

GIS Workflow

How to Map Open Space for Community Rating System Credit

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NOAA Office for Coastal Management
coast.noaa.gov

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Introduction

The Federal Emergency Management Agency (FEMA) Community Rating System (CRS) is a voluntary program that provides discounts on flood insurance premiums for communities that exceed the minimum requirements of the National Flood Insurance Program. Under Community Rating System Activity 420, Open Space Preservation (OSP), a community can earn CRS credit for preserving open space within the regulatory floodplain through land regulations that prohibit infill and development in flood-prone areas, and protect and enhance the natural functions of floodplains.

This GIS Workflow is a companion document to the NOAA resource *How to Map Open Space for Community Rating System Credit*. It was designed for GIS professionals who are assisting a community's CRS coordinator or local planner with mapping eligible open space preservation credit using GIS data and software. The step-by-step approach draws from FEMA's [CRS Coordinator's Manual](#) and instructs communities on how to map and calculate eligible open space preservation credit for open space areas that are already protected, as well as identify places where additional credit could be earned through future preservation efforts. Note that all credit is verified by a community's Insurance Services Office (ISO)/CRS specialist, and final credit is determined by FEMA.

This GIS Workflow outlines detailed steps to map preserved open space with nationally available datasets. Each of the nationally available datasets incorporated in this workflow is accessible, consistent, and authoritative, which means that nearly all communities could map preserved open space for CRS credit by following the detailed steps in this workflow. However, for many communities, there may be state or local datasets that could improve the mapping results if used within this workflow as a supplement or alternative to data specified within this document. Details such as where to locate appropriate local data, which datasets to look for, and how to incorporate them in this workflow can vary significantly from community to community. General guidance for locating, identifying, and using local data are provided where possible in these steps.

The GIS Workflow focuses on the calculations required to determine the following:

- **Element 422a – Open Space Preservation (OSP):** Credit for land kept vacant through local regulations or land ownership.
- **Element 422b – Deed Restrictions (DR):** Extra credit for land protected by legal restrictions that ensure parcels credited for OSP will never be developed.
- **Element 422c – Natural Functions Open Space (NFOS):** Extra credit for OSP-eligible land that is preserved in or restored to a natural state.

The GIS Workflow also provides information in Appendix A for packaging your community's GIS outputs for use in [The Nature Conservancy's \(TNC\) CRS Explorer tool](#). The CRS Explorer tool visualizes areas that are eligible for Open Space Preservation (OSP) credits and helps prioritize unprotected open space in the floodplain that, if protected in the future, would improve a community's CRS score, reduce flood insurance costs, and make their communities more resilient to future flooding.

NOTE: This document does not cover mapping or calculations needed to earn credit under CRS Activity 420 for Element 422d, Special Flood-related Hazard Open Space (SHOS); Element 422e, Coastal Erosion Open

Space (CEOS); Element 422f, Open Space Incentives (OSI); Element 422g, Low-density Zoning (LZ); or Element 422h, Natural Shoreline Protection (NSP). However, for communities that have already mapped special flood-related hazards or coastal erosion areas, the Excel worksheet provided in Step 5 of the online [How to Map Open Space](#) resource can assist with calculations for Elements 422d (SHOS) and 422e (CEOS).

Element 422a and the OSP Equation

Community Rating System credits for preserved open space are calculated using an impact adjustment ratio (rOSP). In the CRS, impact adjustments reflect how much of the Special Flood Hazard Area (SFHA) is affected (or impacted) by the desired activity. In order to measure the impact of preserved open space, you need to calculate the impact adjustment for eligible open space (aOSP), as well as calculate the impact adjustment for the Special Flood Hazard Area (aSFHA). For both eligible open space and the SFHA, calculating the impact adjustment involves excluding certain features from the area (acres). The resulting impact adjustment ratio (aOSP/aSFHA) is multiplied by the maximum available credits for the activity (1450) to calculate the CRS credits.

Steps 1 through 4 of this GIS Workflow outline methods for calculating the impact adjustment ratio (rOSP) and credits available for preserved open space (OSP credit) as defined by Element 422a.

rOSP = aOSP/aSFHA, where:

$$\text{aSFHA} = \frac{\text{the area of the community's SFHA} \text{ minus } \text{excluded areas}}{\text{Step 1 in the GIS Workflow}}$$

$$\text{aOSP} = \frac{\text{area of eligible open space in SFHA}}{\text{Step 2 in the GIS Workflow}} \text{ minus } \frac{\text{area of impervious surface}}{\text{Step 3 in the GIS Workflow}}$$

$$\text{OSP credit} = \text{rOSP} * 1450 \text{ (maximum credit points possible for 422a)}$$

Step 4 in the GIS Workflow

GIS Workflow Overview

The GIS Workflow consists of 7 steps.

- Steps 1 to 4 work toward calculating potential OSP credits for element 422a (OSP).
- Step 5 outlines methods for calculating extra credit for OSP eligible open space.
- Step 6 gives guidance for preparing documentation and maps to submit to FEMA.
- Appendix A lays out steps to prepare GIS Workflow output data for integration into [The Nature Conservancy’s \(TNC\) CRS Explorer tool](#).

Table 1: Mapping objectives and GIS outputs for each section of the GIS Workflow.

Mapping Objective	GIS Output
Step 1. Calculate the community’s adjusted Special Flood Hazard Area (aSFHA).	The community’s Special Flood Hazard Area (SFHA) with federal and tribal lands and water bodies <i>greater than 10 acres</i> excluded.
Step 2. Identify lands that may qualify for Open Space Preservation (OPS) credit.	Eligible protected open spaces.
Step 3. Calculate areas that do not qualify for open space credit.	Area of eligible protected open spaces covered by non-qualifying features, such as impervious surfaces and fill that obstructs flood flows or aggravates flooding.
Step 4. Calculate possible OSP credit for the community’s preserved open space.	OSP credit calculations for eligible preserved open space areas.
Step 5. (Optional) Determine if preserved open space areas qualify for “extra credit.”	Areas that qualify for Natural Functions Open Space (NFOS) or parcels with deed restrictions (DR).
Step 6. Gather supporting documentation for each open space area to submit to FEMA’s ISO/CRS specialist.	List of eligible open space areas that qualify for Activity 420 CRS credit and an impact adjustment map showing eligible OSP and “extra credit.”
Appendix A: Formatting Data for The Nature Conservancy’s CRS Explorer Tool	Package of data formatted for integration into the CRS Explorer.

Getting Ready

Before you get started:

Consult with [FEMA ISO/CRS specialists in your region for information and guidance](#). There are some details to check on with the specialist. The name and contact information for many ISO/CRS specialists are available at [CRSresources.org](https://www.fema.gov/crsresources.org) (100 Series).

- Determine what information your community is required to provide for receiving OSP credit. This will help identify the GIS data that you will need to perform the spatial analysis for Activity 420 and may provide valuable guidance. For example, determine what is expected in reporting and documenting eligible OSP land for submission to FEMA. In some cases, you may need to calculate OSP credit at the parcel level and report eligible credit by parcel ID or APN (assessor's parcel number).
- Find out if any credits have been previously awarded for any Activity 420 elements. Previously awarded open space must be accounted for in the processes and documentation to ensure that they are not double counted. Inquire with the ISO/CRS specialist to determine if and how you should address previously awarded credits for this activity. You may be able to identify those areas and exclude them from the GIS Workflow, or you may be able to replace previous credits with new calculations.

Investigate local GIS data options.

- The GIS Workflow outlines a screening-level OSP analysis that uses nationally available datasets for mapping and calculating OSP credit. However, it is recommended that a community use local-scale (e.g., state, county, or city) GIS datasets to supplement or replace national-level data if they are more complete, more accurate, or more up-to-date. In many cases, utilizing local data will result in better results for the community. For example, in the workflow, data from the Protected Areas Database of the U.S. (PAD-US) are used to identify eligible open space areas. However, PAD-US may not include all open space areas. Local data for parks, nature preserves, or other preserved open spaces could be added to the workflow to complete the OSP input and improve the results.
- Collaborating with various municipal departments and local organizations that maintain open space in your community may be required to help obtain GIS data or locate regulatory documents (e.g., ordinance letters) to verify open space preservation and demonstrate eligibility for OSP credit. These groups can include parks departments, land use or planning departments, floodplain managers, land trusts, and private property owners. For more, see the [Checklist of Information Sources](#).

Throughout this workflow:

Do what you know.

- With work in GIS, there are often different approaches available to achieve similar results. Methods outlined in this workflow represent a tested series of analyses. You may prefer different methods of analyses or data management. Do what you know.
- This workflow was developed using ESRI ArcMap 10.4, but many of the geoprocessing tools referenced are also available in most open-source GIS software.

For technical assistance, contact NOAA's Office for Coastal Management (OCM) by emailing coast.info@noaa.gov.

GIS Data and Sources

This table lists GIS data inputs for Element 422a and specifies sources for acquisition.

Table 2: Open Space Preservation (OSP) Element 422a. GIS data inputs and data sources for mapping preserved open space.

	GIS Data Layer Layers in <i>bold italic</i> are required for OSP spatial analysis	GIS Data Source
Community Areas	<i>Special Flood Hazard Area (SFHA)</i>	National Flood Hazard Layer (NFHL) download from FEMA Map Services Center
	Regulatory floodplain outside of SFHA ¹	Community planning department
	<i>Community boundary</i>	Community planning department, or FEMA NFHL download
	Community parcels	- Tax Assessor’s Office or GIS departments - National Conservation Easement Database (NCED)
	Land use ²	Community planning department
Excluded Areas	<i>Federal and tribal lands</i>	USGS Protected Areas Database of the U.S (PAD-US)
	<i>Open water</i> ³	National Hydrography Dataset (NHD)
	<i>Impervious surfaces</i> (choose one)	USGS National Land Cover Database (NLCD) 2016 Percent Developed Imperviousness
		NOAA Coastal Change Analysis Program (C-CAP) land cover
		Roads and building footprints (e.g., OpenStreetMaps , local data sources)
High-resolution land cover data from regional or local agencies.		
Preserved Open Space	<i>Protected areas</i> (includes public open space)	- USGS Protected Areas Database of the U.S (PAD-US) - Community planning department
	Coastal and stream setbacks ⁴	Community planning department
	Natural land cover ⁵	NOAA Coastal Change Analysis Program (C-CAP) land cover
	Parks, conservation easements and other protected open spaces	Community planning department

¹ If a community enforces development regulations outside the SFHA that are similar to those enforced within the SFHA, then areas outside the SFHA can be eligible for OSP credit (as described in Activity 410: Floodplain Mapping).

² Land use designation must be included in the list of parcels that qualify for OSP credit. This layer is not necessary if “land use” is already a field in the attribute table of the *Parcel* layer. Note that land use is not the same as zoning.

³ Open water includes large water bodies (e.g., lakes, bays) and rivers.

⁴ Areas covered by shoreline, dune, or wetland setbacks, or other protective ordinances in the floodplain.

⁵ Natural land cover is optional and can be used to determine opportunities for future OSP credit (Step 7).

This table lists GIS data inputs for Elements 422b and 422c and specifies sources for acquisition.

Table 3: Open Space Preservation (OSP) “Extra Credit” Elements 422b and 422c. GIS data inputs and data sources.

	Data Inputs	GIS Data Source
Deed Restrictions	Parcel area with deed restriction information	- Tax Assessor’s Office or GIS departments - National Conservation Easement Database (NCED)
Natural Functions Open Space	Undeveloped preserved open space	USGS Protected Areas of the U.S Database (PAD-US)
	Floodplain protection plan ⁶	Community planning department
	Critical habitat ⁷	- Community planning department - State natural heritage program or natural resource agency
	Conservation corridors	- Community planning department - State natural resource agency

Getting Set Up

Follow the steps listed below to get set up for the workflow.

1. Create a project folder to house all input data and outputs from the analyses.
2. Create a new file geodatabase in the project folder. This will be where all outputs are saved throughout the workflow.
 - Name example: CommunityName_CRS_OSP_Outputs.gdb
3. Create a map document and save it to the project folder. It is good practice to establish one map document as the workspace for all of the GIS analyses. Save this map file as you progress through the workflow so it retains inputs/outputs and geoprocessing history.
4. Within the project map document, set the default geodatabase to the file geodatabase created in Step 2. (File > Map Document Properties > Default Geodatabase). This will streamline saving outputs to the correct location.
5. Download and organize input data. The following section outlines data downloading details.
6. Project all data to the same projected coordinate system. Data must be in a projected coordinate system to perform the area calculations in this workflow. A State Plane coordinate system is a good option for accurate area calculations.
 - Data can be reprojected with the Project tool in the Data Management Toolbox (Data Management > Projections and Transformations > Project). Another option that is more streamlined is to set the projection of outputs in the Output Coordinates section of the Environments Settings for geoprocessing tools used throughout the GIS Workflow.
 - Note: For some large datasets (either in geographic coverage or file size or both) it may be best to reproject data after extracting data to the community’s boundary. Methods for creating a community boundary are outlined in the “Data Preparation” section of Step 1 - Calculate the community’s adjusted Special Flood Hazard Area (aSFHA).

⁶ Parcels that are designated in a natural floodplain functions protection plan as described in Activity 512.c

⁷ Habitats of threatened or endangered species (federal- and state-listed species).

Download GIS Data

Guidance below outlines instructions for acquiring input data from nationally available datasets. The OSP analysis can be completed with the input from these nationally available datasets. However, as mentioned in the “Getting Ready” section, local data may be available to supplement or replace national data and improve the results.

FEMA Special Flood Hazard Area (SFHA) Data

Go to the [FEMA Flood Map Service Center](#) website. Click the “Search All Products” link. Select your jurisdiction (state > county > community), and click Search. From the Effective Products drop-down menu, select NFHL Data-County, then download the file with the appropriate county FIPS code.

Note: For some communities, the current effective FEMA flood maps may pre-date the NFHL product line and may not be available to download from FEMA’s website. In those instances, GIS-ready flood data will need to be sourced elsewhere, such as from local or county emergency management or planning departments.

USGS Protected Areas Database of the U.S. (PAD-US)

Go to the download page for the [USGS Protected Areas Database of the U.S \(PAD-US\)](#). Scroll down to the “Download PAD-US by State / Territory” section. Click on the appropriate state download link. It is recommended to download the Geodatabase option.

National Hydrography Dataset (NHD)

Go to the [USGS Access National Hydrography Products](#) website. Scroll down to the section “Download by Link.” Click the link for “Download the NHD by State.” Select the link for “GDB” to access geodatabase downloads. Download the link for the .zip file for the appropriate state.

Impervious Surface Data

High-resolution land cover that maps impervious surfaces or other types of impervious surface data may be available for your geography from local sources. Check with state or county agencies, such as natural resources agencies or community planning departments to see what is available.

If there is not a suitable data option for mapping impervious surfaces from local sources, this section outlines download instructions for several datasets. There may be multiple data options available for your geography. In general, it is best to work with the highest resolution (smallest pixels) data product available, although other factors, such as age, accuracy, and completeness of data must also be considered. You may need to visually compare available data options to determine which would be the most appropriate to use for these analyses.

For communities in coastal states or U.S. territories, the Coastal Change Analysis Program (C-CAP) likely offers one or more data options to map impervious surfaces for this workflow. Start by investigating the highest resolution options first.

For communities in the Conterminous United States (CONUS), the National Land Cover Database (NLCD) Percent Impervious data product is an option if no other data are available.

Explore these data options in the order they are listed to see what is available for your geography. Even if a good data option is available from a local source, you should explore what is available from these national programs to make sure you work with the best data available.

[NOAA Coastal Change Analysis Program \(C-CAP\) Land Cover Data](#)

Multiple resolutions of land cover data are available for coastal communities through this program—from high-resolution 1-meter land cover data to moderate-resolution 30-meter impervious surface data. Investigate data options in order of resolution (as listed below), starting with the high-resolution land cover.

- High-resolution land cover – Currently, a small number of geographies have high-resolution (1-meter, 2.4-meter) land cover data available through this program. To check availability, visit the [C-CAP High-Resolution Land Cover data page](#). Then click Download Data by State and check if data are available for your geography. Download if available.

If high-resolution C-CAP land cover data are not available for your location, try:

- 10-meter land cover – The C-CAP program recently began producing 10-meter land cover data derived from high-resolution imagery. Impervious surface is one of the land cover classes mapped in this product. This product is available for most coastal states. To check availability, visit the [C-CAP Derived Land Cover – BETA data page](#). Then click Download Data by State. In the list of links, click 10m Land Cover. Files are listed alphabetically by state abbreviations. Download the file for your state, if available.

If 10-meter land cover data are not available for your location, try:

- 30-meter Percent Impervious Surface Layer – Like the 10-meter land cover product, this 30-meter C-CAP product was derived from high-resolution imagery. Cell values in this raster, ranging from 0 to 100, represent the percent of impervious surface cover in the area of the cell. For example, a cell with a value of 100 would indicate the area is entirely covered by impervious surfaces. This product is available for most coastal states. To check availability, visit the [C-CAP Derived Land Cover – BETA data page](#). Then click Download Data by State. In the list of links, click 10m Land Cover. Files are listed alphabetically by state abbreviations. Download the file for your state, if available.

If none of these C-CAP products are available for your location, look into the USGS National Land Cover Database Percent Impervious dataset mentioned below.

[National Land Cover Database \(NLCD\) 2016 Percent Developed Imperviousness](#)

This dataset provides full coverage for the Conterminous United States (CONUS) as well as a portion of Alaska (Zone 8). To download, go to the [Urban Imperviousness Data page for the Multi-Resolution Land Characteristics \(MRLC\) Consortium](#). Find and click the Download button for NLCD 2016 Percent Developed Imperviousness (CONUS).

[OpenStreetMap](#)

In some cases you may discover new impervious surfaces were built in the community after the date that the land cover or impervious surface data were created. For this workflow, this issue is only important if the new impervious surfaces are within eligible preserved open space that you map. When you reach the appropriate point in this workflow and you discover that your land cover or impervious surface data are indeed missing man-made features in mapped eligible open space, you will need to find a way to include those missing features in your data. [OpenStreetMap](#) data includes roads and building footprints, and data downloads are available, though the coverage is not complete in many areas. You will need to check to see if OpenStreetMap includes the features missing from your land cover or impervious surface data. Check the online map for your areas of concern and download data if OpenStreetMap offers the data you need. To download, follow the link for OpenStreetMaps in the “GIS Data and Sources” table for Element 422a. Select

the Export tab and visit one of the sources listed. Geofabrik provides an option to download the data as shapefiles. From OpenStreetMap, select the Export tab, scroll down, and click the Geofabrik Downloads link.

Digitize Data

If you need to supplement land cover or impervious surface data to include man-made features missing from the data, and OpenStreetMap does not offer the supplemental data you need, you could create the data yourself by manually digitizing data for the missing features. Simply create a new polygon data file, such as a shapefile. With imagery as a basemap, you could start editing the new shapefile and draw a new feature with an editing tool following the perimeter of the feature.

Remember:

- **Place all downloaded data in the project folder.**
- **Be sure to unzip files to make the data accessible for the following geoprocessing steps.**

Step 1. Calculate the Community's Impact-Adjusted Special Flood Hazard Area (aSFHA)

The community's Special Flood Hazard Area (SFHA), known commonly as the "100-year floodplain," is a key piece of information to calculate open space credit. A community must exclude areas within the SFHA where it has no regulatory control to map the impact adjusted SFHA (aSFHA). The total area of the community's aSFHA is the denominator (bottom number) in the impact adjustment ratio used to calculate OSP credit.

Objectives

Calculate the total area of the aSFHA for CRS purposes by removing areas the community does not regulate, including the following

- Open water. Lakes, bays, and rivers larger than 10 acres, and rivers with reaches that are wider than 500 feet, on average, from bank to bank.
- Federal and tribal-owned or managed lands. Areas larger than 10 acres that are owned either by the federal government (e.g., military installations or national parks), owned by a tribe, or where the federal government prohibits development.
- Other areas the community does not regulate. The community can opt to include or exclude non-federal areas it does not have authority to regulate, such as state lands, or lands owned by another community. Check with your community's CRS coordinator or ISO/CRS specialist to identify which, if any, nonfederal areas to exclude.

If applicable, identify and map any additional regulatory floodplains outside the community's SFHA

Some communities enforce development regulations outside the SFHA that are similar to those enforced within the SFHA. In some cases these areas can count as additional regulatory floodplains. The community must map the area on its impact adjustment map and document its floodplain management regulations pertaining to CRS Activity 430 (Higher Regulatory Standards). A community may use eligible open space in the additional (non-SFHA) regulatory floodplain for OSP credit.

Examples of such regulations include, but are not limited to:

- State or local regulations that prohibit buildings and filling in the floodway.
- State or local regulations that prohibit buildings and filling in wetlands or other designated natural areas.
- Coastal construction setback lines that prohibit buildings.
- Streamside buffers and setback regulations (provided that they prohibit buildings and filling).

If you have additional regulatory floodplains outside of the SFHA, you will need to map those floodplains and calculate the acreage with the method outlined within this section for SFHA. These additional regulatory floodplain areas are not added to the community aSFHA. Instead, additional regulatory floodplains are used to map additional open space areas to contribute to the community's eligible open space. Guidance for this additional mapping is provided throughout the workflow.

Data Preparation

Remember:

- Make sure all of the data are in the same projected coordinate system. A State Plane coordinate system is a good option for accurate area calculations.
- Save outputs to the project file geodatabase. If that is set up as the default geodatabase for your mapping document, all outputs will automatically write to that location.

Prepare the Community Boundary

You will need the community jurisdictional boundary for this workflow. Community boundary data are likely available from either a local or state GIS resource. Otherwise, you should be able to extract the community boundary from a data layer in the FEMA NFHL download.

Extract the community boundary from a local or regional dataset

- If using a dataset that covers more geographies than your community, the polygons representing only the jurisdictional boundary for your community should be extracted. Use the Select tool (Analysis Tools > Extract > Select) to extract the community boundary features into a separate layer. Reproject the community boundary to the projected coordinate system you will use for data throughout this GIS Workflow. Name the output [Community_Name]_boundary.

Extract the community boundary from the FEMA NFHL database

- If local or state data for the jurisdictional boundary are not available, community boundaries can be extracted from one of the layers in the FEMA NFHL download. Follow the steps below to extract the community boundary from the FEMA NFHL database.
 1. From the FEMA NFHL download files, add S_Pol_Ar layer to the map document you will use for this work. Use the identify tool (or Explore tool in ArcPro) and click a polygon that overlays your community. Copy the 6-digit value for CID for the feature you click. This value is the unique identifier for your community in the S_Pol_Ar layer.
 2. With the Select tool, select features where CID = your community's identifier (copied from identify tool in the previous step).
 - Tool: Select (Analysis Tools > Extract)
 - Input: S_Pol_Ar
 - Expression: CID = copied CID value
 - Output: [Community_Name]_boundary
 - Optional: Set the desired coordinate system for the output in the Environment Settings (Environments... > Output Coordinates). Again, use a projected coordinate system – a State Plane coordinate system is a good option for accurate area calculations.
 3. Add the output to the map document and visually check that the features accurately represent the community jurisdictional boundaries.
 4. If necessary, reproject the output to the appropriate coordinate system you will use for this project.

Clip FEMA National Flood Hazard Layer (NFHL) Data to the Community Boundary

- From the NFHL download you will clip the S_FLD_HAZ_AR layer with the community boundary file you created.
 - Tool: Clip (Analysis Tools > Extract)
 - Input Features: S_FLD_HAZ_AR
 - Clip Features: [Community_Name]_boundary
 - Output: S_FLD_HAZ_AR_clip
 - Optional: Set the desired coordinate system for the output in the Environment Settings (Environments... > Output Coordinates). Again, use a projected coordinate system – a State Plane coordinate system is a good option for accurate area calculations.

If necessary, reproject the output to the appropriate coordinate system you will use for this work. This step will not be necessary if the Output Coordinates were set in the Environment Setting when using the Clip tool.

Note: If using data other than NFHL for the regulatory floodplain, be sure to also clip the data to the community boundary.

Prepare Federal_Tribal_Lands_g10acres

This layer will be part of the areas excluded from the community's SFHA, since federal and tribal lands are not eligible for OSP credit.

1. To reduce the size of the file and the number of features included in the next analyses, use the Select by Location tool to spatially select features from the PAD-US data that interest the community boundary.
 - Add data: From the PAD-US download, add PADUS2_0Combined_DOD_Fee_Designation_Easement_(state) to the map document. Also add the community boundary ([Community_Name]_boundary) to the map document.
 - Tool: Select by Location (Accessed from the selection menu in map document)
 - Selection method: select features from
 - Target layer: PADUS2_0Combined_DOD_Fee_Designation_Easement_(state)
 - Source layer: [Community_Name]_boundary
 - Spatial selection method for target features: intersect the source layer feature
2. Export the spatially selected features.
 - In the table of contents of the map document, right-click on the PADUS2_0Combined_DOD_Fee_Designation_Easement_(state).
 - Pick the export option (Data > Export).
 - Save the output to the file geodatabase set up for this work.
 - Output name: PADUS_aoi
3. From the PADUS_aoi output created above, select areas under federal management as well as features owned by federal or tribal entities, which will be excluded from the Special Flood Hazard Area (SFHA).
 - Tool: Select (Analysis Tools > Extract)
 - Input: PADUS_aoi
 - Expression: Mang_Type = 'FED' OR Own_Type = 'FED' OR Own_Type = 'TRIB'

Note: Not all of these distinctions may be present for your community.

- Output: Federal_Tribal_Lands_select
 - Optional: Set the desired coordinate system for the output in the Environment Settings (Environments... > Output Coordinates). Again, use a projected coordinate system – a State Plane coordinate system is a good option for accurate area calculations.
4. Convert multipart features to singlepart features.
 - Tool: Multipart to Singlepart (Data Management Tools > Features)
 - Input: Federal_Tribal_Lands_select
 - Output: Federal_Tribal_Lands_sp
 5. Add a new field to calculate area of features.
 - Tool: Add Field (Data Management Tools > Fields)
 - Input: Federal_Tribal_Lands_sp
 - Field Name: Area_acres
 - Type: Double
 6. Calculate the area of features.
 - Calculate Geometry. In attribute table for Federal_Tribal_Lands_sp, right-click on the field Area_acres in table of contents > Calculate Geometry.
 - Property: Area
 - Coordinate System: same as data source
 - Units: Acres US [ac]
 7. Select features greater than 10 acres.
 - Tool: Select (Analysis Tools > Extract)
 - Input: Federal_Tribal_Lands_sp
 - Expression: Area_acres > 10
 - Output: Federal_Tribal_Lands_g10acres
 8. If necessary, reproject the output to the appropriate coordinate system you will use for this work. This step will not be necessary if the Output Coordinates were set in the Environment Setting for the Select tool as suggested.

OPTIONAL: Supplement tribal lands (owned by tribal entities). In some geographies it may be necessary to supplement tribal lands because PAD-US does not include all tribal lands in the area. Below is a method to supplement tribal lands with data in the [Community Name]_boundary created from the NFHL download.

1. Select data with “Reservation” in the name from the [Community Name]_boundary. Export, if necessary.
 - In the attribute table for [Community Name]_boundary, open the Table Options menu and choose the Select by Attributes tool.
 - Enter this expression and click OK: (POL_NAME1 LIKE '%Reservation%') OR (POL_NAME1 LIKE '%RESERVATION%') OR (POL_NAME2 LIKE '%Reservation%') OR (POL_NAME2 LIKE '%RESERVATION%')
 - If features are selected, export the features. In the table of contents, right-click on [Community Name]_boundary. From the menu, select Data, and then select Export. This should export just the selected features. Name the output: Reservations
2. Append Reservations to Federal_Tribal_Lands_g10acres

- Tool: Append (Data Management > General)
- Input Dataset: Reservations
- Target Dataset: Federal_Tribal_Lands_g10acres
- Schema Type: NO TEST

Note: If specific tribal lands are not mapped in [Community Name]_boundary, you can check the [GIS data from the Bureau of Indian Affairs \(BIA\)](#). You will need to append supplemental data to Federal_Tribal_Lands_g10acres.

Prepare Open_Water_g10acres

This layer will be derived from the data in the National Hydrography Dataset (NHD) download and will also be part of the areas excluded from the community's SFHA.

1. To reduce the size of the file and the number of features included in the next analyses, use the Select by Location tool to spatially select features from the NHDArea and NHDWaterbody data that interest the community boundary.
 - Add data: From the NHD download, add NHDArea and NHDWaterbody to the map document
 - Tool: Select by Location (Accessed from the selection menu in map document)
 - Selection method: select features from
 - Target layers: NHDArea and NHDWaterbody (check the boxes next to both)
 - Source layer: [Community_Name]_boundary
 - Spatial selection method for target features: intersect the source layer feature
2. Export the spatially selected features for NHDArea.
 - In the table of contents of the map document, right-click on the NHDArea layer
 - From the menu, pick the export option (Data > Export)
 - Save the output to the file geodatabase set up for this work.
 - Output name: NHDArea_aoi
3. Export the spatially selected features for NHDWaterbody.
 - In the table of contents of the map document, right-click on the NHDWaterbody layer
 - From the menu, pick the export option (Data > Export)
 - Save the output to the file geodatabase set up for this work.
 - Output name: NHDWaterbody_aoi
4. From the NHDArea_aoi output created above, extract features where "FType" includes 312 (Bay/Inlet), 445 (Sea/Ocean), 460 (Stream/River).
 - Tool: Select (Analysis Tools > Extract)
 - Input: NHDArea_aoi
 - Expression: FTYPE IN (312, 445, 460)
 - Output: NHDArea_aoi_select
5. From the NHDWaterbody_aoi output created above, extract features where "FType" includes 390 (Lake/Pond), 436 (Reservoir), 493 (Estuary).
 - Tool: Select (Analysis Tools > Extract)
 - Input: NHDWaterbody_aoi
 - Expression: FTYPE IN (390, 436, 493)
 - Output: NHDWaterbody_aoi_select

6. Merge NHDArea_aoi_select and NHDWaterbody_aoi_select.
 - Tool: Merge (Data Management Tools > General)
 - Inputs: NHDArea_select, NHDWaterbody_select
 - Output: NHD_Area_Waterbody_select_merge
 - Optional: Set the desired coordinate system for the output in the Environment Settings (Environments... > Output Coordinates). Again, use a projected coordinate system – a State Plane coordinate system is a good option for accurate area calculations.
7. Add a new field for the dissolve step.
 - Tool: Add Field (Data Management Tools > Fields)
 - Input: NHD_Area_Waterbody_select_merge
 - Field Name: Open_Water
 - Type: Short
8. Calculate the new field with the same value for all features.
 - Tool: Calculate Field (Data Management Tools > Fields)
 - Input: NHD_Area_Waterbody_select_merge
 - Field Name: Open_Water
 - Expression Type: Python 9.3
 - Expression: 1
 - Any value would work here. In this case all features are calculated to equal the integer 1.
9. Dissolve features.
 - Tool: Dissolve (Data Management Tools> Generalization)
 - Input: NHD_Area_Waterbody_select_merge
 - Output: NHD_Area_Waterbody_select_merge_dissolve
 - Dissolve field: Open_Water
 - Create multipart features? No (uncheck)
 - Make sure the output does NOT contain multipart features. The output must have single part features for the following steps.
10. Add a new field to calculate area of features.
 - Tool: Add Field (Data Management Tools > Fields)
 - Input: NHD_Area_Waterbody_select_merge_dissolve
 - Field Name: Area_acres
 - Type: Double
11. Calculate the area of features.
 - Calculate Geometry. In attribute table for NHD_Area_Waterbody_select_merge_dissolve right-click on the field Area_acres in table of contents > Calculate Geometry.
 - Property: Area
 - Coordinate System: same as data source
 - Units: Acres US [ac]
12. Select features greater than 10 acres
 - Tool: Select (Analysis Tools > Extract)
 - Input: NHD_Area_Waterbody_select_merge_dissolve
 - Expression: Area_acres > 10
 - Output: Open_Water_g10acres

GIS Analysis

Input GIS Data

- S_FLD_HAZ_AR_clip
- Federal_Tribal_Lands_g10acres
- Open_Water_g10acres

Output GIS Data

[Community_Name]_aSFHA - the SFHA with federal lands, tribal lands, and water bodies excluded, with area calculated.

GIS Steps

1. From the S_FLD_HAZ_AR_clip, extract the community SFHA
 - Tool: Select (Analysis Tools > Extract)
 - Input: S_FLD_HAZ_AR_clip
 - Expression: "SFHA_TF" = 'T'⁸
 - Output: [Community_Name]_SFHA
 - Use the official National Flood Insurance Program/CRS community name
2. Merge areas to exclude from community SFHA
 - Tool: Merge (Data Management Tools > General > Merge)
 - Inputs: Federal_Tribal_Lands_g10acres, Open_Water_g10acres
 - Output: Excluded_Areas
3. Remove excluded areas from community SFHA
 - Tool: Erase⁹ (Analysis Tools > Overlay > Erase)
 - Input Feature: [Community_Name]_SFHA
 - Erase Feature: Excluded_Areas
 - Output: [Community_Name]_SFHA_erase
4. Visually inspect the output for any slivers or missed areas over open water. There may be some areas of open water that were not captured well in the NHD layers, or there may be some small isolated slivers resulting from the running the Erase tool. These extra areas should be removed to improve the accuracy of the adjusted SFHA for the community.

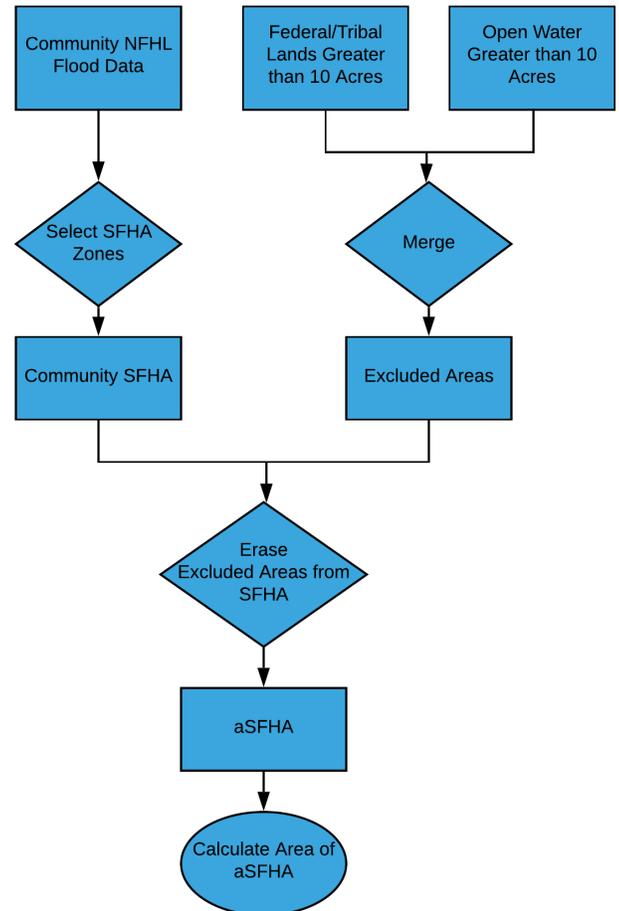


Figure 2: A diagram of the workflow for calculating the area of the impact adjusted SFHA (aSFHA).

⁸ This field is standard in data downloads from the FEMA Map Service Center. Older digital flood zone data or data from other sources may not have a similar field. In those cases, use the Select tool to extract all "A" and "V" zones. The SFHA includes Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, V1-30, VE, and V.

⁹ "Erase" Tool requires the Advanced license for ESRI ArcGIS Desktop. Alternatively, use the "Union" Tool; then select the FID(s) of the polygons you want to remove and delete in an editing session.

- In the map document, review the [Community_Name]_aSFHA output. If you find areas that should be removed, continue with the steps below. Otherwise, move on to the next section of the GIS Workflow.
 - Run the Multipart to Singlepart tool before editing. This makes sure any isolated features are separate.
 - Tool: Multipart to Singlepart tool (Data Management > Features)
 - Output: [Community_Name]_SFHA_erase_singlepart
 - Start an editing session with the Editor toolbar.
 - Use the Select tool to manually select areas that should be deleted.
 - In the attribute table, right-click on the selected feature and choose Delete Selected.
 - Save edits.
 - If necessary, use the Cut Polygon Tool on the Editor Toolbar to split any feature that needs a portion removed. Then use the Select tool to select the portion to remove and deleted the selected feature in the attribute table.
5. Dissolve remaining SFHA features by flood zone type.
- Tool: Dissolve (Data Management Tools > Generalization > Dissolve)
 - Input: [Community_Name]_SFHA_erase (or [Community_Name]_SFHA_erase_singlepart)
 - Output: [Community_Name]_aSFHA
 - Dissolve field: "FLD_ZONE"
 - Create multipart features? Yes (checked)
6. Add field for area calculations to the attribute table for [Community_Name]_aSFHA.
- Open attribute table. Right-click on [Community_Name]_aSFHA in table of contents > Open Attribute Table > Table Options > Add Field
 - Field Name: aSFHA
 - Field Type: Double
7. Calculate areas of aSFHA zones.
- Calculate Geometry. In attribute table for [Community_Name]_aSFHA, right-click on aSFHA in table of contents > Calculate Geometry
 - Property: Area
 - Coordinate System: same as data source
 - Units: Acres US [ac]
8. View total area of aSFHA
- In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics > view value for Sum
 - The "Sum" value will be the denominator in the OSP equation. You will use this value in Step 4 to calculate potential OSP credit points.
 - Record the total area of aSFHA here for future reference:
Hint: If you are working with a downloaded version of this document, you could add a comment here with the aSFHA value. It will be easily accessible for future calculations.

Additional regulatory floodplains (optional): If you have additional regulatory floodplains for these analyses, you will need to repeat the method outlined above for mapping the impact adjusted SFHA (aSFHA). Be sure to follow the data preparation step to clip the data before beginning. Repeat steps 1-7 to create a separate impacted

adjusted layer for the additional floodplains. Later in the workflow, you will also need to repeat steps for mapping open space within this impacted adjusted layer for the additional floodplains.

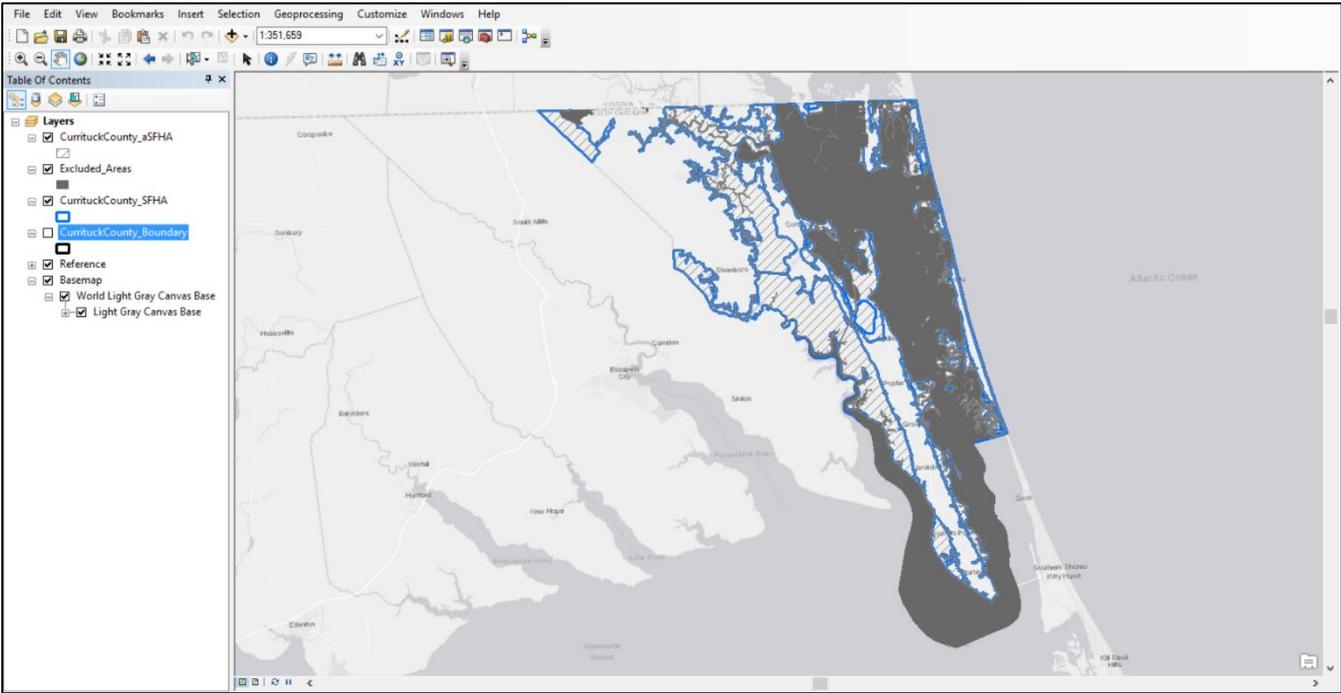


Figure 3: Currituck’s special flood hazard area, as determined by FEMA, and the aSFHA (federal and tribal lands and open water, or excluded areas, removed from the SFHA).

Step 2. Identify Lands That May Qualify for Open Space Preservation Credit

Communities earn open space preservation credit for “preserved” lands or lands “protected” through land development regulations that prohibit buildings, storage, fill, significant pavement, or other encroachment to flood flows. To be eligible, land must be within the SFHA and be protected from future development through land use regulations or by the property owner. Lands that are simply vacant do not qualify. In this section, you will identify land eligible for OSP credit.

This workflow utilizes the Protected Areas Database of the U.S. (PAD-US) as the source data for open space. Local data may be available to supplement the PAD-US data and improve the results of OSP analysis. See the discussion of other data inputs in the “Data Preparation” section below.

Objectives

Identify open space preservation (OSP) areas within the Special Flood Hazard Area (SFHA) or regulatory floodplain

- Types of public land: State and local parks and easements kept as open space (as documented by the owning agency). Examples include state, county, and city parks and forest preserves, publicly owned beaches or natural areas, school playing fields, cemeteries, and floodplain easements dedicated to the community by developers.
- Types of private land: Private wildlife or nature preserves, or private parcels with conservation easements maintained for open space purposes for at least five years (as documented by the owner or deed restriction). Examples include church retreats, hunting club lands, golf courses, or camping areas owned by nonprofit associations. See Section 422a in the CRS Coordinator’s Manual for more information.

Data Preparation

Remember:

- Make sure all of the data are in the same projected coordinate system. A State Plane coordinate system is a good option for accurate area calculations.
- Save outputs to the project file geodatabase. If that is set up as the default geodatabase for your mapping document, all outputs will automatically write to that location.

Prepare Protected_Areas

This layer will be used to map eligible preserved open space within the community.

1. From the PADUS_aoi output that was created in the previous step (by spatial selection with the community boundary), select all features that are NOT federally or tribally managed lands, which will be used as the protected areas input.
 - Tool: Select (Analysis Tools > Extract)
 - Input: PADUS_aoi
 - Expression: NOT (Mang_Type = 'FED' OR Own_Type = 'FED' OR Own_Type = 'TRIB')
 - This expression is the opposite of the expression used in the previous section when preparing the Federal_Tribal_Lands_g10acres layer
 - Output: Protected_Areas
 - Optional: Set the desired coordinate system for the output in the Environment Settings (Environments... > Output Coordinates). Again, use a projected coordinate system. A State Plane coordinate system is a good option for accurate area calculations.
2. Add a new field to create unique ids for the features.
 - Tool: Add Field (Data Management Tools > Fields)
 - Input: Protected_Areas
 - Field Name: OSP_ID
 - Type: Text
3. Calculate unique ids for the features.
 - Tool: Calculate Field (Data Management Tools > Fields)
 - Input: Protected_Areas
 - Field Name: OSP_ID
 - Expression Type: Python 9.3
 - Expression: "PADUS_" + str(!OBJECTID!)
 - This expression uses the OBJECTID value converted to a string. "PADUS_" is used in the unique id to distinguish from any other data inputs that may be incorporated.

If necessary, reproject the output to the appropriate coordinate system you will use for this work. This step will not be necessary if the Output Coordinates were set in the Environment Setting for the Select tool as suggested.

Additional open space data options:

Again, there may be data options available at the state, county, or municipal level that could provide preserved open spaces that are not captured in PAD-US. Parks, nature preserves, natural resource management areas, setback areas, and private easements are a few examples of potential eligible open spaces that may be more thoroughly represented in local data. Parcel-level data for the community may provide some of these areas. Appropriate data could be acquired from a variety of agencies or organizations, such as parks departments, land use or planning departments, floodplain managers, and land trusts.

To include an additional data option for the eligible open space input, you could either append additional preserved open space areas to the Protected_Areas layer developed in the steps above or use the local data as a replacement to PAD-US as you develop the Protected_Areas layer. If appending additional data to Protected_Areas, be sure to add and populate the “OSP_ID” field to the features being appended. It is recommended to use an ID code that keeps each area unique but also makes it easy to distinguish the different data sources. For example, in the steps for Protected_Areas listed above, “OSP_ID” values are made from combining “PADUS_” and the unique object IDs in the attribute table. Similarly, if you append features from an additional data source, use an intuitive naming convention for those features that both distinguishes the data source and creates unique IDs.

GIS Workflow

Input GIS Data

- [Community_Name]_aSFHA
- Protected_Areas

GIS Output Layer

OSP_Eligible – Land areas preserved as open space in the aSFHA and eligible for OSP credit.

GIS Steps

1. Extract Protected_Areas that intersect the [Community Name]_aSFHA. These will be the eligible open space features.
 - Tool: Clip (Analysis Tools > Extract > Clip)
 - Input Features: Protected_Areas
Note: If using a different data source than PAD-US for protected areas, use that dataset as the alternative input here.
 - Clip Features: [Community_Name]_aSFHA
 - Output: Protected_Areas_clip
2. Check for overlaps or duplicate features. The PAD-US database has been developed from combining data from various sources. As a result, there are instances of features overlapping or even exact duplicates of features existing in the same space. Feature overlaps essentially double count the eligible area, which corrupts the results. Therefore, overlaps in mapped eligible areas must be identified and resolved.
 - Run the Intersect tool on only Protected_Areas_clip. This will create an output for all overlap areas, with two or more features for every overlap—one from each of the original overlapping features.

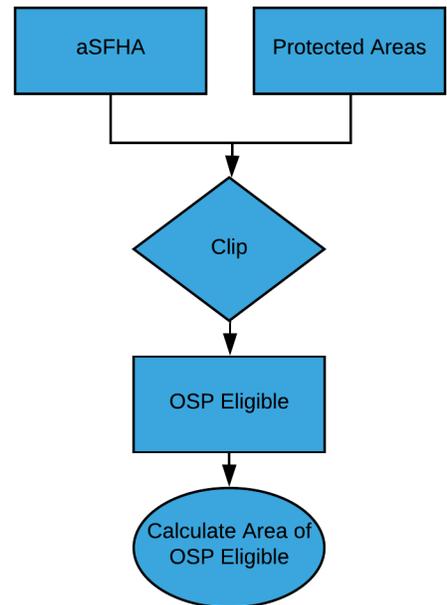


Figure 4: A diagram of the workflow for mapping and calculating areas of OSP eligible lands.

- Tool: Intersect (Analysis Tools > Overlay).
 - Input: Protected_Areas_clip
 - Output: Protected_Areas_clip_SelfIntersect
 - Join Attributes: All
 - Check the attribute table for Protected_Areas_clip_SelfIntersect. If the attribute table is empty, there are no overlap issues and you can move on to number 3 and disregard the Protected_Areas_clip_SelfIntersect output.
 - If there are features in the attribute table, you may need to follow the remainder of this guidance to resolve the overlaps before you proceed with mapping the protected open space.
 - Run the Union tool on just the Protected_Areas_clip output. This will make all overlap areas into sets of unique overlaying identically shaped polygons.
 - Tool: Union ((Analysis Tools > Overlay)
 - Input: Protected_Areas_clip
 - Output: Protected_Areas_clip_SelfUnion
 - Join Attributes: All
 - Use the Delete Identical tool on the Protected_Areas_clip_SelfUnion layer to remove identical features with the exact same values for SHAPE_AREA and SHAPE_LENGTH. This assumes that only overlaying identically shaped features will share the exact same values for these fields.
 - Tool: Delete Identical (Data Management > General)
 - Input: Protected_Areas_clip_SelfUnion
 - Fields: SHAPE_Area, SHAPE_Length (check boxes next to each)
3. Dissolve by OSP_ID. This will ensure that all features for each unique protected area will be grouped together for the analyses in the next sections. The input here will depend upon whether you had to resolve overlap areas prior to this step. If you did resolve overlap areas and ran the Delete Identical Tool, you will use the Protected_Areas_clip_SelfUnion layer as an input here. Otherwise, you will use Protected_Areas_clip layer as the input.
 - Tool: Dissolve (Data Management > Generalization)
 - Input: Either Protected_Areas_clip_SelfUnion or Protected_Areas_clip
 - Dissolve Field: OSP_ID
 - Output: OSP_Eligible
 4. Add a new field to OSP_Eligible to calculate area of eligible open space features.
 - Open attribute table. Right-click on OSP_Eligible in table of contents > Open Attribute Table > Table Options > Add Field
 - Name: OSP_acres
 - Type: Double
 5. Calculate area of eligible open space features.
 - Calculate Geometry. In attribute table for OSP_Eligible, right-click on OSP_acres > Calculate Geometry
 - Property: Area
 - Coordinate System: same as data source
 - Units: Acres US [ac]
 6. Remove slivers and very small areas.
 - Start an Editing session.
 - In the attribute table, right-click on "OSP_acres" and Sort Ascending.

- Under Table Options, use Select By Attributes to select features where $OSP_acres < 0.01$
- Delete selected polygons.
- Save Edits and Stop Editing.

Additional regulatory floodplains (optional): If you mapped an impacted adjusted layer for the additional floodplains in the previous section, you will now need to map the preserved open space within those areas. Repeat the methods outlined in this section. Once you complete mapping eligible open space in the impacted adjusted layer for the additional floodplains, you will need to append all of those additional features to the `OSP_Eligible` layer. Then you can proceed with the standard methods for the remainder of this workflow.

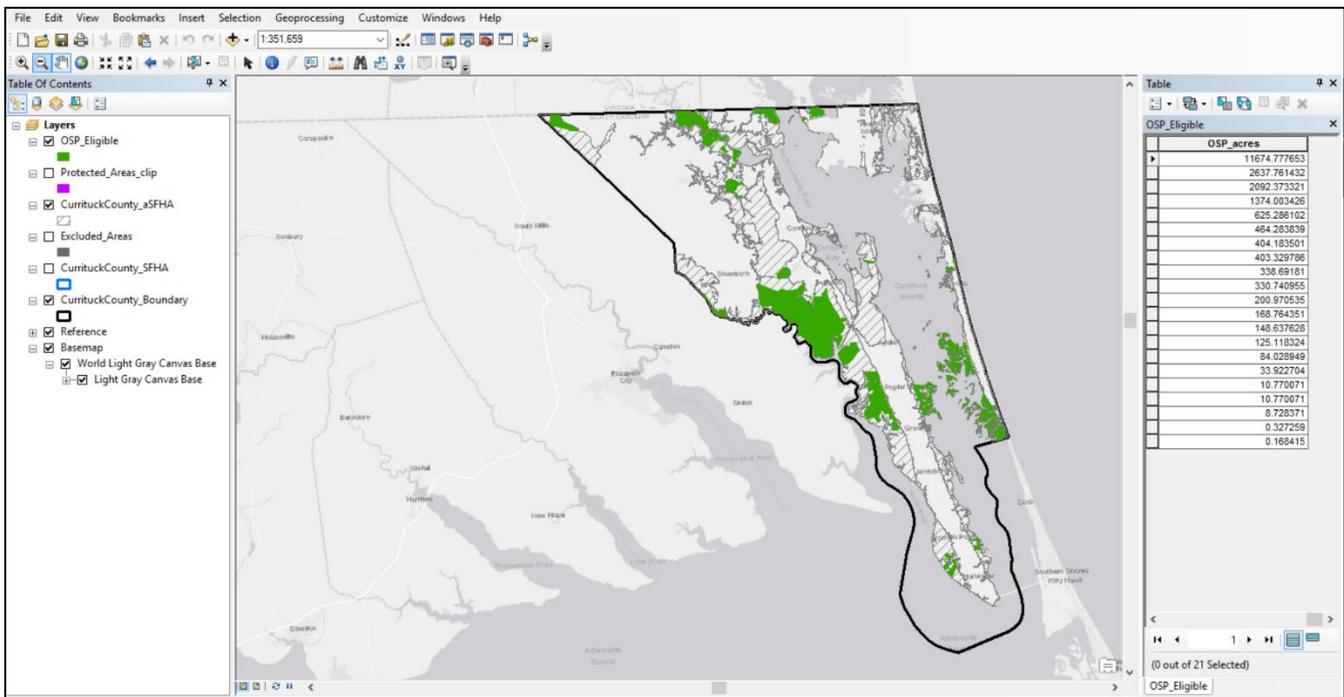


Figure 5: Areas within the aSFHA that contain preserved open space (in green) and are eligible for OSP credit.

Step 3. Calculate Areas That Do Not Qualify for Open Space Credit

In addition to federal and tribal lands and large water bodies, several types of areas do not qualify for credit. Such areas include large impervious surface areas, areas on which certain land uses or encroachments obstruct flood flows or aggravate flooding, publicly owned land that is not intended for open space, and parcels smaller than 10 acres that contain an insurable building.¹⁰ Fill, storage of materials, or other encroachments also need to be excluded¹¹ because they aggravate flooding by creating obstructions to the flow or loss of storage of floodwaters.

In this workflow, the focus is upon impervious surface areas. You will calculate the area of impervious surface within eligible OSP areas, which will ultimately be subtracted from the amount of open space eligible for CRS credit.

Objectives

Calculate the acreage of OSP-eligible areas covered by impervious surfaces, linear features, and rights-of-way that are necessary to serve the development or use of an area. The acreage for these features will be removed from the eligible areas of open space.

- Impervious surfaces: Areas with large amounts of impervious surfaces, such as driveways, parking lots, buildings, or paved amenities (e.g., ball courts). Do not exclude minor areas such as sidewalks, trails, or pervious pavements. See Section 422a of the CRS Coordinator’s Manual.
- Linear features and rights-of-way: Streets, pavement, parkway, railroad, levee, canals, ditches, and channels. See Section 422a of the CRS Coordinator’s Manual.

Data Preparation

Remember:

- Make sure all of the data are in the same projected coordinate system. A State Plane coordinate system is a good option for accurate area calculations.
- Save outputs to the project file geodatabase. If that is set up as the default geodatabase for your mapping document, all outputs will automatically write to that location.

Extract land cover or impervious surface data to closely match the community boundary extent, if necessary.

If your land cover or impervious surface dataset covers an area much larger than the extent of your community boundary, you should consider extracting data to reduce the file size and reduce run time for the geoprocessing

¹⁰ Some exceptions apply – see the CRS *Coordinator’s Manual* for details.

¹¹ This does not apply to construction of sand dunes, beach nourishment, and habitat restoration projects.

tools. For example, if you have a state land cover file, by extracting the land cover data to the extent of your community boundary, the geoprocessing tools could complete significantly faster than if run with the full state land cover file.

Depending on the format of the land cover or impervious surface data, different geoprocessing tools are available for extracting data to exact community boundary polygons. Typically land cover and impervious surface data are in raster format. Therefore, in most cases you would need to extract raster data. The method for extracting raster data with the Extract by Mask tool is outlined below. As noted, the Extract by Mask tool belongs to the Spatial Analyst Toolbox, which requires an extension that is not included with all versions of the ArcGIS Desktop Software. A workaround to extract the raster data to the general extent of the [Community_Name]_boundary is also provided as an alternative approach in case you do not have access to the Spatial Analyst Toolbox.

Choose the option that matches your data format and software set up:

Extracting raster data with the Extract by Mask tool:

1. Extract the raster data with [Community_Name]_boundary as a mask
 - Tool: Extract by Mask (Spatial Analyst Tools > Extraction)¹²
 - Input raster: your raster-based land cover or impervious surface data
 - Input feature mask data: [Community_Name]_boundary
 - Output: Add “_ext” to the end of the input raster file name

Workaround for extracting raster data without Spatial Analyst extension:

1. In the table of contents, right-click on [Community_Name]_boundary. Select Zoom to Layer. This will zoom the map view to the community boundary.
2. In the table of contents, right-click on the land cover or impervious surface data to extract from. Select Data in the menu of options. Then select Export Data.
 - For Extent, select Data Frame.
 - Make sure all information for the export is correct.
 - Specify the export location and name the file by adding “_ext” to the end of the original file name

If you have vector-based data for impervious surfaces to extract to the [Community_Name]_boundary:

1. Clip the data to In the table of contents, right-click on [Community_Name]_boundary. Select Zoom to Layer. This will zoom the map view to the community boundary.
 - Tool: Clip (Analysis Tools > Extract)
 - Input Features: Your vector-based impervious surface data
 - Clip Features: [Community_Name]_boundary
 - Output Feature Class: Add “_ext” to the original file name

This extracted file should be used as the input for land cover or impervious surface data in the steps within this section.

¹² This tool requires the ArcGIS Spatial Analyst extension.

GIS Workflow

Input GIS Data

One of the following (options discussed in the Data Download portion of the GIS Workflow Introduction):

- State or local land cover or impervious surface data; or
- C-CAP land cover data (high-resolution land cover or 10-meter land cover); or
- C-CAP 30-meter impervious surface data; or
- NLCD Percent Impervious data

Output GIS data

Calculations of impervious surface areas for each feature in OSP_Eligible.

GIS Steps

The methods for calculating impervious surface areas varies depending on the input data. Three different methods are outlined below for different data types.

Find the section that matches your impervious surface data type and follow that workflow.

Data type: Raster land cover data with a land cover class specifically for impervious surface or development (e.g., C-CAP high-resolution land cover data or C-CAP 10-meter land cover data)

This section outlines a method to calculate the amount of impervious surface within each eligible OSP area by tabulating the number of pixels classified as impervious surface (or developed) within each area. This method is applicable for land cover data that contain a class (or classes) specifically for mapping man-made impervious surfaces (sometimes called developed or development). C-CAP high-resolution land cover data products as well as the C-CAP 10-meter land cover products contain an Impervious Surfaces land cover class, which is always set at a value of 2 in the raster file (Value = 2). If working with similar land cover or impervious raster data, you need to determine the specific class and row value that represents impervious surfaces.

1. Calculate the area of land cover classes that intersect eligible open spaces.
 - Tool: Tabulate Area (Spatial Analyst Tools > Zonal > Tabulate Area)
 - Input feature zones: OSP_Eligible
 - Zone field: OSP_ID
 - Input raster: C-CAP high-resolution or 10-meter data (or other)
 - Class field: Value
 - Output table: OSP_Eligible_CCAP_TabArea
 - Note: Verify that the processing cell size matches the cell size of your land cover or impervious surface raster
2. Add new field to calculate area of impervious surface in acres.
 - Right-click on OSP_Eligible_CCAP_TabArea in table of contents > Open Attribute Table > Table Options > Add Field

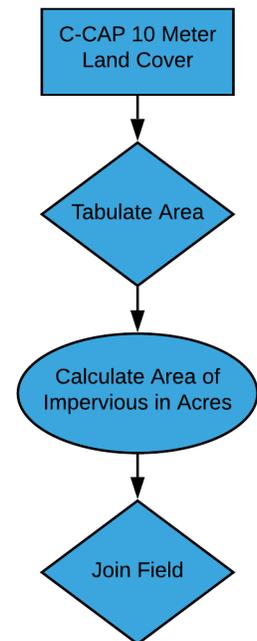


Figure 6: A diagram of the workflow to calculate areas of impervious surfaces from land cover data with the Tabulate Area Tool.

- Name: Imperv_acres
 - Type: Double
3. Calculate the area of impervious surface in acres. Verify the linear units of the input raster in Step 1 above and use the appropriate conversion. Meters: 1 acre = 4046.86 square meters. Feet: 1 acre = 43,560 square feet.
 - In the attribute table for OSP_Eligible_CCAP_TabArea, right-click on Imperv_acres. Select Field Calculator.
 - Choose the appropriate expression below (based on linear unit of raster) and execute the calculation:
 - Meter: $[\text{VALUE}_2]/4046.86$, Feet: $[\text{VALUE}_2]/43,560$Note: For data other than C-CAP products mentioned here, use the appropriate class tabulation field in this expression.
 4. Join Imperv_acres field to OSP_Eligible.
 - Tool: Join Field (Data Management Tools > Joins > Join Field)
 - Input Table: OSP_Eligible
 - Input Join Field: OSP_ID
 - Join Table: OSP_Eligible_CCAP_TabArea
 - Output Join Field: OSP_ID
 - Join Field: Imperv_acres
 5. Check for NULL values in the Imperv_acres field. Convert any NULL values to zero. This is necessary because this field will be used in another calculation later and NULL values are not valid for numeric calculations.
 - In the attribute for OSP_Eligible, open the Table Options menu.
 - Choose Select by Attributes.
 - Build this expression: Imperv_acres IS NULL. Click Apply.
 - If NULL values are found, right-click on the field Imperv_acres . Select Field Calculator. Enter 0 (zero). Click OK.

Data type: Percent impervious surface raster data (C-CAP 30-meter Impervious Surface data or NLCD Percent Developed Imperviousness)

This section outlines a method to calculate an average (or mean) percent impervious surface value for each eligible OSP area. This method applies to raster data where the row value (VALUE) of each cell (ranging from 0 to 100) represents the percent of the cell area covered by impervious surfaces. For example, a cell with a row value of 75 indicates that 75-percent of the area within the cell is covered by impervious surfaces. In this method, the Zonal Statistics tool analyzes all cells of impervious surface data that intersect each eligible OSP area and then calculates a single average (or mean) value for percent of impervious surface for each eligible OSP area.

1. Calculate the average percent impervious value for cells that intersect eligible open spaces.
 - Tool: Zonal Statistics as Table (Spatial Analyst Tools > Zonal , Zonal Statistics as Table
 - Input feature zone data: OSP_eligible

- Zone field: OSP_ID
 - Input value raster: C-CAP or NLCD Impervious Surface data
 - Output table: OSP_Eligible_[CCAP or NLCD]_Impervious_MEAN
Note: Use the appropriate acronym in the brackets to create a continuous string for the output name.
 - Statistics type: MEAN
2. Change the name of the field MEAN to something more descriptive. This is preparation for joining the field to the OSP_Eligible attribute table.
 - Tool: Alter Field (Data Management Tools > Fields > Alter Field)
 - Input Table: OSP_Eligible_[CCAP or NLCD]_Impervious_MEAN
 - Field Name: MEAN
 - New Field Name: [CCAP or NLCD]_MEAN_PctImperv
 - Note: Use the appropriate acronym in the brackets to create a continuous string for the field name.
 3. Join the field for mean percent impervious to the OSP_Eligible attribute table.
 - Tool: Join Field (Data Management Tools > Joins > Join Field)
 - Input Table: OSP_Eligible
 - Input Join Field: OSP_ID
 - Join Table: OSP_Eligible__[CCAP or NLCD]_Impervious_MEAN
 - Output Join Field: OSP_ID
 - Join Field: [CCAP or NLCD]_MEAN_PctImperv
 4. Add a new field to OSP_Eligible to calculate the area of impervious cover in the eligible open spaces
 - Right-click on OSP_Eligible in table of contents > Open Attribute Table > Table Options > Add Field
 - Name: Imperv_acres
 - Type: Double
 5. Calculate the area of impervious cover in the eligible open spaces by multiplying the percent of imperviousness of the open space feature by the area of the open space feature (OSP_acres)
 - In the attribute table for OSP_Eligible, right-click on Imperv_acres. Select Field Calculator.
 - Enter the expression below and execute the calculation:

$$([\text{CCAP or NLCD}]_Mean_PctImperv)/100 * [\text{OSP_acres}]$$
 6. Check for NULL values in the Imperv_acres field. Convert any NULL values to zero. This is necessary because this field will be used in another calculation later and NULL values are not valid for numeric calculations.
 - In the attribute for OSP_Eligible, open the Table Options menu.
 - Choose Select by Attributes.
 - Build this expression: Imperv_acres IS NULL. Click Apply.

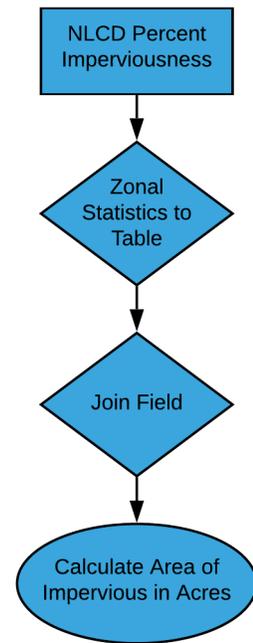


Figure 7: A diagram of the workflow to calculate areas of impervious surfaces from a percent imperviousness raster with the Zonal Statistics Tool.

- If NULL values are found, right-click on the field Imperv_acres. Select Field Calculator. Enter 0 (zero). Click OK.

Data type: Vector Data, such as Roads and Building Footprints from OpenStreetMap

Impervious surface data may be in vector format. Also, as discussed in the “Download GIS Data” section of the “Introduction,” you may need to supplement land cover or impervious surface data that do not completely capture impervious surfaces in the eligible OSP areas you map. Calculating impervious surface cover with vector data requires a different set of tools. Below is a general outline of a method for calculating impervious surface coverage in OSP_Eligible.

1. Clip OSP_Eligible with the vector-based impervious surface data (Analysis Tools > Extract)
 - Input Features: OSP_Eligible
 - Clip Features: vector based impervious surface data
2. In the attribute table for the output, add a new field to calculate the area (type: Double). An example field name if the impervious surface data were OpenStreetMap could be “OSM_imperv_acres”
3. Still in the attribute table of the output, right-click on the new field added in the step above and choose Calculate Geometry.
 - Property: Area
 - Units: Acres US (ac)
4. Join the area field from the clip output to OSP_Eligible
 - Tool: Join Field (Data Management Tools > Joins)
 - Input Table: OSP_Eligible
 - Input Join Field: OSP_ID
 - Join Table: output from clip
 - Output Join Field: OSP_ID
 - Join Field: area field added in step 2
5. Select NULL values in the joined field and calculate to zero. Open the attribute table of OSP_Eligible. Using the Select by Attributes tool in from the table options menu, select where the joined area field is NULL. If features were selected, right-click on the joined area field and choose the Field Calculator. Enter (zero)). Click OK.

Note: if you are using vector-based impervious surface data to supplement another dataset, you will need to add the area calculated in these steps to the “Imperv_acres” which should have been calculated previously.

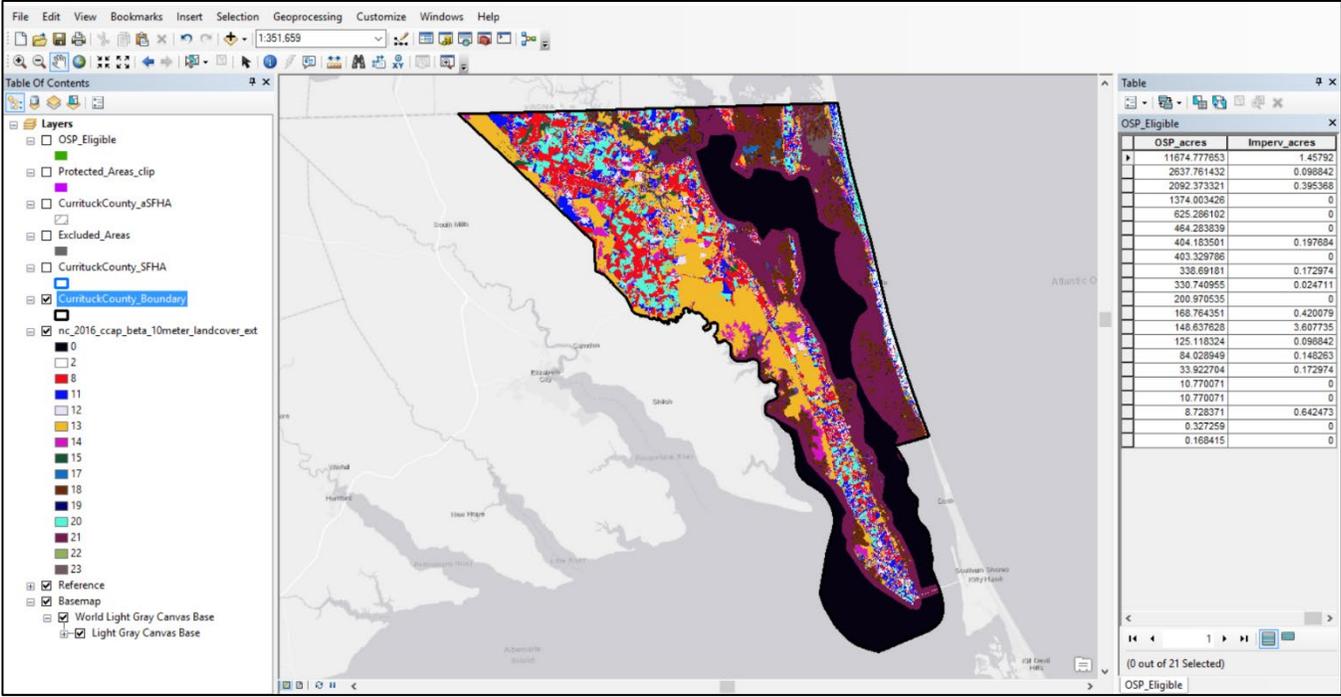


Figure 8: Map showing 10-meter C-CAP land cover as the input for impervious surface calculations. The field Imperv_acres is shown in the attribute table.

Step 4. Calculate Possible Credit for the Community's Preserved Open Space

Open space preservation credit is calculated based on the “impact adjustment” ratio. The total impact adjusted acreage of preserved open space in the regulatory floodplain (aOSP) is divided by the total acreage of the community's impact adjusted Special Flood Hazard Area (aSFHA), and then the resulting ratio (rOSP) is multiplied by the maximum points for Element 422a (1450) to determine total credit that could be earned for Element 422a (OSP).

Objectives

Incorporate the outputs from previous sections into the OSP equation to determine the potential OSP credits.

GIS Workflow

Input GIS Data

- [Community_Name]_aSFHA
- OSP_Eligible

Output GIS Data

OSP eligible areas with attributes for acreage of qualifying preserved open space (aOSP) and potential CRS credit for Element 422a (cOSP).

GIS Steps

1. Add a new field to OSP_Eligible to calculate the impact adjusted area of eligible open space. The area of impervious surface cover must be subtracted from the area of open space.
 - Right-click on OSP_Eligible in table of contents > Open Attribute Table > Table Options > Add Field
 - Name: aOSP
 - Type: Double
2. Calculate the impact adjusted area of eligible open space by subtracting the area of impervious cover from the total OSP area.
 - In the attribute table for OSP_Eligible, right-click on aOSP. Select Field Calculator.
 - Enter the expression below for “aOSP” and execute the calculation:
[OSP_acres] - [Imperv_acres]
3. Add new field to OSP_Eligible to calculate possible opens space credits.
 - Right-click on OSP_Eligible in table of contents > Open Attribute Table > Table Options > Add Field
 - Name: cOSP
 - Type: Double

4. Calculate possible credits for each open space area. Remember, the equation for calculating CRS credits for this activity involved multiplying the impact adjustment ration by the maximum credits. This would be: $(aOSP/aSFHA) * 1450$.
 - Revisit [Community_Name]_aSFHA to get the total area of the impact adjusted SFHA, which will be the denominator in the impact adjustment equation.
Note: If you followed the hint and made a comment or note of the aSFHA value when you first calculated it, you can retrieve that value and skip the next two bullets.
 - In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
 - Copy the Sum in the statistics table. This is the total area of aSFHA in acres.
 - In the attribute table for OSP_Eligible, right-click on cOSP. Select Field Calculator.
 - Enter the expression below for “cOSP” and execute the calculation:
 $([aOSP]/\text{pasted value from step 4a above}) * 1450$
5. View the Sum for cOSP to see the total for potential OSP credits identified through your work.
 - In the attribute table for OSP_Eligible, right-click on cOSP. Select Statistics.
 - The value for Sum in the Statistics table is the total potential credits for preserved open space you have mapped. You may want to paste this value somewhere for future reference.

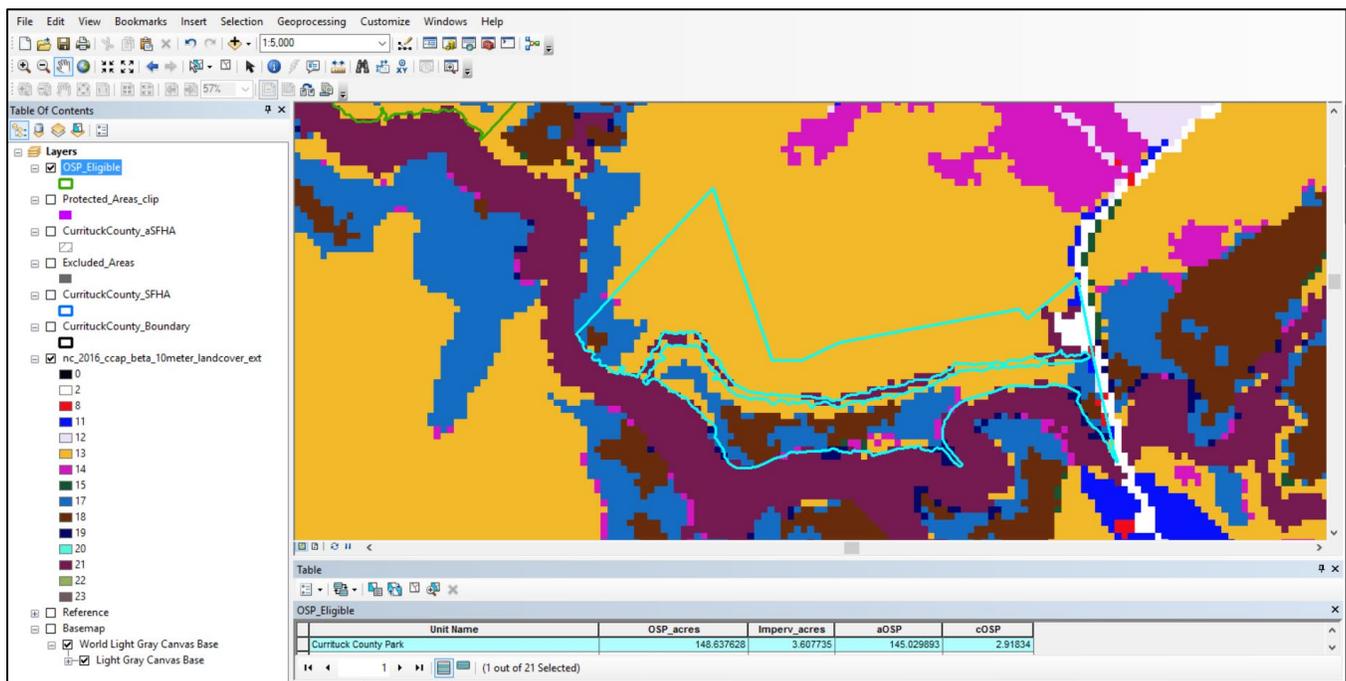


Figure 9: Highlighted example of preserved open space with area of impervious surfaces subtracted to calculate aOSP (area that qualifies as OSP) and cOSP (OSP credit).

Step 5. Determine Whether Preserved Open Space Qualifies for “Extra Credit”

NOTE: This step is optional and not required. Please skip to Step 6 if not completing extra credit analysis.

Areas that qualify as preserved open space (OSP) may also qualify for “extra credit.” Several elements within activity 420 provide additional credits for eligible open space areas based upon characteristics of the area or the nature of established protections. The following are some of the “extra credit” elements within Activity 420:

- 422b. Deed restrictions (DR): Up to 50 points extra credit for legal restrictions that ensure that parcels credited for OSP will never be developed.
- 422c. Natural functions open space (NFOS): Up to 350 points extra credit for OSP-credited parcels that are preserved in or restored to their natural state.

There are four types of NFOS credit. This GIS Workflow provides detailed methods for the first type – NFOS1.

- NFOS1 = open space areas preserved in their undeveloped natural state, or that were formerly farmed or developed but restored to their natural, pre-development conditions. An area must be credited for NFOS1 before it is eligible for NFOS2, NFOS3, or NFOS4. (up to 190 points)
- NFOS2 = areas that qualify as NFOS1 and are designated in a natural floodplain functions protection plan that meets the criteria for such plans¹³ as described in Activity 512c. (Floodplain Management Planning) (up to 50 points)
- NFOS3 = areas that qualify as NFOS1 and are designated as critical habitat for threatened or endangered species or if the species is present. This includes species already on an official federal or state list as threatened or endangered or as a “species of concern.” (up to 50 points)
- NFOS4 = areas that qualify as NFOS1 and are in an open space corridor or connected network (e.g., wetlands, woodlands, or wildlife habitats) designated in an approved plan.¹⁴ (up to 60 points)
- 422d. Special flood-related hazards open space (SHOS): Up to 150 points if the OSP-credited parcels are subject to one of the special flood-related hazards or if areas of special flood-related hazard are covered by low-density zoning regulations.

¹³ Habitat conservation, restoration, or other community plan that recommends actions to protect the ecological attributes of the watershed or floodplain.

¹⁴ [State CELCP plans](#) or [state wildlife action plans](#) may be good sources for this information.

- 422e. Coastal erosion open space (CEOS): Up to 750 points if the OSP-credited parcels are subject to coastal erosion.

This GIS Workflow outlines methods to identify and calculate potential extra credit for the NFOS1 aspect of the Natural functions Open Space (NFOS) element (422c). A general workflow is also provided for the other NFOS extra credit opportunities as well the Deed Restrictions (DR) element (422b) extra credit opportunities, but the approach may vary depending upon the characteristics of the input data. There are additional elements for extra credit within Activity 420, which are not listed above. Those elements focus upon the existence of certain types of local zoning, development regulations, or shoreline management programs.

Calculating NFOS1 Extra Credit

This assumes PAD-US data were used to create OSP_Eligible as outlined in this workflow.

Objective

Determine whether areas eligible for OSP credit qualify for NFOS1 within the **Natural Functions Open Space** element, which credits eligible open spaces that are in an undeveloped natural state or have been restored to a natural state (up to 190 points).

Within this workflow, to identify eligible open spaces that may qualify for additional credit through NFOS1, you will use a field from the Protected Areas Database for the U.S. (PAD-US) that should exist within the OSP_Eligible output developed earlier. The field "GAP_Sts" contains the USGS GAP Status Code,¹⁵ which is a measure of management intent to conserve biodiversity. Protected areas designated as Status 1 are managed to "maintain a natural state" and those designated as Status 2 are managed to "maintain a primarily natural state" (Status 2). Both of these status codes indicate open space areas potentially eligible for NFOS1 extra credit.

The total acreage of qualifying areas (aNFOs#) is divided by the total acreage of the community's Special Flood Hazard Area (aSFHA), and then the resulting ratio (rNFOS#) is multiplied by the maximum credit for the sub-element (190) to determine the number of credits that could be earned for NFOS#. See Section 422c of the CRS Coordinator's Manual.

¹⁵ For more information on the USGS GAP Status Codes, visit the PAD-US Data Manual: <https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/pad-us-data-manual>.

GIS Workflow

Input GIS Data

- OSP_Eligible

Output GIS Data

OSP eligible areas that may also qualify for Element 422c Natural Functions Open Space (cNFOS) credit.

GIS Steps

1. Add field to OSP_Eligible attribute table to flag areas eligible for NFOS1 extra credit.
 - In the table of contents, right-click on OSP Eligible, then go to Open Attribute Table > Table Options > Add Field
 - Name: NFOS1
 - Type: Short Integer
2. Select the features eligible for NFOS1 extra credit.
 - In the attribute table for OSP_Eligible, open the Select by Attributes tool from the Table Options.
 - Select "Create new selection" as the method (should be the default).
 - Enter the expression below and execute:
`GAP_Sts IN ('1' , '2')`
3. Calculate the values for NFOS1
 - In the attribute table for OSP_Eligible, right-click on NFOS1. Select Field Calculator.
 - Enter the value 1 and execute the calculation.
 - Still in the attribute table for OSP_Eligible, use the Switch Selection icon to select the features that are not eligible for NFOS1
 - Right-click on NFOS1. Select Field Calculator.
 - Enter the value 0 and execute the calculation.
4. Add a new field to calculate the area for NFOS1 eligible features.
 - Still in the attribute table for OSP_Eligible, Table Options > Add Field
 - Name: aNFOS1
 - Type: Double
5. Add a new field to calculate potential extra credit points for NFOS1 eligible features.
 - Still in the attribute table for OSP_Eligible, Table Options > Add Field
 - Name: cNFOS1
 - Type: Double
6. Select NFOS1 eligible features again.
 - In the attribute table for OSP_Eligible, open the Select by Attributes tool from the Table Options
 - Select "Create new selection" as the method (should be the default)
 - Enter the expression below and execute:
`NFOS1 = 1`
7. Calculate area of NFOS1-eligible features.
 - In the attribute table for OSP_Eligible, with the NFOS1-eligible features still selected, right-click on aNFOS1. Select Field Calculator.
 - With NFOS1-eligible features selected from the attribute selection in the previous step, in the attribute table, right-click on the aNFOS1 field. Select the Field Calculator.

- Set this field to equal the values for field aOSP since the entire adjusted area previously calculated should be eligible. Enter aOSP in the Field Calculator and execute.
8. Calculate potential extra credit points for NFOS1-eligible features.
- Revisit [Community_Name]_aSFHA (the output from Step 1 - Calculate the community's adjusted Special Flood Hazard Area (aSFHA)) to get the total area of the impact adjusted SFHA, which will be the denominator in the equation for this step.
 - Note: If you followed the hint and made a comment or note of the aSFHA value when you first calculated it, you can retrieve that value and skip the next two bullets.
 - In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
 - Copy the Sum in the statistics table. This is the total area of aSFHA in acres.
 - In the attribute table for OSP_Eligible, with the NFOS1-eligible features still selected, right-click on cNFOS1. Select Field Calculator.
 - Enter the expression below and execute the calculation:
$$([aNFOS1]/aSFHA)*190$$
9. Select features not eligible for NFOS and set the potential credit values to zero.
- Still in the attribute table for OSP_Eligible, use the Switch Selection icon to select the features that are not eligible for NFOS1.
 - Right-click on cNFOS1. Select Field Calculator.
 - Enter the value 0 and execute the calculation.

Calculating Other Natural Functions Open Space Extra Credit

Again, there are three additional NFOS extra credit activities:

- NFOS2 – Floodplain Protection – 50 points
- NFOS3 – Critical Habitat – 50 points
- NFOS4 – Conservation Corridor – 60 points

For NFOS2, NFOS3, and NFOS4 extra credit calculations, the methods are different than outlined above for NFOS1. In general terms, the analysis includes intersecting OSP Eligible areas with data representing extra credit areas, calculating the acreage of extra credit eligible areas, then calculating the potential extra credits for those areas by multiplying the ratio to aSFHA (extra credit area / aSFHA) by the maximum number of credits possible. Data for these other NFOS extra credit options are likely available from state or local agencies.

An example for NFOS3 is outlined below:

1. Intersect OSP_Eligible and Critical Habitats. Save as OSP_Eligible_CH
2. Dissolve OS_Eligible_CH by the unique ID field ("OSP_ID") to remove duplicates. Save as OSP_Eligible_NFOS3.
3. In the table of contents, right-click on OSP Eligible NFOS3, go to Open Attribute Table > Table Options > Add Field (Name: NFOS3, Type: Short Integer). Right-click on NFOS3, go to Field Calculator, and enter 1 for "NFOS3=". This will flag areas eligible for NFOS3.
4. Go to Table Options > Add Field (Name: NFOS3_acres, Type: Double). Right-click on NFOS3_acres

and go to Calculate Geometry to calculate area (in acres) of each area that qualifies as NFOS3.

5. Go to Table Options > Add Field (Name: cNFOS3, Type: Double). Right-click on cNFOS3 > Field Calculator, and for cNFOS3 enter $([NFOS3_acres]/aSFHA)*50$.
NOTE: For aSFHA, revisit [Community_Name]_aSFHA (the output from Step 1 - Calculate the community's adjusted Special Flood Hazard Area (aSFHA)) to get the total area of the impact adjusted SFHA, which will be the denominator in the equation for this step.
 - In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
 - Copy the Sum in the statistics table. This is the total area of aSFHA in acres.
6. Join Field, where OSP_Eligible is the Input Table and OSP_Eligible_NFOS3 is the Join Table, the unique ID (OSP_ID) is both the Input Join Field and Output Join Field, and NFOS3, NFOS3_acres, and cNFOS3 are checked in Join Fields. This may take several minutes to run.

NOTE: Check the attribute table of OSP Eligible after Join Field to make sure it contains all joined fields, and scroll down to check that all values have transferred.

Calculating Deed Restrictions Extra Credit

For deed restriction (DR) extra credit, you will need a parcel layer that specifies parcels with eligible development restrictions or another dataset that represents areas with development restrictions, such as an easement. The example below outlines working with parcel data that have deed restrictions captured in the attribute table. This assumes PA-DUS was used for all eligible open space. The workflow may differ if other data were used to map eligible open space.

1. Add field to the parcel layer to flag parcels with deed restrictions. In the table of contents, right-click on the parcel layer, go to Open Attribute Table > Table Options > Add Field (Name: DR, Type: Short Integer). Then Add Field (Name: cDR, Type: Double).
2. Go to Table Options > Select by Attributes to select parcels with deed restrictions (based on the criteria that are unique to your parcel data). Right-click on DR, go to Field Calculator, and enter 1 for "DR=". This will flag parcels with deed restrictions. Switch Selection, right-click on DR, go to Field Calculator, and enter 0 for "DR=". This will attribute the remaining parcels as non-qualifying for this extra credit.
3. Use the Select tool to extract deed restricted parcels.
 - Input: parcel layer
 - Expression: DR = 1
 - Output: Parcels_DR
4. Intersect OSP_Eligible and Parcels_DR. Save as OSP_Eligible_DR.
5. Add field (Name: DR_acres, Type: Double).
6. In the attribute table, right-click DR_acres > Calculate Geometry.
 - Property: Area
 - Coordinate System: same as data source
 - Units: Acres US [ac]
7. Add Field (Name: cDR, Type: Double).
8. Calculate extra credits. Right-click on cDR, go to Field Calculator and for "cDR=" enter $([DR_acres]/aSFHA)*50$.

- For aSFHA, revisit [Community_Name]_aSFHA (the output from Step 1 - Calculate the community's adjusted Special Flood Hazard Area (aSFHA)) to get the total area of the impact adjusted SFHA, which will be the denominator in the equation for this step.
- In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
- Copy the Sum in the statistics table. This is the total area of aSFHA in acres.

Step 6. Gather Supporting Documentation for Each Parcel or Area to Submit to FEMA

To determine the final number of credits that can be awarded for each activity, FEMA will need to review documentation provided by the community and conduct a verification visit. The documentation needed for each element is summarized in the NOAA “How To” Guide, and described in more detail in the CRS Coordinator’s Manual.

Objectives

Produce a map that displays which parcels or areas qualify for OSP credit as well as any extra credit. This is the “impact adjustment map.” If the community is large and parcels are hard to see, create multiple impact adjustment maps. See Section 403 of the CRS Coordinator’s Manual.

Provide a list of all eligible open space areas. The list must correspond to the impact adjustment map and include property owner, land use designation, total acreage of parcel or area, and the total impact adjusted acreage (aOSP) of the eligible area. If using areas the community regulates outside of the special flood hazard area, the impact adjusted acreage of the parcel in the regulatory floodplain and in the aSFHA must also be included.

NOTE: Check with your ISO/CRS specialist to see if there is additional information they would like included on the impact adjustment map or in the parcel list.

GIS Workflow

Input GIS Data

- aSFHA
- Excluded_Areas
- OSP_Eligible

Outputs

The impact adjustment map and list of eligible OSP areas in an Excel spreadsheet.

GIS Steps

1. Create a base map that includes basic elements of cartography (e.g., map title, date, scale, and a legend). See pages 400-8 in the CRS Manual.
2. Overlay the aSFHA and OSP Eligible. (Include the regulatory floodplain outside the SFHA, if one is used.)
3. Symbolize aSFHA using outlined or shaded polygons to show the flood zones.
4. Symbolize Excluded Areas from the calculations using outlined or shaded polygons.
5. Symbolize OSP Eligible using outlined or shaded polygons to show the area of creditable open space preservation.

6. Label OSP Eligible using a unique ID.
7. Label OSP Eligible to show which areas qualify for extra credit based on deed restrictions (mark as DR) or natural functions (mark with NFOS#).
NOTE: Be sure to complete the [Natural Floodplain Functions Form](#) and include details about species status for NFOS3. See Step 6 (g) of the [NOAA How to Map Open Space for CRS Credit](#).
8. Right-click on OSP Eligible, go to **Open Attribute Table**, right-click on cOSP and **Sort Descending** to view top 10 parcels with the most eligible OSP credit (see Figure 11).
9. Export attribute tables as .txt to import into an Excel spreadsheet.¹⁶
10. Import the exported data into an Excel spreadsheet. Format the spreadsheet to make it presentable and easy to read. Sort the rows by the impact adjusted area of eligible open space (aOSP) in descending order.

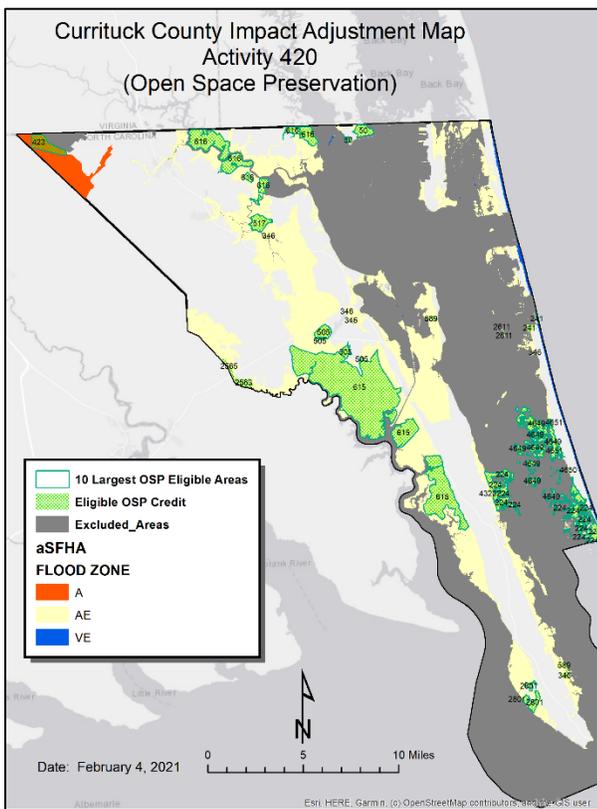


Figure 10: Example of an impact adjustment map ready for export.

OSP_ID	Local Owner	aOSP	cOSP
PADUS_615	NC Wildlife Resources Commission	11673.319733	234.89446
PADUS_616	NC Wildlife Resources Commission	2637.66259	53.075932
PADUS_224	National Audubon Society	2091.977953	42.095483
PADUS_4649	PVT	1374.003426	27.648158
PADUS_423	Elizabeth City State University	625.286102	12.582217
PADUS_505	NC Department of Public Safety	464.283839	9.342475
PADUS_4651	PVT	403.985817	8.129138
PADUS_517	NC Department of Transportation	403.329786	8.115937
PADUS_2801	PVT	338.518837	6.81179
PADUS_50	The Conservation Fund	330.716244	6.654783
PADUS_2583	North Carolina Coastal Land Trust	200.970535	4.043997
PADUS_589	NC Wildlife Resources Commission	168.344272	3.38748
PADUS_346	Currituck County	145.029893	2.91834
PADUS_241	NC DENR, Division of Coastal Management	125.019482	2.515684
PADUS_2565	North Carolina Coastal Land Trust	83.880686	1.687875
PADUS_4320	PVT	33.74973	0.679123
PADUS_2610	NC DENR, Division of Coastal Management	10.770071	0.216719
PADUS_2611	NC DENR, Division of Coastal Management	10.770071	0.216719
PADUS_4650	PVT	8.085898	0.162707
PADUS_4485	NGO	0.327259	0.006585
PADUS_467	NC Department of Cultural Resources	0.168415	0.003389

Figure 11: Example of attribute table ready for export.

¹⁶ For instructions on how to export an attribute table and import into Excel, go to support.esri.com/technical-article/000012471.

Appendix A: Formatting Data for The Nature Conservancy's CRS Explorer Tool

About the CRS Explorer

The Community Rating System Explorer (CRS Explorer) is a tool that helps planners visualize where current land protections are likely earning their community CRS points. Additionally, the tool identifies areas within the floodplain that may be eligible for future Open Space Preservation (OSP) credits if protected via acquisition or conservation easements. In particular, the CRS Explorer aids planners in identifying areas that could qualify for Activity 420 Open Space Preservation (OSP) credits if those areas were in a protected status. These **Potential Future OSP** areas are places within the impact adjusted Special Flood Hazard Area that have natural land uses but are not currently eligible for OSP simply because they are not legally protected from development. With the CRS Explorer, planners, land trusts, and conservation organizations can quickly locate future OSP areas and quantify the number of OSP credits that protection would provide. This information can be used to support community planning decisions around green space, wildlife preserves, and community parks. Find more info at <https://crs.tnc.org>.

Data Preparation for the CRS Explorer

Preparing data for the CRS Explorer requires creating dissolved copies of many of the output layers created throughout the GIS Workflow. Layer names and field names must match a defined data schema so the community data can be easily integrated into the CRS Explorer application. Table 4 at the end of this section presents the specific layer names and field names required for the CRS Explorer data package.

The Nature Conservancy (TNC) requires a parcel data layer to map future preserved open space opportunities. If parcel data were not utilized in this GIS Workflow project, you may need to acquire a copy of the most recent parcel layer for the community. Parcel data are often available from local planning departments or a tax assessor's office. Note that The Nature Conservancy requires assessed tax value information within the parcel attribute table.

Create File Geodatabase

To get started, first create a new geodatabase to store all data related to the TNC CRS Explorer with the naming convention **CommunityName_CRSExplorer** (e.g., DareCo_CRSExplorer.gdb).

Create Community_Bounds

The community boundary layer will be the data source to populate graphs and statistics within the user interface of the CRS Explorer and requires the compiled sums of various fields across several datasets. In this step you will first add some of the required community fields (community id, community name, and state) to the [Community_Name]_boundary layer created in the "Data Preparation" section of Step 1 - Calculate the community's adjusted Special Flood Hazard Area (aSFHA). Then the dissolve tool will be run to copy the community boundary feature to the CRSExplorer database with the correct data schema. In a following step,

fields with compiled sums will be joined to this attribute table.

1. Add community ID information to the community bounds attribute table.
 - Open the attribute table of [Community_Name]_boundary. Use the Add Field tool in the Table Options menu to add three new fields, which will have to be added individually. The three fields added here (CIS_CID, CRS_NAME, STATE) are required in the attribute tables of all layers for the CRS Explorer. Be sure these fields are set up and populated consistently for all layers.
 - It is important the field names, types, and lengths match what is listed below:
 - CIS_CID (Type: text, Length: 50) – FEMA’s community ID code. If the community boundary was extracted from the NFHL layer S_POL_AR, this ID code will be in a field name CID. The CRS Explorer requires the field be named CIS_CID. Use the Field Calculator to populate CIS_CID with the value in CID.
 - CRS_NAME (Type: text, Length: 50) – the community name. Be sure to include distinctions such as “County,” “City,” “Town of,” etc. The name should be in title case.
 - STATE (Type: text, Length: 50) – the capitalized two-letter abbreviation for the state.
2. Use the Field Calculator to populate the new fields with appropriate values.
3. Copy the community boundary to the CRS Explorer geodatabase by dissolving fields.
 - Tool: Dissolve (Data Management > Generalization)
 - Input Features: [Community Name]_boundary
 - Output Feature Class: Community_Bounds (in CRS Explorer geodatabase)
 - Dissolve Fields: CIS_CID, CRS_NAME, STATE
 - Create multipart features: Yes (checked)

Sum Values in OSP_Eligible

Several values from OSP_Eligible need to be summed to calculate community totals for the CRS Explorer application. In this step, the Summary Statistics tool will sum values. Then field names will be changed to match the CRS Explorer data schema.

If you have a dataset representing preserved open space that has already been mapped and credited in CRS, you will need to merge the prior OSP data with the OSP_Eligible layer created in this GIS Workflow. Overlapping and duplicate areas must be removed. Make sure the field names of the prior OSP matches OSP_Eligible before the merge.

1. Add the community ID field to OSP_Eligible.
 - Add field (Name: CIS_CID, Type: String)
 - Copy the CIS_CID value for the community from the Community boundary attribute table.
 - Use the field calculator and paste the CIS_CID value in the expression box with quotes (e.g., “455133”)
2. Calculate community totals.
 - Tool: Summary Statistics (Analysis Tools > Statistics)
 - Input: OSP_Eligible (from the GIS Workflow project database)
 - Output: OSP_Eligible_Sums (save in the GIS Workflow project database)
 - Statistics Fields:
 - aOSP (Statistics Type: Sum)
 - cOSP (Statistics Type: Sum)
 - aNFOS1 (Statistics Type: Sum)

- cNFOS1 (Statistics Type: Sum)
- Case field: CIS_CID

Note: If additional extra credit activities were mapped, they should be summed here as well. Then all extra credit totals should be added in a new field for an overall extra credit total.

3. Rename fields to match the CRS Explorer data schema.
 - Tool: Alter Field (Data Management Tools > Fields)
 - This tool can be run as a batch operation so multiple fields can be altered in one run of the tool. Right-click the Alter Field tool in the tool menu. Select Batch. Add a new row for each additional field to be altered.
 - Input Table: OSP_Eligible_Sums
 - Field Names and New Field Names. Use the drop-down to select the field to change and then manually enter the new field in the adjacent cell.
 - Field Name: SUM_aOSP > New Field Name: aOSP
 - Field Name: SUM_cOSP > New Field Name: cOSP
 - Field Name: SUM_aNFOS1 > New Field Name: aNFOS
 - Field Name: SUM_cNFOS1 > New Field Name: cNFOS
4. Add a new field to calculate the total OSP credits and extra credits.
 - In the attribute table for OSP_Eligible_Sums, add new field (Name: cTotal, Type: Long Integer).
 - Use the field calculator to calculate cTotal with the sum of cOSP and cNFOS (cOSP + cNFOS).

Join OSP_Eligible_Sums to Community_Bounds

In this step, you will join the summed OSP_Eligible values to the Community_Bounds layer in the CRSExplorer database.

1. Join community totals from OSP_Eligible_Sums.
 - Tool: Join Field (Data Management Tools > Joins)
 - Input table: Community_Bounds (in CRSExplorer database)
 - Input Join Field: CIS_CID
 - Join Table: OSP_Eligible_Sums (from the GIS Workflow project database)
 - Output Join Field: CIS_CID
 - Join Fields: aOSP, cOSP, aNFOS, cNFOS, cTotal

Add aSFHA field and calculate with aSFHA Total

1. In the attribute table for Community_Bounds, open the Table Options menu and select Add Field and add the field aSFHA (Type: Double).
 - Revisit [Community_Name]_aSFHA to get the total area of the impact adjusted SFHA, which will be the denominator in the impact adjustment equation.
 - In attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
 - Copy the Sum in the statistics table. This is the total area of aSFHA in acres.
2. Revisit [Community_Name]_aSFHA to get the total area of the impact adjusted SFHA, which will be the denominator in the impact adjustment equation.

- Open the attribute table for [Community_Name]_aSFHA, right-click on aSFHA > Statistics
 - Copy the Sum in the statistics table. This is the total area of aSFHA in acres.
3. Calculate aSFHA with the copied Sum value.
 - In the attribute table for Community_Bounds, right-click on the field aSFHA. And select Field Calculator.
 - Paste the Sum of aSFHA copied from [Community_Name]_aSFHA. Click OK.

Prepare OSP_Eligible

For the CRS Explorer application, the OSP_Eligible layer must have all features dissolved to one multipart feature if there is not extra credit mapped or two multipart features if extra credit areas have been mapped and calculated.

If you have a dataset representing preserved open space that has already been mapped and credited in CRS, you will need to merge the prior OSP data with the OSP_Eligible layer created in this GIS Workflow. Overlapping and duplicate area must be removed. Make sure the field names of the prior OSP matches OSP_Eligible before the merge.

1. Add and calculate fields CIS_CID, CRS_NAME, STATE. Refer back to step 1 in the Preparing Community_Bounds section, if necessary.
 - With the attribute table open, use the Add Fields tool from the table options to add the required fields. Use the Field Calculator to populate the new fields with appropriate values. Be sure these fields are set up and populated consistently for all layers.
 - CIS_CID (Type: text, Length: 50)
 - CRS_NAME (Type: text, Length: 50)
 - STATE (Type: text, Length: 50)
2. Add field to flag all features as OSP.
 - Input: OSP_Eligible (from the GIS Workflow project database)
 - Add field (Name: OSP, Type: short integer)
 - Use the field calculator to calculate all features to 1.
3. Dissolve OSP_Eligible features to make copy for CRS Explorer.
 - Tool: Dissolve (Data Management > Generalization)
 - Input: OSP_Eligible
 - Output: OSP_Eligible (in the CRSExplorer database)
 - Dissolve fields:
 - CIS_CID
 - CRS_NAME
 - STATE
 - OSP
 - NFOS1

Note: This assumes the extra credit activity for NFOS1 has been performed and the output fields are within the OSP_Eligible attribute table. Run the dissolve on the other 4 fields if NFOS1 extra credit has not been mapped.
4. If NFOS1 extra credit was mapped, alter the field name of NFOS1 to match the CRS Explorer data schema.
 - Tool: Alter Field (Data Management Tools > Fields)

- Field Name: NFOS1
- New Field Name: NFOS

Prepare Excluded_Areas

Starting with the Excluded_Areas output from the GIS Workflow, follow these steps to create a CRS Explorer-ready version of that layer.

1. Add and calculate fields CIS_CID, CRS_NAME, STATE. Refer back to step 1 in the Preparing Community_Bounds section, if necessary.
 - With the attribute table open, use the Add Fields tool from the table options to add the required fields. Use the Field Calculator to populate the new fields with appropriate values. Be sure these fields are set up and populated consistently for all layers.
 - CIS_CID (Type: text, Length: 50)
 - CRS_NAME (Type: text, Length: 50)
 - STATE (Type: text, Length: 50)
2. Dissolve features to required fields:
 - Tool: Dissolve
 - Input: Excluded_Areas (from the GIS Workflow project database)
 - Output: Excluded_Areas (in the CRS Explorer database)
 - Dissolve Fields:
 - CIS_CID
 - CRS_NAME
 - STATE

Prepare aSFHA

Starting with the [Community Name]_aSFHA output from the GIS Workflow ([Community_Name]_aSFHA), follow these steps to create a CRS Explorer-ready version of that layer.

1. Add and calculate fields CID, CRS_NAME, STATE. Refer back to step 1 in the Preparing Community_Bounds section, if necessary.
 - With the attribute table open, use the Add Fields tool from the table options to add the required fields. Use the Field Calculator to populate the new fields with appropriate values. Be sure these fields are set up and populated consistently for all layers.
 - CIS_CID (Type: text, Length: 50)
 - CRS_NAME (Type: text, Length: 50)
 - STATE (Type: text, Length: 50)
2. Dissolve features to required fields:
 - Tool: Dissolve
 - Input: aSFHA (from the GIS Workflow project database)
 - Output: aSFHA (in the CRS Explorer database)
 - Dissolve Fields:

- CIS_CID
- CRS_NAME
- STATE
- FLD_ZONE

Prepare Future_OSP_Parcels

As part of adding a community to the CRS Explorer, TNC will map unprotected open space areas that would be eligible for OSP credit if they were in protected status (also known as future OSP). TNC will need an up-to-date parcel layer for the community to map these future OSP areas. For future OSP, at minimum, unique parcel ID's are required to help prioritize and target future land easements, acquisitions, and landowner engagement.

1. Ensure that your parcel data are projected to the same state coordinate system as your other data.
2. Using the Select tool, select parcels under private ownership. Save the output to the CRSExplorer geodatabase. Name the output Future_OSP_Parcels.
3. Add and calculate fields CIS_CID, CRS_NAME, STATE. Refer back to step 1 in the Preparing Community_Bounds section, if necessary.
 - With the attribute table open, use the Add Fields tool from the table options to add the required fields. Use the Field Calculator to populate the new fields with appropriate values. Be sure these fields are set up and populated consistently for all layers.
 - CIS_CID (Type: text, Length: 50)
 - CRS_NAME (Type: text, Length: 50)
 - STATE (Type: text, Length: 50)
4. Add and calculate the additional fields that are required for the CRS Explorer App. Below are the additional fields that are required.
 - In the attribute table, use the Add Field tool to add each of these fields, being sure the field types are set correctly.
Required fields:
 - OWNER_TYPE (Type: text, Length: 50) – distinction of ownership (public, private, etc.)
 - OWNER_NAME (Type: text, Length: 200) – name of property owner
 - OSP_ID (Type: text, Length: 50) – unique parcel identification code
 - TAX_VALUE (Type: Long Integer) – assessed value of the propertyOptional fields(if data are available):
 - ADDRESS (Type: text, Length: 100) – physical address, if available
 - LAND_USE (Type: text, Length: 100) – current land use, if available
 - Use the field calculator to populate the new fields with values from equivalent fields existing within the parcel attribute table. If one or the more equivalent fields does not exist in the attribute table, leave the values as NULL. Again, at a minimum, the OSP_ID field must be populated with the official unique parcel identifier.
 - Delete any additional fields other than those added in previous steps of this section. Use the Delete Field tool (Data Management Tools > Fields) and select all fields to delete by placing a check beside each on the Drop Field list.

Transfer data to TNC

Add the CRS Explorer geodatabase with all of the prepared layers to a compressed zip file for transfer to TNC. Coordinate the data transfer to your point of contact at The Nature Conservancy. Find more info at <https://crs.tnc.org>.

CHECKLIST

- All datasets are projected to the same state plane coordinate system
- All datasets have the fields listed in Table 4
- All datasets reside in a single geodatabase, which is in a zipped folder for data transfer

CRS Explorer Data Schema

Table 4: Data schema for integrating data into the TNC CRS Explorer.

DATASET	FIELD	TYPE	DESCRIPTION
OSP_Eligible	CIS_CID	text	FEMA's community id code
	STATE	text	State abbreviation all caps (case dependent)
	CRS_NAME	text	Community Name (case dependent, NO apostrophes or commas)
	OSP	short	Binary 0,1 where 1 is current and/or proposed
	NFOS	short	Binary 0,1 where 1 is current and/or proposed NFOS and 0 is not eligible for NFOS
Excluded_Areas	CIS_CID	text	FEMA's community id code
	STATE	text	State abbreviation all caps (case dependent)
	CRS_NAME	text	Community Name (case dependent)
aSFHA	CIS_CID	text	FEMA's community id code
	STATE	text	State abbreviation all caps (case dependent)
	CRS_NAME	text	Community Name (case dependent)
	FLD_ZONE	text	100year Flood Zones: A, AE, AH, AO, AR, A1-A30, or VE, V1-V30
Community_Bounds	CIS_CID	text	FEMA's community id code
	STATE	text	State abbreviation all caps (case dependent)
	CRS_NAME	text	Community Name (case dependent)
	cTOTAL	long	Total amount of current and proposed OSP credits (cOSP + cNFOS + any prior points)
	aOSP	double	Total acreage of proposed OSP
	cOSP	double	Total credits of proposed OSP
	aNFOS	double	Total acreage of proposed NFOS
	cNFOS	double	Total credits of proposed NFOS
	aSFHA	double	SUM acreage of aSFHA
Future_OSP_Parcel	CIS_CID	text	FEMA's community id code
	STATE	text	State abbreviation all caps (case dependent)
	CRS_NAME	text	Community Name (case dependent)
	OWNER_TYPE	text	Filtered for private
	OWNER_NAME	text	If available
	OSP_ID	text	Unique parcel ID
	TAX_VALUE	long	Required for tax value range filter
	LAND_USE	Text	Optional to populate parcel information in the app popup
	ADDRESS	Text	Optional if available