

MINE MAP GRANT PROCESSING STANDARDS (Revised 2023)

1. Mine Map Scanning Standards – Required for all deliverables processed under the Scanning category.

1.1. Scanned Map Image Standards - The goal is to preserve the image on the map and let it represent what is shown. The original mine map is to be scanned as a “historic document” and shall be unchanged. The end result will be an “Archive Mine Map Image”.

- i. A resolution of 400 dots-per-inch (dpi) is the minimum for scanning the maps. A higher dpi can be used if 400 dpi does not reproduce the desired image. *If for technical reasons large format maps need to be scanned at a lower resolution, prior approval from the DEP Project Manager is required.*
- ii. A color depth of 24-bit 3-band RGB color is the scanning standard.
- iii. Images shall be saved in an uncompressed Tagged Image File Format (TIFF) format.
- iv. No objects, notes, scale bars, and/or tags shall be added on top of the map image before the map is scanned. No objects shall be placed on the map to “weigh it down” or flatten the map. *Untinted, transparent glass or plexiglass, no greater than 0.25 inches, may be used to flatten the map during scanning with prior approved by the DEP Project Manager.*
- v. There is no need to standardize particular scanning hardware or software, as long as the hardware and software are capable of providing a quality scanned map image.
- vi. Image extents shall include the entire map with as little as possible additional space in the digital image beyond the hard-copy map. Once a scan image is created, the image may be cropped as long as none of the hard-copy map is removed from the digital image. This is the only post-processing allowed for the Archive Mine Map Image.
- vii. The map shall be scanned in its entirety in one image with the scanner whenever possible. If a mine map is too large to be scanned in its entirety in one image with the scanner, the map may be scanned in sections with at least two inches of overlap on each of the section images. *Each map only counts as one deliverable, regardless of how many section images it takes to scan the map.*

1.2. Scanned Map Naming Conventions – Each mine map collection/repository may have its own naming convention to reference the maps it contains. The name of a map will be referred to as its “Local Sheet ID”.

- i. The DEP Project Manager will determine the naming convention of the Local Sheet ID for each collection.
- ii. The deliverable of the Archive Mine Map Image shall have a filename of the Local Sheet ID. *(Examples: Local_Sheet_ID.tif ; BMSB_UMM_100_001.tif)*
- iii. If a map is scanned in several sections, the filename of the TIFFs shall be the Local Sheet ID followed by an underscore, then an “A” for the first section, “B” for the second section, etc. *(Example: BMSB_UMM_100_001_A.tif ; BMSB_UMM_100_001_B.tif)*

1.3. Scanned Map Cataloging – Metadata of each Archive Mine Map Image must be entered into the Pennsylvania Historic Underground Mine Map Inventory System (PHUMMIS). This information includes, but is not limited to: mine name, operator, locational data, map date, etc. The metadata can be interpreted from the map itself or other available sources. PHUMMIS will also be used as an Inventory Control and used to track the grantee’s progress.

- i.* The DEP Project Manager will determine the metadata needed to be collected and entered into PHUMMIS for each map mine collection/repository.
- ii.* An appropriate Data Dictionary (provided by the DEP Project Manager) shall be used when entering data.
- iii.* The grantee must have a computer system that can make a VPN connection with DEP’s computer network so they can enter data into the PHUMMIS database. The grantee will have to agree to the Commonwealth’s Information Technology Acceptable Use Policy.

1.4. Scanned Map Deliverables – Each Archive Mine Map Image shall be delivered to the Department as described below for each delivery period.

- i.* The Archive Mine Map Images shall be delivered to the Department on a portable external hard drive, supplied by the Department, or via an online upload at the Department discretion.
- ii.* The delivery shall contain all Archive Mine Map Images that are deemed to have been completed between two given dates, referred to as the delivery period. Delivery periods shall not overlap subsequent delivery periods.
- iii.* The Archive Mine Map Images shall all be in one file folder on the hard drive for each delivery. No other files shall be in this file folder.
- iv.* No duplicate Archive Mine Map Image shall be submitted if previously submitted in another delivery.
- v.* The Inventory Control Report generated from PHUMMIS shall match the contents of the hard drive for the delivery period.

1.5. Scanned Map Quality Control – The grantee shall have in place a Quality Assurance/Quality Control system that checks and verifies that Scanned Map Image, Naming Conventions, Cataloging, and Deliverable Standards have been met before any data is delivered to the Department. If data is delivered below standards, the DEP Project Manager may request the data be adjusted to meet standards and be resubmitted and/or the DEP Project Manager may request the grantee’s Quality Assurance/Quality Control system be adjusted to prevent future below standard deliverables.

2. Mine Map Georeferencing Standards – Required for all deliverables processed under the Georeferencing category.

2.1. Georeferenced Map Image Standards – The Archive Mine Map Image can be a very large file due to its uncompressed format. For more efficient computer processing speed and use in a Geographic Information System (GIS), the Archive Mine Map Image shall be converted into a compressed Multi-resolution Seamless Image Database (MrSID). Depending on the grantee’s proposed project, the MrSID image files may be supplied by the Department or generated by the grantee.

- i. The image file to be georeferenced shall be compressed into a MrSID file format. *The recommended software to complete this task is Extensis’s (formally LizardTech’s) GeoExpress.*
- ii. The Output Format of the compressed image file shall be “MrSID Generation 4” or higher generation.
- iii. The compression ratio shall be 20:1.
- iv. The MrSID’s metadata tags containing georeferenced data (I.E. x_rotation, y_rotation, xy_origin, WKT coordinate system, etc.) shall not be updated after compression. The DEP Project Manager may specify a coordinate system tag to be added at initial compression for particular map collections.

2.2. Georeferenced Maps Scanned into Multiple Sections Standards – If a map was scanned in several sections (as described in 1.1.vii), it may be easier to georeference if the sections were merged back together beforehand. Not all maps with sections can be merged back into one image, and therefore each section can be georeferenced separately. It is up to the grantee to determine the best course of action.

- i. The TIFF files of multiple sections for a single Archive Mine Map Image can be merged back together into one image file. *The recommended software to complete this task is Adobe’s Photoshop CS. The recommended methodology is to use the Photomerge tool to merge section TIFFs into one image, then use the Flatten tool to make a single layered uncompressed TIFF.*
- ii. This merged TIFF image file can then be compressed into a MrSID file.
- iii. The merged TIFF image file will no longer be needed and shall be not submitted with deliverables.
- iv. *Note: Each georeferenced complete map counts as only one deliverable, regardless of how many section images are georeferenced.*

2.3. Georeferencing Map Methodology Standards – The MrSID Image will be aligned in a Geographic Information System (GIS) to a known coordinate system so it can be viewed and analyzed with other geographic data at the same spatial location. The software needed to complete this task is a current version of *ESRI's ArcMap* application.

- i. A minimum of four control points shall be established between the source mine map and approved basemaps/base data. The minimum number of control points shall be chosen from the highest level of priorities listed below before choosing a point in the next priority category.
- ii. The order in which source control points on the map image should be chosen are:
 - a. Drawn Coordinate Pairs
 - b. Road Intersections
 - c. Bridges / Culverts
 - d. Structures
 - e. Property Lines
 - f. Other features approved by DEP Project Manager
- iii. The order in which target control points on the base data should be chosen are:
 - a. Matching Projected Coordinate Points
 - b. Aerial Ortho-imagery that meets or surpasses the accuracy of the PAMAP Project's 2003 dataset (*Details found at www.pasda.psu.edu*)
 - c. Most recent USGS 7.5 Minute Topographic Maps. (*Details found at www.usgs.gov/pubprod/*)
 - d. Historic Aerial Imagery (*Pre-approved source: Penn Pilot, the historic photo may need to be georeferenced to these standards itself first*)
 - e. Property Parcel Shapefiles, if approved by DEP Project Manager, which can usually be purchased by grantees from county governments.
 - f. Historic USGS Topographic Maps.
 - g. Previously georeferenced mine maps, if approved by DEP Project Manager.
- iv. Do not use waterways as control points.
- v. The georeferencing Transformation setting shall be *1st Order Polynomial (Affine)*.
- vi. The mine map image shall be georeferenced in the geographic horizontal datum known as the North American Datum of 1983 (NAD83)
- vii. The mine map image shall be georeferenced in the one of these four projected coordinate systems that best work for the map collection:
 - a. UTM Zone 17 North, NAD83 (*EPSG WKID: 26917*)
 - b. UTM Zone18 North, NAD83 (*EPSG WKID: 26918*)
 - c. State Plane Pennsylvania North (U.S. Feet), NAD83 (*EPSG WKID: 2271*)
 - d. State Plane Pennsylvania South (U.S. Feet), NAD83 (*EPSG WKID: 2272*)
- viii. The "Update Georeferencing" command in the software shall be used to generate an ESRI Georeferencing Auxiliary file (extension .sid.aux.xml) that contains the projected coordinate system and the minimum four control points.
- ix. The MrSID Image file and its accompanying ESRI Georeferencing Auxiliary file shall be referred to as the "Georeferenced Mine Map files".
- x. If the minimum of four satisfactory control points cannot be obtained by the grantee, the map is assigned a status of "Unable to Georeference" for purposes of the grant.

2.4. Georeferenced Map Naming Conventions – The MrSID file shall have the same Local Sheet ID as the Archive Mine Map Image file it was compressed from.

- i.* The deliverable of the georeferenced MrSID file shall have a filename of the Local Sheet ID prefixed with “geor_”. (Example: *geor_BMSB_UMM_100_001.sid*)
- ii.* If a map is scanned in several sections and the sections were georeferenced separately, the filename of the georeferenced MrSID file shall be the Local Sheet ID prefixed with “geor_”, suffixed by an underscore, then an “A” for the first section, “B” for the second section, etc. (Example: *geor_BMSB_UMM_100_001_A.sid* ; *geor_BMSB_UMM_100_001_B.sid*)
- iii.* If a map is scanned in several sections and the sections were merged back together before georeferencing, the filename of the georeferenced MrSID file shall be the Local Sheet ID prefixed with “geor_”, suffixed by “_FLAT”. (Example: *geor_BMSB_UMM_100_001_FLAT.sid*)
- iv.* The ESRI Georeferencing Auxiliary file shall have the same filename as its accompanying MrSID file. (Example: *geor_BMSB_UMM_100_001.sid.aux.xml*)

2.5. Georeferenced Map Cataloging – Additional metadata of a mine map might be identifiable after the georeferencing process, especially locational data. Any newly identified metadata must be entered into PHUMMIS. The status of a georeferenced mine map must also be updated in PHUMMIS for Inventory Control and use to track the grantee’s progress.

- i.* The DEP Project Manager will determine the metadata needed to be collected and entered into PHUMMIS for each map mine collection/repository.
- ii.* An appropriate Data Dictionary (provided by the DEP Project Manager) shall be used when entering data.
- iii.* The grantee must have a computer system that can make a Virtual Private Network (VPN) connection with DEP’s computer network so they can enter data into the PHUMMIS database. The grantee will have to agree to the Commonwealth’s Information Technology Acceptable Use Policy.

2.6. Georeferenced Map Deliverables – Each set of Georeferenced Mine Map files shall be delivered to the Department as described below for each delivery period.

- i.* The Georeferenced Mine Map files shall be delivered to the Department on a portable external hard drive, supplied by the Department, or via an online upload at the Department discretion.
- ii.* The delivery shall contain all Georeferenced Mine Map Images that are deemed to have been completed between two given dates, referred to as the delivery period. Delivery periods shall not overlap subsequent delivery periods.
- iii.* The Georeferenced Mine Map files shall all be in one file folder on the hard drive for each delivery period. Only the MrSID files and their accompanying ESRI Georeferencing Auxiliary files shall be in the folder. No other files shall be in this file folder, including world files, metadata files, or other auxiliary files.
- iv.* No duplicate Georeferenced Mine Map files shall be submitted, if previously submitted in another delivery.
- v.* The Inventory Control Report generated from PHUMMIS shall match the contents of the hard drive for the delivery period.

2.7. Georeferenced Map Quality Control – The grantee shall have in place Quality Assurance/Quality Control system that checks and verifies Georeferencing Map Image, Methodology, Naming Conventions, Cataloging, and Deliverable Standards have been met before any data is delivered to the Department. If data is delivered below standards, the DEP Project Manager may request the data be adjusted to meet standards and be resubmitted and/or the DEP Project Manager may request the grantee’s Quality Assurance/Quality Control system be adjusted to prevent future below standard deliverables.

3. Mine Map Digitizing/Vectorizing Standards – Required for all deliverables processed under the Digitizing/Vectorizing category. Refer to Grant Agreement for which feature classes are required to be processed in a grantee’s Scope of Work.

3.1. Determining which Maps to Vectorize – The goal is to determine which mine map is the “best” representation of the mine workings for a given spatial area and to identify any duplication of mapping in the digital repository. The criteria to determine what the “best” map is will be different for each mine map collection/repository and/or each individual map. The grantee is ultimately responsible for making this determination, but usually maps of larger scale, better draftsmanship, and containing the most identifiable information will more likely be the “best”. It is possible only a portion of one map is determined to be the “best” over a spatial area, and another overlapping map be the “best” for an adjacent area. Once the “best” map for a given location is determined, the maps shall be compiled into an *ESRI’s Mosaic Dataset* with “footprints” of each map identifying the area of that map to be vectorized. The Mosaic Dataset will organize and display the maps in a seamless image of a spatial area of a given coal seam. Grantees should consult the DEP Project Manager to determine the best approach.

3.2. Vectorized Geodatabase Standards – The goal is to convert particular coal, geologic, and mining related features shown on georeferenced mine map raster images to vector data to be viewed and analyzed with other geographic data at the same spatial location. The software needed to complete this task is a current version of *ESRI’s ArcMap* application.

- i.* Vector data shall be generated as feature classes within an *ESRI File Geodatabase*. Template feature classes will be provided by the DEP Project Manager. The *version* of the geodatabase will be determined by the DEP Project Manager.
- ii.* The grantee shall be, or be able to be consulted by a party that is, already familiar with interpreting features on a coal mine map. The grantee may ask the DEP Project Manager for assistance with interpretations, but the grantee is ultimately responsible for the interpretation.
- iii.* The recommended methodology for this task is manual heads-up digitizing (as opposed to tablet or board digitizing).
- iv.* The horizontal geographic coordinate system of the geodatabase and all feature classes shall be the Geographic Coordinate System based off the North American Datum of 1983 (*EPSG WKID: 4269*).



3.3. Vectorized Feature Class Standards – Each feature type has different standards as described below. The software needed to complete this task is a current version of *ESRI's ArcMap* application.

- i.* **Coal_Elevation_Points** feature class: The goal is to capture surveyed coal seam elevations found throughout the mine workings.

 - a.* All coal seam elevation survey points as depicted on the mine map images shall be vectorized and saved as point feature classes.
 - b.* Surface elevation points depicted on the mine map shall not be vectorized.
 - c.* Coal seam elevation contour lines depicted on the mine map should not be vectorized.
 - d.* The location of the surveyed point is generally depicted on the mine map as a + or correspond to a depicted borehole (generally a circle). The vectorized point shall be placed at this depiction. Sometimes there are elevations written in the middle of coal pillars with no corresponding depiction, the grantee shall use their best judgment to place the point.
 - e.* Elevation points depicted in or at the opening of a slope entry generally do not correspond to the coal seam and shall not be vectorized.
 - f.* The exact vertical datum is usually unknown; therefore no vertical datum shall be defined in the feature class properties.

- ii.* **Digitized_Mined_Area** feature class: The goal is to capture all possible mine voids that could cause mine subsidence on the surface and therefore should encompass any part of the coal seam that has been removed due to mining.

 - a.* The maximum extent/boundary of mine workings and mined out areas as depicted on the mine map shall be vectorized in order to capture the “footprint” of each mined out void and saved as polygon feature classes.
 - b.* All intersecting polygons of the same mine, on the same coal seam, on the same map sheet shall be one polygon/feature. *I.e., multiple polygons representing the same mine on the same map sheet shall be merged into one feature.*
 - c.* If a map depicts multiple mines on one sheet, each mine shall be vectorized as separate features/polygons.
 - d.* If a map depicts a mine on multiple coal seams, mine workings on each seam shall be vectorized as separate features/polygons.
 - e.* The recommended methodology to determine if an un-mined area inside a mined area polygon should be cut out is as follows: *Un-mined areas inside mined area polygons can be cut out of the polygon if the un-mined area's smallest radius is wider than the depth of the overburden to the coal seam. The grantee should use their best judgment if cutting out the un-mined area is appropriate.*

- iii. **Mine_Shfts_Entries** feature class: The goal is to capture entries into mines at the surface that a person could (or could have, if the shaft has been reclaimed) fit through or could collapse and cause subsidence on the surface.
 - a. All shafts and entries into the mines as depicted on the mine map images shall be digitized and saved as point feature classes.
 - b. Boreholes, which are usually less than a foot wide, shall not be vectorized.
 - c. The location of mine entries are generally depicted on the mine map with these symbols:
 - i.  **Shaft** entries found in the middle of mine workings.
 - ii.  **Drift** entries if the symbol is on the coal seam outcrop or **Slope** entries if symbol is above or below the outcrop.

3.4. Vectorized Features' Attribute Standards – Each feature vectorized from a georeferenced mine map shall have the appropriate attribute data entered into its attribute table. Not all attributes in the supplied templates need to be filled in by the grantee. See below for which attributes are required, desired if available, or should be left blank. If an attribute is not listed below, the grantee shall leave it blank. Each feature type has different standards as described below.

- i. An appropriate Data Dictionary (provided by the DEP Project Manager) shall be used when entering data into the attribute tables.
- ii. Some mine maps also show adjacent mines to the main mine of the map. Those adjacent mines shall be attributed with their own Operator, Operation, and LastMined where appropriate.
- iii. **Coal_Elevation_Points** feature class attributes:
 - a. **COALSEAM- Required.** Some coal seams are referred to by multiple names; use the name depicted on the map and that matches the Data Dictionary. If the coal seam cannot be determined, the field shall be filled with "Undetermined".
 - b. **ELEVATION- Required.** While elevations are generally surveyed from spads in the mine roof, they are generally recorded on maps as the mine floor (the mine height is subtracted from the surveyed elevation), which is the value that shall be recorded in the attribute table. The elevation values are generally written in feet above mean sea level and are written to the first decimal place, but the exact vertical datum is usually unknown. The depicted value shall be recorded, regardless of decimal place. *Note: No vertical datum shall be defined in the feature class properties.*
 - c. **SOURCE- Required.** This shall be the Local Sheet ID of the mine map.

- iv. **Digitized_Mined_Area** feature class attributes:
- a. **Coal_Seam- Required.** Some coal seams are referred to by multiple names; use the name depicted on the map and matches the Data Dictionary. If the coal seam cannot be determined, the field shall be filled with “Undetermined”.
 - b. **Operation – Required.** The name of the mine. The word “Mine” does not need to be added to the field. Abbreviations shall only be used if the whole name will not fit in the space (50 characters) or the abbreviation is the only information known. If the name of the mine cannot be determined, the field shall be filled with “Undetermined”.
 - c. **Operator – Required.** The name of the mining operator, usually a coal or coke company. Abbreviations of the name shall only be used if the whole name will not fit in the space (50 characters) or the abbreviation is the only information known. The word “Company” shall only be truncated if it does not fit in the space, or “Co.” is an acceptable abbreviation. If the name of the mine cannot be determined, the field shall be filled with “Undetermined”.
 - d. **LastMined – Desired.** The most recent date shown on the map that indicates mining occurred. This is usually the survey date in the legend (if available), but sometimes maps are updated and the legends are not changed, look through the working for more recent dates. Some maps in a series will use alphabet date codes such as “AB” or “HG”, the cross reference chart may be found on only one sheet in a map series. Note: This should not be engineers’ seal dates or offices’ stamped received dates. Leave blank if information is not available.
 - e. **Source - Required.** This shall be the Local Sheet ID of the mine map(s).
- v. **Mine_Shfts_Entries** feature class attributes:
- a. **Operation – Required.** The name of the mine. The word “Mine” does not need to be added to the field. Abbreviations shall only be used if the whole name will not fit in the space (50 characters) or the abbreviation is the only information known. If the name of the mine cannot be determined, the field shall be filled with “Undetermined”.
 - b. **Operator – Required.** The name of the mining operator, usually a coal or coke company. Abbreviations of the name shall only be used if the whole name will not fit in the space (50 characters) or the abbreviation is the only information known. The word “Company” shall only be truncated if it does not fit in the space, or “Co.” is an acceptable abbreviation. If the name of the mine cannot be determined, the field shall be filled with “Undetermined”.
 - c. **Type – Required.** Select from the data dictionary that best describes the entry as it is depicted on the map.
 - d. **Source - Required.** This shall be the Local Sheet ID of the mine map.
 - e. **Coal_Seam- Required.** Some coal seams are referred to by multiple names; use the name depicted on the map and that matches the Data Dictionary. If the coal seam cannot be determined, the field shall be filled with “Undetermined”.

3.5. Vectorized Features Cataloging – The status of vectorizing a mine map must be updated in PHUMMIS for Inventory Control and use to track the grantee’s progress.

- i.* The grantee must have a computer system that can make a VPN connection with DEP’s computer network so they can enter data into the PHUMMIS database. The grantee will have to agree to the Commonwealth’s Information Technology Acceptable Use Policy.

3.6. Vectorized Features Deliverables – Each geodatabase of vectorized feature classes shall be delivered to the Department as described below for each delivery period.

- i.* The geodatabase of vectorized feature classes shall be delivered to the Department on a portable external hard drive, supplied by the Department, or via an online upload at the Department discretion.
- ii.* The delivery shall contain all vectorized feature classes that are deemed to have been completed between two given dates, referred to as the delivery period. Delivery periods shall not overlap subsequent delivery periods.
- iii.* Each delivery shall contain one single file geodatabase. The geodatabase shall contain only one feature class for each template (three total). *I.e., all feature classes of the same template shall be appended together by the grantee before delivery.*
- iv.* No other files, including but not limited to map projects(.mxd), shapefiles(.shp), a copy of the georeferenced map, etc., shall be submitted as part of the delivery (with the exception of a geodatabase with any compiled Mosaic Dataset).
- v.* No duplicate vectorized feature shall be submitted, if previously submitted in another delivery (*unless other ways approved by DEP Project Manager*).
- vi.* The Inventory Control Report generated from PHUMMIS shall match the contents of the hard drive for the delivery period.
- vii.* Additionally, any Mosaic Datasets in a file geodatabase compiled for this project shall be delivered to the Department once it is completed.

3.7. Vectorized Features Quality Control – The grantee shall have in place Quality Assurance/Quality Control system that checks and verifies that all Mine Map Digitizing/Vectorizing standards have been met before any data is delivered to the Department. If data is delivered below standards, the DEP Project Manager may request the data be adjusted to meet standards and be resubmitted and/or the DEP Project Manager may request the grantee’s Quality Assurance/Quality Control system be adjusted to prevent future below standard deliverables.

4. Mine Map Three-Dimensional (3D) Modeling Standards – Required for all deliverables processed under the Three-Dimensional (3D) Modeling category. The goal is to convert the two-dimensional data previously created in the Digitizing/Vectorizing category into three-dimensional data for use in Geographic Information Systems (GIS). Refer to Grant Agreement for which datasets are required to be processed in a grantee’s Scope of Work.

4.1. Creating a Digital Elevation Raster (DER) of Coal Seams – The geometric elevation values (or z-values) of features in a coal seam shall be derived from a Digital Elevation Raster of Coal Seams. Coal Seam DERs shall be created for each processing area. They shall be delivered to and then approved for use by the DEP Project Manager prior to creation of other 3D datasets in the same processing area. The software recommended to complete these tasks is a current version of *ESRI’s ArcGIS Pro* application, but grantees may use other software with prior approval from the DEP Project Manager.

- i.* Coal seam elevation points (representing the bottom of the coal seam) were previously captured from georeferenced mine maps. This data shall be used as the default source dataset layer for interpolation into a DER.
- ii.* Additional coal seam elevation dataset sources, such as drill logs, may be used to augment the vectorized elevation points from mine maps. These additional sources must be approved by the DEP Project Manager to ensure they meet acceptable accuracy standards for a given processing area.
- iii.* Extensive Quality Control shall be performed on source datasets prior to processing to ensure all outliners and elevation value typos are removed or corrected.
- iv.* The minimum spatial resolution of the DER’s cells’ size shall be 100 feet squared, but smaller spatial resolutions shall be sought after where source datasets have adequate information to accurately process the smaller size.
- v.* The vertical coordinate system of the DER shall be the *North American Vertical Datum of 1988 (NAVD88)* in U.S. feet.
- vi.* The horizontal projected coordinate system of the DER shall be either *State Plane Pennsylvania North* or *State Plane Pennsylvania South* in U.S. feet, based from the *North American Datum of 1983 (NAD83)*.
- vii.* The interpolation method used to generate a DER from source datasets and the parameters of those interpolation methods shall be determined by the grantee so that the most accurate DER values can be derived in a given processing area. It is expected that different processing areas will require different interpolation methods and parameters based on the available source datasets in each area. Interpolation methods used in each area shall be documented.
- viii.* Any known geological faults shall be considered and incorporated into the interpolation method as interpolation barriers. Any faults vectorized for this purpose shall be delivered to the Department with other deliverables.
- ix.* The generated DER shall be hydrologically correct, to be used to determine the flow of water within a mine void and mine pool. The grantee shall be, or be able to be consulted by a party that is, already familiar with hydrologic flow in a mine system.

4.2. Three-Dimensional Feature Class Conversion Standards – Each feature class has different standards as described below. All attributes in the original feature class shall be transferred to the new 3D feature classes. The software needed to complete this task is a current version of *ESRI's ArcGIS Pro* application.

- i. Digitized_Mined_Area_3D** feature class shall be created from the previously vectorized Digitized_Mined_Area feature layer.

 - a. The feature class shall have a Multipath geometry type with Z values enabled.
 - b. The Z values of the vertices of the mine floor shall be the coal seam elevation at the corresponding horizontal x/y coordinates.
 - c. The coal seam elevations shall be derived from approved Digital Elevation Raster (DER) of Coal Seams created for the Mine Map Grant program.
 - d. The Z values of the vertices of the mine roof shall be the coal seam elevation at the corresponding horizontal x/y coordinates plus an extrusion height based of the average thickness of the particular coal seam. The DEP Project Manager will supply the thickness values.
 - e. The vertical coordinate system of the feature class shall be the *North American Vertical Datum of 1988 (NAVD88)* in U.S. feet.
 - f. The horizontal projected coordinate system of the feature class shall be either *State Plane Pennsylvania North* or *State Plane Pennsylvania South* in U.S. feet, based from the *North American Datum of 1983 (NAD83)*.
- ii. Mine_Shafts_Entries_3D** feature class shall be created from the previously vectorized Mine_Shafts_Entries feature layer.

 - a. The feature class shall have a Point geometry type with Z values enabled (PointZ type).
 - b. The Z values shall be the surface elevation at the corresponding horizontal x/y coordinates.
 - c. The surface elevations shall be derived from the publicly available USGS LiDAR QL2 Digital Elevation Models (DEM), no older than 2017. These datasets can be acquired at no cost on the Pennsylvania Spatial Data Access (PASDA) website.
 - d. The vertical coordinate system of the feature class shall be the *North American Vertical Datum of 1988 (NAVD88)* in U.S. feet.
 - e. The horizontal projected coordinate system of the feature class shall be either *State Plane Pennsylvania North* or *State Plane Pennsylvania South* in U.S. feet, based from the *North American Datum of 1983 (NAD83)*.
- iii. Vertical_Mine_Shafts** feature class shall be created from extracted vertical shafts of the Mine_Shafts_Entries_3D feature class.

 - a. The feature class shall have a Line geometry type with Z values enabled (LineZ type).
 - b. The horizontal x/y coordinates of each vertex of a feature shall be the same. The starting point of a line shall have a Z value of the surface elevation and the end point shall have a Z value of the bottom of the shaft, generally the elevation of the bottom most coal seam mined
 - c. The surface elevations shall be derived from the publicly available USGS LiDAR QL2 Digital Elevation Models (DEM), no older than 2017. These datasets can be acquired at no cost on the Pennsylvania Spatial Data Access (PASDA) website.
 - d. The vertical coordinate system of the feature class shall be the *North American Vertical Datum of 1988 (NAVD88)* in U.S. feet.
 - e. The horizontal projected coordinate system of the feature class shall be either *State Plane Pennsylvania North* or *State Plane Pennsylvania South* in U.S. feet, based from the *North American Datum of 1983 (NAD83)*.

4.3. Three-Dimensional (3D) Rasters and Features Deliverables – Each geodatabase of 3D rasters and feature classes shall be delivered to the Department as described below for each delivery period.

- i.* The geodatabase of 3D rasters and feature classes shall be delivered to the Department on a portable external hard drive, supplied by the Department, or via an online upload at the Department discretion.
- ii.* The delivery shall contain all vectorized feature classes that are deemed to have been completed between two given dates, referred to as the delivery period. Delivery periods shall not overlap subsequent delivery periods.
- iii.* Each delivery shall contain one single file geodatabase (*unless other ways approved by DEP Project Manager*).
- iv.* No duplicate data shall be submitted, if previously submitted in another delivery (*unless otherwise approved by DEP Project Manager*).

4.4. Three-Dimensional (3D) Rasters and Features Quality Control – The grantee shall have in place Quality Assurance/Quality Control system that checks and verifies that all Mine Map 3D modeling standards have been met before any data is delivered to the Department. If data is delivered below standards, the DEP Project Manager may request the data be adjusted to meet standards and be resubmitted and/or the DEP Project Manager may request the grantee’s Quality Assurance/Quality Control system be adjusted to prevent future below standard deliverables.