

North Cascades National Park Service Complex

Culvert Inventory Using Survey123 for ArcGIS and ArcGIS Online: Data Analysis Guide



Purpose

To address the lack of a spatially-based comprehensive culvert inventory in North Cascades National Park Service Complex. During the North Cascadia Adaptation Partnership, culvert inventorying and design improvement was identified as a climate adaptation strategy as climate change impacts peak flows. The limited spatial information on culverts at NOCA in FMSS prevents accurate conversion of culvert data into a GIS layer for analysis. This guide provides an overview on the information provided by the culvert inventory project and how the data can be used in analytics and predictions.

Written by: Angelina Nguyen, National Park Service George Melendez Wright National Park Service Young Leaders in Climate Change Program, August 2016.

Supervisor: Regina Rochefort, North Cascades National Park Service Complex
810 State Route 20, Sedro-Woolley, WA 98284

Table of Contents

Introduction.....	3
Key Indicators and Considerations in the Inventory Data.....	4-5
Accessing Photos from Inventory Data.....	6
Using Inventory Data in GIS Analysis.....	7

Introduction

A culvert is any structure not classified as a bridge that provides an opening under a roadway or trail at a stream or drainage crossing. A culvert is typically defined by one of the following:

- A structure that is usually designed hydraulically to take advantage of submergence to increase hydraulic capacity.
- A structure used to convey surface runoff through embankments.
- A structure, as distinguished from bridges, that is usually covered with embankment and is composed of structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert.

Culverts are used primarily to convey water through embankments or other type of flow obstructions. They are also used as a passage for pedestrians, stock, wildlife, and fish, as well as for land access and to carry utilities.

As flood extremes magnify with climate change, culverts are at an increased risk of inundation and failure, impacting stream function, aquatic organism passage, and park transportation infrastructure for staff and visitors. Existing Global Climate Models (GCMs) meteorological data have been utilized as inputs into the Variable Infiltration Capacity (VIC) macroscale hydrological model by University of Washington researchers to estimate future peak flows in the NOCA region. With a geospatial database of culverts, researchers and park staff will be able to overlay these hydrologic models with culvert point location data to determine which culverts are most at risk under projected flood extremes. This will be a crucial tool for transportation infrastructure management as we continue to weigh the impacts of changing temperatures.

This project utilizes the mobile application Survey123 for ArcGIS in tandem with the cloud-based mapping system ArcGIS Online, enabling us to create an online culvert database that can be accessed and downloaded by NPS employees through the ArcGIS Online portal. Given that NOCA comprises at least 75 road miles and 389 trail miles, relying solely upon staff to survey the park's hundreds of culverts would be a costly and time-consuming process. With a mobile app, we empower volunteers to submit culvert data easily, and minimize the training and equipment necessary. In crowdsourcing the data, we have the opportunity to survey culverts more rapidly while also engaging and educating volunteers on the implications of climate change in our local parks.

Our aim is to develop a comprehensive georeferenced inventory of culverts with help from volunteers. Volunteers will work alongside NPS employees with park-furnished iPads or data sheets and measuring tools to gather details on culverts and the surrounding environment.

Key Indicators and Considerations in the Inventory Data

Date and Weather Conditions

The time of year and current weather conditions may play a role in the stream flow observed. Expect lower flows during the summer. Precipitation will lead to heavier flows.

Access Type

Culverts serving roads will tend to be larger than culverts serving trails.

Surrounding Land Cover Type

The land cover, particularly upstream of the culvert, can play a substantial role in the structure's potential to fail. Debris upstream has the potential to plug or damage the culvert. The type of land cover upstream indicates the size, type, and quantity of debris we should plan for at the crossing site.

Culvert Dimensions

Dimensions are generally standardized – any dimension value that appears to be out of the norm may indicate that the inlet or outlet is damaged.

Azimuth

The azimuth measurements can indicate how fitted the culvert is to the stream's natural flow path. If the upstream, downstream, and culvert azimuths are within a close range of one another, the culvert is successfully replicating the natural stream flow direction. If the change between the azimuths is substantial, the culvert is forcing the stream to bend, which can cause issues with scouring and flow speed.

Slope

Similar to azimuth measurements, the slope measurements can indicate unnatural changes in steepness caused by the culvert.

Inlet and Outlet Treatment

Flaring serves to increase effective culvert capacity. Aprons protect the structure from scour and storm damage, but can lead to shallow depths with high velocities, creating a barrier for aquatic organism passage. Headwalls and wing walls improve flow of water, provide anchoring support for the culvert pipe, prevent dislodging under pressure, and help to control erosion and scour. A perched or projecting culvert indicates that the pipe is suspended over the immediate downstream pool, creating a barrier for passage that requires aquatic organisms to leap into the culvert pipe. Native channel material or riprap used around the inlet and outlet can slow flow rates.

Internal Structures

Internal structures can heavily impact aquatic organism passage. Baffles and weirs influence flow rate as well as providing steps that, depending on water depth in the culvert, can either help or hinder passage.

Inlet/Outlet Condition

If the inlet or outlet is fully submerged, it is not properly sized and a larger replacement should be considered (unless observation was made during peak flood conditions). If the inlet or outlet is not submerged at all, there is no flow through the culvert, indicating the stream is dry.

Culvert Condition

The culvert's structural, functional, and overall condition can provide information on if the culvert is damaged or needs maintenance.

Sediment Bars

Sediment bars are formed by deposition when the stream's discharge or velocity decreases. The presence of sediment bars, and their location, can tell where the stream experiences a reduction in flow speed.

Crossing Span

If the culvert constricts the stream, the flow rate is subject to increase. A culvert's diameter should span, at minimum, from bank to bank, and ideally would span the channel and banks.

Scour Pool Downstream

Scour pools are created by high velocity waters exiting the culvert. A scour pool can indicate unnaturally high flows caused by the structure.

Substrate Match

If the substrate in the culvert is not comparable to the stream, the flow velocity in the culvert is likely different than the rest of the stream. Coarser substrate indicates lower flows in the culvert, and finer substrate indicates higher flows.

Water Depth and Velocity Match

If the depth and velocity do not match, the culvert is causing unnatural stream conditions. This may cause reduced water quality and be a barrier to aquatic organism passage.

Fish/Amphibians Observed

If aquatic life is observed, special attention should be paid to other characteristics that impact aquatic organism passage.

Accessing Photos from Inventory Data

Unfortunately, there is not yet an easy tool for batch downloading images that are attached to the culvert features on ArcGIS Online. The only solution that currently allows for batch downloading is outlined at the following link: <http://support.esri.com/technical-article/000011912>. However, this necessitates ArcPy scripting and the data must be saved as a file geodatabase.

An alternative solution, though inefficient, is to individually view and download photos through the Map Viewer on ArcGIS Online. When you select a point, the pop-up window contains all of its attribute values. At the very bottom of the pop-up are a series of links to each attachment. Clicking the link will open the photo in a new tab, where they can then be viewed and saved.

Using Inventory Data in GIS Analysis

A primary motivator for this project was the lack of a spatially referenced database of culverts. With a geodatabase of culverts, the data can be directly integrated with other data through GIS to perform more complex analyses. The culvert point data can be overlaid with geomorphological and aquatic layers as well as basemap features such as roads, trails, and streams. A comprehensive risk assessment will necessitate a multi-layered map that utilizes both natural resources and infrastructure data to determine which culverts are most sensitive and at risk.

Using the hydrologic models from UW (described in the Introduction) and StreamStats, a USGS tool, we can calculate peak streamflow statistics given a culvert's location for both current and projected future climatic conditions. Future peak flow levels can be predicted for each culvert and compared to the culvert's current capacity. This will enable us to identify the culverts that are most at-risk in light of climate change and consider replacement or redesign. Refer to the two separate guides, "Utilizing USGS StreamStats and ArcGIS to Predict Peak Flow Levels for Culvert Management" or "Utilizing USGS StreamStats and MS Excel to Predict Peak Flow Levels for Culvert Management," for instructions on determining future peak flow.