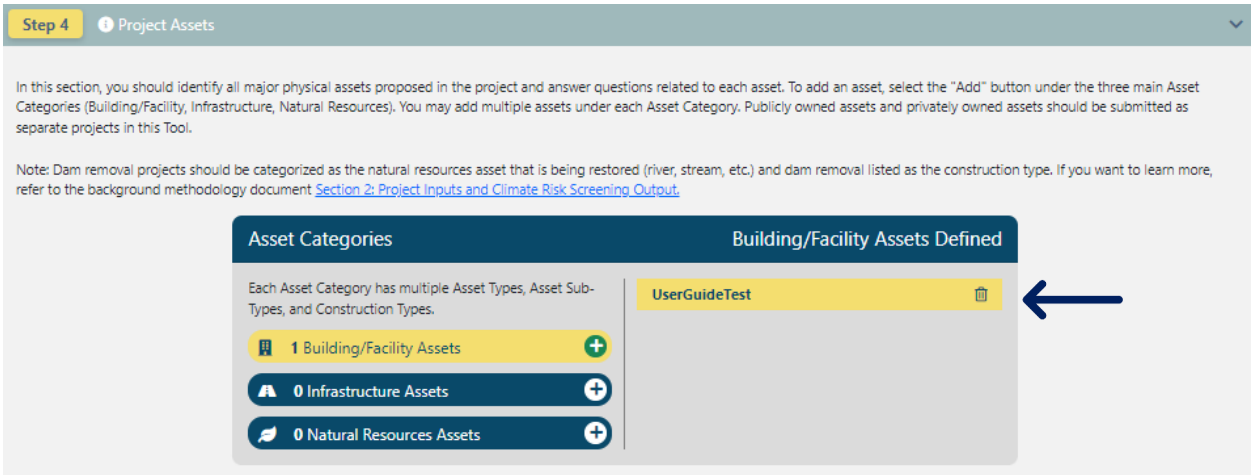


Figure 33. Deleting an asset.

Once a building/facility and/or infrastructure asset is added, the user must answer questions to inform the asset’s Preliminary Climate Risk Screening and Climate Resilience Design Standards outputs. To answer a question, click on the question itself, as shown in Figure 34. **All questions should be completed within the context of the selected answer for the first question, “Identify the length of time the asset can be inaccessible/inoperable without severe consequences.”**

For example: if the building is a primary residence, it will likely need to be accessible even during a natural hazard event, as indicated in Figure 34. If there is an evacuation plan in place, it may be able to be vacated and returned to within one day, one week, or longer (depending on the plan). Users will need to use their best judgement and are encouraged to expand the question mark icon for additional guidance to support answering the questions.

Note: If the asset is intended for hazard mitigation, it is likely that it will need to be operable at all times during a natural hazard event.

Note: Natural resources assets will not be prompted to answer criticality questions.

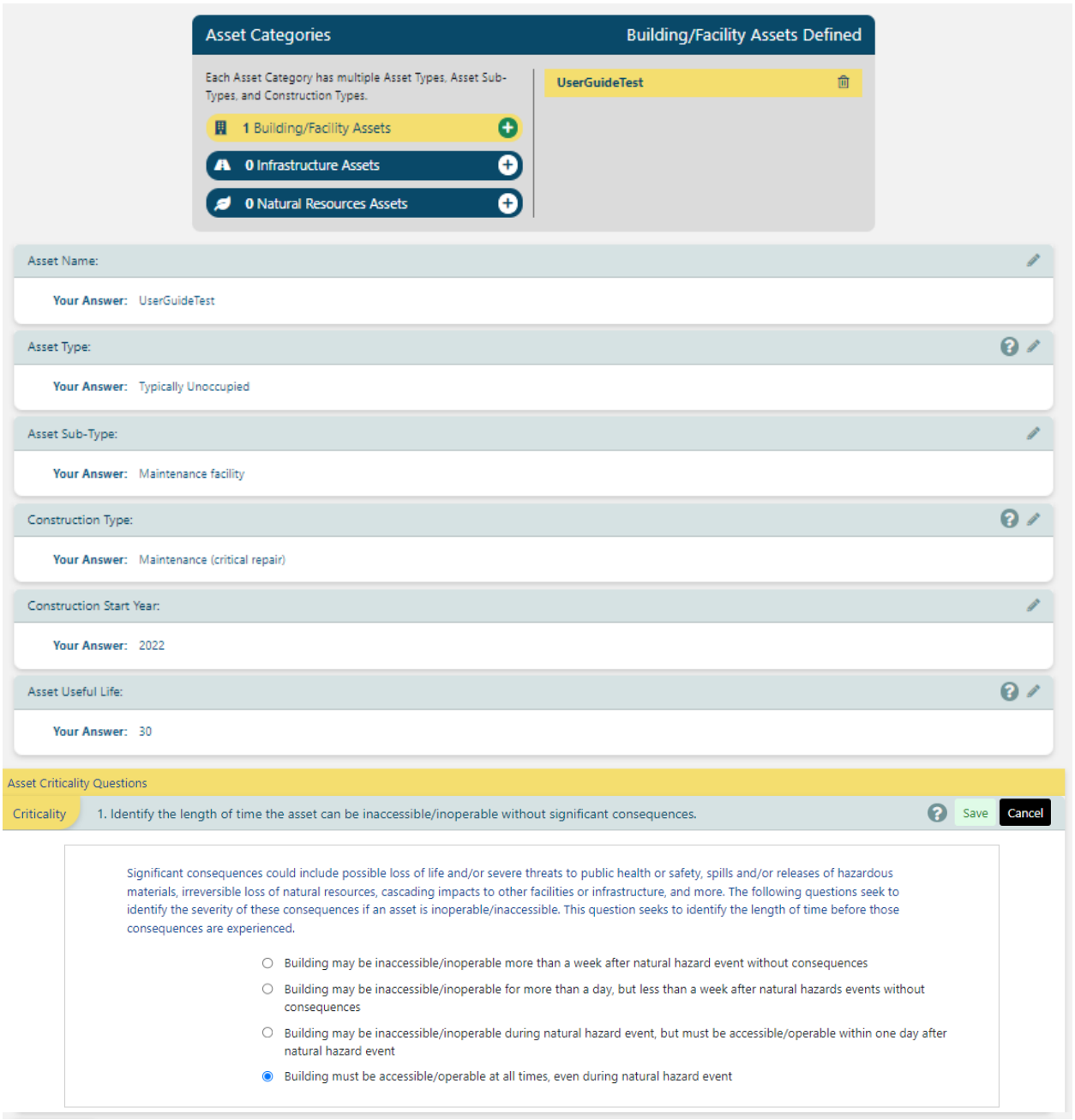


Figure 34. Example drop-down selection of a building/facilities asset's first question.

Once all project and asset(s) inputs have been completed and saved, and the outputs are ready to be reviewed, a “Scored” symbol will appear on the left side of the screen, adjacent to the project name, as shown in Figure 35, below.

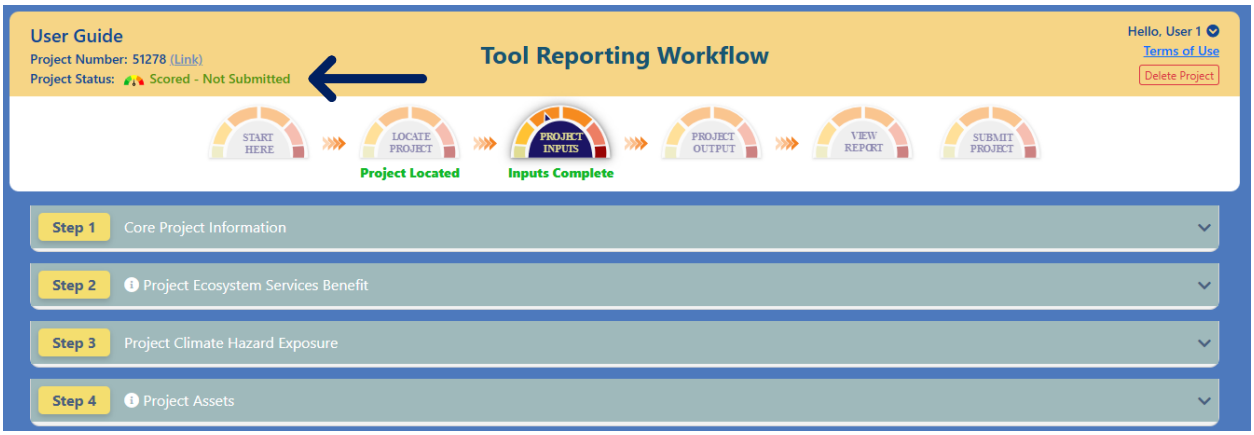


Figure 35. Example of a Scored project alert. This signals completion of the Project Inputs section.

2.5. Page: Project Outputs

Upon completion of the Project Inputs, the user may then navigate to the "Project Outputs" page, shown in Figure 36, below. Here, the user can view the selected project's and assets' Preliminary Climate Risk Screening output and Recommended Climate Resilience Design Standards output. The Ecosystem Benefits Score and Exposure Scores are assigned to the overall project, while the Risk Ratings and Standards are asset-specific. Note: Outputs may take a moment to fully generate, especially is project is located on the coast.

Environmental Justice (EJ) population evaluation, Ecosystem Service Benefits Score, and Preliminary Climate Hazard Exposure Ratings are available for each project, under "Overall Project Scores" (below the first banner). Projects with multiple assets will show different Standards for *each* asset, under "Preliminary Asset Climate Risk Rating and Recommended Design Standards Output." Users can navigate between assets by selecting the assets on the left side of the screen, under "Project Assets" (below the second banner). This is illustrated in Figure 37, below.

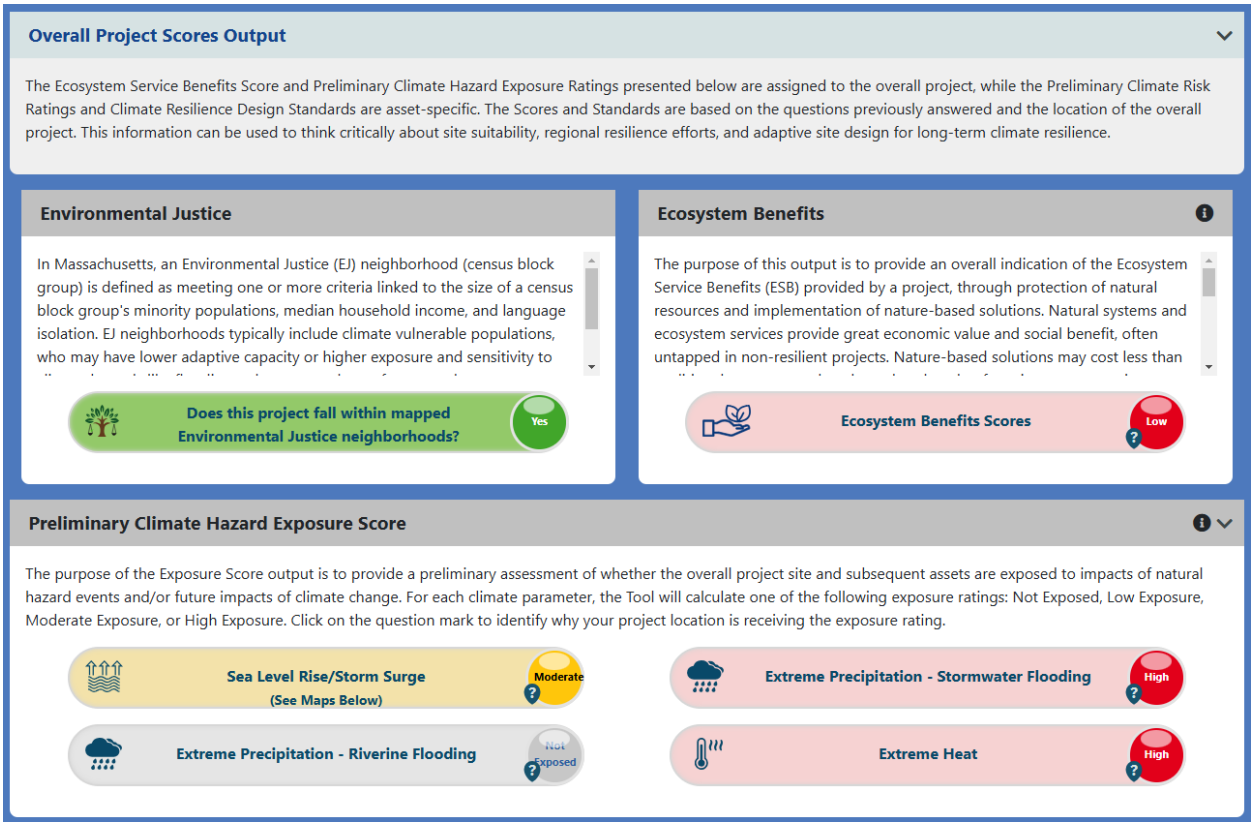


Figure 36. Overview of the "Project Outputs" page.

Tip: There's more on Project Outputs! Refer to the Supporting Documents tab on the Start Here page, to learn more about Project Outputs and how they were established.

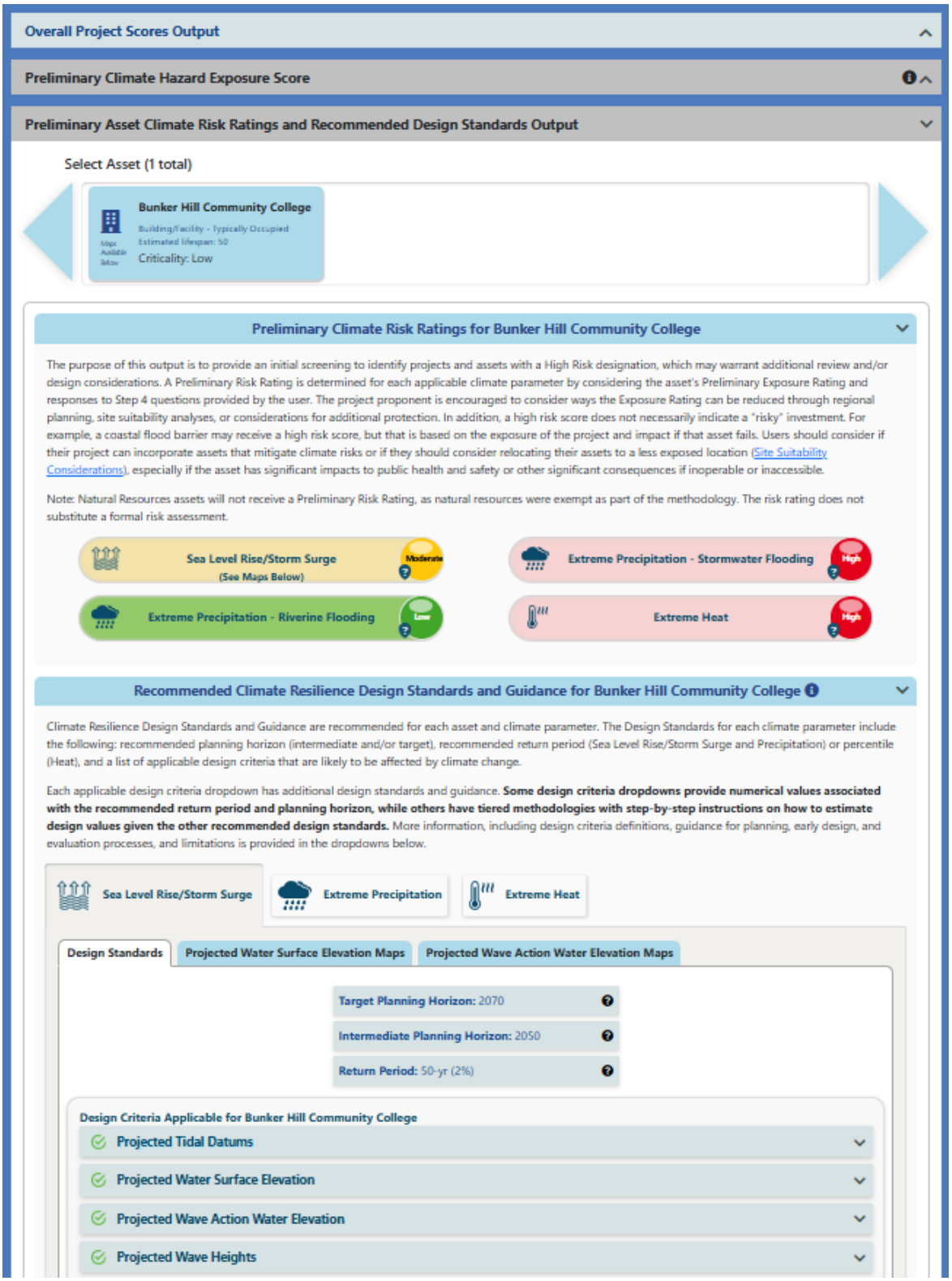


Figure 37. Overview of the “Project Outputs” page, continued.

Environmental Justice (EJ) Evaluation

The purpose of this output is to inform users if their project polygon intersects with a mapped historically vulnerable population. In Massachusetts, an Environmental Justice (EJ) neighborhood (census block group) is defined as meeting one or more criteria linked to the size of a census block group's minority populations, median household income, and language isolation. EJ neighborhoods typically include climate vulnerable populations, who may have lower adaptive capacity or higher exposure and sensitivity to climate hazards like flooding or heat stress due to factors such as access to transportation, income level, disability, racial inequity, health status, or age. Project polygons are either within an EJ population ("YES") or not within one ("NO"). **This output differs from Criticality Question #4, answered by users on the Project Inputs page. Criticality Question #4 asks if the asset provides services to EJ or climate vulnerable populations, whereas this output is a GIS analysis of if the project polygon falls within a mapped EJ neighborhood.** Click on the link in the item text description for a state-wide map of the EJ communities in Massachusetts.

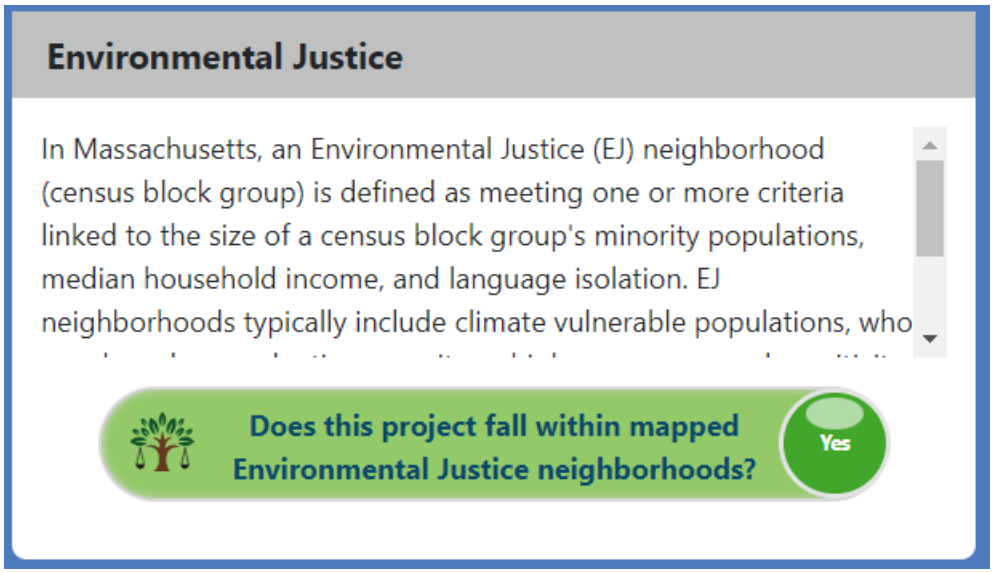


Figure 38. Example of a project's evaluation of within a mapped EJ population.

Ecosystem Service Benefits Score

The purpose of this output is to provide an overall indication of the ecosystem service benefits (ESB) provided by a project, through protection of natural resources and implementation of nature-based solutions. Low ESB scores indicate projects do not provide substantial benefits to ecosystem services and suggests that nature-based solutions are not part of project design. High ESB scores, as shown in Figure 39, indicate that projects significantly benefit ecosystems and suggests nature based solutions are a central part of the overall project. Users are encouraged to identify how their project may provide or protect ecosystem services in design to increase this score. Additional guidance is available under the Supporting Documents tab on the Start Here page.

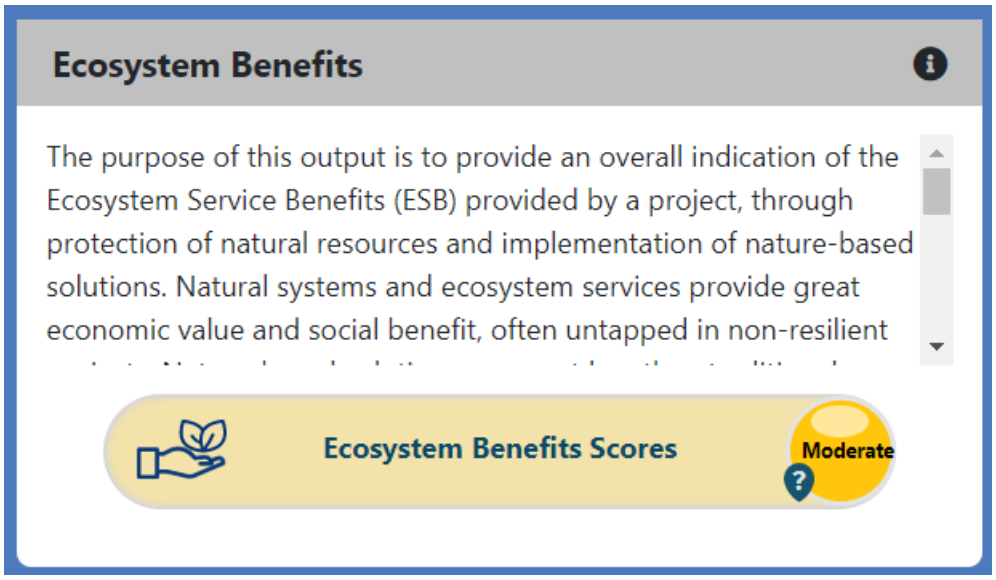


Figure 39. Example of a project's overall Ecosystem Service Benefits Score.

Tip! Click on the question mark icon to view the Ecosystem Service Benefits detailed Expanded Output. Here users will see the reasons why a project received its score, and ecosystem service benefits to incorporate into a project to improve its score.

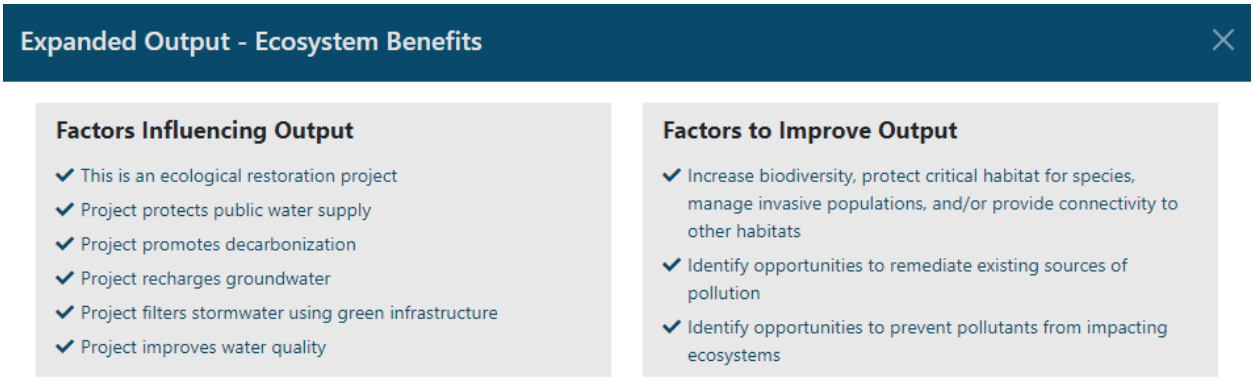


Figure 40. Example of a project's expanded output for the Ecosystem Service Benefits Score.

Preliminary Climate Hazard Exposure Rating

The purpose of this output is to provide a preliminary assessment of whether the project site and subsequent assets are exposed to impacts of natural hazard events and/or future impacts of climate change.

Preliminary Climate Hazard Exposure Ratings are calculated based on submitted Project Inputs—the project location polygon and user question responses, analyzed for each climate parameter: sea level rise and storm surge, extreme precipitation (stormwater and riverine flooding), and extreme heat.

For each climate parameter, the Tool will calculate one of the following exposure ratings: Not Exposed, Low Exposure, Moderate Exposure, or High Exposure. An example of this output for a project is shown in Figure 41.

Note: The exposure is not based on individual asset locations—only the overall project location. The exposure rating does not substitute a formal vulnerability assessment.

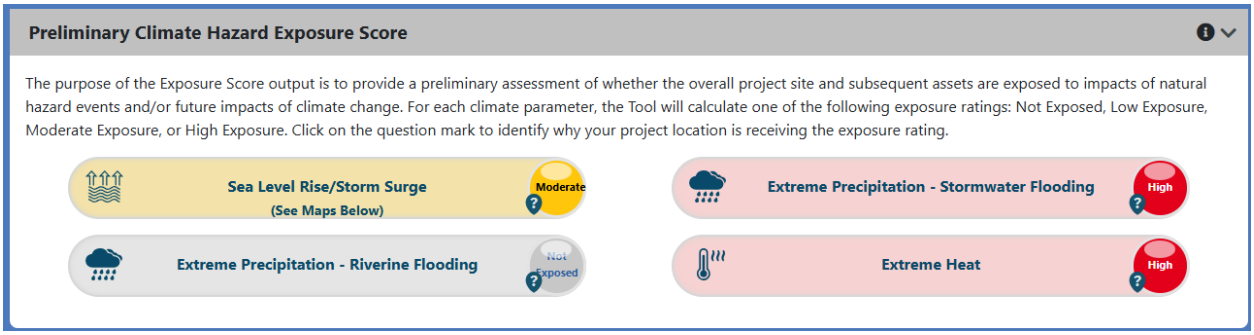


Figure 41. Example of a project's Preliminary Climate Hazard Exposure Rating for each climate parameter.

For project locations exposed to sea level rise/storm surge, the user will receive the first Planning Horizon in which the site is exposed to coastal flooding for the 100-year or 1% annual exceedance probability (AEP) flood event. This can be viewed in the expanded dashboard, found by selecting the icon, as shown in Figure 42. These descriptions vary for each climate parameter and are based on resulting Project Inputs and GIS-based analysis within the Tool.

Figure 42. Expanded exposure rating dashboard output for an example project with a Moderate Exposure to Sea Level Rise/Storm Surge.

Projected Water Surface Elevation and Projected Wave Action Water Elevation maps may be available for the project site, which will be indicated in the Preliminary Climate Hazard Exposure

Score shown in Figure 43. Refer to the Recommended Climate Resilience Design Standards Output section below for more information on how to view these maps.

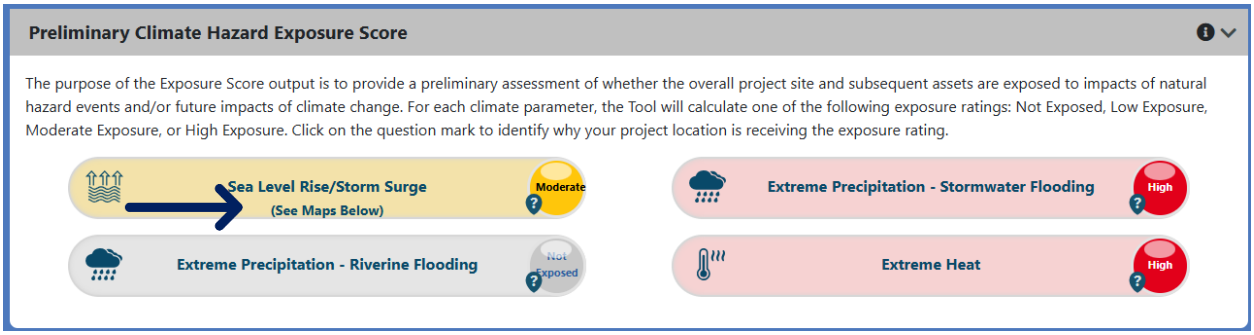


Figure 43. The Tool indicates that Projected Water Surface Elevation and Wave Action Water Elevation maps are available to view.

Preliminary Climate Risk Rating

The purpose of this output is to provide an initial screening to identify projects and assets with a High Risk designation, which may warrant additional review and/or design considerations.

A Preliminary Risk Rating is determined for each applicable climate parameter, and for building, and infrastructure assets, based on the Preliminary Exposure Rating and responses to questions provided by the user. An example output for each climate parameter is shown in Figure 44, with the expanded dashboard output providing further detail on the inputs informing the high risk output shown in Figure 45.

A project may have one or multiple assets which can be viewed within this section. Figures 44 and 46 show five (5) assets total, with one asset selected. To view the Preliminary Climate Risk Ratings and Recommended Climate Resilience Design Standards Output associated with each asset, select the asset of interest. When selected, the asset will be highlighted blue.

Note: Natural resources assets will not receive a Preliminary Climate Risk Rating output as part of the screening, as natural resources were exempt from risk ratings as part of the methodology.

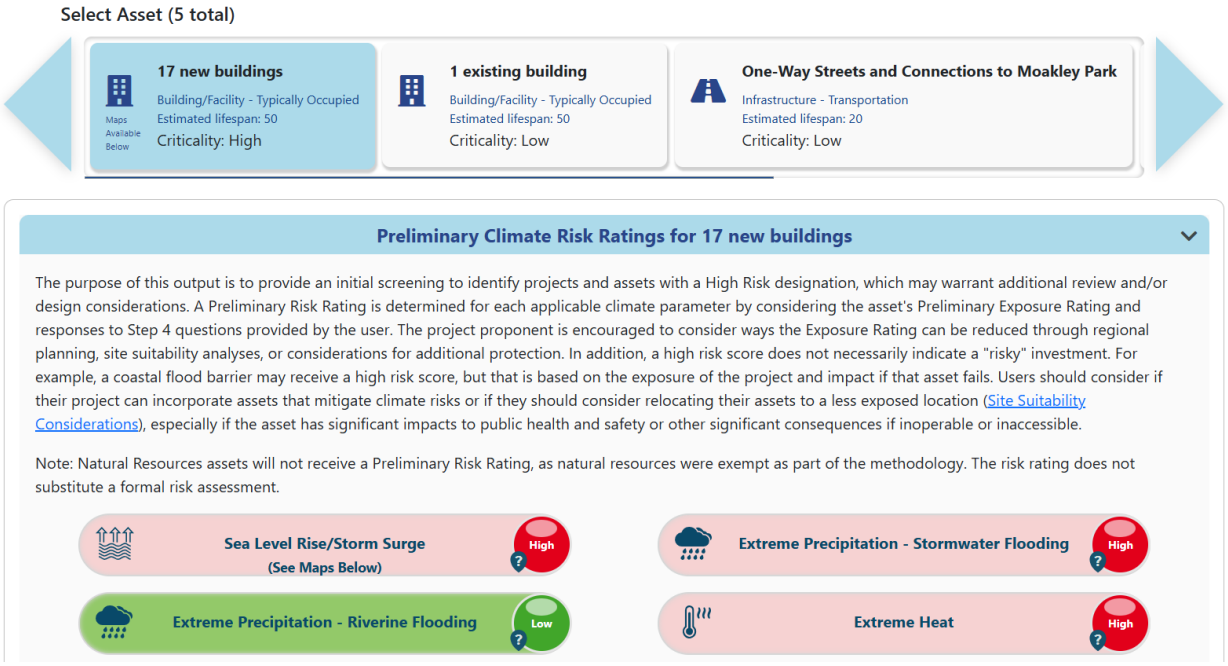


Figure 44. Example Preliminary Climate Risk Rating outputs for an asset for each climate parameter.

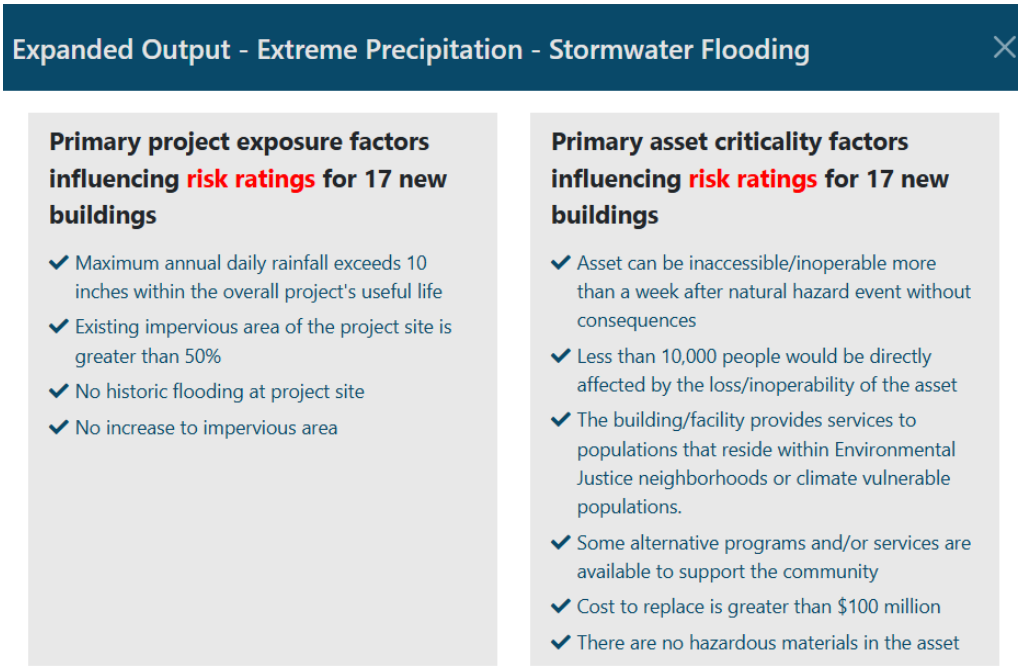


Figure 45. Example expanded risk rating output for an asset.

Recommended Climate Resilience Design Standards Output - Overview

The Tool provides Recommended Climate Resilience Design Standards ("Standards"). This is intended to be a basis-of-discussion for planning, early design, and evaluation that is standardized across the Commonwealth based on asset type, location, criticality, construction type, and useful life of physical assets.

Assets will receive recommended design standards for two climate parameters (extreme precipitation and extreme heat), and a third for sea level rise/storm surge if applicable.

Standards include recommended intermediate and/or target planning horizons, return period or percentile, and applicable design criteria that may be affected by climate change. Projected values and/or methodologies to calculate projected values are also provided for each asset entered.

Note: Applicable design criteria are shown with green checkmarks. Red symbols indicate design criteria that are not relevant or recommended to be calculated for the particular asset. As shown in Figure 47, each applicable design criteria will have the following subsections within the dropdown:

- *Definition*
- *[Applicable Design Criterion] Projected Values OR How to Estimate [Applicable Design Criterion] Values*
- *How [Applicable Design Criterion] may inform Planning*
- *How [Applicable Design Criterion] may inform Early Design*
- *How [Applicable Design Criterion] may inform Project Evaluation*
- *Limitations for [Applicable Design Criterion] Values, Standards, & Guidance*

Sea Level Rise / Storm Surge Design Standards Output

If the project is not exposed to sea level rise/ storm surge within the useful life of the asset entered, the asset will not receive Standards for this climate parameter.

The Standards provided for sea level rise/ storm surge climate parameter for each asset include recommended target and intermediate planning horizon, return period, and the following design criteria that are likely to be affected by climate change: projected tidal datums, projected water surface elevation, projected wave action water elevation, projected wave heights, projected duration of flooding, projected design flood velocity, projected scour & erosion. There are either projected values provided for design criteria based on recommended planning horizon and return period, or recommended methodologies to estimate projected design criteria values, as shown in Figures 46-48.

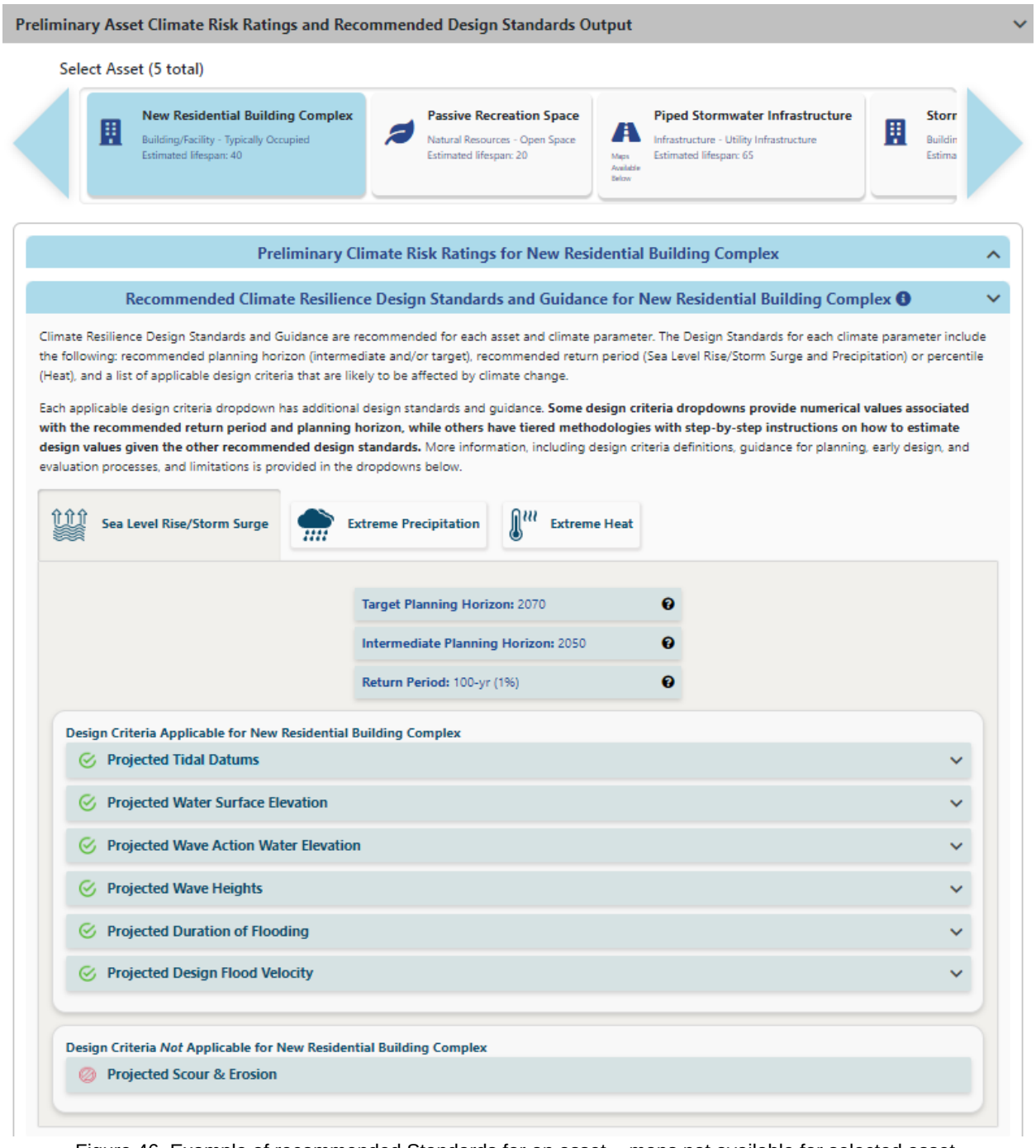
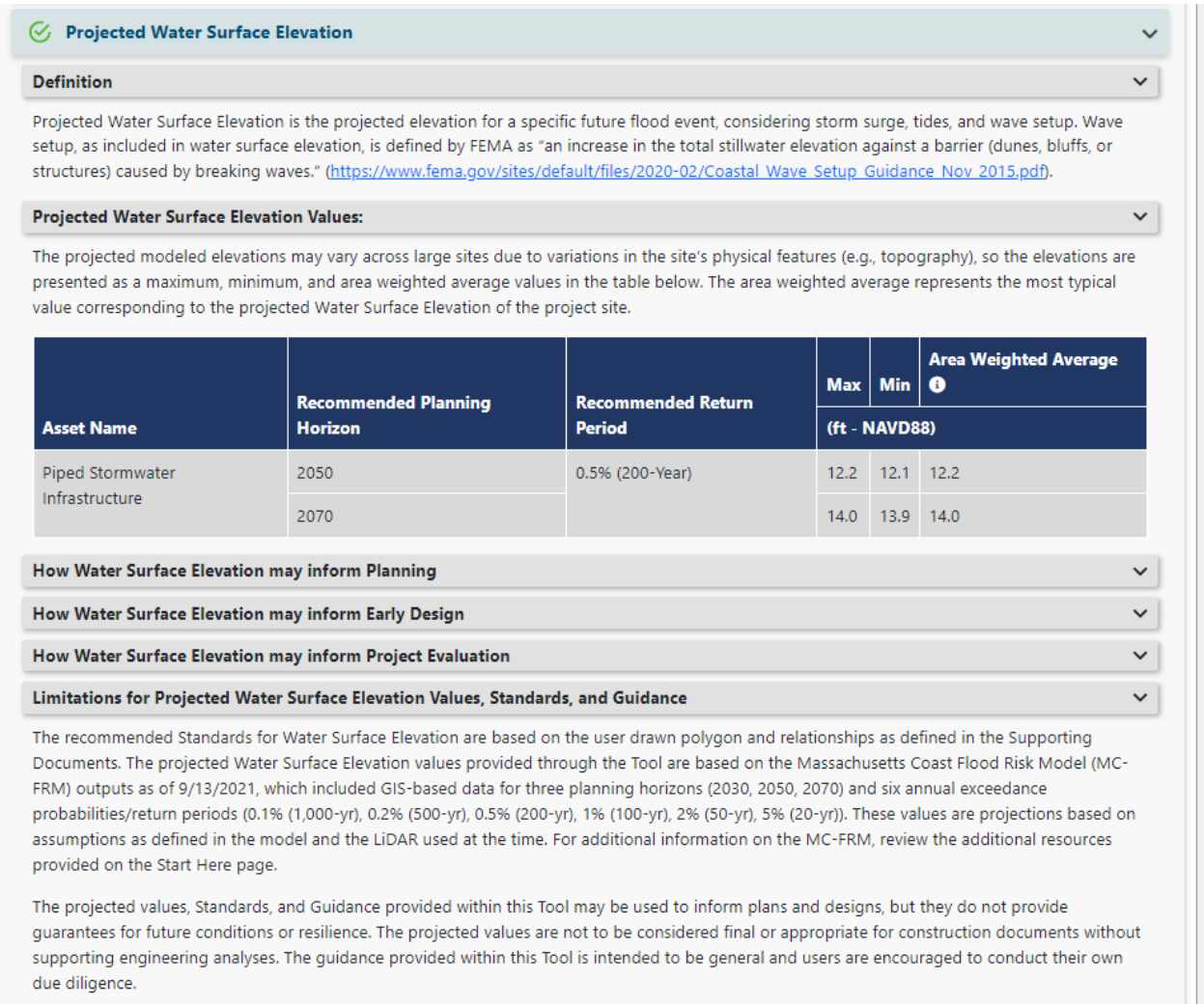


Figure 46. Example of recommended Standards for an asset – maps not available for selected asset.



Projected Water Surface Elevation

Definition

Projected Water Surface Elevation is the projected elevation for a specific future flood event, considering storm surge, tides, and wave setup. Wave setup, as included in water surface elevation, is defined by FEMA as "an increase in the total stillwater elevation against a barrier (dunes, bluffs, or structures) caused by breaking waves." (https://www.fema.gov/sites/default/files/2020-02/Coastal_Wave_Setup_Guidance_Nov_2015.pdf).

Projected Water Surface Elevation Values:

The projected modeled elevations may vary across large sites due to variations in the site's physical features (e.g., topography), so the elevations are presented as a maximum, minimum, and area weighted average values in the table below. The area weighted average represents the most typical value corresponding to the projected Water Surface Elevation of the project site.

Asset Name	Recommended Planning Horizon	Recommended Return Period	Max (ft - NAVD88)	Min (ft - NAVD88)	Area Weighted Average (ft - NAVD88)
Piped Stormwater Infrastructure	2050	0.5% (200-Year)	12.2	12.1	12.2
	2070		14.0	13.9	14.0

How Water Surface Elevation may inform Planning

How Water Surface Elevation may inform Early Design

How Water Surface Elevation may inform Project Evaluation

Limitations for Projected Water Surface Elevation Values, Standards, and Guidance

The recommended Standards for Water Surface Elevation are based on the user drawn polygon and relationships as defined in the Supporting Documents. The projected Water Surface Elevation values provided through the Tool are based on the Massachusetts Coast Flood Risk Model (MC-FRM) outputs as of 9/13/2021, which included GIS-based data for three planning horizons (2030, 2050, 2070) and six annual exceedance probabilities/return periods (0.1% (1,000-yr), 0.2% (500-yr), 0.5% (200-yr), 1% (100-yr), 2% (50-yr), 5% (20-yr)). These values are projections based on assumptions as defined in the model and the LiDAR used at the time. For additional information on the MC-FRM, review the additional resources provided on the Start Here page.

The projected values, Standards, and Guidance provided within this Tool may be used to inform plans and designs, but they do not provide guarantees for future conditions or resilience. The projected values are not to be considered final or appropriate for construction documents without supporting engineering analyses. The guidance provided within this Tool is intended to be general and users are encouraged to conduct their own due diligence.

Figure 47. Example of expanded dropdown for "Projected Water Surface Elevation"

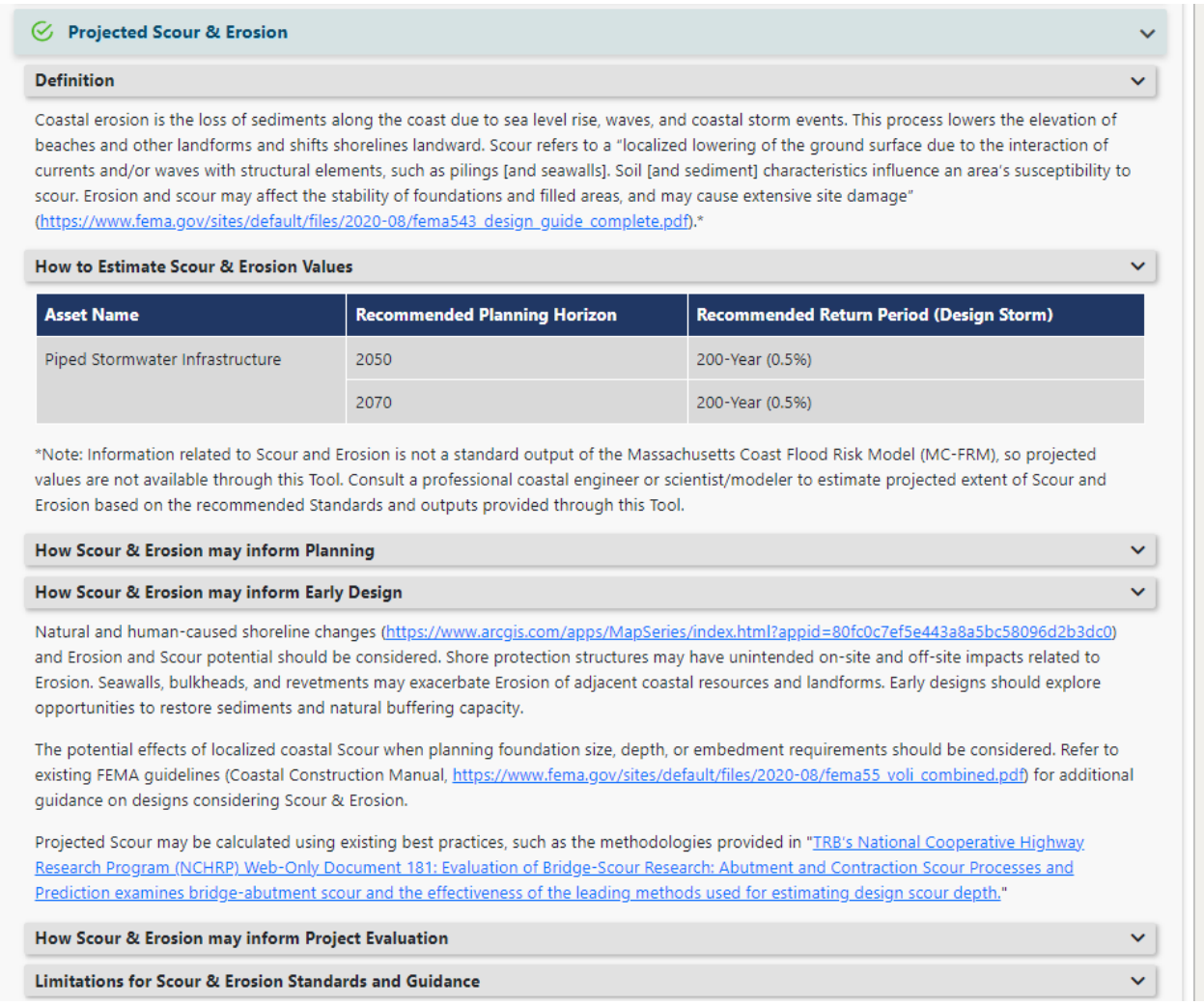


Figure 48. Example of expanded dropdown for "Projected Scour & Erosion"

If Projected Water Surface Elevation or Projected Wave Action Water Elevation is a recommended design criteria for an asset, users will see "Maps Available Below" next to the asset icon in the carousel, and an additional tab shown under Sea Level Rise/Storm Surge, as shown in Figure 49. **Note: The assets appear in the order entered in the Tool, so users may need to scroll through the carousel to find the asset with the maps.**

The Projected Water Surface Elevation and Projected Wave Action Water Elevation maps provided through the Tool reflect the overall project location (based on the polygon drawn by the user with a 0.1 mile minimum buffer) but the values shown in the map reflect the corresponding asset's recommended return period. The maps do not reflect the location of specific assets on the site.

Maps are only produced for the asset with the lowest return period (largest design storm) recommendation out of the assets entered. For projects that only have Natural Resource assets, the maps will show the Projected Water Surface Elevations and Projected Wave Action Water

Elevation corresponding to the 5% (20-year) return period. Maps are provided for the 2030, 2050, and 2070 planning horizons.

Figure 49. Example of recommended Standards for an asset – maps available for selected asset.

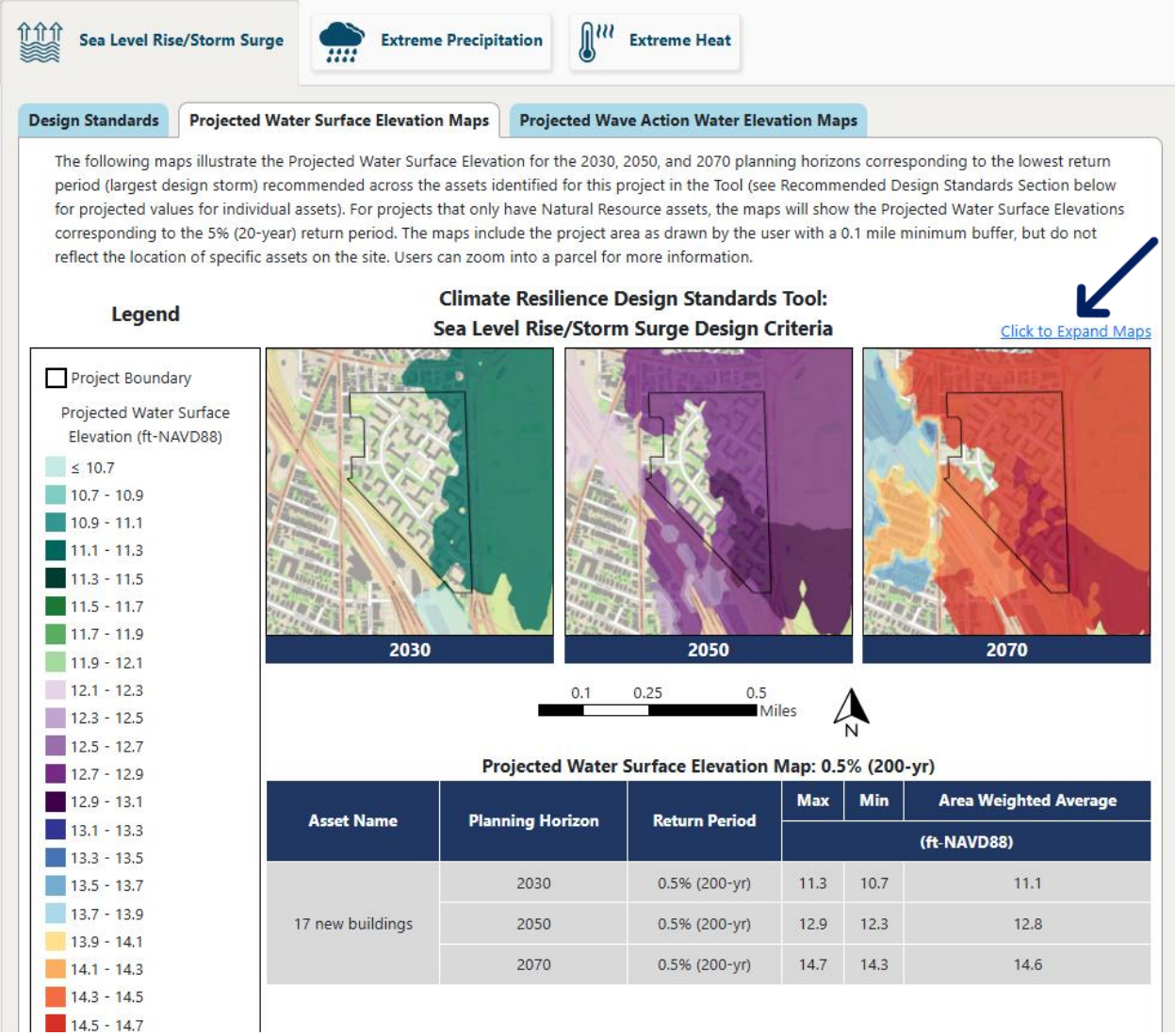
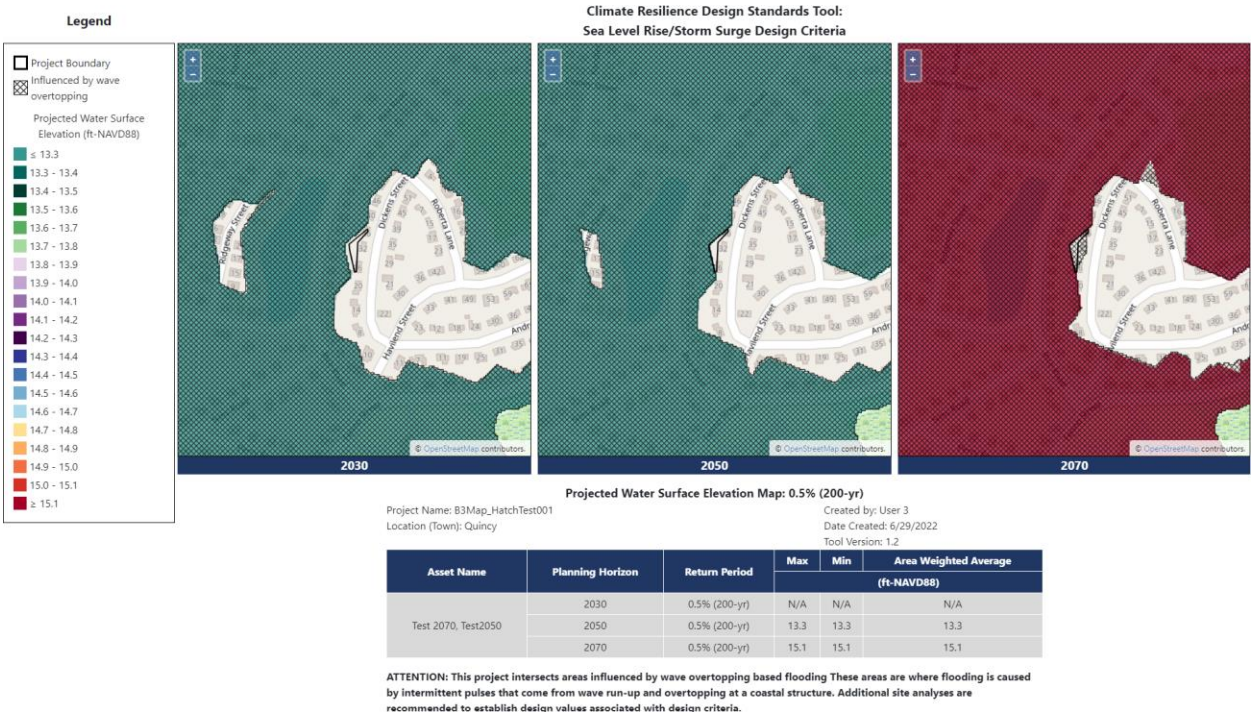


Figure 50. Projected Water Surface Elevation Maps Tab

The Projected Water Surface Elevation and Projected Wave Action Water Elevation maps are visible by selecting the corresponding map tab, indicated with an arrow in Figure 49. The maps can also be viewed in a new window by selecting “Click to Expand Maps,” indicated with an arrow in Figure 50. In the new window, additional functionality allows users to zoom in and zoom out (to a maximum 0.5 mile buffer). The maps are also available to view or download as part of the Project Report. The Project Report includes a compiled map with 2030, 2050, and 2070, as well as individual maps for each of these planning horizons (eight maps total).



Asset Name	Planning Horizon	Return Period	Max	Min	Area Weighted Average
			(ft-NAVD88)		
Test 2070, Test2050	2030	0.5% (200-yr)	N/A	N/A	N/A
	2050	0.5% (200-yr)	13.3	13.3	13.3
	2070	0.5% (200-yr)	15.1	15.1	15.1

Figure 51. Expanded Projected Water Surface Elevation Maps – Hatch Overlay

Some projects will include areas with a hatch overlay, as shown in Figure 51. In case where hatched areas intersect with the project polygon location, users receive an ATTENTION note that accompanies projected value table for the design criteria. The hatch areas represent areas of uncertainty in the underlying Massachusetts Coast Flood Risk Model (MC-FRM) data, for example areas where:

- flooding is caused by intermittent pulses of water from wave overtopping of major coastal structures (e.g., revetments, seawalls) only (i.e., no water directly flows to the location) during simulated events
- flooding may vary drastically due to dynamic landforms and geomorphology
- shallow water flooding is expected or there is minor water depth during the most extreme events (>1,000-yr [0.1%] design storm).

The hatched areas indicate uncertainty in the data and additional site analyses are recommended to establish design values associated with design criteria. The attention text below the map details the type of uncertainty present within the project site.

Extreme Precipitation Design Standards Output

The Standards provided for the extreme precipitation climate parameter include recommended target planning horizon, return period, and the following design criteria that are likely to be affected by climate change: Projected Total Precipitation Depth & Peak Intensity for 24-hour Design Storms and Projected Riverine Peak Discharge & Peak Flood Elevation. There are either projected values provided for design criteria based on recommended planning horizon and return period, or recommended methods to estimate projected design criteria values.

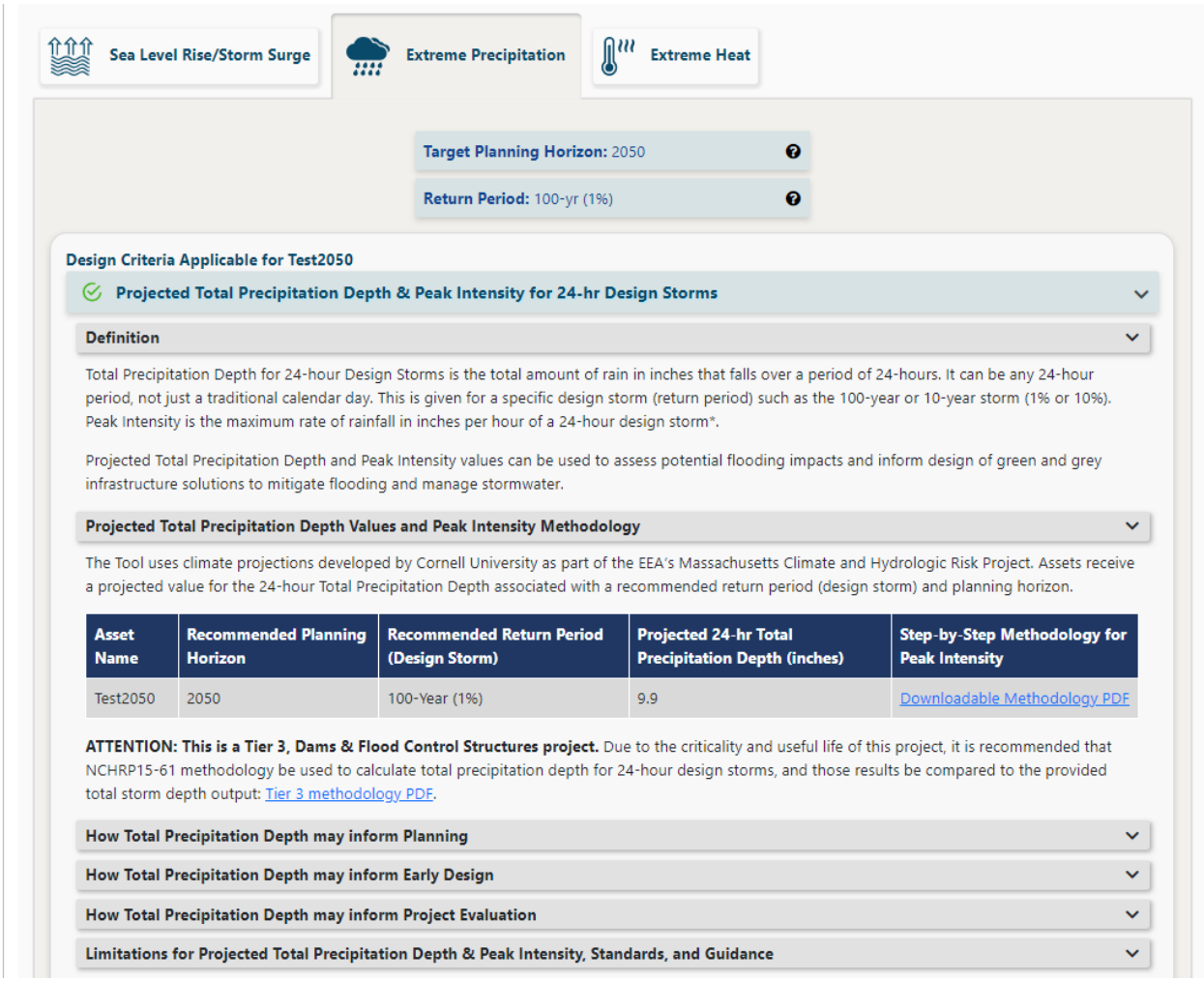


Figure 52. Example of dropdown for Projected Total Precipitation Depth & Peak Intensity for 24-hr design storms

In addition to projected values for total precipitation depth for 24-hr design storms, there are two special cases when users receive additional information to calculate projected values following other methods. Users will see “ATTENTION” text with a link to a downloadable PDF providing a step-by-step process to estimate total precipitation depth, as shown in Figure 52.

Extreme Heat Design Standards Output

The Standards provided for the extreme heat climate parameter include recommended planning horizon, percentile, and the following design criteria that are likely to be affected by climate change: Projected Annual/Summer/Winter Average Temperature, Projected Heat Index, Projected Days per year with max temperature > 95°F, > 90°F, < 32°F, Projected Number of Heat Waves Per Year and Average Heat Wave Duration (days), Projected Cooling Degree Days (base = 65F) and Heating Degree Days (base = 65F), and Projected Growing Degree Days. There are

either projected values provided for design criteria based on recommended planning horizon and percentile, or recommended methods to estimate projected design criteria values.

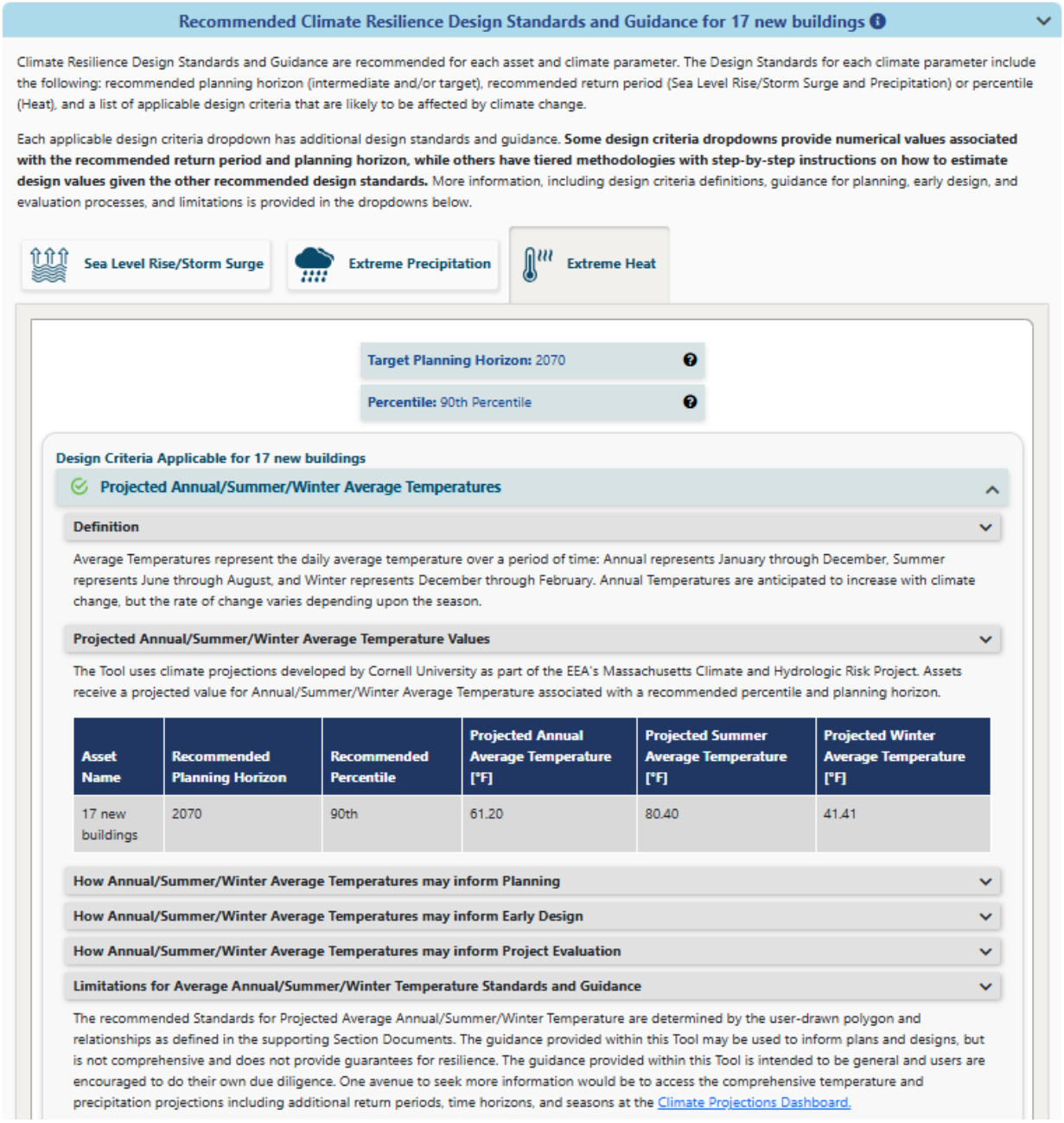


Figure 53. Example dropdown for Projected Annual/Summer/Winter Average Temperature.

Optional Report Comment Box

In addition to the Project Inputs, users can add optional report comments, after reviewing the Project Outputs. These comments provide the opportunity to describe how the Tool's Project Output information may be incorporated into the project. The comments will be included with the Project Report. For example, users might describe measures that will be taken to adapt the site and/or assets to climate change, for any of the climate parameters assessed (sea level rise/storm

surge, extreme precipitation (stormwater or riverine flooding), extreme heat). If no measures are planned, explain why. The Report Comment Box is shown in Figure 54, below.

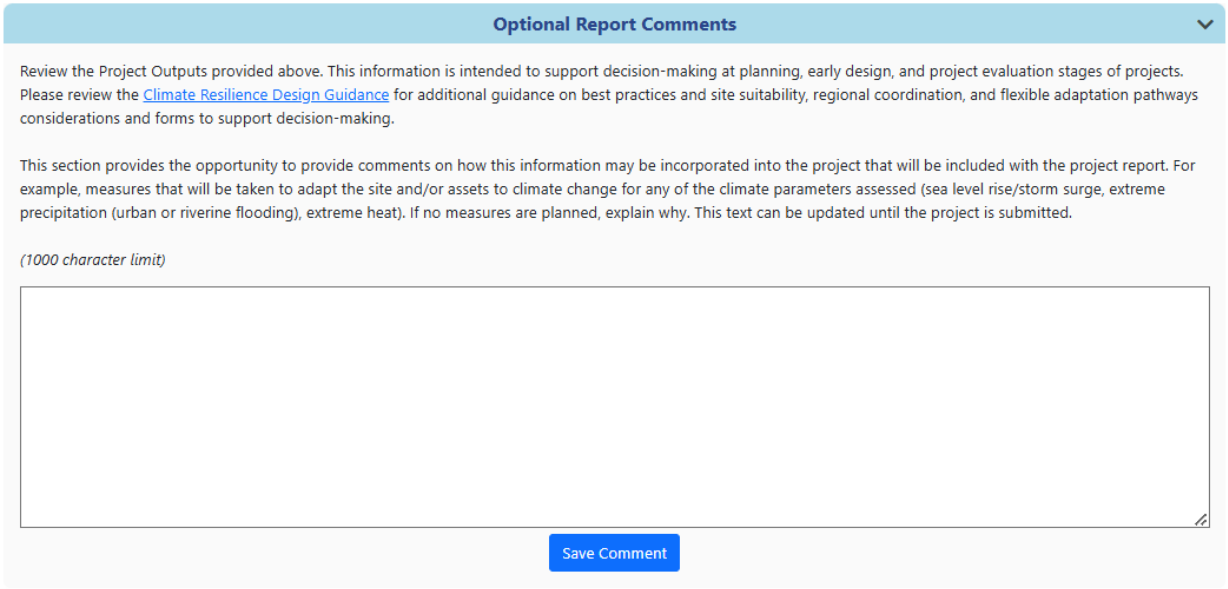


Figure 54. Optional Report Comments Box.

Tip: Wait, your work isn't done! Review the Guidance and Forms in the first page: Start Here. These supplemental materials support the design phase and serve to document climate resilience decision-making.

Congrats! The Project Outputs have been reviewed.

Cloning Projects

Users have the option to “clone” or “copy” a project. This action creates an entirely new project, with the same Project Inputs and, subsequently, the same Project Outputs. This action may be performed by selecting the Clone button on the left-sided panel, shown in Figure 55, below.

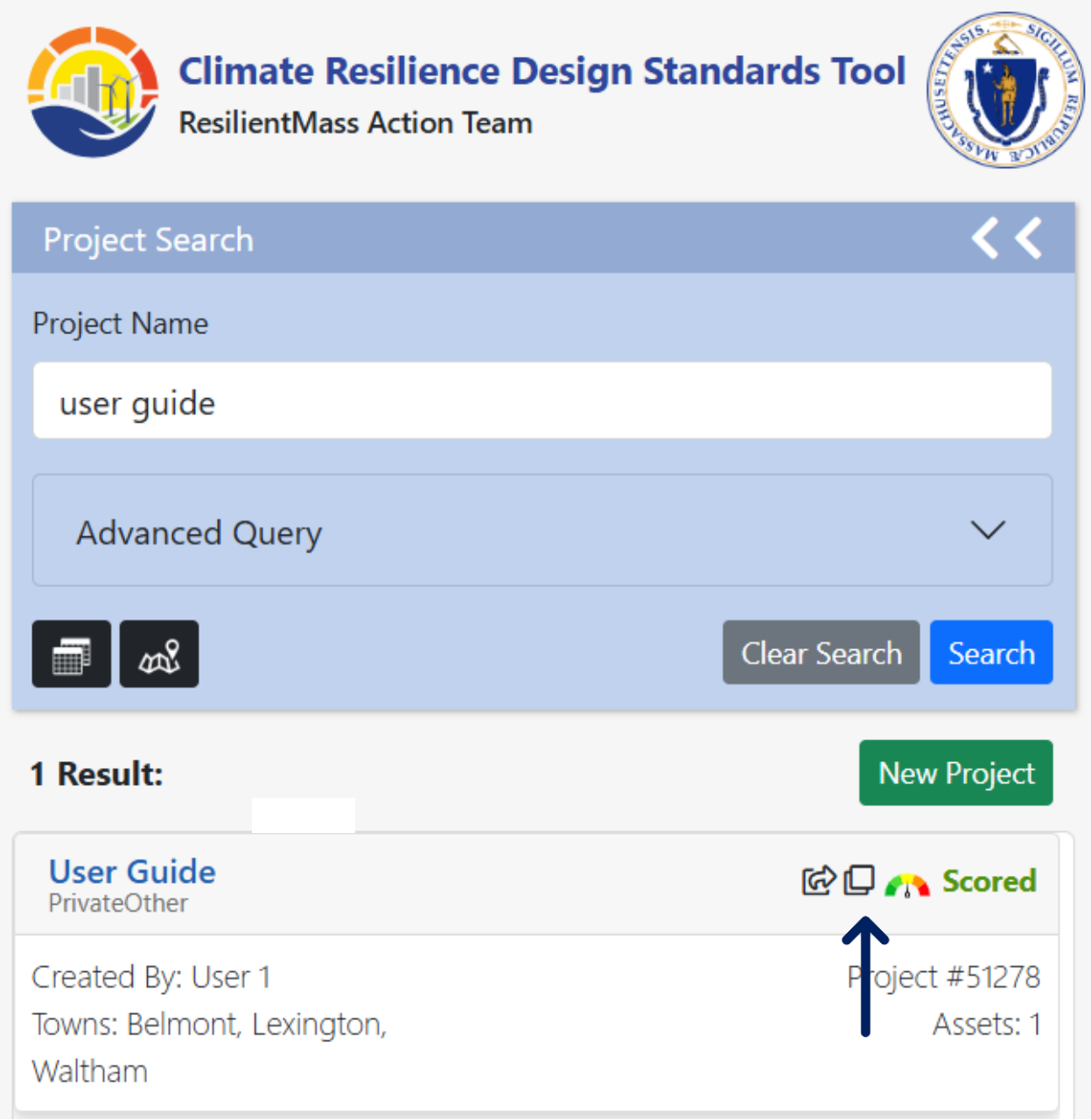


Figure 55. Clone/Copy Project Button.

Sharing Projects

Users have the option to share a project with other users, and give them read only, edit only, or edit and submit privileges. Users need the Tool username of the recipient user—this is not the same as their email address. The button to share a project is shown in Figure 56, below.

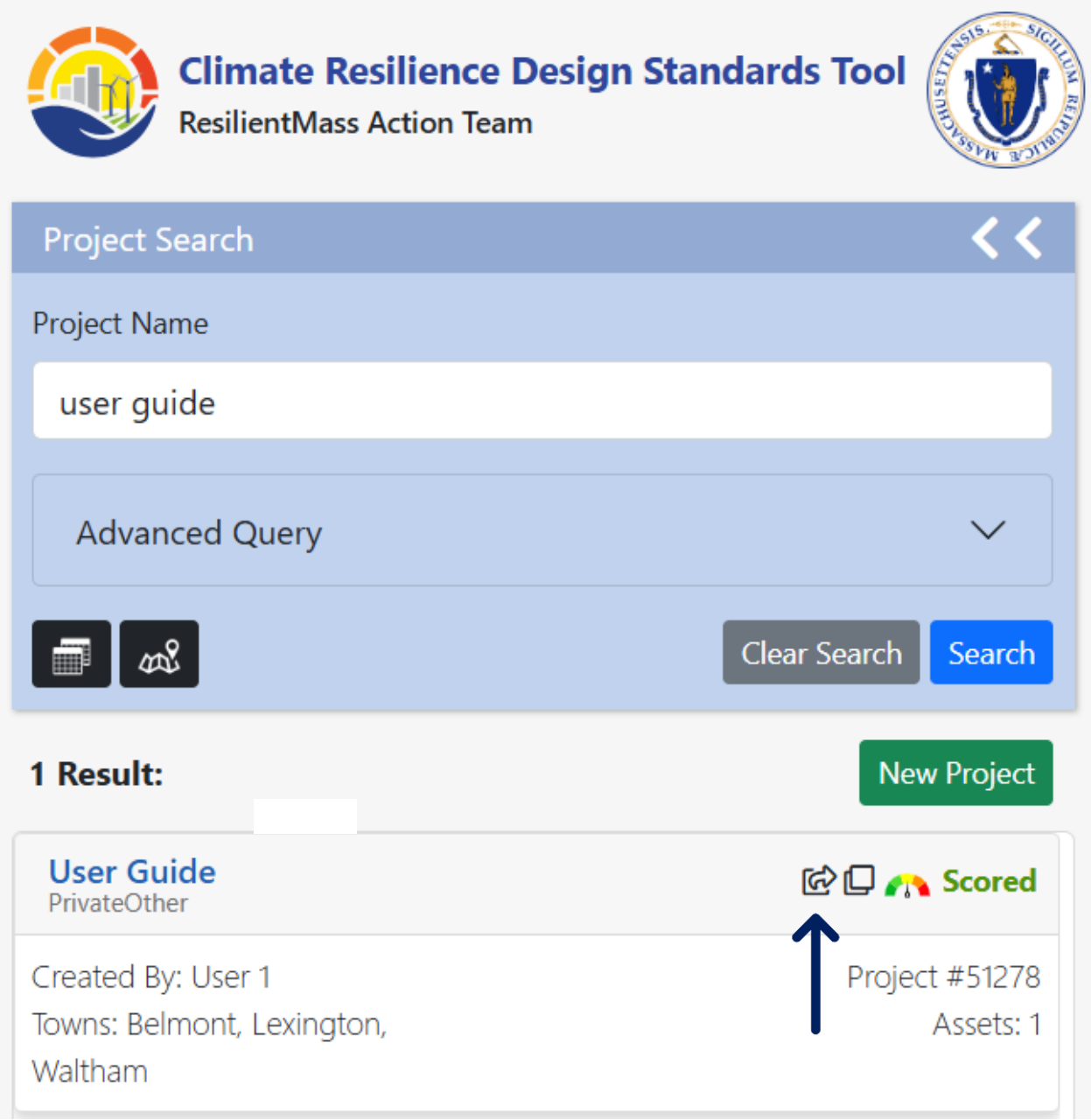


Figure 56. Share Project Button.

Tip: Share the Project URL! Users can copy their project url(s) from the Tool's address bar and share the url(s) with others. This way others can view the Project Inputs until they have been submitted.

2.6. Page: View Report

Users may view and download their Project Report under the View Report page. Here, the Project Inputs and Outputs have been summarized in report format.

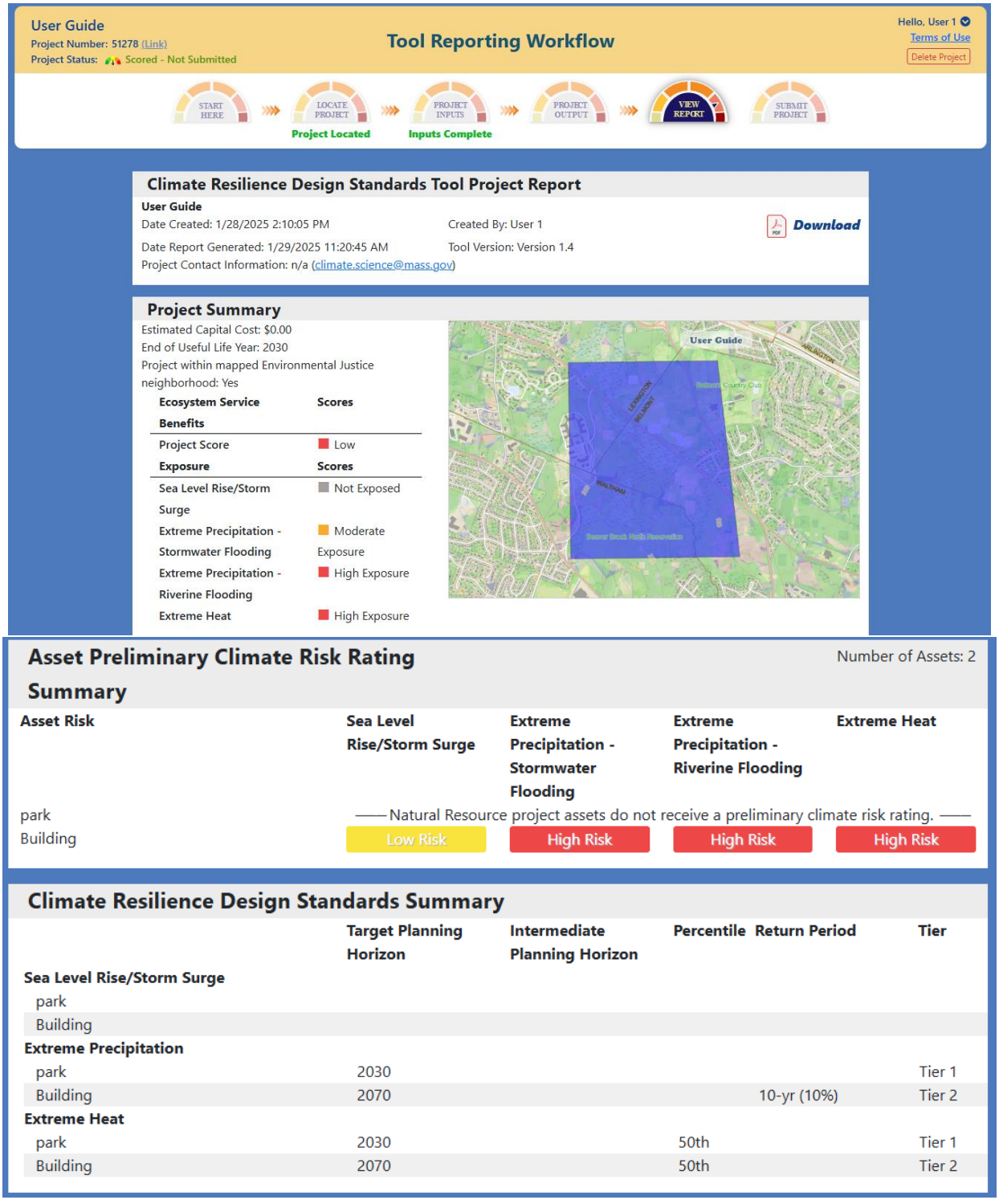


Figure 57. Example Report Preview page view.

Projected Water Surface Elevation and Projected Wave Action Water Elevation maps for the project area are included in the Report when available. For each of these two design criteria, a compiled map showing 2030, 2050, and 2070, as well as individual maps for each of these planning horizons are included (i.e., eight maps total).

It may take a few minutes for map images to fully render – you may see a "maps generating" message followed by a pop-up box to "click to see maps". Once displayed, users should click the button "Download" to generate and download the report for their project. A PDF of the report will then download to the download folder of the web browser, as shown in Figure 58. **You do not need to submit your report to download it, however, some grant processes may require this step.**

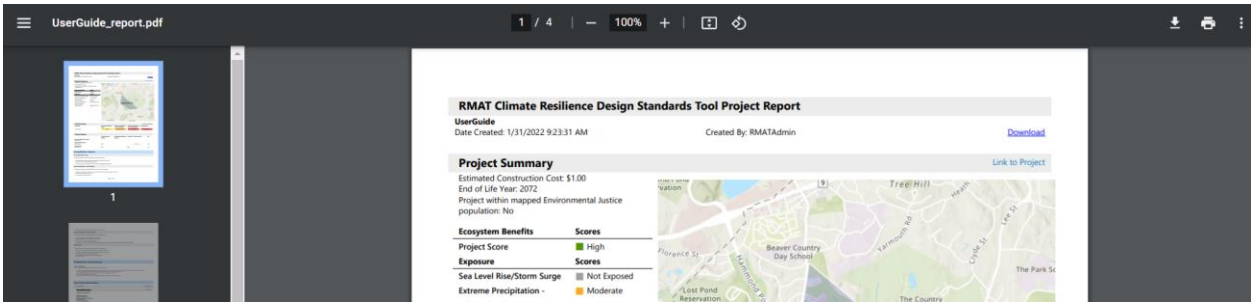


Figure 58. Example downloaded report in browser window.

Tip: Generating the report does not submit the report! Users should proceed to the Submit Project page to submit their project to the database. This may be a requirement for some grant processes.

2.7. Page: Submit Project

Users may be asked to submit their project (to the Tool database) for various grant applications or state agency requirements. Users should review project and asset(s) inputs and outputs carefully before submitting. Once a project is submitted, users can still search for the project but can no longer edit Project Inputs. Once submitted, users with “viewer” role functionality will be able to search for this project, but not make changes. Users can create a clone of a submitted project to be able to modify information at any time. Submission is not required to view or download the Project Report.

Note: No Project Inputs can be changed upon submitting the project but projects can be cloned/copied to alter input fields.

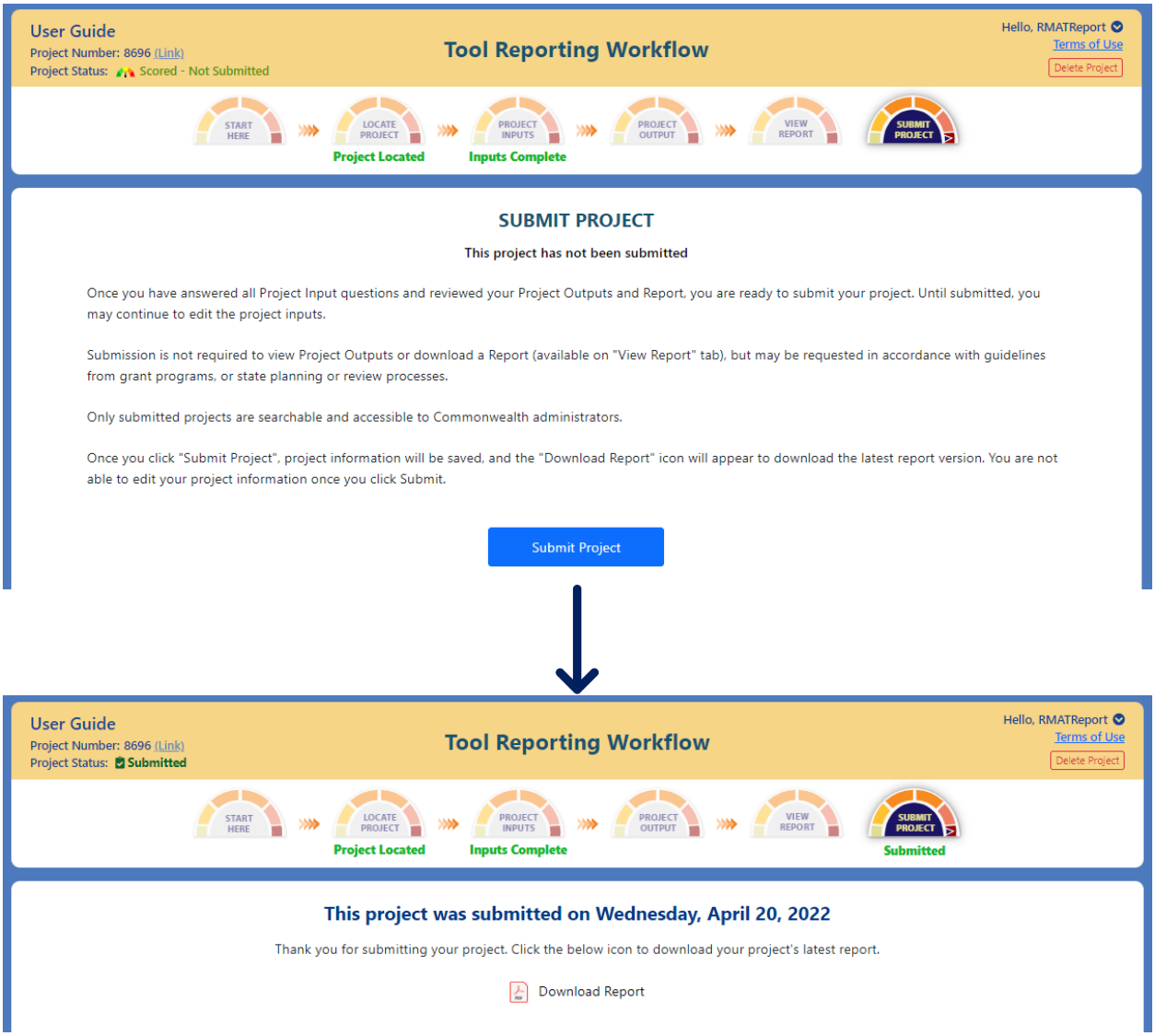


Figure 59. Example of a submitted project process. This signals that the project has been submitted and no additional changes may be made.

Congrats! The Tool workflow is complete and project is successfully submitted.