

SWAP User's Manual

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1 Introduction

1.1 Background and Purpose

The Delineation Phase of the Colorado Source Water Assessment and Protection (SWAP) Program was conducted by URS Corporation between January 2000 and March 2001. The Delineation Phase involved delineation of source water assessment areas (SWAAs) and sensitivity zones for approximately 2,100 public water systems (PWSs) in Colorado, including approximately 3,700 public drinking water sources.

The main purposes of this User's Manual are as follows:

- Identify the components of the Delineation Phase deliverable;
- Describe the data structure;
- Outline the software and tools required to use the data;
- Explain the methodologies used to delineate SWAAs and sensitivity zones; and
- Provide step-wise instructions for using and editing the data.

1.2 Intended Audience

This User's Manual was developed for use by Colorado Department of Public Health and Environment (CDPHE), Water Control Division (WQCD) staff with intermediate- to expert-level knowledge of Geographic Information System (GIS) and database software. In addition, the manual assumes that the user is knowledgeable of and proficient in applying the principles of groundwater flow and surface water hydrology.

2 Data Structure

2.1 Groundwater Data Structure

Lookup table *gw_lookup.dbf* must be used to link groundwater sources with SWAAs. Before you can properly use the lookup tables in ArcView, it is important to understand the table linking function in ArcView.

The data used to describe SWAAs for groundwater sources consists of four ArcView shapefiles and a data table in DBF format.

<i>gw_source.shp</i>	Groundwater sources with defined sensitivity zones.
<i>gw_zone1.shp</i>	Sensitivity Zone 1s for sources in <i>gw_source.shp</i> .
<i>gw_zone2.shp</i>	Sensitivity Zone 2s.
<i>gw_zone3.shp</i>	Sensitivity Zone 3s.
<i>gw_lookup.dbf</i>	Lookup table matching sources to sensitivity zones.

Linking the sensitivity zones to sources depends on selecting the fields to be linked in the correct order. In ArcView, first select the SRCID field in *gw_lookup.dbf* and the attribute table of *gw_source.shp*, then select “Link” in the “Table” menu. Next, link the SWAAID fields in *gw_zone3.shp* and *gw_lookup.dbf*. Repeat for Zones 1 and 2.

Two ID numbers are used for matching sources to sensitivity zones. The SRCID is used to uniquely identify each source, and the SWAAID identifies each sensitivity zone. Another ID number, PWSID, identifies the public water system.

In most cases, each sensitivity zone will match to one source. For example, the sensitivity zones for a source delineated using the calculated fixed-radius method will match only to that source. For these sensitivity zones, the SWAAID is based on the SRCID with a zone designation appended to the end. For example, the sensitivity zones for SRCID 120010-003 are numbered 120010003Z1, 120010003Z2, and 120010003Z3. Figure 1 illustrates the connections between sources and sensitivity zones for zones that match to only one source.

If a sensitivity zone is shared by two or more sources, the SWAAID is based on the PWSID, followed by a number incrementing sequentially from “901”, followed by a zone designation. In Figure 2, each source has a unique Zone 1 and shares a Zone 2 and Zone 3. The Zone 1 for SRCID 147020-006 is numbered 147020006Z1. The shared zones are numbered 147020901Z2 and 147020901Z3. The shared zones can only be matched to sources by using the lookup table.

Figure 1. Selecting Sensitivity Zones for Sources with Unique SWAAs

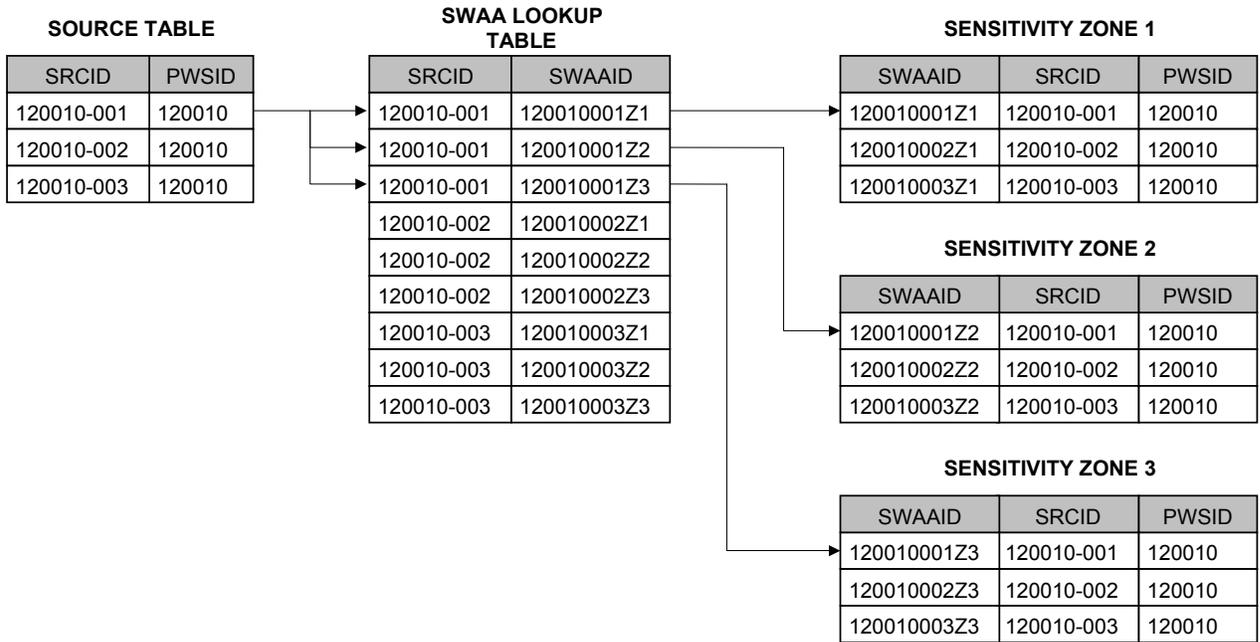
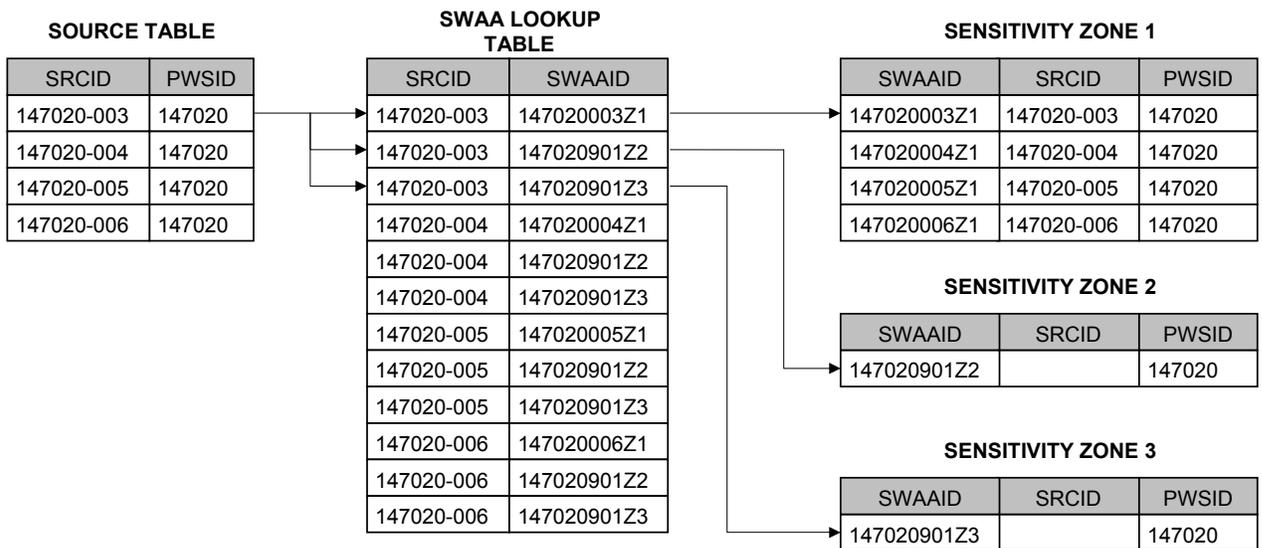


Figure 2. Selecting Sensitivity Zones for Sources with Shared SWAAs



2.2 Surface Water Data Structure

Lookup tables *sw_lookup.dbf*, and *aoi_lookup.dbf* must be used to link surface water sources with SWAAs. Before you can properly use the lookup tables in ArcView, it is important to understand the table linking function in ArcView.

The data used to describe SWAAs for surface water sources consists of five ArcView shapefiles and two data tables in DBF format.

<i>sw_source.shp</i>	Surface water sources.
<i>sw_diversions.shp</i>	Surface water diversions.
<i>sw_aor.shp</i>	AOR subunits defined by surface water sources and diversions.
<i>sw_zone1.shp</i>	Sensitivity Zone 1s for each AOR subunit.
<i>sw_zone2.shp</i>	Sensitivity Zone 2s.
<i>sw_nearzones.shp</i>	Near Zones for each surface water source.
<i>sw_lookup.shp</i>	AOR lookup table.
<i>aoi_lookup.shp</i>	AOI lookup table.

Each surface water source is described by seven separate delineation areas.

- Area of Interest (AOI);
- Area of Responsibility (AOR);
- Sensitivity Zone 1;
- Sensitivity Zone 2;
- Sensitivity Zone 3;
- 15-mile Near Zone for the AOI;
- Far Zone for the Area of Interest.

Each type of delineation area is defined for each surface water source.

The basic building block for each of these delineation areas is the *AOR Subunit*, contained in file *sw_aor.shp*. An AOR or AOI for a source will often consist of more than one AOR Subunit. Each AOR Subunit has an associated Sensitivity Zone 1 and 2; therefore, the Zone 1 or 2 for a source is built by aggregating the zones associated with each AOR Subunit in the AOR or AOI. The Zone 3 for a source is simply the entire AOR or AOI. Data flow for AOIs is illustrated in Figure 3.

AOR Subunits are identified by a 10-digit SWAAID. The first six digits are the HUC basin ID number, followed by a three-digit identifier numbered sequentially. Each SWAAID must be unique.

The HUC basin IDs used are listed below.

<u>Basin ID</u>	<u>Basin</u>
101800	North Platte River
101900	South Platte River
110200	Upper Arkansas River
140100	Colorado River Headwaters
140200	Gunnison River
140300	Upper Colorado-Dolores Rivers
140500	White-Yampa Rivers
140801	Upper San Juan River

Usually, an AOR for a source will consist of one AOR subunit. However, if an AOR contains one or more diversions, the AOR will be “split” at the diversion locations. Part of the water is diverted, and the rest continues downstream. AOR subunits are "shared" by the downstream source and the first source downstream from the outlet from the conveyance structure associated with the diversion.

Sources take precedence over diversions in assembling AORs. Sources "own" an AOR, but diversions do not. For example, if one PWS has a source at Reservoir A and another diverts water from Reservoir A to their own reservoir, the AOR including Reservoir A "belongs" to the source, and it would not be shared. The AOR above Strontia Springs Reservoir belongs to a Denver Water source despite the presence of an Aurora diversion.

An AOR subunit containing an source is only shared if more than one source is in the subunit. Ralston Reservoir is an example of an AOR subunit that is shared because of the presence of multiple sources.

The methods used to extract each delineation area from SWAP data are described below.

2.2.1 Area of Interest

Three files are needed to build an AOI for a source.

- Source Theme ([sw_source.shp](#))

- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*aoi_lookup.dbf*)

See Figure 1. Link the AOI Lookup Table to the Source Theme using the SRCID field. Then link the AOR Subunit Theme to the AOI Lookup Table using the SWAAID field. With the tables linked, selecting a source will return all of the AOR subunits that make up the AOI for that source.

2.2.2 Area of Responsibility

Three files are needed to build an AOR for a source.

- Source Theme (*sw_source.shp*)
- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*sw_lookup.dbf*)

The process for building AORs is similar to AOIs, but with a different lookup table.

2.2.3 Sensitivity Zone 1

Four files are needed to determine if a PSOC is located within a source's Zone 1.

- Source Theme (*sw_source.shp*)
- Zone 1 Theme (*sw_zone1.shp*)
- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*aoi_lookup.dbf*)

Set up the links described above for the Area of Interest. Then link the Zone 1 Theme to the AOR Subunit Table using the SWAAID field. With the tables linked, selecting a source will return the Sensitivity Zone 1s in the AOI for that source.

The Zone 1 for a surface water source is created by aggregating the Zone 1s for all of the AOR Subunits that make up the AOI for that source. A PSOC is within Zone 1 of a source if it is anywhere within the aggregate Zone 1 area.

2.2.4 Sensitivity Zone 2

Five files are needed to determine if a PSOC is located within a source's Zone 2.

- Source Theme (*sw_source.shp*)
- Zone 1 Theme (*sw_zone1.shp*)
- Zone 2 Theme (*sw_zone2.shp*)
- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*aoi_lookup.dbf*)

Set up the links described above for the Area of Interest. Then link the Zone 2 Theme to the AOR Subunit Table using the SWAAID field. With the tables linked, selecting a source will return the Sensitivity Zone 2s in the AOI for that source.

Similar to Zone 1, two steps are required to determine which PSOCs are located within a source's Zone 2. First, all of the sources located within the aggregate Zone 2 area are selected. Second, all sources located within the Zone 1 area are subtracted from the selection set.

2.2.5 Sensitivity Zone 3

Five files are needed to determine if a PSOC is located within a source's Zone 3.

- Source Theme (*sw_source.shp*)
- Zone 1 Theme (*sw_zone1.shp*)
- Zone 2 Theme (*sw_zone2.shp*)
- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*aoi_lookup.dbf*)

Set up the links as described above for Sensitivity Zone 1 and 2.

Two steps are required to determine which PSOCs are located within the Zone 3 of a source. First, all of the sources within the AOI for the source are selected. Second, all sources within Zone 1 or 2 are subtracted from the selection set.

2.2.6 15-Mile Near Zone

Two files are needed to determine if a PSOC is located within a source's Near Zone.

- Source Theme (*sw_source.shp*)
- Near Zone (*sw_nearzones.shp*)

There is one 15-Mile Near Zone for each source, identified by the same SRCID as the source.

A Near Zone is the portion of the AOI within 15 radial miles of the source. To determine which PSOCs are located in the Near Zone for a source, simply select the Near Zone with the same SRCID as the selected source, and then select all of the PSOCs located within that Near Zone.

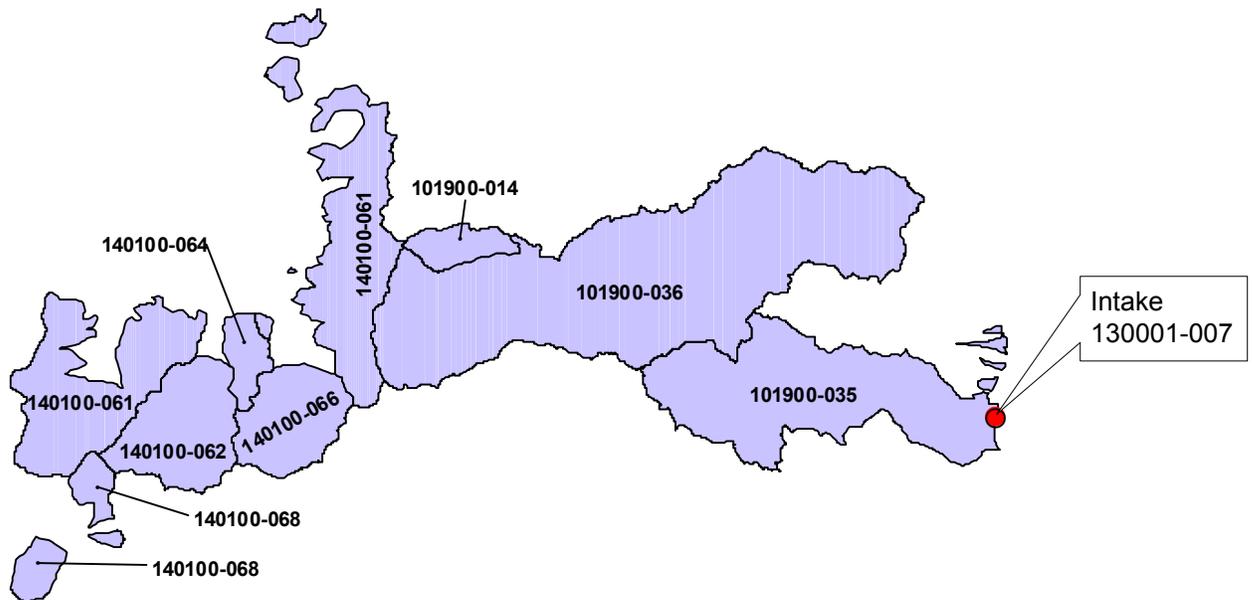
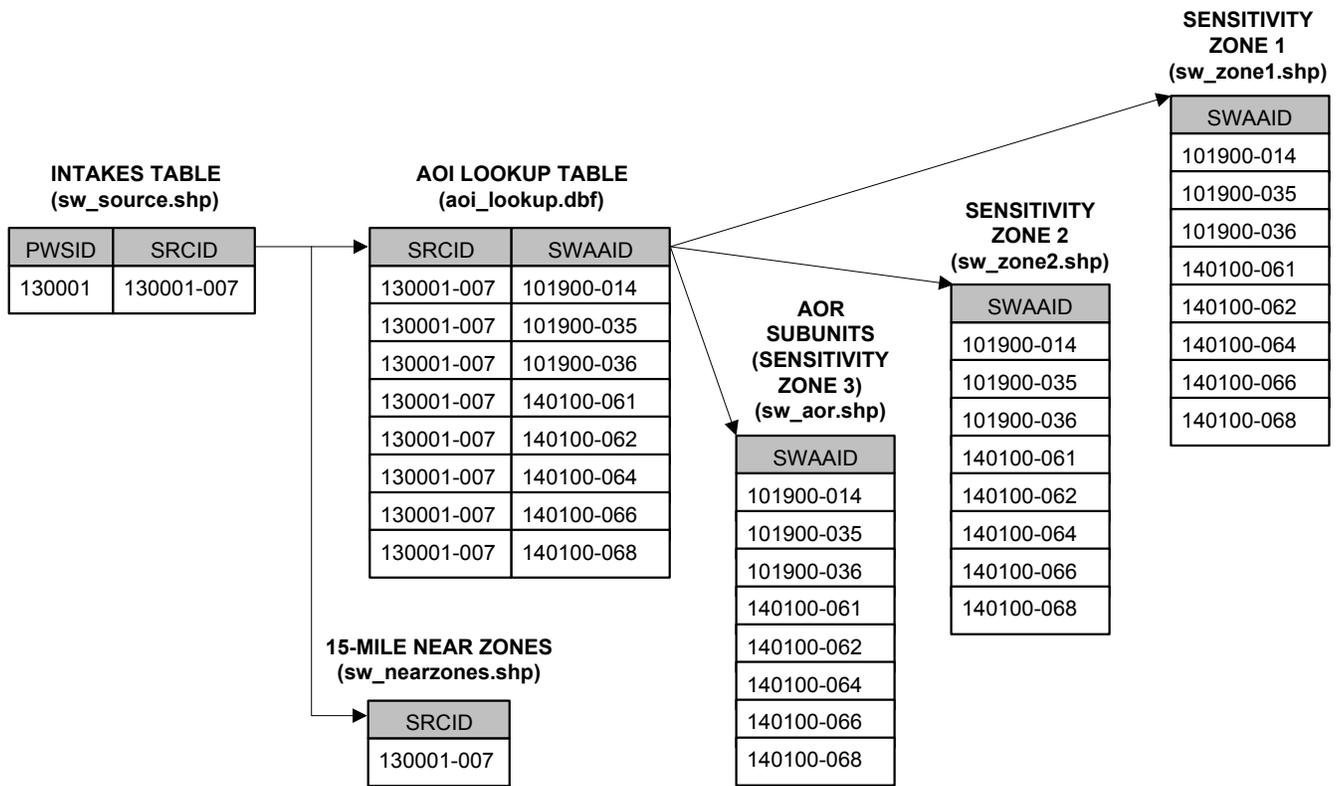
2.2.7 Far Zone

Four files are needed to determine if a PSOC is located within a source's Far Zone.

- Source Theme (*sw_source.shp*)
- Near Zone (*sw_nearzones.shp*)
- AOR Subunit Theme (*sw_aor.shp*)
- AOI Lookup Table (*aoi_lookup.dbf*)

Two steps are required to determine which PSOCs are located within the Far Zone of a source. First, select all of the PSOCs located within the AOI. Second, subtract all PSOCs located within the Near Zone from the selection set.

Figure 3 Data Flow for AOIs



3 Groundwater Delineation Edits

3.1 Add, Delete, or Move a Groundwater Source

Files to edit in this step:

[gw_sources.shp](#)

Software Functions required:

Adding point features in ArcView from coordinates or a map.

Editing attribute tables in ArcView.

Coordinates from different sources can vary widely in accuracy. Always verify the location of sources after adding them. Coordinates must be in UTM Zone 13, NAD83, meters.

3.1.1 Add a Source

Step 1: In ArcView, add the source to [gw_source.shp](#). If the source is to be added using coordinates, enter the new coordinates in the “Shape Properties” dialog box (accessible by right-clicking in the ArcView view window).

Step 2: Add a delineation for the source or diversion (section 4.2).

Step 3: Add the source to the SWAP database.

3.1.2 Delete a Source

Step 1: In ArcView, link the Source Theme ([gw_source.shp](#)), the Groundwater Lookup Table ([gw_lookup.dbf](#)), and the Groundwater Sensitivity Zone Files ([gw_zone1.shp](#), [gw_zone2.shp](#), and [gw_zone3.shp](#)) as described in Section 3.1, “Groundwater Data Structure”.

Step 2: Select the source. If the files are properly linked, the sensitivity zones for the source will be selected automatically. Delete all of the selected records in [gw_zone1.shp](#), [gw_zone2.shp](#), and [gw_zone3.shp](#).

Step 3: Delete the selected records from the lookup table.

Step 4: Delete the source.

Step 5: Edit the SWAP database to reflect the status of the source. If it was abandoned, leave it in the database and change the “AVAIL” flag to show that it’s abandoned.

3.1.3 Move a Source

Step 1: After enabling editing, select the source to be moved. If the source is to be moved to new coordinates, enter the new coordinates in the “Shape Properties” dialog box (accessible by right-clicking in the ArcView view window). Otherwise, edit *gw_source.shp* by dragging the point to the new location. Update the appropriate attribute table record for each moved point by modifying the “LOCSOURCE” field. If applicable, update the date of the edit and the initials of the person performing the change.

Step 2: Modify the delineation for the source or diversion (section 4.2).

3.2 Modify delineations by Type

Files to edit in this step:

gw_zone1.shp
gw_zone2.shp
gw_zone3.shp
gw_lookup.dbf

Software Functions required:

Modeling 5-year and 2-year capture zones using WhAEM2000
Adding polygon features using the “Create Buffers” function in ArcView. Adding polygon features using on-screen digitizing.
Editing attribute tables in ArcView.

The Zone 1, 2, and 3 for different sources often overlap. Use the “Theme Definition” function in ArcView to limit the displayed zones to a single PWS. Add the attribute values used in the theme definition before saving, or your new features may “vanish” until you turn the theme definition off.

3.2.1 Deleting existing delineations

Step 1: In ArcView, link the Source Theme (*gw_source.shp*), the Groundwater Lookup Table (*gw_lookup.dbf*), and the Groundwater Sensitivity Zone Files (*gw_zone1.shp*, *gw_zone2.shp*, and *gw_zone3.shp*) as described in Section 3.1, “Groundwater Data Structure”.

Step 2: Select the source. If the files are properly linked, the sensitivity zones for the source will be selected automatically. Delete all of the selected records in *gw_zone1.shp*, *gw_zone2.shp*, and *gw_zone3.shp*.

Step 3: Delete the selected records from the lookup table.

3.2.2 WhAEM2000 Modeled Delineations

Zone 3 (5-year TOT)

Step 1: Download the USGS DLG(s) that covers the PWS's source area. All WhAEM2000 DLGs are available at the following website. <http://www.epa.gov/ceampubl/whaemhtm/co/cowhamap.htm>. An executable file is downloaded from this website and several basemap coverages can be added into the project file. (**NOTE:** If the basemaps are moved into a different directory after the first delineation, then the basemaps will need to be re-pathed when the project file is opened.)

The coordinates for the DLGs downloaded from the EPA site are referenced from the NAD27 datum. All SWAP GIS data is in NAD83. Source coordinates must be converted from NAD83 to NAD27 to work with the DRGs in WhAEM2000 modeling. Output from WhAEM2000 must then be re-projected to NAD83 before it can be used in the GIS.

Step 2: Obtain the most recent, updated coordinates for the source. If necessary, re-project the source coordinates to NAD27.

Step 3: Enter the source coordinates in WhAEM2000. Verify that the source plots in the correct location compared to the DRGs. If the location is incorrect, re-check the original coordinates and the re-projected coordinates. If the location doesn't match a map from another source (e.g. a map from a previously filed Wellhead Protection Plan), edit the location as necessary (Section 4.1).

Step 4: Review the source and aquifer input data to confirm accuracy and completeness.

Step 5: Input the source and aquifer property data into the WhAEM2000 model. Ensure that the well is discharge specified.

Step 6: Select a point on the land surface that is near the source and outside of the anticipated 5-year TOT capture zone, and input a representative head value for the aquifer at this location. The head value can be estimated based on the location of this point relative to the subject source, hydraulic gradient and ambient flow direction.

Step 7: Run the model.

Step 8: Save the input text file.

Step 9: Export the flow pathlines to a DXF file. Re-project to a NAD83 shapefile.

Step 10: In ArcView, view the flow pathlines shapefile with USGS 1:24,000 DRGs and surface geology. Create the 5-year TOT capture zone in file *gw_zone3.shp* by digitizing around the extent of the pathlines. It may be necessary to modify the capture zone based on the DRGs or surface geology. For example, if the pathlines for an alluvial well cross a stream or obviously leave the alluvial channel, cut off or re-shape the capture zone to match the observed features.

Step 11: Edit the attributes for the new feature in *gw_zone3.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 12: Add a single record to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new digitized 5-year capture zone. If the capture zone was created by modeling several sources together, an entry must be made in the lookup table for each source. Enter the same SWAAID for each source.

Zone 2 (2-year TOT)

Step 13: Create a duplicate input file and re-run the model using a 2-year TOT (i.e., 730 days) Zone 2. Save the input text file and export the flow pathlines to a .dxf file. Re-project to a NAD83 shapefile.

Step 14: Create the 2-year TOT capture zone in file *gw_zone2.shp* by digitizing around the extent of the flow pathlines. Use the previously completed 5-year TOT capture zone (in file *gw_zone3.shp*) as a guide. The 2-year capture zone must not extend beyond the extents of the 5-year capture zone. (Rather than digitizing all the way around the 2-year capture zone, it is sometimes preferable to copy the 5-year capture zone into the Zone 2 shapefile and then use the Polygon Split tool to cut it off at the limit of the 2-year flow pathlines.)

Step 15: Edit the attributes for the new feature in *gw_zone2.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 16: Add a single record to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new digitized 2-year capture zone. If the capture zone was created by modeling several sources together, an entry must be made in the lookup table for each source. Enter the same SWAAID for each source.

Zone 1

Step 17: Create Zone 1 with the ArcView “Create Buffers” tool. Add a 500-foot buffer around the source to *gw_zone1.shp*.

Step 18: Edit the attributes for the new feature in *gw_zone1.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 19: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 1.

Update Database and Metadata

Step 20: Add any new or modified input parameters used in WhAEM2000 to the SWAP database. Revise the metadata sheet for the PWS. (If necessary, create a new metadata sheet.) Include all assumptions made for aquifer property values and the source of information (i.e., topography, maps, technical paper, etc.) Discuss information used in interpreting the model results.

3.2.3 Calculated Fixed Radius Delineations

All SWAP GIS data is in meters. The data used in Calculated Fixed Radius Delineations is in feet. Always set the Map Units in ArcView to meters. Buffer distances can be entered in feet in the ArcView “Create Buffers” tool even if the Map Units are in meters.

Zone 3 (5-year TOT)

Step 1: Use the following equation to calculate the 5-year TOT radial distance.

$$R = \sqrt{\frac{Qt}{n\pi H}}$$

Where:

R = radial distance (ft)

Q = flow rate (ft³/day)

n = porosity (dimensionless)

t = time = 1825 (day)

H = saturated thickness (ft)

Step 2: Use the 5-year radial distance to add a buffer around the source to *gw_zone3.shp* using the ArcView “Create Buffers” tool.

Step 3: Edit the attributes for the new feature in *gw_zone3.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 4: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 3.

Zone 2 (2-year TOT)

Step 5: Use the following equation to calculate the 2-year TOT radial distance.

$$R = \sqrt{\frac{Qt}{n\pi H}}$$

Where:

R = radial distance (ft)

Q = flow rate (ft³/day)

n = porosity (dimensionless)

t = time = 730 (day)

H = saturated thickness (ft)

Step 6: Use the 2-year radial distance to add a buffer around the source to *gw_zone2.shp* using the ArcView “Create Buffers” tool.

Step 7: Edit the attributes for the new feature in *gw_zone2.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 8: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 2.

Zone 1

Step 9: Create Zone 1 with the ArcView “Create Buffers” tool. Add a 500-foot buffer around the source to *gw_zone1.shp*.

Step 10: Edit the attributes for the new feature in *gw_zone1.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 11: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 1.

Update Database and Metadata

Step 12: Add any new or modified input parameters used in calculating the TOT radial distances to the SWAP database. Revise the metadata sheet for the PWS. (If necessary, create a new metadata sheet.) Include all assumptions made for saturated thickness, porosity, and pumping rate. List the source of information (i.e., maps, technical paper, etc.)

3.2.4 Default Fixed Radius Delineations

Always set the Map Units in ArcView to meters. Buffer distances can be entered in miles or feet in the ArcView “Create Buffers” tool even if the Map Units are in meters.

Zone 3

Step 1: Create Zone 3 with the ArcView “Create Buffers” tool. Add a **2.5-mile** buffer around the source to *gw_zone3.shp*.

Step 2: Edit the attributes for the new feature in *gw_zone3.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 3: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*.

Zone 2

Step 4: Create Zone 2 with the ArcView “Create Buffers” tool. Add a **1.5-mile** buffer around the source to *gw_zone2.shp*.

Step 5: Edit the attributes for the new feature in *gw_zone2.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 6: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*.

Zone 1

Step 7: Create Zone 1 with the ArcView “Create Buffers” tool. Add a **500-foot** buffer around the source to *gw_zone1.shp*.

Step 8: Edit the attributes for the new feature in *gw_zone1.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 9: Add a single record for each source to the groundwater SWAA lookup table, *gw_lookup.dbf*.

Update database and metadata

Step 10: Revise the metadata sheet for the PWS. (If necessary, create a new metadata sheet.) If the PWS isn’t Transient Non-Community, include the reason for using the Default Fixed Radius Delineation and the attempts made to collect information necessary for a Calculated Fixed-Radius or WhAEM2000 modeled delineation.

3.2.5 Karst/Fracture-flow or Spring (Hydrogeologic Mapping)

The Zone 3 polygons for these sources are created using Hydrogeologic Mapping. The Zone 2 and the Zone 1 polygons are similar to Default Fixed-Radius Delineations, except that they are clipped at the Zone 3 boundary.

Zone 3

- Step 1:** In ArcView, overlay the source on USGS 1:24,000 DRGs and surface geology.
- Step 2:** Verify (if possible) that the well or spring location is correct.
- Step 3:** If possible, identify the boundaries of the karst or fractured formation(s) within the watershed that serves as the aquifer. Use DRGs, surface geology, and any other available information. (Often, the best method is to print a 1:24,000 scale map showing the source, the DRGs and geologic information. Then, manually draw the SWA directly on the paper map.)
- Step 4:** Create the hydrogeologic delineation in file *gw_zone3.shp* by digitizing the boundary of the SWA identified in Step 3.
- Step 5:** Print a check plot of the new delineation showing the DRGs and surface geology. Verify the accuracy of the new delineation.
- Step 6:** Edit the attributes for the new feature in *gw_zone3.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.
- Step 7:** Add a single record to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new digitized delineation. If the source water areas of several sources were combined into a single delineation, an entry must be made in the lookup table for each source. Enter the same SWAAID for each source.

Zone 2

- Step 8:** In ArcView, copy the new delineation polygon from *gw_zone3.shp* to *gw_zone2.shp*.
- Step 9:** Add a 1.5-mile buffer around the source to *gw_zone2.shp* using the ArcView “Create Buffers” tool.
- Step 10:** With editing enabled for *gw_zone2.shp*, select the two new features (the new delineation polygon and the 1.5 mile buffer). Use the “Intersect Features” function in ArcView to clip the 1.5-mile buffer at the boundary of the delineation polygon. The resulting polygon is the new Zone 2.

Step 11: Edit the attributes for the new Zone 2 in *gw_zone2.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 12: Add a single record to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 2. Every source will have a unique Zone 2.

Zone 1

Step 13: In ArcView, copy the new Zone 3 delineation polygon from *gw_zone3.shp* to *gw_zone1.shp*.

Step 14: Add a **500-foot** buffer around the source to *gw_zone1.shp* using the ArcView “Create Buffers” tool.

Step 15: With editing enabled for *gw_zone1.shp*, select the two new features (the new delineation polygon and the 500-foot buffer). Use the “Intersect Features” function in ArcView to clip the 500-foot buffer at the boundary of the delineation polygon. The resulting polygon is the new Zone 1.

Step 16: Edit the attributes for the new Zone 1 in *gw_zone1.shp*. Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 17: Add a single record to the groundwater SWAA lookup table, *gw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new Zone 2. Every source will have a unique Zone 1.

Update Database and Metadata

Step 18: Revise the metadata sheet for the PWS. (If necessary, create a new metadata sheet.) Include information used in the creation of the hydrogeologic delineation besides DRGs and surface geology, such as a Wellhead Protection Area map.

3.2.6 GWUDI

The Zone 3 polygons for these sources are the entire watershed above the source. The delineation is started at a *substitute intake*, rather than at the source. The Zone 2 and Zone 1 polygons are created by combining a groundwater-type sensitivity zone (fixed-radius or WhAEM2000 modeled) and a surface-water type zone (Section 5.).

Substitute Intake

Step 1: Complete WhAEM2000 or fixed-radius delineations for the source. Both 2-year and 5-year TOT capture zones will be needed. If not enough data is

available, use **500 feet** as the default fixed radius, rather than the usual 1.5 and 2.5 miles.

Step 2: Overlay the delineation on USGS 1:24,000 DRGs. The GWUDI source should be near a stream. The location downstream where the 5-year TOT capture zone crosses the stream is the *substitute intake*.

Zone 3

Step 3: In ArcView, digitize the extents of the watershed above the substitute intake using topographic contours in the USGS 1:24,000 DRGs. Add to [gw_zone3.shp](#).

Step 4: Add the 5-year TOT capture zone created for the substitute intake to [gw_zone3.shp](#).

Step 5: Select both the new watershed delineation and the 5-year TOT capture zone polygons. Use “Union Graphics” to combine them into a single polygon.

Step 6: Edit the attributes for the new feature in [gw_zone3.shp](#). Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 7: Add a single record to the groundwater SWAA lookup table, [gw_lookup.dbf](#). Add the SRCID for the source, and the SWAAID of the new feature.

Zone 2

Step 8: Create a surface-water Zone 2 for the source. Use the procedures in Section 5.3, “Edit Sensitivity Zone 1 and 2” to create a **2320-foot** stream buffer (1/4 mile plus 1000’). Substitute the new Zone 3 for the AOR subunit used in Section 5.3. Add the new stream buffer polygon to [gw_zone2.shp](#).

Step 9: Add the 2-year TOT capture zone created for the substitute intake to [gw_zone2.shp](#).

Step 10: Select both the new stream buffer and the 2-year TOT capture zone polygons. Use “Union Graphics” to combine them into a single polygon.

Step 11: Edit the attributes for the new feature in [gw_zone2.shp](#). Add the PWSID for the system, and an SWAAID following the numbering convention detailed in Section 3.1.

Step 12: Add a single record to the groundwater SWAA lookup table, [gw_lookup.dbf](#). Add the SRCID for the source, and the SWAAID of the new feature.

Zone 1

Step 13: Repeat steps 1-5 above, with two changes. First, use a **1000-foot** buffer. Second, add the result to *sw_zone1.shp*.

Update database and metadata

Step 14: Add any new or modified input parameters used to create WhAEM2000 or fixed-radius delineations to the SWAP database. Revise the metadata sheet for the PWS. (If necessary, create a new metadata sheet.) Include all assumptions made for aquifer property values, saturated thickness, porosity, and pumping rate and the source of information (i.e., topography, maps, technical paper, etc.) Discuss information used in interpreting the model results.

4 Surface Water Delineation Edits

4.1 Add, Delete, or Move a Source or Diversion

Files to edit in this step:

[sw_sources.shp](#)

[sw_diversions.shp](#)

[conveyance_structures.shp](#)

Software Functions required:

Adding point features in ArcView from coordinates or a map.

Adding linear features in ArcView.

Editing attribute tables in ArcView.

Coordinates from different sources can vary widely in accuracy. Always verify the location of sources after adding them. Coordinates must be in UTM Zone 13, NAD83, meters.

4.1.1 Add a Source or Diversion

Step 1: As needed, add one or more points to either [sw_sources.shp](#) or [sw_diversions.shp](#) and fill out the applicable attribute table for the added feature(s). In particular, be sure to keep the new “SRCID” or “DIVERID” name in sequence within the same PWSID. This prevents duplication of names or creation of names that vary significantly from the standard nomenclature. Edit the record in the attribute table for the diversion or source.

Step 2: Update the metadata sheet for the PWS for which points were added. Fill out the fields that list sources/diversions and the reason for adding them to the system. Dates and initials of the person making the additions are highly recommended for tracking changes.

Step 3: In cases where diversions are added to a system, one or more conveyance structures need to be added to [conveyance_structures.shp](#) that show the flow path and direction of diverted water. Fill out the attribute table for the added features. Be sure to associate the new conveyance structure with the new diversion point name in the field “START_PNT”.

Step 4: Delineate the watershed for new sources or diversions. In addition, if an added conveyance structure is shown to collect local runoff, a new delineation must be completed for the watershed tributary to the watershed.

4.1.2 Delete a Source or Diversion

Source

Step 1: To delete a source from a PWS, do not initially delete the point feature itself. Instead, edit the record in the attribute table of *sw_sources.shp* for the feature to be removed. Specifically, change the value in the “LOCSOURCE” field to ABANDONED.

Step 2: Add the newly designated ABANDONED feature to *abandoned.shp*, and then delete it from *sw_sources.shp*. This method preserves both the location and attribute information of the “deleted” point for future reference. Update the metadata sheet for the PWS to reflect that a source was removed, and document the reasons for the change.

Step 3: Remove the delineation for the source and modify the delineation for the next downstream source or diversion (section 5.2).

Diversion

Step 1: Copy or back up *sw_diversions.shp* to a backup directory in case the diversion has to be retrieved in the future. Delete the feature from the shapefile. Update the metadata sheet to indicate that a diversion was deleted and the reasons for the action.

Step 2: Update *conveyance_structures.shp* by deleting the flow line associated with the diversion point that no longer exists.

Step 3: Remove the delineation for the diversion and modify the delineation for the next downstream source or diversion (section 5.2).

4.1.3 Move a Source or Diversion

Step 1: After enabling editing, select the source or diversion to be moved. If the point is to be moved to new coordinates, enter the new coordinates in the “Shape Properties” dialog box (accessible by right-clicking in the ArcView view window). Otherwise, simply edit *sw_source.shp* or *sw_diversions.shp* by dragging the point to the new location. Update the appropriate attribute table record for each moved point by modifying the “LOCSOURCE” field. If applicable, update the date of the edit and the initials of the person performing the change.

Step 2: If a diversion was moved, the conveyance structure alignment must also be altered to once again connect with the new diversion location. Edit file *conveyance_structures.shp* to accomplish this.

Step 3: Update the metadata sheet for the PWS to reflect that points were moved and the reasons for the change.

Step 4: Modify the delineation for the source or diversion (section 5.2).

4.1.4 Change a Source to a Diversion or a Diversion to a Source

Source to Diversion

Step 1: Add the source feature to *sw_diversions.shp*, then delete it from *sw_sources.shp*. Update the attribute table for the new diversion record and rename the “DIVER_ID” to stay in sequence with other diversion names within the same PWSID.

Step 2: Edit the file *conveyance_structures.shp* by adding a new flow line that starts at the diversion point and ends at whatever feature is appropriate for the PWS (e.g. a reservoir, stream, or pipeline.)

Step 3: Update the metadata sheet for the PWS and note that the source was converted to a diversion and the reasons for making the change.

Step 4: Update the attribute table in the appropriate HUC subunit file to show that the SWAA delineation is now associated with a diversion point rather than a source (section 5.2).

Diversion to Source

Step 1: Add the diversion feature to *sw_sources.shp*, then delete it from *sw_diversions.shp*. Update the attribute table for the new source record and rename the “SRCID” to stay in sequence with other source names within the same PWSID.

Step 2: Edit the file *conveyance_structures.shp* by deleting the flow line that started at the diversion that has been converted to a source.

Step 3: Update the metadata sheet for the PWS and note that the diversion was converted to a source and the reasons for making the change.

Step 4: Update the attribute table in the appropriate HUC subunit file to show that the SWAA delineation is now associated with a source point rather than a diversion (section 5.2).

4.2 Modify Delineation for a Source

Files to edit in this step:

huc_subunit_es.shp
huc_subunit_ws.shp
sw_aor.shp
sw_lookup.dbf
aoi_lookup.dbf

Software Functions required:

Adding, splitting, and unioning polygon features in ArcView.
Editing attribute tables in ArcView.

Surface water delineations are done in the HUC Subunit files, *huc_subunit_es.shp* and *huc_subunit_ws.shp*. Exactly one HUC subunit is split for each source or diversion. This way, only a small portion of the watershed (the HUC containing the source or diversion) must be delineated. The USGS has already done the rest for you.

4.2.1 Delete Existing Delineations in the HUC Subunit Files

- Step 1:** Back up existing files before editing.
- Step 2:** Determine which of the HUC subunit files must be modified. Symbolize this file so it has shaded polygons in your view window. Copy or back-up the file prior to deleting an existing delineation.
- Step 3:** Perform a query on the attribute table of this file to search within the “POINT_NO” field for the source or diversion of interest (i.e. the point for which the delineation was completed). The record selected represents the HUC split that needs to be removed. Zoom in to the selected HUC subunit.
- Step 4:** Add the adjacent HUC to your selection (one HUC on either side of the point of interest should now be selected or highlighted in yellow).
- Step 5:** Edit the HUC subunit file by performing a union of the features selected. The boundary between the selected HUCs should have been removed. Then, edit the attribute table by removing the point name from the field “POINT_NO”.
- Step 6:** Update the metadata sheet for the PWS by editing the sections Delineation and Watershed Description. Deleting the HUC names and point name associated with the HUC split that has been removed.

4.2.2 Edit HUC Subunits

- Step 1:** Back up existing files before editing.
- Step 2:** Turn on the local digital topography as background information for the level-6 HUC boundaries. Create a new line shapefile called *delineations.shp* (or something similar) to record your draft delineations.
- Step 3:** Within *delineations.shp*, digitize on-screen the delineation for the new source or diversion. Digitize a delineation on both sides of the point until you reach the nearest level-6 HUC boundary.

Step 4: Print a check plot of the proposed delineation that shows the local topography and the unsplit HUC subunit boundaries. Verify the accuracy of the draft delineation and, if necessary, complete edits in [delineations.shp](#).

Step 5: Edit the applicable HUC subunits by tracing over the draft delineation in [delineation.shp](#) with the Polygon Split tool. **Be sure to extend the line past each of the two existing HUC boundaries!** DO NOT ATTEMPT TO DRAG OR MOVE POINTS AT THIS STAGE OF EDITING! Moving or dragging points will create sliver polygons. If not satisfied with the resulting split polygons, exit without saving and try again until it is acceptable. Exiting and saving the edit session automatically splits the HUCs. The newly created HUC subunit should now be the selected one (highlighted in yellow if you have your HUC subunits shapefile symbolized as shaded polygons). Add the other side of the HUC split to your selection so that both polygons are highlighted.

Step 6: Open the attribute table and inspect the newly created HUC subunit. If it was a first time split of an original level-6 HUC, you need to copy the name from field “SUBWATERSH” to the field “SUBUNIT” and add either the extension “AA” or “ZZ” to the name. If not, proceed to Step 7. Be sure “AA” is added to the name of the UPSTREAM polygon and “ZZ” is added to the name of the DOWNSTREAM polygon. Also, fill out the remainder of the attribute table for each new polygon.

Step 7: If the new HUC split was not the first split of a level-6 HUC, you must follow a different nomenclature for the polygons because extensions “AA” and “ZZ” will already have been used in the field entitled “SUBUNIT”. Perform a query on this field to find all records that have the same 12-digit prefix (e.g., subunit = 110200030106*). This will indicate what the next extension in sequence needs to be for the newly created UPSTREAM subunit. In this case, the extension must be equal to or between BB and YY, depending on how many previous splits have been made within the original level-6 HUC.

Step 8: Update the metadata sheet for the PWS. The Delineation section deals with the point just delineated and the two resulting subunits that have been identified. The Watershed section describes the HUCs or HUC subunits that flow into the newly created subunit (*AA through *YY are the possibilities).

4.2.3 Edit AOR subunits

Note the difference between the definitions of AOR Subunits and AORs. Sources and diversions are treated exactly the same in the creation of AOR Subunits. However, these features are treated quite differently in the creation of AORs.

Step 1: Back up existing files before editing.

Step 2: In ArcView, select all of the HUC Subunits upstream of the new source or diversion to the next upstream source or diversion.

Step 3: Compare the selected HUC subunits with the existing AOR subunits shapefile, *sw_aor.shp*.

Step 4: If the selected HUC subunits do not overlay an existing AOR subunit, a new AOR subunit must be created. If they do overlay an existing subunit, proceed to Step 5. Write the selected HUC subunits into a temporary shapefile. Aggregate the HUC subunits in the temporary shapefile into a single polygon using the ArcView “Union” function. Add the new polygon to the AOR Subunits file. Assign an SWAAID to the new polygon following the AOR subunit numbering convention presented in Section 3.2. Editing is completed. STOP.

Step 5: If the selected HUC subunits overlay an existing AOR Subunit, the AOR subunit polygon must be replaced by two new polygons. In effect, it will be split at the location of the new delineation. Write the HUC subunits overlaying the AOR subunit to a temporary file. Create a new polygon by aggregating the upstream HUC subunits in the temporary file into a single polygon (using the ArcView “Union” function). Create the second new polygon using the remaining downstream HUC subunits.

Step 6: Note the SWAAID of the existing AOR Subunit and delete it. Add the two new polygons.

Step 7: Assign an SWAAID to each polygon. The new downstream polygon must have the same SWAAID as the deleted polygon. This will minimize edits to the AOR and AOI lookup tables. The new upstream polygon will be assigned an SWAAID following the AOR subunit numbering convention presented in Section 3.2. Check the AOR Subunit attribute table to ensure that the new SWAAID is not a duplicate.

4.2.4 *Edit AOR lookup table*

It is very important to read Section 3.2 (“Surface Water Data Structure”) before editing the AOR and AOI lookup tables.

Step 1: If an AOR subunit was deleted, delete all references to it in the AOR lookup table.

Step 2: If an AOR subunit was added, add a single record to the AOR lookup table, *sw_lookup.dbf*. Add the SRCID for the source, and the SWAAID of the new AOR subunit. If the AOR subunit was created from a diversion, an entry must be made in the lookup table for each source that shares the subunit. Enter the same SWAAID for each source.

Step 3: The new AOR subunit may be between an existing source and an upstream shared AOR subunit. Add or delete upstream shares as necessary.

4.2.5 Edit AOI lookup table

It is very important to read Section 3.2 (“Surface Water Data Structure”) before editing the AOR and AOI lookup tables.

Step 1: If an AOR subunit was deleted, delete all references to it in the AOI lookup table.

Step 2: If a new AOR subunit was created from a source, a record must be added to *sw_aoi.dbf* for each downstream source, including sources across diversion structures. The existing AOI lookup table can be used as an aid in this process. Find the SWAAID of the first downstream AOR subunit and record the SWAAID. Copy each record in the AOI lookup table that has the same SWAAID. Change the SWAAID in the copies from the downstream SWAAID to the new SWAAID (retain the existing SRCIDs). Then add a single record with the new SWAAID and the SRCID of the new source. If there is no downstream AOR subunit, use the next upstream AOR subunit.

Step 3: An AOR subunit created from a diversion will have two downstream AOR subunits. Perform the AOI lookup table edits from Step 2 using the downstream AOR subunit and the first subunit downstream from the outlet of the conveyance structure associated with the diversion.

4.3 Edit Sensitivity Zone 1 and 2

Files to edit in this step:

[sw_zone1.shp](#)

[sw_zone2.shp](#)

Software Functions required:

Buffer, Merge, Clip, and Intersect themes in ArcView
Editing attribute tables in ArcView.

Surface water sensitivity zones are created for each AOR Subunit, not for each source. There are no lookup tables for sensitivity zones. See Section 3.2 (“Surface Water Data Structure”) for more details.

4.3.1 Delete buffers associated with changed AOR subunits

Step 1: In ArcView, compare *sw_zone1.shp* with the AOR subunit file, *sw_aor.shp*. Note which AOR subunits have changed. Delete any Zone 1 polygon that overlays a changed AOR subunit.

Step 2: Repeat for *sw_zone2.shp*.

4.3.2 Data Pre-Processing

Surface water sensitivity zones are created from NHD 1:100,000-scale streams and lakes. Reservoirs and surface hydrography needed for creating sensitivity zones are sometimes missing from NHD. In these cases, it is necessary to extend NHD by digitizing additional streams or lakes from other sources. These extensions are in files *nhd_stream_extensions.shp* and *nhd_lake_extensions.shp*.

Step 1: In ArcView, use the “Merge themes together” function of the GeoProcessing Wizard to combine the NHD streams coverage *DRAIN_UTMN83* with *nhd_stream_extensions.shp*. Repeat to combine the NHD lake coverage *LAKE_UTMN83* with *nhd_lake_extensions.shp*.

Step 2: In ArcView, intersect the merged stream theme with the changed AOR subunits. Use the “Intersect two themes” function of the GeoProcessing Wizard. The result will be a temporary working file named *intsectstream.shp*. This file contains streams clipped at AOR subunit boundaries. Repeat to intersect the merged lake theme with the changed AOR subunits. Save as file *intsectlake.shp*.

4.3.3 Create Zone 1

Always set the Map Units in ArcView to meters. Buffer distances can be entered in feet in the ArcView “Create Buffers” tool even if the Map Units are in meters.

Step 1: Create Zone 1s for one AOR subunit at a time. In ArcView, use “Select By Theme” to select all of the streams in *intsectstream.shp* and lakes in *intsectlake.shp* that occur within the selected AOR subunit.

Step 2: Using the “Create Buffers” tool, create a **1000-foot** buffer around the selected streams in *intsectstream.shp*. Dissolve barriers between buffers. Save to a temporary working file *buff1.shp*.

Step 3: Create a **1000-foot** buffer around the selected streams in *intsectlake.shp*. Dissolve barriers between buffers. Save in existing theme *buff1.shp*.

Step 4: With editing enabled, select the two buffers in *buff1.shp*. Use the “Union Features” function to combine them. Save changes.

Step 5: Clip *buff1.shp* at the boundary of the AOR subunit with the “Intersect two themes” function of the GeoProcessing Wizard.

Step 6: Add the clipped polygon to *sw_zone1.shp* and attribute it with the SWAAID of the AOR subunit.

4.3.4 Create Zone 2

Step 1: Repeat steps 1-6 above, with two changes. First use a **2320-foot** buffer (1/4 mile plus 1000’). Second, add the result to *sw_zone2.shp*.

4.4 Edit Near Zone

Files to edit in this step:

sw_nearzones.shp

Software Functions required:

Buffering and clipping polygon features in ArcView.
Merge and intersect themes in ArcView
Editing attribute tables in ArcView.

Always set the Map Units in ArcView to meters. Buffer distances can be entered in miles in the ArcView “Create Buffers” tool even if the Map Units are in meters.

4.4.1 Create 15 mile Near Zone

Step 1: Link the AOR Subunits file (*sw_aor.shp*), the Source Theme (*sw_source.shp*), and the AOI lookup table (*aoi_lookup.dbf*) as described in Section 3.2, “Surface Water Data Structure”.

Step 2: Select the source. With the tables properly linked, all of the AOR subunits that make up the AOI for the source will be selected. Write the selected subunits to a temporary file.

Step 3: Using “Union Graphics”, merge all of the AOR subunits in the temporary file into a single AOI polygon.

Step 4: Using the ArcView “Create Buffers” tool, add a 15-mile buffer around the source to the temporary file.

Step 5: Select both polygons in the temporary file. Use “Intersect Graphics” to clip the 15-Mile Buffer at the extents of the AOI. The resulting polygon is a 15-Mile Near Zone.

Step 6: Add the new near zone polygon to [sw_nearzones.shp](#).

Step 7: Add the SRCID and PWSID for the source to the attribute table.

5 Glossary

Area of Interest (AOI): The term AOI applies to surface water systems, and is synonymous with its SWAA.

Area of Responsibility (AOR): The term AOR applies to surface water systems, and consists of that portion of the delineated SWAA located between a PWS's source and the source(s) of the PWS(s) located immediately upstream, that actually drains to the PWS's source. The AOR defines that portion of the SWAA that the PWS and community should focus on when conducting local contaminant inventory and susceptibility analysis efforts.

AOR Subunit: A region based on a framework of NRCS Level-6 HUCs. Some HUCs were modified by subdividing the HUC at source or diversion locations, based on topography. AOR Subunits were created by aggregating all of the modified and unmodified HUCs between a source or diversion and the sources and diversions located immediately upstream. An AOR will contain more than one AOR Subunit if portions of the AOR are split by diversions or separated by conveyance structures.

Conveyance Structure: A canal, pipeline, tunnel, or other structure designed to convey water. Except for canals that collect surface drainage, conveyance structures are considered only if they convey water from a diversion to an open water body such as a reservoir, stream, or lake. Canals that receive surface drainage are included even if they convey water directly to a PWS.

Digital Line Graph (DLG): A DLG is a digital representation of data found on USGS topographic maps. DLGs are created at scales ranging from 1:24,000 to 1:2,000,000 and have full topological structuring and attribute databases, thus allowing the user to manipulate the data using a GIS.

Digital Raster Graphic (DRG): A DRG is a raster image of a USGS topographic map, created by scanning the original hardcopy map. All DRGs maintain the accuracy and datum of the source map, and are scanned at a minimum resolution of 250 dots per inch.

Diversion: A point where surface water is diverted from the natural watercourse for use by a PWS. Diversion points typically include turnouts to tunnels, canals, pipelines, etc.

HUC Subunit: A region created during surface water source delineations by subdividing NRCS Level-6 (12-digit) HUCs. These regions are analogous to Level-7 HUCs, except that the subdivisions are based on PWS source or diversion point locations. These regions are neither an AOR nor an AOI, but provide the necessary building blocks to create AORs and AOIs. The subunits are denoted by 14 digits, which is similar to Level-7 HUCs. The first 12 digits are the same as those of the Level-6 HUC within which the subunit lies, and the last two digits are alphanumeric.

Source: The last point at which a PWS diverts water from a surface water or groundwater body prior to treatment. A source can be a well, surface water diversion, or spring.

Sensitivity Zones: This term refers to zones surrounding a drainage network or wellhead that are developed based on distance and/or time of travel criteria. These zones are utilized in assessing the vulnerability of a PWS to potential sources of contamination within the SWAA.

Time of Travel (TOT): The period of time required for a drop of water to travel from some point within an aquifer and arrive at the well. For example, the State of Colorado Wellhead Protection Program has established that well capture zones for Community PWSs be developed based upon a 5-year time of travel criterion.