Tidegate Pipe Sizing Tool User Manual

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1   INTRODUCTION

There are over one thousand tidegates on the Oregon coast and lower Columbia River, owned by private landowners, various special purpose districts, and government agencies. Many of these tidegates were installed decades ago and are nearing the end of their lifespan. The permits required to construct a replacement tidegate are numerous and complex, especially for individual landowners and small districts. In many cases tidegate owners have had to hire engineers to perform the complex analysis needed to meet permit submittal conditions.

The Oregon Tidegate Partnership was formed to address the challenge of repairing this aging tidegate infrastructure and provide assistance to tidegate owners in Oregon. Two of the focus areas of the Partnership are in reducing project engineering costs and providing regulatory clarity and coordination. The Partnership determined that development of a tool to assist in the design of replacement tidegates could both reduce engineering design costs and provide a smoother regulatory permit pathway by providing consistent analysis from a tested methodology that demonstrated culvert performance under state and federal fish passage criteria.

The Tidegate Pipe Sizing Tool was developed to achieve the above purposes. This user manual describes the use of the Tool, including instructions on how to prepare the inputs and guidance on reviewing and interpreting the results.

2   PURPOSE AND SCOPE OF TOOL

The overall goal of the project was to develop a simple tool for tidegate owners to use in developing designs and permitting tidegate replacement. By doing so, the engineering and permitting costs and effort will be reduced. The Tool development Project Team used two general considerations in developing the scope and limitations of the proposed Tool. These were developed at the outset of the project to help in development of the possible forms the Tool could take:

Balancing simplicity vs. accuracy: The challenge in developing the Tool was to balance the need for simplicity for the user versus accuracy for the reviewers. A tool that could be used by anyone would be unlikely to be accurate enough to satisfy agency reviewers, or would require conservatism in the design outputs, potentially leading to recommending oversized, more expensive culverts. Conversely, a highly accurate tool would likely require knowledge and techniques outside of the range of the expected user base.

Defining the range of tidegates to be analyzed: The Project Team decided that the Tool should not be expected to analyze all known or potential tidegate systems but endeavour to cover the majority of smaller, basic tidegates owned by individual landowners and small districts. It was assumed that larger, more complex tidegates are generally owned by jurisdictions or districts with greater financial resources that would not necessarily need or use this Tool.

From these considerations and Project Team discussions, the following assumptions and limitations (Table 1) were developed for the Tool.

Table 1. Tool assumptions and limitations

Assumption/Limitation	Note
Culvert Size: circular pipes, 4–8-foot diameter	State and federal regulations generally require a minimum culvert diameter of 4 feet, although it is anticipated smaller culverts will be allowed on a case by case basis. Circular culvert diameters above 8 feet are very rare. Concrete box culverts generally require formal engineering design and are rarely installed by individual landowners due to cost. The size range allowed covers the vast majority of tidegates in the project area.
Number of Culverts to be Designed at Once: 1	Most systems consist of a single tidegate. The Tool allows analysis of systems with multiple tidegates, but only allows one culvert at a time to be considered for replacement.
No Interior Tidegates	The Tool should not be used to analyze or design interior tidegates, which are tidegates that discharge into a waterbody where there is another tidegate downstream. The Tool only works on primary tidegates that discharge into a free flowing tidal waterbody.
Side-Hinged Gates Only	Lightweight side-hinge gates are already required on new tidegate installations in fish-bearing waters.
Primary Tidegate Purpose	The Tool is primarily designed to facilitate sizing of replacement tidegates for rural sites where it is intended that existing landuses (primarily agriculture) will continue.

Assumption/Limitation	Note
Area of Application	Tidally influenced Oregon Coast rivers and the Lower Columbia River up to St Helens with dominately rural and/or forested watersheds.
User Ability and Knowledge, Need for Support	The Tool assumes users will have good knowledge of the tidegate site being evaluated and the ability to use an application using a modern web browser. It is not designed to ensure all possible tidegate owners will be able to use it. It is assumed that local resource agency staff will be able to assist landowners with the Tool when necessary.
Flow Regime	The Tool will only evaluate normal flow conditions when fish passage is likely to occur. It will not evaluate culvert flood capacity.
Regulatory Use	The Tool will not be formally adopted or used on its own by regulatory agencies to make determinations of the permitability of proposed tidegate replacement projects. The Tool should be accurate enough that regulatory agencies have a high degree of confidence in the outputs and use it as one of their primary sources in considering tidegate replacement permits.

3   QUICKSTART GUIDE

This section provides a summary overview for using the Tool. More details, including complete instructions and explanations of the individual components, are provided in the remainder of the User Manual.

Step 1: Open the Tool

In a computer connected to the Internet, launch a modern web browser (e.g., Microsoft Edge) and visit the Tool's web address. After the Tool webpage has loaded select Analyze Pipe from the navigation bar at the top of the page or from the hamburger menu (☰) if the page is too narrow to display the full navigation bar. You will then be directed to the Site Selection page.

Step 2: Select your site

Within the map on the Site Selection page, zoom and pan around using the mouse or trackpad to find your site. Click on the blue map pin representing the tidegate pipe you would like to analyze with the Tool. You may also add a new (red) map pin to the map if your desired tidegate pipe is not shown (see instructions provided on the page or in the manual in the Site Selection section). If you add a new map pin you must then click on it to advance to the next page.

Step 3: Provide and review tidegate properties

On the Tidegate Properties input page review all sections and provide any missing required input. Some or all the required inputs may have already been populated. Refer to the Usage section for instructions for modifying prepopulated inputs using the override checkboxes. The required inputs include the following:

- **Description** – Enter a descriptive name as the location name.

- **Analysis Method** – Use the default *Find my best pipe size and elevation* option to use the automated sizing feature (recommended) or select *Analyze specified pipe configuration* to analyze the performance of a specific pipe.

- **Floodplain and Watershed Properties** – The map will show an outline of the tidegate tidal floodplain and watershed area. Review the boundaries and use the tools provided in the map to modify the floodplain and watershed boundaries if needed.

- **Culverts** – A length and material must be provided for the culvert being sized. Typically, the length will be very similar to the length of the existing culvert. The choice of pipe material is typically driven by cost and desired design life. Optionally, other tidegated pipes in the system may be accounted for by adding auxiliary culverts. Note that auxiliary culverts are not sized; rather, they allow for a more accurate solution for the primary culvert being sized.

- **Ditch Network Data** – At least one ditch section is required to define the ditch/channel network. Optionally, additional ditch sections can be added to better characterize the ditch network.

- **Tide Data** – One of the three options must be selected: Simulated tide data (default if available at your site), Manually measured tide difference, or User-defined tide timeseries. If simulated

tide data are not available then one of the other two options must be used. Detailed instructions are provided in the Tide Data section.

Once all the inputs have been entered and/or reviewed, click the Analyze button at the bottom to run the Tool. A message will appear if there are any missing required inputs.

Step 4: Results

A summary of the Tool output and results from the best-performing culvert size and invert elevation is provided on the Results page after the Tool processing is complete. Options to view detailed results and generate a PDF file of the results are provided.

4   USAGE

To access the Tidegate Pipe Sizing Tool, launch a modern web browser (e.g., Microsoft Edge) on a computer connected to the Internet and visit the Tool's web address. The Tool's Home page will be displayed. At the top of every page within the Tool, a navigation bar provides access to the Home page, the Analyze Pipe feature, Review Scenario page, and Documentation (Docs) page (Figure 1). If the options shown in Figure 1 are not displayed, then the web browser window may be too narrow to fit all the navigation links. In this case, a hamburger menu (▤) is displayed on the right side of the navigation bar. Click on the hamburger menu to reveal the complete list of navigation options.

Figure 1. Navigation bar found at the top of every page within the Tool

Four links are provided in the navigation bar for easy access to the main sections of the Tool: Home, Analyze Pipe, Review Scenario, and Docs. The Home link provides access to the home page, that also serves as the Tool landing page, providing a brief overview of the Tool and a *Get started* button at the bottom that will take you directly to the Tool's primary function: the Analyze Pipe feature. The Review Scenario page provides a way to revisit and review previous applications of the automated pipe sizing tool. The Docs page is where this user manual can be found.

4.1   Analyze Pipe

The Analyze Pipe feature is the primary function of the Tidegate Pipe Sizing Tool. Using the Tool consists of selecting a tidegate pipe, entering the required inputs, and viewing the results. The following sections walk through this process in detail, providing instructions for using the individual components.

4.1.1   Site Selection

The first step in using the Tool is to select a tidegate pipe from the Site Selection page. In the interactive map (Figure 2), use the mouse or trackpad to pan around and zoom in on the site containing the tidegate pipe you would like to analyze. The icon in the upper right corner of the map (▾) provides control over the basemap. Available basemaps include a topographic map (Esri World Topo Map, displayed by default) and satellite imagery (Esri World Imagery).

Figure 2. Site Selection page

There are two types of markers displayed on the map by default: blue map pins and gray dots. The blue map pins represent tidegate pipe locations present in the tidegate database that are valid for use with the Tool. Gray dots represent locations of known tidegate pipes that are not valid for use with the Tool (see

Purpose and Scope of Tool). These sites are displayed for reference only.

A third marker type, a red map pin, can be added to the map by clicking on an empty space where a marker does not already exist. The red map pin is used to represent a tidegate pipe not found in the Tool's database. Consider the following when adding a red map pin:

- Only one red map pin can be placed at a time; it can be moved by clicking on a new empty space on the map.

- The red map pin may not be added outside of the Tool's mapping boundaries. See

- Purpose and Scope of Tool for more information on where the Tool may be used.

- It is up to the user to select a realistic site for new tidegates given the Tool purpose and limitations. This means new tidegates should only be located on the banks of larger tidally influenced rivers, sloughs, and streams where there are no downstream tidegates. The Tool cannot detect if a tidegate marker is placed on a hilltop or other unrealistic location.

Once a map pin (either blue or red) exists for the desired tidegate pipe, click on it to proceed to the Input page.

4.1.2   Input Page

Following the Site Selection page map you will be prompted to enter your tidegate pipe properties on the Input page. The inputs are grouped into the following sections:

- Description

- Analysis Method

- Floodplain and Watershed Properties

- Culverts

- Ditch Network Data

- Tide Data.

Each section contains one or more input fields. Most input fields are required for the Tool to run. If the Tool is run with missing required values a message will be displayed next to the first missing field as a reminder that a value needs to be provided.

Some or most of the input fields may already contain values. If a blue pin was selected on the Site Selection page then all available precomputed inputs were retrieved from a database of precomputed values and filled in to their respective fields. Precomputed values should still be reviewed for accuracy and revised if better estimates are available. Instructions for revising precomputed values, along with interacting with the various types of input fields, are provided in the following sections. Except where noted, values must be provided for all fields.

If you selected the wrong tidegate marker by mistake, or would like to select a different site, you may either press the browser's Back button to go back to the Site Selection page or click the Automated Sizing navigation bar option.

The following sections provide instructions for preparing and inputting the information for each section of the Input page. After reviewing and providing necessary inputs, click the Find My Pipe button at the bottom of the page to run the Tool and advance to the next page.

4.1.2.1 Description

Input field type(s):
• text box

The Description section contains a single text box for a location name (Figure 3). The location name is used to more easily reference the site during later stages of review and permitting. Therefore, try to use a descriptive name specific to the site.

Figure 3. **Description location name input text box**

4.1.2.2 Analysis Method

Input field type(s):
• radio button
If using Manual method:
• numerical slider/value input
• checkbox

You can use the Tool in one of two ways as defined in the Analysis Method section. The Automated method is the default (and recommended) option and provides the functionality the Tool was originally created for which is to automatically size a tidegate pipe for a given site. The Manual method is an additional option that allows you to analyze the performance of a single, specific tidegate pipe configuration.

Automated

The Automated analysis method is the recommended method for using the Tool. This approach evaluates dozens of possible pipe configurations for the provided site conditions, ranks the performance of each based on an assigned score, and reports the configuration with the best performance. The scoring criteria includes both fish passage (e.g., percent of the time the tidegate is open) and economic considerations. Figure 4 shows the Automated method selected in the Tool. Note that no additional inputs are required when selecting this option.

Figure 4. Automated analysis method

Manual

The Manual analysis method is provided for those who wish to analyze the performance of a specific tidegate pipe configuration instead of having the Tool automatically size a pipe. This feature is not the primary intent of the Tool but is included to allow users more advanced options and control over the analysis.

The Manual analysis option is selected in Figure 5, which also shows the additional required and optional inputs that appear upon selecting the associated radio button. The required inputs include the two pipe properties that are otherwise automatically sized when using the Automated method (diameter and invert elevation). To enter a value, either use the slider by clicking and dragging on the round "knob" or enter the desired value into the input box. It is the users responsibility to enter realistic values.

Figure 5. Manual pipe analysis method with additional required inputs

Optionally, you may choose to add a tidal mitigator on the culvert by checking the "Use tidal mitigator" checkbox. A tidal mitigator is a device that hold the tidegate open for some time to allow a rising tide to flow in reverse up through the culvert. The most common version in Oregon is the Muted Tidal Regulator manufactured by Nehalem Marine Mfg., Inc. If you select this option, you must provide a set point (tidal mitigator water level) to define the landside water level that must be reached before the tidegate is allowed to close. Again, it is the users responsibility to select a realistic value. The default value of 0 ft NAVD 88 will be used as the set point unless it is changed.

IMPORTANT
You cannot revisit Tool inputs or results later if you used the Manual method like you can with the Automated method (via the Review Scenario feature). Any results will need to be recreated by repopulating all inputs on the Input page and rerunning the Tool. If you believe you might rerun the Tool for the same site, consider first running with the Automated method to generate a Scenario ID that you can use later to revisit the same site conditions using the Review Scenario feature. Refer to the Review Scenario section for more information on revisiting scenarios to modify inputs.

4.1.2.3 Floodplain and Watershed Properties

Input field type(s):
• interactive map
• numerical field
• override checkbox
If using the optional additional baseline flow feature:
• numerical slider/value input

The Floodplain and Watershed Properties section consists of an interactive map and several numerical input fields underneath. The map shows the selected tidegate and any available mapped site features from the precomputed inputs database (e.g., tidegate watershed). The floodplain and watershed inputs below the map will automatically be calculated and filled in when those polygons exist (either when they are provided for you or after you create them). There is also an option to manually enter or override the values if desired. Details on how to edit both map features and numerical fields below the map are provided below. A final input field at the end of the section allows for the addition of a constant baseflow to the system.

Using the interactive map

The primary function of the interactive map is to provide a built-in method to delineate, or outline, the tidegated system's contributing watershed and tidal floodplain. The watershed should contain all the land, including uplands and the floodplain, that drains to your tidegated system. The tidal floodplain is the part of the watershed that is generally flat, protected by levees, and would flood if the tidegate was not functioning correctly.

While these two outlines (referred to as polygons) are not strictly necessary, having them can greatly simplify the process of providing the related required inputs below the map since those values are automatically computed based on how the areas are delineated. Any time the polygons are modified, either when creating new polygons or editing existing, the related values below the map are recomputed. The ditch network associated with the site might also be shown in the map (black lines). All ditch network lines are displayed for reference only and may not be modified within the map. An example interactive map is shown in Figure 6 with labels annotating the various map components.
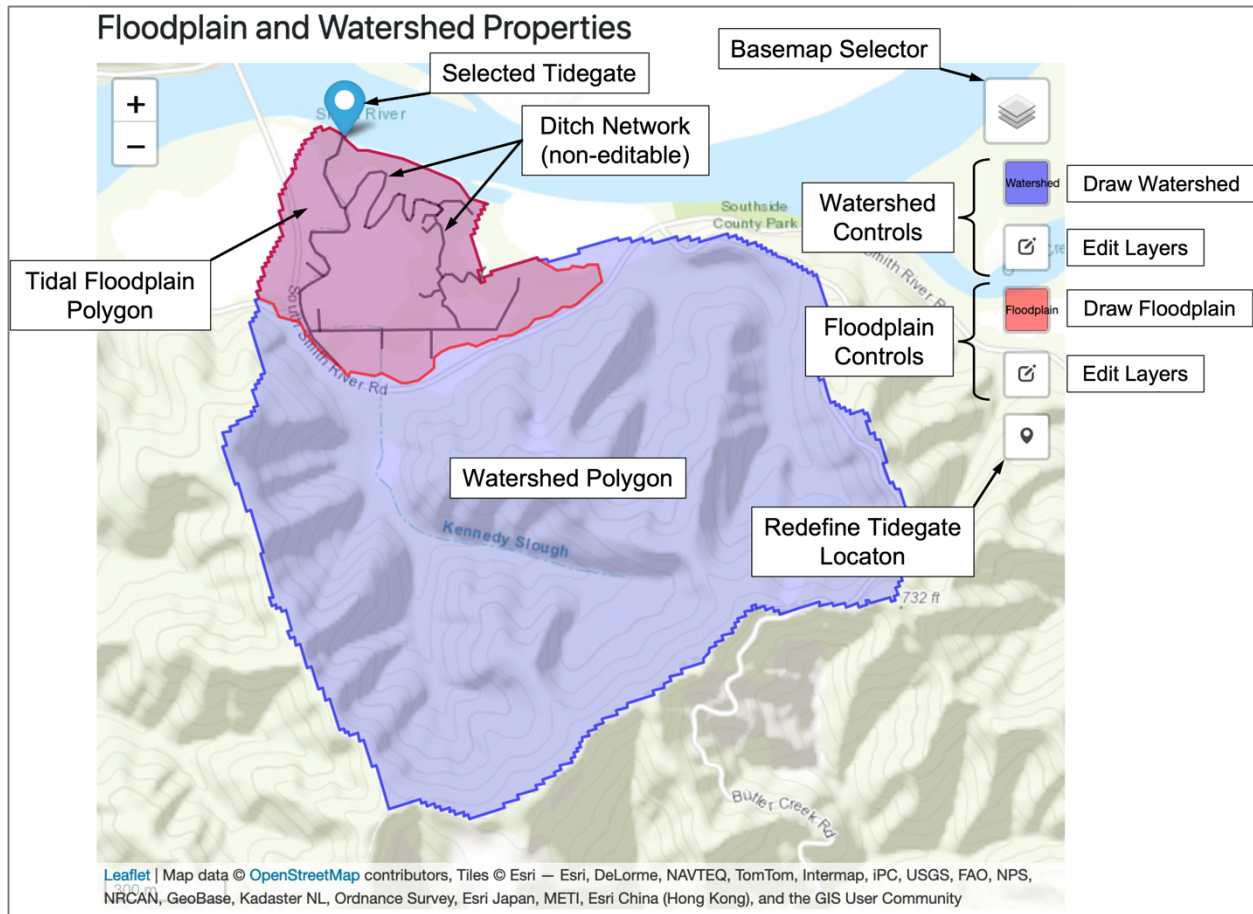
Figure 6. Floodplain and Watershed Properties interactive map

This interactive map has all the same basic functionality as the Site Selection page map. You can pan around and zoom using the mouse and change the displayed basemap (topographic or aerial imagery) by clicking the basemap selector icon at the top right of the map window.

Additional functionality in this map allows you to create and/or edit the tidal floodplain and watershed polygons. If one or both polygons have been precomputed they will automatically be displayed, the watershed polygon with a blue hue and the floodplain polygon with a red hue. The tools along the right edge of the map allow you to either create a new or edit an existing polygon.

Create new watershed polygon

To create a new watershed polygon click on the button labeled Draw Watershed in Figure 6. Polygon editing options will appear to *Finish*, *Delete last point*, and *Cancel*, and you will be prompted to "Click to start drawing shape." Considering principles of [manual watershed delineation](https://en.wikipedia.org/wiki/Watershed_delineation)[1], begin clicking to create the boundary of the new watershed polygon. The topographic basemap (Esri World Topo Map) is recommended for watershed delineation, though it may be helpful to toggle back and forth between

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[1] https://en.wikipedia.org/wiki/Watershed_delineation

the topographic and aerial imagery. This can be done at any time while creating or editing polygons by clicking on the basemap selector icon (⌄) and selecting a different basemap.

Each time you click on the map a new point, or vertex, will be added to the polygon boundary. You can still pan around and zoom using the mouse and scroll wheel, however, if you click and hold the mouse button to pan, a new point will be added to the polygon. You can simply delete that point or any most recently added point by clicking the *Delete last point* button from the polygon editing options. Note that you may not move any points created in this editing session. You are only allowed to delete the last point. If you would like to move points you must first end this polygon creation session and use the Edit Layers tool discussed below.

Once you have finished delineating the watershed you can either complete or delete the polygon. To complete the polygon, either click *Finish* from the polygon editing options or single-click on the first point you added. If you would like to end the editing session and delete the polygon, click *Cancel*. Note that clicking *Cancel* will discard all your changes. Once the polygon is created, the associated input values below the map will automatically be calculated and filled in. To make changes to an existing watershed, which will update the related input values, use the button labeled Edit Layers in Figure 6. The following section details the use of the polygon editing feature.

Edit existing watershed polygon

To edit an existing watershed polygon click the button labeled Edit Layers in Figure 6. Polygon editing options will appear next to the button allowing you to either *Save* or *Cancel* changes made during the current editing session. Instructions will also appear next to the cursor with a reminder for how to edit the polygon: "Click cancel to undo changes. Drag handles, or marker to edit feature." Handles refer to the points along the perimeter of the polygon, the same points that were added if a new watershed polygon was created.

The same basic map features are still available while editing the watershed, e.g., you can pan around and zoom, in addition to now being able to move, add, or delete polygon points. To move a point, simply click and drag the point. To add or delete points you will need to distinguish between the two different square point markers: solid white and transparent white. The two types are shown in Figure 7. The transparent white points are not yet actual points but indicate locations where you may add new (solid white) points. They are only found along straight edges since they are not actual points and cannot define bends in the watershed boundary.
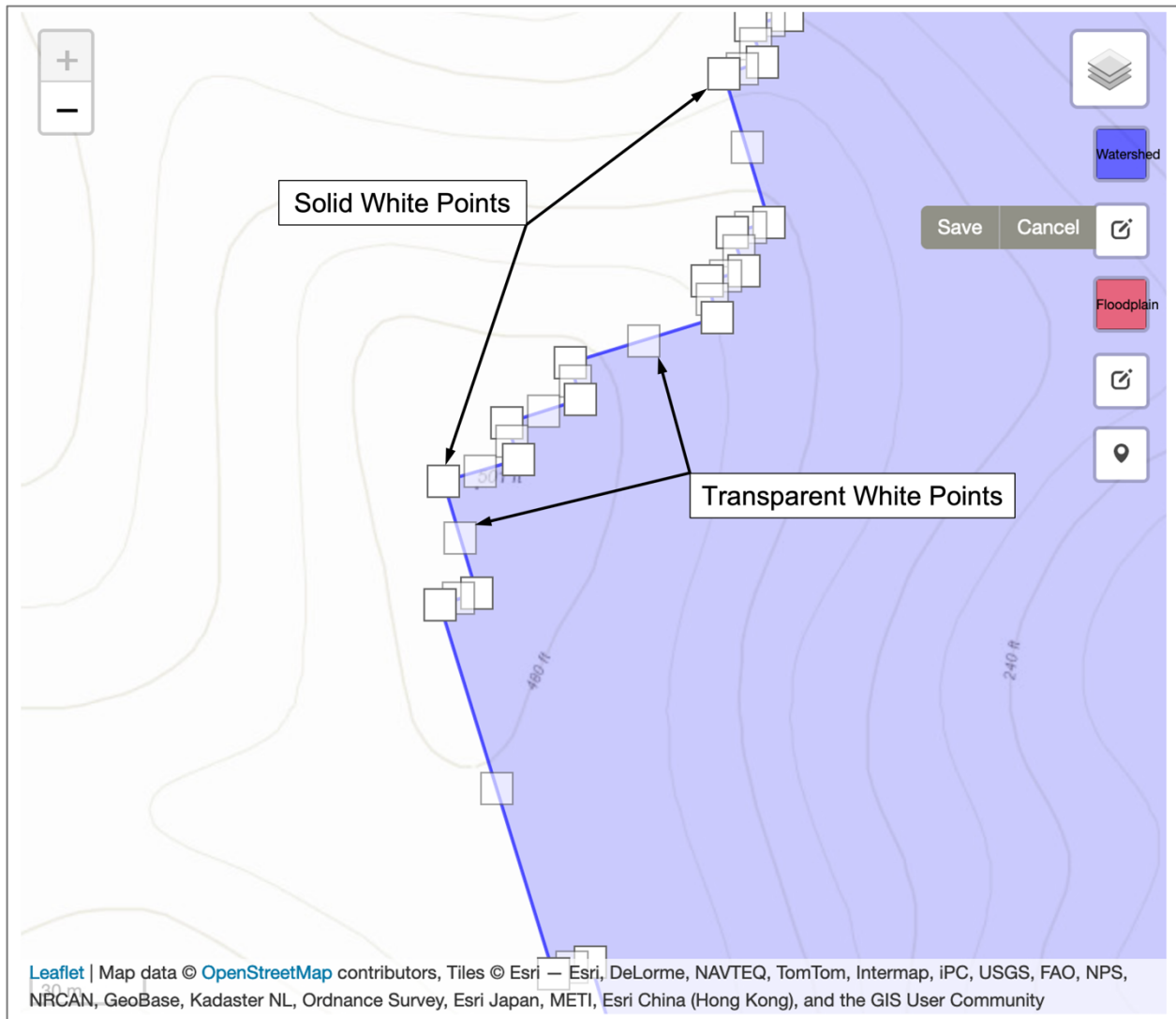
Figure 7. Solid and transparent white polygon points when editing an existing polygon

To add a point, click on (or click and drag) a transparent white point to convert it to a solid white point. When you do, two new transparent white points will be added to the polygon boundary, one on each side of the now-solid point.

To move points, and edit the watershed definition, click and drag either type of point and release the mouse at the desired location. Moving transparent white points will turn them solid white and create a new point.

To delete points, single-click on a solid white point. Transparent white points cannot be deleted since they are not yet real points. Plus, they necessarily do not define bends in the boundary, so removing them would not affect the watershed definition.

To exit the watershed editing session, click *Save* when you are finished editing or *Cancel* if you would like to undo and discard all changes made during this session.

Creating and editing floodplain polygon

The tools for creating and modifying a floodplain polygon are identical to the watershed polygon. Simply use the tools labeled Floodplain Controls in Figure 6 instead of Watershed Controls. For a new floodplain polygon, select the tool labeled Draw Floodplain and begin adding points to define the boundary. The floodplain polygon should encompass the tidal floodplain within the watershed polygon. Where the two polygons share a border at the downstream end of the watershed polygon try to follow the watershed boundary as you add points. While they physically share the same exact boundary at the downstream section, it is not critical that the two mapped polygon boundaries exactly align. Try to keep them reasonably close. To edit a floodplain polygon, refer to the guidance in the previous section for using the Watershed Controls Edit Layers tools (Figure 6) applying those methods with the Floodplain Controls instead.

Note about saving polygons
Polygons themselves cannot be saved or downloaded, and revisions made to existing polygons will not affect the polygons in the Precomputed Inputs Database. The only way to revisit your new or modified polygon is by using the Review Scenario feature and the Scenario ID generated when the Tool is run using the Automated analysis method. As long as the Scenario ID remains valid, you may enter it into the Review Scenario page and access the polygons used in that Scenario. Refer to the Review Scenario section for more information about reviewing previously run scenarios.

IMPORTANT
To help prevent loss of modifications to polygons or other input fields, do not close or refresh the browser or otherwise navigate away from the Input page before clicking the *Analyze* button at the bottom of the page.

Redefine tidegate marker location

If desired, you may reposition the tidegate marker (map pin) by selecting the map tool labeled Redefine Tidegate Location in Figure 6. You will be prompted to "Click map to place marker." Clicking the map will move the pin to the new location. Note that the only time this feature should be used is to refine the map pin's location for the tidegate intended to be analyzed, i.e., the one selected on the Site Selection page. If you would like to run the Tool for a different tidegate pipe altogether, use the web browser's back button or click Analyze Pipe from the navigation bar to return to the Site Selection page and start over by choosing a different tidegate pipe. This will ensure that all available and correct precomputed inputs are automatically populated on the Input page.

Input fields below the map

All the values in the input fields below the map (shown in Figure 8) should be automatically calculated and populated if both a floodplain and watershed polygon exist, but you may also override the values and manually enter your own. Since the only purpose of the polygons is to derive these values, you may wish to *not* delineate the watershed and/or floodplain if they do not already exist and instead supply the values directly in the input fields. The override checkboxes next to each field allow you to manually enter values. Instructions on how to obtain these values outside of the interactive map are not provided in this user manual.

Figure 8. Floodplain and Watershed Properties input fields below interactive map

The last row of this section displays the constant average inflow calculated by the Tool based on these inputs. This value will be used as a constant inflow into the tidegated system when the Tool is run, representing hydrologic inputs (e.g., hillside drainage). If you believe the calculated value is not representative of the site, you may override one, or some, of the values in the input fields. **Note that the floodplain elevation is also used in the Ditch Network Data section, so you should use care and understand the implications if you decide to override this value.**

Note on overriding values
If you modify a polygon in the map (either floodplain or watershed), any values that are computed based on that polygon will be automatically updated, regardless of if the override checkboxes are checked. Any overridden values will be updated based on the new polygon geometry and you will lose your updates. You will need to recheck and reinput your values if you do not want to use the updated value(s). You may also manually uncheck override checkboxes yourself at any point to revert the fields to the last automatically calculated value.

Additional baseline flow

The last field in this section provides an optional means to account for additional flow into the tidegated system (Figure 9). This field is disabled by default but may be enabled by checking the override checkbox and entering a positive value. One of the more common examples of its use includes accounting for groundwater seepage underneath the dike from the river to the interior side. Determining an appropriate value for the selected tidegate site, or if a value should even be used at all, can be a complex process and is not described here.

Figure 9. Additional baseline flow optional input field

If used, this value is added to the estimated hillside drainage to increase the overall steady inflow into the diked interior area. To enter a value, click the override checkbox to enable the field and either use the slider by clicking and dragging on the round "knob" or enter the desired value into the input box.

4.1.2.4 Culverts

The culvert properties section (shown in Figure 10) can be divided into two parts: the primary culvert section, which is a required input, and the auxiliary culverts input section.

Figure 10. Culvert properties section on Input page

Primary Culvert

The primary culvert represents either the single tidegate pipe that will be automatically sized or the specific pipe configuration to be analyzed, depending on the selected Analysis Method. You are required to provide a pipe length and material. If using the Automated analysis method, the size (diameter) and

invert elevation for the best-performing configuration will be provided after the Tool run is complete. If using the Manual analysis method, the length and material entered in this section is used in conjunction with the pipe properties entered in the Analysis Method section to define the specific pipe configuration to be analyzed.

If other tidegated pipes exist on the same interconnected ditch network, it is recommended to provide their information to the Tool by adding auxiliary culverts, discussed in the following section.

Auxiliary Culverts

Auxiliary culverts allow other tidegated pipes on the same ditch network system as the primary culvert to be accounted for by the Tool to help improve its accuracy. Two common occurrences include multiple pipes drain the same channel and two culverts in the river or bay levee that are separated by some distance but are connected via the interior ditch network. If other outlets in the ditch network exist, and the Tool is unaware of them, then a less accurate, and possibly unnecessarily more expensive, solution may be provided by the automated sizing function. For example, preference may be given to a larger pipe size if the Tool expects that the culvert to be sized is the only outlet to drain the flow into the tidegated system. A similar negative effect could exist when using the Manual analysis method, e.g., the reported velocities could be unrealistically large.

Any number of auxiliary culverts may be added. Some auxiliary culverts may already be present if multiple tidegated pipes exist in the Precomputed Inputs Database. As with all other precomputed inputs, review the provided inputs and make any necessary changes as needed.

To add an auxiliary culvert card, fill in the four required input fields—length, diameter, material, and invert elevation—and click the *Add culvert* button. Unlike the primary culvert, a diameter and invert elevation are required for each auxiliary culvert since the Tool will not automatically size any auxiliary culvert.

To delete an auxiliary culvert card, click the *Delete* button on the card.

There is no way to edit auxiliary culvert properties once the card is added. Instead, you must recreate the card with the desired revisions. First, make note of any properties you would like to keep. Then, click the *Delete* button on the card you wish to update, reenter the correct auxiliary culvert properties in the input fields on a new card, and click *Add culvert*. The order of auxiliary culvert cards does not affect the Tool, so they may be added in any order.

4.1.2.5 Ditch Network Data

Input field type(s):
• radio button
• numerical field
• add/delete cards

The ditch network serves as the primary means of water storage in the tidegate system interior. The ditch network includes all constructed ditches and natural channels on the tidal floodplain that are part

of the active drainage system, meaning they regularly fill and drain during the normal tidegate system function. When the tidegate is closed, the ditch network fills from the continued inflow, e.g., hillside drainage, and the water level in the ditch network rises. The stored water can then drain when the tidegate is open. Having an accurate estimate of the total available storage within the ditch network will allow the Tool to properly size a tidegate pipe that will, in part, minimize the risk of the ditch network overtopping and spilling out onto the surrounding land.

The ditch network section, shown in Figure 11, allows key properties of the interconnected ditch and channel network to be provided so the Tool can represent the available storage. The three properties the Tool uses to describe ditches within the ditch network are: length, average top width (i.e., bank-full width), and side slope. The Tool also uses the floodplain elevation defined in the Floodplain and Watershed Properties section as a representative top of bank for all ditch sections. Any number of segments, or ditch sections, can be provided to represent the available storage more accurately in the system. In fact, it is recommended that you break up the ditch network at significant changes in either the average top width or side slope to help the Tool provide a better solution.

Figure 11. Culvert properties section on Input page

Measuring your ditch network

There are multiple methods to prepare your ditch network properties. A recommended approach is to start by determining the total length of the network. This can be done manually by measuring the ditches. If you prefer a digital approach, you can use the aerial images and measurement tools included with many widely available online mapping services (e.g., Google Maps[2]). Identify active ditch sections in the aerial imagery and measure the segments with the provided measurement tools. Whether you

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[2] The developers and maintainers of the Tidegate Pipe Sizing Tool have no affiliation with Google products nor do they endorse their products. Google Maps is suggested as an example of current, widely available free mapping services that allow the described types of ditch network measurements to be obtained.

use a manual or digital approach, it is helpful to sketch out the ditch network as you collect the measurements and record individual segment properties as you go.

Estimate an average top width, or bank-full width, and an average side slope for each significant change in width and/or side slope. It may save time to do this while you measure the total ditch network length, but it may be easier to separate this step and do it after gathering the total length measurements so you can better assess the network as a whole and identify where significant changes in the width or side slope exist. When noting significant changes in width and/or side slope, take measurements that are representative of the ditch segments on both sides of the change. For wide ditches this may require the assistance of another person to reach a measuring tape or rope across the ditch. Side slopes should be recorded using a run:rise format and simplified to have a unit run, i.e., run = 1. For example, if you estimate that for every 2 feet in the horizontal (i.e., run) the side of the ditch rises 4 feet, the side slope would be 2 feet run to 4 feet rise, which simplifies to an equivalent side slope of 1:2. The side slope rise, 2 in this example, is what will be entered for the associated ditch section. Note that both width and side slope values can be measured to the whole number. Measuring down to tenths or hundredths of feet has shown to have negligible impacts on the Tool's performance. If you have any concerns about how your measurements or grouping of ditch sections affects the solution you can always run the Tool multiple times using different approaches and see how the solution changes, if at all.

Once you have recorded your ditch network properties, prepare the information to be entered into the Tool. The best way to do this is to group ditch sections that have the same width and side slopes, what is called a ditch type here, and add the lengths within each of these groups to get a subtotal length for each ditch type. If your entire ditch network has a consistent width and side slope throughout then you would only have a single group. The Tool only needs the total length for each type. You should, however, note the ditch type that is connected to the primary tidegate pipe as this will be used when entering the ditch network properties into the Tool as discussed in the next section.

Entering and modifying your ditch network properties

In the ditch network section, you will add a new ditch section card for each unique ditch type you prepared. You may see that some ditch sections cards have already been prepared. Compare your calculated ditch types to any precomputed cards. You may choose to keep some or all of them or remove any that you would like to refine by adding your own.

To enter new ditch sections, fill in the length, average top width, and side slope values in the "Add ditch section" area located below any already entered ditch section cards and click the *Add ditch section* button. That ditch type will be added to the collection of ditch section cards. Repeat this process for any remaining ditch types. If you need to make changes to any ditch section cards already entered, first note the values for that ditch section, click the *Delete* button on that section card, and re-enter the properties as a new ditch section. The ditch sections can be in any order, so there is no need to attempt to delete and re-add sections in a specific order. The only critical ditch section property related to the actual ditch network layout is the type of ditch connected to the selected tidegate pipe. For the ditch section card representing that ditch type, click the *At Design Culvert* button on that card. The button will turn blue indicating that that card represents the ditch type connected to the primary tidegate pipe.

If prepopulated ditch section cards exist, review the values, and make any necessary changes (i.e., delete and add new cards). The precomputed ditch property values used to create the ditch sections are

based on length and width estimates derived from coast-wide aerial imagery and elevation data (LiDAR). Side slopes are set to a default value of 1:2. While significant effort was made to estimate these values and bin the ditch types into reasonable ditch section cards, there is an inherent limitation to describing the ditch network based on remote measurements (imagery and LiDAR) compared to field-verified measurements and knowledge about the site, e.g., if additional ditches were added more recently than the remote measurements were taken. Due to the automated methods used to estimate ditch widths and group them, it is unlikely that the grouping and widths will match what a user would come up with manually. However, the total length of all pre-populated ditches should match the total length measured manually, and the average widths should fall between the maximum and minimum widths manually measured.

Tip for working with prepopulated ditch section cards
When reviewing prepopulated ditch section cards, it may help to reference the ditch network linework shown in the Floodplain and Watershed Properties interactive map (Figure 6) from which the precomputed ditch properties were estimated. Again, the ditch lines are not editable in the map, but they may serve as a valuable reference if, for instance, linework is missing for a portion of the ditch network you know to exist. In this case the prepopulated ditch section cards would underestimate the total capacity of the ditch network.

4.1.2.6 Tide Data

Input field type(s):
• radio button • checkbox
If providing manually measured tide difference: • override checkbox • dropdown menu • date selector • numerical slider/value input
If providing user-defined tide timeseries: • file upload

The Tool uses the data in this section to define the tides on the river or bay on the outside of the tidegate. There are up to three options for providing this information: simulated tide data, manually measured tide difference, and user-defined tide timeseries (Figure 12). If precomputed simulated tide data are available at your tidegate site, the simulated tide data option will be automatically selected, and a message will be displayed below indicating that tide data are available.

Figure 12. Tide Data section when precomputed simulated tide data are available for the selected tidegate

Otherwise, that option will be grayed out as shown in Figure 13, and the second option, manually measured tide difference, will be automatically selected by default. The third option, user-defined tide timeseries, can be selected if you have your own tide timeseries data and would like to use that.

Figure 13. Tide Data section when precomputed simulated tide data are *not* available for the selected tidegate

There is also the option, shown in Figure 12 and Figure 13, to account for future sea-level rise in the Tool. If checked, an additional 1 foot is added to the tide timeseries.

Simulated tide data

The precomputed simulated tide data are considered to be more accurate than the manually measured tide difference method and avoids the time and effort required for the manual method. The simulated tide data should generally be used if the option is available for the selected tidegate. These data are based on results from available hydraulic models, so not every tidegate has this option. If the simulated tide data option is used, no additional inputs are required for this section. If you choose the manually measured tide difference option, you are required to provide additional inputs that are discussed in the following section.

Manually measured tide difference

The manually measured tide difference option allows for the representation of typical tides at the selected tidegate from a minimal number of inputs. In fact, as shown in Figure 13, only three inputs are required: the reference tide station, the measured tide difference, and the date measured. The first input, the reference tide station, is automatically selected for you based on the selected tidegate's proximity to available NOAA tide reference stations. The measured difference and date are the two values you must obtain and provide.

The measured tide difference is the vertical distance between the lowest and the highest water level at the selected tidegate site on any single day where normal river and weather conditions exist. It is important to avoid taking this measurement during times that the tides may be affected by significant weather events (e.g., extended or intense rainfall, flooding, high winds, or notably low-pressure systems). It may be helpful to reference a weather forecast and tide tables to plan a day with relatively normal conditions and identify the times of day when the lower low and higher high tides will occur. Additionally, it may make the process easier to select a day during which the higher high tide occurs before the lower low tide. The instructions below will make this more apparent, but it helps ensure that both markers used to indicate the highest and lowest stage remain exposed (i.e., not underwater) and visible while taking the required measurement.

The process can be broken down into three steps: prepare your equipment, mark the higher high and lower low tides, and take the measurement. These steps are described below.

Step 1: Prepare equipment

Prepare equipment in advance to measure the vertical distance between two points that may be several or tens of feet apart. A simple piece of land surveying equipment, an autolevel (along with a tripod and level rod), is ideal for this type of measurement, but there are plenty of techniques you can use that do not require specialized equipment. Simple tools like a couple of long wooden dowels or even straight sticks (here called a staff), string, a carpenter's level, and a tape measure can be used to measure a vertical distance.

Step 2: Mark the higher high and lower low tides

To collect the measured tide difference, start by placing markers at the highest and lowest river stage during the respective higher high and lower low tides on the single day you take the measurement. During the higher high tide, mark the edge of the water by securing a painted rock, or other identifiable marker that is relatively stable, so the top of the marker is level with the surface. Observe the marker for several minutes, and if the water level was still rising, adjust the marker accordingly to ensure the top of the marker is at the higher high tide.

If there is a nearby concrete structure or piling you can also place a mark at the water surface instead of using a stone. This may be helpful in areas with steep banks. Another option is to drive a piece of rebar into the ground and mark the water level on the rebar, e.g., with some tape wrapped around it.

After you mark the highest stage, wait until the expected lower low tide, and use a similar method to mark the lowest stage.

Step 3: Measure the vertical distance

While the river stage is still at the lowest point, measure the vertical distance between the two markers. In an ideal case, there is a single vertical structure on which you marked the water level during the higher high and the lower low tides and you can simply measure the distance between the two markers with a tape measure. Various smartphone applications also provide measurement tools using their cameras that can be used. This scenario will not be available in many cases, so you may need a few more tools and the help of a second person.

One possible approach is to rest a staff vertically on each marker, tie a string taught between the two staffs, position the string horizontal using a long carpenter's level, and measure the distance from the string to the bottom of both staffs where they rested on the two water level markers. Subtracting the smaller length from the larger length will give the vertical distance between the two markers.

However you measure the vertical distance between the highest and lowest river stage, enter that value as the tide measured difference, along with the date on which the measurement was taken, into the appropriate input fields. Note that you may need to check the override checkbox if any of the fields are grayed out and inactive. Input the date either by clicking on the date numbers and entering the date in MM/DD/YYYY format or by clicking on the calendar icon on the right side of the input field and selecting the date from the small popup calendar. To enter the tide measured difference either use the slider by clicking and dragging or enter the number in the value input box.

User-defined tide timeseries

The last option for providing tide data is to upload a file containing a stage timeseries. This option is useful when local water level datalogger data during normal hydrometeorological conditions are available. The data file must be formatted so the Tool can read it. An example file can be downloaded by clicking on the link in the text shown in Figure 14. Use the formatting in the example file as a guide to format your own file.

Figure 14. Tide Data section using the user-defined tide timeseries option

The user-defined file should contain 3 weeks of data using a consistent interval. A 15-minute or shorter interval is recommended to ensure the full tide signature is captured. The Tool will linearly interpolate any missing data points. The first of the 3 weeks of data is used in the model spinup, so you will only see

results during the last 2 weeks of the provided period. <u>The data must be provided in NAVD 88 vertical datum.</u>

Once the timeseries file is prepared, click the *Browse* button, and use the dialogue that appears to search for and select the file. No additional inputs are needed.

4.1.3 Processing Page

After clicking the *Analyze* button at the bottom of the Input page the Tool will begin running and you will be automatically redirected to the Processing page (Figure 15). The page will display your position in the Tool's queue along with a progress bar indicating the Tool's progress for your run in percent complete. If you are not already in queue position 1 you will be automatically advanced to the first position as other previously initiated runs complete. When you are at position 1 the Tool typically takes a couple of minutes to complete, after which time you will be automatically redirected to the Output Page to review the results.
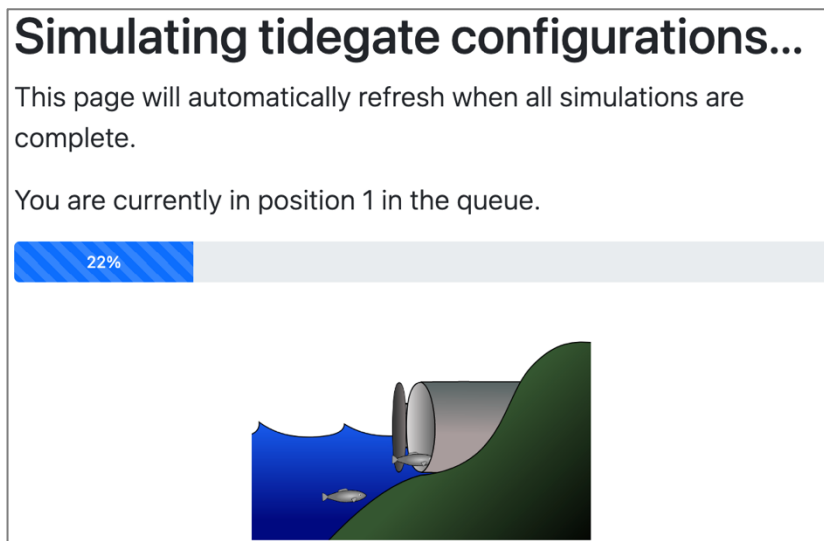

Figure 15. Processing page showing position in the run queue and progress bar

Please note that the Tool may take longer to run at times. If the progress bar takes a while to begin or is advancing slowly, please wait patiently. Unless you receive a message indicating otherwise, the Tool will run as expected. Note that refreshing the web page or relaunching the Tool will not speed up the processing but will instead likely delay or interrupt the processing of your results.

Tip if using the Automated analysis method
If you are using the Automated analysis method and your session is interrupted for any reason, or you simply cannot wait for the processing to complete, you may retrieve the Scenario ID embedded in the long string of text in the browser's address bar (URL) and revisit your scenario at a later time. To do this, copy the string of text following "scen_id=" in the URL. This is the Scenario ID. Save the Scenario ID somewhere where you can enter it into the Review Scenario page when you want to revisit your inputs and results. Note that the results are saved for a limited amount of time and will eventually expire. You can, however, always revisit the inputs from the Review Scenario page (using your Scenario ID) and regenerate the results.

4.1.4 Results Page — Automated Analysis Method

The Results page will have one of two layouts depending on the chosen analysis method (see Analysis Method). The Automated analysis method will produce the results page shown in Figure 16. The Manual analysis method results page is discussed in the next section.

Figure 16. Example Automated analysis method Results page contents

The Automated analysis method Results page contains a summary of the Tool's solution for a given scenario along with buttons to review more detailed results and generate a scenario PDF report that can be saved to your computer. The blue shaded region at the top relates to the scenario run selected as the best-performing tidegate configuration, i.e., the Tool solution. The gray shaded region provides a means to access all scenario runs.

4.1.4.1 Tool Solution Information

The Tool solution information consists of a summary of the results for the best-performing tidegate configuration for the given site conditions. The culvert size and invert elevation that the Tool selected is shown at the top. Below that, summary information for the selected tidegate pipe's performance is provided and include categories related to fish passage regulatory requirements and interior flooding. Descriptions of each category are provided in Table 2. Generally, larger gate open time percentages and flow depths and smaller flow velocity values are better from a fish passage perspective.

Table 2. Tool solution run results summary categories

Category	Description
Gate open time	Lists the percentage of the total 2-week simulation that the tidegate was open
Flow velocity criterion	Represents the velocity in the culvert that was exceeded 10% of the time that the tidegate was open during the simulation
Flow depth criterion	Represents the depth through the culvert (the minimum depth if more than one was found through the culvert at a given point in time) that was exceeded 90% of the time the tidegate was open during the simulation
Water stays in ditch?	(Yes or No) Indicates whether interior flooding was avoided—i.e., Yes, the ditch network contained the stored water—or if the simulated water level spilled over onto the surrounding floodplain—i.e., No, the ditch network capacity was exceeded

Two buttons in the solution run information section proved options for accessing more details about the solution and saving the scenario in PDF format. The *View detailed results* button provides detailed information for the best-performing tidegate configuration. This is the same content as is provided in the Manual analysis method results page. Refer to the Results Page — Manual Analysis section below for more information.

The *Generate PDF report* button will produce a PDF file containing a summary of the scenario and the best-performing tidegate pipe configuration, a complete listing of all Tool inputs for the scenario, and detailed output of selected results. The PDF file will open in your current browser window where you will have the opportunity to review it in the browser and download the PDF file for later use. Refer to your browser-specific help guidance for assistance downloading PDF files from within your browser.

4.1.4.2   Scenario Information

The information related to the scenario, consisting of all the individual tidegate configuration runs, contains a Scenario ID and a button to access summary results for all runs. The Scenario ID can be used to return to the scenario inputs and results later via the Review Scenario page. The Scenario ID is also included in the report if you choose to create and save that PDF file for reference.

The *View results for all scenario runs* button provides access to an overview of the performance of all scenario runs. An example of the results for all scenario runs is shown in Figure 17. A series of tables shows how each combination of culvert size (table rows) and invert elevation (table columns) combinations performed for a select number of metrics. The results are color coded, with green indicating that combination fully meets the ODFW fish passage metric, yellow indicating the combination does not quite meet the metric, and red indicating poor fish passage performance. Note that red does not indicate a "Fail" state. It is expected there will be numerous cases where it will not be possible for any replacement tidegate to meet some or all of the ODFW fish passage requirements. The color coding serves only as a visual aid; the Tool in automated mode will always select the best possible fish passage combination even if all options are colored red.

The first three tables provide performance results for the fish passage metrics summarized on the Results page: gate open time, flow velocity, and flow depth. The same values for each metric found on the Results page for the best-performing configuration are present in these tables at the intersection of

the row corresponding to the diameter and the column corresponding to the invert elevation for the identified configuration.

Figure 17. Summary results for all scenario runs available by clicking the *View results for all scenario runs* button on the Automated analysis results page

The fourth table presents the percentage of time the culvert was perched while the tidegate was open during the 2-week simulation. For the purposes of this metric, the pipe is considered perched if the river/bay side water level is more than 0.5 feet below the culvert invert elevation. As can be seen in the example table in Figure 17 this value has a direct correlation with the invert elevation, and in general, a smaller number creates more fish passage opportunity.

The fifth and final table presents a combined metric, or score, that can be used to compare the individual performance components—including fish passage and economic considerations—from all the configurations to one another and select the best-performing configuration. In general, the larger the number the better. All values within 10% of the largest value or boldfaced in the table. Of the boldfaced values, the Tool selects the configuration at the highest invert elevation that uses the smallest pipe size. This results in selecting the lowest cost and easiest to replace pipe that still provides close to the best

fish passage option. This value—0.44 (for a 3 ft diameter pipe at -1 ft invert elevation) in the example shown in Figure 17—is colored blue.

4.1.5 Results Page — Manual Analysis Method

The Manual Analysis Method Results page gives detailed information for the results of a single tidegate pipe configuration. A summary is provided at the top—including the tidegate pipe size and invert elevation and key performance metrics—followed by input run parameters and plots of significant statistics and selected variable timeseries. Tabulated timeseries data are also provided at the bottom. These data can be downloaded by clicking the *Download as CSV* (comma-separated value text file) button.

The key performance metrics in the summary at the top include gate open time, flow velocity and depth, and score. Refer to Table 2 for details on how gate open time and flow velocity and depth are defined.

The run parameters section lists the parameters and their values that were used in the simulation. They include both user inputs and internally referenced values.

The remainder of the Results page contains interactive plots and tables of key model information. More details and instructions on how to use the interactive plots are provided in the following sections.

4.1.5.1 Plots

All the plots on the Results page are interactive, meaning that you can zoom, pan, and hover over traces within each plot to explore the data. All the plots are created using the Plotly plotting library (Plotly Technologies Inc., 2015). Refer to the Plotly <u>Zoom, Pan, and Hover Controls guide</u>[3] for complete instructions for interacting with the plots.

Duration plots

The first few plots present duration curves associated with the three key metrics in the summary information at the top of the page. The metric values can be read from their respective depth-duration, velocity-duration, and tidegate-state–duration plots. Target thresholds for each metric from state and federal fish passage regulatory guidance are indicated by red dashed horizontal lines.

Duration plots are useful for characterizing timeseries, showing for example, the percent of the time while the tidegate was open during the 2-week simulation that the flow velocity was at or below the target velocity threshold of 1 ft/s. The depth-duration plot analyzes the flow depth through the culvert over the same gate-open period. Conversely, the tidegate-state–duration plot shows the percent of the time of the *entire* 2-week simulation that the gate was in the open and closed positions.

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[3] https://plotly.com/chart-studio-help/zoom-pan-hover-controls/

Performance timeseries

The remaining plots present timeseries of some of the most important performance metrics from the Tool run. All plots share a common datetime axis, displayed on the bottom-most plot. The x-axis labels update when panning and zooming in any of the state variable plots, and all other plots adjust accordingly to sync to the common x-axis. Examples of the provided state variable timeseries include the water levels on both sides of the tidegate, maximum velocity through the culvert, and storage volume in the interior of the tidegate system.
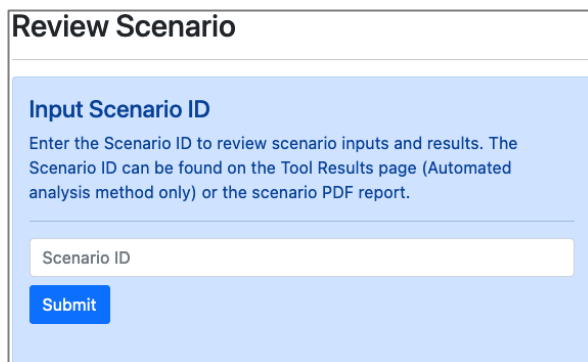
4.1.5.2 Tables

The tables at the bottom of the page present some of the same state variable timeseries shown in the plots above but in tabular form. These data are provided for convenience if you wish to use them in your own separate analysis. Use the *Download as CSV* button to download the data in a plain text CSV format.

4.2   Review Scenario

The Review Scenario page provides a means to review inputs and results for scenarios that have been previously run. Tool scenarios are specific to the Automated analysis method and consist of several runs, one run for each combination of pipe size and invert elevation, for a unique set of inputs. If two sets of otherwise identical inputs for the same tidegate location have even a single different input value, e.g., a different design culvert material, then these are considered two different scenarios and each will have a unique Scenario ID.

You can use the Scenario ID to revisit the inputs specific to that scenario or to review the scenario results by entering the Scenario ID into the input field on the Review Scenario page, shown in Figure 18. Click the *Submit* button after entering your Scenario ID, and additional buttons will appear on the page (Figure 19). Select *Rerun scenario* to go to the Input page where all the input fields will be populated with the scenario inputs. Here you can review, modify, and rerun the Tool. Note that by changing any inputs before rerunning the Tool you will, by definition, be working with a different scenario since a scenario is defined by a unique set of inputs for a specific tidegate site. A new Scenario ID will be generated upon running the Tool if inputs are modified.

Review Scenario

Input Scenario ID

Enter the Scenario ID to review scenario inputs and results. The Scenario ID can be found on the Tool Results page (Automated analysis method only) or the scenario PDF report.

Scenario ID

Submit

Figure 18. Review Scenario page where you can enter the Scenario ID

Figure 19. Review Scenario page showing options after entering a Scenario ID

Select the *Review results* button to go directly to the Results page for the scenario. If the results have expired a message will be displayed indicating that the results are unavailable and that they will automatically be recreated. You will be redirected to the Processing page while the Tool regenerates the results. When the processing finishes you will be redirected to the Results page.

If you access the Review Scenario page from within the PDF report (see Results Page — Automated Analysis Method) by clicking on the included hyperlink, the options to either rerun the scenario or review the results will be displayed without the need to enter a Scenario ID. You may go directly to the *Rerun scenario* or *Review results* options by clicking on either button.

5   REFERENCES

Plotly Technologies Inc. (2015). Collaborative data science. [online] Available from: https://plot.ly.