Quality Assurance Project Plan

PLAYA RESTORATION, MONITORING AND STABILITY ASSESSMENT PROJECT
CWA Section 104(b)(3) Wetlands Program Development Grant
Assistance Agreement CD #01F78801-0 (FY2020)

Submitted by:

New Mexico Environment Department
Surface Water Quality Bureau

GROUP A: PROJECT MANAGEMENT

A.1 Title and Approval Sheet

Maryann Mcgraw — Digitally signed by Maryann Mcgraw Date: 2023.03.23 10:54:28 -06'00'

Maryann McGraw
Wetlands Program Coordinator, SWQB — Date

Miguel Montoya — Digitally signed by Miguel Montoya Date: 2023.03.23 14:09:45 -06'00'

Miguel Montoya
Quality Assurance Officer, SWQB — Date

Abraham Franklin — Digitally signed by Abraham Franklin Date: 2023.03.23 14:06:19 -06'00'

Abraham Franklin
Program Manager, SWQB Watershed Protection Section — Date

Kyla Chandler — 4/18/2023

Kyla Chandler
Project Officer, WDAS, EPA Region 6 — Date

NELLY SMITH — Digitally signed by NELLY SMITH Date: 2023.04.18 19:06:56 -05'00'

Nelly Smith
Chief, State and Tribal Programs Section, WDAS, EPA Region 6 — Date

THIS PAGE INTENTIONALLY LEFT BLANK

A.2 Table of Contents

Table of Contents

List of Tables

List of Figures

ACRONYMS

2D	Two Dimensional
ACOE	Army Corps of Engineers
DQO	Data Quality Objectives
EPA	United States Environmental Protection Agency
GPS	Global Positioning System
KRE	Keystone Restoration Ecology
NCD	Natural Channel Design, Inc
NPS	National Park Service
NMED	New Mexico Environment Department
NMRAM	New Mexico Rapid Assessment Method
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedures
SWQB	Surface Water Quality Bureau
TBD	To Be Determined
TMDL	Total Maximum Daily Load
USFWS	U S Fish and Wildlife Service

A.3 Distribution List

Table 1. below contains the distribution list, project roles and responsibilities for this project. The Quality Assurance Officer (QAO) will ensure that copies of this QAPP and any subsequent revisions are distributed to members who have signature authority to approve this QAPP. The NMED/SWQB Wetlands Program Coordinator will ensure that copies of the approved QAPP and any subsequent revisions are distributed to all other project personnel listed in Table 1. All members of the distribution list who do not have signature authority to approve this QAPP will review the QAPP and sign the Acknowledgment Statement (Appendix 2) prior to initiating any work for this project. The signed Acknowledgement Statements will be collected by the NMED/SWQB Wetlands Program Coordinator and will be given to the QAO for filing with the original approved QAPP.

Table 1. Distribution List, Project Roles, and Responsibilities

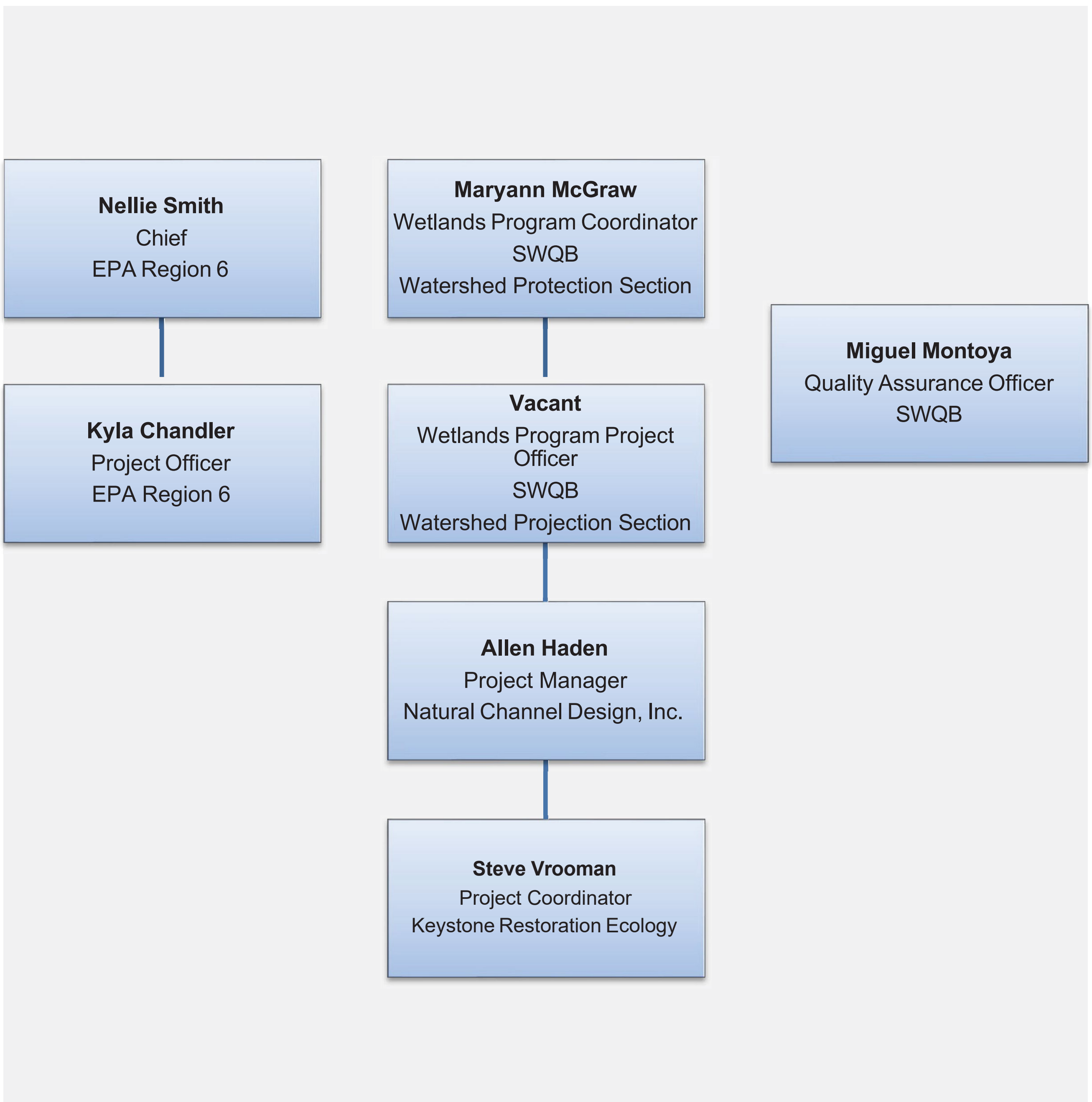
Name	Organization	Title/Role	Responsibility	Contact Information
Abe Franklin	SWQB	Watershed Protection Program Manager	Reviewing and approving QAPP	505-946-8952 abraham.franklin@env.nm.gov
Maryann McGraw	SWQB	Wetlands Program Coordinator	Preparing and revising QAPP, distribution of QAPP, project reporting, coordinating with contractor, oversight of data collection, EPA reporting, reviewing and approving QAPP, managing project personnel and resources	505-490-3135 maryann.mcgraw@env.nm.gov
Miguel Montoya	SWQB	Quality Assurance Officer	Reviewing and approving QAPP	505-819-9882 miguel.montoya@env.nm.gov
Allen Haden	Natural Channel Design, Inc (NCD)	Project Manager	Project oversight, data management, data collection, staff management and submittal of annual reports to SWQB	928-774-2336 allen@naturalchanneldesign.com
Steve Vrooman	Keystone Restoration Ecology (KRE)	Project Coordinator	Project design and implementation, construction, monitoring	505-490-0594 stevevrooman@gmail.com

Kyla Chandler	EPA	Project Officer WDAS, Region 6	Reviewing and approving QAPP	214-665-2166 Chandler.Kyla@epa.gov
Nelly Smith	EPA	Chief, State and Tribal Programs Section WDAS, Region 6	Reviewing and approving QAPP	214-665-7109 smith.nelly@epa.gov

A.4 Project Organization

The SWQB Quality Management Plan (NMED/SWQB 2019) documents the independence of the QAO from this project. The QAO is responsible for maintaining the official approved QAPP. Figure 1 presents the organizational structure for the Playa Restoration, Monitoring, and Stability Assessment Project.

Figure 1. Organization Chart



A.5 Problem Definition/Background

The purpose of this Quality Assurance Project Plan (QAPP) is to document procedures for determining the extent of wetlands before and after implementation of a restoration project that is intended to demonstrate new restoration techniques and restore wetland acreage on playas of the Southern High Plains (SHP). This project will also initiate the development of a Regional Assessment Curve for playa wetlands in eastern New Mexico that will also be applicable to playa wetlands in neighboring states of southern Colorado and West Texas. This QAPP refers to the project as the "Playa Restoration, Monitoring, and Stability Assessment Project" project. The Playa Restoration, Monitoring, and Stability Assessment Project is contracted to Natural Channel Design, Inc. (NCD) in cooperation with Keystone Restoration Ecology (KRE) and the evaluation of a restoration design will be performed principally on a playa belonging to the Grasslans Foundation located near Causey, New Mexico in Roosevelt County. The Regional Assessment Curve will be developed using data from 20 playas in surrounding Counties including Quay, Curry, Roosevelt and Lea Counties in eastern New Mexico.

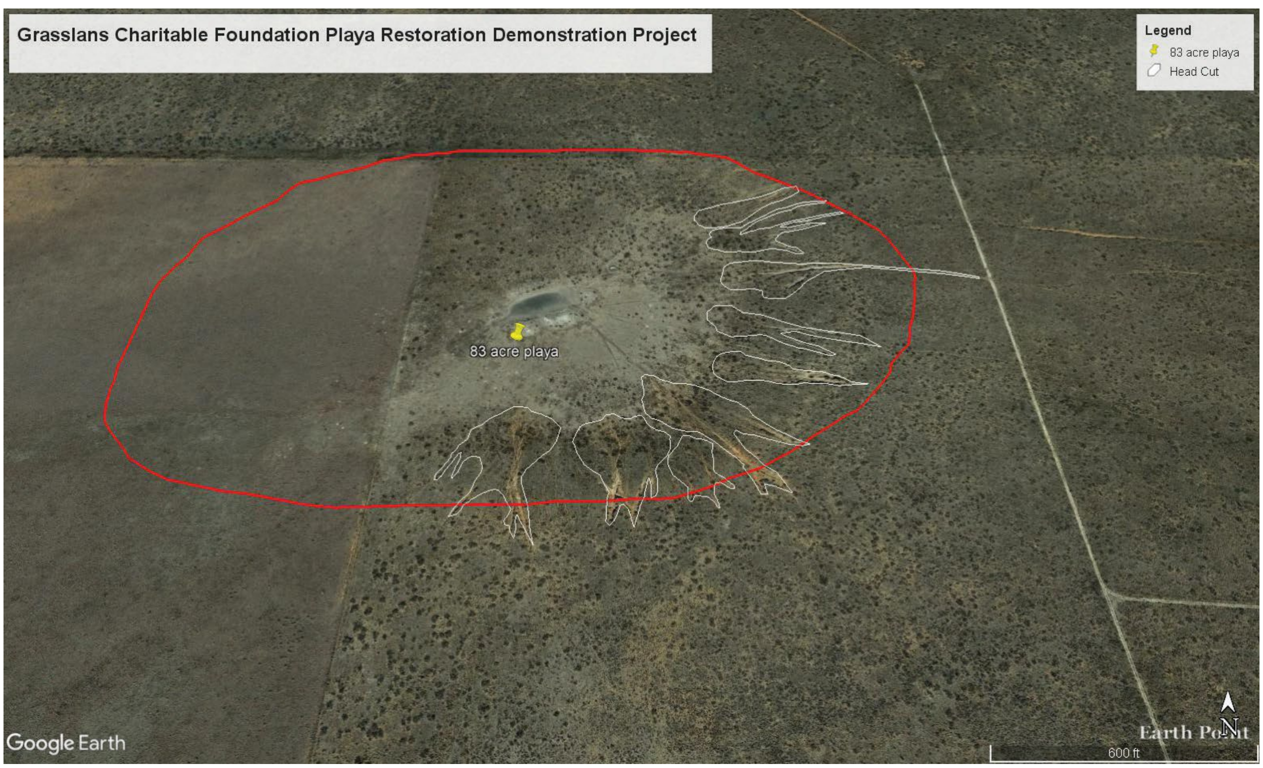


Figure 1. Degraded playa owned by the Grasslans Foundation in Roosevelt County, New Mexico. Headcuts and gullies have been created and exacerbated by cattle trailing to water and grazing in the playa and surrounding playa watershed. Road runoff on the eastern side has also contributed to gully formation.

NCD will work cooperatively with KRE to develop a design and hydrologic modeling of proposed headcut repairs and other treatments proposed by KRE. NCD will utilize existing Lidar-based topography to build a base condition 2D hydrologic model estimating depth, velocity and shear stress during peak runoff periods. NCD will then modify the topography to emulate KRE's proposed design to test improvements in shear stress, depth and erosion potential with the goal of both improving the design and providing educational maps to illustrate the design principles and goals for the design. Drawings of the proposed construction will be developed to aid construction.

NCD will initiate the development of a Regional Assessment Curve for playa wetlands. NCD will collect geomorphic and vegetation data on stable and unstable drainage swales in the region. The data will be analyzed for stability using the grass lined channel design tools developed by Natural Resources Conservation Service Engineers (Conservation Practice Standard Grassed Waterway (Code 412) (usda.gov) (Appendix 3). This tool uses slope, shear stress estimations, hydrology, soil type and vegetation type, density and height to estimate stability. Once 'tuned' to regional conditions in eastern New Mexico this tool could provide a valuable means of integrating range condition, hydrology and geomorphic conditions into an assessment and design tool for playa conservation. NCD proposes to analyze approximately 20 sites (10 functioning and 10 degraded) to test the viability of this method. The Project will require the collection of landscape and land-use, soils, and vegetation data at 20 playa wetlands. This will require using laser levels and measuring tapes to measure slopes and photography to describe land use in and surrounding the playas within each playa watershed. The digging of soil pits 30 inches in diameter and 36 inches deep will also be required to describe the soil profile and take soil data such as soil color and texture, layer boundaries, soil type, root density and water table measurements. Vegetation data will require the measurement of density of cover and identifying plants. These data will then be used to determine how to restore playa wetlands that have headcuts and erosion of drainages leading to the playa. Locations of the sites will be chosen from review of aerial photography to identify survey areas. NCD will focus on playas located on state lands to simplify access permission. However, there are private landowners cooperating with the project that could provide access to suitable areas. The New Mexico Rapid Assessment Method (NMRAM) for Playas of the Southern High Plains (Appendix B) will also be conducted at a representative sample of the 20 playa sites.

Results and recommendations for use or future refinement will be summarized in the form of a Technical Guide explaining the design principals, techniques for assessment, and repair of playas in this region. We plan to utilize information collected from implementation of this project as well as best practices described by KRE and others to provide an accessible summary of the various techniques which could be utilized for successful playa restoration.

NCD will also develop a monitoring plan for the playa enhancement project. The monitoring plan will focus on use of ground-based photo points, drone photography and continuous soil moisture monitoring recorders that can help to relate improvements in soil moisture conditions within the improved playa with changes in vegetation community and density. NCD will implement the monitoring program in cooperation with KRE and collect data for two years beyond the implementation of the proposed improvements at the Grasslans Playa site. Annual monitoring reports, that summarize collected data, recovery trends as well as assessment of monitoring methods will be provided as deliverables to the SWQB Wetlands Program.

Background

The New Mexico Environment Department Surface Water Quality (SWQB) Bureau Wetlands Program (Wetlands Program) is working with various agencies, non-profit organizations, and private landowners to improve function, habitat quality and water quality for playa wetland systems in eastern New Mexico. Playas are depressional wetlands each within their own relatively small watershed on the SHP. The Wetlands Program Coordinator, Maryann McGraw, is working with partners in Roosevelt County to demonstrate incentives to form a playa watershed group around a playa cluster. Demonstration design, restoration and innovative pre-and post-monitoring methods will be used in the sandy soils that are filling playas in the project area. The Wetlands Program has the need to design, develop new, accessible, and functionally focused monitoring and assessment tools. In addition, they have need to assist with modeling and analysis of specific designs developed by others for the restoration of degraded playas.

Specifically, it has been determined that numerous gullies where livestock created trails by walking up and down to the playa bottom creating the drainage channels have degraded playas by allowing sediment to flow into the playas disrupting their unique water holding capacity, changing infiltration properties, and disrupting the ecology of the playa (Figure 1). These trails captured water and funneled it directly down the channel, creating V-shaped and u-shaped gullies where flow would normally be characterized by sheet flow and sediment capture by native grassland vegetation. These gullies are the demonstration sites for playa restoration on the Grasslans Playa and will be applicable to numerous similar situations on playas of the SHP and on a larger regional scale.

The design and installation of this project will improve the hydrology of the playa and its watershed by allowing water to infiltrate and restoring sheet flow to the playa bottom. The design will eliminate excessive sediment creating alluvial fans and infilling at the playa bottom. The ecological functioning of playa wetlands will be restored as the hydrology and natural wetland vegetation is restored in the playa, thereby, improving wildlife habitat and water storage capacity of these depressional wetlands. Playa restoration structures will be designed to carry the 25-year storm event and will also incorporate prevailing wind deposition to refill gullies. The SHP is predicted to have fewer but larger storm events that could exacerbate erosion and gully formation that are already degrading playas. In addition, drying and more severe prevailing wind events are occurring on the SHP. The development, design and implementation of restoration structures using local materials and harnessing the effects of weather patterns has the capacity to help mitigate effects of climate change. The monitoring plan will provide the details of the restoration success.

Objective

The objective of the project will demonstrate the effectiveness of these innovative restoration of playas degraded by channeling, headcuts and gully formation. Design and implementation information about the new techniques will be shared with multiple agencies, landowners, restoration volunteers, and the public through the development of a playa cluster watershed group, presentations to local Soil and Water Conservation Districts (SWCD) , guided tours, presentations and the distribution of a Technical Guide and fact sheet. The new techniques will be applicable to gullies in playa wetlands. Restoration structures and seeding will work together in series to redirect and slow the flow of water at various locations along the flow path within a degraded channel: 1) upstream of a headcut, 2) at the headcut, and 3) downstream of the headcut. This project will also convene the Playa Cluster Watershed Group to develop a Wetlands Action Plan to guide future monitoring, restoration, management and protection in a coordinated and comprehensive manner.

Project/Task Description

Description

1. Data will be collected to determine the effectiveness of the innovative restoration techniques by evaluating the change in drainage patterns into the playa wetlands and the prevention of sediment filling the playas though erosion at the Grasslans Playa. Structures will be constructed using machinery and hand labor under a separate contract from the US Fish and Wildlife Service Partners for Fish and Wildlife at the Grasslans Playa. The techniques employed will use local materials, be low maintenance and hands-on. Some techniques will also employ equipment that playa owners will likely have available to them.

2. Data will also be collected at 20 additional playa sites in surrounding Counties including Quay, Curry and Roosevelt Counties in eastern New Mexico to develop the Regional Assessment Curve and the Technical Guide.

Post treatment monitoring data and collection activities will be used to evaluate the effectiveness of the project and to develop the Regional Curve. Changes within the project area will be addressed by the following monitoring methodologies:

For the Grasslans Playa:

1. Monitoring changes to the wetland perimeter and overall wetland acreage using vegetation and hydrology indicators (Army Corps of Engineers 2008);
2. Establishing permanent photo point locations to visually and qualitatively monitor changes to the wetlands and the structures installed following *Stream Channel Reference Sites: An Illustrated Guide to field Technique* (Harrelson et al. 1994):
3. Monitoring changes to vegetation abundance and species along treated channels on the Grasslans Playa.
4. Monitoring soil moisture using in-ground meters and data loggers.
5. Assessing terrain, wetland vegetation, and surface water extent using drone survey techniques.

For the Grasslans Playa and the additional 20 playas;

6. Terrain assessment of slope, aspect, and elevation using clinometers, measuring tapes, laser levels, compasses, and GPS
7. Estimating shear stress of existing channels and headcuts by measuring bank width, height, side slope angle, length and length
8. Collect data at targeted sites using NMRAM for Playas of the High Plains
9. Digging soil pits up to 30 inches in diameter and 36 inches deep to describe the soil profile and take soil data such as soil color and texture, layer boundaries, soil type, root density and water
10. Ground and aerial photography of playa conditions.
11. table measurements. Field assessment using Munsel's soil color chart. AND/OR Photographing soil columns or transporting samples to NCD in Flagstaff for identification and analysis.
    a. Alternatively collecting a lesser amount of soil and following assessment methods above

   b. Alternatively assessing soil field water capacity by wetting soil and rolling in hands to determine general soil type and moisture capacity
12. Measuring terrain profiles, assessing existing erosion and headcut channels using a laser level and measuring tape to survey channel cross-sections and topography
13. Using chaining pins or pin flags as temporary markers for field measurements and photo markers
14. Measuring vegetation density, cover extent, and height by visual identification along sampling transects or within temporary quadrat placements
15. Plant identification through photography or collecting whole plant samples (including flowers, stems, leaves, and root mass) for ex-situ identification
16. Ground photography of existing playa conditions including the placement by digging or auguring of rebar or similar materials for locating sites for taking repeat photographs, and the photographing at several times per year of the playa wetland
    a. Alternatively, ground photography at known distances and azimuths from recognizable features to eliminate the need for ground disturbance and permanent object placement
17. Drone photography will also be required to capture topography, vegetation density, and the existence and extent of standing water.
18. Long-term monitoring of soil assessment by the placement by auguring or machinery into the ground soil temperature and soil moisture sensors attached to a data logging device.

Schedule

Table 2. Project tasks, products, responsible party, timeline

Task	Product	Responsible Party	Approximate Start Date	Approximate Completion Date
Administrative	Procurement for contract	NMED/SWQB, NCD	May 2022	October 2022
Planning	Field site visit (no data collection)	NMED/SWQB, USFWS, KRE	Pre-project	
Develop restoration design	Restoration Design	KRE, USFWS and Playa Cluster Group	Summer 2022	Winter 2022
Quality Assurance Project Plan	Approved QAPP	NMED/SWQB with input from NCD	February 2023	April 2023
Hydrologic Modeling of design		NCD	Winter 2022/ 2023	Winter 2022/2023

Drone Flight for Wetland Data Collection	Changes in vegetation, hydrology	KRE, USFWS	Summer 2022 under USFWS contract	Summer 2023 and Summer 2024 under this project
Implementation of restoration design	Restoration implementation	KRE	November 2022	November 2022
Post-treatment Wetland Data Collection	Wetland delineation using vegetation, soils, hydrology, etc.	NCD	April 2023	June 2025
Development of Regional Assessment Curve		NCD	December 2022	June 2025
Technical Guide	Technical Guide	NCD	Summer 2023	June 2025
Reporting to SWQB Wetlands Program Project Officer	Annual Progress Report	NCD	June 2023	June 2025
Reporting to EPA	Semi-Annual Report on this Task to EPA	NMED/SWQB Wetlands Program Coordinator	December 2022	December 2025

Project Area

The Project Area is located in eastern New Mexico in the Southern High Plains. Playa Cluster Groups are situated in four groups, the Clovis Group (Figure 3) the Portales Group (Figure 4) the Highway Mid Group (Figure 5) and the Hobbs Group (Figure 6) in Curry, Quay, Roosevelt and Lea Counties NM.

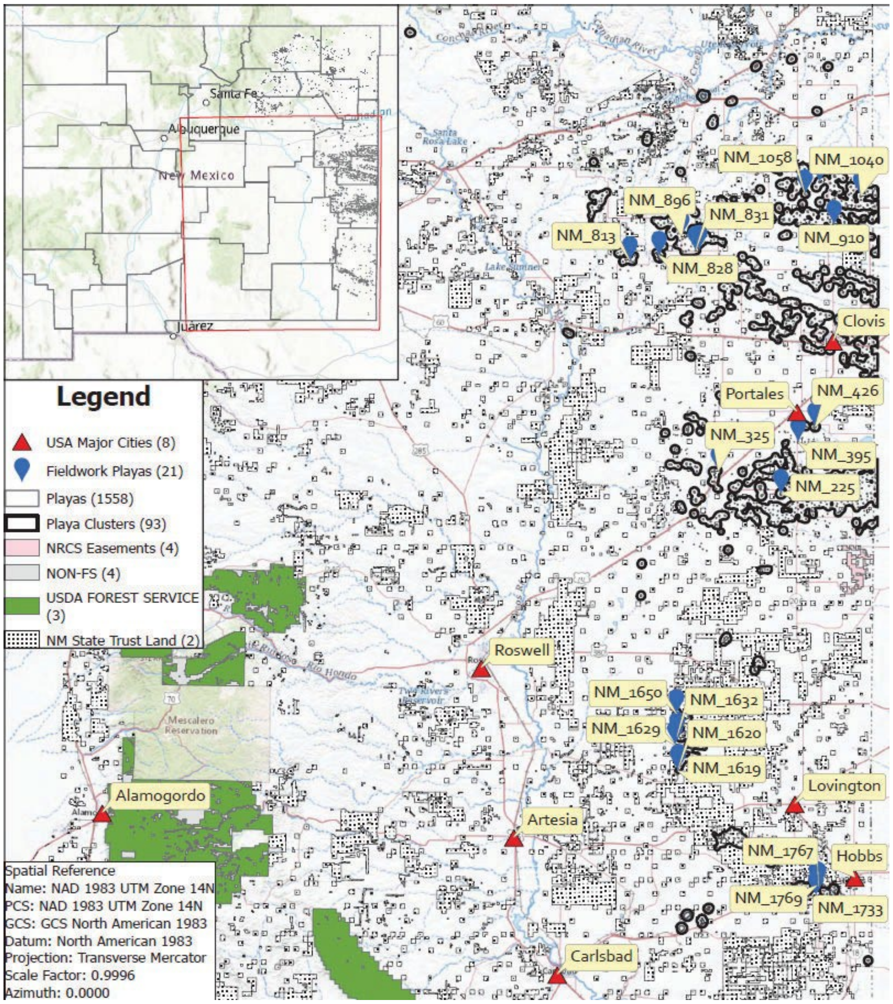


Figure 2. Project Area Map.

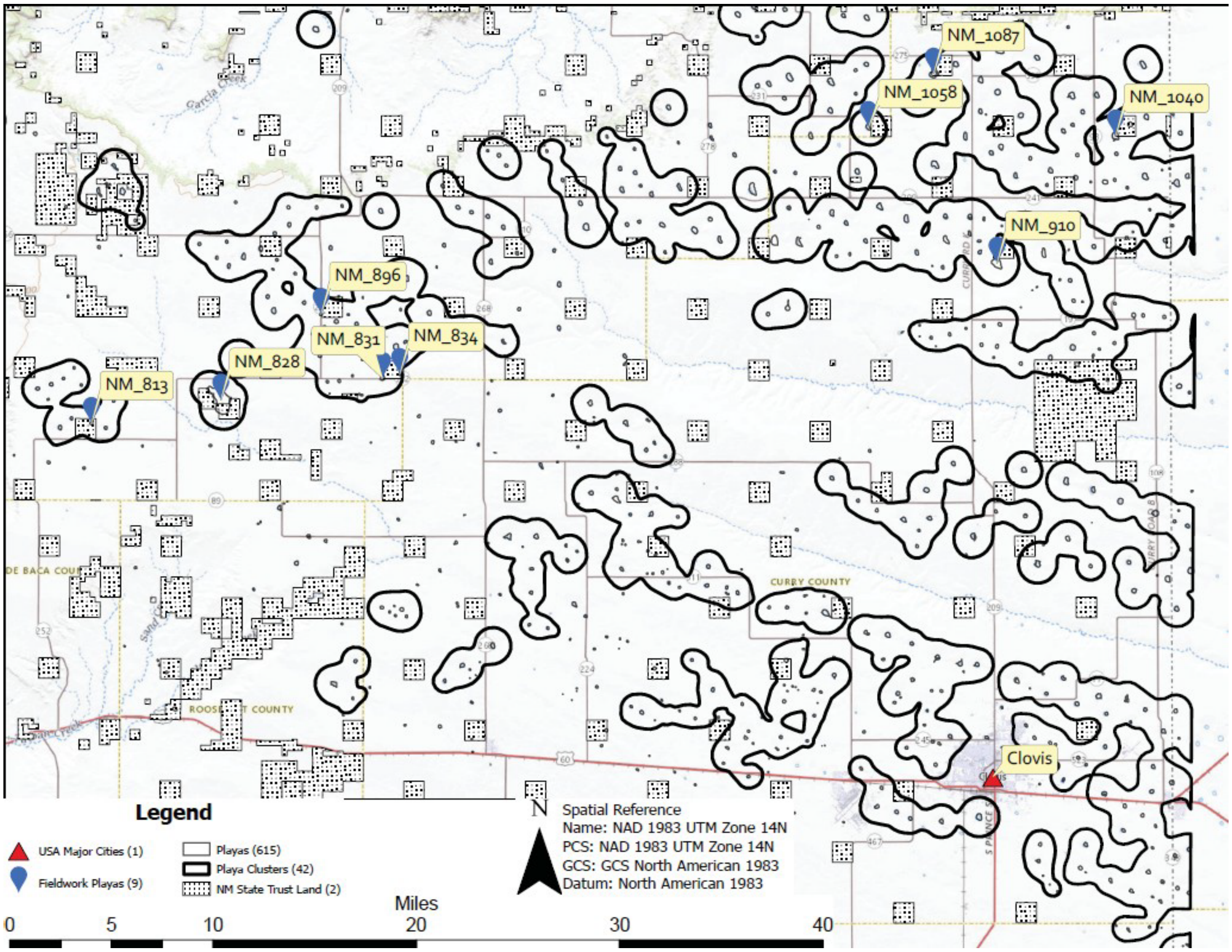


Figure 3. Clovis Group

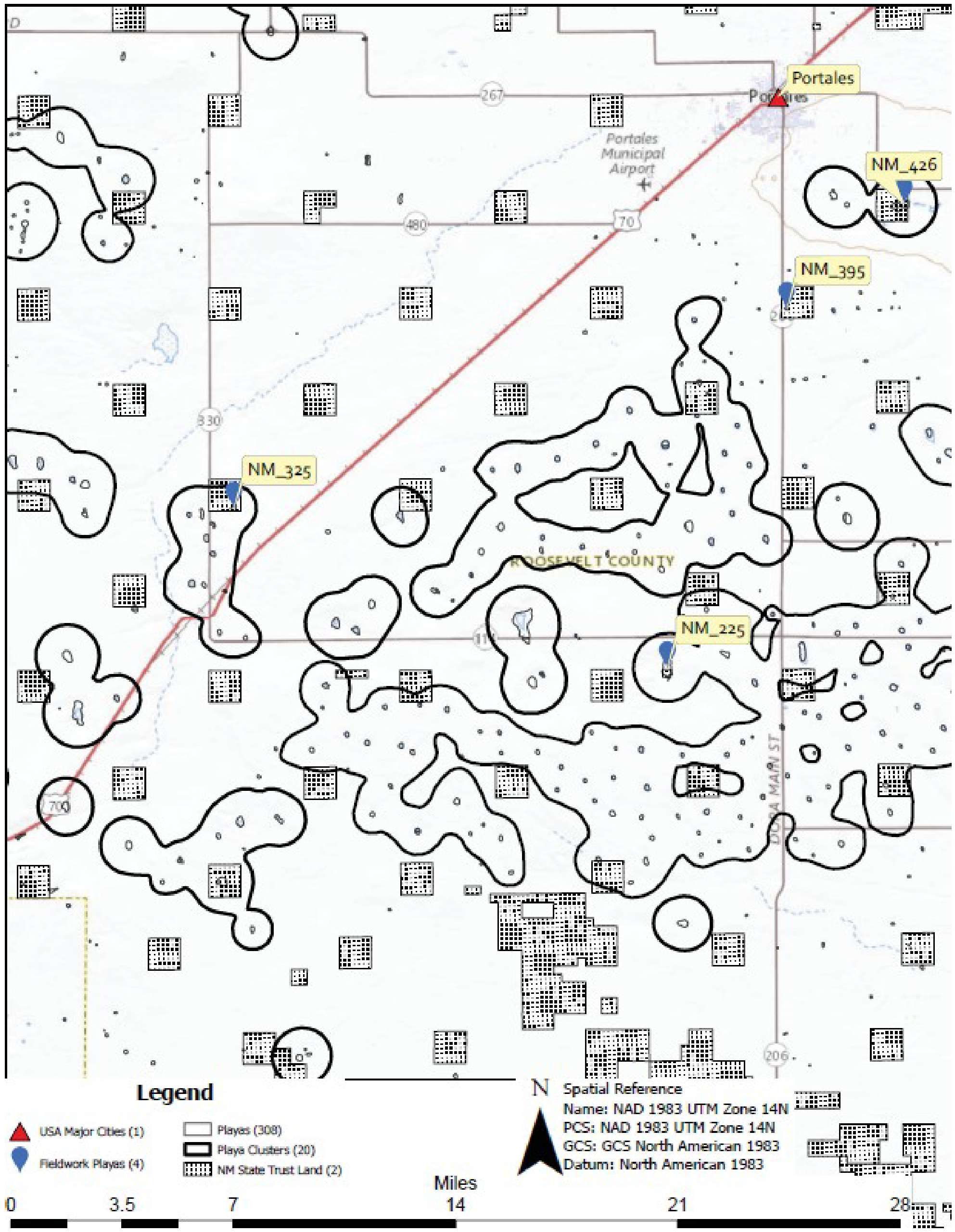


Figure 4. Portales Group

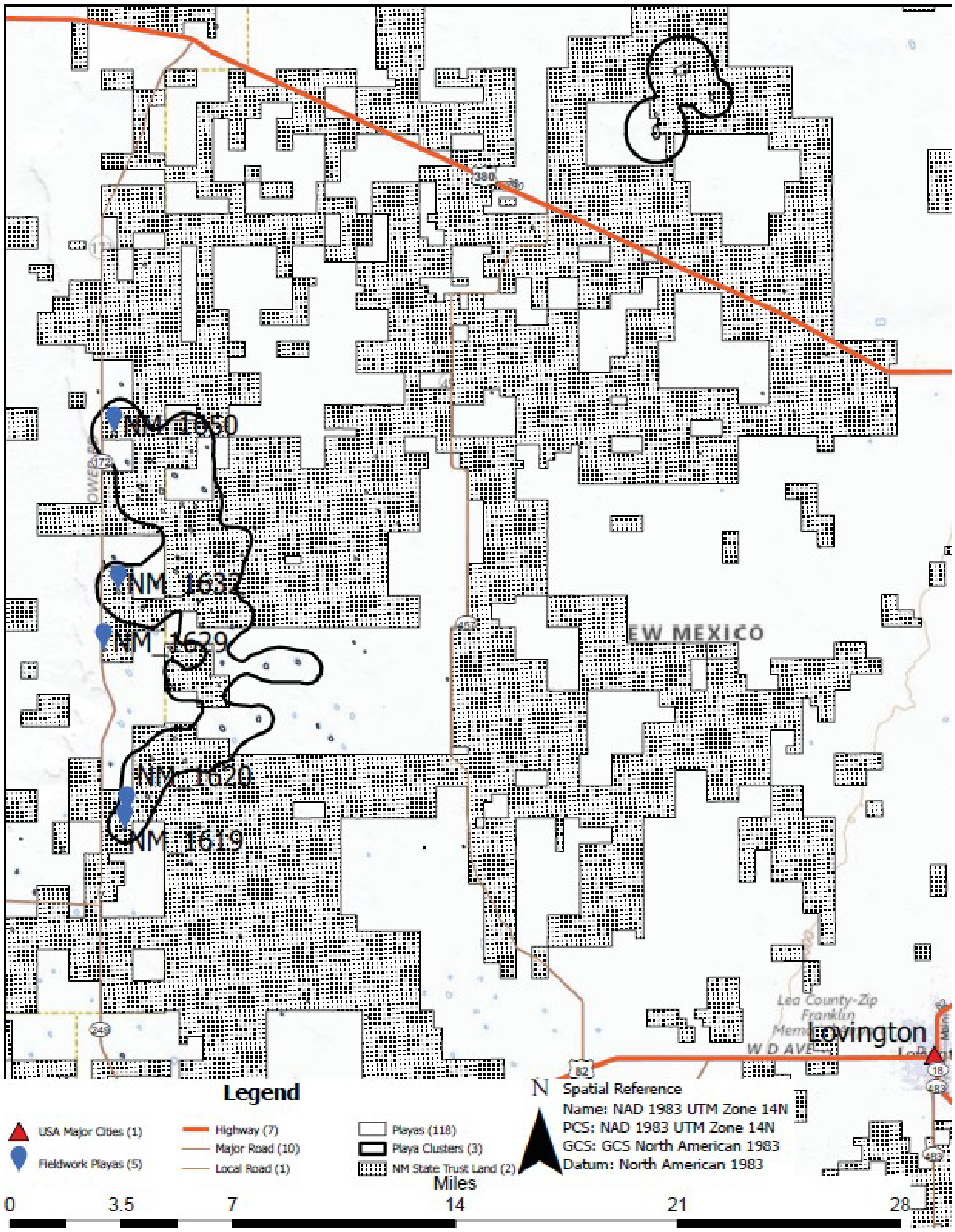


Figure 5. Highway Mid Group

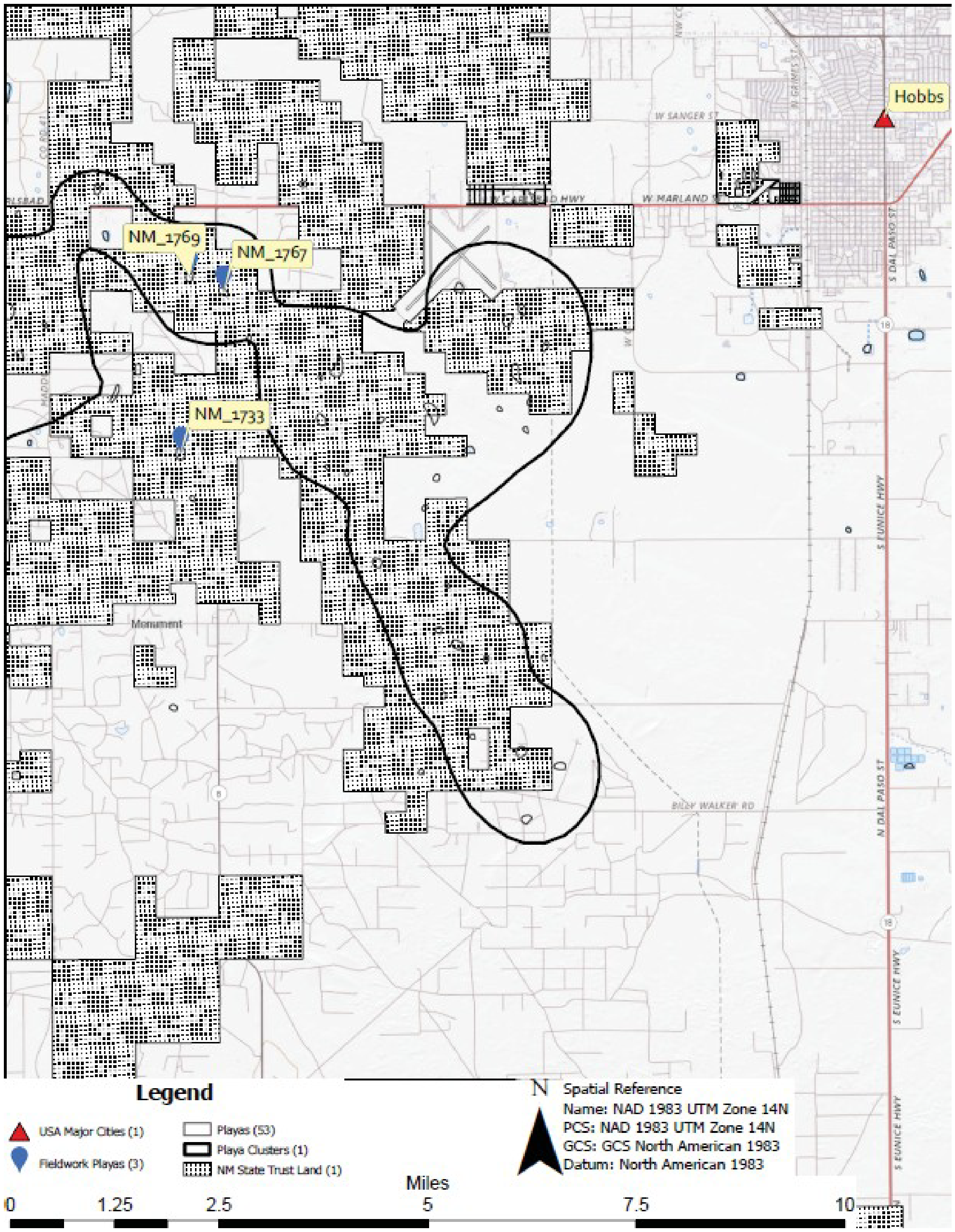


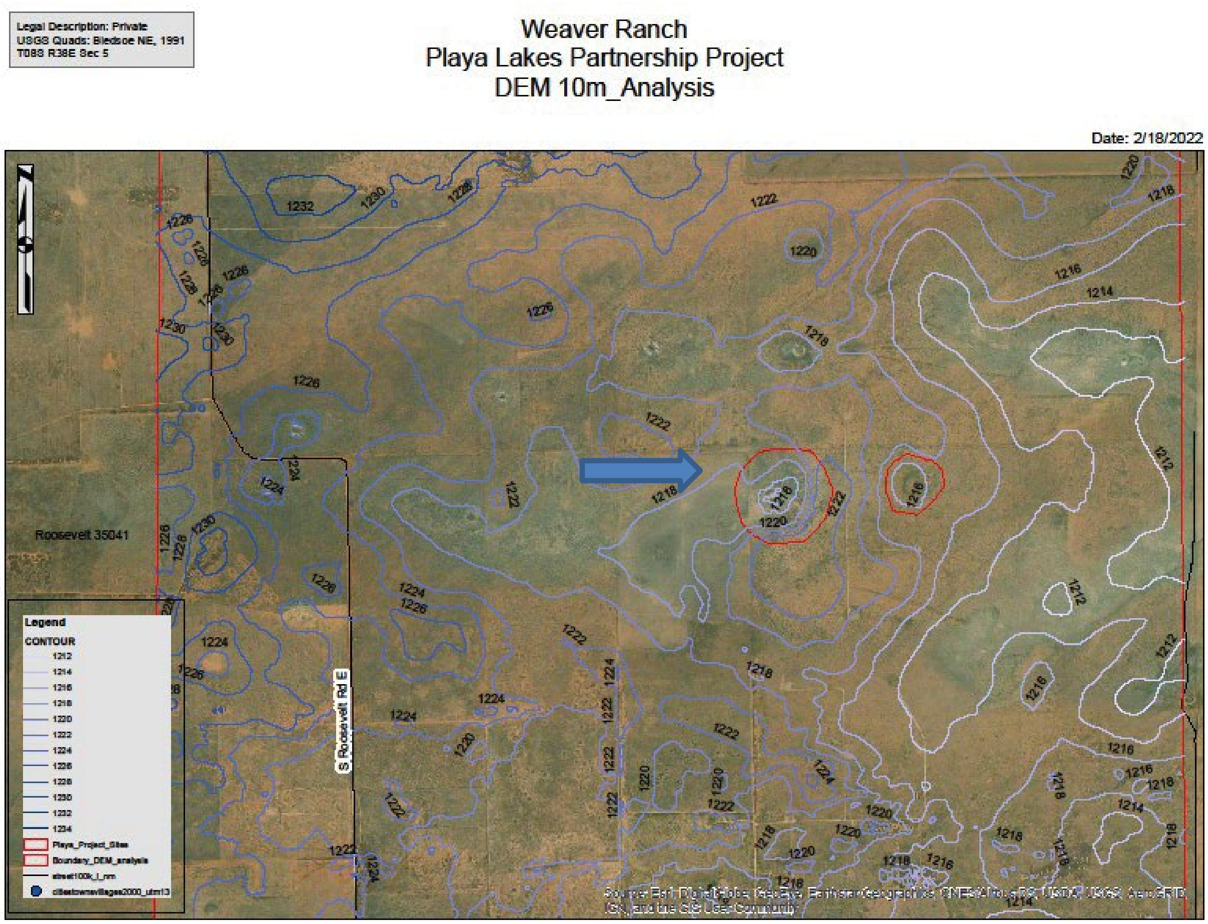
Figure 6. Hobbs Group

Monitoring Location Selection Criteria

Monitoring for the effectiveness of the restoration is located on the Grasslans Playa (Figure 1) near Causey, New Mexico, where the demonstration restoration methods were implemented. The additional 20 sites were located to represent the spectrum of disturbance caused by varying degrees of erosion along the playa perimeters and sedimentation within the playa bottom caused by cattle trailing and other forms of human disturbance.

Restoration Activities

A draft project design by KRE was completed for the restoration implementation under a contract with the USFWS. The restoration design was also reviewed by staff of NCD. The restoration was then implemented by KRE under a contract with the USFWS Partners for Fish and Wildlife grant program to the landowners. Under the USFWS Partners for Fish and Wildlife Program, Cultural Resources clearance and Threatened and Endangered species clearances were obtained for the Grasslans Playa. Some initial data collection and drone imagery was also collected at the Grasslans Playa under the contract with USFWS Partners for Wildlife Program.



Innovative restoration techniques that will be monitored under this project are described below:

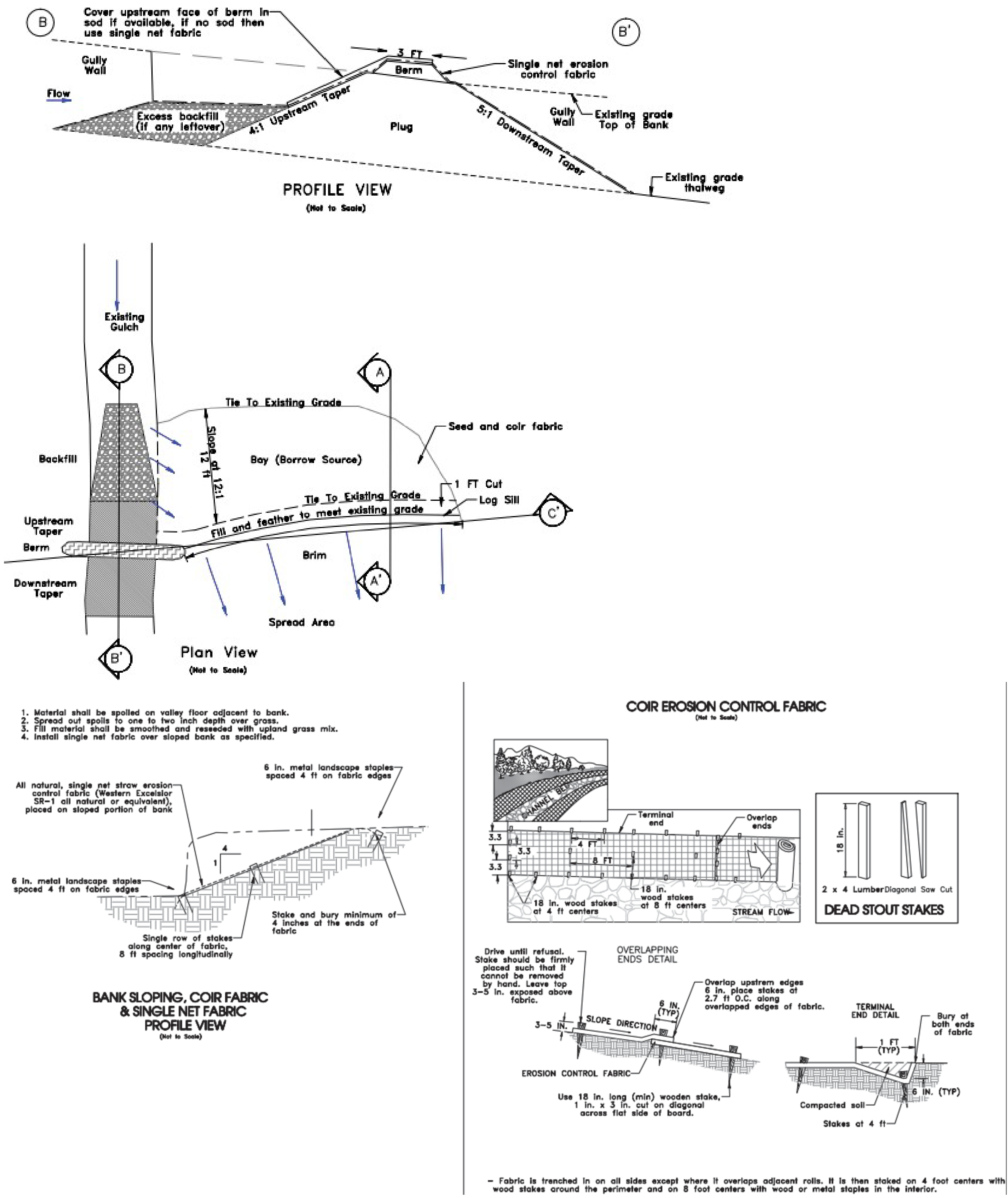
1. Contour swales installed upstream of gully-forming headcuts. Machinery will be used to dig contour swales, shaped concave-down, on the slopes above the headcuts. The downslope edges of the contour swales will be deeper than the upslope edges. Stormwater runoff and snow melt will catch on the lower lips of the contour swales, then either infiltrate or be shunted off to the side slopes, thereby changing water flow directions and dissipating erosive energy. Contour swales will route the flow away from headcuts and create sheet flow to the playa. Seepage through the contour swale will flow down the channel where it will then encounter the next innovative structure at the headcut.

2. Soft, absorbent treatment structures (grass plugs) that fill a headcut and capture blowing soils will be stacked and layered from the base to the top of the headcut, forming the overall shape of a bowl. The layers will create small terraces for the water to descend, each terrace dropping only a couple of inches along the gully. The bowls will be effective because the contour swales installed upstream will route some of the flow away from the gully, reducing the erosive energy of water within the channel.

3. Soft, absorbent berms (grass and soil) will be installed in series in the gullies downstream of the headcuts. The bottoms of V-shaped gullies will be flattened and smoothed with machinery and berms will be laid across the channel at low-height berms (approximately 3-6 inches high) oriented perpendicular to flow direction. The berms will create small rises at intervals as water moves down slope. The berms will provide grade control that slows and infiltrates water, and propagules for local native wetland vegetation to spread. Installation of the berms will render the valley form and width more suitable for grass growth within the former gullies, and catching sediment by increasing the roughness of the channel bottom.

Structure designs will be based on the principles of natural channel design and will adapt and expand on structures developed and used in New Mexico for previous SWQB Wetland Program Development Grants (such as Zuni bowls for headcuts, one rock dams for water-slowing and worm ditches and media lunas for water-spreading). These structures are expected to lie gently on the land and become invisible after two or three growing seasons with adequate rainfall during the growing season. Because this is a demonstration project, conceptual designs of the innovative restoration structures are subject to revision and improvement as the project develops.

Figure7. Draft Project Design.



Quality Objectives and Criteria for Measurement Data

Question/Decision

1. The monitoring components for the Grasslans Playa are intended to answer the following questions: 1) Have restoration treatments restored sheet flow and prevented additional erosion and sedimentation within the Grasslans Playa; and 2) are structures intact and functioning as intended?

Stated as a decision: The information gathered will be used to decide whether the restoration treatments have improved natural playa function and whether structures remain intact and functional throughout the monitoring period.

2. The monitoring components for the 20 playa sites are intended to answer the following questions: 1) Does the data from the playa sites with a range of disturbance lend itself to the development of a regional curve? And will the regional curve reflect potential stability using the grass lined channel design tools developed by Natural Resources Conservation Service Engineers (Appendix 3)?

Stated as a decision: The grass lined channel design tools will be modified to represent the stable configuration of the playa edge to prevent further erosion and sedimentation into the playa.

Data Quality Objective (DQO)

The quality of the data will be adequate to provide a high level of confidence in determining whether the regional curves can act as a sufficient predictor of channel and playa edge stability in the project area as identified by hydrology and vegetation indicators of the 20 playa sites, and whether structures remain intact and functioning throughout the monitoring period at the Grasslans Playa.

Data Quality Indicators

The measurement quality objectives will be sufficient to achieve the DQO and will be in conformance with those listed in the SWQB's QAPP. The Data Quality Indicators listed in the SWQB's QAPP and applicable to the data collected for this project are precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity (Table 3).

Table 3. Data Quality Indicators

DQI	Determination Methodologies

Precision	The basis for determining precision will be the comparison of photo-documentation of prior and post project construction activity images. Photos and vegetation transects will be GPS-ed and monumented for repeat sampling events for the life of project. Precision will also be ensured by consistently assigning the same people the responsibilities of collecting, recording and analyzing data with the expert assessments of members of the monitoring team.
Bias	To reduce the systematic or persistent distortion of any measurement process, bias will be minimized by using professional and experienced staff to collect and analyze data.
Accuracy	The basis for determining accuracy will be the comparison of photo-documentation, measurements obtained from predetermined monument locations, the recording of GPS location data for each sampling event as well as through the expert assessments of members of the monitoring team.
Representative	Data collection will be completed at sites that are targeted to represent results of the restoration project and for the development of regional curves for playas in the Southern High Plains.
Comparability	This project will collect new data where no data is available for comparison. However, methods for data collection are standardized and reproducible using procedures identified in this QAPP. Terrain assessment, measurements of shear stress, soils data, vegetation and photographic monitoring employ established methods that can be compared to other data collected with same method.
Completeness	Completeness will be achieved by following the sampling design and methods within this QAPP required to obtain useable data that will enable the proper evaluation of project success or failure using the expert assessments of members of the SWQB/NCD project team. Complete datasets will be ensured by collecting all of the required data for each sampling method and verifying before leaving the field.
Sensitivity	Sensitivity is ensured based on the manufacturer's specified range and accuracy of the equipment being used and the expertise of the field staff to use and apply data collection methods in a manner that minimizes subjectivity or gross data collection errors.

A.6 Special Training/Certification

This project will be primarily implemented by NCD with technical assistance from KRE and oversight from the NMED/SWQB Wetlands Program Coordinator. Any individual conducting work for the project will review this QAPP and sign the acknowledgment statement prior to initiating any work for this project. The signed acknowledgment statements will be kept on file with original QAPP by the QAO.

Allen Haden, Natural Channel Design, Inc. (NCD) - President, Principal Project Manager, & Lead Ecologist. Allen has been involved in research and management of environmental impacts on southwest river ecosystems for more than 25 years. He has provided numerous fish barrier, riparian, and wetland assessments for Southwest streams and watersheds and managed the development of restoration designs for those projects. He has expertise in sampling and statistical techniques for monitoring biological and physical aspects of riparian/aquatic/wetland habitats, as well as an understanding of life history requirements and threats to southwestern native species. He has extensive experience with habitat enhancement projects. Allen has authored and coauthored several refereed manuscripts on effects of nonnative species and links between habitat quality and ecology of aquatic communities. He has also conducted and written detailed assessments of fire-impacted watersheds—notably on the Coconino National Forest for the 2010 Schultz Fire and 2019 Museum Fire—and coordinated the permitting and NCD's bio-engineered practices to mitigate post-fire impacts and flooding risk. Allen has completed Wildland Hydrology's Courses I-IV. He has a B.S. in Forestry and Wildlife, from Virginia Tech, 1989 and a M.S. in Aquatic Ecology, from Northern Arizona University, 1997.

Jake Fleishman, PE (AZ,NM), CFM has been with NCD since 2016. He has a B.S. in Civil Engineering from Northern Arizona University. He is a licensed engineer in Arizona and New Mexico and a Certified Floodplain Manager with 6 years of experience in the engineering/restoration discipline. He has completed Level 1 of the Rosgen Applied Fluvial Geomorphology. His specialty is hydrologic and hydraulic modeling using HEC-RAS 1D and 2D, HEC-HMS, HydroCAD, Terramodel, and AutoCAD software, as well as design of erosion control projects using natural materials. He has worked on projects in river and wetland systems focusing on erosion control and habitat improvement in Arizona, Nevada and New Mexico.

Samuel Ebright, earned his Bachelor's and Master's Degrees in Forestry from Northern Arizona University, and is a Geospatial Specialist and Drone Pilot at Natural Channel Design. His prior experience was in academia, research, and Federal land management with specialties in GIS and remote sensing. During his M.S. research, he studied spatiotemporal trends in deforestation, the role of fire, and protected area efficacy in Vietnam with satellite data. Prior to NCD, he worked with the USDA Forest Service Washington Office, where he designed monitoring plans for wildfire hazard reduction and ecological integrity for the Collaborative Forest Landscape Restoration Program (CFLRP) Common Monitoring Strategy. He has experience collaborating with diverse stakeholders in multiple-use paradigms and leveraging technology for landscape assessment.

Steve Vrooman, President, Keystone Restoration Ecology Inc. (KRE) will assist with monitoring and development of the regional curves. Keystone Restoration Ecology is a business specializing in the ecological restoration of watersheds. Mr. Vrooman has over 19 years of experience as a professional ecologist and scientist as well as stream and wetland restoration designer. He is trained in ACOE wetland delineation protocol and has experience delineating numerous wetlands. He teaches applied stream morphology workshops and trainings for environmental professionals and the public throughout the southwest and internationally. Mr. Vrooman has completed several restoration projects in the VCNP from 2010 thru 2019 including work on La Jara Creek, Valle Seco, Rito de los Indios, Jaramillo Creek, and slope wetland restoration work on East Fork Jemez River, Nina Springs, six tributaries to San Antonio

Creek and Tres Arroyos. Recently, he has co-authored a wetland restoration book with Bill Zeedyk, titled *The Plug and Pond Treatment: Restoring Sheetflow to High Elevation Slope Wetlands in New Mexico.*

Maryann McGraw, Wetlands Program Coordinator (WPC), received her Bachelor's and Master's Degrees in Geology from University of Texas at Austin, and is an Water Resources Manager for SWQB. Ms. McGraw has attended advanced training sessions in fluvial geomorphology assessment of stream conditions and departures conducted by Dave Rosgen, California Rapid Assessment Method (CRAM), HGM training, NWCA training and Stream Pyramid Training. The WPC has also conducted monitoring of riparian areas and assisted monitoring protocols for other wetlands projects during the last 20 years. She worked for NRCS Los Lunas Plant Materials Center propagating wetland plants. Maryann has been the principal investigator and contributing author for all NMRAMs to date. She has also participated in the development of the Rio Puerco Monitoring Manual and is qualified for reviewing the design, conducting and participating in workshops, and for overseeing the restoration and monitoring procedures specified for this project.

A.7 Documents and Records

The NMED/SWQB Wetlands Program Coordinator will make electronic copies of this approved QAPP and any subsequent revisions available to all individuals on the distribution list who do not have signature authority for approving the QAPP.

When changes affect the scope, implementation, or assessment of the outcome, this QAPP will be revised to keep project information current. The SWQB Wetlands Program Coordinator, with the assistance of the QAO, will determine the effects of any changes to the scope, implementation, or assessment of the outcome on the technical and quality objectives of the project. This Project Plan will be reviewed annually by the SWQB Wetlands Program Coordinator to determine the need for revision. Project documents include this QAPP and recorded field data. Also included are project annual reports.

Data captured on a global positioning system (GPS), camera, smart phone, tablet, or laptop will be downloaded to a NCD or SWQB computer or an external hard drive at the end of each day. Copies will be made of all data and stored separately from the original data.

All digital project data will be kept in a project file on a NCD computer and on a separate external backup hard drive at the respective office. Hard copy project documents will be kept in a project folder in a filing cabinet at the respective office. All hard copy documents will be digitized and stored on an NCD computer and backup hard drive (see Table 5). Copies of the data will be distributed by NCD to the NMED/SWQB Wetlands Program Coordinator after data collection (prior to paying an invoice for data collection).

Table 4. Data Records for the Project

Document	Type of Form	Storage Location	Field Sheet Used
QAPP	Electronic (.doc) and PDF	NMED/SWQB Central Wetland Program files	EPA Requirements for Quality Assurance Project Plan. EPA QA/R-5. Located at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf
Terrain Assessment data	Electronic GPS files	NMED/SWQB Wetlands Program Coordinator files, upon submittal by NCD	To be supplied by NCD
Shear Stress data	Electronic, GPS, Excel Macro files	NMED/SWQB Wetlands Program Coordinator files, upon submittal by NCD	To be supplied by NCD
NMRAM data	Electronic and Hard copy	NCD	Electronic data collection worksheets for NMRAM Playas of the Southern High Plains
Soils data	Electronic and Hard copy	NCD	To be supplied by NCD
Vegetation data and plant ID	Electronic and Hard copy	NCD	To be supplied by NCD
Photopoints	Electronic	NCD	To be supplied by NCD
Drone Photography	Annotated/audio/video	NCD/KRE	To be supplied by NCD
Annual Reports	Electronic (.doc) & PDF	NMED/SWQB Central Wetland Program files	NA

GROUP B: DATA GENERATION AND ACQUISITION

B.1 Sampling Design

Table 5 describes specifics for the monitoring that will be conducted for the Grasslans Playa and for the 20 playa sites.

Table 5. Project Monitoring Specifics

Responsible Party	Monitoring	Location	Frequency
CONTRACTOR/COOPERATOR	TYPE OF MONITORING	LOCATION OF MONITORING	FREQUENCY OF MONITORING
NCD	Terrain Assessment data	20 playa sites	once
NCD	Shear Stress data	20 playa sites	once
NCD	NMRAM data	Select representative playas	Once
NCD	Soils data	Grasslans Playa and 20 playa sites	Long term at Grasslans Playa and once at 20 playa sites
NCD	Vegetation data and plant ID	Grasslans Playa and 20 playa sites	Long term at Grasslans Playa and once at 20 playa sites
NCD	Photopoints	Repeat photos at Grasslans Playa and 20 playa sites	Annually and once at 20 playa sites
NCD and KRE	Drone Photography	Repeat photos at Grasslans Playa	Annually

B.2 Sampling Methods

Terrain Assessment

Terrain assessment of slope, aspect, and elevation using clinometers, measuring tapes, laser levels, compasses, and GPS.

Estimating shear stress of existing channels and headcuts by measuring bank width, height, side slope angle, length and length.

Absolute playa size will be measured through GIS and field checked for significant deviations or misinterpretations. Surrounding land use, assessed in the field visually and through GIS layers, in land use zone (LUZ) (500 m for playas < 8ha, 1000 meters for playas 2' 8ha). Measuring terrain profiles, assessing existing erosion and headcut channels using a laser level and measuring tape to survey channel cross-sections and topography. Using chaining pins or pin flags as temporary markers for field measurements and photo markers. Surrounding land use, assessed in the field visually and through GIS layers, in land use zone (LUZ) (500 m for playas < 8ha, 1000 meters for playas 2' 8ha).
Playa configuration, checking features that impinge on the natural shape and boundary configuration and the interior of the playa. Provide visual estimate of percent playa area

occupied by each disturbance feature type that causes departure from natural shape of playa including features within the playa.

Water Source Augmentation: check water sources that increase inflows from artificial sources within LUZ.

Playa Watershed Connectivity: Check watershed features that decrease inflows to playa watershed, within LUZ.

Playa Hydroperiod Reduction, measuring pit area as a percentage of the current basin floor and average pit depth. Pit area measured in field and or GIS, pit depth measured in field.

Vertical Habitat Disruption to check vertical structure features that occur within the SA or 100 m (328ft) of the SA Boundary (buffer).

Vegetation Assessment

Playa vegetation will be assessed based on community types, functional groups, and species when identification is possible. Vegetation cover will be measured within quadrats and transects within specific playa basins, in four directions from randomly placed origin points. Local vegetation keys will be used for field identification and plant samples will be collected for ex-situ identification as necessary. Plant identification through photography or collecting whole plant samples (including flowers, stems, leaves, and root mass) for ex-situ identification. Measuring vegetation density, cover extent, and height by visual identification along sampling transects or within temporary quadrat placements. This more intensive measurement will occur in select playas. Others will be broadly assessed using visual and drone photography.

Measuring Wetland Species Index according to the NMRAM by identifying and recording species abundance as wetland/non wetland species; exotic/native, annual/biennial/perennial. As well as field survey of exotic annual plant abundance within quadrats.

Moisture Sampling

Multiple soil sampling techniques can be used at each site. They will not necessarily all happen at each location and will depend on site condition when visited. Soil Condition Index: collect, characterize, and photograph 3 soil cores to a depth of 50 cm (20 in) along abiotic transect. Digging soil pits up to 30 inches in diameter and 36 inches deep to describe the soil profile and take soil data such as soil color and texture, layer boundaries, soil type, root density and water table measurements. Field soil moisture capacity will be assessed using the ball and ribbon technique. Visually assessment of soil type using the Munsell Soil Color Chart. AND/OR Photographing soil columns or transporting samples to NCD in Flagstaff for identification and analysis. Long-term soil moisture will be monitored on the Graslans Charitable Foundation playa using six TEROS 10 soil moisture meters attached to a data logger. Meters will be placed in the playa basin in three tethered locations, at two depths per location. Meters will be placed in non-rocky soil. Data will be logged at fixed intervals at thirty-minute or hourly intervals; and uploaded remotely from the ZL6 data logger with a 15-minute cellular uplink.

Drone Photography
Aerial imagery will be captured by a DJI Mavic Air or DJI Mavic Enterprise series drone. Drone will be flown with GPS location active, ensuring home point GPS coordinates has been recorded, all firmware and flight map data has been updated with manufacturer's specifications, and airspace clearance has been authorized. The pilot will fly the drone above the playa up to 400 feet above ground level, or the highest altitude authorized in the case of airspace restrictions; and take nadir photos of the playas at 50 ft altitude intervals. These photos will be used as high-resolution imagery to map erosion features in playas and show the surrounding land use.

Data for quantification of wetland vegetation area will be collected by capturing drone imagery and calculating wetland vegetation area using GIS. Where multispectral (RGB+NIR) imagery is captured, the analyst will test wetland community classification based on the color signature (NDVI) and moisture index (NDWI). Wetland species found in the playa may be easily identified by visible color signature combined with the ground truthing to effectively associate on-the-ground vegetation cover to photos with the colors shown in aerial photos.

Photographic Monitoring

Ground photography of existing playa conditions including the placement by digging or auguring of rebar or similar materials for locating sites for taking repeat photographs, and the photographing at several times per year of the playa wetland. Permanent photo points will only occur on Grasslans Playa, other 20 playas are a one-time visit.
Photos will be taken of general site conditions, erosion features, and typified scenarios for monitoring and assessment. In addition, photos will be taken at fixed photo locations that are monumented or referenced for photo replication. Where monuments are placed, the camera distance and azimuth will be recorded from the monument. When monuments cannot be placed, longstanding reference features will be used for future photo alignment. Repeated photos will be taken of the structures constructed on the Graslans playa and monitored using ground and aerial photography. At least two photos will be taken at each repeat photo point showing a landscape view (upslope and downslope).

B.3 Sample Handling and Custody

Because there are no plans to collect samples for laboratory analysis, there are no handling requirements. Because there are no plans to collect samples for analyses, no analytical methods are needed.

B.4 Quality Control

Quality control (QC) activities are technical activities performed on a routine basis to quantify the variability that is inherent to any environmental data measurement activity. The purpose for conducting QC activities is to understand and incorporate the effects the variability may have in the decision-making process. Additionally, the results obtained from the QC analysis, or data quality assessment, may identify areas where the variability can be reduced or eliminated in future data collection efforts, thereby improving the overall quality of the project being implemented.

Quality Control mechanisms are implemented as described under the Quality Objectives and Criteria for Measurement Data as well as the sampling methodologies identified under this QAPP. Additional Quality Control includes the professional expertise of the personnel working under this project.

The monitoring team has many years of experience working on wetland restoration projects and have successfully completed many seasons of monitoring.

Repeat photography will be conducted from the same location each field season documented by a GPS location and by metal stake monuments using a Nikon 5300 (or comparable) camera.

B.5 Instrument/Equipment Testing, Inspection and Maintenance

Equipment used for this project includes SWQB's GPS unit (Garmin MAPS 64 or comparable) and camera (Nikon 5300 or comparable). NCD and Keystone Restoration Ecology will use their own comparable or more accurate equipment.

Samuel Ebright and Jake Fleishman of Natural Channel Design Engineering Inc. are responsible for the inspection of equipment and supplies prior to data collection. All field equipment will be inspected before each monitoring event. All instruments and equipment will be tested, inspected and maintained in accordance with the manufacturer's specifications as included in the associated instrument/equipment manual. The equipment is listed in Table 7.

If there is reasonable evidence that the laser level, GPS, drone or camera has been damaged or is not up to manufacture specification, the equipment will not be used for the Project. There are no other supplies or consumables that could affect the quality of data related to this project.

The DJI drones (Mavic Air 2S and Mavic Enterprise 2) will be inspected for damage and fully charged before each flight. In addition, flight restriction maps will be updated before each flight.

B.6 Instrument/Equipment Calibration and Frequency

All data will be collected with monitoring devices that can be shown to have been properly calibrated.

Field equipment will be inspected prior to each sampling trip. All instruments and equipment will be tested, inspected and maintained in accordance with the manufacturer's specifications as included in the associated instrument/equipment manual. If condition of equipment is in doubt, it will not be used. In the event of instrument failure, the SWQB Wetlands Program Coordinator will correct the problem, rejecting the resultant data or accepting the data with notations.

The calibration of the laser level will be verified according to the manufacturer's specifications.

The drones will only be flown when airspace clearance is authorized, with GPS location is active, a home point has been recorded, and all firmware and flight map data has been updated with manufacturer's specifications.

Table. Instruments and Equipment to be Tested and Inspected

Camera	DJI Mavic Air Drone	DJI Mavic Enterprise Drone
Video lens	Computer	GPS
Laser Level and Rod	Compass	TEROS Moisture Meter & Data Logger
Trimble R10 RTK GPS Survey		

Table. Instruments and Equipment to be Calibrated (Frequency)

Laser Level and Rod (6 months)	DJI Drones (each flight)	TEROS Moisture Meter & Data Logger (prior to installation)
Trimble R10 (each survey set up)		

B.7 Inspection Inspection/Acceptance for Supplies and Consumables

There are no supplies or consumables that could affect the quality of data related to this project.

B.8 Non-direct Measurements

Existing aerial and satellite imagery and wetland mapping will be used to aid in determining post-implementation data collection sites at the Grasslans Playa and at the 20 playa sites. These data are available through Google Earth, NM RGIS, and the National Wetlands Inventory.

No non-direct measurements used during the course of this project will affect the quality of data related to this project.

B.9 Data Management

NCD and the NMED/SWQB Wetlands Program Coordinator will be responsible for data management. All data will be converted to electronic format, stored and backed up by NCD. Computer hard drives are backed up daily or will be backed up on external hard drives, respectively. Hard copies of field sheets will be maintained in a project electronic binder organized by assessment and date and stored on computer hard drives and a project back-up hard drive at NCD offices.

Data will be sent to the NMED/SWQB Wetlands Program Coordinator by the end of each field season by NCD as part of the project Annual Report. The Annual Report will be provided with the June (end of state fiscal year) reimbursement request for the monitoring work. Upon receiving data, the SWQB Project will store data on SWQB network drive. The SWQB network drive is backed up daily and maintained by the NMED Office of Information Technology. Electronic data files will be stored on the SWQB network drive in accordance with 1.21.2 NMAC, *Retention and Disposition of Public Records.*

GROUP C: ASSESSMENT AND OVERSIGHT

C.1 Assessment and Response Actions

The NMED/SWQB Wetlands Program Coordinator will provide project oversight by periodically assisting with and/or reviewing data collection efforts. A review of the data collection and monitoring efforts by the SWQB Wetlands Program Coordinator will take place at the end of each monitoring season. The SWQB Wetlands Program Coordinator will assess project progress to ensure the QAPP is being implemented, including periodic audits by the QAO, as needed. Any problems encountered during the course of this project will be immediately reported to the NMED/SWQB Wetlands Program Coordinator who will consult with appropriate individuals to determine appropriate action. Should the corrective action impact the project or data quality, the NMED/SWQB Wetlands Program Coordinator will alert the QAO. If it is discovered that monitoring methodologies must deviate from the approved QAPP, a revised QAPP must be approved before work can be continued. All problems and adjustments to the project plan will be documented in the project file and included in the final report.

C.2 Reports to Management

Annual Reports will be submitted by NCD to the NMED/SWQB Wetlands Program Coordinator and will include progress of project and any available monitoring data. Printouts, status reports or special reports for SWQB or EPA will be prepared upon request. The SWQB Wetlands Program Coordinator will be responsible for submitting the project deliverables to EPA through semi-annual reports to EPA.

GROUP D: DATA VALIDATION AND USABILITY

D.1 Data Review, Verification and Validation

Data will be reviewed by the Monitoring Team in the field for erroneous data, incomplete data and transcription errors prior to demobilization from the field site. Data will be considered usable if the requirements of this QAPP were followed and the data is within acceptable range limits as defined under this QAPP. Data that appears incomplete or questionable for the parameter will be flagged for review. Flagged data will be discussed with the SWQB Wetlands Program Coordinator to determine the potential cause and usability. If a reasonable justification for use of the data cannot be attained, those data will be not used in analysis and implementation of activities listed under this QAPP unless the data can be recollected and assessed for usability.

D.2 Validation and Verification Methods

NCD, KRE and NMED will ensure that valid and representative data are acquired. Review of field data will be performed as described in section D1 of this QAPP, Verification of data will be completed using the attached Verification and Validation (V&V) worksheets. Verification of data will occur after returning from the field, or as soon as practical. Validation (V&V) of data will occur after every field season, both the Verification and Validation of data will utilize the attached V&V worksheets. The V&V will be completed by appropriate monitoring team members in accordance with the applicable sections of SWQB SOP 15.0 for *Data Verification and Validation* (NMED/SWQB 2020). In the event questionable data are found, the SWQB Wetlands Program Coordinator will notified and will consult appropriate personnel to determine the validity of the data. Results of the verification and validation process will be included in the final reports.

D.3 Reconciliation with User Requirements

The user requirement is a restatement of the data quality objective: The information gathered by the Playa Restoration, Monitoring And Stability Assessment Project will be used to decide whether the regional curves can act as a sufficient predictor of channel and playa edge stability in the project area as identified by hydrology and vegetation indicators of the 20 playa sites, and whether structures remain intact and functioning throughout the monitoring period at the Grasslans Playa. The quality of the data will be adequate to provide a high level of confidence in determining whether the Playa Restoration, Monitoring And Stability Assessment Project is meeting the project goals, as stated in the approved scope of work. If the project's results do not meet this requirement, then additional monitoring may be necessary to fill in data, which may include an extension of the monitoring period to measure effects that were not apparent during the project period.

REFERENCES

Army Corps of Engineers. 2008. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0) Wetlands Regulatory Assistance Program. U.S. Army Corps of Engineers.

NMED/SWQB. 2016a. Quality Assurance Project Plan for Water Quality Management Programs [QAPP]. Approved January 26, 2016. https://www.env.nm.gov/swqb/QAPP/2016QAPPFinal_Complete_withAppendices_Approval_Signatures.pdf

NMED/SWQB. 2020. 15.0 SOP Data Verification and Validation. Effective May 28, 2020. https://www.env.nm.gov/swqb/SOP/documents/15VVSOP03_15_2016.pdf

USDA NRCS. 2020. National Handbook of Conservation Practices, Conservation Practice Standard, Grassed Waterways. Code 412 (ac) Washington, D.C. Conservation Practice Standard Grassed Waterway (Code 412) (usda.gov)

Vepraskas, M. J., Richardson, J. L., Tandarich, J. P., & Teets, S. J. (1999). Dynamics of hydric soil formation across the edge of a created deep marsh. Wetlands, 19(1), 78–89.

Zeedyk, W.D; Clothier, V. 2009. *Let The Water Do The Work,* Appendix I, Outline for Photographic Monitoring Plan. The Quivira Coalition, Santa Fe, NM.

APPENDIX 1

Data Verification and Validation Worksheet

Type of Data, Name and Date of Personnel Collecting Data	Verification of Complete Record [Y/N]	Instrument in working order [Y/N]	Checked for anomalous data [Y/N]	Validated by [name of reviewer]	Validated on [Date]

APPENDIX 2

Acknowledgement Statement

New Mexico Environment Department Surface Water Quality

PLAYA RESTORATION, MONITORING AND STABILITY ASSESSMENT PROJECT

Quality Assurance Project Plan Acknowledgement Statement

This is to acknowledge that I have received a copy (in hard copy or electronic format) of the **PLAYA RESTORATION, MONITORING AND STABILITY ASSESSMENT PROJECT** *Quality Assurance Project Plan*.

As indicated by my signature below, I understand and acknowledge that it is my responsibility to read, understand, become familiar with and comply with the information provided in the document to the best of my ability.

____

Signature

____

Name (Please Print)

____

Date

Return to SWQB Wetlands Program Coordinator **Maryann McGraw**

APPENDIX 3

PROJECT NAME: Clovis Playas

Clovis Playa NO.: ****
DATE OF VISIT: **/**/2023 **REPORT NO.** ***
OBSERVER NAME(S):

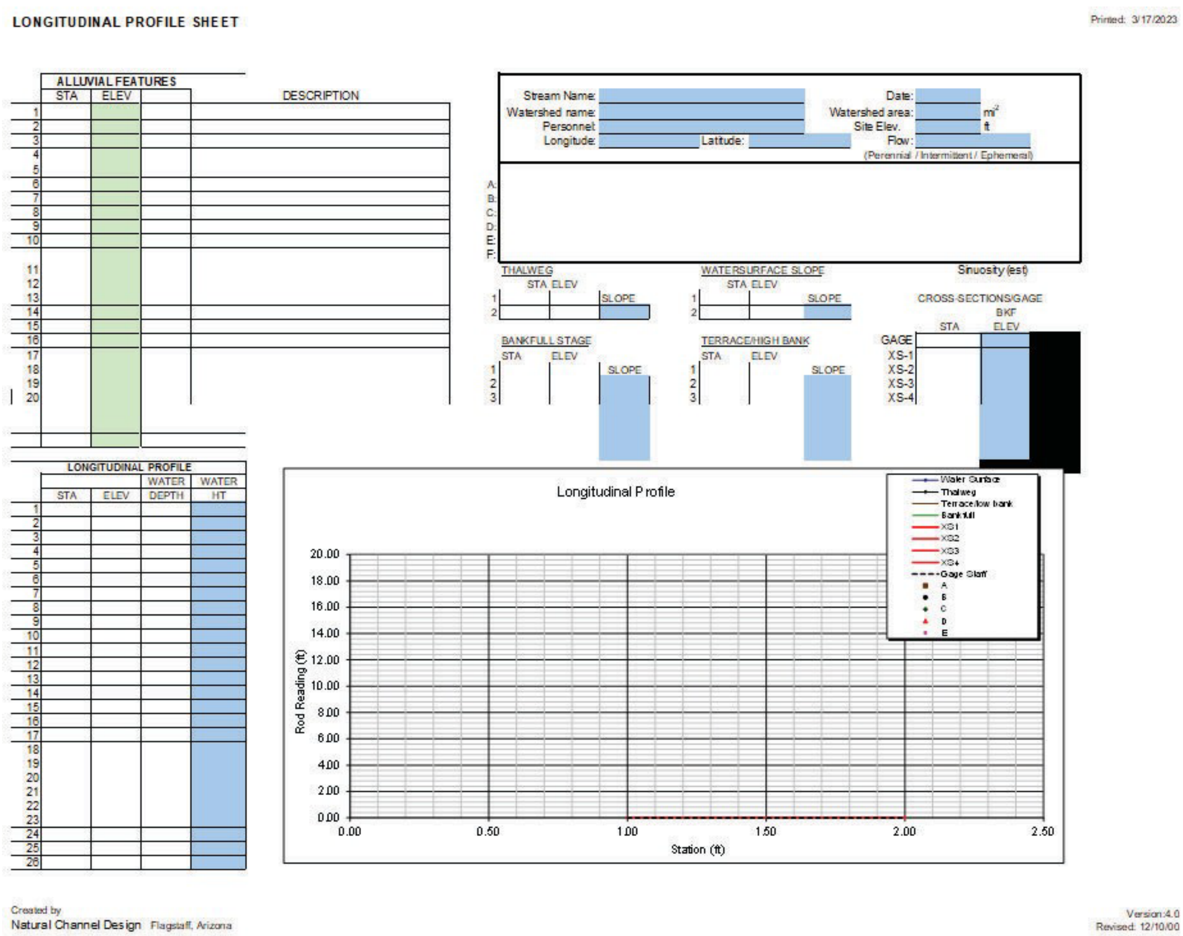
Weather Observations:
General Conditions:
Temperature:
Wind:
Precipitation:

Work Force and equipment:

Item No. &	Description	Photo #	Direction	Notes

Conditions Narrative:

SITE PHOTOS:



LONGITUDINAL PROFILE SHEET

Printed: 3/17/2023

	ALLUVIAL FEATURES			
	STA	ELEV		DESCRIPTION
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Stream Name: Date:
Watershed name: Watershed area: mi²
Personnel: Site Elev. ft
Longitude: Latitude: Flow:
(Perennial / Intermittent / Ephemeral)

A:
B:
C:
D:
E:
F:

THALWEG	STA	ELEV	SLOPE
1			
2			

WATERSURFACE SLOPE	STA	ELEV	SLOPE
1			
2			

Sinuosity (est)

BANKFULL STAGE	STA	ELEV	SLOPE
1			
2			
3			

TERRACE/HIGH BANK	STA	ELEV	SLOPE
1			
2			
3			

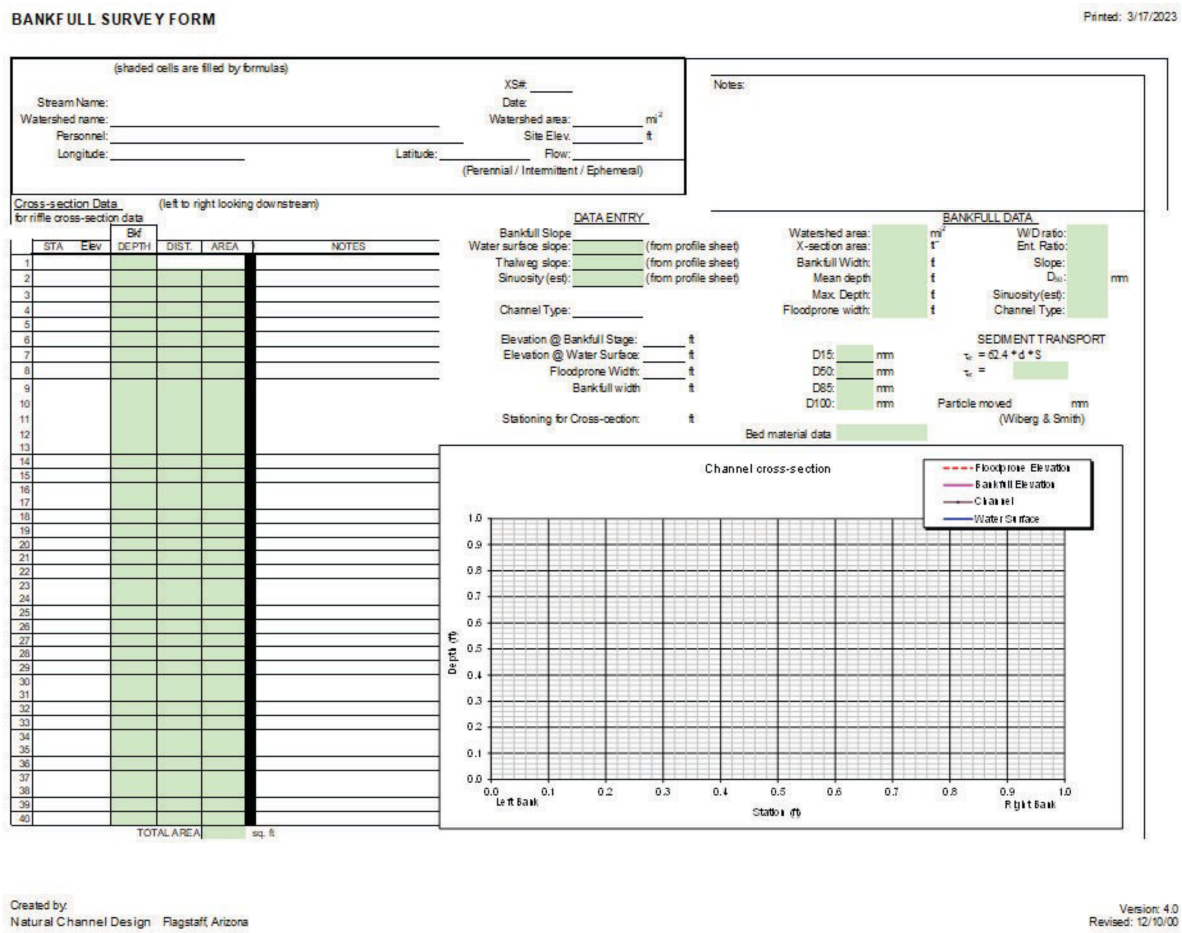
CROSS-SECTIONS/GAGE	STA	BKF ELEV
GAGE		
XS-1		
XS-2		
XS-3		
XS-4		

	LONGITUDINAL PROFILE			
	STA	ELEV	WATER DEPTH	WATER HT
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				

Created by
Natural Channel Design Flagstaff, Arizona

Version:4.0
Revised: 12/10/00

Figure 3 Laser Level Long profile data sheet



BANKFULL SURVEY FORM

Printed: 3/17/2023

(shaded cells are filled by formulas)

XS#: ______
Stream Name:
Date:
Watershed name: ______
Watershed area: ______ mi^2
Personnel: ______
Site Elev. ______ ft
Longitude: ______ Latitude: ______ Flow: ______
(Perennial / Intermittent / Ephemeral)

Notes:

Cross-section Data (left to right looking downstream)
for riffle cross-section data

	STA	Elev	Bkf DEPTH	DIST.	AREA	NOTES
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

TOTAL AREA ______ sq. ft

DATA ENTRY
Bankfull Slope
Water surface slope: ______ (from profile sheet)
Thalweg slope: ______ (from profile sheet)
Sinuosity (est): ______ (from profile sheet)
Channel Type: ______
Elevation @ Bankfull Stage: ______ ft
Elevation @ Water Surface: ______ ft
Floodprone Width: ______ ft
Bankfull width ft
Stationing for Cross-section: ft

BANKFULL DATA
Watershed area: mi^2
X-section area: ft^2
Bankfull Width: ft
Mean depth ft
Max. Depth: ft
Floodprone width: ft
W/D ratio:
Ent. Ratio:
Slope:
D_{50}: mm
Sinuosity(est):
Channel Type:

D15: mm
D50: mm
D85: mm
D100: mm
Bed material data

SEDIMENT TRANSPORT
$\tau_{cr} = 62.4 * d * S$
τ_{cr} =
Particle moved mm
(Wiberg & Smith)

Created by:
Natural Channel Design Flagstaff, Arizona

Version: 4.0
Revised: 12/10/00

Figure 4 Laser Level Cross Section Form

TEROS 10 QUICK START

Preparation

Inspect and verify TEROS 10 components. The TEROS verification clip gives the best assessment of proper sensor function and accuracy. The TEROS 10 should read 0.35 to 0.42 m^3/m^3 on the verification clip. If a verification clip is not available, test basic sensor functionality in air and water. The TEROS 10 will read ~0.64 m^3/m^3 in water and a slightly negative value in air.

NOTE: The sensors are optimzed to read in soils, therefore the sensor will not read 100% in pure liquid water. Values above use the mineral soil calibration.

What is soil moisture?

Soil moisture is a key variable in controlling the exchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration.

Learn more at metergroup.com

Soil moisture meter calibration guidelines