A p p e n d i x B

HEC-RAS Import/Export Files for Geospatial Data

At version 2.0, HEC-RAS has introduced three-dimensional (3D) geometry for the description of river networks and cross-sections. This capability makes it possible to import channel geometry from CADD or GIS programs without conversion from real-world coordinates to station-elevation descriptions for the cross-sections, as HEC-2 required. Similarly, water-surface elevations calculated at cross-sections can be exported to CADD or GIS programs, where they can be used to create model water surfaces for inundation mapping**.**

Supported HEC-RAS Data Exchange

Using a formatted ASCII text file, HEC-RAS will import a basic description of the channel geometry including:

- The structure of the stream network, as represented by interconnected reaches.
- The location and description of cross-sections.

Using the same file format, HEC-RAS can write a file exporting the results of a hydraulic model run to a CADD or GIS program. At a minimum, reported results include the locations of cross-sections and the calculated water-surface elevations at those cross-sections.

The Import/Export Data File Structure

This section gives general rules for the construction of an HEC-RAS geometric data import or export file. It is not necessary to understand all these rules to build an import file, but they may be useful when debugging failed imports. The rules given here are a portion of the definition of a general-purpose geometric data exchange format being developed at HEC for its NexGen model programs. **Note: These file formats are evolving, in that additional data types will be added, and some of the existing ones may be modified for future versions. If you are writing software to read and write these file formats, please keep in mind that you may need to modify your software to stay compatible with future versions**

of HEC-RAS.

Records and Keywords

The HEC-RAS geometric data import file is composed of records, which in turn are composed of keywords and values. All records must contain one keyword, and all keywords end with a colon (:). A record can also contain a value or a set of values following the keyword, i.e., after the colon. Spaces, tabs, or line ends can be placed between a keyword and values within a record.

A record that contains a keyword and no value marks the beginning or the end of a group of related records (for example, the record "BEGIN HEADER:" marks the beginning of the header section of a data file). A record that contains a keyword and a value assigns that value to the part of the model named by the keyword.

When a keyword is read, all spaces up to the colon are removed and all letters are capitalized. The keywords "Begin Header:", "Begin header:", and " Be GiNH eadEr:" are all equivalent to "BEGINHEADER:". For readability, keywords named in this manual will contain internal spaces.

Values

A record can assign a single value to a single variable, or multiple values to an array. Values can be integers, floating point numbers, text strings, or locations (X,Y,Z, label). A single value in an array of values is called an "element" of that array.

A **numerical value (integer or floating point)** cannot contain internal blanks. A floating point number can contain a decimal point; an integer cannot. Elements in an array of numerical values can be separated by commas, blanks, tabs, or line ends.

A **text string** can contain internal blanks, tabs, and commas, but cannot contain internal line ends. Elements in an array of text strings must be separated by line ends.

A **location** consists of three coordinate values and a label (X, Y, Z, label). The first two coordinates are planar, the third gives elevation. The coordinate values are floating point numbers, and the label can be any type of value (although the label can be restricted to a particular data type in a particular context). In certain contexts, the elevation value or the label may not be required. If a label is used, all three coordinate values must be given; the value "NULL" is valid for the elevation coordinate only. The coordinate values and the label can be separated by commas, blanks, or tabs, but a location cannot contain internal line ends. Elements in an array

of locations must be separated by line ends.

Data Groups

Records in the data file can be collected in two types of groups: objects and file sections. An object is a group of records that combine to describe an entity within the model, a cross-section for example. A file section is a logical or functional grouping of data, the file header, for example, is a section that contains a description of the whole file.

Objects and file sections begin and end with records that contain keywords, but no values. A file section starts with a record containing a keyword composed of the word "BEGIN" followed by the section name and a colon, and ends with a keyword composed of the word "END" followed by the section name and a colon. For example, records containing only the keywords "BEGIN HEADER:" and "END HEADER:" are used to start and end the header section of a file. An object starts with a record containing a keyword naming the object type and ends with a record containing the keyword "END:" only. For example, a cross-section object begins and ends with records containing the keywords "CROSS-SECTION:" and "END:" only.

Comments

Hash characters (#) are used to identify comments. When a hash character is encountered in the file, all data from the hash to the next line end are ignored. A line that begins with a hash is equivalent to a blank line.

HEC-RAS Channel Geometry Import File

HEC-RAS reads channel geometry from a text file composed of three data sections:

1. A header, containing descriptions that apply to all data in the file.
2. A description of the stream network, containing reach locations and connectivity.
3. A descriptions of the model cross-sections, containing their location on the stream network and data required to support the HEC-RAS model.

An example HEC-RAS Channel Geometry Import file and HEC-RAS model results export file is shown at the end of this appendix.

Header

The header is bounded by the records "BEGIN HEADER:" and "END HEADER:" and must contain a record to identify the units system used in the imported data set. The units system can be ENGLISH or METRIC.

```
BEGIN HEADER:
 UNITS: ENGLISH
END HEADER:
```

minimum import file header

Records that may be included in the header are listed in the Table B.1:

Table B.1

Keyword	Value Type	Value
UNITS:	string	ENGLISH or METRIC
PROFILES:	string array	List of profiles exported from HEC-RAS. Not used on import.
DTM TYPE:	string	type (e.g., TIN or raster)
DTM:	string	name of digital terrain model
STREAM LAYER:	string	name of stream layer in CADD or GIS
NUMBER OF REACHES	integer	number of hydraulic reaches contained in the file.
CROSS-SECTION LAYER:	string	name of cross-section layer in CADD or GIS
NUMBER OF CROSS-SECTIONS:	integer	number of cross sections in the file
MAP PROJECTION:	string	projection (coordinate) system used (e.g., STATEPLANE)
PROJECTION ZONE:	string	projection zone (if applicable, e.g., 5101)
DATUM:	string	reference datum for planar coordinates
VERTICAL DATUM:	string	reference datum for vertical coordinates

Stream Network

The stream network section is bounded by the records "BEGIN STREAM NETWORK:" and "END STREAM NETWORK:" and contains records describing reaches and reach endpoints. At a minimum, the stream network section must contain at least two endpoints and one reach. The minimum requirements for a stream network are shown below.

```
BEGIN STREAM NETWORK:
  ENDPOINT: 476132.66, 65291.86, 155.28, 1
  ENDPOINT: 478144.53, 64296.61, 123.72, 2

  REACH:
    STREAM ID: Below Springfield
    REACH ID: Blue River
    FROM POINT: 1
    TO POINT: 2
    CENTERLINE:
      476132.66, 65291.86, 155.28, 23.13
      476196.08, 65196.61, 154.47
       lines omitted
      478144.53, 64296.61, 123.72, 22.41
  END:
END STREAM NETWORK:
```

minimum import stream network section

A reach endpoint is represented by a record containing the keyword "ENDPOINT:" followed by four comma-delimited fields containing the endpoint's X,Y,Z coordinates and an integer ID.

A reach is represented by a multi-record object that begins with a record containing only the keyword "REACH:" and ends with a record containing only the keyword "END:." At a minimum, a reach object must contain records setting values for a stream ID, a reach ID, a FROM point, and a TO point. A reach's FROM and TO point IDs must match IDs for endpoints listed before the reach object in the file. The reach object must also contain an array of locations defining the stream centerline. This array begins with a record containing only the keyword "CENTERLINE:" and ends when any keyword is encountered. A location element in the array contains the X, Y, and Z coordinates of a point on the stream centerline, and the point's river station. In HEC-RAS, elevation and stationing are optional in the stream network definition. If a location element includes a station value, it must occupy the fourth field in the element. If the elevation is not known, the word "null" must take its place.

Station values are assumed to be in miles for data sets in English units,

and in kilometers for data sets in metric units. Stationing is used for indexing locations along reaches, and is not used to precisely locate objects in the model.

Records that may be included in a stream network section are listed in Table B.2:

Table B.2

Keyword	**Value Type**	**Value**
ENDPOINT:	location	coordinates and integer ID
REACH:	none	marks beginning of reach object
END:	none	marks end of reach object
The following records are required for a reach object.		
STREAM ID:	string	identifies reach's membership in stream
REACH ID:	string	unique ID for reach within stream
FROM POINT:	string	integer reference to upstream endpoint
TO POINT:	string	integer reference to downstream endpoint
CENTERLINE:	location array	array elements contain coordinates and (optionally) floating point station value.

Cross-Sections

The cross-section file section begins with a record containing the only the keyword "BEGIN CROSS-SECTIONS:" and ends with a record containing the only the keyword "END CROSS-SECTIONS:." A cross-section is represented by multi-record object beginning with a record containing only the keyword "CROSS-SECTION:" and ending with a record containing only the keyword "END:."

A cross-section object must include records identifying the stream, reach, and station value of the cross-section, a 2D cut line, and a series of 3D locations on the cross-section. Stationing is given in miles for data sets with plane units of feet and in kilometers for data sets with plane units of meters. A cut line is composed of the label "CUT LINE:" followed by an array of 2D locations. A cross-section polyline consists of the label "SURFACE LINE:" plus 3D coordinates written as comma-delimited X,Y,Z real-number triples, one triple to a line.

Records that may be included in the cross-section file section are listed in Table B.3:

Table B.3

Keyword	Value Type	Value
CROSS-SECTION:	none	marks beginning of cross-section object
END:	none	marks end of cross-section object
The following records are required for a cross-section object.		
STREAM ID:	string	identifiers for stream and reach where cross-section is located (must refer to existing streams and reaches in the model)
REACH ID:	string	
STATION:	floating point	relative position of cross-section on stream
CUT LINE:	location array	array elements contain 2D coordinates of cross sectione stike line
SURFACE LINE:	location array	array elements contain 3D coordinates of cross section points
The following records are optional for a cross-section object.		
BANK POSITIONS:	floating point (2 elements)	Fraction of length along cut line where main channel bank stations are located. (values 0.0 - 1.0)
REACH LENGTHS:	floating point (3 elements)	Distance along left overbank, center channel, and right overbank flow paths to next cross-section downstream (units are feet or meters).
WATER ELEVATION:	floating point array	Water surface elevation values. Used for export of model results. Not read on import.

HEC-RAS Model Results Export File

HEC-RAS exports model results to a text file using the same format as the data import file. The contents of the files, however, are not identical. The stream network section is not required for data export, and the surface line may be omitted from the cross-section objects. An example HEC-RAS model export file is shown at the end of this discussion. Model results are reported with the following elements (Table B.4), which are not required (and are not read) in the import file.

Table B.4

Keyword	Value Type	Value
The following record is optional in the Header section of the export file.		
PROFILE NAMES:	string array	name(s) of water surface profiles reported in the file. This record is required if more than one profile is reported.
The following record is required for each cross-section object.		
WATER ELEVATIONS:	floating point array	Elevation of water surface at the cross-section. The array must contain one value for each profile.
The following records make up a section defining a bounding polygon of the water surface limits.		
BEGIN BOUNDARIES:	none	Marks start of boundaries file section.
END BOUNDARIES:	none	Marks end of boundaries file section.
PROFILE LIMITS:	none	Marks start of an object defining the limits of a single water surface profile.
PROFILE ID:	string	Name of profile. This must match a name in the Profile Names record in the header.
POLYGON	location array	A series of 2D locations marking the limits of a water surface. A single profile limit can be merged from multiple polygons.

1. **Profile names can contain up to 11 characters for HEC-GeoRAS.** They must begin with a letter.

2. If no profile name is provided, only one water elevation will be written for each cross section.

Water Surface Bounding Polygon

In addition to a water surface elevation at each cross section (one for each profile), the HEC-RAS program sends a bounding polygon for each hydraulic reach in the model (the program outputs a new set of bounding polygons for each profile computed). The bounding polygon is used as an additional tool in assisting the GIS (or CADD) software to figure out the boundary of the water surface on top of the terrain.

In most cases, the bounding polygon will represent the outer limits of the

cross section data, and the actual intersection of the water surface with the terrain will be inside of the polygon. In this case, the GIS software will use the water surface elevations at each cross section and create a surface that extends out to the edges of the bounding polygon. That surface is then intersected with the terrain data, and the actual water limits are found as the location where the water depth is zero.

However, is some cases, the bounding polygon may not represent the extents of the cross-section data. For example, if there are levees represented in the HEC-RAS model, which limit the flow of water, then the bounding polygon will only extend out to the levees at each cross section. By doing this, when the information is sent to the GIS, the bounding polygon will prevent the GIS system from allowing water to show up on both sides of the levees.

In addition to levees, the bounding polygon is also used at hydraulic structures such as bridges, culverts, weirs, and spillways. For example, if all of the flow is going under a bridge, the bounding polygon is brought into the edges of the bridge opening along the road embankment on the upstream side, and then back out to the extent of the cross-section data on the downstream side. By doing this, the GIS will be able to show the contraction and expansion of the flow through the hydrualic structures, even if the hydraulic structures are not geometricaly represented in the GIS.

Another application of the bounding polygon is in FEMA floodway studies. When a floodway study is done, the first profile represents the existing conditions of the flood plain. The second and susequent profiles are run by encroaching on the floodplain until some target increase in water surface elevation is met. When the encroached profile is sent to the GIS, the bounding polygon is set to the limits of the encroachment for each cross section. This will allow the GIS to display the encroached water surface (floodway) over the terrrain, even though the water surface does not intersect the ground.

Import/Export Guidelines

The following rules apply to channel and cross-section import/export data.

Defining The Stream Network

1. The stream network is represented by a set of interconnected reaches. A stream is a set of one or more connected reaches that share a common stream ID.

2. A stream is composed of one or more reaches with the same stream ID, and each reach in a stream must have a unique reach ID. Every reach must be identified by a unique combination of stream and reach IDs.

3. Stream IDs and Reach IDs are alphanumeric strings up to 16 characters long. Reach endpoint IDs are integers.

4. Streams cannot contain parallel flow paths. (If three reaches connect at a node, only two can have the same stream ID.) This prevents ambiguity in stationing along a stream.

5. A reach is represented by an ordered series of 3D coordinates, and identified by a stream ID, a reach ID, and IDs for its endpoints.

6. A reach endpoint is represented by its 3D coordinates and identified by an integer ID.

7. Reaches are not allowed to cross, but can be connected at their endpoints (junctions) to form a network.

8. The normal direction of flow on a reach is indicated by the order of its endpoints. One point marks the upstream or "from" end of the reach, the other marks the downstream or "to" end of the reach.

Defining Cross-Sections

1. Each cross-section is defined by a series of 3D coordinates, and identified by a stream name and reach name (which must refer to an existing stream and reach) and a station, indicating the distance from the cross-section to the downstream end of the stream.

2. Stationing is given in miles for projects using English units and in kilometers for projects using metric units.

3. A cross-section line can cross a reach line exactly once, and cannot cross another cross-section line.

Results of a water surface calculation are exported in a file that contains cross-section locations in plane (2D) coordinates, water-surface elevations for the cross-sections, and boundary polygons for the reaches.

The Following Rules Apply to Water-Surface Export Data

1. A cross-section is represented by a water surface elevation and a series of 2D coordinates on the cross-section cut line. The full width of the cross-section is included.

2. One bounding polygon is created for each reach in the stream network, and for each profile.

3. A reach's bounding polygon is made up of the most upstream cross-section on the reach, the endpoints of all cross-sections on the reach, and the most upstream cross-sections of reaches downstream of the reach.

4. For purposes of defining bounding polygons *only*, the endpoints of a cross-section are adjusted to the edge of the water surface at the cross-section if the cross-section is part of a floodway, a leveed section of the reach, or the water extent is controlled by a hydraulic structure. This allows calculated water surfaces that are higher than the land surface to be reported back to the CADD or GIS program.

Sample HEC-RAS Geometry Import File

```
BEGIN HEADER:

  DTM TYPE: TIN
  DTM: /HEC63/USR1/EVANS/WAILUPE/WAI_TIN (TIN)
  STREAM LAYER: /HEC63/USR1/EVANS/WAILUPE/WAI_STR
  NUMBER OF REACHES: 3
  CROSS-SECTION LAYER: /HEC63/USR1/EVANS/WAILUPE/WAI_XS
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE: 5101
  DATUM: NAD27
  UNITS: ENGLISH

END HEADER:

BEGIN STREAM NETWORK:

  ENDPOINT:   582090.19,    49360.46,   220.17, 1
  ENDPOINT:   583638.69,    47559.38,   266.80, 2
  ENDPOINT:   582307.31,    46985.66,   112.84, 3
  ENDPOINT:   584128.44,    41274.97,    -3.41, 4

  REACH:
    STREAM ID: Kulai Gorge
    REACH ID: Headwaters
    FROM POINT: 2
    TO POINT: 3
    CENTERLINE:
      583638.69,    47559.38,  266.80,    0.33
  11 lines omitted
      582307.31,    46985.66,  112.84,    0.00
  END:

  REACH:
    STREAM ID: Wailupe
    REACH ID: Upper
    FROM POINT: 1
    TO POINT: 3
    CENTERLINE:
      582090.19,    49360.46,  220.17,    1.65
  14 lines omitted
      582307.31,    46985.66,  112.84,    1.19
  END:

  REACH:
    STREAM ID: Wailupe
    REACH ID: Lower
    FROM POINT: 3
    TO POINT: 4
    CENTERLINE:
      582307.31,     46985.66,   112.84,   1.19
  33 lines omitted
```

```
      584128.44,     41274.97,        -3.41,      0.00
  END:

END STREAM NETWORK:

BEGIN CROSS-SECTIONS:

  CROSS-SECTION:
    STREAM ID: Kulai
    REACH ID: Headwaters
    STATION: 0.312
    BANK POSITIONS:  0.5562,  0.6294
    REACH LENGTHS:   84.541,  89.110,  82.013
    CUT LINE:
      583613.16,     47441.98
      583567.80,     47529.68
      583558.73,     47575.04
      583567.80,     47638.55
    SURFACE LINE:
      583613.16,     47441.98,       309.69
  29 lines omitted
      583567.80,    47638.55,      278.10
  END:

6 Cross-Sections omitted

  CROSS-SECTION:
    STREAM ID: Kulai
    REACH ID: Headwaters
    STATION: 0.019
    BANK POSITIONS:  0.4454,  0.4799
    REACH LENGTHS:   187.942, 193.195, 163.246
    CUT LINE:
      582769.62,     46950.81
      582598.07,     46978.64
      581981.41,     47224.45
    SURFACE LINE:
      582769.62,    46950.81,      167.62
  78 lines omitted
      581981.41,    47224.45,      169.89
  END:

  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Upper
    STATION: 1.629
    BANK POSITIONS:  0.4781,  0.5615
    REACH LENGTHS:   55.965,  53.626,  40.370
    CUT LINE:
      582159.78,     49259.60
      582013.48,     49223.76
    SURFACE LINE:
      582159.78,    49259.60,      235.49
  29 lines omitted
```

```
      582013.48,    49223.76,       241.78
   END:
```

7 Cross-Sections omitted

```
  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Lower
    STATION: 1.183
    BANK POSITIONS:  0.5236,  0.5686
    REACH LENGTHS:   171.000, 164.796, 159.249
    CUT LINE:
      582723.17,     46846.45
      582426.44,     46878.92
      581953.51,     47082.99
    SURFACE LINE:
      582723.17,    46846.45,      161.92
  70 lines omitted
      581953.51,    47082.99,      165.01
  END:
```

23 Cross-Sections omitted

```
  CROSS-SECTION:
    STREAM ID: Wailupe
    REACH ID: Lower
    STATION: 0.037
    BANK POSITIONS:  0.5034,  0.5155
    REACH LENGTHS:   82.365,  192.982, 137.742
    CUT LINE:
      586214.12,     42127.92
      581980.99,     40806.06
    SURFACE LINE:
      586214.12,    42127.92,        4.01
  71 lines omitted
      581980.99,    40806.06,        6.39
  END:

END CROSS-SECTIONS:

FILE COMPLETE: 28 October 1996,  17:17
```

Sample HEC-RAS Geographic Data Export File

```
BEGIN HEADER:

# RAS output file created 29 Oct 96 16:36:41 Tuesday
# by HEC-RAS
  NUMBER OF REACHES: 3
  NUMBER OF CROSS-SECTIONS: 46
  NUMBER OF PROFILES: 2
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE: 5876
  DATUM: NAD27
  PLANE UNITS: FEET
  ELEVATION UNITS: FEET
  STATION UNITS: MILES
  PROFILE NAMES: PF#1, PF#2

END HEADER:

BEGIN CROSS-SECTIONS:

  CROSS-SECTION:
    WATER ELEVATIONS: 265.8189, 268.7436
    CUT LINE:
      583613.16,   47441.98
      583567.80,   47529.68
      583558.73,   47575.04
      583567.80,   47638.55
  END:

  CROSS-SECTION:
    WATER ELEVATIONS: 257.7377, 270.6435
    CUT LINE:
      583537.56,   47429.88
      583474.05,   47529.68
      583474.05,   47568.99
      583492.20,   47662.74
  END:
```

119 cross-sections omitted

```
  CROSS-SECTION:
    WATER ELEVATIONS: 5.964032, 6.43543
    CUT LINE:
      586202.53,   42188.21
      583941.76,   41483.75
      581932.30,   40961.43
  END:

  CROSS-SECTION:
    WATER ELEVATIONS: 5.662289, 6.12576
    CUT LINE:
      586214.12,   42127.92
```

```
      581980.99,  40806.06
  END:

END CROSS-SECTIONS:

BEGIN BOUNDS:

  PROFILE LIMITS:
    PROFILE ID:PF#1
    POLYGON:
      582013.48 , 49223.76
    63 lines omitted
      581819.14 , 49209.56

    POLYGON:
      581953.51 , 47082.99
    141 lines omitted
      581934.965 , 47008.78

    POLYGON:
      583567.8 , 47638.55
    43 lines omitted
      583530 , 47650.645
  END:

  PROFILE LIMITS:
    PROFILE ID:PF#2
    POLYGON
      582013.48 , 49223.76
    63 lines omitted
      581819.14 , 49209.56

    POLYGON:
      581953.51 , 47082.99
    141 lines omitted
      581934.965 , 47008.78

    POLYGON:
      583567.8 , 47638.55
    43 lines omitted
      583530 , 47650.645
  END:

END BOUNDS:

#FILE COMPLETE: 17 Jan 97 16:38:04 Friday
```