KS650.180 Procedure for field surveys for design of earth dams and spillways

(a) General

This procedure is intended to provide basic data for any project dam in which the Natural Resources Conservation Service (NRCS) participates in the geologic investigation by drilling and sampling and any Class V or higher dam.

The procedure is specific on the extent of work needed, accuracy of the field work, and methods of plotting the data. It will be useful as a guide or reference for surveys for any dam regardless of size or purpose.

Examples KS1-1 through KS1-8 illustrate the format and content of the plottings required by this procedure.

(b) Bench marks and baseline

A minimum of 2 permanent bench marks shall be established outside the anticipated construction area and referenced. The bench marks may also serve as baseline monuments.

Datum shall be either mean sea level or an assumed elevation.

A baseline consisting of a minimum of 3 intervisible points coinciding with the centerline of the dam shall be established and monumented. The ends of the baseline should be located and monumented near the limits of the mapping area and beyond the anticipated construction area. The third monument should be located on the flood plain. Angle points, if any, in the baseline shall be monumented.

Monuments and permanent bench marks shall consist of a ½-inch or larger steel bar that is at least 36 inches long and is firmly set. It will be driven nearly flush with the ground and marked by a guard stake. Each monument shall be referenced to nearby permanent or semi-permanent landmarks and in Universal Transverse Meridian (UTM) coordinates using available Global Positioning System (GPS) equipment.

Each bench mark and baseline point shall be witnessed by a steel fence post firmly set 3 feet from the point.

Baseline points in solid rock shall consist of a chiseled mark adequately described or a nail firmly set and referenced.

The surveys shall meet the requirements for “Ordinary surveys” as shown in Table 1-1, “Accuracy standards for horizontal and vertical control” in Chapter 1.

(c) Detail topographic survey

The detail topographic survey shall encompass the area to be occupied by the dam, auxiliary spillway, exit channel, outlet channel, and other appurtenant features. The survey shall extend beyond the expected construction and flowage limits by at least 100 feet, including the area from the auxiliary spillway exit channel to the natural channel.

A finished map shall be made to show all topographic and land use features. It either may be an electronic file or on standard size sheets suitable for the job.

(1) Accuracy

Ninety percent of the elevations determined from the solid line contours of the topographic maps shall have an accuracy with respect to true elevation of ½ contour interval or better, and the remaining 10 percent of such elevations shall not be in error by more than 1 contour interval. This

accuracy shall apply only to the contours that are on each map. Thus, in each particular area where the intermediate contours have had to be omitted because of steepness of the ground slopes and only the index contours are delineated on the maps, the accuracy stipulations apply to the contour interval of the index contours.

Ninety percent of all planimetric features shall be plotted so that their position on the finished maps shall be accurate to within at least 1/40 inch of their true coordinate position (as determined by the test surveys) and none of the features tested shall be misplaced on the finished map by more than 1/20 inch from their true coordinate position.

Ninety percent of all spot elevations placed on the maps shall have an accuracy of at least ¼ the contour interval, and the remaining 10 percent shall be not in error by more than ½ the contour interval.

(2) Map contents

The maps shall contain all representable topographic features. Within accuracy requirements, contours shall be delineated to represent their true locations and the exact shape of the ground. Wherever they exist, topographic features required on the maps include the following: all drainage-ways of draws, creeks, rivers, and tributary streams that are longer than 1 inch at map scale; springs, falls, and rapids; water bodies of ponds and lakes; swamps, marshes, bogs, and flood plains; ledgerock and cliffs; and other essential topographic features required for design purposes.

Large surface boulders protruding from the ground shall be noted by spot elevations. They shall be outlined on the map if the surface area is greater than 1/10 inch at map scale. The height above ground shall be accurately noted.

Other details required on the map are a north arrow, bar scale, centerline of dam, bench mark descriptions, monument descriptions, GPS coordinates, and ties to baseline monuments and bench marks.

The maps shall also contain all land use features such as buildings; ditches; reservoirs; trails; roads and highways; railroads; quarries; borrow pits; cemeteries; wooded areas; and individual, lone, large trees. In addition, they shall include the trace of telephone, telegraph, and electric power transmission lines and their poles and towers; underground cables; pipelines and sewers; fence lines; billboards; rock and other walls; and similar details of land use. Structures such as bridges, trestles, tunnels, piers, retaining walls, dams, oil, water, other storage tanks, and the like shall also be shown.

Buildings and similar dimensionable objects shall be correctly outlined and oriented on the maps and shall be to actual scale, except building dimensions smaller than representable by 1/20 inch in size. Minor irregularities in building outlines not representable by 1/40 inch (at map scale) shall be ignored.

Spot elevations shall be shown on the maps in proper position at water level on the shoreline of lakes, reservoirs, ponds, and the like; on hilltops; in saddles; at the bottom of depressions; at the intersection of well-traveled roads, railroads, and highways; and on the centerline at each end of bridges and like structures of importance. In areas where the contours are more than 3 inches apart at map scale, spot elevations shall also be shown, and the horizontal distance between the contours and such spot elevations or between the spot elevations shall not exceed 2 inches at the map scale.

(3) Scale and contour interval
The finished map scale shall be 1 inch equals 50 feet or 1 inch equals 100 feet--depending upon the area mapped. The contour interval shall be 2 feet.

(4) Symbols and draftsmanship
The symbols to be used for the major land use and topographic features shall be in accordance with symbols contained in the National Map Symbols Handbook Title 170, Part 601, or National Engineering Handbook Part 641, *Drafting and Drawings*. Whether fully identifiable by contour shape or not, each drainageway shall meander on the map as its course or channel meanders on the ground. Streams and drainage ditches averaging more than 1/20 inch in width on the map shall be shown by 2 symbolized lines which are spaced and delineated properly in correct position so as to indicate each shoreline, and other streams and ditches shall be as shown as a single, symbolized line. All line-like features such as highways, railroads, telephone and electric power transmission lines, fences, curb and sidewalk lines, and so forth shall be drawn as a straight or curved line as necessary.

The designations of state- and federal-numbered highways shall be lettered on the maps. All names and numbers shall be legible and clear in meaning and shall not interfere with map features.

Each contour shall be drawn sharp and clear as a solid line, except where it is obscured by an overhanging bluff or ledge. In such ground-hidden places, the contours shall be shown as dashed (broken) lines. To establish index contours, every fifth contour shall be accentuated as a heavier line than the intermediate 4 contours and each shall be numbered with its actual elevation. Wherever index contours are closer together than ¼ inch, the intermediate 4 may be omitted wherever the ground slope is uniform; but wherever it is not uniform, omission will not be permissible unless contours are shown at changes in ground slope.

Professional standards of draftsmanship shall be maintained throughout the preparation of the map. Each line shall be uniform in width and density for its entire length. Symbols, lines, letters, and numbers shall be clear and legible.

(5) Orientation of views
The plan view is to be drawn so that flow is toward the right side or to the top of the sheet.

(d) Profiles

An accurate, representative profile of the ground or water surface shall be run along the axis of principal features of the dam or those affected by the dam.

Profiles will be plotted on paper neatly and legibly. The stations and title for each profile shall be plotted above the profile, and the elevation at each station shall be listed directly below the station designation.

The profiles shall be positioned to permit the additional plotting of 50-foot test holes without interfering with other plotted data.

Maximum profile stationing shall be 100 feet--with plus stations at all significant breaks in topography.

The maximum vertical error shall be ±0.2 foot.

(1) Centerline of dam
The profile shall extend the full width of the dam site topographic map, well beyond the top of dam elevation and the construction limits of the auxiliary spillway.

Stationing will progress from left to right when looking in a downstream direction. Station 10+00 will be established on the left abutment near the crest of the dam.

The profile will be plotted on standard size sheets and shall be plotted to a 10-foot by 100-foot scale when the dam is longer than 1,000 feet and a 10-foot by 50-foot scale for shorter structures.

The plus station and elevation information for the breaks at the top of the channel should be shown on the profile.

The elevation of the top of dam, auxiliary spillway, and principal spillway shall be noted on the drawings insofar as they are available from planning data.

(2) Foundation Drain
A profile of a potential foundation drain will be located downstream of the dam centerline and extend up each abutment to at least the principal spillway elevation. The profile will be located 70 feet downstream of the dam centerline for dams with less than 40 feet of fill at the lowest point along centerline and 90 feet downstream for dams with greater than 40 feet of fill.

Stationing of the drain profile will be based on the centerline of dam stationing. The profile will be plotted on the same sheet as the dam centerline or a separate sheet as needed. It will be plotted to the same scale as the dam centerline. The station and elevation will be shown on the plots for each staked location as well as the station and elevation for the breaks at the top of the channel.

(3) Centerline of principal spillway
Profile the line selected for the principal spillway location based upon favorable topography for the drawdown works, stilling basin, and outlet channel. The profile shall start upstream of the inlet to the drawdown works and extend downstream to where the outlet channel enters the main stream.

The intersection angle with the centerline of the dam shall be 90 degrees insofar as possible.

Stationing shall increase in a downstream direction. The intersection with the centerline of the dam shall be Station 5+00.

The profile will be plotted to a 10-foot by 50-foot scale. The plus station and elevation information for the breaks at the top of the channel should be shown on the profile. It may be placed on the same sheet as the centerline of the dam profile (if space permits).

(4) Natural stream channel
The plan and profile survey of the stream channel should begin approximately 300 feet upstream from the dam centerline using chords in the channel for horizontal distance. Continue the survey to approximately 1,600 feet downstream from the approximate intersection of the constructed outlet channel and natural channel. Stationing will increase in a downstream direction.

Horizontal accuracy will be the same as required of the topographic survey.

The plan view will consist of the thread of the stream or water line at low water.

The profile need not go below the low water surface, except that the streambed will be profiled through riffles.

The plan view and profile may be an electronic file or be plotted on a standard size sheet. Horizontal scales shall be 1 inch equals 100 feet. The plot will show the

centerlines of the dam and principal spillway profile. All plus stations will be plotted at the intersection of the centerline of dam, outlet channel, bridges, and any other features.

(5) Centerline of affected roads
The crown of roads upstream from the dam--any part of which is lower than the top of dam elevation--will be profiled throughout the lengths of the road crown below that elevation. Stationing will progress from left to right when looking in a downstream direction and should be referenced to a section corner or similar location. The centerline of the bridge or culvert will be located on the road profile.

The profile will be plotted on a standard size sheet at a 10-foot by 100-foot scale. Each road profile shall be identified. The bridge or culvert will be drawn on the profile showing size, material, and flow line elevations.

(6) Orientation of views
Sections representing surfaces essentially parallel to the direction of stream flow are to be drawn so the upstream ends of the sections are on the left-hand side indicating flow from left to right.

Sections representing surfaces essentially normal to streamflow are to be drawn so that they are viewed from upstream (observer looking downstream).

(e) Stream channel cross sections

The natural stream channel shall be cross sectioned at distances approximately 400, 800, 1,200, and 1,600 feet downstream from the approximate intersection of the outlet channel and natural stream channel. The cross sections shall be taken perpendicular to bankfull stream flow. The cross section shall define the bottom width of the channel and the top of the bank and shall extend at least 50 feet horizontally beyond the bank.

Distances on the cross section will be referenced to 0 at the approximate centerline of the channel and will be measured right and left when facing in the direction of increasing stationing.

The cross section information should be provided to the designer in an electronic file format, preferably Excel or another spreadsheet format. They may be plotted on a standard size sheet if desired at a 10-foot by 50-foot scale.

(1) Drainage structures
Any bridges or other structures in the channel within the surveyed stream length will be measured in sufficient detail to permit determination of the hydraulic characteristics of the bridge or structure. This may include (but is not be limited to) a cross section of the bridge or structure to give the waterway area, the skew to flow direction, the shape and number of piling and/or piers, the width of a bridge or the length of a conduit, and the size and angle of wing walls and flow line elevations.

Roads over these bridges shall be profiled each way from the bridge to a point beyond the last sag that is a minimum of 2 feet above the roadway over the bridge. Stationing will be from left to right when looking downstream.

Required are two orthographic sketches of the structure at a scale that will facilitate clear dimensioning of the hydraulic characteristics of the structure and/or notes that clearly describe the bridge dimensions, elevations, materials, and condition.

The road profile information will be provided to the designer in an electronic file format, preferably Excel or another spreadsheet format. It may be plotted on a standard size sheet at a 10-foot by 100-foot scale. Each road profile shall be identified. The location of the bridge or culvert will be shown.

(2) Orientation of views
Sections representing surfaces essentially normal to streamflow are to be drawn so that they are viewed from upstream (observer looking downstream).

(f) Title blocks

A title block will be used on each sheet that is used to plot survey data and will follow the format as required in National Engineering Manual Part 541.

The project identification area will include the watershed or owner name, site number, legal description, and county. Show the name or initials of the persons who plotted and checked the data along with the date they completed the work.

Identify each drawing by the appropriate title just above the revision record block. Include the file name and drawing name on all electronically drafted sheets along with the corresponding sheet number.

(g) Surveys for geologic investigation

Sites that will be drilled or otherwise investigated to determine the geology will have the borrow area gridded, staked, and profiled; the auxiliary spillway area gridded and staked; and the centerlines of the dam, foundation drain, auxiliary spillway exit channel, and principal spillway staked and profiled.

A plan view of the grid systems and plottings of the profiles will be prepared for the geologist to use in the field.

Each station shall be marked by a wooden guard stake and a fluorescent red marking flag 4 inches by 5 inches on a 30-inch wire staff. The guard stake shall be marked with the station identification on one side and the ground elevation on the other. The stakes shall be firmly set with the guard stake sloped to protect the elevation side.

All stationing will originate at the baseline.

Marking shall be by paint marker or other permanent marking material.

(1) Accuracy
The surveys shall meet the requirements for “Rough surveys” as shown in Table 1-1, “Accuracy standards for horizontal and vertical control” in Chapter 1.

(2) Borrow area
A 100-foot by 200-foot grid will be staked in the borrow area. The grid shall cover enough area to provide at least 150 percent of the estimated volume of embankment in the dam.

Grid lines will be laid out parallel to the baseline at 200-foot intervals measured perpendicular to the baseline. In case of baselines consisting of 2 or more courses, the one that best fits the borrow area shall be used. Each grid line upstream from the baseline will be designated alphabetically starting with A. Any borrow areas downstream from the baseline will have the

grid lines designated alphabetically starting with AA.

The baseline is not designated with a letter.

Each grid line will be staked at 100-foot intervals coinciding with full stations on the baseline. These grid points will be identified by station and letter such as 9+00 A.

Each lettered grid line shall be profiled showing all significant breaks at plus stations.

The profiles shall be plotted on a standard size sheet at a 10-foot by 100-foot scale. The maximum number of profiles in a vertical direction shall be 4 per sheet. Two columns of profiles may be placed on a sheet provided there is sufficient room. The profiles should be positioned to permit the additional plotting of 20-foot test holes.

Stationing shall be placed across the top of the sheet, and the profiles shall be aligned accordingly in alphabetical order starting at the top of the sheet.

The title or identification (Line A, Line B, etc.) shall be placed across the top of each profile.

(3) Auxiliary spillway area
A 100-foot by 100-foot grid shall be staked in the auxiliary spillway area to cover the construction limits of the inlet, control section, and any significant excavation in the exit channel. The centerline of the auxiliary spillway exit channel should be staked and profiled using the centerline of the dam as the baseline.

Grid lines perpendicular to the baseline will originate at full stations. Grid points shall be designated by baseline stations and distance upstream or downstream.

Guard stakes shall be set and marked in a fashion similar to stations in the borrow area(s) at all grid points.

(4) Centerline of dam
Guard stakes shall be set and marked with station and elevation on all full stations. “CL” will precede the station number.

The surveying and plotting of the centerline profile shall be in accordance with the requirements under Section KS650.180(d)(1), Centerline of Dam.

(5) Foundation Drain
Guard stakes shall be set at each +50 foot station along the profile and marked with the station and elevation for all staked locations. “FD” will precede the station number.

The surveying and plotting of the foundation drain profile shall be in accordance with the requirements under Section KS650.180(d)(2).

(6) Centerline of principal spillway
Guard stakes shall be set and marked with station and elevation on all full stations. "PS" will precede the station number.

The surveying and plotting of the principal spillway profile shall be in accordance with the requirements under Section KS650.180(d)(3).

(7) Plan of borrow area(s) and dam site
A plan view of the borrow and auxiliary spillway area grid systems, centerlines of the dam and the principal spillway, stream channel(s), and land use features shall be plotted on a standard size sheet at a scale of 1 inch equals 100 feet. Grid lines will be identified on 2 sides of the drawing.

The plan will show the stream channel(s) from the most upstream letter profile to a

point 200 feet downstream from the baseline. It will also show land use features such as ditches; ponds; wells; fences; buildings; and the trace of any pipelines, cables, and transmission lines within the grid areas.

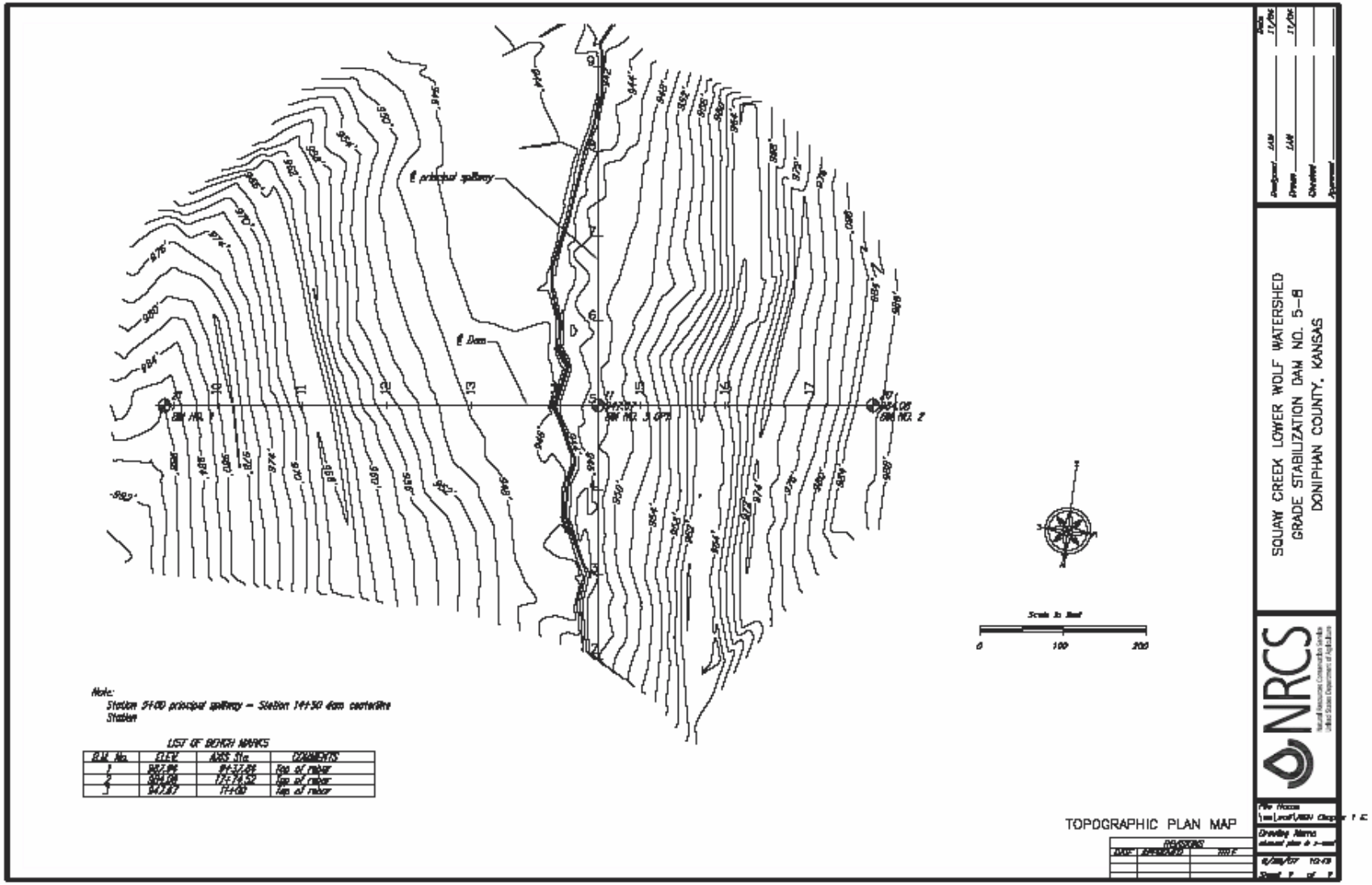
(8) Draftsmanship

Plotting of lines, map detail, and descriptive material must be clear-cut, sharp, and legible so that reproduction of the drawings will result in readable prints.

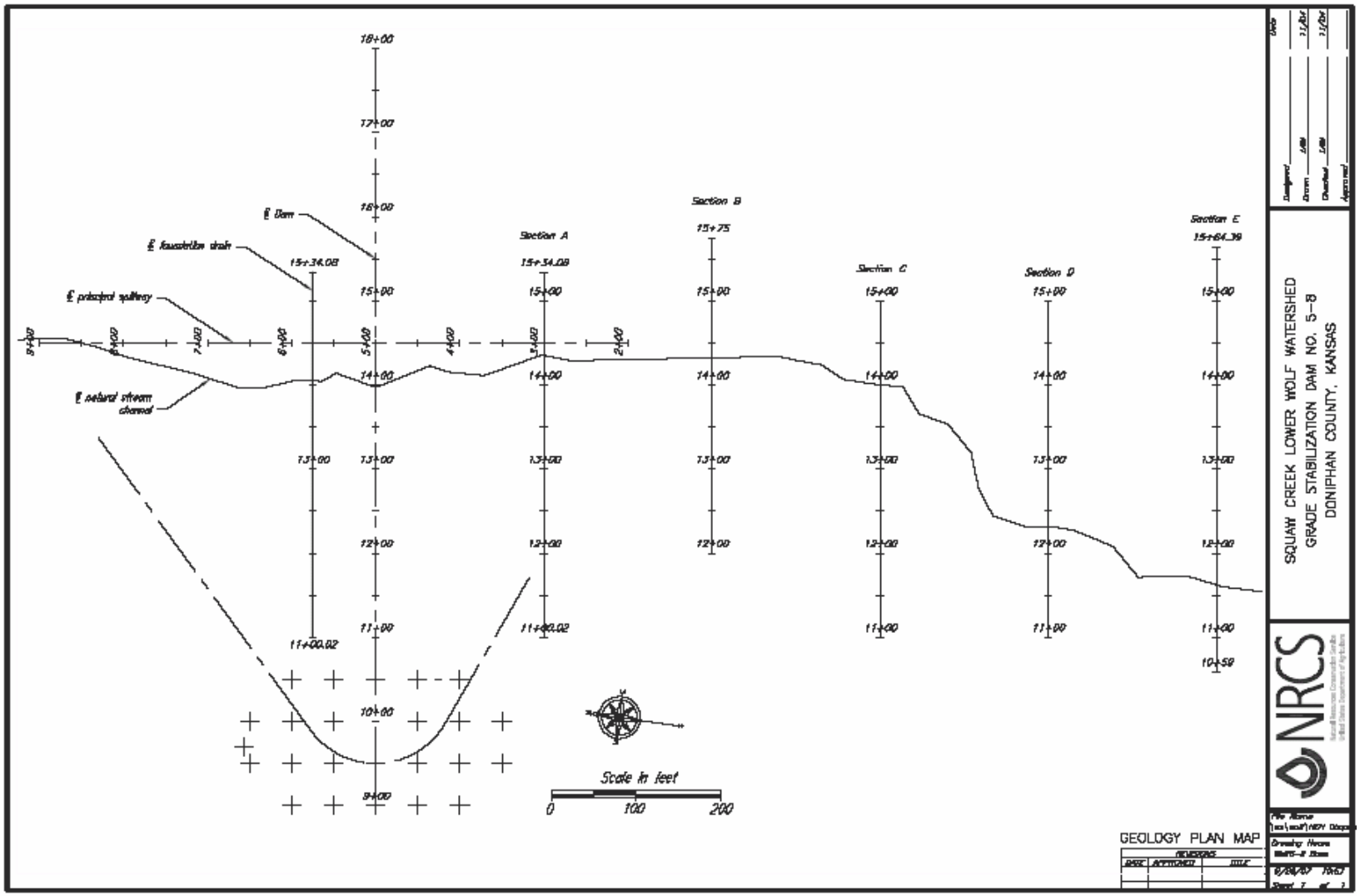
(9) Notes

A copy of all survey notes shall be available to complement the completed maps and drawings. The notes shall be in electronic or other engineering format. The original survey notes should be kept in a bound engineering survey notebook. The notebook should be kept on file in the office completing the survey work until the design is completed. After that, it should be made a part of the case file records for that specific project.

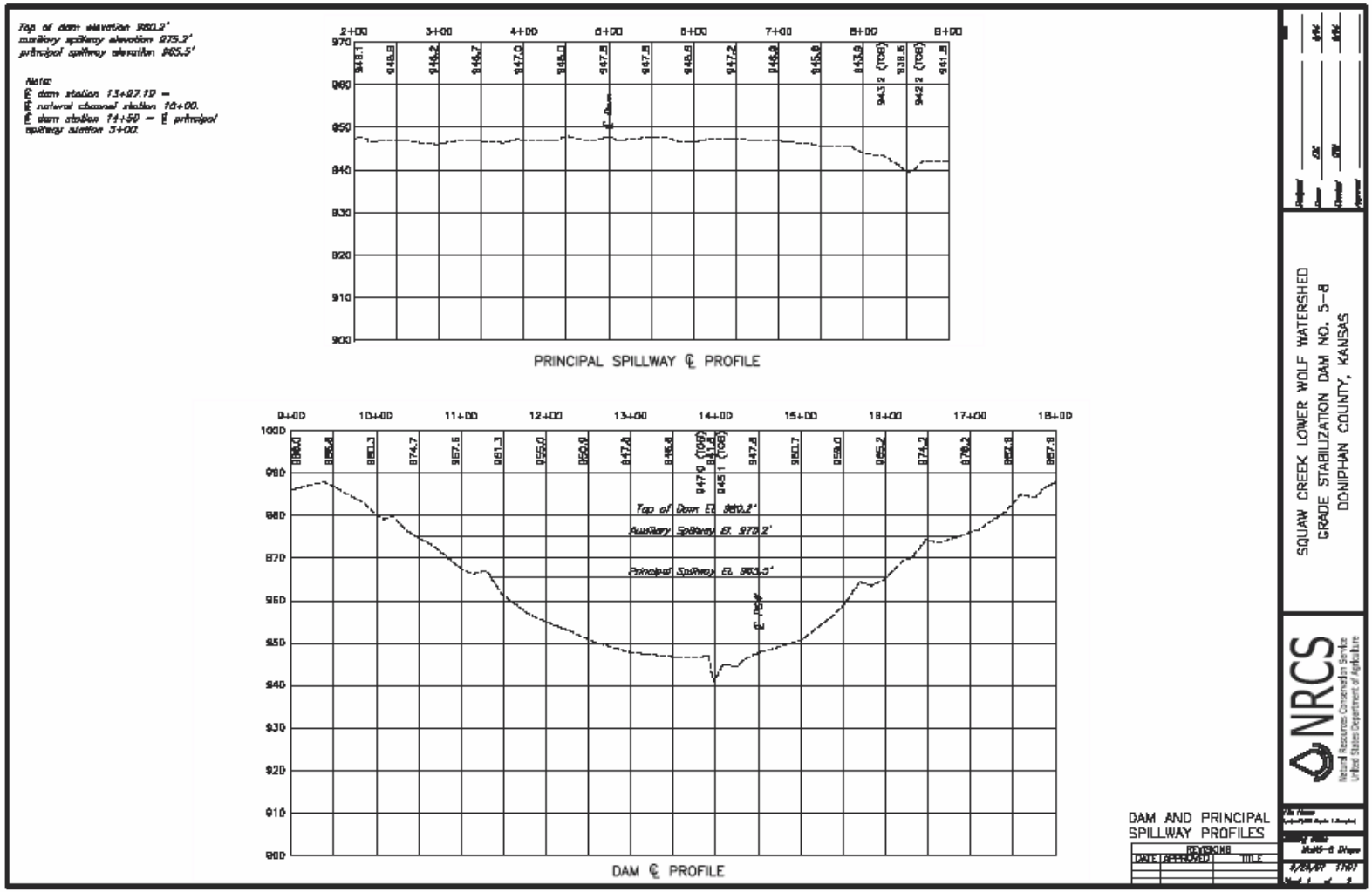
Example KS1-1 Topographic Plan Map



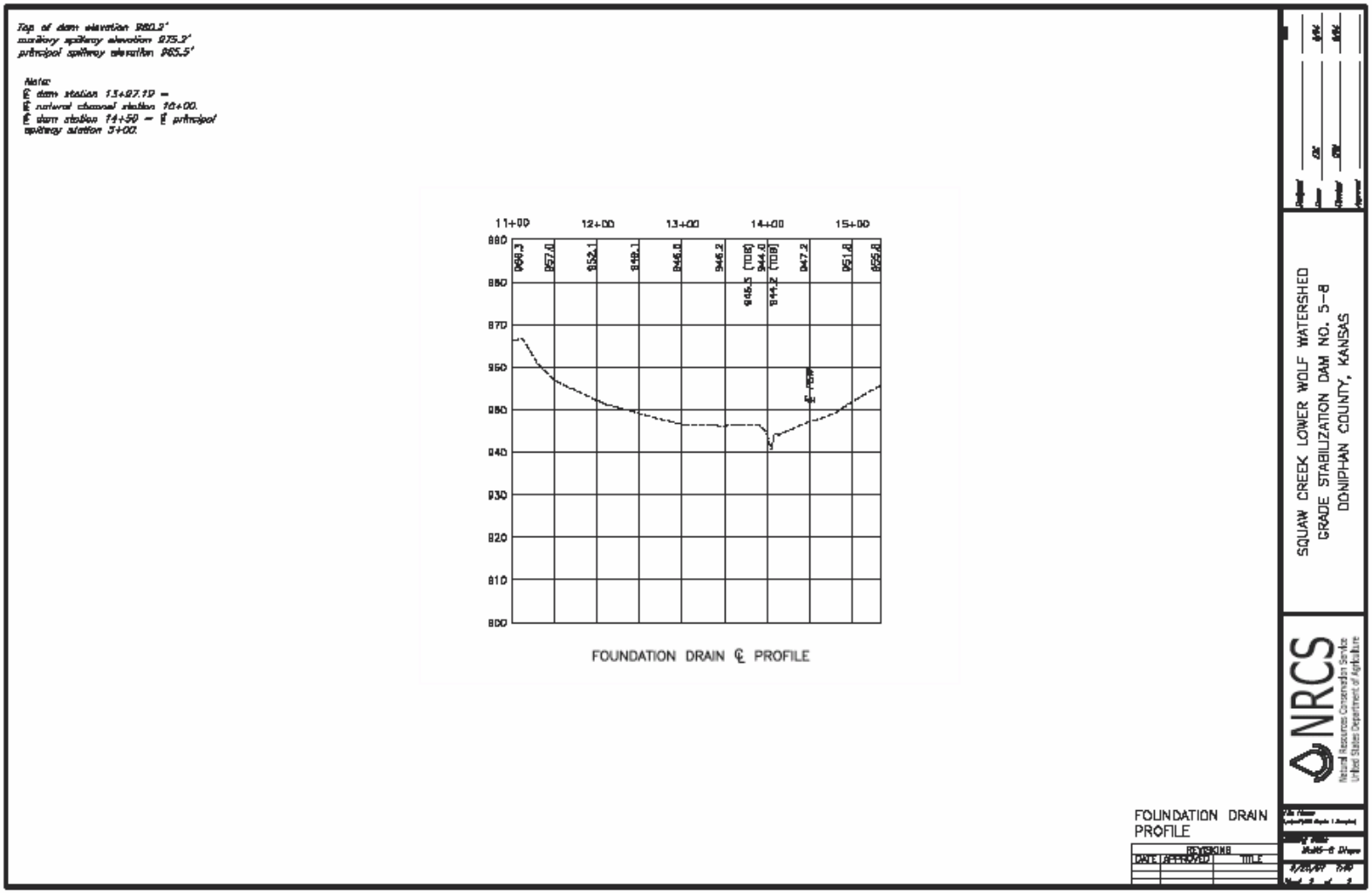
Example KS1-2 Geology Plan Map



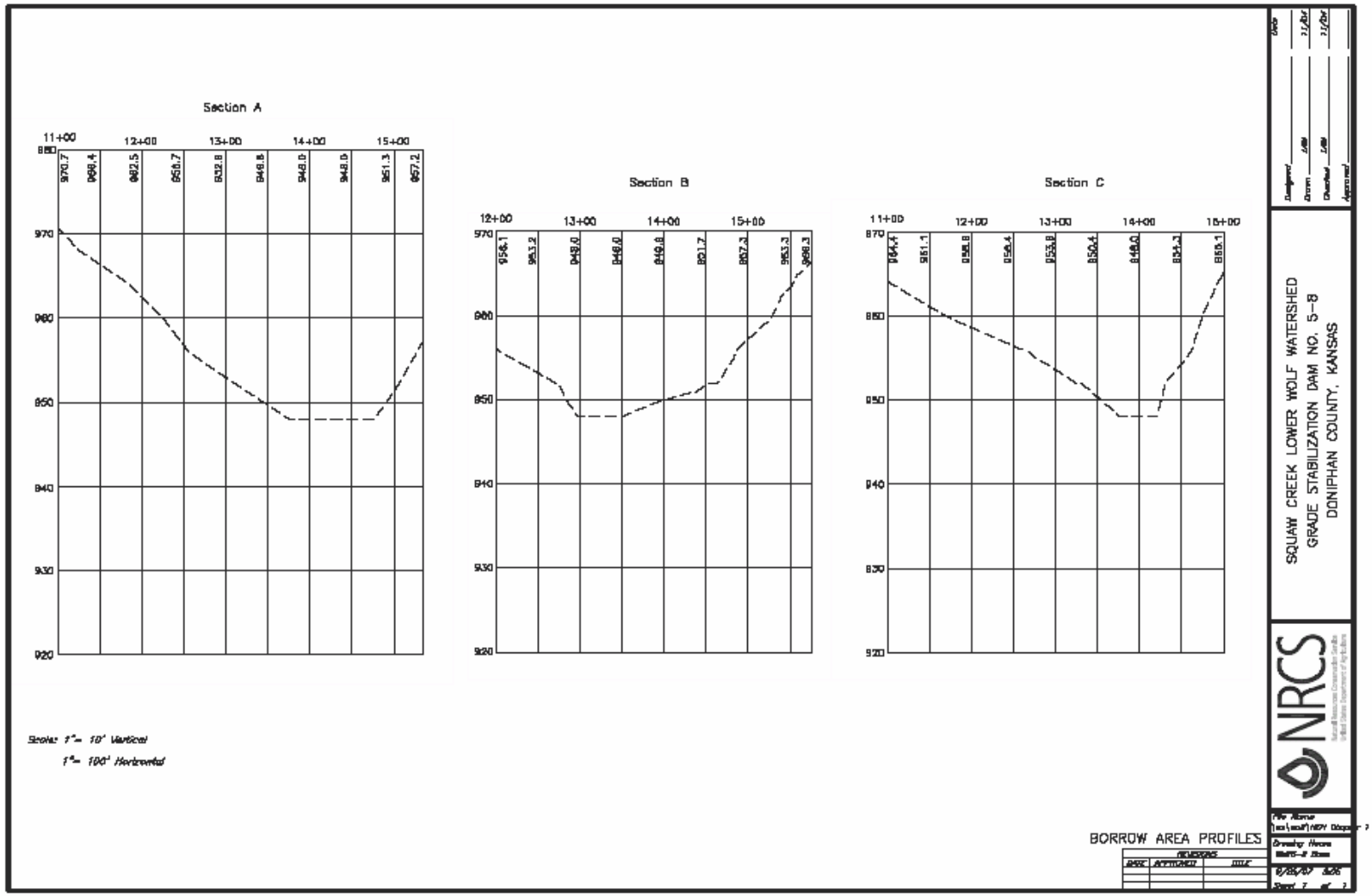
Example KS1-3 Dam and Principal Spillway Profiles



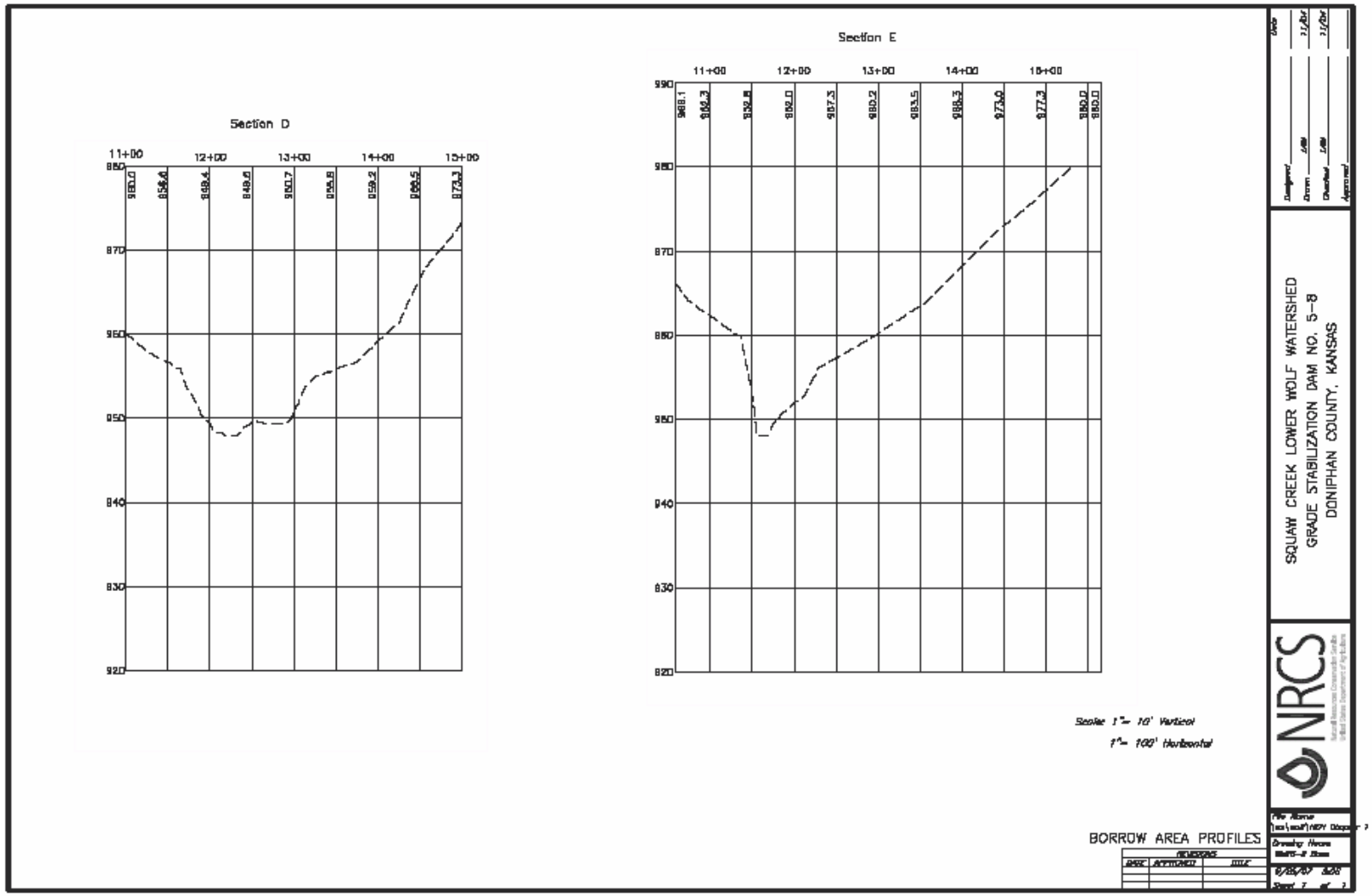
Example KS1-4 Foundation Drain Profile



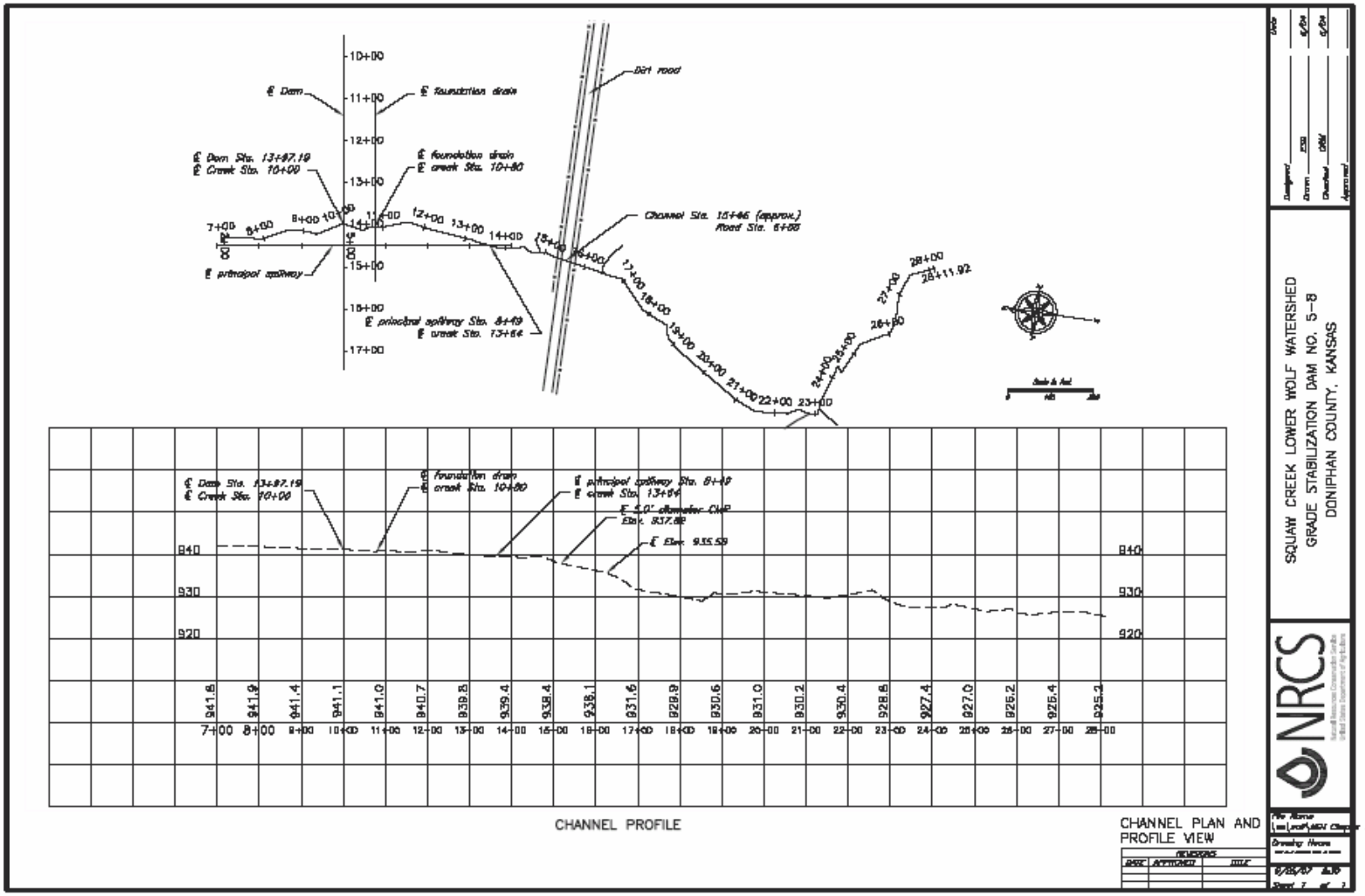
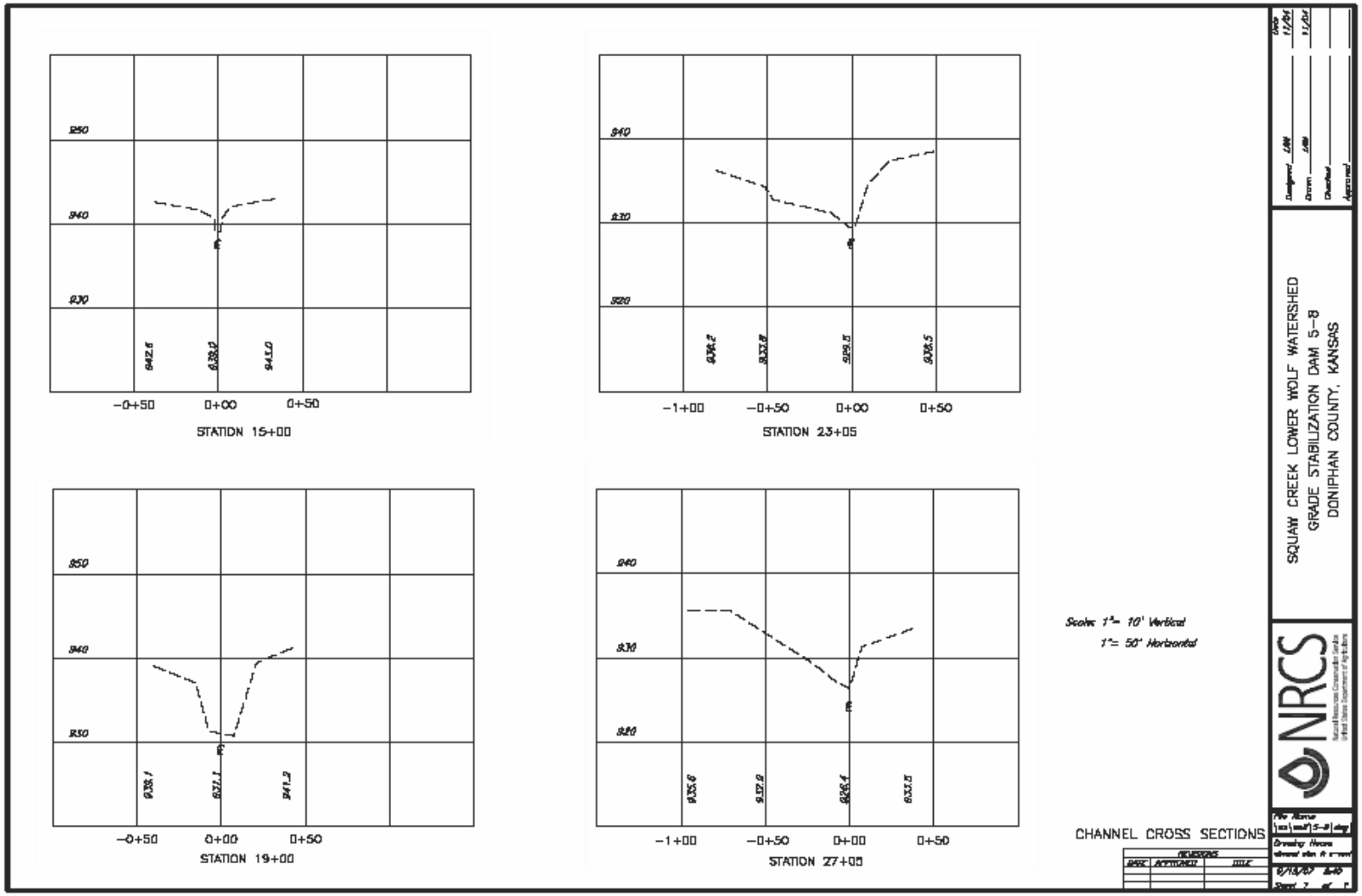
Example KS1-5 Borrow Area Profiles (Sections A through C)



Example KS1-6 Borrow Area Profiles (Sections D and E)



Example KS1-7 Channel Plan and Profile View



Example KS1-8 Channel Cross Sections