

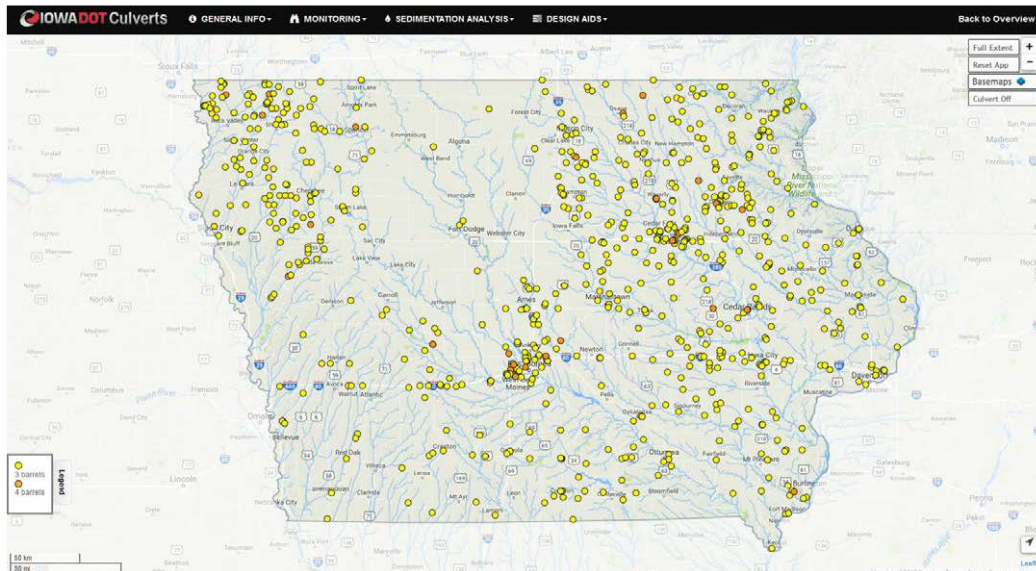
USER MANUAL

Iowa DOT Culvert Platform

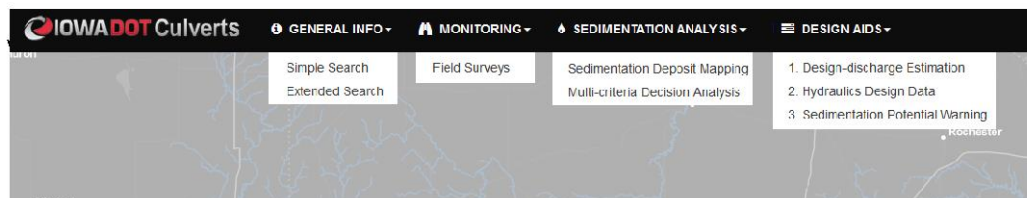


1. Overviews of the portal workflows

The “Iowa DOT Culverts” geo-portal prototype describes the potential for inception and development of sedimentation at culverts. By combining information from data-driven analyses at hundreds of culvert sites in Iowa with watershed and stream information available in national and local databases, the portal enables users to establish the degree of sedimentation at any existing or planned culvert location in the state. In addition, the platform aids designers and operation personnel to store, retrieve, analyze, and visualize a wide range of information about culverts using friendly web-interfaces.



The prototyping geo-portal contains four major workflows: (1) General information, (2) Monitoring, (3) Sedimentation analysis, and (4) Design aids for promoting culvert information access, inspection, and facility culvert sediment mitigation design through data-driven sediment analysis. The present documentation provides detailed guidance on the Graphical User Interface (GUI) for each of these workflows. The GUIs are presented in the order display below (from left to right).

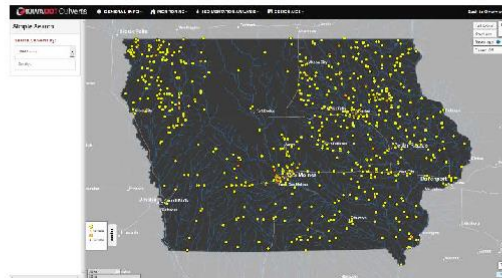


2. "General Info" Workflow GUI

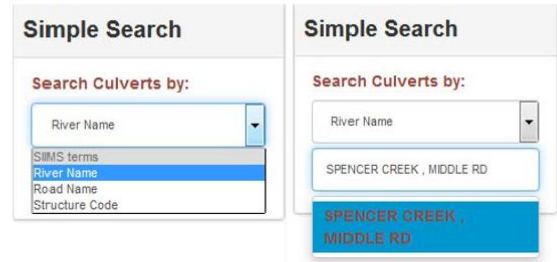
The "General Info" workflow is intended to create an easily accessible repository based on culvert specifications. The workflow contains two tools which provide accurate culvert identification based on different specifications.

2.1 Simple Search

The "Simple Search" identifies the location of culverts based on three fundamental criteria: (1) river name, (2) road name, and (3) structure codes.



Overview of the "Simple Search" Interface displaying the application panel (left) and map tools (right).



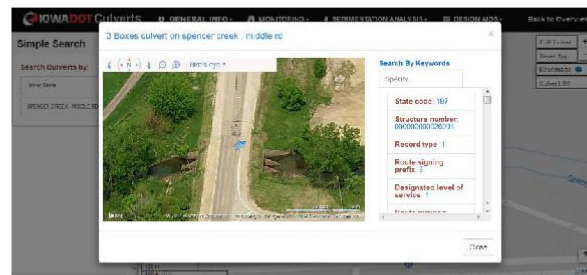
Choices of search criteria with autocomplete features embedded.

Let's assume a scenario where the user wants to locate a culvert on Spencer Creek in Iowa. As the user only knows the river name where the culvert is located, the user would select "Search culverts by" and then the "River Name" option and type in "Spencer Creek". Subsequently, the tool locates and zooms to the culvert location.



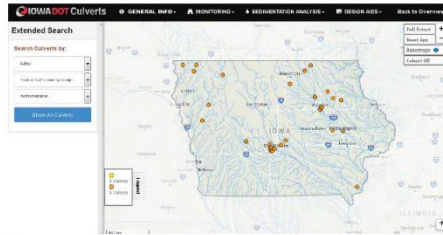
Zoomed view to culvert location.

By clicking on the culvert location on the map, a culvert information window that contains a bird's-eye view of the culvert and detailed culvert structure specifications appears in the window. Using the rotation tools in the bird's-eye view, users can visually inspect culvert structures from four different directions. Meanwhile, culvert structure information is displayed in the culvert information window. On the right-hand side, detailed culvert structure information, including culvert geometry, site codes, and maintenance information is displayed. All culvert specifications are retrieved from Iowa DOT SIIMS database and can be filtered by keywords.

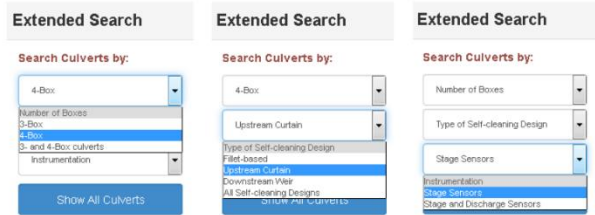


Culvert information window.

The “Extended Search” menu provides users with capabilities to filter culverts by additional attributes, such as number of boxes, types of self-cleaning design, and instrumentation. Click the “Show All Culverts” button to restore the default culvert map.



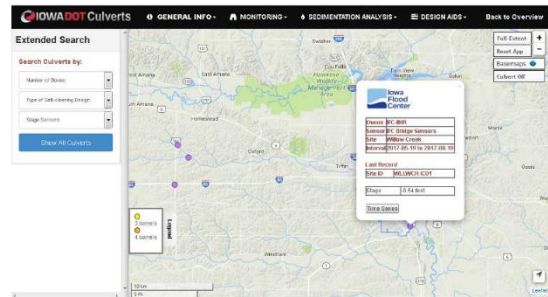
Display of 4-box culvert locations.



Choices of search criteria.

In a user case scenario, users can filter culverts with specific attributes on a map. Through the tool, the user can also display culvert sites with self-cleaning designs (e.g. file-based, downstream weir, and upstream curtain).

In addition to culvert structure attributes, the portal connects and visualizes real-time sensor measurements at culvert sites. The user can display locations of sensors from the United States Geological Survey (USGS) and the Iowa Flood Center (IFC) by switching the “Instrumentation” dropdown menu to “Stage Sensors”. By clicking on sensor location (●), an information tab showing sensor meta-data (e.g. measuring variables, locations, site-ID) is displayed. To view sensor measurement, click the “Time Series” button to launch the “time-series window”.



Filter culvert by “Stage Sensors”.

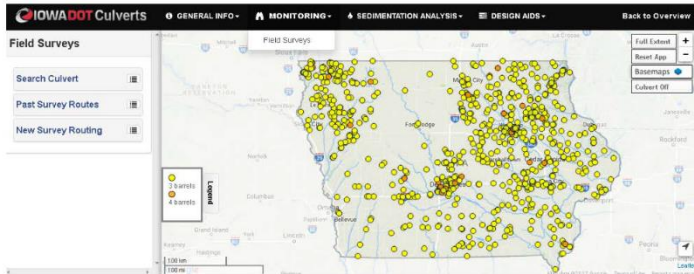
At some culvert sites, a “local view” that visualizes a realistic digital culvert structure with free surface level dynamically generated from real-time sensor measurements. The digital culvert model illustrated in the figure is surveyed using Unmanned Aerial Vehicle (UAV)-based photogrammetry. By hovering on time series plots, inundation scales in the “local view” are changed



Time series of stage measurements visualized in a realistic digital culvert view

3. "Monitoring" Workflow GUI

The "Monitoring" workflow provides tools to retrieve past survey information (data & routes) and plan new survey trips (navigation, field data uploader, and routes planning). The workflow contains a "Field Surveys" tool with three functional tabs: (1) search culverts, (2) past survey routes, and (3) new survey routing.



"Field surveys" interface overview.

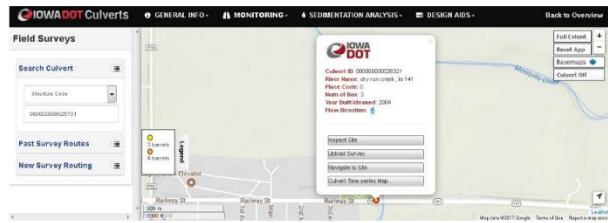


Application panell.

3.1 Search Culvert

The "Search Culvert" tab provides an easy way to search for culvert locations based on culvert specifications such as road name, river name, and structure code. The tab is similar to "Simple Search" in "General Info" to locate specific culverts, with extended field trip assistance workflows that enable users to (1) inspect sites, (2) upload surveys, (3) navigate to sites, and (4) view culvert time-series maps.

Let's assume a scenario, where a user locates the culvert of interest by searching structure code "000000000025731" in the "Search Culvert" tab. After locating the culvert, the user can access past culvert inspection data conducted by IHR - Hydrosience & Engineering by clicking the "Inspect Site" button. The culvert survey information page contains both survey notes and survey images acquired from previous culvert inspection. To upload a new survey, a user can click "Upload Survey" to access a field data uploader to ingest real-time survey data during a site inspection. The survey uploading page is protected by password.



Field surveys interface overview.

Culverts Field Survey

Survey Notes

Manage Survey Notes (+)

You may optionally enter a comparison operator (<, =, >, <=, >=, <>) at the beginning of each of your search values to specify how the comparison should be done.

Site	Site No	Culvert No	Sediment Storage	Sediment Left %	Sediment Middle %	Sediment Right %	Abutment Location	Abutment Width	Abutment Height	Sediment Location	Sediment Status	Photo	Special	Description	Created By	Created At
0000000000														The bridge spans both wetland and easement. Link to see complete files.		2016-03-25 11:31:01

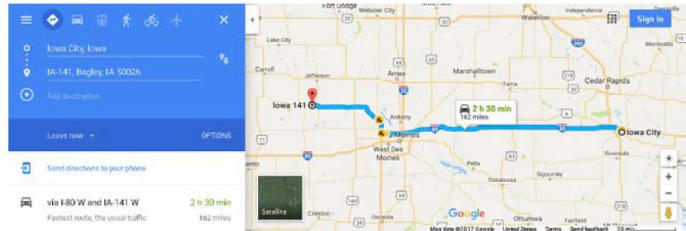
Manage Survey Images (+)

You may optionally enter a comparison operator (<, =, >, <=, >=, <>) at the beginning of each of your search values to specify how the comparison should be done.

Site	Name	Location	Revised Time	Created At
0000000000				

Photo acquired during previous culvert inspection

After identifying a specific culvert from the search, users can use the portal as a navigation tool to visit the site location by clicking the “Navigate to Site” button. The platform provides a Google navigation that guides users to the geographic coordinate of the site. The navigation tool is mobile-friendly and works with mobile devices that have GPS chips.



“Navigate to the site” command connects the portal with Google Map navigation tools.

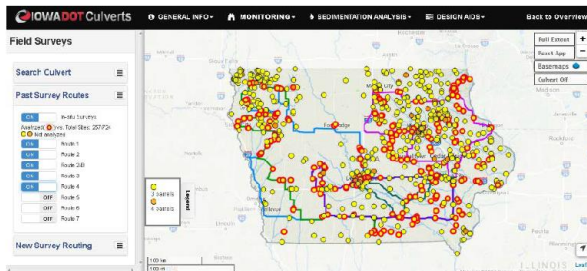
The portal also provides a culvert time-series viewer that assembles aerial imageries of culvert sites taken from different years (2004 – 2015). Sources of aerial imageries include Google, Esri, Iowa GIS server, and National Agriculture Imagery Program (NAIP), showing the development of culvert sediment at a site throughout time.



Time-series of culverts using aerial photographs.

3.2 Past Survey Routes

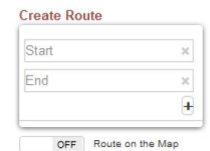
The “Past Survey Routes” tab displays the overall progress of past culvert sediment surveys conducted by IIHR - Hydroscience & Engineering. Within the tab, the switch “ OFF In-situ Surveys” visualizes the locations of inspected culverts, which is color-coded in “●”. Users can view past survey routes by clicking on different route switches (e.g. route 1, route 2). Past routes are displayed as colored lines on map.





Surveyed culverts and past inspection routes.

3.3 New Survey Routing

The “New Survey Routing” tab assists the planning of culvert inspection trips in surveyed areas by providing tools for address searches, route planning, and weather forecasting. The “Create Route” tool allows users to establish routing between specified addresses. In a user case scenario, a user can plan a trip from Iowa City to Ames by entering two addresses in the “Start” and “End” search boxes. Additional waypoints can be added by clicking the “+” button.



Address specification block.

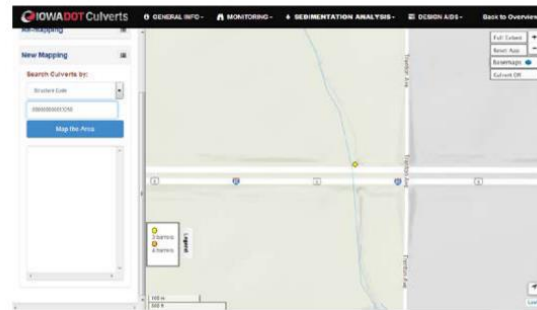
After enabling the mapping, culverts with past field inspections are color-coded in , while culverts with their sediment degree mapped are color coded in . In addition to the mapping, structure codes of culverts with aerial-image analysis are also listed under “Select an Analyzed Site”. By clicking on these structure codes, the user can access past delineations by visualizing them on the map. On the map, sediment delineation is displayed as the blue polygons.




The tools under the “Re-mapping” tab allow users to update and modify past sediment delineations when the latest aerial imagery become available. The “New Mapping” tab, in contrast, allows users to search and map sediment at new culverts. Both tabs have a built-in culvert search tool that only allows users to search and select culverts that have sediment mapping records.



Retrieval of previous mapping under “Re-Mapping” tab.



Identification of unmapped culverts under “New Mapping” tab.




The culvert sediment delineation section in both tabs are very similar: (1) the user has to specify a culvert through the culvert search by typing in a structure code. (2) After the culvert is located, the user needs to click  to trigger the sediment mapping interface. The mapping interface contains a display of culvert structure codes (e.g. 013250), a switch that enables delineation toolsets on the map, a button to show attributes (e.g. length) of delineated geometry, a dropdown menu to specify the location of delineation, and a flow direction arrow that indicates the downstream of the culvert. (3) Before tracing the sediment area on the map, the user needs to activate “ Delineate on Map ” to enable the mapping toolset (the tool appears in the upper left corner)

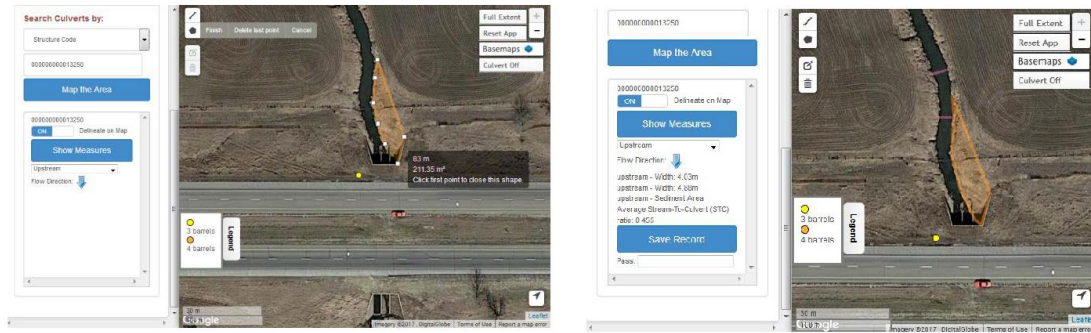


2) Triger the mapping tools.



3) Enable mapping activities.

(4) To map sediment areas, the user simply needs to click on  to draw polygons at culvert sites using aerial imagery overlays. The  button enables users to draw lines that can be used to measure the river width on the map. When the tracing of the sediment area is finished, press “Enter” on the keyboard to finalize the polygon delineation. After the delineation, the user can view delineation details by clicking the “  ” button.

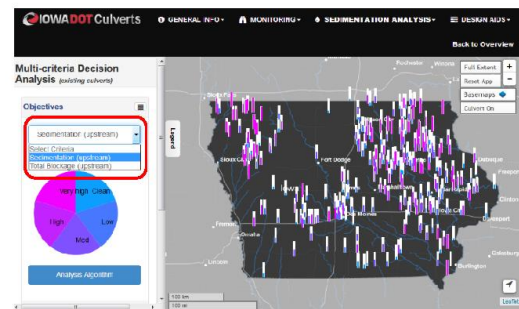


4) Delineating sediment area at culvert upstream and showing details by clicking “Show Measurement”.

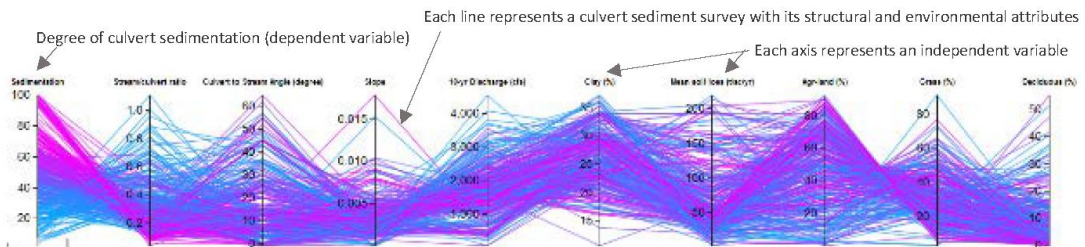
(5) To upload the delineation results to the database for later use, the user needs to click the **Save Record** button under “Multi-Criteria Decision Analysis”. The uploading is password protected to ensure data quality and integrity. To get the password, please contact our team.

4.2 Multi-Criteria Decision Analysis

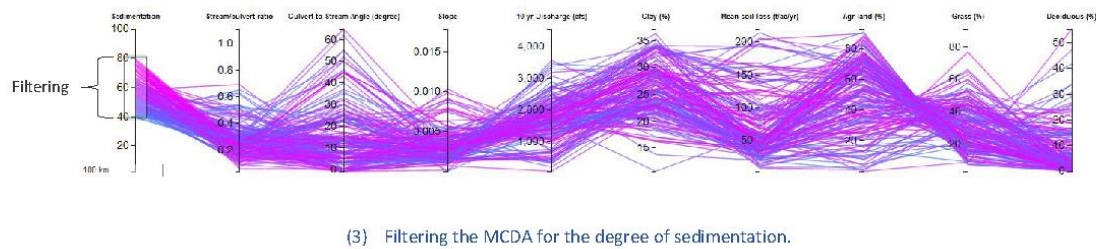
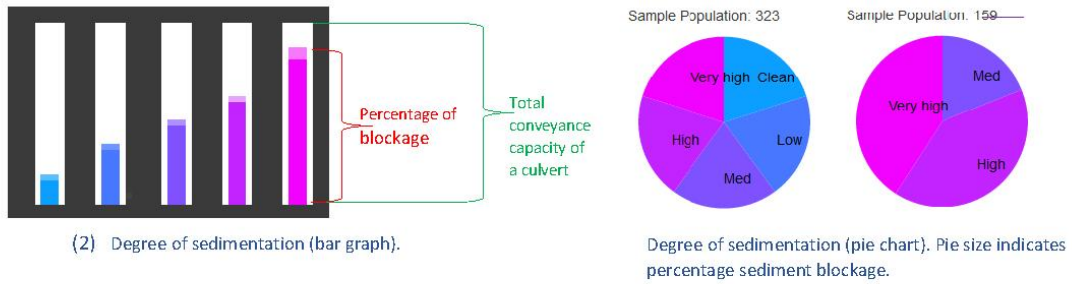
The Multi-Criteria Decision Analysis (MCDA) aims at exploring environmental drivers that contribute to culvert sedimentation in culvert upstream drainage areas. The tool reveals the causal relationships between culvert sediment degree and the structural attributes (e.g. height, design discharge) as well as the watershed and stream characteristics (e.g. channel slope, mean soil loss) using a visual-analytics approach. The results of the MCDA are visualized into a parallel coordinate plot supported by dynamic machine learning algorithms (e.g. decision tree). The tool is interactive and user-friendly, so that users can play with the tool to get a sense of how different factors affect culvert sedimentation. To conduct an analysis, the user needs to: (1) define sediment criteria in objectives via the dropdown menu, and (2) enable the data visualization (parallel coordinate plots) using the switch **ON** Show Analysis Results.



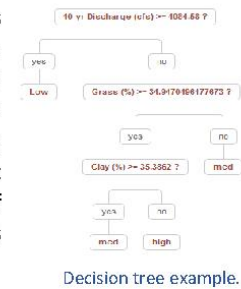
- Two criteria are available in the dropdown menu:
 - “Sedimentation (upstream)” indicates the degree of sedimentation as obtained from the mapping of the sediment mapping (obtained from aerial imagery), and
 - “Total Blockage (upstream)” indicates the volume of sediment blockage in the vertical plane (obtained from field surveys).



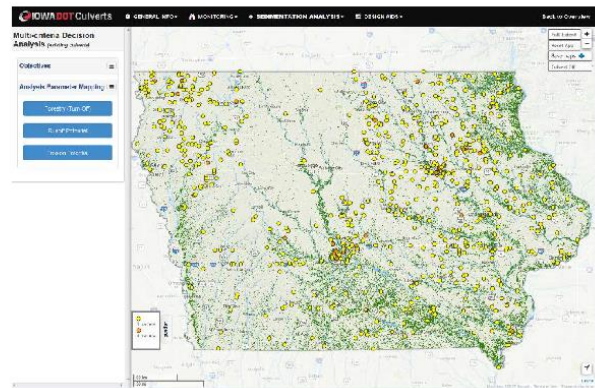
2) Parallel coordinate multi-axis plot relating culvert sediment degree with culvert structural attributes and environmental drivers.



The parallel coordinate plot is connected with the web map and provides dynamic data “brushing” capabilities that allow users to filter or select data records, certain ranges, and attributes. To create a brushing range, simply click and drag on each parameter axis. In addition to the visually explicit variability revealed from the parallel coordinate plots, users can also view quantification of the MCDA by clicking the “Analysis Algorithm” button, which enables a decision tree that visualizes the sediment relationship. A detailed user case scenario is provided below. A small bunch of decision trees with only two sediment classes (med and high) and few parameters (e.g. discharge, grass, and clay) are shown in the figure as an example.



In addition to the main analysis, the portal provides “Analysis Parameter Mapping” to display spatial distribution maps of environmental parameters (e.g. forestry, runoff, erosion) that are involved in the MCDA. To activate those maps, simply expand “Analysis Parameter Mapping” by clicking the button “☰” next to the tab “Analysis Parameter Mapping ☰”. Afterward, the interface expands and displays blue buttons for the following categories: (1) Forestry, (2) Runoff Potential, and (3) Erosion Potential. If a user wants to view a forestry map, they need to simply click the “Forestry” button to activate the map.



Forestry map.

5. "DESIGN AIDS" Workflow GUI

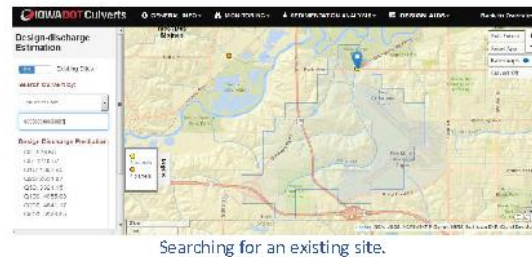
The "Design Aids" workflow uses analytical results from the MCDA conducted in previous workflows (Sedimentation Analysis) to support culvert design and retrofitting for mitigating sedimentation. The workflow contains three design-aids tools: (1) Design-Discharge Estimation, (2) Hydraulics Design Data, and (3) Sedimentation Potential Warning.

5.1 Design-discharge Estimation

Culvert design discharge is a very important parameter that determines the opening of culvert structures. The "Design-Discharge Estimation" calculates river discharge for multiple return periods (e.g. 5 year, 10 year, 50 year) using flood probability methods (e.g. USGS Lara method). The tool is designed to estimate design discharge for both (1) Existing Sites and (2) New Sites.

<div style="border: 1px solid #ccc; padding: 5px; background-color: #f9f9f9;"> <p>Design-discharge Estimation</p> <p><input type="checkbox"/> OFF Existing Sites</p> <p><input type="checkbox"/> OFF New Sites</p> </div> <p style="text-align: center;">Location of the site.</p>	<div style="border: 1px solid #ccc; padding: 5px; background-color: #f9f9f9;"> <p>Design-discharge Estimation</p> <p><input checked="" type="checkbox"/> ON Existing Sites</p> <p>Search Culvert by:</p> <p>Structure Code <input type="text" value="00000000003683"/></p> </div> <p style="text-align: center;">Existing site.</p>	<div style="border: 1px solid #ccc; padding: 5px; background-color: #f9f9f9;"> <p>Design-discharge Estimation</p> <p><input checked="" type="checkbox"/> ON New Sites</p> <p>Enter Site Coordinates</p> <p>North: <input type="text"/></p> <p>East: <input type="text"/></p> <p style="color: green; font-size: small;">Set the cross-fire at POI & click on map</p> </div> <p style="text-align: center;">New site.</p>
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To estimate discharge for existing sites, click " Existing Sites" to enable the estimation interface. The procedure is very similar to the culvert search in that the user needs to specify a culvert location by its structural code. Afterwards, the portal traces the upstream drainage area and reports the result in the sidebar.



To estimate discharge for a new site, the user needs to click " New Sites" to trigger the new site interface. When the interface is loaded, follow the guide and enter the site coordinates (point of interest). The portal automatically zooms to the coordinates and calculates the design discharge.



5.2 Sedimentation Potential Warning

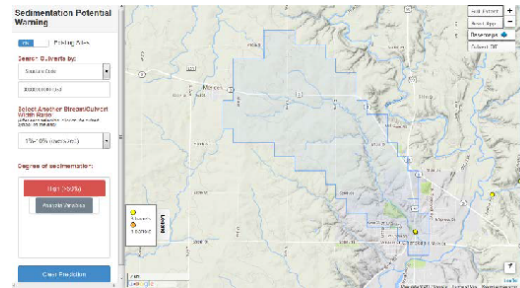
“Sedimentation Potential Warning” uses a decision tree generated from the previous sediment analysis (Multi-Criteria Decision Analysis) to predict sediment potential at both existing sites and new sites. The tool is intended to inform the designer when to apply the “Self-Cleaning Design” based on sediment potential while designing new sites. The tool provides predictions for both existing sites and new sites. General user interfaces of this tool are listed below.

Location of the site.


Existing sites.

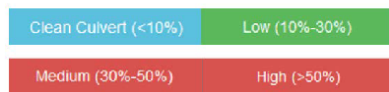
New site.

The interface of this tool is very similar to that of the discharge estimation. To estimate sediment potential for existing sites, click on the switch “ Existing Sites ” to activate the corresponding interface. First, specify the structural code for estimation--the procedure is the same as the discharge estimation. Second, define the stream/culvert width ratios through the dropdown menu “ 1%-10% (oversized) ”, as culvert geometry plays an important role in culvert sedimentation. Results of sediment estimation will be provided under the “Degree of sedimentation” section.

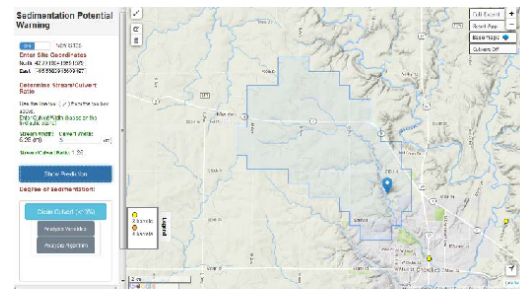


Estimating sediment potential for existing sites.

To evaluate the sediment potential at new sites, activate the switch “ New Sites ” to display the interface. Steps are as follows: (1) enter coordinates for a new site, (2) delineate river cross-section using the “  ” tool to measure river width, and (3) specify culvert width using “ ” and click “ ”. Afterward, the result of the estimation is provided under the “Degree of sedimentation” section. The system uses four classes to describe sediment potential at a site:



Classes for sediment potential estimation.



Estimating sediment potential for a new site.