Attachment 3 –
NRCS Engineering Design Statement of Work

PSC 18-21-HFP-01

Buena School (Coyote Wash) Watershed
Cochise County, Arizona

NRCS is requesting engineering design assistance to perform all tasks necessary in accordance with the following Statement of Work to design and prepare construction drawings and specifications for the Buena School (Coyote Wash) Watershed, Cochise County, Arizona.

Objective: Engineering design is to provide conservation improvements having the quality and durability required for the economic life of a structure at the least total cost consistent with functional requirements. Engineering designs are to be determined by comparative design studies and cost estimates prepared with full consideration of the landscape, topography, foundation, and other site conditions including environmental quality, and the economy and feasibility of construction, operation, and maintenance. Economic comparisons of alternative designs are to be determined by the amortized average annual cost of installation (including costs of landrights), operation, and maintenance. Environmental comparisons are to consider ecological, cultural, and aesthetic values.

The Sponsor shall perform the following tasks-where needed:

1. Analyses to determine the hydrology and hydraulics for the watershed
2. Evaluation of the condition of the existing topography and geology
3. Preparation of a cost analysis
4. Preparation of a Design Report
5. Identify required easements and permits
6. Development of an Operation and Maintenance Plan Other agreed-to tasks.

Any proposed changes will be in conformance with the final Watershed Plan/EA or EIS document, and will be documented in the Design Engineers Report, and approved in writing by NRCS. After the review and approval of the design recommendations by NRCS, the SPONSOR will finalize construction drawings and specifications.

Work submitted by the SPONSOR to NRCS for review will be discussed at conferences scheduled for that purpose. SPONSOR will notify NRCS at least seven (7) calendar days in advance of the time for each conference. When such conferences are held, SPONSOR will prepare notes summarizing discussions and decisions reached and, within ten (10) calendar days following the conference, submit one (1) electronic copy of the notes via email to the NRCS Project Manager and Administrative Contact.

Liaison with NRCS is the responsibility of the SPONSOR to ensure NRCS concurs in the selection of alternate designs, alternate appurtenances, or other matters affecting the development of general or specific elements of the design. The SPONSOR will submit a memorandum that includes a full presentation of pertinent facts and copies of computations, sketches, notes, and drawings that are necessary for NRCS to perform a complete review of the proposal. Such memoranda will be incorporated into the design report.

STATEMENT OF WORK

Table of Contents

1 General

1.1 The proposed alternative will be used to determine any further analysis required to produce a Final Engineering Design Report for the proposed measures documented in the Final Plan-EA/EIS.

1.2 The SPONSOR will designate a project manager and he/she will be fully aware of the requirements of this Statement of Work, submitted by the SPONSOR and incorporated into the agreement, including the budget and work schedule. Liaison with NRCS is the responsibility of the SPONSOR to ensure that NRCS is aware of and concurs with the progress of the design, analysis, plans and specifications.

1.3 The SPONSOR will maintain a record of all notices, computations, drawings, and other pertinent data developed for the work. Assumptions made shall be clearly stated, and all sources of reference data will be included in project record. This record will be neatly recorded, indexed, and organized into a technical report or set of planning folders. The technical report or planning folders can be provided as electronic files or as paper files in topical folders to the NRCS Project Manager.

1.4 The SPONSOR is responsible for obtaining permission to enter all private lands to conduct resource inventories, gather data, conduct engineering or cultural resource surveys, conduct geologic investigations, or for any other project related reason. Within the SPONSOR's permanent easement or land rights, the SPONSOR as a representative of the NRCS and, therefore, of the local watershed sponsor(s) has permission to enter onto the existing land rights and complete all needed work. Outside the sponsor's permanent easement, the SPONSOR, assisted by the owner and stakeholders, will document permission using a simple, signed agreement and will file them in the planning folders.

2 Quality Control Plan

2.1 The SPONSOR shall coordinate with NRCS staff to submit a Quality Control Plan (QCP). The QCP will:

- Describe procedures that will be implemented by the SPONSOR to assure quality control;
- Include an explanation of the responsibilities of each member of the SPONSOR's design staff and review team;
- The SPONSOR shall assure the professional qualifications of sub-consultants whose services the SPONSOR will procure.

2.2 The QCP shall be submitted to NRCS for review and approval as an initial item of work. The SPONSOR is responsible for ensuring that product development and independent technical review for the design and specifications are carried out in accordance with the approved QCP. The QCP will be updated as needed.

3 Meetings

3.1 The SPONSOR shall attend meetings with the NRCS, project stakeholders and others as necessary during the design/planning effort to gather and impart information.

3.2 Normally, NRCS will keep SPONSORs updated on project progress during the owner's routine monthly meetings. However, periodically one or more of the SPONSOR staff will need to attend these meetings to update the sponsor or to collect specific information from the sponsor's governing board.

3.3 Travel costs for these meetings will be estimated and included in the SPONSOR budget.

4 Field Surveys

4.1 The SPONSOR shall utilize existing surveys where appropriate or perform such measurements and ground surveys as may be required to complete this project (LiDAR). This may require establishing centerlines, developing topographic information, collecting profiles and cross-sections for various lines and structures, and furnishing documentation of the field surveys in

the form of electronic media and notes. All survey notes shall follow the format of good surveying practice.

4.2 Accuracy and Precision.

4.2.1 All measurements and ground surveys shall be located with Universal Transverse Mercator (UTM) coordinates. Benchmarks shall be on the North American Datum 1983 (NAD 83) for horizontal and North American Vertical Datum 1988 (NAVD 88) for vertical unless otherwise approved by NRCS.

4.2.2 The SPONSOR may use a traditional transit field survey methods or photogrammetry to compile any required survey data.

4.2.3 The SPONSOR shall be responsible to do checks to see that all errors of closure and tolerances are met. NRCS will be free to spot-check any or all information provided to determine compliance with the requirements.

4.3 Permanent Control Points.

4.3.1 A permanent brass cap in concrete or other permanent bench mark shall be used and tied into all surveys carried out in this contract.

4.3.2 The location, description, and elevation of this bench mark shall be accurately recorded in the notes and described in relation to fixed landscape features.

4.4 Deliverables.

4.4.1 An electronic or paper copy of all survey notes shall be furnished. Electronic files shall be in PDF or Microsoft Office format.

4.4.2 An electronic or paper copy of all maps and drawings shall be furnished. Electronic files shall be in AutoCAD DWG or ASCII DXF or ArcGIS format. AutoCAD DWG files shall be purged to remove unused blocks and drawing objects. A layer table or legend (defining layer names and layer contents, such as contours, trees, roads, etc.) shall be provided. So that exact duplicates can be produced, AutoCAD files shall contain a named view and paper space for each map or drawing and ArcGIS files shall contain a View and Layout for each map or drawings. DEM, TIN or TNN data shall be on a separate drawing layer in the AutoCAD DWG file or supplied as a separate AutoCAD DWG or ArcGIS format file.

4.4.3 Point data, such as the locations of survey control points, spot elevation, drill holes, excavations, etc., shall be provided in a comma-delimited text file using a point-north-east-elevation-description (PNEZD) format.

4.4.4 The electronic files shall be supplied on a CD or DVD or other electronic media.

5 Hydrology and Hydraulics

5.1 The work shall consist of all operations needed to complete the hydrologic and hydraulic modeling of the watershed as presented in the Plan/EA.

5.2 The SPONSOR will evaluate the hydraulics using the projected future conditions for all alternatives or plans.

5.3 Hydrology and Hydraulics Analyses

5.3.1 A Sediment Survey and volume calculations shall be completed. The SPONSOR Project Geologist/Hydrologist and/or Soil Mechanics Engineer will review the sediment yield to the basin under projected future conditions.

5.3.2 Water surface profiles for the routed storms shall be completed using HEC-RAS, or other approved models and the hydrology and hydraulic models with sensitivity analysis shall be run through several iterations so that the models provide consistent results.

5.3.3 The hydrology and hydraulics report shall be a narrative summary of all procedures and assumptions. Alternative analyses runs shall be summarized in the report. Supporting data and inputs must be provided to NRCS. Consideration of pertinent stream gages will be utilized to determine appropriate Time of Concentrations and Runoff Curve Numbers.

5.3.4 Electronic data files will be cleaned or purged so that only final input, output and associated files are delivered to the NRCS. Electronic data files for final alternative analyses will also be delivered. The electronic data files shall be delivered on DVD or other electronic media.

5.4 Flood Plain Maps

5.4.1 For the recommended alternative, flood plain mapping shall be developed for eight 24-hour storm events (2, 5, 10, 25, 50, 100, 200, 500 year events) and shall show the plan or aerial view only.

5.4.2 The flood plain mapping shall be plotted with an orthophoto base at a maximum scale of 1:4,800 (1" = 400'). Flood plain mapping shall be in an AutoCAD DWG or ASCII DXF format on CD-ROM.

5.5 Deliverables

5.5.1 An electronic or paper copy of the hazard classification memorandum shall be furnished. Electronic files shall be in PDF or Microsoft Office format.

5.5.2 The hydrology and hydraulics report shall be furnished. Electronic files shall be in PDF or Microsoft Office format.

5.5.3 Electronic copies of all data and modeling files shall be furnished in their native format. If software, other than NRCS programs, Microsoft Office, AutoCAD, ArcGIS, is needed to use, display, or evaluate the data files, the SPONSOR shall provide the needed software. The SPONSOR will discuss any such needed software with NRCS during development of the Plan of Work so that arrangements for NRCS purchases of copyrighted software can be made.

5.5.4 An electronic or paper copy of the flood plain and breach inundation maps.

5.5.5 The electronic files shall be supplied on a DVD.

6 Geologic Investigations

6.1 The work shall consist of all operations as necessary to complete the geologic investigation as specified in the Plan/EA.

6.2 The SPONSOR shall review available data and shall determine if geologic investigations are needed to complete the design of this project and shall incorporated needed work into the approved Plan of Work.

6.3 The SPONSOR's geologist shall have previous experience in the geological investigation nad shall meet the minimum requirements outlined in NEM Part 531, Geology.

6.4 The geologist shall develop an investigation plan and submit it to NRCS, who will review, suggest changes, discuss those suggestions to resolution and approve within 7 working days.

6.5 NRCS requirements for geologic investigation and sampling are stipulated in the NEM Part 531 and Geology Note 5, dated 1991. Additional requirements are contained in TR-60 and NEH Section 8. Refer to Appendix IV for NRCS geotechnical terms and preferences.

6.6 The geologist shall log all test holes, rock cores, rock outcrops, and excavations and shall direct the investigation in the field.

6.7 When 75 percent of the work at a site has been completed or at least ten days prior to the anticipated completion of the investigation, the geologist shall notify the NRCS project manager, and they will schedule a field review. The field review will discuss progress, review the recorded logs and sampling, and agree on remaining work to complete the investigation.

7 Subsurface Investigations

7.1 This phase of the work shall consist of performing subsurface investigations, field testing, and obtaining samples for laboratory testing in accordance with American Standard Testing & Materials (ASTM) D 420 as necessary to provide data adequate to serve as a basis for design of the project works. Such field testing shall include testing for dispersive clays and collapsible soils.

8 Plan of Investigation

8.1 Not less than 5 working days prior to the start of detailed subsurface investigations, the SPONSOR shall meet with NRCS and present a Preliminary Plan of Investigation. The preliminary plan of investigation shall include the plan of operations proposed for

accomplishing the work and shall be based on consideration of all available data, a physical reconnaissance of the site and other investigations as the SPONSOR may deem appropriate.

8.2 The preliminary plan of investigation must be of such scope as to show clearly that the work may be effectively accomplished in accordance with the requirements of the contract. The preliminary plan of investigation shall include, but not be necessarily limited to: a preliminary drawing of the site showing the location of each of the site components; the proposed location and depth of drill holes and/or excavations; the proposed location and depths of field tests; the proposed location and depths of disturbed and undisturbed samples; the personnel to accomplish the work; the equipment to be used in accomplishing the work; and the schedule proposed for carrying out the work within the allotted performance time.

8.3 Soil sampling methods shall conform to the requirements of the applicable ASTM methods. Soils shall be identified and classified by means of the Unified Soil Classification System as prescribed in ASTM D 2487 and D 2488.

9 Site Preparation

9.1 Site preparation shall consist of preparing drill rig travel ways, stream crossings, and drill rig setup locations on abutments and flood plains and the removal of trees and brush. It shall also include replacement of excavated material where feasible. All dozer operations shall be conducted in such a manner as to produce a minimum amount of erosion and to prevent sediment and other pollutants from entering nearby lakes, waterways or streams. The location of stream crossing shall be as shown on the site map. Moving equipment to the site(s) is considered mobilization.

10 Foundation Investigations

10.1 Sufficient borings will be made in the foundation to accurately delineate and describe foundation materials and conditions to a sufficient depth where materials and/or conditions will have no adverse effect on the stability and performance of the structure from the standpoint of strength, consolidation, or seepage.

10.2 Undisturbed samples of representative and critical materials encountered in the foundation will be collected and tested. Undisturbed samples will be approximately 5” in diameter or larger unless smaller sized samples are approved by NRCS. Cohesive soils too soft to be recovered with a Shelby tube type sampler shall be secured with a piston type sampler or equivalent. All undisturbed samples shall be handled, preserved, packed and transported in a manner that will prevent changes in moisture content (except for the removal of free water) or physical condition between the time they are collected from the foundation and delivered to the testing facility.

10.3 Standard penetration tests shall be performed in accordance with ASTM D 1586 in representative foundation borings. In uniform soils, penetration tests may be performed at depth intervals not exceeding five (5) feet. In non-uniform soil deposits, penetration tests shall be performed continuously from the surface to a depth equal to the height of the measure and at intervals not exceeding five (5) feet below this depth until blow counts of 30 in cohesive soils and 50 in non-cohesive soils are encountered. The depth investigated need not exceed three (3) times the height of the measure. Standard penetration tests shall not be applicable to cohesive materials which are not at or near saturation and to materials which contain 10% or more gravel.

11 Borrow Area Investigations

11.1 Borrow areas may not be shown on the maps provided. If borrow areas are not shown or if the designated areas do not provide sufficient usable borrow, the SPONSOR and NRCS shall jointly locate and secure an appropriate borrow area. Borrow areas shall be explored and representative samples recovered. The volume of borrow shall be "proved out" by

exploration and shall exceed the estimated required volume by at least 30 percent. When making computations of borrow material available, excavated side slopes of 4:1 shall be used.

11.2 Materials to be excavated shall be fully described and classified as to methods required for excavation and shall be sampled and tested for use as earth or rock embankment materials.

11.3 Excavated materials to be used in the embankment that contain more than 5% larger than No. 4 sieve will be sampled and tested according to Technical Release Numbers 26 and 27. Samples representing each kind of borrow material available for use shall be collected for laboratory testing according to ASTM D 420. For the site investigated, the SPONSOR shall prepare a sample list itemizing all undisturbed and disturbed samples collected.

11.4 The SPONSOR shall preserve all drill holes for at least 24 hours to determine whether ground water is present or whether ground water levels have stabilized (two successive readings taken at least one hour apart remain the same). The SPONSOR shall provide temporary covers, plugs, fences, barricades, lights, markers, or other measures consistent with the hazard involved to prevent injury to humans or livestock.

11.5 A log of each test hole and/or excavation in accordance with ASTM D 5434 shall be recorded. Holes will be numbered in accordance with the following numbering system. Abbreviations used in recording and plotting logs shall be as listed below. The numbering system and abbreviations shall be shown on the drawings. Plan, profile, and cross section views shall be plotted to delineate location of the holes and subsurface conditions. The format and content shall be adequate for the purpose of the investigation in accordance with accepted geologic practice.

12 Borings

12.1 Wash borings, probing, fishtail bits, roller bits, flight augers, helical augers, unverified geophysical soundings and other similar borings shall be considered adequate only for determining rough bedrock profiles. Auger borings (except large diameter bucket augers) or small diameter split spoon borings, with or without supplemental geophysical soundings, shall be considered adequate only for determining bedrock profiles or rough soil profiles. Core borings (including push tube and piston samplings) of medium to large diameter, excavations, test trenches, or inspection holes shall be considered adequate for determining detailed profiles. Bucket augers (6” or larger in diameter) shall be considered adequate for detailed profiles of uniform, non-gravelly materials. Large diameter (12” or more) bucket auger borings shall be considered adequate for this purpose in very coarse or very mixed materials. Auger borings shall be drilled so that representative materials from depth intervals not to exceed two (2) feet are recovered for logging.

13 Bedrock Profile

13.1 A bedrock profile determined by borings, probing, or soundings shall be verified by means of trenches or large diameter inspection holes at any point or in any zone where the founding of a structural element on rock is critical to the stability or functional integrity of the structure and/or when needed to estimate grouting or dental concreting requirements.

14 Permeability Tests

14.1 Tests to determine the permeability of foundation materials on site, including bedrock, shall be conducted in drill holes using the appropriate boundary conditions, shape factors, and techniques outlined in National Engineering Handbook, Section 8, or other methods approved by NRCS.

15 Safety

15.1 Borings and other excavation (if needed) shall be so excavated, braced, and supported (or cased) as to safeguard the work and the workers and to provide that ground adjacent to the excavation will not slide or settle so as to cause damage to adjacent existing improvements.

the SPONSOR shall furnish, place, and subsequently remove such supporting installations as needed.

15.2 When drill holes or other excavations are left open at the end of a day's work or for observation after completion of work, the SPONSOR shall provide temporary plugs, covers, fences, barricades, lights, markers, or other measures consistent with the hazard involved, to prevent, injury to humans or livestock, and to protect the other installations.

16 Changes in Plan and Completion of Work

16.1 During the progress of the investigation, the SPONSOR shall promptly notify NRCS of any unexpected conditions encountered that would direct a material change in his proposed plan or scope of investigation. In this event, the SPONSOR will furnish NRCS with copies of a revised plan and scope of investigation for NRCS review.

17 Site Cleanup

17.1 Upon completion of the work at each site, the SPONSOR shall do the following:

- Securely plug all borings and backfill any excavations which are not required for future observations.
- All borings shall be filled in conformance with Arizona state regulations and ASTM D 5299 except for all borings that do not penetrate an aquifer shall be backfilled with drill cuttings from the original drilling. However, when borings are backfilled in this manner, the hole shall be capped with a rock, metal cover, or other durable, nontoxic material. This cover must overlap the diameter of the boring by at least 3 inches and must be buried at least 2 feet below the ground surface. Above the hole cover, the hole shall be filled with compacted silts and clays. Restore the land surface to the original grades (except for access roads).
- Remove from the site all scrap or abandoned equipment, materials, and supplies of any nature.
- Repair or replace all damaged fences to their original or better condition.
- Surveys necessary to determine the locations and elevations of all test holes (bored or excavated) during the site investigations shall be completed at this time.

18 Seismic Assessment

18.1 SPONSOR will transmit the seismic report to NRCS for engineering design consideration. As part of this investigation, a map is to be prepared showing the location and intensity or magnitude of all intensity V or magnitude 4 or greater earthquakes of record, and any historically active faults, within a one-hundred kilometer radius of the site(s). The 100-kilometer radius may need to be expanded if a large historic earthquake or seismically active zone may affect the project site. The report shall also summarize other possible earthquake hazards such as ground compaction, landslides, excessive shaking of unconsolidated soils, liquefaction and seiches. The report shall address the seismic criteria in TR-60, NEM Part 531, the current building code or the Arizona Office of the State Engineer, whichever is applicable upon review.

18.2 Upon completion of the seismic assessment, NRCS may direct additional investigations, explorations or analysis.

19 Geologic Report

19.1 SPONSOR will transmit the Geologic Report to NRCS for engineering design consideration. A detailed geologic report shall be prepared. This report will generally conform to the guidelines in the NEM, Part 531, Geology, and to the example geologic report being furnished as a guide. This report shall include a narrative discussion interpreting the geologic conditions at the site and their possible relation to the suitability of the site and to the design, construction, and operation of the proposed structure. Any anticipated problems

likely to result from the geologic conditions, such as foundation weaknesses, seepage problems, difficult excavation, or other problems shall be discussed in the report. Any measures considered necessary to correct adverse conditions or utilize favorable conditions also should be discussed in the report. The data resulting from field or laboratory tests, such as permeability tests or standard penetration tests shall also be reported and interpreted. The results of surface and ground water investigations shall be discussed.

19.2 The report shall include recorded logs of investigations and a site geology map using the reservoir topographic map as a base. The map shall show the locations of all excavations, test holes, and drill holes. It shall show the surficial geology, location of bedrock outcrops, springs, seeps, and any other pertinent information. Bedrock contour maps, ground water contour maps, or other illustrations appropriate to the site shall be included as necessary. Plotted profiles and cross section of subsurface conditions shall be furnished and shall include the locations of undisturbed and disturbed samples and field tests. The seismic assessment shall be included as part of the geology report. The geology report shall be prepared and signed by the project geologist. If the geologic maps and drawings are generated in electronic form, NRCS shall supply the SPONSOR with those maps and drawings in both electronic media and hard copy.

19.3 Geologic data shall be in AutoCAD, ArcGIS, ASCII DXF, or gINT format. http://www.gintsoftware.com/ . The geologic data shall include all borings, excavations, drill holes, baselines, benchmarks, monuments, etc.

19.4 A layer table (legend) shall be submitted defining layer names used to describe various components of the drawing, such as contours, trees, roads, etc.

19.5 The data files shall be supplied on a CD or DVD.

20 Soil Mechanics

20.1 The SPONSOR shall review the site data provided for accuracy and completeness and shall determine if soil mechanics testing and analysis is needed to complete the planning and design of this project. Soil mechanics testing and analysis incorporated into the approved Plan of Work.

20.2 The work shall consist of performing soil mechanics and other physiochemical tests adequate to serve as a basis for design and construction control of the structure and appurtenances. The soil testing program shall include both index and complex testing when appropriate. All testing shall be done on samples that represent the range of materials at the site. Testing methods shall be compatible with the type of engineering analysis made and the field conditions that will exist.

21 Testing Plan

21.1 The SPONSOR shall review any existing reports, proposed testing plans, completed testing plans and existing testing results prior to formulating the laboratory testing program for this specification. The SPONSOR shall submit for review and approval a plan detailing the number and kinds of tests to be performed, the sources of the materials to be tested, and a schedule for completion of the testing program. The plan shall include narrative statements indicating the purpose for making the proposed tests, the proposed use of the test results, and a reference to the delineated materials represented by the samples to be tested.

21.2 When the index testing (Ex. grain size, Atterberg limits, specific gravity, compaction, relative density) has been completed and prior to commencing complex testing, the SPONSOR and NRCS will review the testing program and results, and agree on remaining needs and testing requirements.

22 Sample Handling

22.1 The following conditions apply to all soil samples that are going to be used in the testing:

22.2 Samples will be packaged and transported in accordance with ASTM D 4220 or D 5079.

22.3 Soil samples shall be inspected prior to testing and their general condition noted. Any unusual conditions shall be reported. Any sample disturbance shall be described and, in the case of tube samples, the amount of wash material, compression, or other distortion shall be measured and reported. Any other information that the testing organization feels is pertinent to the engineering application of the test result shall be reported.

22.4 Soil samples shall be tested as soon as possible after they are received by the laboratory in order to reduce storage time and possible disturbance from unnecessary handling. Particular care is to be taken with undisturbed samples to assure that the water content (except for removal of free water) and physical condition does not change prior to testing. If undisturbed samples are to be stored in excess of seven days before testing, they must be removed from the tubes, waxed, and stored in a room with controlled, high humidity.

22.5 The laboratory shall visually describe samples and classify each according to the Unified Soil Classification System (ASTM D 2487 or ASTM D 2488). A log of an undisturbed sample shall be made if changes in the character of the soil are noted within the sample. This log shall show the exact location of test samples.

23 Laboratory Testing

23.1 All necessary soil tests shall be made on a sufficient number of samples to provide adequate data for design and subsequent construction control.

23.2 Soil testing shall be done in accordance with the methods or procedures listed for the following tests. If other procedures are used or other tests are deemed necessary, they shall be those generally accepted by the soil engineering profession and approved by NRCS prior to beginning the test.

23.3 Grain Size Analysis of Soils - Method ASTM D 422

23.4 Atterberg Limits - Method ASTM D 423 and D 424

23.5 Specific Gravity - Method ASTM D 854

23.6 Compaction (moisture-density) - Method ASTM D 698

23.7 Determine the specific gravity of the soil and develop the complete saturation (zero air voids) curve over the full range of the test.

23.8 When ASTM D 698 - Method C is used, the percentages of material between the 2 inch and No. 4 sieve size will not be replaced as specified in Note 2.

23.9 When materials are subject to breakdown and degradation when compacted, a separate and new sample will be used for each point on the compaction (ASTM D 698 - Method A -Note 1).

23.10 Method ASTM D 1557 shall be used when so designated by NRCS or when requested by the SPONSOR and approved by NRCS.

23.11 Relative Density of Cohesionless Soils - Method ASTM D 204.

23.12 Permeability - U.S. Army Corps of Engineers, EM 1110-2-1906, Appendix VII

23.13 Dry Unit Weight - U. S. Army Corps of Engineers, EM 1110-2-1906, Appendix II

23.14 Consolidation and Permeability - Method ASTM D 2435 or USBR Designation E-15. The minimum sample size shall be 2 1/2 inches in diameter by 1 inch thick.

23.15 Foundation samples tested for design will be saturated at the start of the test unless a collapse potential exists. If collapse is suspected, the samples will be loaded normally until the overburden pressure plus the load of the embankment is reached. The sample will then be saturated with the collapse measured and then normal testing can be resumed.

23.16 Load increments sufficient to define the pre-consolidation pressure of over-consolidated foundation soils will be used.

23.17 Load increments will be added to 32,000 psf or until the straight line or virgin portion of the void ratio-pressure curve is obtained.

23.18 At least one point will be determined on the unload or rebound portion of the void ratio-pressure curve for foundation samples.

23.19 Water content, density, and degree of saturation will be determined both before and after testing. This will require a specific gravity determination.

23.20 All consolidation-time curves will be included in the report. Consolidation results will be plotted as void-ratio versus log of pressure. Overburden pressure, preconsolidation pressure (if any), and compression index will be shown on void ratio versus pressure plot for foundation samples. The coefficient of consolidation will be computed and shown.

24 Shear

24.1 Triaxial Compression - Procedures described in "Soil Testing for Engineering" by T. William Lambe or "The Triaxial Test" by Bishop and Henke or EM 1110-2-1906 Appendix X.

24.2 Direct Shear — Procedures described in "Soil Testing for Engineers" by T. William Lambe or U.S. Army Corps of Engineers EM 1110-2-1906 Appendix IV

24.3 Special requirements:

24.3.1 The shear test parameters defined in TR-60 shall be used.

24.3.2 Shear tests on materials with maximum particle sizes less than 3/4" diameter will be triaxial compression tests except for those nonplastic soils that cannot be trimmed or remolded for triaxial testing.

24.3.3 Specimens shall be saturated by back pressuring. A B—parameter (ratio of change in pore pressure to change in stress) of 0.95 or more shall be obtained.

24.3.4 Consolidated-undrained tests at saturation will be made with pore pressure measurement for critical and representative foundation samples.

24.3.5 Consolidated-undrained tests at saturation with pore pressure measurements will be made for critical and representative samples of materials proposed for use in each zone of the embankment. Average placement moisture content may be made on critical and representative samples of materials proposed for use above the fully developed phreatic line in the downstream shell.

24.3.6 Unconsolidated-undrained tests of embankment materials at average placement moisture and of foundation materials at saturation will be made if sampling and testing reveal the presence of foundation strata which necessitates analysis of stability for the end of construction condition. Samples will be tested to failure or to a maximum strain of 15%, whichever occurs first, and the stress-strain curves will be included in the report.

24.3.7 The maximum deviator stress will be used as the failure criterion. Failure may not exceed 15% strain.

24.3.8 A minimum of three stress circles from three separate specimens shall constitute a shear test.

24.3.9 Water content, dry density and degree of saturation shall be determined for each specimen before and after testing.

24.3.10 Visual differences between specimens will be noted, and visual failure condition of each specimen also will be noted. Plots of Mohr's circles and the envelope(s) for total stress (and effective stress when measured) will be given in the report.

25 Dispersion

25.1 Laboratory Dispersion Test - Procedures described in "Piping in Earth Dams of Dispersive Clay" by James L. Sherard, Rey S. Decker, and Normal L. Ryker; Proceedings of the Specialty Conference on the Performance of Earth and Earth-Supported Structures, Purdue University/June 1972/ASCE.

25.2 Pinhole Test - Procedures described in "Pinhole Test for Identifying Dispersive Soils" by James L. Sherard, Lorn P. Dunnigan, Rey S. Decker, and Edgar F. Steele; Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, Volume 102, No. GT1, January 1976.

25.3 Both the Laboratory Dispersion and Pinhole Tests shall be conducted on each sample for which dispersion data is presented. The presentation and analysis of data generated by these two tests shall constitute a complete test unit.

26 Soluble Salts

26.1 If soluble salts are thought to be present based on field logging, a soil conductivity test shall be used for screening purposes. A 12.5 gram sample of soil is immersed in 250 milliliters of distilled water. If the eC is greater than 300 microsiemens a Gravimetric Salt test will be performed. The Gravimetric Salt test takes 10 milliliters of solute, which is evaporated at 60° Centigrade and weighed on an analytical balance. If the evaporate is greater than 4% than the test is redone with a more dilute solution until the value drops below 4% by weight. The National Soils Laboratory has some procedural guidelines for these tests.

26.2 If any sample is thought to contain soluble salts the sample should be dried in an oven with a temperature of 60° Centigrade so that the chemically bound water is not released.

27 Testing Report

27.1 The SPONSOR shall furnish to NRCS a summary of all index testing (grain size, Atterberg limits, specific gravity, compaction, relative density) using NRCS Form 354 prior to undertaking other soils testing. As part of this submittal, the SPONSOR shall recommend any needed changes to the testing plan. A meeting shall be held to discuss and concur in the remaining laboratory testing to be done.

27.2 The SPONSOR shall furnish to NRCS a report presenting all laboratory test data; interpretation and analytical analysis of tests; narrative discussion of conditions pertinent to design, construction, and performance of the works, and design recommendations for those elements of the project dealing with earth or earth-rock construction.

27.3 The SPONSOR shall evaluate the results of the geological investigation and the soil mechanics testing program and perform the necessary analyses to develop a geotechnical report. The analyses and report shall be in accordance with the requirements of the following divisions of this specification and shall be adequate to provide design, construction, and monitoring recommendations for all elements of the project.

27.4 The complete geotechnical report shall summarize all analyses made and recommendations for the design, construction, and monitoring of the structure(s). The report shall include all information required in the appropriate division of this specification and any additional data considered by the SPONSOR to be relevant to the design. Unless otherwise specified, all computation and other material adequate to document the work shall be furnished to NRCS.

27.5 The geotechnical analysis shall determine and document the following items:

27.6 The SPONSOR shall include a summary of material strength, consolidation, permeability, and identification properties. The summary shall include, as appropriate, sections on foundation bedrock, foundation soils, proposed fill materials, and any other fills that may be appropriate. The basis for any assumed parameters shall be adequately documented if substantiated by actual borings and field or laboratory tests. The report shall include a narrative summary accompanied by appropriate drawings and tabular summaries of data.

27.7 Recommendations for treatment of the soil foundation shall be based on results of field and/or laboratory test, soil mechanics analyses and site geology.

27.8 Recommendations for removal of undesirable material shall include: (1) rationale for the recommendations; (2) the extent, both lateral and vertical, of recommended removal; (3) suggested field procedures for identifying materials to be removed, and (4) alternative methods of treatment considered.

27.9 Recommendations for methods other than removal for treating undesirable foundation soils shall include a rationale for selection of the alternative, including cost consideration and details of recommended procedures adequate for design.

27.10 Foundation removal shall be identified on plotted cross sections and profile of the embankment alignment that includes plotted logs of test holes. Other design parameters may be included in a narrative report.

27.11 Recommendations for treatment methods other than removal shall be included in the narrative report and shall be accompanied by sufficient sketches or drawings to document the design and to form a basis for construction drawings and specifications.

27.12 Recommendations shall be based on the nature of bedrock materials as determined from the foundation investigation and the appropriate laboratory tests and analyses performed.

27.13 Recommendations for pressure grouting, dental grouting, slush grouting, gunnite protection, cleaning operations, or other special treatments shall include a rationale for selection of the method or methods of treatment, including cost considerations and details of the treatment methods adequate to provide the basis for design.

27.14 A narrative summary of the rationale and the treatment methods recommended shall be included. For complicated foundation problems requiring extensive treatment, the narrative shall be accompanied by graphical and/or tabular illustrations which can be used to document the design and to form a basis for construction drawings and specifications.

27.15 The settlement analyses shall be based on geological site conditions, engineering properties determined by laboratory tests, or by documented reference to data that can be correlated. Calculations shall be made for any potential differential settlement problems in a direction both transverse and parallel to the fill centerlines.

27.16 Recommendations based on laboratory tests, correlations, and calculations made shall include, but not necessarily be limited to: (1) maximum settlement in the foundation and embankment; (2) estimated percentage of total settlement occurring during construction; (3) settlement beneath the structures and appurtenanes; and (4) alternatives correcting problem situations, including shaping of natural slopes, excavation and removal of highly compressible deposits, pre-wetting or removal of collapsible soils, or other special procedures such as pre-loading and staged construction of soft clays.

A narrative summary of conditions analyzed and assumptions made, together with results of the analyses, shall be included in the report. Any correlations used shall be clearly stated.

28 General Design Considerations

28.1 The work will consist of all operations described herein to design and prepare the construction drawings and specifications, quantities, bid schedule, design report, cost estimate, operation and maintenance plan, and other related documents for the selected alternative identified in the Plan/EA.

28.2 The design will conform to the objectives, provisions, and requirements of the respective watershed plan and to all federal, state and local laws, codes, rules and regulations. The design will provide for an installation that will function to accomplish the intended purpose; provide for the safety of the public; be economical to construct, operate and maintain; be compatible with the specific site conditions; and provide a visual resource that enhances the adjacent landscape and is aesthetically appealing.

28.3 The SPONSOR will report to NRCS any omissions, discrepancies, or inadequacies in the data furnished by NRCS as a basis for design. The need for supplementary data or additional investigations will be conveyed to NRCS in writing with suggestions for corrective actions.

28.4 The SPONSOR will maintain a record of all notices, computations, drawings, and other pertinent data for the design. These records will be neatly recorded, indexed, and organized into the following design folders.

General Data	Hydrology	Landscape

Geology	Sedimentation	Land rights
Drainage	Structure	Emergency Action Plan
Survey	Quantity Computations	Operation and Maintenance
Soil Mechanics	Specifications	Correspondence

28.5 Assumptions made as a basis for design shall be clearly stated, and all sources of reference data will be listed in the design report.

29 Preliminary Design (30%, 60% and 90%)

29.1 The SPONSOR shall review and verify the adequacy of the existing site data. The preliminary design must develop the general features of the structural installation including the selection of the most suitable types of structures, the optimum layout and arrangement of the elements of the structural system, and the types and locations of appurtenances. These general features must be determined by considering geologic and topographic site conditions and economy and feasibility of construction, operation, and maintenance. Design criteria and standards for all elements of the project shall comply with the NRCS technical material furnished. When it becomes necessary to depart from NRCS criteria and standards, the request shall be submitted to NRCS for approval. The design shall comply with all local and state rules and regulations necessary to gain approval by state regulatory agencies.

29.2 The SPONSOR shall prepare and submit copies of the preliminary design to NRCS for review. The submittal shall include preliminary design work for the complete structure and appurtenances and shall include, as a minimum, the following information:

30 Layout

30.1 Structure site topographic maps needs to show in detail the layout of the embankment, drainage system, outlet basin, and other appropriate appurtenances.

30.2 Profiles and Cross sectional view of the measures along the centerline showing lines, grades, and elevations of the embankment, structural elements, excavation, and other measures.

31 Hydraulic and Hydrologic Design

31.1 The SPONSOR shall perform computational checks as necessary to verify that coordinates of design analysis (fixing the design elevations and discharges) are mathematically correct.

31.2 Hydraulic and hydrologic data not furnished but required for proper functioning and design of the structure shall be prepared by the SPONSOR and shall conform to the criteria and standards of NRCS technical materials. Copies of hydraulic and hydrologic data and computations shall be included in the report.

32 Structural Design

32.1 Only the structural details essential to the study of the design shall be developed in preliminary design. Structural dimensions shall be sufficiently refined to allow reasonable estimates of quantities and costs. Structural design shall conform to the criteria and guides contained in the NRCS technical material.

33 Miscellaneous

33.1 The SPONSOR shall prepare the necessary applications for the 401 and 404 permits to be reviewed and finalized by the sponsors.

34 Preliminary Design Report

34.1 The report shall be assembled in a manner that will facilitate a thorough engineering review and understanding of the proposed design. In addition to layout, hydraulic and hydrologic design, and structural design, the report shall include:

34.1.1 A narrative description of the project.

34.1.2 A summary of data used as a basis for design.

34.1.3 A summary of design criteria used to include stability analyses of earth materials.

34.1.4 Drawings and/or sketches sufficient to define all essential elements of design.

34.1.5 A summary of alternate layouts and designs considered and a detailed description of the alternate chosen. The summary shall clearly demonstrate the reasons for the choice.

34.1.6 Computations and design notes developed during the preparation of the preliminary design.

34.1.7 A preliminary set of the construction specifications (complete with items of work and construction details), material specifications, bid schedule, cost estimate and performance time estimate.

34.2 A meeting for review of the work accomplished under this step will be held with the SPONSOR and NRCS.

35 Final Design

35.1 Following review and approval of the preliminary design, the SPONSOR shall prepare the final design.

35.2 This work shall consist of completing the design and preparing a complete set of construction drawings, construction specifications, quantity calculations, cost estimate, bid schedule, construction performance time, design report, construction pollution prevention plan, quality assurance plan and an operations and maintenance plan.

36 Layout, Hydraulic and Hydrologic Design

Layout shall consist of presenting the items outlined for the preliminary design with changes incorporated by the more detailed design analysis and NRCS comments.

37 Structural Design

37.1 Structural design shall consist of incorporating NRCS's comments on the preliminary design and completing the structural analysis as may be required for final and complete dimensioning of the structure.

38 Construction Drawings

38.1 The SPONSOR shall prepare final construction drawings using AutoCAD and shall present all details necessary for construction.

38.2 Drawings shall conform to the drafting standards set forth by NRCS. NRCS standard drawings shall be used where applicable.

38.3 The drawings shall contain projected plan, elevation, and isometric views with adequate explanatory notes, specification references, and dimensions to ensure construction in accordance with the intent of design. There shall be adequate steel schedules, drawings, and bending diagrams to facilitate fabrication and proper placement of all steel, including trash racks, reinforcing bars, valves, etc.

39 Construction Specifications

39.1 The SPONSOR shall prepare construction and material specifications for the project and appurtenances. Unless otherwise approved by NRCS, specifications shall conform to standard NRCS specifications contained in National Engineering Handbook, Part 642.

40 Bid Schedule

40.1 The SPONSOR shall prepare a bid schedule listing all items of work for which payment is to be made. The format shown in National Engineering Handbook, Part 642, shall be followed when preparing the bid schedule.

41 Cost Estimate

41.1 The SPONSOR shall prepare an estimate of construction costs for each item listed in the bid schedule.

41.2 The cost estimate shall be an itemized list for the significant items of work showing the item, specification number, quantity, unit cost, and total cost. The items used in the cost estimate shall be the same as the bid items on the bid schedule and specifications.

41.3 Cost data shall be logically and clearly presented. Up-to-date prices shall be used. Costs shall be determined for completed work and shall include furnishing and installing materials, transportation, labor, overhead, profit and any other items incidental to the work.

42 Construction Performance Time Estimate

42.1 An estimated construction performance time schedule shall be prepared by the SPONSOR showing the major items of work, the items that may be performed concurrently, and the estimated performance time to complete each item. The performance time will be based on the estimated amount and types of equipment required to do the job, weather, holidays, and sponsor preferences.

43 Quality Assurance Plan

43.1 The quality assurance plan must document the quantity, quality, and timeliness for providing appropriate quality assurance. The components of the plan are:

43.1.1 Section 1 - Inspection Requirements
43.1.2 Section 2 - Timing of Inspection
43.1.3 Section 3 - Skills Needed to Perform Inspections
43.1.4 Section 4 - Staff Hours Needed to Perform Inspections
43.1.5 Section 5 - Testing Equipment and Facilities Needed

43.2 The plan will assure that adequate quality control and quality assurance measures are planned. NRCS Construction Specification 94 and the Quality Assurance Plan must be in accord.

44 Construction Pollution Prevention Plan (CPPP)

44.1 The CPPP should focus on: providing a site description that identifies sources of pollution to storm water discharges; and, identifying and implementing appropriate measures to reduce pollutants in storm water discharges. In order to accomplish this, the CPPP should contain the following:

- Site Description, including the following:
- Sources of pollution affecting water quality
- Construction activities expected
- Sequence of major activities disturbing soil
- Area(s) to be disturbed
- Runoff coefficient from post construction site conditions
- Site map with drainage patterns identified and
- Name of the receiving waters
- Controls to Reduce Pollutants
- Erosion and sediment controls
- Storm water management intentions
- Specified other controls (404, dust, access roads, et cetera) and,

- State, local, or other requirements

44.2 The plan must also address maintenance procedures for the required facilities and details for inspection.

45 Operation and Maintenance (O&M)

45.1 An operation and maintenance plan shall be prepared to summarize the inspection and maintenance needs to ensure the project will operate adequately for its design life. The plan shall include numerous operation, maintenance, and repair features of all component parts. The plan shall also identify the approximate yearly cost estimate to execute the O&M plan.

46 Final Design Report

46.1 The SPONSOR shall prepare and furnish to NRCS copies of the final design report.

46.2 The report shall be a bound volume consisting of design notes pertinent to final design including computations, sketches, drawings, specifications, quantity estimates, bid schedule, cost estimate, performance schedule, and other data pertinent to final design and not included in the preliminary design report.

46.3 Data relating to final design but presented in the preliminary design report may be referenced in the final design report.

46.4 The report shall be sectionalized and indexed (hyper-linked bookmarks) in a logical manner. The number of sections required will vary with the scope and complexity of the design; however, the organization of the report shall generally conform to the following outline:

- Work Plan
- Geologic Investigation Report
- Soil Mechanics Report

Design Report

Summary

Authority

Description of job

Design objective

Basis for design

General basic data

Hydrology

Foundation design

Instrumentation

Cost estimate

Construction considerations

Structural design

Environmental considerations

Construction drawings

Specifications

Bid schedule

Location and layout

Hydraulic design

Embankment design

Construction schedule

O&M requirements

Design Analysis Appendices

Hydraulic Design

Geotechnical Design ➔ ➔ Seepage and control; Stability Analysis; Foundation;

Embankment; Instrumentation

Structural Design

Instructions to the Engineer

Construction Drawings

Specifications

Bid Schedule

Cost Estimate

Construction Schedule

O&M Plan

Quality Assurance Plan

47 Deliverables for Final Review and Approval

47.1 NRCS will review the final design before the SPONSOR/NRCS review meeting. NRCS will initiate this review meeting.

- Four copies of the following:
  - Construction specifications.
  - Construction drawing sheets
  - Operation and Maintenance Plan
  - Final Design Report and its appendices
  - Bid schedule
  - Cost estimate and supporting data
  - Construction performance time
  - Construction Pollution Prevention Plan
  - Draft Emergency Action Plan
  - Quality Assurance Plan

48 Final Deliverables

48.1 Upon final approval of the Deliverables for Field Check, Review and Approval, the SPONSOR shall furnish the following items to NRCS:

48.2 Printed Documents:

- Five bound copies and one original of the Final Design Report and its appendices signed and sealed by the designer.
- Five bound copies and one original (34 inch x 22 inch) of all construction drawing sheets signed and sealed by the designer.
- Five bound copies and one original construction specifications signed and sealed by the designer.
- Six copies of the accepted bid schedule.
- Two copies of the accepted cost estimate signed and sealed by the designer and supporting data.
- Six copies of the accepted construction performance time.
- Five bound copies and one original of the accepted Operation and Maintenance Plan.
- Five bound copies and one original of the accepted Construction Pollution Prevention Plan.

- Six bound copies of the accepted Draft Emergency Action Plan.
- Five bound copies and one original of the accepted Quality Assurance Plan.

48.3 Electronic Documentation

- The data files shall be supplied on a DVD.
- One copy of all CAD generated construction drawings sheets of the accepted, final plan using pdf format.
- One copy of all text prepared with a word processor suitable to be read with pdf.

49 New or Supplemental Watershed Plan and Environmental Document Connection

49.1 The SPONSOR shall use the Final Supplemental or (NEW) Watershed Plan and Environmental Document in conjunction with and in support of the engineering design tasks. The proposed/selected alternative documented in the Final Plan-EA/EIS will be used for generation of a final engineering design based on the specific watershed measure carried forward for Final Design.

50 Landrights Work Maps

50.1 Landrights work maps shall be prepared electronically on a georeferenced aerial photographic base. Maps shall be prepared to be no less accurate than required by nationally recognized map accuracy standards for 1:4,800 maps (scale of 1 inch to 400 feet). The landrights work map(s) shall, at a minimum, show the following features:

- Existing physical features in the project area.
- Proposed project feature locations and or project boundary.
- Major project features.
- Easement limits, including construction campsite or other easement needed for construction.
- Property lines and owners with address.
- Utilities and owners with contact name, phone number and address.
- Section numbers and corners, township and range lines, and benchmark locations.
- Access routes for construction and maintenance.
- Table of easement requirements by property owner.
- Map scale and North arrow.
- Legends and title block.
- Match line between corresponding sheets, if applicable.

50.2 This item shall also consist of preparing drawings and data for any required permits and NEPA documents.

51 Conferences, Review and Approval

51.1 Work shall be reviewed and verified for accuracy by the SPONSOR's personnel prior to conference meetings and prior to submittals to NRCS.

51.2 Liaison will be maintained by the SPONSOR with the Sponsor and NRCS to the extent necessary to ensure that NRCS is aware and concurs with the progress of the work, selection of alternatives, and other matters concerning the development of general or specific elements of the supplemental watershed plan.

51.3 NRCS will provide technical oversight on all phases of the planning process from initiating planning to final plan completion. Conferences shall be held whenever requested by the SPONSOR or the Sponsor and NRCS during which questions relating to the project will be discussed, work previously performed will be reviewed, and decisions made with a view toward expediting the plan of work. Work that in the opinion of NRCS does not require conference discussions may be reviewed and accepted by correspondence or telephone conversations. Where conferences are required, the SPONSOR shall notify NRCS and the Sponsor in advance of the time of each conference. An agenda for each meeting/conference should be considered.

51.4 The SPONSOR shall prepare notes summarizing discussions and decisions reached during conferences or in telephone conversations and promptly furnish one copy of the notes to NRCS. Meetings will be held wherever practicable.

52 Ownership of Documents

52.1 The NRCS acknowledges that the supporting data and documents generated by the SPONSOR are instruments of professional service. However, all documents, including resource inventory data, engineering, and economic model outputs, geologic investigation reports, drawings, maps, estimates, and all other data used in the preparation of the Supplemental Watershed Plan and Environmental Assessment and Final Design are the property of the NRCS.

53 Appendix I. NRCS Reference Material

NRCS may have additional technical material available for reference. The SPONSOR should discuss specific needs with the appropriate NRCS discipline representative to determine applicable references and to obtain copies of those references.

Primary References are:

National Watershed Program Manual (NWPM)
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/

National Resources Economics Handbook (NREH)

National Engineering Manual (NEM)
https://directives.sc.egov.usda.gov/RollupViewer.aspx?hid=27418

NEM Part 511 - Design

NEM Part 512 - Construction

NEM Part 520 – Soil And Water Resource Development, Subpart C - Dams

National Engineering Handbook (NEH)

National Operation and Maintenance Manual (NO&MM)

Technical Release (TR)-60 - Earth Dams and Reservoirs

"Economic And Environmental Principles And Guidelines For Water And Related Land Resources Implementation Studies" Dated March 10, 1983.

Specific Additional References, listed by discipline, include:

Survey

NEM Part 540 – Field Surveys

TR-62 - Engineering Layout, Notes, Staking and Calculations

Economics

National Resources Economics Handbook (NREH)

Econ2, Floodwater Damage Computer Program

Urb1, Urban Economics Damage Computer Program

Principals, Requirements and Guidelines for Federal Investments in Water Resources, March 2013 (PR&G)

Abbreviations:

DN - Design Notes

GN - Geology Notes

NEH - National Engineering Handbook

NEM - National Engineering Manual

NO&MM - National Operation & Maintenance Manual

NREH - National Resources Economics

Hydrology

NEM Part 530 - Hydrology

NEH Section 4 - Hydrology

NEH Part 630 - Hydrology

- Chapter 1, Introduction
- Chapter 2, Procedures
- Chapter 3, Preliminary Investigations
- Chapter 4, Storm Rainfall Depth
- Chapter 5, Streamflow Data
- Chapter 6, Stream Reaches And Hydrologic Units
- Chapter 12, Hydrologic Effects Of Land Use And Treatment
- Chapter 18, Selected Statistical Methods

NRCS-Arizona Standard Rainfall Distributions and Procedure

NEH Part 728.5 - Sites Water Resources Site Analysis Computer Program

TR-20 - Computer Program for Project Formulation (Hydrology)

TR-55 - Urban Hydrology

Hydraulics

NEH Section 5 - Hydraulics

TR-25 - Design of Open Channels

TR-29 - Hydraulics of Two-Way Covered Risers

TR-39 - Hydraulics of Broad-Crested Spillways

TR-66 - Simplified Dam-Breach Routing Procedure

TR-70 - Hydraulic Proportioning of Two-Way Covered Baffle Inlet Riser

TR-49 - Criteria for the Hydraulic Design of Impact Basins Associated with Full Flow in Pipe Conduits

TR-64 - Floodway Determination Computer Program

DN-6 - Armored Scour Hole for Cantilever Outlet

DN-8 - Entrance Head Losses in Drop Inlet Spillways

DN-18 - “Unattached” Engineering Standard Drawings

HRB-108 - Highway Research Board Tentative Design Procedure for Riprap Lined Channels

SCS TP-106 - Hydraulic Design of the Box Inlet Drop Spillway

SCS TP-107 - Tests On Chutes with SAF Stilling Basins

USBR EM-25 - Hydraulic Design of Stilling Basins and Energy Dissipators

Geology

NEM Part 531 - Geology

NEH Section 3 - Sedimentation

NEH Section 8 - Engineering Geology (Chapter 5 Is Void; See Part 531 of the NEM)

NEH Part 628 - Dams

Chapter 51, Earth Spillway Erosion Model

Chapter 52, Field Procedures Guide For The Headcut Erodibility Index

NEH Part 631 - Geology

Chapter 12, Rock Material Field Classification System

TR-17 - Geologic Investigations for Watershed Planning

TR-27 - Laboratory and Field Test Procedures for Control of Density and Moisture of Compacted Earth Embankments

TR-32 - Procedure for Determining Rates of Land Damage, Land Depreciation and Volume of Sediment Produced by Gully Erosion

TR-51 - Procedure for Computing Sheet and Rill Erosion on Project Areas

TR-78 - The Characterization of Rock for Hydraulic Erodibility

GN-3 - Geologic Investigation Process

GN-5 - Soil Sample Size Requirements for Soil Mechanics Laboratory Testing

SMN-6 - Glossary, Symbols, Abbreviations, and Conversion Factors

Soil Mechanics

NEH Part 628 - Dams

Chapter 50, Earth Spillway Design

Chapter 51, Earth Spillway Erosion Model

NEH Part 633 - Soils Engineering

Chapter 26, Gradation Design Of Sand And Gravel Filters

TR-26 - The Use of Soils Containing More Than 5 Percent Rock Larger Than the No. 40 Sieve

TR-27 - Laboratory and Field Test Procedures for Control of Density and Moisture of Compacted Earth Embankments

TR-68 - Seismic Analysis of Risers

SMN-3 - Soil Mechanics Considerations for Embankment Drains

SMN-5 - Flow Net Construction and Use

SMN-6 - Glossary, Symbols, Abbreviations, and Conversion Factors

SMN-7 - The Mechanics of Seepage Analysis

SMN-8 - Soil Mechanics Testing Standards

SMN-9 - Permeability of Selected Cleans Sands and Gravels

SMN-12 - Portable Pinhole Test Apparatus

SMN-13 - Dispersive Clays

DN-24 - Guide for the Use of Geotextiles

Forms

Form 127 - Soil Permeability

Form 128 - Consolidation Test

Form 128A - Log Time Consolidation

Form 129 - Undisturbed Sample Characteristics

Form 130 - Grain Size Analysis

Form 352 - Compaction and Penetration Resistance

Form 353A - Soil Classification

Form 354 - Soil Mechanics Laboratory Data

Form 355A - Triaxial Shear Test

Form 355B - Triaxial Shear Test with Pore Pressure Measured

Form 357 - Summary – Slope Stability Analysis

Form 366 - Direct Shear Test

Form 372A - Placement of Earth Fill Materials

Drafting

NEM Part 541 - Drafting

TR-73 - Computer Aided Design and Drafting (CADD) Standards

Design

NEM Part 536 - Structural Engineering

NEM Part 542 - Specifications

NEM Part 543 - Materials

NEH Section 6 - Structural Design

NEH Section 11 - Drop Spillways (Hydraulic Portion Only)

NEH Section 14 - Chute Spillways

NEH Section 19 - Construction Inspection

NEH Part 642 - Specifications For Construction Contracts

- Chapter 1, General Contract Specification Procedures
- Chapter 2, National Standard Construction Specifications
- Chapter 3, National Material Specifications

TR-5 - Structural Design of Underground Conduits

TR-18 - Computation of Joint Extensibility Requirements

TR-30 - Structural Design of Standard Covered Risers

TR-31 - Structural Analysis and Design at Low Stage Inlets

TR-37 - Structural Analysis and Design at Base of Riser with Conduit Openings in Both Endwalls

TR-50 - Design of Rectangular Structural Channels

TR-54 - Structural Design of SAF Stilling Basins

TR-63 - Structural Design of Monolithic Straight Drop Spillways

TR-67 - Reinforced Concrete Structural Design

TR-74 - Lateral Earth Pressures

TR-77 - Design and Installation of Flexible Conduits

DN-2 - Required Three-Edge Bearing Strength for Rigid Pipe

Example Construction Drawings

Example Construction Specifications

Example Quality Assurance Plan

Example Construction Pollution Prevention Plan

General - All paper or electronic survey notes and sketches shall follow recognized professional practice and industry standards. Notes, sketches, and other data shall be complete, neat, legible, and reproducible. The work shall be organized to facilitate ease in review and shall allow reproduction or production of hard copies. When survey equipment that requires little or no manual recording of field data is used, the survey data shall include information allowing NRCS to review and interpret the raw data.

Natural Stream Channel - Begin plan and profile stationing at the most upstream extent of the area of interest. The thread of the stream or water line at low water shall be shown on the plan. The profile need not go below the low water surface, except that the streambed shall be profiled through riffles.

Borrow Area(s) - Profiles of borrow area(s) in the reservoir should parallel the proposed measures at 200-foot intervals beginning 200 feet upstream from the centerline. If the centerline has angle point, use the longest leg as the baseline for layout of borrow grids. Each profile upstream from the centerline should be designated alphabetically starting with A. Profile stationing should mimic the stationing identified by station and letter (such as 19+00, A). Profile downstream from the centerline could be designed alphabetically starting with AA.

Geologic Investigation - Investigation boring holes and excavations should be located horizontally using the above suggested centerlines or grids with a vertical elevation established at each hole.

Valley Cross Sections - The valley downstream should be cross sectioned at intervals not to exceed 2500 feet starting from the centerline and extending down to the point of intersection where the breach wave crest and the flood level of the 100-year frequency storm from the uncontrolled drainage area. If development exists downstream from this point and is below the 100-year flood level, valley sections should be extended to include such development or until the depth of the flooding from the breach discharge no longer creates a hazard. Valley sections should be taken more often if the valley cross sectional area changes significantly. Each valley section shall be taken perpendicular to the direction of floodwater flow and shall define the bottom width and centerline of the channel and the tops of bank. The portion of the valley section across the channel shall be perpendicular to stream flow, which may cause the section to be bent. Valley sections should extend vertically to at least six tenths of the planned height above the stream channel. Distances should be measured from right and left when facing downstream.

Centerline of Downstream Affected Roads - The crown of all downstream roads within the study area should be profiled to an elevation which is equal to or higher than six tenths the planned height above the stream channel. Stationing shall progress from left to right when looking in a downstream direction. The centerline of the bridge or culvert shall be located on the road profile. Structure dimensions and skew angle from the road should be measured. Valley sections should be taken upstream and downstream of roads.

Drainage Structures - Structures in the channel should be measured in sufficient detail to permit determination of the hydraulic characteristics of the structure. This may include, but not be limited to, a cross section of the structure, its skew to flow direction, the shape and number of pilings and/or piers, width and or length of the structure, size and angle of wing walls, flow line elevations, and cross sections upstream and downstream of the structure.

Building Elevation Surveys - Threshold elevations of buildings in the potentially inundated area should determined. The project economist should be present or consulted during surveys of building threshold elevations to assure that locations on the buildings are surveyed. Additional vertical dimensions should be recorded to support accurate economic evaluations, particularly related to the elevation of zero damage (e.g. basement windows, et cetera).

Permanent Benchmarks - These must be positioned such that they will not be disturbed or made useless by future construction operations. They should consist of a bronze pin or caps set in concrete or a number 5 reinforcing bar 36 inches long, firmly set and driven flush with the ground. An aluminum or plastic cap should be set on the #5 re-bar with a lath set nearby.

General - All maps, drawings, and notes, whether paper or electronic, shall follow recognized professional practice and industry standards. Notes, sketches, and other data shall be complete, neat, legible, and reproducible. The drafting work shall be organized to facilitate ease in review and allow reproduction or production of hard copies. Where drafting products are delivered as electronic files, NRCS must be able to reproduce the same view, map, drawing, or note. Therefore, AutoCad files must contained named views and layouts and ArcGIS must contain unique view with associated layouts, or the drafting products can be delivered as pdf files or a similar format.

NRCS uses drawing sheets measuring 22 by 34 inches with a one-half inch margin on top, bottom, and right end and a one and one-half inch border on the left end. Plan views should be drawn so that flow is toward the right side or the top of the sheet or with north to the top of the sheet. Profiles representing a view essentially parallel to the direction of stream flow should be drawn so the upstream end is on the left and flow progresses from left to right. Elevations and sections representing views essentially normal to stream flow are to be drawn so that they are viewed from upstream (with the observer looking downstream). A series of sheets should be numbered (example: Sheet 10 of 27).

Map or drawings must, as appropriate, include the following details: north arrow, bar scale, and contour interval. In addition, Map and drawings must, as appropriate, include the following: centerlines, bench mark descriptions, monument descriptions, ties between centerlines and monuments or bench marks, coordinate grid system.

If requested, NRCS will furnish a typical, blank drawing file in the following formats: AutoCad dwg or dxf, ASCII file, or ArcGIS template. This blank drawing will include NRCS title blocks in a 22-inch by 34-inch drawing template.

Topographic Maps and Plan Views - Maps shall contain planimetric features, which are visible or identifiable on the base aerial image, including buildings, ditches, terraces, reservoirs, trails, roads, railroads, quarries, borrow pits, cemeteries, wooded areas, utilities (i.e. telephone, telegraph, electric, underground cables, and pipelines and sewers), fence lines, walls, and similar man-made features. The designation of state and federal numbered highways should be shown. Structures such as bridges, trestles, tunnels, piers, retaining walls, dams, oil, water, other storage tanks, and the like should also be shown. Maps should also show drainage ways which are longer than one inch at map scale, water features (i.e. springs, falls, rapids, ponds, lakes, swamps, marshes, and bogs), rock ledges, cliffs, and other essential topographic features.

Spot elevations should be shown for: water levels, hilltops, saddles, depression bottoms, intersections of important roads and railroads, and along the ridge and channel of terraces. Spot elevations should also be shown where contours are more than three inches apart at map scale.

Each contour should be drawn as a 3D polyline and shown as a solid line, except where it is obscured by an overhanging bluff or ledge, and on maps compiled by photogrammetry where the ground cannot be seen due to dense woods. In such ground-hidden places, the contours should be shown as dashed (broken) lines. Index contours should be established using every fifth contour, and these index contours should be labeled with its actual elevation.

Horizontal control point used for photogrammetric surveys must be plotted on the finished maps with an accuracy of 1/100 of an inch of its true position as expressed by the plane coordinates calculated for the point. Ninety percent of all planimetric features should be plotted so that their position on maps are accurate to within at least 1/40th of an inch, and no feature should be more than 1/20th of an inch from their true coordinate position. Ninety percent of all spot elevations placed on maps should have an accuracy of at least one-fourth the contour interval and the remaining 10 percent shall be not in error by more than one-half the contour interval.

Profiles of Centerlines - Profiles should typically be plotted so that the ratio of horizon scale to vertical scale is equal to 5 or 10. For example, if the horizontal scale is 1 inch equals 100 feet then the vertical scale would be 1 inch equals 10 or 20 feet. For plan and profile views, NRCS typically uses a horizontal scale of 1 inch equals 100 feet.

Cross Sections – Cross sections should be plotted with the smallest station number in the lower left corner of the drawing and the next station plotted above the first. If space exists, a second or third column of cross sections may by plotted to the right of the first column. By plotting up the sheet in order of increasing stationing, the view shows left on the left and right on the right, and the individual viewing the cross sections can visualize the stream reach. The plot should show the centerline location. The human eye can perceive the actual land form if the plotted ratio between the horizontal scale and vertical scale is 5.

Cross section of drainage structures should be included. Typically, it takes two orthographic sketches of the structure at a scale that facilitates clear dimensioning of the hydraulic characteristics of the structure or one cross section with notes that describe the structure's dimensions, elevations, materials, and condition.

Terms relating to geology and soil mechanics should be accordance with SCS Soil Mechanics Note 6. Geologic terms not contained in NRCS reference material should conform to "Glossary of Geology and Related Sciences," the American Geological Institute. Soil mechanics definitions not contained in NRCS reference material should conform to ASTM D 653, "Terms and Symbols Relating to Soil and Rock Mechanics."

The following additional definitions should also apply:

- Rough Profile (or Profile Section): A soil or rock profile showing the depths to principal strata and depths to the free groundwater level (in cases where exploration extends below groundwater levels).
- Detailed Profile (or Profile Section): A soil or rock profile showing not only the major strata but also the dip and strike of the strata, thin strata, seams, faults, lenses, shear planes, water bearing strata, piezometric pressure at various depths (when pertinent) and other details critical to the purpose of the investigation.
- Bedrock Profile: A profile showing only surface elevations and depths to rock, or, in some cases, to strata of exceptional bearing capacity such as hardpan, hard clay or very dense sands and gravels.
- Significant Depth: The vertical distance below the ground surface within which: (1) the loads applied to the foundation may be expected to alter the state of stress in the foundation materials enough to produce critical shear strains or to cause significant increments of settlement by compression of the foundation; or, (2) the permeability characteristics of the foundation profile may be expected to influence the stability or functional adequacy of the proposed structure.
- Representative Samples: Samples of soil or rock (either disturbed or undisturbed) selected and recovered in such a manner as to insure that they indicate the true nature of the material in the zone under consideration to the extent required to determine the characteristics and properties pertinent to the purpose of the investigation