Form 3160-5
(March 2012)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

OCD Artesia

FORM APPROVED
OMB No. 1004-0137
Expires: October 31, 2014

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to re-enter an abandoned well. Use Form 3160-3 (APD) for such proposals.

SUBMIT IN TRIPLICATE – Other instructions on page 2.

5. Lease Serial No. NM-013413
6. If Indian, Allottee or Tribe Name
7. If Unit of CA/Agreement, Name and/or No.
8. Well Name and No. RIVERBEND 14 FEDERAL COM 1H
9. API Well No.
10. Field and Pool or Exploratory Area: WILDCAT WOLFCAMP
11. County or Parish, State: EDDY, NM

1. Type of Well
☐ Oil Well ☑ Gas Well ☐ Other

2. Name of Operator
CIMAREX ENERGY COMPANY

3a. Address
600 N. MARIENFELD, SUITE 600
MIDLAND TEXAS 79701

3b. Phone No. *(include area code)*
9432) 620-1959 (Michelle Chappell)

4. Location of Well *(Footage, Sec., T.,R.,M., or Survey Description)*
SHL: 700 FNL & 1160 FWL, SECTION 14
BHL: 660 FSL & 710 FWL, SECTION 14

12. CHECK THE APPROPRIATE BOX(ES) TO INDICATE NATURE OF NOTICE, REPORT OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION			
☑ Notice of Intent	☐ Acidize	☐ Deepen	☐ Production (Start/Resume)	☐ Water Shut-Off
	☐ Alter Casing	☐ Fracture Treat	☐ Reclamation	☐ Well Integrity
☐ Subsequent Report	☐ Casing Repair	☐ New Construction	☐ Recomplete	☑ Other GAS PIPELINE
	☐ Change Plans	☐ Plug and Abandon	☐ Temporarily Abandon	
☐ Final Abandonment Notice	☐ Convert to Injection	☐ Plug Back	☐ Water Disposal	

13. Describe Proposed or Completed Operation: Clearly state all pertinent details, including estimated starting date of any proposed work and approximate duration thereof. If the proposal is to deepen directionally or recomplete horizontally, give subsurface locations and measured and true vertical depths of all pertinent markers and zones. Attach the Bond under which the work will be performed or provide the Bond No. on file with BLM/BIA. Required subsequent reports must be filed within 30 days following completion of the involved operations. If the operation results in a multiple completion or recompletion in a new interval, a Form 3160-4 must be filed once testing has been completed. Final Abandonment Notices must be filed only after all requirements, including reclamation, have been completed and the operator has determined that the site is ready for final inspection.)

CIMAREX ENERGY COMPANY REQUESTS APPROVAL FOR A BURIED, 6" STEEL (900 PSI), AND A 4", FLEX PIPE (1500 PSI), GAS PIPELINES (2 LINES IN THE SAME DITCH) TO AN EXISTING ENTERPRISE SALES PIPELINE. THE 6" LINE WILL TAKE GAS PRODUCTION TO THE ENTERPRISE SALES LINE AND THE 4" LINE WILL TAKE GAS FROM ENTERPRISE LINE BACK TO OPERATE THE LIFT ON THE PROPOSED RIVERBEND WELLS.

THE LINE SYSTEM IS ALL WITHIN FEDERAL LEASE NM-013413 AND ON PRIVATE SURFACE BELONGING TO COOKSEY RANCH AND WAYLAND PERRY (WITH WHOM AN AGREEMENT HAS BEEN REACHED).

THE TOTAL FOOTAGE FOR THE PROJECT WILL BE 6100.7 FT., 1.16 MILES OR 4.20 ACRES (3329.4 FT. OR 2.29 ACRES ON FEDERAL LANDS). THE LINE ROUTE WAS DEVISED TO FOLLOW THE EXISTING LEASE ROADS AND A RANCHER TWO-TRACK UNTIL IT ENDS IN SW/4SE/W OF SECTION 11. THE LINE ROUTE THEN STAYS BELOW THE LARGE HILLS TO THE SOUTH AND THE DRAINAGE SYSTEM TO THE NORTH. THE ACTUAL SALT DRAW WILL BE BORED UNDER (SEE PLATS FOR BORE HOLE LOCATIONS). THE ROW WIDTH WILL BE 30 FT.

A CLASS III ARCHAEOLOGICAL REPORT WILL BE SUBMITTED BY LONE MOUNTAIN ARCHAEOLOGICAL SERVICES, INC.

NM OIL CONSERVATION
ARTESIA DISTRICT
DEC 03 2014
RECEIVED

Accepted for record
NMOCD

14. I hereby certify that the foregoing is true and correct. Name *(Printed/Typed)*
BARRY W. HUNT

Title PERMIT AGENT FOR CIMAREX ENERGY COMPANY

Signature Barry W. Hunt

Date 8/26/14

THIS SPACE FOR FEDERAL OR STATE OFFICE USE

Approved by **Steve Caffey**

Title

Date NOV 20 2014

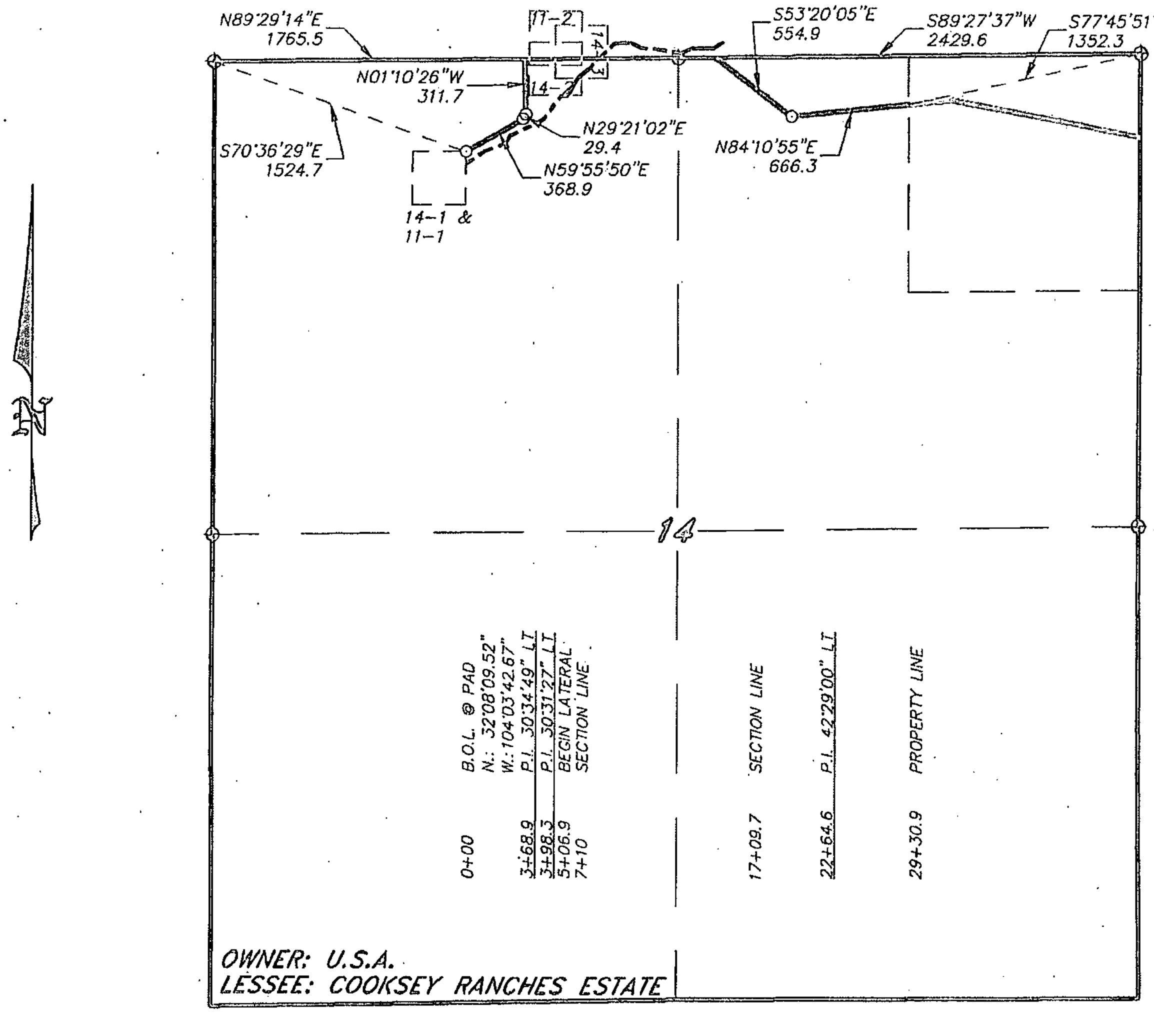
Conditions of approval, if any, are attached. Approval of this notice does not warrant or certify that the applicant holds legal or equitable title to those rights in the subject lease which would entitle the applicant to conduct operations thereon.

Office

Title 18 U.S.C. Section 1001 and Title 43 U.S.C. Section 1212, make it a crime for any person knowingly and willfully to make to any department or agency of the United States any false fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

(Instructions on page 2)

SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

A STRIP OF LAND 30.0 FEET WIDE, LOCATED IN SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO AND BEING 15.0 FEET LEFT AND RIGHT OF THE ABOVE PLATTED CENTERLINE SURVEY.

SECTION 14 = 1931.2 FEET = 117.04 RODS = 0.37 MILES = 1.33 ACRES

I HEREBY CERTIFY THAT THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

GARY L. JONES N.M. P.S. No. 7977
TEXAS No. 5074

GARY L. JONES NEW MEXICO 7977 PROFESSIONAL LAND SURVEYOR

1000 0 1000 2000 FEET

basin surveys
focused on excellence in the oilfield
P.O. Box 1786
1120 N. West County Rd.
Hobbs, New Mexico 88241
(575) 393-7316 – Office
(575) 392-2206 – Fax
basinsurveys.com

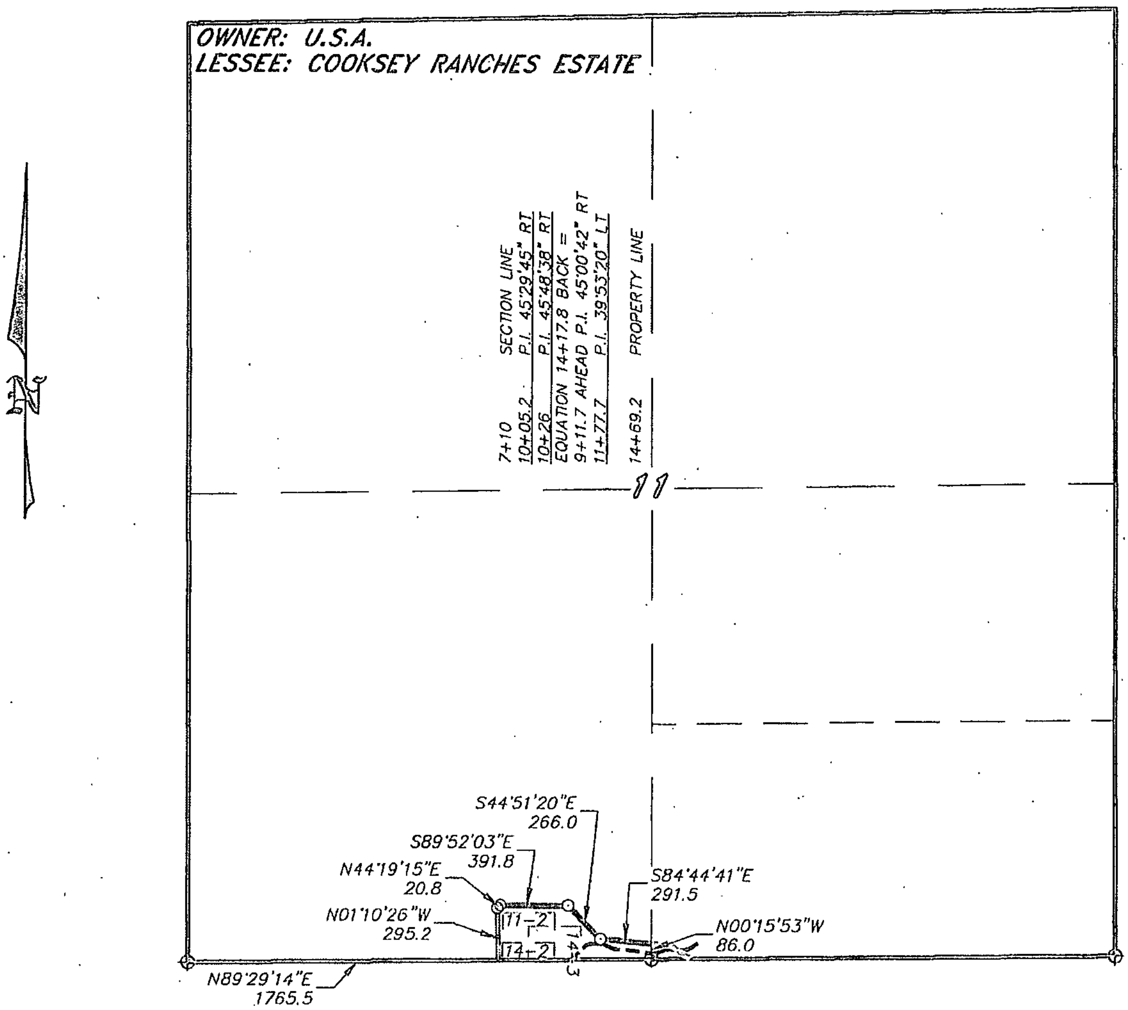
CIMAREX ENERGY CO.

REF: PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

A PIPELINE CROSSING USA LAND IN SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.

W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 1 of 5 Sheets

SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M.,
EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

A STRIP OF LAND 30.0 FEET WIDE, LOCATED IN SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO AND BEING 15.0 FEET LEFT AND RIGHT OF THE ABOVE PLATTED CENTERLINE SURVEY.

SECTION 11 = 1265.3 FEET = 76.68 RODS = 0.24 MILES = 0.87 ACRES

I HEREBY CERTIFY THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

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TEXAS P.L.S. No. 5074

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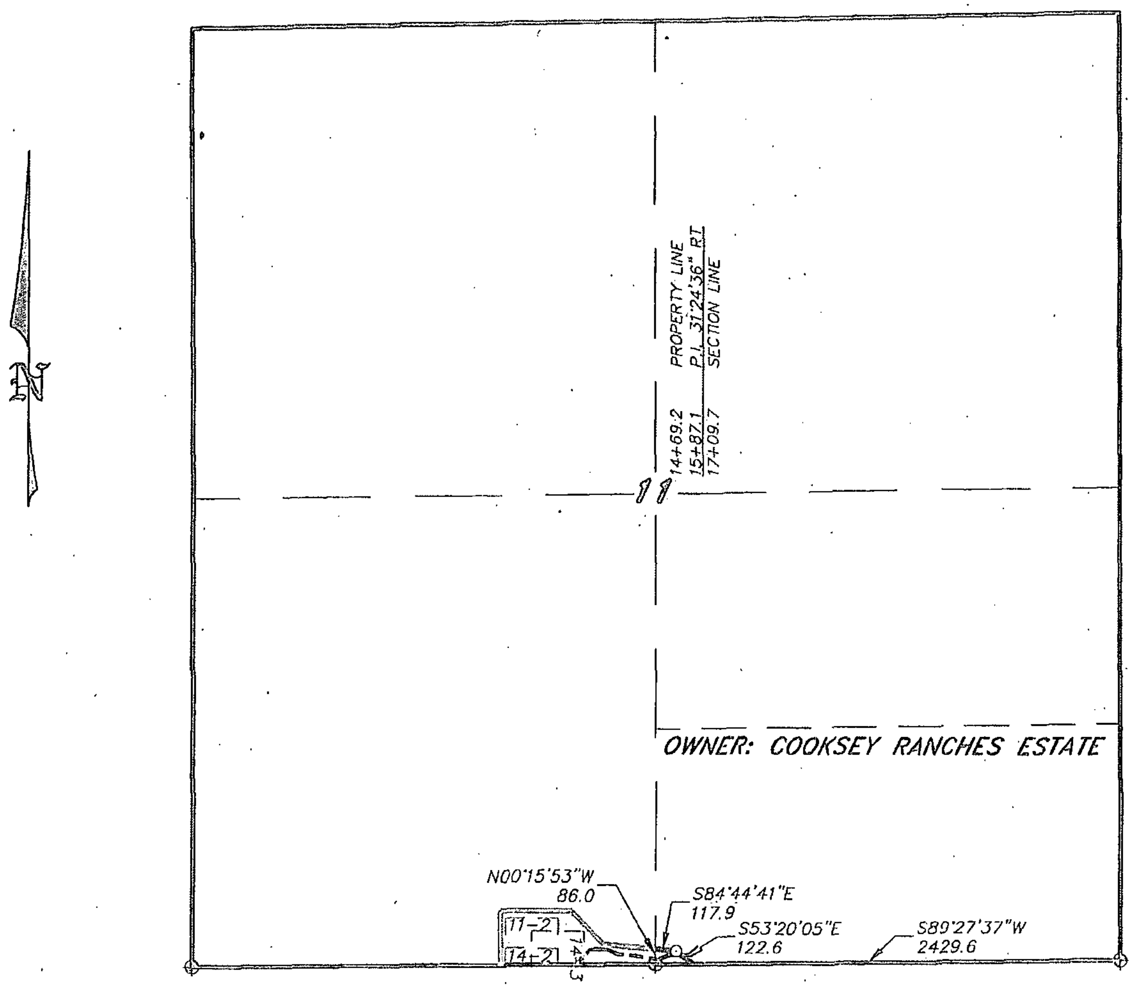
A PIPELINE CROSSING USA LAND IN SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.

W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 2 of 5 Sheets

SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

A STRIP OF LAND 30.0 FEET WIDE, LOCATED IN SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO AND BEING 15.0 FEET LEFT AND RIGHT OF THE FOLLOWING DESCRIBED CENTERLINE SURVEY.

BEGINNING AT A POINT WHICH LIES N.00°15'53"W., 86.0 FEET FROM THE SOUTH QUARTER CORNER OF SAID SECTION 11; THENCE S.84°44'41"E., 117.9 FEET; THENCE S.53°20'05"E., 122.6 FEET TO A POINT ON THE SOUTH SECTION LINE WHICH LIES S.89°27'37"W., 2429.6 FEET FROM THE SOUTHEAST CORNER OF SAID SECTION 11. SAID STRIP OF LAND BEING 240.5 FEET OR 14.58 RODS IN LENGTH AND CONTAINING 0.17 ACRES, MORE OR LESS.

I HEREBY CERTIFY THAT THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

GARY L. JONES N.M.P.S. No. 7977
TEXAS R.P.L.S. No. 5074

GARY L. JONES NEW MEXICO 7977 PROFESSIONAL LAND SURVEYOR

1000 0 1000 2000 FEET

CIMAREX ENERGY CO.

REF: PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

A PIPELINE CROSSING FEE LAND IN SECTION 11, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.

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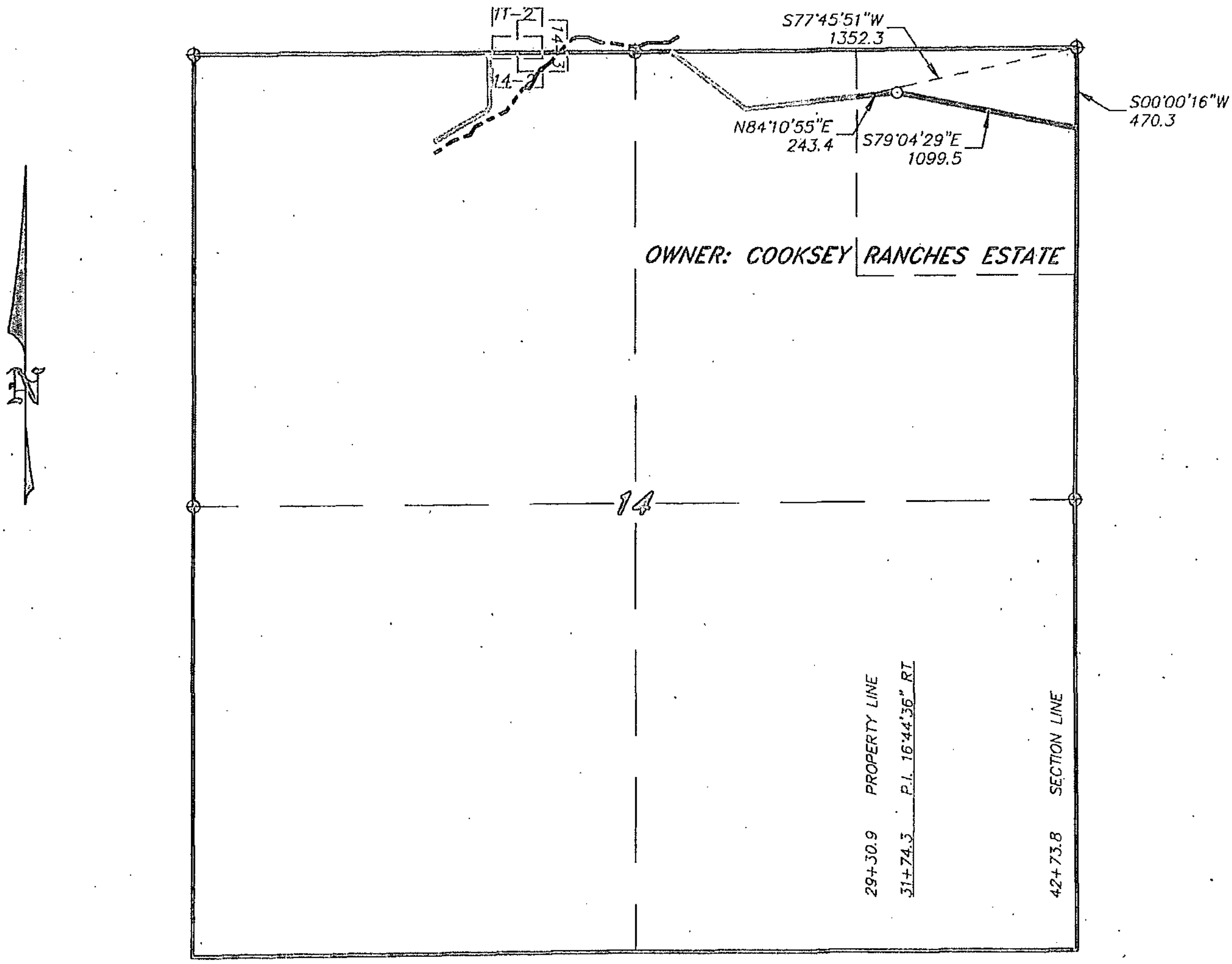
W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 3 of 5 Sheets

SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

A STRIP OF LAND 30.0 FEET WIDE, LOCATED IN SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M.; EDDY COUNTY, NEW MEXICO AND BEING 15.0 FEET LEFT AND RIGHT OF THE FOLLOWING DESCRIBED CENTERLINE SURVEY.

BEGINNING AT A POINT WHICH LIES S.77°45'51"W., 1352.3 FEET FROM THE NORTHEAST CORNER OF SAID SECTION 14; THENCE N.84°10'55"E., 243.4 FEET; THENCE S.79°04'29"E., 1099.5 FEET TO A POINT ON THE EAST SECTION LINE WHICH LIES S.00°00'16"W., 470.3 FEET FROM THE NORTHEAST CORNER OF SAID SECTION 14. SAID STRIP OF LAND BEING 1342.9 FEET OR 81.39 RODS IN LENGTH AND CONTAINING 0.92 ACRES, MORE OR LESS.

I HEREBY CERTIFY THAT THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

GARY L. JONES N.M.P.S. No. 7977
TEXAS R.P.L.S. No. 5074

GARY L. JONES
NEW MEXICO
7977
REGISTERED PROFESSIONAL LAND SURVEYOR

1000 0 1000 2000 FEET

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1120 N. West County Rd.
Hobbs, New Mexico 88241
(575) 393-7316 -- Office
(575) 392-2206 -- Fax
basinsurveys.com

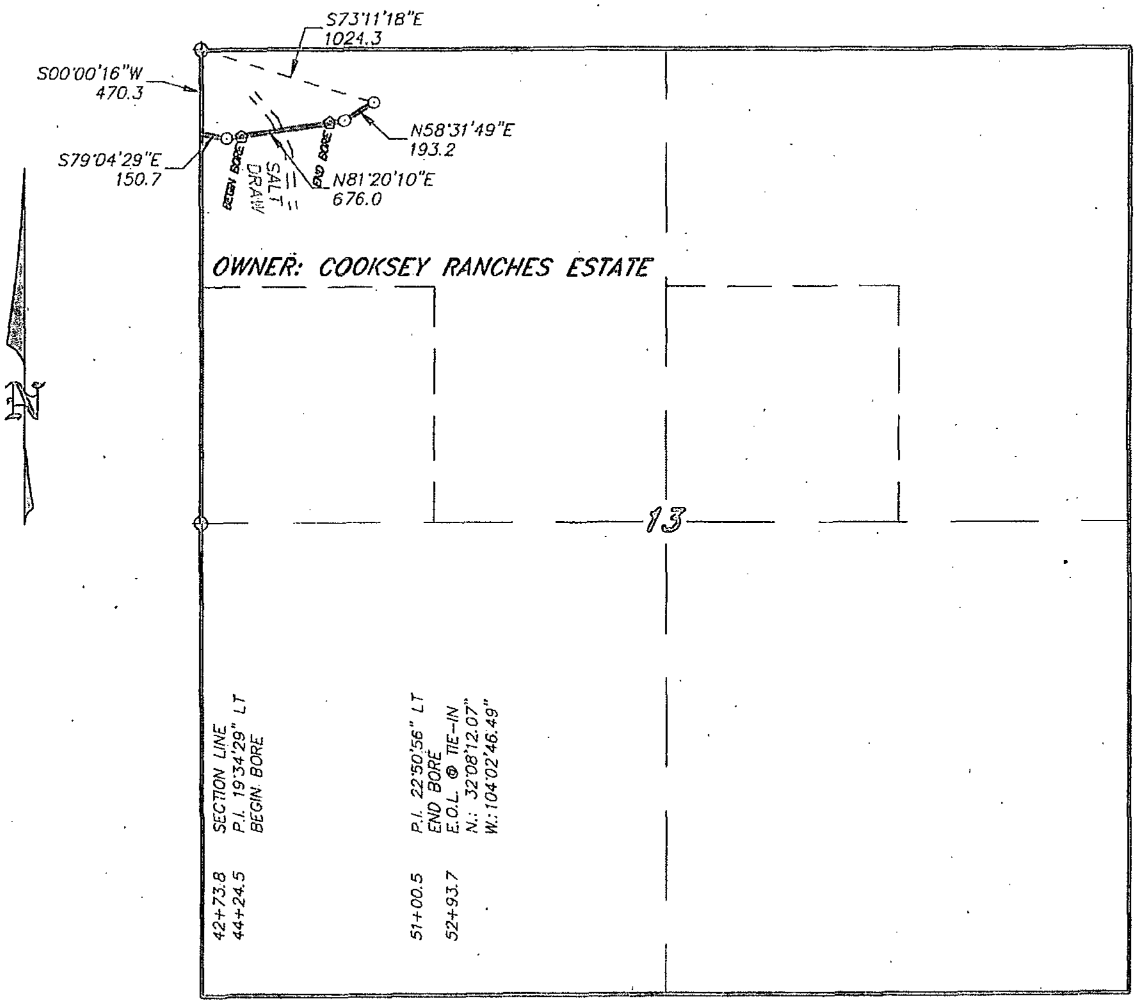
CIMAREX ENERGY CO.

REF: PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

A PIPELINE CROSSING FEE LAND IN SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.

W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 4 of 5 Sheets

SECTION 13, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M.,
EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

A STRIP OF LAND 30.0 FEET WIDE, LOCATED IN SECTION 13, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO AND BEING 15.0 FEET LEFT AND RIGHT OF THE FOLLOWING DESCRIBED CENTERLINE SURVEY.

BEGINNING AT A POINT WHICH LIES S.00°00'16"W., 470.3 FEET FROM THE NORTHWEST CORNER OF SAID SECTION 13; THENCE S.79°04'29"E., 150.7 FEET; THENCE N.81°20'10"E., 676.0 FEET; THENCE N.58°31'49"E., 193.2 FEET TO THE END OF THIS LINE WHICH LIES S.73°11'18"E., 1024.3 FEET FROM THE NORTHWEST CORNER OF SAID SECTION 13. SAID STRIP OF LAND BEING 1019.9 FEET OR 61.81 RODS IN LENGTH AND CONTAINING 0.70 ACRES, MORE OR LESS.

I HEREBY CERTIFY THAT THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

GARY L. JONES N.M.P.S. 7977
GARY L. JONES TEXAS R.P.L.S. No. 5074

GARY L. JONES NEW MEXICO 7977 PROFESSIONAL LAND SURVEYOR

1000 0 1000 2000 FEET

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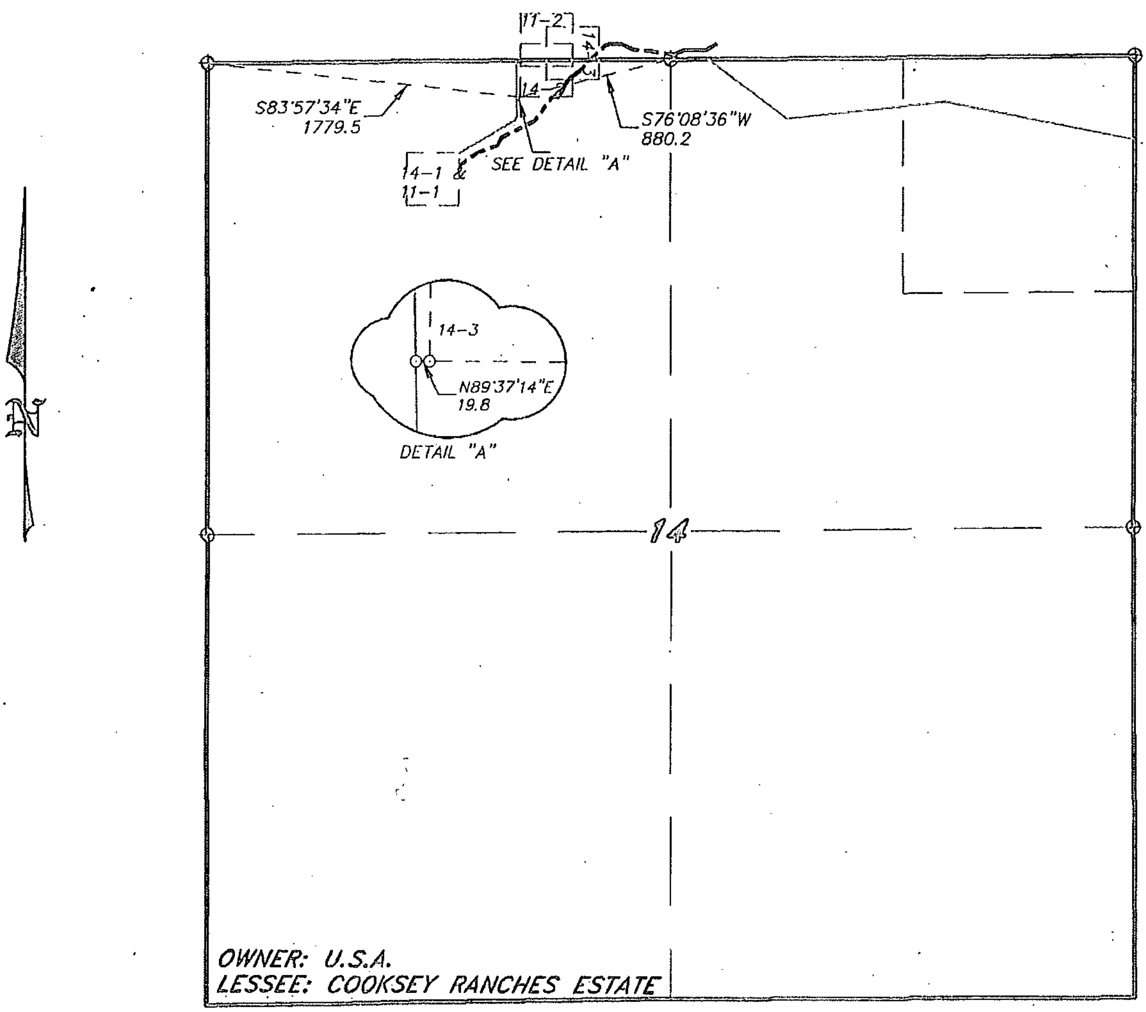
CIMAREX ENERGY CO.

REF: PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

A PIPELINE CROSSING FEE LAND IN SECTION 13, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M., EDDY COUNTY, NEW MEXICO.

W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 5 of 5 Sheets

SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST, N.M.P.M.,
EDDY COUNTY, NEW MEXICO.



LEGAL DESCRIPTION

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SECTION 14 = 19.8 FEET = 1.20 RODS = 0.004 MILES = 0.01 ACRES

I HEREBY CERTIFY THAT THIS PLAT WAS PREPARED FROM FIELD NOTES OF AN ACTUAL SURVEY AND MEETS OR EXCEEDS ALL REQUIREMENTS FOR LAND SURVEYS AS SPECIFIED BY THIS STATE.

GARY L. JONES N.M. P.S. No. 7977
TEXAS R.P.L.S. No. 5074

1000 0 1000 2000 FEET

CIMAREX ENERGY CO.

REF: PROPOSED RIVERBEND LATERAL TO 14-3 WELL

A PIPELINE CROSSING USA LAND IN
SECTION 14, TOWNSHIP 25 SOUTH, RANGE 28 EAST,
N.M.P.M., EDDY COUNTY, NEW MEXICO.

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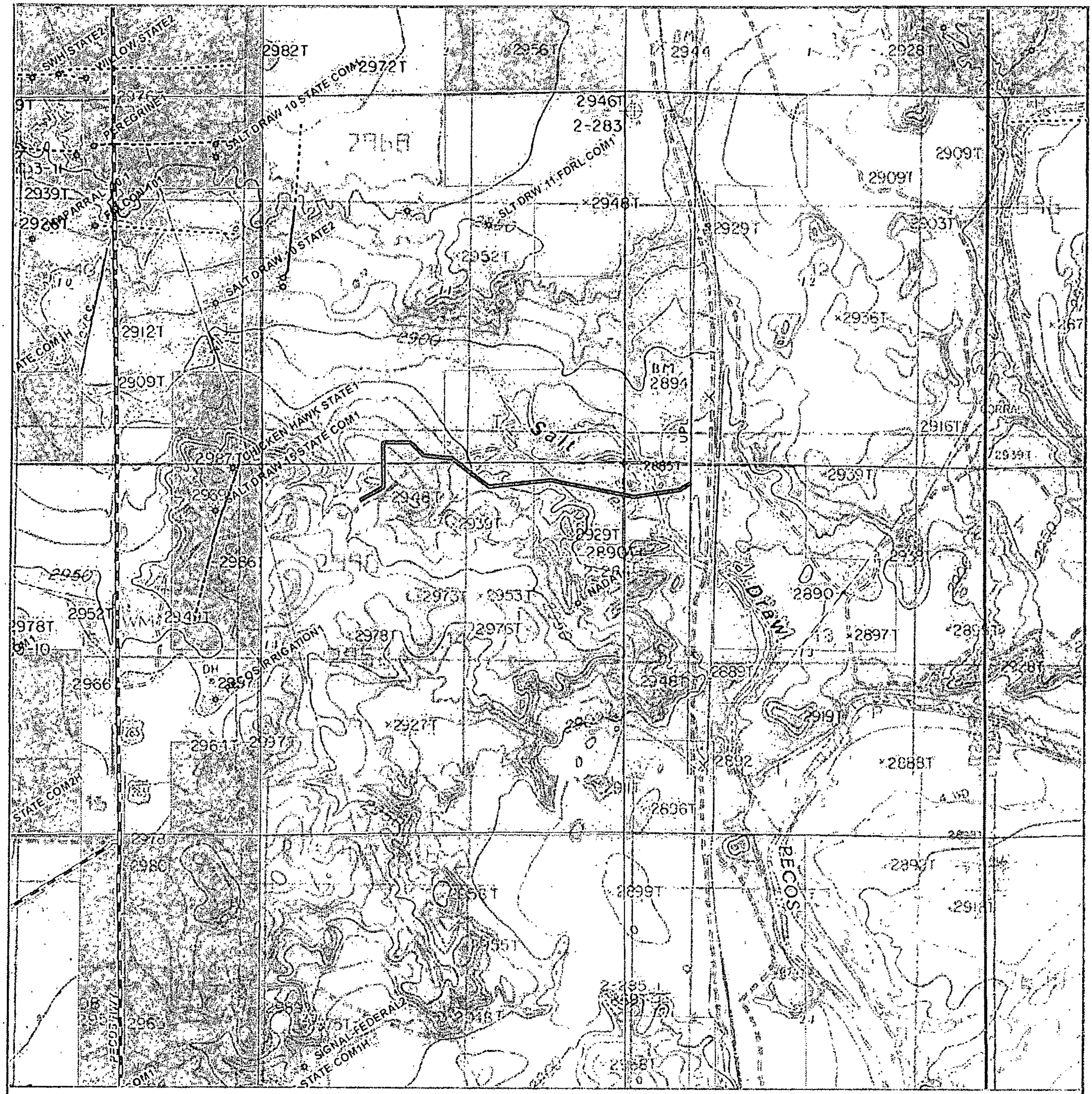
W.O. Number: 31077	Drawn By: K. NORRIS	Date: 10-14-2014	Survey Date: 10-06-2014	Sheet 1 of 1 Sheets



PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

Sections 11,13&14, Township 25 South, Range 28 East,
N.M.P.M., Eddy County, New Mexico.

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basinsurveys.com

0' 1000' 2000' 3000' 4000'

SCALE: 1" = 2000'

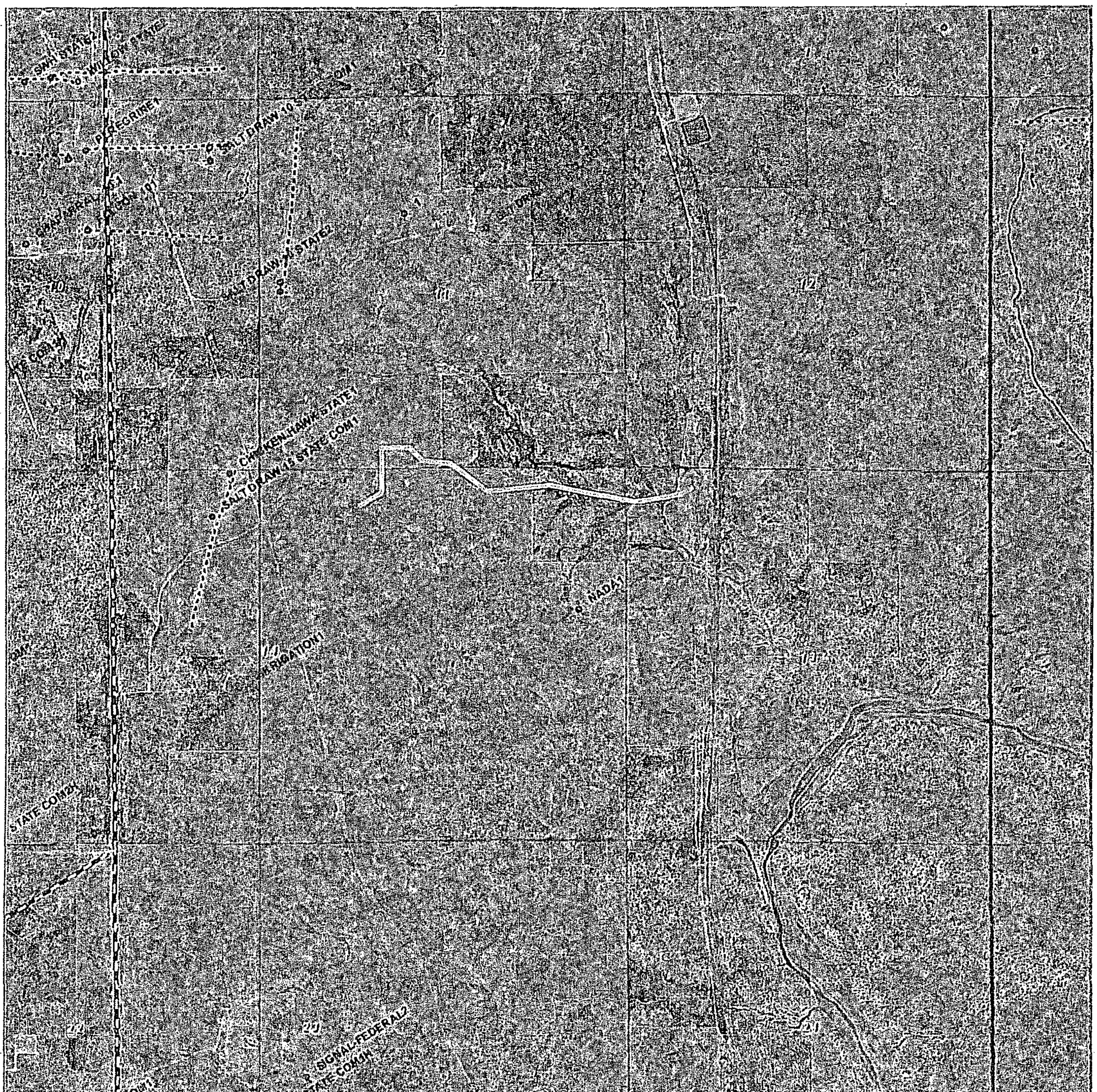
W.O. Number: KAN 31077

Survey Date: 10-06-2014

YELLOW TINT – USA LAND
BLUE TINT – STATE LAND
NATURAL COLOR – FEE LAND

N

CIMAREX ENERGY CO.



PROPOSED RIVERBEND PIPELINE ROW RE-ROUTE

Sections 11,13&14, Township 25 South, Range 28 East, N.M.P.M., Eddy County, New Mexico.

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basinsurveys.com

0' 1000' 2000' 3000' 4000'
SCALE: 1" = 2000'

W.O. Number: KAN 31077

Survey Date: 10-06-2014

YELLOW TINT – USA LAND
BLUE TINT – STATE LAND
NATURAL COLOR – FEE LAND

CIMAREX ENERGY CO.

Cimarex Energy Co.
600 N. Marienfeld St. ◊ Suite 600 ◊ Midland, TX 79701 ◊ (432) 620-1938 ◊ Fax (432) 620-1940
◦ *A NYSE Listed Company* ◦ *"XEC"*

October 31, 2014

Department of the Army
Albuquerque District, Corps of Engineer
Las Cruces Regulatory Field Office
505 S. Main St., Suite 142
Las Cruces, NM 88001

Attention: Mr. Justin Riggs

Re: Directional Bore
Salt Draw
Sec. 13, T-25S, R-28E
Eddy County, NM

Dear Mr. Riggs:

Cimarex Energy Co. respectfully requests approval to directional bore under Salt Draw for approximately 700'. Please see attached plat for information regarding the location of the bore.

Cimarex Energy Co. proposes the following bore underneath Salt Draw and upon approval Cimarex will construct a gas pipeline, specifications below:

700' bore
20" scheduled 40 welded pipe (bore casing)
8" scheduled 40 well gas pipeline

Please call me at 432-620-1936 should you have questions or need additional information.

Sincerely,

Terri Stathem
Regulatory Compliance

Riverbend Pipeline Reroute Project

Stormwater Pollution Protection Plan for Federal Lands/BLM

Salt Draw Wet-Weather Creek Area

Details

November 2014

Project Description

The Riverbend Pipeline Reroute project will be located in Eddy County, New Mexico and will be a non-DOT gathering pipeline that will serve the Cimarex Energy Co. leases within the Salt Draw area. The pipeline will be a 6" and 4" inch schedule 40 welded steel line and will be placed in a 20 inch schedule 40 steel line (bore casing). The pipeline will be constructed per API and the National Pipeline Construction standards. The wet-weather creek boring will be approximately 700 feet in length. Refer to the attached survey plat for specific location of the line in reference to the creek crossing.

The crossing will be completed by a third party contract company that is on the Cimarex approved vendor list and that is qualified for pipeline construction and GPS borings. The third party contractor will comply with Cimarex and BLM requirements.

Geographic and Soils Factors

The area that will be impacted by the pipeline construction is as follows:

- Approximately 1020 feet in length
- Approximately 0.70 acres in surface impact
- ROW of 30.0 feet
- Reeves-Gypsum land and Cottonwood association: Loamy soils that are very shallow to moderately deep over gypsum beds and Gypsum land.
- Soils can have a slope of 0 to 3 percent. Note area of impact is < 1.0 percent slope.
- Grazing is the predominant use of these areas and this is the use within the project area.
- Soil capability (irrigated versus dryland) ranges from an III to VII.

- Vegetation is typically short to mid-grasses, mesquite, yucca, salt-cedar and American Tarbush (grease wood).

Erosion and Sedimentation Controls

The Cimarex SWPP will be utilized for this project. The following specific controls will be used to prevent and control soil erosion and sedimentation of the Salt Draw:

Bench Terraces – the use of bench type terraces on both sides of the wet-weather creek crossing. Terraces will be installed on the ROW that has a 4 to 5 ft. drop in elevation. Currently the maximum terraces required will be two per side of the creek. Terraces will be constructed per the NRCS standards. All top soil will be segregated during construction and placed back onto the surface for aid in the re-vegetation of the terraces and ROW.

Silt Fences – the use of silt fences will be used at the creek edge to ensure the integrity of the creek. The fencing will be installed per the NRCS and Oklahoma State University guidelines (see attached and XEC SWPP - Appendix B).

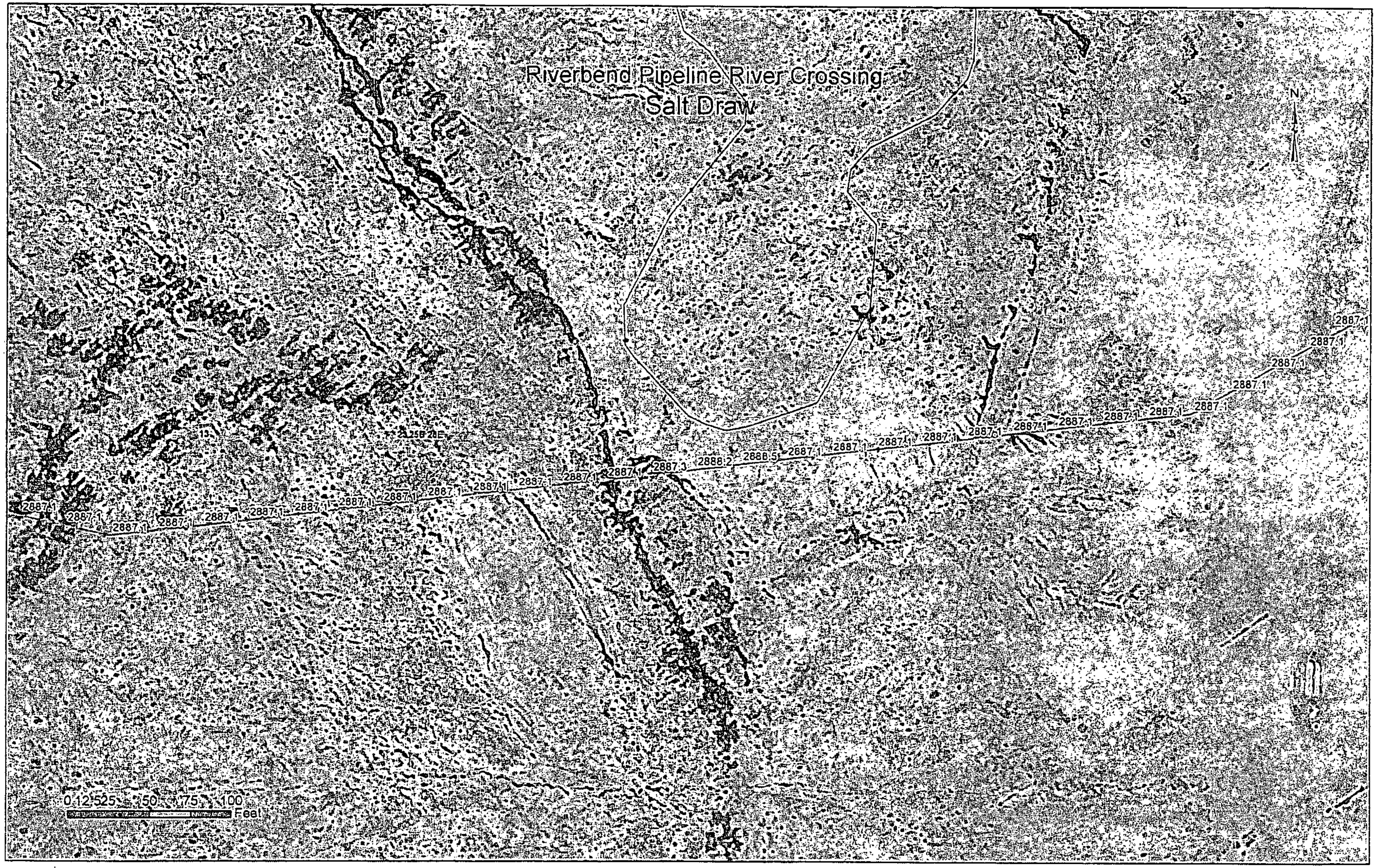
Vegetation – Vegetation will be used to stabilize the area by the use of mulching with the removed trees and brush. In addition the use of hay mulch (secured from the local rancher) will be used to control water flow and encourage soil moisture retention.

Follow-Up – the site will be visited on a two week cycle to ensure erosion controls are performing as designed. If a rainfall event of 1 inch or greater occurs then the site will be visited within 48 hours of the rain event.

Hay Bale Use for Erosion and Sedimentation Control

The following guideline should be used in the installation and use of hay bales for control of erosion and sedimentation from a Cimarex facility or construction site:

- Hay should be from the local landowner or area.
- Hay should be free of noxious weeds.
- Hay should be placed at a near run-off points or entry ways to water ways, surface impoundments, creeks, etc.
- The use of square bales is preferred over round bales.
- All bales shall be secured with either steel T-post or wooden survey post/stakes. Note the type of post will be dependent on the area rainfall, soil profile, soil type and maximum amount of water flow expected within the site.
- All hay bales should be checked on a regular basis to ensure integrity of the control.
- Silt fencing or mulching or sodding may be required if the water flow if greater than calculated or expected.


Riverbend Pipeline River Crossing
Salt Draw
N
0 12.525 50 75 100
Feet

Cimarex Energy Co.
202 S. Cheyenne Ave.
Suite 1000
Tulsa, Oklahoma 74103-4346

Stormwater Guidelines

A. Stormwater Overview – The U.S. EPA and the oil and gas industry agreed to protect the waters of the United States from sedimentation, reduced water quality due to run-off, erosion, etc. by the use of Best Management Practices (BMP's). The XEC guidelines are designed to utilize BMP's across all operations to comply with this federal requirement.

B. Applicability – The following departments will be required to utilize BMP's on all surface disturbance projects:
   a. Drilling & Completions
   b. Construction
   c. Production
   d. Midstream

C. Training – Training will be conducted annually for all applicable XEC employees and resident contractors. The training will be conducted by classroom and/or computer based (classroom will be first preference).

D. Stormwater Pollution & Protection Plan – a plan shall be developed by the ESH Department and the Regulatory Department should a surface disturbance be significant or on any federal land/mineral or per the state requirements.

Stormwater Pollution & Prevention Plan

Cimarex Energy will comply with Best Management Practices while surface disturbance operations are occurring within or could have an impact on waters of the United States. Note waters of the U.S. may include seasonal and intermittent streams/creeks.

Erosion and Sediment Controls

The following controls will be considered and the appropriate control(s) will be utilized per the specific site characteristics, weather conditions and landowner stipulations:

- Terraces will be used to control the flow of surface water. The type of terrace will be determined by the project manager.
- Silt fencing
- Hay bales
- Soil cementing
- Mulching
- Sodding/Sprigs
- Seasonal grasses or vegetation considerations

Terraces

The type of terrace will be dependent on the degree of slope, land use and soil type. The local ASCS/SCS office will be a reference source for this determination. Refer to Appendix A for terrace examples.

Silt Fencing

Silt fencing will be utilized for small areas that will be influenced for sheet flow water and can be installed up gradient of the surface water structure (creek, stream, pond, etc.). Proper support of the fencing should be a priority. Refer to Appendix B for examples.

Hay Bales

Hay bales may be used when the water flow is expected to be greater than a silt fence capacity. The anchoring of the hay bales needs to meet the expected water flow and degree of slope. The hay material shall be from a local farmer/rancher and be weed free or friendly to the local area. Refer to Appendix C for examples.

Soil Cementing

The use of soil cementing should be considered when water flow and annual rainfall exceed 36 inches per year or the work site is within an environmentally sensitive area. The local construction companies and/or civil engineers should be consulted for proper ratio of cement additives to the soil material.

Mulching

The use of mulching will be used to stabilize an area and encourage plant growth. Mulching can be completed by a hydro application (preferred) or by the manual method. See Appendix A.

Sodding or Sprigs

The use of sodding or sprigs for erosion control and prevention of sedimentation should be considered when immediate vegetation is required. The landowner and local ACS/SCS office should be consulted as to the proper grass/plant species and variety for the area. See Appendix A for examples.

Seasonal Grasses or Vegetation Considerations

The following characteristics should be considered when selecting a grass or plant for erosion and sedimentation control:

- Landowner use and requirements
- Land use
- Availability of water and annual rainfall
- Wildlife or livestock
- Time of the year (winter vs summer or wet vs dry)
- Slope
- Soil type
- Amount of sunlight
- Access

Remember that the site may require multiple types of vegetation and may require two seasons to complete the task.

Appendix A

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

TERRACE

(Ft.)

CODE 600

DEFINITION

An earth embankment, or a combination ridge and channel, constructed across the field slope.

PURPOSE

This practice is applied as part of a resource management system for one or more of the following purposes:

- Reduce erosion by reducing slope length
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion caused by water and excessive slope length is a problem
- Excess runoff is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and reasonably farmed
- A suitable outlet can be provided

CRITERIA

General Criteria Applicable to All Purposes

Spacing. Space terraces at intervals across the slope to achieve the intended purpose. The maximum spacing of terraces for erosion control is that necessary to achieve soil loss tolerance (T). Include both the terrace system with planned as-built slopes and cultural practices such as residue management when determining soil loss. The slope length used when checking soil loss for a proposed terrace spacing is the distance from the terrace ridge to the next lower terrace channel measured along the natural flow direction. Maximum spacing for erosion control based on soil loss tolerance may be increased by as much as 10 percent to provide better location, alignment to accommodate farm machinery or to reach a satisfactory outlet.

The methods that may be used to determine terrace spacing include the current NRCS accepted erosion prediction technology, the Vertical Interval Equation or state developed methods that address unique soil, cropping or other farming practices that affect terrace spacing. Refer to the current NRCS accepted erosion prediction software and user guide to determine soil loss. Refer to the Engineering Field Handbook, Chapter 8, Terraces for use of the Vertical Interval Equation.

Alignment. To accommodate farm machinery and farming operations, design cropland terraces with long gentle curves. When multiple terraces are used in a field, design the terraces to be as parallel to one another as practicable.

Capacity. Design terraces to have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terrace systems designed to control excess runoff or to function with other structures, choose a larger design storm that is appropriate to the risk associated with the installation. For terraces with underground outlets, the capacity to contain the design storm can be a combination of storage and out flow through the underground outlet. Increase the capacity of terraces by the estimated 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses the annual removal of sediment.

For terraces with open outlets, the capacity is based on the terrace channel size and stability. Base the capacity of the channel on a bare earth channel for crop fields or in the case of a permanently vegetated channel, the appropriate vegetation. For bare earth channels use a Manning's n value of 0.035 or greater to calculate capacity. For permanently vegetated channels refer to Conservation Practice Standard (412), Grassed Waterway for design criteria to determine capacity.

Design level terraces to contain the runoff from a 10-year 24-hour rainfall event, and the expected 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses the annual removal of sediment.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. Add ridge height if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, or safety. At the design elevation, the ridge shall have a minimum width of 3 ft. For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

All farmable terrace slopes shall be no steeper than those on which farm equipment can be operated safely. For non-farmable terrace slopes, the steepest slopes allowable are 2 horizontal to 1 vertical unless an analysis of site specific soil conditions indicate that steeper slopes will be stable.

End closures. Level terraces may have open ends, partial end closures, or complete end closures. Use partial and complete end closures only on soils and slopes where stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, install the end closures before the terraces are completed. End closures less than or equal to half the effective height of the terrace ridge are considered partial closures while those greater than half the height are considered complete closures. The cross-sectional area of the end closure fill may be less than the terrace cross section. For level terraces that have end closures that are lower than the terrace ridge elevation, areas downstream from the end closure must be protected from flow that will exit from the closure before the design storm is reached.

Channel grade. Design the terrace channel to be stable with non-erosive velocities but with sufficient grade to prevent damage to crops or to prevent delay of farming activities from prolonged ponding.

For cultivated terraces, base the channel stability on a bare earth condition. The maximum velocity for erosion-resistant soils (clay textural classification) is 2.5 ft/s; for average soils (silt textural classification), 2.0 ft/s; and for easily erodible soils (sand textural classification), 1.5 ft/s. If Manning's equation is used to compute velocity, use a maximum n value of 0.035 to determine velocity for channel stability.

For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to Conservation Practice Standard 412, Grassed Waterway for design criteria to determine stability.

For short distances in the upper reaches of a channel, grades may be increased to improve alignment. For terraces with an underground outlet, channel grades can be steeper for short distances within the impoundment area.

Level terrace length. The volume of water stored in level terraces is proportional to the length. To reduce the potential risk from failure, do not design level terraces with lengths that exceed 3,500 feet unless the channel is blocked at intervals not exceeding 3,500 feet.

Outlets. All terraces must have adequate outlets. The outlet must convey runoff water to a point where it will not cause damage.

Vegetated outlets are suitable for gradient or open-end level terraces. Grassed waterways or naturally vegetated drainage ways may be used as a vegetated outlet. Install and stabilize grassed waterways prior to the construction of the terrace so that the terrace will have a stable outlet when it is constructed. The capacity of the vegetated outlet must be large enough so that the water surface in the outlet is below the water surface in the terrace at the design flow.

Underground outlets are suitable on gradient or level terraces. The outlet consists of an intake and an underground conduit. Refer to Conservation Practice Standard (620), Underground Outlet for design criteria for the underground outlet.

Design the intake structure for the underground outlet to control the flow out of the terrace and to prevent excessive pressure in the underground conduit. Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crops. If sediment retention is a primary design goal, adjust the release rate according to sediment particle size. Locate the inlet for the underground outlet to accommodate farming operations and to allow for sediment accumulation.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration rates, under average rainfall conditions, must permit infiltration of the design storm from the terrace channel within the inundation tolerance of the planned crops.

Combinations of different outlet types may be used on the same terrace system to optimize water conservation, improve water quality, accommodate farming operations or to provide for economical installation.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to Conservation Practice Standard, 342, Critical Area Planting for seeding criteria.

Drainage. Install subsurface drainage to stabilize soils and improve terrace function as needed. Refer to Conservation Practice Standard, 606, Subsurface Drain for design and installation criteria.

Additional Criteria Applicable to Retaining Runoff for Moisture Control

For terraces installed to retain moisture, perform a water budget analysis to determine the volume of water that must be collected to meet the requirements of the water budget. As a minimum the terrace must still meet the design storm and sediment volume requirements in the **Capacity** section of this standard.

CONSIDERATIONS

One of the keys to a successful terrace system is to make sure that the terrace layout fits the farm equipment. This includes making curves long and gentle and spacing terraces so that the operator can make an even number of trips between terraces so that they end up on the same side of the field they started on.

Terrace ridges and cut slopes can introduce steep and potentially hazardous slopes into a crop field. Where slopes will be farmed, make sure they can be safely negotiated with the operator's equipment. Where steep slopes are unavoidable make sure the operator is aware of the location and potential danger of the slopes.

The soil survey can be a valuable resource when planning and designing terrace systems. The soil survey can identify potential problems such as the presence of limiting layers to plant growth in the soil profile. Field investigations can then identify problem areas to avoid such as shallow bedrock or dense, acid or saline layers that will adversely affect plant growth if construction brings them into the root zone.

Steep sided terraces that are in permanent vegetation can provide significant areas of habitat for wildlife. Consider planting native species that provide food and cover for wildlife. Do not mow these areas until after the nesting season to improve wildlife production.

Hillside seeps in a crop field can cause cropping problems. Consider aligning terraces and/or installing subsurface drainage to intercept and correct seepage problems.

Erosion can be a problem at the outfall of an underground outlet. To ensure an adequate outlet, protect the outfall of the underground outlet so that it is stable.

Outlets from terraces can provide a direct conduit to receiving waters for contaminated runoff from crop land. Terraces should be installed as part of a conservation system that addresses issues such as nutrient and pest management, residue management and filter areas.

Inlets for underground outlets can be easily damaged during cultivation, planting and harvesting operations. Using brightly colored inlets, barriers around the inlet or otherwise clearly marking the inlet will help prevent damage.

For terraces that will be farmed or otherwise revegetated, the stripping and stockpiling of topsoil from the construction area prior to excavation and then spreading the topsoil on the completed terrace will improve the growth of vegetation after construction.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for terraces that describe the requirements for applying the practice according to this standard. As a minimum the plans and specifications shall include:

1. A plan view of the layout of the terrace system.
2. Typical cross sections of the terrace(s).
3. Profile(s) or planned grade of the terrace(s).
4. Details of the outlet system
5. If underground outlets are used, details of the inlet and profile(s) of the underground outlet.
6. Seeding requirements if needed.
7. Site specific construction specifications that describe in writing the installation of the terrace system.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are:

1. Periodic inspections, especially immediately following significant runoff events.
2. Prompt repair or replacement of damaged components.
3. Maintenance of terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
4. Removal of sediment that has accumulated in the terrace channel to maintain capacity and grade.
5. Regular cleaning of inlets for underground outlets. Repair or replacement of inlets damaged by farm equipment. Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the terrace channel.
6. Where vegetation is specified, seasonal mowing and control of trees and brush.
7. Notification of hazards about steep slopes on the terrace.

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Bench Terrace Design Made Simple

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Abstract: Bench terraces are effective soil conservation measures used on slopelands for crop production. When world's population increases rapidly, with a rate of 77 million a year and mostly in developing countries, many slopelands are brought into cultivation where land pressures are high. In many instances in the past, however, bench terraces were built without proper design, resulting in either high construction and maintenance costs or limited use. On the other hand, some design criteria are over-complicated which hampers their application.

This paper introduces a simple but scientific design for bench terraces. The design is based on many decades of field experience in the countries of Asia and Central America. It employs a step by step approach using basic arithmetic that can be understood by field technicians, extension officers, or farmers. Based on this design, a realistic estimate of construction cost and a land use plan can be easily produced.

Keywords: bench terraces, terrace design, land treatment, conservation measures

1 Foreword

For cultivation of slopelands, bench terraces are one of the most effective measures for erosion control and crop production. With the world's population rapidly approaches 9 billion in next five decades, many of the slopelands in the developing countries will be brought into food production. In many instances in the past, bench terraces were built without scientific design, resulting in unusually high cost, maintenance difficulties, or limited use. On the other hand, some over-complicated designs have discouraged people from using them.

The present paper concentrates on the design of two major types of bench terraces: Level Bench Terraces for dry land environment and Reverse Sloped Terraces for humid regions. The principles, however, can be applicable to the other types. For instance, level bench terraces can easily be converted to paddies by simply adding a small dike on the edge for impounding water. Outward sloped terraces can be designed using similar approaches and calculations.

Using land slope and the width of the bench (flat part) as two starting points, the design proceeds step by step with basic arithmetic that can be easily understood by field workers, land users, or farmers.

2 Design basics

- Use simple arithmetic and a step-by-step approach to design.
- Design bench terraces such that the volumes of cut and fill are to be equal for minimizing construction cost.
- Design terraces according to the needs of farmers, crops, climate, and tools to be used for farming.

3 Design procedures and criteria

(1) Widths of Bench

In designing bench terraces, the width of the bench (flat part) needs to first be determined by the farmers according to crop needs, tillage tools, as well as their individual preferences. Field technicians or extension officers need to check soil depths and inform farmers that wide benches require deep soils and higher construction costs. Experience has shown that for hand cultivation 2.5 m to 5 m wide are appropriate widths whereas for mechanization 3. 5 m to 8 m are proper where depth of soil does not constitute a limit.

(2) Slopes

Slopes can be measured by using a hand level or a clinometer. In design of terraces, a representative slope or a mode slope should be obtained from the field.

If the farmer will build terraces by hand, the appropriate slope range is from 7 degrees to 25 degrees (or 12.3% to 46.6%). If machines will be used for construction, the range is from 7 degrees to 20 degrees (or 12.3% to 36.4%) according to past experience. Slopes gentler than 7 degrees may best use simple conservation measures or agronomic measures. Using machines on a slope over 20 degrees is unsafe.

(3) Vertical Intervals

After the slope and the width are determined, the Vertical Interval (*VI*) can be calculated by a simple equation. *VI* is the elevation difference between two succeeding terraces. It is essential to calculate the *VI*; it not only shows roughly the height of future terraces but also provides the basis for further designing.

The simple equation using slope and the width of the bench as the main inputs is as follows:

$$VI = (S \times Wb) / (100 - S \times U) \tag{1}$$

Where S is land slope in percent (%), Wb is the width of the bench, and U is the slope of the terrace riser or side slope. Use a horizontal to vertical ratio to put into the equation such as 1 for machine built terraces, 0.75 for hand-made terraces, and 0.5 for stone terraces.

Example: The *VI* of 4m-wide bench, machine-built, on 15 degree (26.8%) slope is as follows:

$$VI = (26.8 \times 4) / (100 - 26.8 \times 1) = 107.2 / 73.2 = 1.46 \text{ m}$$

To verify the validity of this simple equation, an equation used in Peru (Low & Paulet, 1967) was tested and the results were found to be the same. However, their equation is rather complicated, requiring two steps to get an answer and tangent values of two slope angles.

$$VI = 2d / (1 - \tan\alpha \tan\beta) \tag{2}$$
$$d = (Wb / 2) \tan\alpha$$

α is the slope of the land in degrees and β is the top slope angle of the riser, in degrees, in relation to a vertical line. Wb is the width of the bench.

Another complicated equation using trigonometric functions was also tested and the same answer was obtained (Sheng, 1981). Consequently, it is appropriate to us Equation (1) which is simpler and easier to apply.

In Taiwan, three different equations are used for design of level, reverse sloped, and outward sloped bench terraces. (Chinese Soil and Water Conservation Society,1987). In fact, when width of bench and slope are fixed, *VI* does not change regardless of the type of bench terraces. *VI* is measured from center to center of the succeeding terraces which also marks the non-cut and non-fill point.

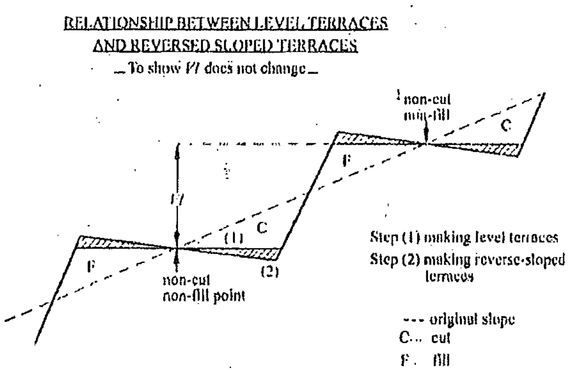


Fig.1 Same vertical interval (*VI*) between level and reverse sloped bench terraces

Fig.1 Shows that VI does not change between level and reverse sloped terraces. For outward sloped type, the VI is also the same.

(4) Heights of Riser

After VI is obtained it is easy to figure out the height of riser of the terraces. For level terrace, VI equals the height of the riser. For rice paddies, a 15 cm dike may be added to the VI to get the total height. For reverse sloped terraces, the VI needs to add a reverse height to get the total height. The reverse height can be easily calculated by the following equation:

$$RH = Wb \times 0.05 \tag{3}$$

Where RH is reverse height, Wb is width of bench, 5% is the reverse slope. A five percent (5%) reverse slope is sufficient to keep runoff away from the riser and it does not interfere with farming operation.

The height of riser (Hr) of reverse sloped terraces can therefore be obtained using the following equation:

$$Hr = VI + RH \tag{4}$$

Experience shows that the overall height of a riser should not exceed 1.8 m to 2 m; above that the maintenance work will become difficult.

(5) Widths of Terraces

The width of a terrace can be obtained by adding the width of the bench (Wb) to the width of the riser (Wr). Wr is calculated by multiplying the height of the riser to a riser slope (U) which has been explained in Equation (1).

$$Wr = Hr \times U \tag{5}$$

Where Wr is the width of the riser, Hr is the height of the riser, and U is the slope of riser giving value 1 for machine built terrace, 0.75 for hand made terrace, and 0.5 for stone made terrace. The total width of a terrace (Wt) is obtained as shown below:

$$Wt = Wr + Wb \tag{6}$$

(6) Lengths of Terraces

The length of a terrace is limited by the size and shape of the field and the degree of land dissection. Longer terraces will increase farming operation efficiency especially using machines for cultivation. However, too great a length in one direction in the case for drainage may cause accelerated runoff velocity and erosion. Based on past experience, 100 m in one inclined direction or 200 m in total is recommended for reverse sloped or drainage type terraces. The gradient for drainage is 0.5 % to 1 % according to soils and rainfall.

Leaner length (L), expressed in meters (m) in a hectare (ha), can be calculated as follows:

$$L = 10{,}000 / Wt \tag{7}$$

Where Wt is the width of terrace which has been explained previously.

(7) Net Area

Farmers are interested in knowing the net area for cultivation when terraces are to be built. The net area (NA) in a hectare (ha) can be obtained easily by multiplying leaner length (L) to the width of the bench (Wb):

$$NA = L \times Wb \tag{8}$$

Consequently, the percent of net area or percent of benches (Pb) in a ha can thus be obtained, as follows

$$Pb(\%) = NA / 10{,}000 \times 100 \tag{9}$$

It is important to know that on the same slope, the percent of bench or net area does not change regardless the width of the bench. In other words, building a wide bench or a narrow bench will get same percentage or flat area for cultivation, though too narrow a terrace will be impractical whereas too wide a terrace will need to cut deeper and cost more.

(8) Volumes to be Cut and Filled

To build bench terraces, as mentioned previously, the volume of soil to be cut and filled has to be equal in order to minimize the cost. There should be no extra volume of soil to be disposed of or borrowed from other places. Therefore, when we calculate volumes we need only to consider one volume (cut volume) that will eventually be moved down slope to form a terrace (See Fig. 1).

Volumes can usually be obtained by multiplying an area to a length. In our case, the area is a triangle or the cross-section of the cut part (C). Therefore, multiplying C by the linear length, L, will obtain the volume.

For level terraces, the equation for the cross-section (C) is simply as follows:

$$C = (Wb \times VI) / 8 \tag{10}$$

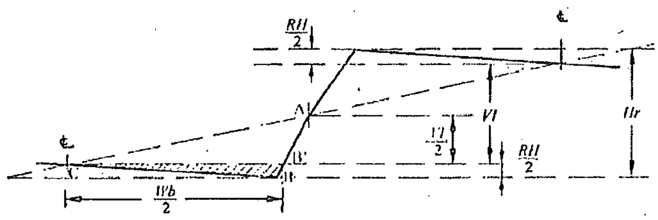
In case a small dike is needed, cross-section of the dike must be added to the above equation.

For reverse sloped terraces, the cut and fill is more and its equation is shown below:

$$C = (Wb \times Hr) / 8 \tag{11}$$

The following figure (Fig. 2) shows the calculation of the cross-section (C) of the reverse sloped terraces.

COMPUTATION OF CROSS-SECTIONAL AREA OF BENCH TERRACE



$$ABC = AB'C + B'BC$$

$$= \frac{\frac{Wb}{2} \times \frac{VI}{2}}{2} + \frac{\frac{Wb}{2} \times \frac{RH}{2}}{2}$$

$$= \frac{\frac{Wb \times VI}{4} + \frac{Wb \times RH}{4}}{2}$$

$$= \frac{\frac{(Wb \times VI) + (Wb \times RH)}{4}}{2}$$

$$= \frac{(Wb \times VI) + (Wb \times RH)}{8}$$

$$= \frac{Wb(VI + RH)}{8}$$

$$= \frac{Wb \times Hr}{8}$$

Fig.2 Computation of cross-sectional area of reverse sloped bench terraces

After the cross-section, C, is obtained, the volume to be cut and filled in a ha can be quickly calculated:

$$V = C \times L \tag{12}$$

Where V is the volume, C is the cross-section, and L is the linear length per ha.

(9) Depths of Cut

To find out depth of cut is essential. It is needed to compare with the soil depth measured in the field. If the measured depth is insufficient, then the width of the bench needs to be reduced to fit the depth on site (Sheng, 2000). The following equations are used to calculate the depth of cut for level terraces (Eq.13) and reverse sloped terraces (Eq.14) respectively. All the abbreviations have been explained previously.

$$(Wb/2)\,(S/100) \tag{13}$$

$$(Wb/2)\,(S/100) + RH/2 \tag{14}$$

(10) Specification Tables and Computer Software

For the convenience of field workers, a set of specific tables was produced and published (FAO,1988) for reference. Also, a special software, CONTREAT, has been produced since 1990s (Sheng, 2000).

4 Final remarks

The above-mentioned equations and calculations should be considered practical and sufficient in terrace design, bearing in mind that we are dealing with earth moving and farm work in the field. The survey, layout and construction of bench terraces are discussed in several publications (FAO, 1977; FAO, 1988; Sheng,1986).

Land slopes are usually not even and smooth. When we design terraces we need to use the mode slope or the representative slope of the site as the basis for calculation so that future terraces will produce an even width. It is important to have an even width to benefit farming operations, especially if machines are to be employed.

To design bench terraces for lasting uses, accessibility roads, waterways or irrigation installations should be considered integrally and early in the planning process.

Finally, bench terraces can be costly; they should not be built everywhere on the slope. For gentler slopes, and for semi-permanent and permanent crops, other simple conservation measures and inexpensive terrace systems can be applied (FAO, 1989; Sheng, 2000).

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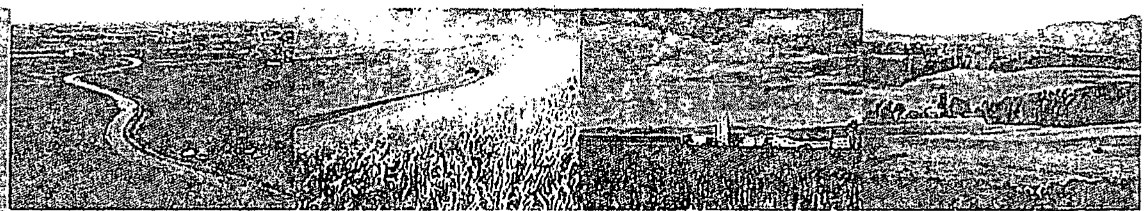

Terraces

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Definition:

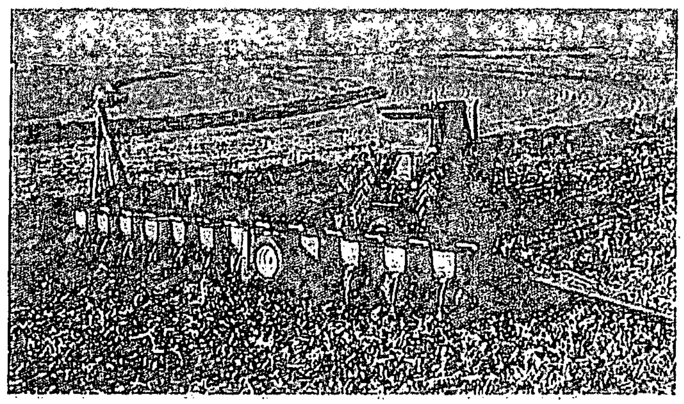
An earth embankment, or a combination ridge and channel, constructed across the field slope that intercepts, detains and safely conveys runoff to an outlet.

Purpose:

Terraces are used to reduce sheet-and-rill erosion and prevent gully development. Terracing reduces sediment pollution to lakes and streams, and traps phosphorus attached to sediment particles. Terraces may also retain runoff for moisture conservation.

How Does This Practice Work?

Terraces intercept runoff on moderate to steep slopes. They transform long slopes into a series of shorter slopes. Terraces reduce the rate of runoff and allow soil particles to settle out. The resulting cleaner water is then carried off the field in a non-erosive manner. Terraces reduce phosphorus transport by reducing soil erosion and runoff. Water erosion moves soil particles that have phosphorus attached. Sediment that reaches water bodies may release the phosphorus into the water.



Where This Practice Applies and Its Limitations:

Terraces can be used on fields where sheet-and-rill erosion or ephemeral gullies are a problem. They can also be used where runoff or sediment could impair water quality or cause damage downstream.

Terraces may be used where:

- Soil erosion by water is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and farmed with reasonable effort
- A suitable outlet can be provided
- Excess runoff is a problem

Effectiveness:

The erosion reduction potential of terraces ranges from 10 to 50 percent. Terraces are most effective when used in a planned conservation system that includes a combination of practices such as conservation tillage, crop rotations, contour farming and field borders. Primary factors affecting erosion include climatic conditions, land slope, cropping intensity, tillage practices and soil erodability.

Types of Terraces:

There are two types of terraces:

- Storage terraces collect water and store it until it can infiltrate into the ground or be released through a stable outlet.

Underground outlets with pipe intakes are the most common type of outlet.

- **Gradient terraces** are designed as channels to slow runoff water and carry it to a stable outlet such as a grassed waterway.

There are three typical terrace cross-section types.

- **Grassed backslope terraces** have a farmable frontslope with a 2:1 back slope (2 feet horizontal to every 1 foot of vertical drop). Downhill slope is seeded to perennial grass.

Grassed backslope

- **Narrow base terraces** have 2:1 slopes on both the frontslope and backslope. Both front and back slopes are seeded to perennial grasses.

- **Broadbase terraces** are flatter looking and are farmed on both slopes. This configuration will require a flatter land slope, normally less than 8 percent.

Cost of Establishing and Putting the Practice In Place:

The cost of terrace installation includes earth work costs associated with the terrace construction, the establishment of an adequate outlet such as a grassed waterway or underground outlet and vegetation establishment of the respective terrace slopes on grassed backslope or narrow base terraces.

Potential losses in production because of construction and some reduction in crop acres may result from terrace and waterway placement. Terrace construction costs vary widely and range from $1 to $6 per linear foot of terrace, with additional costs associated with construction of waterways and underground outlets for conveyance of water to the outlet.

Operation and Maintenance:

Where terraces are parallel, there are few problems with planting. If terraces are not parallel, consider how short rows (point rows) are best managed for farmability.

Avoid farming too close to intakes. Farming operations can cause ridges that block drainage of the terrace channel.

Remove sediment build-up in the terrace channel to maintain the required water-holding capacity.

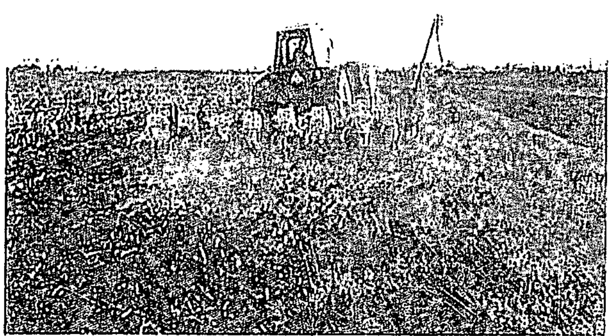
Repair sections of the terrace that have eroded or have excessive settlement.

References:

USDA AG Handbook 703, NRCS National Conservation Practices Standards (600), NRCS Engineering Field Manual, and NRCS local field office technical guides. Specific information for this factsheet was taken directly from the NRCS Iowa Job Sheet on Terraces.

For Further Information:

Contact your local conservation district, USDA-NRCS or Cooperative Extension Service office. Cost share may be available. Contact your local USDA offices.



Narrow base

Broadbase

Appendix B

United States Department of Agriculture

NRCS Natural Resources Conservation Service

SILT FENCE

What is it?

This is a temporary barrier made of woven wire and fabric filter cloth that is used to catch sediment-laden runoff from small areas of disturbed soil such as following a fire. Silt fences are easy to construct, and materials are available from hardware stores, nurseries, and lumberyards.

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When is it used?

Silt fences are used for specific situations. Major considerations are slope, slope length, and the amount of drainage area from which the fence will catch runoff. Here are some design considerations:

Slope Steepness	Maximum Slope Length
2:1 = 50%	50 feet
3:1 = 33%	75 feet
4:1 = 25%	125 feet
5:1 = 20%	175 feet
<5:1 = <20%	200 feet

*For longer slopes, add additional silt fences.

Drainage Area:

The area that contributes runoff to be caught by the silt fence should not be greater than 1/2 acre for 100 feet of fence.

Type of Runoff:

Silt fences are designed to catch runoff that is in the form of "sheet flow" and not "concentrated flow." Sheet flow differs from concentrated flow in that the runoff is spread evenly over the ground surface (like a sheet) rather than concentrated in small rills or gullies.

Methods and Materials:

Fence Posts:

Posts should be at least 36 inches long. Wood posts should be of hardwood with a minimum cross sectional area of 3 inches. Steel posts should be standard "T" or "U" section and should weigh no less than 1 pound per linear foot.

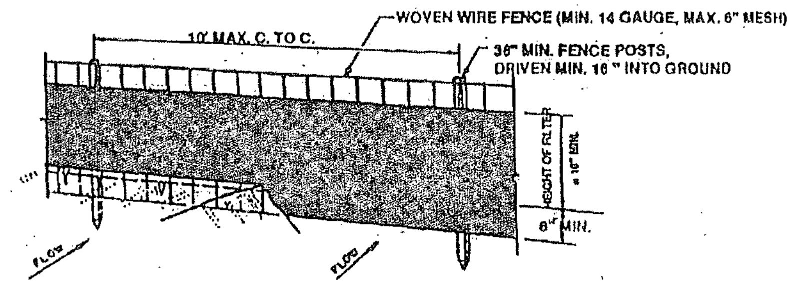
July 2002 Arizona

Silt Fence

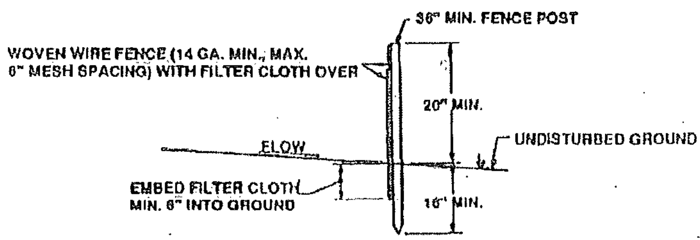
Fabric Properties:
Filter fabric properties should be as follows (hardware store personnel can help you with these):

Fabric Property	Minimum Acceptable Value	Test Method
Grab tensile strength (LBS)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (PSI)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751 (mod)
Slurry flow Rate (gal./min/sf)	0.3	
Equivalent Opening Size	40-80	US Std Sieve
Ultraviolet Rad. Stability	90	ASTM-G-26

Perspective View



Section View



Construction Notes

1. Woven wire fence to be fastened securely to fence posts with wire ties or staples.
2. Filter cloth to be fastened securely to woven wire fence with ties spaced every 24" at top and midsection.
3. When 2 sections of filter cloth adjoin each other, they shall be overlapped by 6" and folded.
4. Maintenance shall be performed as needed and material removed when "bulges" develop in the silt fence.

Appendix C

Hay Bale Use for Erosion and Sedimentation Control

The following guideline should be used in the installation and use of hay bales for control of erosion and sedimentation from a Cimarex facility or construction site:

- Hay should be from the local landowner or area.
- Hay should be free of noxious weeds.
- Hay should be placed at a near run-off points or entry ways to water ways, surface impoundments, creeks, etc.
- The use of square bales is preferred over round bales.
- All bales shall be secured with either steel T-post or wooden survey post/stakes. Note the type of post will be dependent on the area rainfall, soil profile, soil type and maximum amount of water flow expected within the site.
- All hay bales should be checked on a regular basis to ensure integrity of the control.
- Silt fencing or mulching or sodding may be required if the water flow if greater than calculated or expected.

BLM LEASE NUMBER:
COMPANY NAME:
ASSOCIATED WELL NAME:

BURIED PIPELINE STIPULATIONS

A copy of the application (Grant, APD, or Sundry Notice) and attachments, including conditions of approval, survey plat and/or map, will be on location during construction. BLM personnel may request to you a copy of your permit during construction to ensure compliance with all stipulations.

Holder agrees to comply with the following stipulations to the satisfaction of the Authorized Officer:

1. The Holder shall indemnify the United States against any liability for damage to life or property arising from the occupancy or use of public lands under this grant.

2. The Holder shall comply with all applicable Federal laws and regulations existing or hereafter enacted or promulgated. In any event, the holder shall comply with the Toxic Substances Control Act of 1976 as amended, 15 USC 2601 et seq. (1982) with regards to any toxic substances that are used, generated by or stored on the right-of-way or on facilities authorized under this right-of-way grant. (See 40 CFR Part 702-799 and especially, provisions on polychlorinated biphenyls, 40 CFR 761.1-761.193.) Additionally, any release of toxic substances (leaks, spills, etc.) in excess of the reportable quantity established by 40 CFR Part 117 shall be reported as required by the Comprehensive Environmental Response, Compensation, and Liability Act, section 102b. A copy of any report required or requested by any Federal agency or State government as a result of a reportable release or spill of any toxic substances shall be furnished to the authorized officer concurrent with the filing of the reports to the involved Federal agency or State government.

3. The holder agrees to indemnify the United States against any liability arising from the release of any hazardous substance or hazardous waste (as these terms are defined in the Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 U.S.C. 9601, et seq. or the Resource Conservation and Recovery Act, 42 U.S.C.6901, et seq.) on the Right-of-Way (unless the release or threatened release is wholly unrelated to the Right-of-Way holder's activity on the Right-of-Way), or resulting from the activity of the Right-of-Way holder on the Right-of-Way. This agreement applies without regard to whether a release is caused by the holder, its agent, or unrelated third parties.

4. If, during any phase of the construction, operation, maintenance, or termination of the pipeline, any oil or other pollutant should be discharged from the pipeline system, impacting Federal lands, the control and total removal, disposal, and cleaning up of such oil or other pollutant, wherever found, shall be the responsibility of holder, regardless of fault. Upon failure of holder to control, dispose of, or clean up such discharge on or affecting Federal lands, or to repair all damages resulting therefrom, on the Federal lands, the Authorized Officer may take such measures as he deems necessary to control and clean up the discharge and restore the area, including where appropriate, the aquatic environment and fish and wildlife habitats, at the full expense of the holder. Such action by the Authorized Officer shall not relieve holder of any responsibility as provided herein.

5. All construction and maintenance activity will be confined to the authorized right-of-way.

6. The pipeline will be buried with a minimum cover of __36__ inches between the top of the pipe and ground level.

7. The maximum allowable disturbance for construction in this right-of-way will be **30** feet:

- Blading of vegetation within the right-of-way will be allowed: maximum width of blading operations will not exceed **20** feet. The trench is included in this area. (*Blading is defined as the complete removal of brush and ground vegetation.*)

- Clearing of brush species within the right-of-way will be allowed: maximum width of clearing operations will not exceed **30** feet. The trench and bladed area are included in this area. (*Clearing is defined as the removal of brush while leaving ground vegetation (grasses, weeds, etc.) intact. Clearing is best accomplished by holding the blade 4 to 6 inches above the ground surface.*)

- The remaining area of the right-of-way (if any) shall only be disturbed by compressing the vegetation. (*Compressing can be caused by vehicle tires, placement of equipment, etc.*)

8. The holder shall stockpile an adequate amount of topsoil where blading is allowed. The topsoil to be stripped is approximately ___6___ inches in depth. The topsoil will be segregated from other spoil piles from trench construction. The topsoil will be evenly distributed over the bladed area for the preparation of seeding.

9. The holder shall minimize disturbance to existing fences and other improvements on public lands. The holder is required to promptly repair improvements to at least their former state. Functional use of these improvements will be maintained at all times. The holder will contact the owner of any improvements prior to disturbing them. When necessary to pass through a fence line, the fence shall be braced on both sides of the passageway prior to cutting of the fence. No permanent gates will be allowed unless approved by the Authorized Officer.

10. Vegetation, soil, and rocks left as a result of construction or maintenance activity will be randomly scattered on this right-of-way and will not be left in rows, piles, or berms, unless otherwise approved by the Authorized Officer. The entire right-of-way shall be recontoured to match the surrounding landscape. The backfilled soil shall be compacted and a 6 inch berm will be left over the ditch line to allow for settling back to grade.

11. In those areas where erosion control structures are required to stabilize soil conditions, the holder will install such structures as are suitable for the specific soil conditions being encountered and which are in accordance with sound resource management practices.

12. The holder will reseed all disturbed areas. Seeding will be done according to the attached seeding requirements, using the following seed mix.

( ) seed mixture 1	( ) seed mixture 3
( ) seed mixture 2	( ) seed mixture 4
( ) seed mixture 2/LPC	( ) Aplomado Falcon Mixture

13. All above-ground structures not subject to safety requirements shall be painted by the holder to blend with the natural color of the landscape. The paint used shall be color which simulates "Standard Environmental Colors" – **Shale Green**, Munsell Soil Color No. 5Y 4/2.

14. The pipeline will be identified by signs at the point of origin and completion of the right-of-way and at all road crossings. At a minimum, signs will state the holder's name, BLM serial number, and the product being transported. All signs and information thereon will be posted in a permanent, conspicuous manner, and will be maintained in a legible condition for the life of the pipeline.

15. The holder shall not use the pipeline route as a road for purposes other than routine maintenance as determined necessary by the Authorized Officer in consultation with the holder before maintenance begins. The holder will take whatever steps are necessary to ensure that the pipeline route is not used as a roadway. As determined necessary during the life of the pipeline, the Authorized Officer may ask the holder to construct temporary deterrence structures.

16. Any cultural and/or paleontological resources (historic or prehistoric site or object) discovered by the holder, or any person working on his behalf, on public or Federal land shall be immediately reported to the Authorized Officer. Holder shall suspend all operations in the immediate area of such discovery until written authorization to proceed is issued by the Authorized Officer. An evaluation of the discovery will be made by the Authorized Officer to determine appropriate actions to prevent the loss of significant cultural or scientific values. The holder will be responsible for the cost of evaluation and any decision as to proper mitigation measures will be made by the Authorized Officer after consulting with the holder.

17. The operator shall be held responsible if noxious weeds become established within the areas of operations. Weed control shall be required on the disturbed land where noxious weeds exist, which includes associated roads, pipeline corridor and adjacent land affected by the establishment of weeds due to this action. The operator shall consult with the Authorized Officer for acceptable weed control methods, which include following EPA and BLM requirements and policies.

18. <u>Escape Ramps</u> - The operator will construct and maintain pipeline/utility trenches that are not otherwise fenced, screened, or netted to prevent livestock, wildlife, and humans from becoming entrapped. At a minimum, the operator will construct and maintain escape ramps, ladders, or other methods of avian and terrestrial wildlife escape in the trenches according to the following criteria:

a. Any trench left open for eight (8) hours or less is not required to have escape ramps; however, before the trench is backfilled, the contractor/operator shall inspect the trench for wildlife, remove all trapped wildlife, and release them at least 100 yards from the trench.
b. For trenches left open for eight (8) hours or more, earthen escape ramps (built at no more than a 30 degree slope and spaced no more than 500 feet apart) shall be placed in the trench.

19. The period of time that any trenches or other excavations are kept open will be held to the minimum compatible with construction requirements. The holder shall not leave more than one-half mile of trench open overnight or otherwise unattended. Open trenches will have ramps, bridges, or earthen plugs, at least six feet wide, every one-quarter mile to pass livestock and wildlife.

EXHIBIT B
BLM SERIAL #:
COMPANY REFERENCE:

Seed Mixture 1, for Loamy Sites

The holder shall seed all disturbed areas with the seed mixture listed below. The seed mixture shall be planted in the amounts specified in pounds of pure live seed (PLS)* per acre. There shall be no primary or secondary noxious weeds in the seed mixture. Seed will be tested and the viability testing of seed will be done in accordance with State law(s) and within nine (9) months prior to purchase. Commercial seed will be either certified or registered seed. The seed container will be tagged in accordance with State law(s) and available for inspection by the authorized officer.

Seed will be planted using a drill equipped with a depth regulator to ensure proper depth regulator to ensure proper depth of planting where drilling is possible. The seed mixture will be evenly and uniformly planted over the disturbed area (small/heavier seeds have a tendency to drop the bottom of the drill and are planted first). The holder shall take appropriate measures to ensure this does not occur. Where drilling is not possible, seed will be broadcast and the area shall be raked or chained to cover the seed. When broadcasting the seed, the pounds per acre are to be doubled. The seeding will be repeated until a satisfactory stand is established as determined by the authorized officer. Evaluation of growth will not be made before completion of at least one full growing season after seeding.

Species to be planted in pounds of pure live seed* per acre:

Species	lb/acre
Plains lovegrass (Eragrostis intermedia)	0.5
Sand dropseed (Sporobolus cryptandrus)	1.0
Sideoats grama (Bouteloua curtipendula)	5.0
Plains bristlegrass (Setaria macrostachya)	2.0

*Pounds of pure live seed:

Pounds of seed **x** percent purity **x** percent germination = pounds pure live seed