SECTION 34

POST-RECLAMATION TOPOGRAPHY

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POST-RECLAMATION TOPOGRAPHY

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REV. NUMBER	REVISION DESCRIPTION	DATE APPROVED

SECTION 34 POST-RECLAMATION TOPOGRAPHY

34.1 Post-Reclamation Final Surface Configuration

Through the mining process the original or pre-mine surface configuration and surface contours are altered. Reclamation plans are based on grading the mined areas to meet specific criteria outlined in this section. In order to ensure that these criteria will be met and the material balance maintained, the designs of a new topographical surface are created based on current mine plans and features for a given operating area. This replacement surface is defined as the final surface configuration (FSC) or approximate original contours (AOC); the terms can be used interchangeably within this permit application package. Refer to Exhibit 34.1-1 for FSC designs for Pinabete Mine Plan permit area (permit area). Reclamation plans are based specifically around meeting the drainage requirements of this FSC surface. Because this FSC surface is created from a modeled post-mine surface, the actual contour configuration of the reclaimed topography may deviate from the design FSC. The locations, configurations, and sequence of mining operations and features may vary slightly from preliminary plans (e.g., ramp centerline locations, dragline plug locations). However, these deviations will not be significant. The actual reclaimed surface will closely approximate the approved FSC and this surface will ensure current FSC drainage designs are maintained, meet the requirements this section, and ensure a material balance.

BHP Navajo Coal Company (BNCC) will utilize both traditional and fluvial geomorphic reclamation approaches to develop the FSC for the Pinabete Permit area. These reclamation approaches are discussed further in Section 38 (Post-Reclamation Surface Stabilization and Sediment Control). The combination of these approaches enables BNCC to meet the objectives of the FSC as described below:

1. Achieve mass balance while maximizing contemporaneous regrade acreage between ramps,
2. Achieve positive drainage, except for the small depressions mentioned below, from all areas including pits and ramps,
3. Develop an adequate drainage density,
4. Allow development of stable drainage channels,
5. Support the approved post-mining land use.

The fluvial geomorphic reclamation approach utilizes site-specific fluvial geomorphic data, including but not limited to drainage density, tributary lengths and associated areas, sinuosity, width to depth ratios, and length between channels, to develop a reclamation surface model that generally mimics the natural landscape. The field reconnaissance activities and technical evaluation used to develop the fluvial geomorphic design inputs for Area 4 are included in Appendix 34.A.

The slope analysis for the post-reclamation final surface in Area 4 North and Area 4 South is provided in Table 34.1-1.

34.1.1 AOC Exemption for Thin Overburden

BNCC is not requesting an AOC exemption for thin overburden. Therefore, this section is not applicable to the permit area.

34.1.2 AOC Exemption for Thick Overburden

BNCC is not requesting an AOC exemption for thick overburden. Therefore, this section is not applicable to the permit area.

34.1.3 Highwall Elimination Exemption for Operations on Previously Mined Areas

BNCC is not requesting a highwall elimination exemption on previously mined areas, as there are no previously mined areas that contain preexisting highwalls within the permit area. Therefore, this section is not applicable to the permit area.

34.1.4 AOC Variance for Mountaintop Removal Operations

BNCC is not requesting an AOC variance for mountaintop removal, as this is not a mountaintop removal operation. Therefore, this section is not applicable to the permit area.

34.1.5 AOC Variance for Steep Slope Mining Operations

BNCC is not requesting an AOC variance for steep slope mining, as this is not a steep slope mining operation. Therefore, this section is not applicable to the permit area.

34.2 Backfilling and Grading Plan

Overburden and parting materials are removed by a dragline and cast into the adjacent mined-out cuts. Such placements create spoil ridges (rows) or peaks, which need to be backfilled and/or graded. BNCC contracted Norwest Corporation (Norwest) to develop a post-mining topography (PMT) (Exhibit 34.2-1), based on a computer simulation of mining in Area 4 North and Area 4 South. The computer simulation models the mining methods and dragline operation to create simulated PMT. The PMT was then used to optimize the mass balance of the FSC design (Exhibit 34.1-1). By combining the PMT and FSC designs, BNCC is able to develop mass-balanced logical reclamation blocks (Exhibit 34.2-2) for the mining area. Unbalanced surplus material will be redistributed within the reclamation blocks, and is not expected to significantly affect the overall FSC design. Backfilling and grading will be completed in these logical reclamation blocks, which follow the stripping sequence, and allow for large areas to be regraded at one time.

These reclamation blocks will provide for a more consistent topography between regraded areas. In most cases, these logical reclamation blocks become available every 1 to 3 years in each mining area. The scheduling of these backfilling and grading blocks will result in a distance between the previous regraded area and the active pit; however, this distance will be operationally advantageous and improve the reclamation process as it will allow for larger areas to be reclaimed at one time. Less area will need to be redisturbed to tie into existing reclaimed areas. Larger portions of the post-mine watersheds can be constructed at a single time, thereby reducing the number of temporary drainage and sediment control structures. Topdressing, revegetation, and irrigation operations will be operationally easier and more efficient at larger scales than in small irregular blocks. The areas around active ramps and final pits will remain ungraded until all mining activities are complete in order to preserve the material required to fill in these features. Backfilling and grading operations of each logical block are divided into primary and secondary operations.

Primary regrading utilizes track dozers to level off the spoil ridges. Primary regrading will be accomplished as necessary to accommodate the FSC and the regrading schedule in Section 51 (Reclamation Schedule). Some pits and ramps might not have sufficient backfill material readily available for track dozers to adequately regrade the area. In these instances, supplemental equipment may be used to facilitate primary regrading activities. This equipment includes, but is not limited to, scrapers, draglines, and end-dump trucks working with a large front-end loader.

Several areas may require delays in reclamation in order to facilitate reaching the desired post-mining topography. Changes or fluctuations in the dragline stripping sequence may cause variations in spoil placement, resulting in localized peaks or valleys that may require regrading equipment and cause primary regrading delays.

Secondary regrading may, if needed, follow primary grading for additional contouring of the land surface to accommodate topdressing replacement. At this time, any special water control or wildlife habitat features will be constructed.

During the process of secondary grading, small depressions may be established on an opportunistic basis. These features will enhance post-mining topographic diversity and act as seasonal surface water collection sites. Small area depressions are discussed in Section 34.2.3.

Highwalls and ramps will be backfilled and graded per FSC maps shown in Exhibit 34.1-1. Portions of highwalls may remain in the FSC surface to replace natural escarpment features for wildlife habitat. Natural escarpment features and other wildlife habitat features are discussed in Section 38 (Post-Reclamation Surface Stabilization and Sediment Control) and Section 39 (Fish and Wildlife Enhancement).

BNCC will strive to reclaim the lands disturbed by mining activities through the implementation of established fluvial geomorphic principles (Dunne and Leopold 1978; Rosgen 1996); however, in some instances this approach might not be feasible or applicable. In these instances, BNCC will implement a traditional reclamation approach based on "hard-engineered" structures. Geomorphically appropriate slopes do not have the same design constraints as traditional reclamation approach slopes. Geomorphically appropriate slopes are dependent on their position within the landscape. Areas higher in the watershed may have steeper slopes, while areas lower in the watershed will have shallower, or flatter, slopes. Post mining FSC slopes within Area 4 North and Area 4 South are presented in Table 34.1-1. Interior slopes constructed using the traditional reclamation approach will have grades equal to or less than 6.5 horizontal to 1 vertical (6.5h:1v). Outslopes constructed using the traditional reclamation approach will have grades less than or equal to 4h:1v. The overall slope for both the fluvial geomorphic and traditional reclamation approaches will be measured from the crest to the toe of the slope. Post-reclamation drainages and reclamation approaches are discussed in further detail in the Hydrologic Reclamation Plan (Section 35) and in the Post-Reclamation Surface Stabilization and Sediment Control Plan (Section 38).

Regraded lands are blended into the surrounding topography to establish drainage patterns, and the post-mining land use of range livestock grazing will be unimpaired following topdressing distribution and revegetation.

The mining operations, described in Section 20 (Mining Operations), will not generate any coal mine waste or coal processing waste as defined by 30 CFR 701.5.

The plans to minimize erosion and water pollution during backfilling and grading, and descriptions of the post-reclamation drainage and permanent impoundments is described in Section 38 (Post-Reclamation Surface Stabilization and Sediment Control) and Section 35 (Hydrologic Reclamation Plan).

34.2.1 Covering Acid-Forming and Toxic-Forming Materials and Combustibles

BNCC may encounter strata that contain limited quantities of potentially acid- and toxic-forming materials (PATFM). Based on the geologic description and overburden characterization in Section 17 (Geologic Information), the quantity of PATFM will be minimal and thus does not require special handling and disposal procedures.

BNCC will not generate coal mine waste or coal processing wastes. Small quantities of spilled coal and coal materials that do not meet quality standards (e.g., low BTU) will be hauled to mined-out areas and free dumped along the bottom of the pit or placed in an alternate location where the materials will not adversely affect reclamation operations. This coal material represents a low combustion risk; however, BNCC will follow the procedures discussed in the combustibles and coal mine waste fire control plan in Section 20 (Mining Operations) in the event that the material does combust.

The small quantity of PATFM and coal materials placed in mined-out areas will be handled in a manner that protects the environmental resources and will not impact surface drainages or the FSC. The handling and disposal procedures for these materials are presented in Section 20 (Mining Operations).

34.2.2 Post-Reclamation Slope Stability

The FSC surfaces for Area 4 North and Area 4 South have been designed using a combination of fluvial geomorphic and traditional reclamation approaches. Areas designed with the fluvial geomorphic reclamation approach will contain geomorphically appropriate slopes, drainage densities, and channel profiles to mimic the pre-mine topography. Areas designed with traditional reclamation approaches will have interior slopes graded to less than or equal to 6.5h:1v overall and outslopes graded to less than or equal to 4h:1v overall. The designed slopes contained in the FSC surfaces have been designed to eliminate slopes at angle of repose and minimize the risk of slides. Slopes of the FSCs for both Areas 4 North and Area 4 South are presented in Table 34.1-1.

BNCC may include natural escarpment replacement features (e.g., thin exposed areas of end walls or final pits) into the final FSC. These features will enhance the wildlife habitat of the post-reclamation topography. The natural escarpment replacement features will typically be less than 15 feet in height and less than 500 feet in length and have a safety factor of 1.3 or greater. The criteria for designing natural escarpment replacement features are described in Section 38 (Post-Reclamation Surface Stabilization and Sediment Control).

34.2.3 Small Depressions and Final Surface Preparation

Small depressions may be established on an opportunistic basis during secondary regrading. These features will enhance post-mining topographic diversity and act as seasonal surface water collection sites. Small depressions will serve as wildlife enhancement features and microtopographic niches for establishment of mesic and/or hydric plant species. Although these depressions will not have specific design criteria, they will be small enough that they will occur within the limits of the approved FSC. These small depressions will also meet the following specific criteria:

- Each depression or combination of directly adjacent depressions will be less than 1 acre foot total capacity;
- No depression will be deeper than 10 feet
- All small depressions will be incised (below ground level);
- The maximum inslope for the small depression will be 6h:1v;
- At bond release, small depression areas will be subject to vegetation sampling similar to any area within the bond release parcel.

Small depressions meeting the design criteria listed above will not require design approval prior to construction from the Office of Surface Mining Reclamation and Enforcement (OSM). However, OSM must authorize the retention of small depressions prior to final bond release.

34.3 Post-Reclamation Topography Collection and Analysis

Norwest developed the initial PMT surface model using QUICKSURF™ software and dragline spoil modeling techniques that jointly operate in an AutoCAD environment. Their surface model was based on inputs provided by BNCC. These inputs included, but are not limited to, the operational mine plan, material swell factors and geologic modeling. This final PMT was used by Norwest to design the FSC, develop the cut/fill contours, reclamation blocks, and perform volumetric calculations for Area 4 North and Area 4 South.

Along with the final PMT surface, Norwest utilized site-specific field measurements and Carlson Natural Regrade with GeoFluv™ to develop the FSC surface. Appendix 34.A describes in detail the field investigations, design criteria, and FSC surface.

BNCC performed the post-mining slope analysis of the FSC using ArcGIS™ geographical information system software with the Spatial Analyst™ and 3D Analyst™ software extensions. Utilizing a combination of triangular irregular network (TIN) surfaces and raster datasets, BNCC was able to calculate the percent slopes and determine percentage of permit area for each slope class in 3% slope increments. For a more detailed discussion on the slope analysis, see the pre-mine slope analysis discussion in Section 13 (Topography).

34.4 Certification of Designs and Exhibits

All certified exhibits for this section of the permit application package are available for review upon request at the mine office or OSM, Western Region, technical office in Denver, Colorado. Certified as-built drawings will be kept on file at the mine site and made available upon request.

Personnel

Persons or organizations responsible for data collection, analysis, and preparation of this permit application package section:

Ron Van Valkenburg	Norwest Corporation
Kent Applegate	Salt Lake City, UT
Matt Owens	
BHP Navajo Coal Company	

References

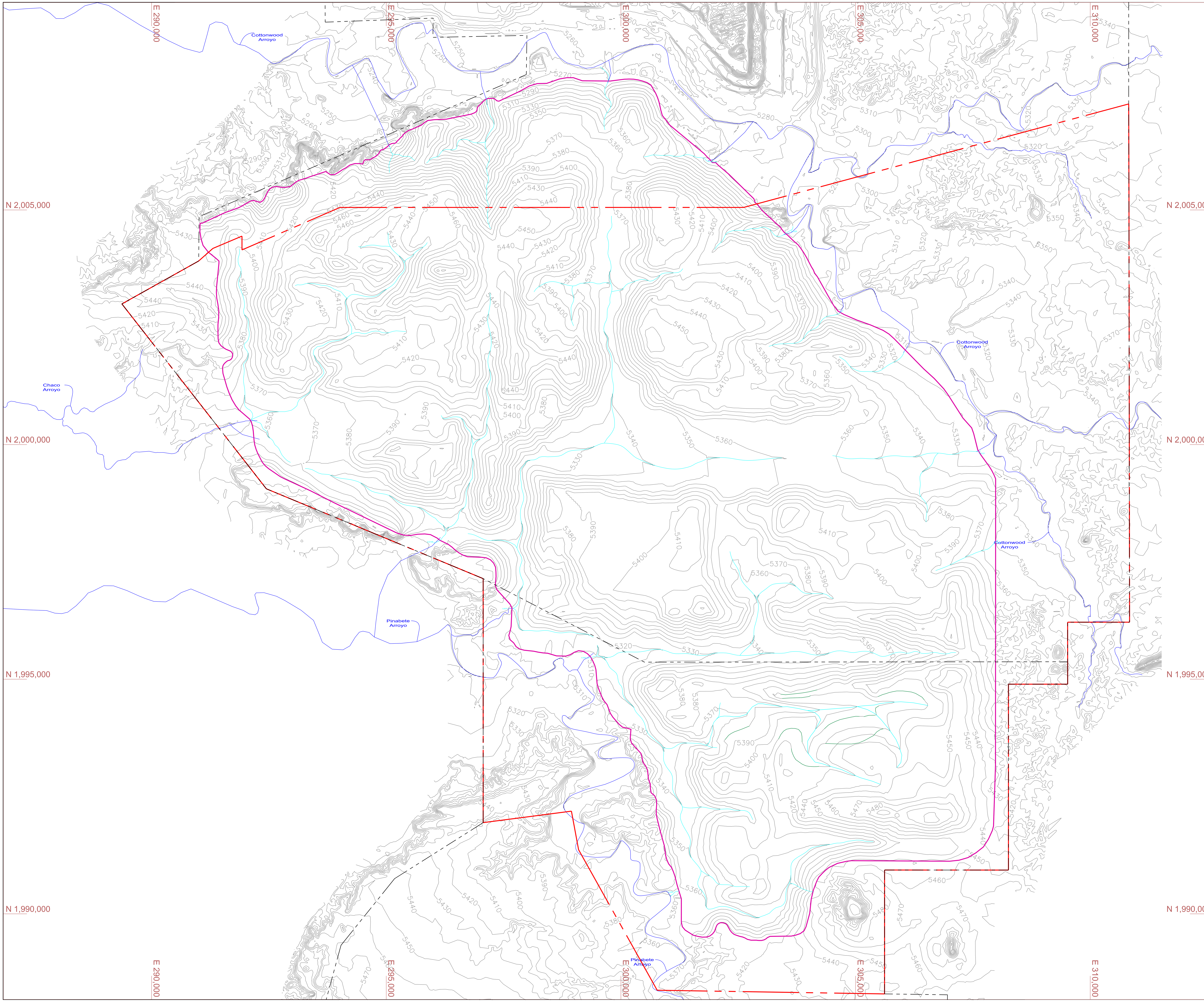
Dunne T., and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Feeman, San Francisco, California.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Table 34.1-1 Post-Reclamation Final Surface Configuration Slope Analysis for Area 4 North, Area 4 South, and the Pinabete Permit Area

	Area 4 North Resource Area		Area 4 South Resource Area		Pinabete Permit Area	
Slope Class	Acres	Percent (%)*	Acres	Percent (%)*	Acres	Percent (%)*
0 – 3%	1,598.3	38.7	478.7	33.2	2,076.9	37.3
>3 – 6%	1,298.4	31.4	455.1	31.6	1,753.6	31.5
>6 – 9%	552.2	13.4	238.2	16.5	790.4	14.2
>9 – 12%	370.7	9.0	136.0	9.4	506.7	9.1
>12 – 15%	242.0	5.9	85.6	5.9	327.6	5.9
>15 – 18%	50.0	1.2	24.2	1.7	74.2	1.3
>18 – 21%	6.7	0.2	7.6	0.5	14.3	0.3
>21%	10.5	0.3	14.3	1.0	24.9	0.4
Total*	4,128.8	100.1	1,439.7	99.8	5,568.6	100.0

* Total percent may not equal 100 due to rounding



LEGEND

- PERMIT BOUNDARY
- LEASE BOUNDARY
- GRADING LIMIT
- EXISTING DRAINAGE
- 5320 FSC CONTOURS
- FSC DRAINAGE LINE

0 600 1200 1800ft

SCALE 1":600'

SCALE INDICATED BASED ON A 36"x48" PLOT CONFIGURATION

CONTOUR INTERVAL: 10'

Original certified signed exhibits are maintained at the mine site and at OSM.

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	DATE CERTIFIED
12-A	Mar 2012	NL	PREPARED FOR SUBMITTAL TO OSM	NL		OSE	

APPROVALS

CERTIFICATION STATEMENT

I, Sean Ennis, hereby certify that this drawing was reviewed by me and that the information shown is complete and accurate to the best of my knowledge.

SEAN ENNIS NEW MEXICO 16668 LICENSED PROFESSIONAL ENGINEER

Sean Ennis Mar. 30, 2012

EXHIBIT 34.1-1

BHP NAVAJO COAL COMPANY

bhpbilliton

P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416

PHONE (505) 598-4200
Fax (505) 598-4229

PINABETE PERMIT FINAL SURFACE CONFIGURATION

PREPARED BY NL	DRAWN BY NL	SCALE: 1" = 600'
APPROVED BY	DATE 03/19/2012	

LEGEND

- PERMIT BOUNDARY
- LEASE BOUNDARY
- GRADING LIMIT
- 5320 PMC CONTOURS

0 600 1200 1800ft

SCALE 1":600'

SCALE INDICATED BASED ON A 36"x48" PLOT CONFIGURATION

CONTOUR INTERVAL: 10'

Original certified signed exhibits are maintained at the mine site and at OSM.

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	DATE CERTIFIED
12-A	Mar 2012	NL	PREPARED FOR SUBMITTAL TO OSM	NL		OSE	

APPROVALS

CERTIFICATION STATEMENT

I, Sean Ennis, hereby certify that this drawing was reviewed by me and that the information shown is complete and accurate to the best of my knowledge.

SEAN ENNIS NEW MEXICO 16668 LICENSED PROFESSIONAL

Mar. 30, 2012

EXHIBIT 34.2-1

BHP NAVAJO COAL COMPANY

bhpbilliton

P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416

PHONE(505)598-4200
Fax(505)598-4229

PINABETE PERMIT POST MINING CONFIGURATION

PREPARED BY NL	DRAWN BY NL	SCALE: 1" = 600'
APPROVED BY	DATE 03/20/2012	

LEGEND

- PERMIT BOUNDARY
- LEASE BOUNDARY
- RAMP
- GRADING LIMIT
- -30 CUT CONTOURS
- 40 FILL CONTOURS

N

0 600 1200 1800ft

SCALE 1":600'

SCALE INDICATED BASED ON A 36"x48" PLOT CONFIGURATION

CUT AND FILL CONTOUR INTERVAL: 10'

Original certified signed exhibits are maintained at the mine site and at OSM.

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	PRE'D BY	E.Q.	P.E.	DATE CERTIFIED
12-A	Mar 2012	NL	PREPARED FOR SUBMITTAL TO OSM	NL		OSE	
				APPROVALS			

CERTIFICATION STATEMENT

I, Sean Ennis, hereby certify that this drawing was reviewed by me and that the information shown is complete and accurate to the best of my knowledge.

SEAN ENNIS NEW MEXICO 16668 LICENSED PROFESSIONAL

Mar. 30, 2012

EXHIBIT 34.2-2

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Fax(505)598-4229

PINABETE PERMIT
RECLAMATION CUT & FILL BLOCKS
TIMING MAP

PREPARED BY NL	DRAWN BY NL	SCALE: 1" = 600'
APPROVED BY	DATE 03/19/2012	

Appendix 34.A

Final Surface Configuration Technical Report – Pinabete Mine Plan Permit Area

February 28, 2012

APPENDIX 34.A

**FINAL SURFACE CONFIGURATION TECHNICAL REPORT –
PINABETE MINE PLAN PERMIT AREA**

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**FINAL SURFACE CONFIGURATION TECHNICAL REPORT –
PINABETE MINE PLAN PERMIT AREA**

LIST OF ATTACHEMENTS

INTRODUCTION

BHP Navajo Coal Company (BNCC) contracted Norwest Corporation (Norwest) to develop a Final Surface Configuration (FSC) contour reclamation surface within the Pinabete Mine Plan permit area (permit area). BNCC provided to Norwest information, such as the mine operational plan, material swell factors and geologic model data, to assist them in designing the FSC, developing cut/fill contours and reclamation blocks, and performing volumetric calculations. Norwest also utilized site-specific field measurements and data from the attached report (See Attachment 34.A) “Approximate Original Contour Technical Report”, by URS Corporation. Norwest utilized the Carlson Natural Regrade with GeoFluv™ software to develop the FSC surface.

BACKFILLING AND GRADING DESCRIPTION

Following topsoil removal for proposed mining operations, the majority of the overburden is removed by a dragline stripping operation. This operation is assisted by a truck-loader stripping operation which will primarily remove overburden in the box-cuts as well as partings or interburden layers that exist between coal seams near the pit floor.

Development of the west advance in the southern portion of the permit area required a step down approach where the full pit depth was reached over a series of four cuts. The box cut was 250’ wide and reached the No. 8a2 and 8b2 coal seams. The successive cuts were progressively narrower and required truck loader assist. Approximately 12.0 million bank cubic yards of overburden/interburben material was removed by the truck-loader fleet and placed as minefill in the dragline spoils and ramps in the northern portion of the pit (Area 4 North). An additional 6.7 million bank cubic yards was removed and placed ahead of the southern stripping operation in areas of low overburden cover (Area 4 South). In strip #70 the pit extends 1500’ to the south which required 9.4 million bank cubic yards of truck-loader assist over the first four cuts. This overburden/interburden material was spoiled in the pit access ramps of the west advance.

The draglines at operating in the permit area will be used for overburden and interburden removal. Dragline cut widths are generally 150’ to 160’ and cut lengths vary from 1,000’ to 15,000’. Multiple coal seams within each cut require that the draglines conduct multiple passes in order to uncover successively deeper seams as each exposed seam is removed. Generally, each dragline will operate on the high wall side of the pit to expose the upper seams and will uncover the lower seams from the spoil side.

Developing the final surface contours (FSC) requires that a balanced backfill surface be determined first. The initial step in this process was to model the associated dragline spoils that result from the coal removal sequence provided by BNCC. Modeling of the mined-out cuts and illustrating the resulting dragline spoils was accomplished using a combination of QUICKSURF™ software and dragline spoil modeling techniques that jointly operate in an AutoCAD environment.

Dragline spoil modeling is performed using routines that provide elevated contour drawings of the spoil peaks and valleys based on range diagram calculations inherent in the software programming. The spoil configuration consists of inputting AutoCAD drawn entities representing a 38° slope (measured from horizontal) that commences at the toe of the lowermost coal seam and includes a 30' wide bench approximately midway between the toe and spoil peak. Waste or unrecovered coal is assumed to remain in the pit and is accounted for by adding 8% of the total coal thickness to the pit floor surface prior to placement of the dragline spoils. The bank overburden material is also swelled 25% for spoil balance calculations. Final material cut/fill balance is achieved by incrementally raising or lowering the spoil peaks and valleys to match the modeled stripping volume. Any such adjustment is maintained within the operating parameters of the draglines.

Modeling to determine the dragline spoil surface also includes spoil displaced by coal haulage ramps that traverse the spoils. Spoil volumes for these entities are locally balanced to the cut volumes within corresponding cut(s) depending on the complexity of the mining and/or ramp configuration.

After the dragline spoils are modeled, the next step in developing the FSC is to bring the dragline spoils to a balanced state by cutting the spoil peaks and filling the valleys. This creates an adjusted surface to either begin manipulating for FSC or to commence placement of truck loader assist overburden stripping volume. The resulting balanced surface will, in many cases, contain low areas that do not properly drain as well as elevated areas possessing slopes that exceed the allowable maximums. These areas require further manipulation to develop an acceptable FSC where material balance is maintained throughout.

In addition to the iterative surface manipulations, drainages are also integrated into the FSC. Drainages were generally located where the final cut(s) and coal haulage access ramps create depressions in the spoil contours and can be incorporated into the graded spoils to allow proper drainage of the spoils. Spoil drainage gradient determinations are either based on the gradients of the undisturbed portions of the associated drainage or maintained in a concave profile to insure hydraulic stability. The upper drainage gradients mimic the undisturbed gradient while the slope of the lower reaches is lessened to the extent possible. Generally, the overall gradient is kept as flat as practical to minimize the volume of material required to fill the final voids or ramps. Ramp areas and final pit voids are commonly graded with dozers using locally available fill. In some cases, material is dozed from the final high walls to assist in regrading the final voids. When such areas require more fill than the dozers can practically push, additional material is obtained from more distant spoil areas using the truck loader operation. Additionally, any remaining boxcut spoil will be utilized in these areas to minimize the additional disturbance for backfill material. The resulting FSC is a materially-balanced surface with stable drainages and contours that approximate the pre-mining conditions.

GEOMORPHIC RECLAMATION APPROACH

BNCC will utilize both traditional and fluvial geomorphic reclamation approaches to develop the FSC for the Pinabete Mine Plan permit area. The combination of these approaches enables BNCC to meet the objectives of the FSC as described below:

1. Achieve mass balance while maximizing contemporaneous regrade acreage between ramps,
2. Achieve positive drainage, except for the small depressions mentioned below, from all areas including pits and ramps,
3. Develop an adequate drainage density,
4. Allow development of stable drainage channels,
5. Support the approved post-mining land use.

The fluvial geomorphic reclamation approach utilizes site-specific fluvial geomorphic data, including but not limited to drainage density, tributary lengths and associated areas, sinuosity, width to depth ratios, and length between channels, to develop a reclamation surface model that generally mimics the natural landscape.

Natural Regrade Software

The Natural Regrade software was utilized to develop the FSC reclamation surface. This is a computer model that applies fluvial geomorphic principles to develop a landscape design that generally mimics the natural landscape, as it would evolve over time under existing physical and climatic conditions. The software identifies the type of drainage network that would tend to form over a long period of time given the site's earth material, relief, and climate to achieve a stable landform. The product of the model represents the guide to design and build a suitable stable landform. The input variables are:

- Boundary Conditions
  - Disturbance limits
  - Drainage basins
  - Local stream base level for the main channel
  - Elevation at the head and mouth of the main drainage channel
- Watershed Characteristics
  - Reference Watershed
    - Length between channels, ridge to head length
    - Meander wavelength, A-channel length
  - Target drainage density
  - Stream Classification
    - Width to depth
    - Sinuosity

- Hydrologic/Hydraulic Parameters
  - Precipitation from the 2 year 1 hour (2yr-1hr) and 50yr-6hr storm events to determine the backfull and flood-prone flows
  - Runoff coefficient
  - Offsite drainage basins
  - Maximum discharge velocity

Boundary Conditions

Project limits include indentation of the overall regrade boundary, potential drainage basin, location of the main channel and elevations and the head and mouth of the main channel. The project limits were set by the BNCC grading limit for Pinabete permit area. The main channel that currently runs through the project limits is the Pinabete Arroyo.

Contemporaneous reclamation is planned for the site during mining. As part of the contemporaneous reclamation plan the Pinabete Arroyo and tributary drainage basins were laid out to best manage storm water. Currently there are several large drainage basins contributing to the Pinabete Arroyo. Channels will be constructed concurrently with the conclusion of mining within portions of Area 4 South.

Watershed Characteristics

Reference Watershed

As part of the development of parameters for the Natural Regrade software, a reference watershed is chosen that will represent the post reclamation area. This watershed has the same general characteristics, soil type, relief, drainage pattern, and precipitation that is proposed for the post-reclamation area. The drainage basins and watershed analysis data was used from field investigations for previous proposed project (Attachment 34.A).

Within Rosgen's channel classifications (Rosgen 1996), channels are classified based on slope and overall channel geometry. A-channels are those which have a slope greater than 4%, and tend to occur at the headwaters of a channel or near the ridge lines. The ridge to head length input into the model was 80 feet.

Drainage Density

The drainage density for Area 4 North and Area 4 South were based on previous studies and field investigations. Area 4 North has significant relief, rock channel bottoms and bedrock outcrops resulting in a higher drainage density than Area 4 South. A drainage density of 80 feet/acre (+/- 10%) was used. Area 4 South has mild slopes, minimal bedrock outcrops with alluvial sand deposits. A drainage density of 40 feet/acre (+/- 10%) was used.

Stream Classification

As previously stated, the Natural Regrade model utilizes principles described by Rosgen (Rosgen 1996). The Rosgen classification for a natural channel is based on slope, width to depth ratio, entrenchment ratio, sinuosity, and streambed particle size. The Rosgen classification scheme describes channels as A through G using multiple and single thread channels to differentiate between geological settings.

Channels A and A+ are narrower channels that exist in slopes greater than 4%. B type channels have a relatively low sinuosity, with stepped transitions generally related to resistant rock strata generally occurring in narrow canyons with limited sinuosity. Types C and E differ through their width-to-depth ratio and sinuosity. An E channel generally has a lower width-to-depth ratio, is generally stable but is sensitive to disturbance of bank material and vegetation. A type C channel tends to migrate laterally through cutbank erosion and subsequent deposition. Multiple thread D and single-thread F and G are transitional formed channels that exist as the channel develops a more stable form and are generally associated with high erosion rates, sediment transport and deposition.

Based on these classifications channel types A, C and E are generally utilized in developing stable reclamation designs. The model defaults create A and A+ channels at slopes greater than 4% and Bc channels for slopes less than 4%, which can be modified.

Based on previous field investigation and studies, it was assumed that the existing Pinabete Arroyo is a Type C5c channel. This designates that the channel has a slope less than 1%, the sinuosity ratio is greater than 1.2, and the width-to-depth ratio is greater than 12. This channel type is transitional and possibly more stable in another phase. A more stable channel would have higher sinuosity and result in larger radius of curvature than the current condition. A type C5c channel was utilized for the current design. This channel type utilizes the following channel characteristics:

- Width-to-depth
  - 12 – when the slope is greater than 4%
  - 16 – when the slope is less than 4%
- Sinuosity
  - 1.2 – when the slope is greater than 4%
  - 1.5 – when the slope is less than 4%

These channel characteristics were utilized for all tributary areas to the regrade area.

Hydrologic/Hydraulic Parameters

Precipitation-Bank and Flood Prone

The Natural Regrade model estimates widths and depths for the channel based on precipitation during the 2yr-1hr and the 50yr-6hr storm events. Precipitation depths for these storm events are estimated based on the location and the elevation of the proposed reclamation site. The precipitation depths estimated for the proposed reclamation area are 0.62 inches and 1.75 inches for the 2-year and 50-year storms, respectively.

Runoff Coefficient

The Natural Regrade model defaults to the Rational Method to estimate peak discharges for the channels. Peak discharges for the design storm can be input at the head of the channel but it not distributed along the length of the channel. The default runoff coefficient for the model is 0.89.

Maximum Discharge Velocity

The Natural Regrade model uses the permissible velocity method which uses a parameter called the maximum discharge velocity. A value of 4.5 feet per second was used, this value is the default value in the Natural Regrade model and represents the minimal channel erosion.

References

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Attachment 34.A

Approximate Original Contour Technical Report – Navajo Mine Extension Project
March 28, 2008

FINAL REPORT

APROXIMATE ORIGINAL CONTOUR TECHNICAL REPORT-NAVAJO MINE EXTENTION PROJECT

Prepared for
BHP Billiton
300 West Arlington, Suite 200
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March 28, 2008

URS

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Project No. 22236776
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INTRODUCTION

BHP Navajo Coal Company (BNCC) plans to develop an expansion surface coal project in northern New Mexico, the Navajo Mine Extension Project (NMEP). The NMEP is located in San Juan County on the Navajo Indian Reservation adjacent to BNCC's Navajo Mine, within the BHP Navajo Coal Company Lease Area. The NMEP will include BNCC lease Areas 4 South (4S) and 5; however, this project focuses on Area 4S.

An Approximate Original Contour (AOC) reclamation surface was developed within Area 4S of the BNCC mine lease. The AOC is being developed in order to satisfy regulatory, corporate and commercial requirements that BNCC must comply with before beginning mining within the area. To develop the AOC, the existing drainage conditions must be approximated and recreated. These include the Pinabete Arroyo and its tributary channels. Additionally, during mining the drainage upstream of the southern pit boundary will be temporarily diverted and conveyed into the adjacent No Name Arroyo. Post-mining, the surface water drainage from the reclaimed mine area will flow into the re-established Pinabete Arroyo and drainage channels.

FIELD INVESTIGATION

A field investigation was completed from August 27 to 29, 2007, to conduct a drainage density survey of the Pinabete and No Name Arroyos within the NMEP Area 4S. The field investigation included examining the Pinabete and No Name Arroyos and their major tributaries to develop inputs for the AOC analysis. Data gathered included drainage density, tributary lengths and associated areas, sinuosity, width to depth ratios, length between channels (Head to ridge length), and length between meanders in steep channel sections (A-channel length).

Several drainage areas were identified for the field investigation prior to and during the field survey based on their identified hydrologic features, soil types, channel and surrounding areas relief. This included review of three to four separate watersheds over the three-day period.

DESIGN BASIS

The *Carlson Natural Regrade with GeoFluv* ™ model software (Natural Regrade) software was utilized to develop the AOC reclamation surface. This is a computer model that applies fluvial geomorphic principles to develop a landscape design that generally mimics the natural landscape, as it would evolve over time under existing physical and climatic conditions. The product of the model represents the guide to design and build a suitable stable landform. The model generally follows the morphologic principles developed by Dave Rosgen (Rosgen, 1996). The input variables include:

- Boundary Conditions
- Watershed Characteristics
- Hydrologic/Hydraulic Parameters

The majority of the above parameters were developed from field data, including the drainage density, channel sinuosity, ridge to head length and A-channel length.

Boundary Conditions

Project limits include identification of the overall regrade boundary, potential drainage basin, location of the main channel and elevations and the head and mouth of the main channel. The project limits were set by the BNCC Lease Boundary for Area 4S.

Watershed Characteristics

Watershed characteristics include the identification of a reference watershed, drainage density, establishment of angles for channel confluences, and classification of stream orders.

A reference watershed was chosen for the area that would have the same general characteristics, soil type, relief, drainage pattern and precipitation as that which is proposed for the post reclamation area. Drainage Basin 18 was used as the reference watershed because it was the most typical of the watersheds in the Project area.

Drainage density is a measurement of channel spacing and is generally the ratio of the total length of channel to the drainage area. The drainage density of the Project area was evaluated during the field investigation. Several drainage basins were examined, including, Drainage Basins 18 and 28. Drainage Basin 18 was relatively flat with the majority being alluvial deposits, Drainage Basin 28 has steeper slopes and rock outcrops. The drainage densities for Drainage Basins 18 and 28 were 20 and 260 feet per acre (ft/acre) respectively. Drainage Basin 18 was considered to be within an alluvial deposit. The soil type within an alluvial deposit is the most representative of the post-mining soil condition.

As part of the reclamation model, a representative drainage density had to be evaluated for the site. The appropriate drainage density should be a function of terrain aspect and slope as well as precipitation and soils. The overall reference drainage density is between 25 and 80 ft/acre based on the location within the regraded site, the lower being on the south and the higher being to the north.

The channel confluences with the reclaimed or AOC surface were modified to have sufficient angle and velocity to transport sediment through the confluence and to enter the main channel at the concave outer bank of the meander where possible.

Hydrologic/Hydraulic Parameters

The Natural Regrade model estimates widths and depths for the channel based on precipitation during the 2-year, 1-hour and the 50-year, 6-hour storm events. Precipitation depths for these storm events are estimated based on the location and the elevation of the proposed reclamation site. The precipitation depths estimated for the proposed reclamation area are 0.62 and 2.67 inches for the 2-year and 50-year storms, respectively.

Natural Regrade defaults to the Rational Method to estimate peak discharges for the channels. Comparing the values from three methods, the Rational Method, the preliminary SEDCAD™ model, and the SCS unit-hydrograph method suggest that the values from the SCS method appear to be the most representative of the current hydrologic conditions. For offsite basins, SCS unit discharge rates were utilized for estimating the upstream watershed contribution to channels. However, for channels originating within the geofluvial boundary the Rational Method is used for comparing hydrographs of the basin and, are appropriate for the smaller basin where both

SEDCAD™ and the SCS method do not apply. Natural Regrade utilizes the peak discharges estimated by the rational method to size the onsite channels. To adjust for the inaccuracy of the Rational Method, the coefficient was reduced based on the results of the SCS methodology. The resulting coefficient utilized was 0.75. Using this coefficient, the Natural Regrade model calculated channel widths and depths that were representative of the existing hydrologic conditions.

The Natural Regrade model uses the permissible velocity method utilizes a parameter called the maximum discharge velocity. The velocity is defined based on the soil materials that will be utilized in the channel bed formation. Based on review of the soil type and the previously utilized velocities for this area, a velocity of 4.5 feet per second (fps) was utilized based on previous studies by the Natural Regrade software developer.

APPROXIMATE ORGINAL SURFACE

Following the design basis outlined above, a surface configuration was developed to reflect the post-mining topography of the project site. The site was broken down into seven major drainage basins, three on the west and two on the east side of the Pinabete reconstruction, and two contributing runoff offsite.

The limits of seven basins on the project site were established. These included three on the west side of the Pinabete reconstruction, two on the east side, and two watersheds that convey runoff offsite. The overall site drainage density was estimated as 30 ft/acre.

A cut and fill analysis was completed to evaluate the AOC in comparison with the PMT. The Natural Regrade software was utilized to evaluate the excavation requirements. The overall cut and fill for the site was estimated as 82,000,000 cubic yards (Mcy) and 73Mcy respectively. The average depth of cut and fill for the entire surface is approximately 25 and 28 feet respectively. The overall percent difference in cut versus fill is approximately 10 percent.

BHP Navajo Coal Company (BNCC) requested URS Corporation (URS) develop an Approximate Original Contour (AOC) reclamation surface within Area 4 South (4S) of the BNCC mine lease. The AOC is being developed in order to satisfy regulatory, corporate and commercial requirements that BNCC must comply with before beginning mining within the area.

URS has performed a field investigation, evaluated the existing pre-mine hydrologic and hydraulic conditions, developed a pre-graded and preliminary regraded surface (AOC) from the provided Post Mining Topography (PMT), as well as developed initial cut and fill quantities.

1.1 PROJECT BACKGROUND

BNCC plans to expand a surface coal project in northern New Mexico, the Navajo Mine Extension Project (NMEP). The NMEP is located in San Juan County on the Navajo Indian Reservation adjacent to BNCC's Navajo Mine, within the BHP Navajo Coal Company Lease Area. The NMEP will include BNCC lease Areas 4S and 5; however, this project focuses on Area 4S.

BNCC provided URS with the Post Mining Topography (PMT) for Area 4S as the basis for developing the post-mining drainage network, as part of the AOC. The PMT included the disturbed surface along with the location of ash deposition, box cuts, spoils piles, and ramps for the ultimate pit configuration. The proposed mining activities disrupt the current hydrology of the site, excavating over existing channels and drainage basins. To develop the AOC, the existing drainage conditions must be approximated and recreated. These include the Pinabete Arroyo and its tributary channels.

The Pinabete Arroyo currently runs through the proposed mining area. During mining, the drainage upstream of the southern pit boundary will be temporarily diverted and conveyed into the adjacent No Name Arroyo and the drainage from the active mine area will be contained within the mine site. Post-mining, the surface water drainage from the reclaimed mine area will flow into re-established Pinabete Arroyo and drainage channels. The regrade for the Pinabete Arroyo will serve as the main drainage channel through the reclaimed site and all of the adjacent regraded areas are tributary to this channel.

BHP Billiton has previously used the *Carlson Natural Regrade with GeoFluv* ™ model software (Natural Regrade) to develop designs for post-mining reclamation. This program, developed by Carlson Software, was recommended by BNCC for use within this project and was utilized for the development of the AOC. For the program, several watershed, hydrologic, hydraulic, and channel morphologic parameters are required as input to the model. These parameters were developed during a field investigation and through discussions with both the software developer and personnel from BHP Billiton who had previously utilized the model.

1.2 REPORT ORGANIZATION

This report presents the design basis for the developed of the AOC surface. The report has been organized into the following sections:

- Section 1 – Introduction
- Section 2 – Field Investigation
- Section 3 – Design Criteria

- Section 4 – AOC Surface
- Section 5 – References

2.1 FIELD INVESTIGATION

A field investigation was completed from August 27 to 29, 2007, to conduct a drainage density survey of the Pinabete and No Name Arroyos within the NMEP Area 4S. The results of the investigation were previously submitted to BNCC within the technical memorandum dated September 28, 2007, but are summarized within this section to provide clarification for the development of the AOC. For reference, the September 28, 2007 Technical Memorandum is presented as Attachment A of this report.

The field investigation included examining the Pinabete and No Name Arroyos and their major tributaries to develop inputs for the Natural Regrade model. Data gathered included drainage density, tributary lengths and associated areas, sinuosity, width to depth ratios, length between channels (Ridge to Head length), and length between meanders in steep channel sections (A-channel length).

Several drainage areas were identified for the field investigation prior to and during the field survey based on their identified hydrologic features, soil types, channel and surrounding areas relief. This included review of three to four separate watersheds over the three-day period.

2.1.1 Day 1- Reconnaissance and Selection of Representative Drainages

The URS team performed an overall reconnaissance of the area by driving through the project area from north to south over the watersheds of both the arroyos. The first basin explored was Drainage Basin 18. This drainage basin is located immediately downstream of Burnham Road and drains to the Pinabete Arroyo directly downstream of cross section P-3. A Global Positioning System (GPS) receiver was used to mark the drainage features of the tributary channels within Drainage Basin 18 .

The channels within Drainage Basin 18 were fairly flat and narrow, with rectangular shapes, having a bottom width varying from less than 1-foot to over 10-feet and sideslopes from 1H:1V to 3H:1V. The main channel extended approximately 5,000 feet to the southwest from the discharge point into the Pinabete, the total length of channel within the basin is 18,400 feet. During the last day of the site visit, the contributing drainage area was estimated. The drainage area is approximately 322 acres. The estimated drainage density was 60 feet per acre (ft/acre).

From the field investigation, it was estimated that there were minimal channels having a classification of A or B, with the majority of the channels classified as C. For this reason, it was difficult to measure A-channel length. Additionally due to the flat area and small changes in grade between channels, there were no measured Ridge to Head lengths that were deemed representative.

The soil within channel was alluvial deposits and bedrock outcrops. The area within the channel identified contained large rock fragments along the channel bottom, extending into the channel side slopes. The channel was unstable resulting in continuous erosion in areas unlined with rock, as presented in Photos 7, 8 and 9, within the attached photo log (Attachment B).

2.1.2 Day 2- A-Channel and Head to Ridge Lengths

During the second day of the field activities, the URS team identified several features within Drainage Basin 22, located adjacent to Drainage Basin 18, and within a northeast portion of Drainage Basin 21. Within both Drainage Basins 22 and the northeast area of Drainage Basin 21, the team identified ridges and valleys where A-channel lengths could be evaluated and the overall terrain contained a greater amount of elevation change including ridges and valleys with concave to convex channels.

The channel lengths were measured and GPS points were taken along the channel alignments to estimate elevation change and length of the A channels. The areas with identifiable ridges and valleys contained a slightly different soil type with less alluvial sands and a greater volume of gravel sized rocks. These areas were found to have a more stable channel formation, narrower with a reduced amount of rilling. The estimated average A-channel length and Ridge to Head length was approximately 30 and 150 feet respectively, with one outlying Ridge to Head length of 650 feet.

At the end of the second day, the URS team examined the two additional basins, Drainage Basin 21 within the Pinabete watershed and Drainage Basin 1 within the No-Name watershed that had been identified as potential sources for information prior to the site visit. Both of these basins had fairly flat topography with no measurable ridges and valleys.

The URS team conducted a foot survey along the Pinabete Arroyo to identify the contributing drainage areas that would be representative a post mine surface after modeling.. The URS team identified Drainage Basin 28 as a potential representative basin for this purpose. This basin was approximately 1 mile downstream, to the northeast of Drainage Basin 18. At the end of the second day, the evaluation of the drainage density in Basin 28 was initiated.

2.1.3 Day 3- Drainage Basin 28 and Input Elevations

On the third day, the URS team continued to measure the length of the channels within Drainage Basin 28. The channels within this basin were steeper than those previously measured, having slopes varying from 2 to 20 percent. The channels were narrow in comparison with those within Drainage Basin 18. The channels generally had a trapezoidal shape, varying bottom width from 0.5 to 4 feet, and 1H:1V to 2H:1V sideslopes. The main channel extended approximately 1,080 feet to the outfall into the Pinabete, the total length of channel within the basin is 2,350 feet. During the last day of the site visit, the contributing drainage area was estimated. The drainage area is approximately 16.8 acres. The estimated drainage density was 140 ft/acre.

Based on our examination in the field, the majority of the channels contained an A-channel reach and a measurable Ridge to Head length. Measurements were taken as deemed necessary on the channels. The estimated average A-channel length and Head to Ridge Length was approximately 20 and 100 feet, respectively.

The soil within this area, adjacent to Drainage Basin 28, was similar to the soil in Drainage Basin 22 identified during the second field day with lower fraction of alluvial deposits and more gravel-sized rocks. For the majority of the channels, it was noted that within the transition between the concave to convex area there were larger rock fragments. Generally, this basin seemed to be more stable than Drainage Basin 18.

During the last part of Day 3, the URS team took GPS data at the estimated upstream and downstream elevation of the main channel within regrade area. Because it was difficult to estimate the exact area, the URS team walked a significant portion of the channel. The upstream and downstream elevations were estimated using GPS readings at 5440 feet and 5310 feet mean sea level (MSL), respectively.

The Natural Regrade software was utilized to develop the AOC reclamation surface. This is a computer model that applies fluvial geomorphic principles to develop a landscape design that generally mimics the natural landscape, as it would evolve over time under existing physical and climatic conditions. The software identifies the type of drainage network that would tend to form over a long period of time given the site's earth materials, relief, and climate to achieve a stable landform. The product of the model represents the guide to design and build a suitable stable landform. The model generally follows the morphologic principles developed by Dave Rosgen (Rosgen, 1996). The input variables include:

- Boundary Conditions
  - Disturbance Limits;
  - Drainage Basins;
  - Local stream base level to which the area within the boundary drains for the main channel; and,
  - Elevation at the head and mouth of the "main" drainage channel.
- Watershed Characteristics
  - Reference Watershed;
    - Length between channels, ridge to head length; and,
    - Meander wavelength within reaches steeper than 4 percent, A-channel length.
  - Target drainage density; and,
  - Stream Classification -Width to depth ratio and sinuosity.
- Hydrologic/Hydraulic Parameters
  - Precipitation from the 2-year, 1-hour and 50-year, 6-hour storm events to determine the bankfull and flood-prone flows;
  - Runoff Coefficient;
  - Offsite Drainage Basins; and,
  - Maximum discharge velocity.

The majority of the above parameters were developed from field data, including the drainage density, channel sinuosity, ridge to head length and A-channel length.

3.1 BOUNDARY CONDITIONS

Project limits include identification of the overall regrade boundary, potential drainage basin, location of the main channel and elevations and the head and mouth of the main channel. The project limits were set by the BNCC Lease Boundary for Area 4S.

The main channel that currently runs through the project limits is the Pinabete Arroyo. Following mining, this channel will be restored and will serve as the main channel through the regrade area. The elevation at the edge of the project limits for both the head and the mouth of the Pinabete was estimated during the field investigation to be 5440 and 5310 feet MSL, respectively. Elevations were estimated using GPS equipment with a tolerance of approximately 0.5 feet.

Contemporaneous reclamation is planned for the site during mining. As part of the contemporaneous reclamation plan the Pinabete Arroyo and tributary drainage basins were laid out to best manage stormwater. A review of the existing drainage basins within the project area was completed during the field investigation. Currently, there are several large drainage basins contributing to the Pinabete Arroyo. Channels will be constructed concurrently with the conclusion of mining within portions of Area 4S. The Pinabete channel will not be finalized until all mining is completed, as such runoff contributing to the Pinabete will need to be stored in ponds. To minimize the number of ponds required during reclamation the number of confluences with the Pinabete was reduced.

3.2 WATERSHED CHARACTERSTICS

3.2.1 Reference watershed

As part of development of parameters for Natural Regrade, a reference watershed is chosen that will represent the post reclamation area. This watershed has the same general characteristics, soil type, relief, drainage pattern and precipitation as that which is proposed for the post reclamation area. As described within Section 2.1, a field investigation was completed. Prior to the field investigation, several watersheds or drainage basins were identified as potentially representative of the topography in Area 4S. These drainage basins were used as reference watersheds including Drainage Basins 1, 18, 21, 22, and 28 were then evaluated for suitability as reference watersheds during the field reconaissance. Ultimately, Drainage Basin 18 was used as the reference watershed because it was the most typical of the watersheds in the Project area. Drainage Basin 18 was considered to be within an alluvial deposit. The soil type within an alluvial deposit is the most representative of the post-mining soil condition.

The length from the ridge of a drainage basin to the head of a channel defines the length between channels and drainage basins within the model. This parameter was measured within the field and an average value of 110 feet was utilized.

Within Rosgen's channel classification, channels are classified based on slope and overall channel geometry. A-channels are those which have a slope greater than 4 percent, and tend to occur at the headwaters of a channel or near the ridge lines. During the field investigation measurements were taken of the typical length of the A-channels along with the length of the channel meanders. The length input into the model was 80 feet.

3.2.2 Drainage Density

Drainage density is a measurement of channel spacing and is generally the ratio of the total length of channel to the drainage area. Across the United States, drainage density varies from three to 1300 miles per square mile. The larger the number the higher density or closer together the channels are. Studies have shown that there is a correlation between drainage-density, precipitation and evaporation.

The drainage density of the Project area was evaluated during the field investigation. Lengths were measured from the estimated head to the mouth of the channel. For this study channels were defined as having a minimum 6-inch width and 2 inch depth. Areas with drainages having dimensions smaller than this were not considered within the evaluation of drainage density. Two drainage basins, 18 and 28, were evaluated for drainage density during the site visit. Resulting drainage densities were from 20 to 260 ft/acre.. Drainage Basin 18 is on the southern portion of the site and has mild slopes, minimal bedrock outcrops with alluvial sand deposits. Drainage Basin 18 is representative of the topography of the southern portion of Area 4S as a whole. The drainage density of Drainage Basin 18 was approximately 20 ft/acre. Drainage Basin 28, on the northeast portion of the site has a significant amount of relief, rock channel bottoms and many bedrock outcrops, resulting in a drainage density of approximately 260 ft/acre.

3.2.3 Channel Confluences

The channel confluences within the reclaimed surface area were evaluated due to the potential for rapid changes in flow, sediment discharge, and changes in hydraulic geometry. There was concern of sediment transport at the channel confluences based on the angle and placement of the incoming channel. Sediment transport studies examining the angle of channel confluences have been completed by others. The *Sediment transport and bed morphology at river confluences* paper by James L. Best describes how the confluence angle and ratio of discharges between the tributary and main channels controls the sediment deposition (Best, 2006). As the confluence angle and discharge increase, the sediment contribution from the confluence channel is transported around rather than in the center of the confluence. Additionally, studies including the *Field Investigation of Flow Structure and Channel Morphology at Confluent Meander Bends* by Riley and Rhoads have shown that natural stream and river confluences tend to occur on the concave outer bank of the mender bends (Riley and Rhoads, 2007).

The channel confluences with the reclaimed or AOC surface were modified to have sufficient angle and velocity to transport sediment through the confluence and to enter the main channel at the concave outer bank of the meander where possible.

3.2.4 Stream Classification

As previously described, the model utilizes principles described by Rosgen. The Rosgen classification for a natural channel is based on slope, width to depth ratio, entrenchment ratio, sinuosity, and streambed particle size. The Rosgen classification scheme describes channels as A through G using multiple and single thread channels to differentiate between geological settings (Rosgen, 1996).

Channels A and A+ are narrower channels that exist in slopes greater than 4 percent. Multiple thread D and single-thread F and G are transitional formed channels that exist as the channel develops a more stable form and are generally associated with high erosion rates, sediment transport and deposition. B type channels have relatively low sinuosity, with stepped transitions generally related to resistant rock strata generally occurring in narrow canyons with limited sinuosity. Types C and E differ through their width-to-depth ratio and sinuosity. An E channel generally has a lower width to depth ratio, is generally stable but is sensitive to disturbance of bank material and vegetation. A Type C channel tends to migrate laterally through cutbank erosion and subsequent deposition.

Based on these classifications channel types A, C and E are generally utilized in developing stable reclamation designs. The model defaults create A and A+ channels at slopes greater than 4 percent and Bc for slopes less than 4 percent, however, this can modified.

For the design of the Pinabete Arroyo reconstruction, the pre-mining channel conditions were evaluated along with the transition phases of the channel, and the overall objectives defined by BNCC. Based on this evaluation, it was assumed that the existing Pinabete Arroyo is a Type C5c channel. This designates that the channel has a slope less than one percent, the sinuosity ratio is greater than 1.2, and the width to depth ratio is greater than 12. This channel type is transitional and possibly more stable in another phase. A more stable channel would have higher sinuosity and result in larger radius of curvature than the current condition. A Type C5c channel was utilized for the current design, with an understanding that the channel may tend to degrade and channel banks may erode slightly, forming a deeper low flow section. This channel type utilizes the following channel characteristics:

- Width to Depth Ratio
  - 12 – When the slope is greater than 4 percent
  - 16 – When the slope is less than 4 percent
- Sinuosity Ratio
  - 1.2 – When the slope is greater than 4 percent
  - 1.5- When the slope is less than 4 percent

These channel characteristics were utilized for all tributary areas to the Pinabete regrade area. The only modification was the subridge spacing on sinusoidal channels, which is applicable for channels with slopes less than 4 percent with floodplains adjacent to the channel.

3.3 HYDROLOGIC/HYDRAULIC PARAMETERS

3.3.1 Precipitation-Bank and Flood Prone

The Natural Regrade model estimates widths and depths for the channel based on precipitation during the 2-year, 1-hour and the 50-year, 6-hour storm events. Precipitation depths for these storm events are estimated based on the location and the elevation of the proposed reclamation site. The precipitation depths estimated for the proposed reclamation area are 0.62 and 2.67 inches for the 2-year and 50-year storms, respectively.

3.3.2 Runoff Coefficient

Natural Regrade defaults to the Rational Method to estimate peak discharges for the channels. Peak discharges for the design storm can also be input at the head of the channel but is not distributed along the length of the channel. The default runoff coefficient for the model is 0.89.

During the development of the conceptual AOC, the Rational Method was utilized to estimate the peak discharge contributing to the head of the onsite channels, with the exception of the Pinabete Arroyo. This resulted in tributary channels that had flood prone widths similar to that of the Pinabete Arroyo. Therefore, it was concluded that the Rational Method was over-estimating the contributing discharge to the channels. Typically, the Rational Method is not recommended for areas larger than 90 acres. In addition, the rational runoff coefficient is not constant across storm events. It varies with the storm event being evaluated, i.e. 0.5 for the 2-year and 0.65 for the 50-year. As a result URS decided to utilize a different method to estimate peak discharges for tributary channels.

To estimate a peak discharge that resulted in flood prone widths similar to those seen in the field, several methodologies for estimating peak discharge were compared. These included the preliminary SEDCAD™ models developed for the Pinabete and No Name Arroyos and the Soil Conservation Service (SCS) Curve Number method. The purpose of the SEDCAD™ model development is for evaluating potential surface water Probable Hydrologic Consequences (PHC) of the proposed NMEP.

SEDCAD™

Preliminary SEDCAD™ models have been developed for both the Pinabete and No Name Arroyos under the pre-mining and during-mining conditions. The results of the model were compared and the average peak discharge per acre was found to be 0.05 cubic feet per second per acre (cfs/acre) for the 50-year, 6-hour and 0.012 cfs/acre for the 2-year, 1-hour storm events.

SCS Unit Hydrograph Method

The SCS methodology estimates the storm runoff from a drainage basin based on basin size, curve number and lag time. Basin area was delineated using the existing 10-foot contours. SCS curve numbers were estimated based on the soil properties soil condition (type and cover), and assuming an antecedent moisture condition of Type II.

The land use was assumed to be arid to semiarid rangelands with a pinion/juniper cover type and a SCS hydrologic soil group classification of D. The soil condition was assumed to be "good", with a Type II antecedent moisture condition. The resulting curve number was 85. The method used to calculate sub-basin lag times were estimated by the SCS Curve Number Method.

The rainfall depths previously estimated (0.62 and 2.67 for the 2-year 1-hour and 50-year 6-hour, respectively) were distributed assuming a frequency storm which is typical of the storm event that occurs within the mine area. Rainfall distributions and drainage basin characteristics were then input into the USACE HEC-HMS (Version 3.0.0) rainfall/runoff computer program to calculate the peak discharges for each basin.

Comparing the values from the three methods, the Rational Method, the preliminary SEDCAD™ model, and the SCS unit-hydrograph method indicated that the values from the SCS method appear to be more reasonable for the existing hydrologic conditions. For offsite basins, SCS unit discharge rates were utilized for estimating the upstream watershed contribution to channels. However for channels originating within the geofluvial boundary the Rational Method is used for comparing hydrographs of the basin is appropriate for the smaller basin where both SEDCAD™ and the SCS method do not apply. Natural Regrade utilizes the peak discharges estimated by the Rational Method to size the onsite channels. To adjust for the inaccuracy of the Rational Method, the coefficient was reduced based on the results of the SCS methodology. The resulting coefficient utilized was 0.75. Using this coefficient, the Natural Regrade model calculated channel widths and depths that were representative of the existing hydrologic conditions.

3.3.3 Offsite Contributing Areas

Several channels have upstream drainage basins that contribute runoff to the GeoFluv regraded area, including the Pinabete Arroyo and tributary channels on the east, west and south sides of the regrade area. As part of the initial site investigation, drainage basin boundaries were identified for drainage basins contributing to the proposed regrade area, these are summarized below:

- The Pinabete Arroyo has a drainage basin that is approximately 5 square miles; a portion, about 4,000 acres, is upstream of the Project area, including a portion (4000 acres;)
- The northeast corner of the site drains to the north and into the Pinabete Arroyo downstream of the Project site. This is approximately 277 acres;
- The central portion of the site on the east side has several drainage basins that contribute to the Pinabete Arroyo and were accounted for and integrated in the best as possible configuration into the regraded channels or allowed to flow overland. This includes a total of approximately 301 acres to Panel 3 and 2100 acres to Panel 4 (Figure 2). A portion of this upstream watershed area will be temporarily diverted to and flow within a diversion that will connect to the Pinabete Diversion;
- The southern portion of the site has several drainage basins that contribute to the southern portion of Panel 4 (Figure 2). Drainage channels from these basins will be tied into existing drainages and low points. All contributing runoff will be accounted for in the overall channel capacity required. This is approximately 675 acres;
- Several drainage basins on the southwest side drain into the No Name Arroyo, approximately 101 total acres; these have been included within the regrade but will not drain into the Pinabete.

For the upper watershed contributing to the regraded Pinabete Arroyo, two methodologies were compared to evaluate the contributing runoff. The first methodology was SEDCAD™, which estimated a preliminary value of approximately 180 cubic feet per second (cfs) and 4500 (cfs) for the 2-year, 1-hour and 50-year, 6-hour storm events, respectively. Based on discussions with the Natural Regrade software developer, Nicholas Bugosh, and examining the measured bankfull height and width of the Pinabete Arroyo, it was inferred that the discharge of 180 cfs did not adequately describe the bankfull capacity of the existing channel (Bugosh, 2007a).

Therefore, a normal depth calculation was performed to estimate the representative bankfull discharge for the Pinabete Arroyo at the eastern boundary of the regrade area. Several surveyed channel cross-sections at Pinabete monitoring station P2 were used to estimate the bankfull depth as well as the longitudinal slope of the existing arroyo (Attachment A). The bankfull depth was estimated to be 4-feet with a channel slope of approximately 0.5 percent. Based on these inputs and assuming a Manning's "n" of 0.030, the bankfull discharge was estimated to be about 1,350 cfs. The 1,350 cfs, which represents the 2-year, 1-hour discharge, along with the previously estimated 50-year, 6-hour discharge of 4,500 cfs were then used within the model.

3.3.4 Maximum Discharge Velocity

There are several methods for developing what is considered a stable channel (static equilibrium). These include the permissible velocity approach and the permissible tractive force approach. For the velocity approach, the channel is assumed to be stable if the mean channel velocity is lower than the maximum permissible velocity. The tractive force approach examines the channel stresses developed at the interface between water and the material at the channel boundary. Permissible tractive force has been defined as the maximum force that will not result erosion of the channel bed material.

The Natural Regrade model uses the permissible velocity method utilizes a parameter called the maximum discharge velocity. Maximum discharge velocity is based on channel bed soil materials. Based on review of the soil type and the previously utilized velocities for this area, a velocity of 4.5 feet per second (fps) was utilized. Additionally, this value was developed as representative of minimal channel erosion in the preliminary studies completed in the development of the Natural Regrade model (Bugosh 2007b).

Section Four provides a brief description of the layout of channels and drainage basins within the proposed AOC, the developed drainage density, and the overall earthwork to develop the surface as compared with the PMT.

4.1 SURFACE CONFIGURATION

Following the design basis outlined above, a surface configuration was developed to reflect the post-mining topography of the project site. The site was broken down into seven major watersheds, three on the west and two on the east side of the Pinabete reconstruction, and two contributing runoff offsite. Figure 2 presents the designed AOC.

On the west side, there is one major channel within that contributes runoff to the Pinabete, this channel is directed from the north to the south of the site with several contributing channels along the way. The channel was directed against the natural basin flowpath to reduce the gradient of the channel, facilitate contemporaneous reclamation, and optimize the overall earthwork required within this area. This basin has been designated West 2. Directly to the south, there is a small watershed which contributes directly to the Pinabete reconstruction this is designated the West 1 basin. The West-Pinabete watershed is immediately east of West 2. West 2 and West-Pinabete are separated by a ridge. This ridge was located as an area where ash fill can be placed. Runoff to the east of this ridge runs directly into the Pinabete reconstruction through a series of channels.

On the east side of the Pinabete reconstruction, the basins are divided into East 1 and East 2. The southern most basin is East 1. This basin includes one major channel and several tributary channels that direct upstream runoff across the reclamation and into the Pinabete reconstruction. The main channel is separated from the Pinabete by a ridge. This area has several significant watersheds that contribute runoff from offsite. Channel alignments were based on identified offsite low-points for the contributing runoff. Basin East 2 contains one main channel and two tributary channels that direct runoff from the north portion of the site into the Pinabete reconstruction. Basins East 1 and East 2 are separated by a ridge.

Finally, there are two basins, offsite north and offsite south that convey runoff offsite. These are on the boundary of the post-mining drainage basin for the Pinabete reconstruction. The offsite north basin contributes runoff into the undisturbed reach of the Pinabete Arroyo downstream of the lease boundary and offsite south basin contributes runoff to the No Name drainage channel to the west of the post-mining drainage basin.

4.1.1 Drainage Density

As part of the reclamation model, a representative drainage density had to be evaluated for the site. The appropriate drainage density should be a function of terrain aspect and slope as well as precipitation and soils. For example, runoff from relatively flat terrain would not be expected to have the same energy and shear stress as if it were from steep terrain and, would not have as complex of a stream pattern. Higher drainage densities, greater than 200 ft/acre, resulted in a large number of channels that didn't necessarily reflect the general current site conditions, particularly in the southwest quadrant of the least area where the terrain is fairly flat. The overall reference drainage density is between 25 and 80 ft/acre based on the location within the regraded site, the lower being on the south and the higher being to the north.

The limits of seven basins on the project site were established. These basins included three on the west side of the Pinabete reconstruction, two on the east side, and two watersheds that convey runoff offsite. The drainage density was defined by the total straight length of the channels (in feet) within the watershed divided by the area of the watershed (in acres), resulting in a unit of ft/acre. The length of the Pinabete was only included in the overall drainage density for the entire site. Table 4.1 summarizes the results of this analysis.

Table 4.1
Drainage Density Analysis

Basin	Drainage Density (ft/acre)
Entire Site	30
West 1 Watershed	12
West 2 Watershed	29
West- Pinabete Watershed	14
East 1 Watershed	37
East 2 Watershed	26
Offsite-North	15
Offsite-South	25

4.2 CUT AND FILL ANALYSIS

A cut and fill analysis was completed to evaluate the AOC in comparison with the PMT. The Natural Regrade software was utilized to evaluate the excavation requirements. The limits of the cut and fill boundaries were based on the limits of the four dragline pits (panels), the centerline of the Pinabete reconstruction, and the centerline of the ramps to be utilized during mining. Carlson Civil Design 2008™ was used to estimate the cut and fill quantities developing a grid file for each surface and then comparing them, the surface for the AOC-AOC Pregrade Final Rev 4.grd, and the grid file for PMT was PMT.grd. Overall cut and fill is 81,000,000 cubic yards (Mcy) and 73 Mcy respectively, with a percent difference in cut versus fill is approximately 10 percent. The average depth of cut and fill for the entire surface is approximately 25 and 28 feet respectively.

Best, James L. 2006. *Sediment transport and bed morphology at river channel confluences*, Sedimentology 35 (3), 481–498 doi:10.1111/j.1365-3091.1988.tb00999 June.

Bugosh, N. 2007a. *Personal communication during the Approximate Original Contour development by URS Corporation*, September to December 2007.

Bugosh, N. 2007b. *Carlson Natural Regrade with GeoFluv ™ Training Session to URS Corporation*, August.

Riley, J.D and Rhoads, B.L. 2007. *Field Investigation of Flow Structure and Channel Morphology at Confluent-Meander Bends*, American Geophysical Union, Fall Meeting 2007, abstract #H51E-0814,December.

Shultits, S, Professor of Civil Engineer Pennsylvania State University, *Quantitative Formulation of Stream and Watershed Morphology.*

U. S. Army Corps of Engineers, HEC-HMS Version 3.1.0 Flood Hydrograph Package.

U. S. Army Corps of Engineers, 2003. HEC-RAS River Analysis System. May.

U.S. Department of Commerce, National Oceanic and Atmospheric Agency (NOAA), Precipitation Atlas 2, Volume IV New Mexico.

U.S. Department of Transportation, Federal Highway Administration, 2006. Design of Roadside Channels with Flexible Linings Hydraulic Engineering Circular Number 15, Third Edition. April.

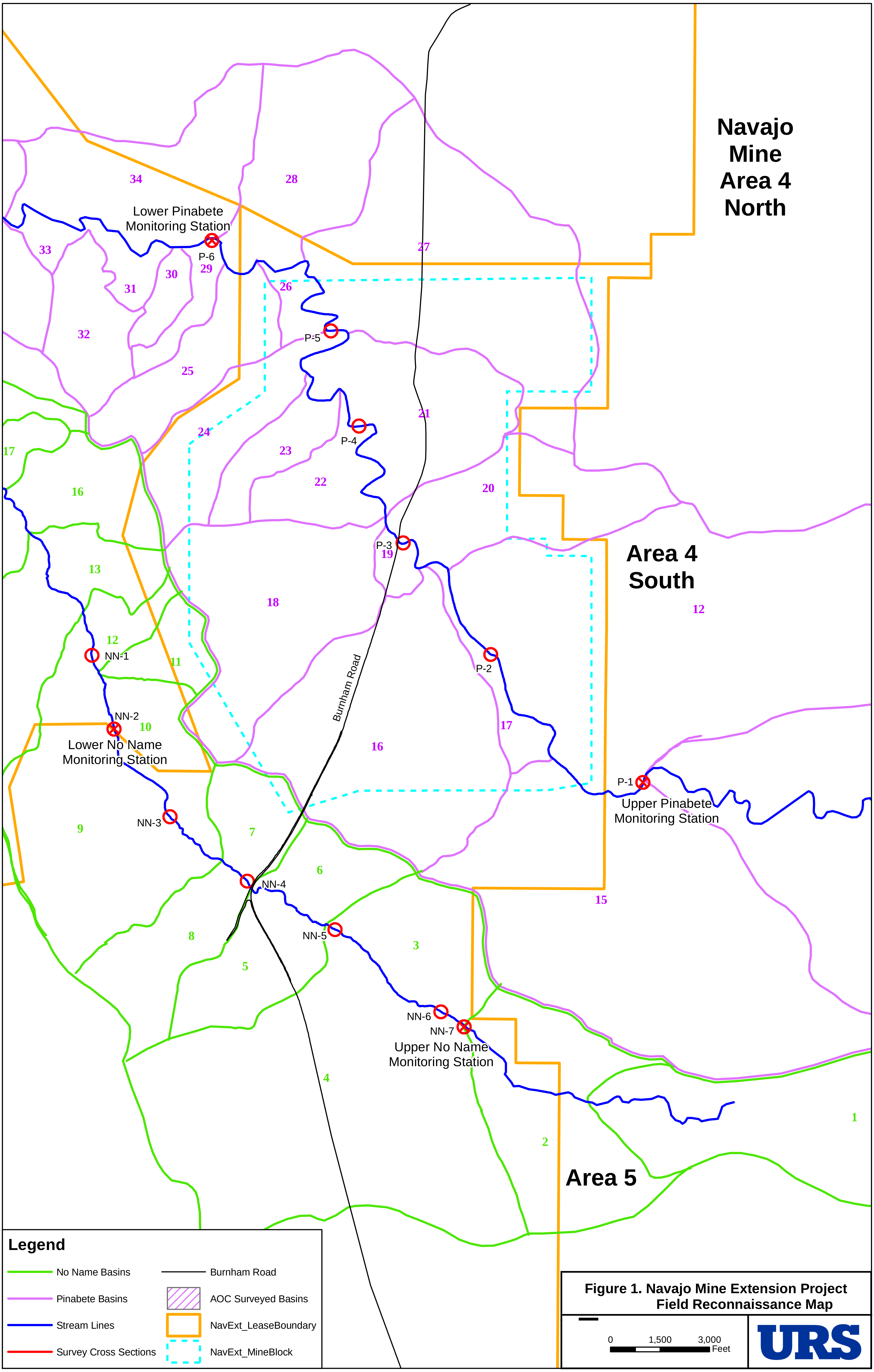
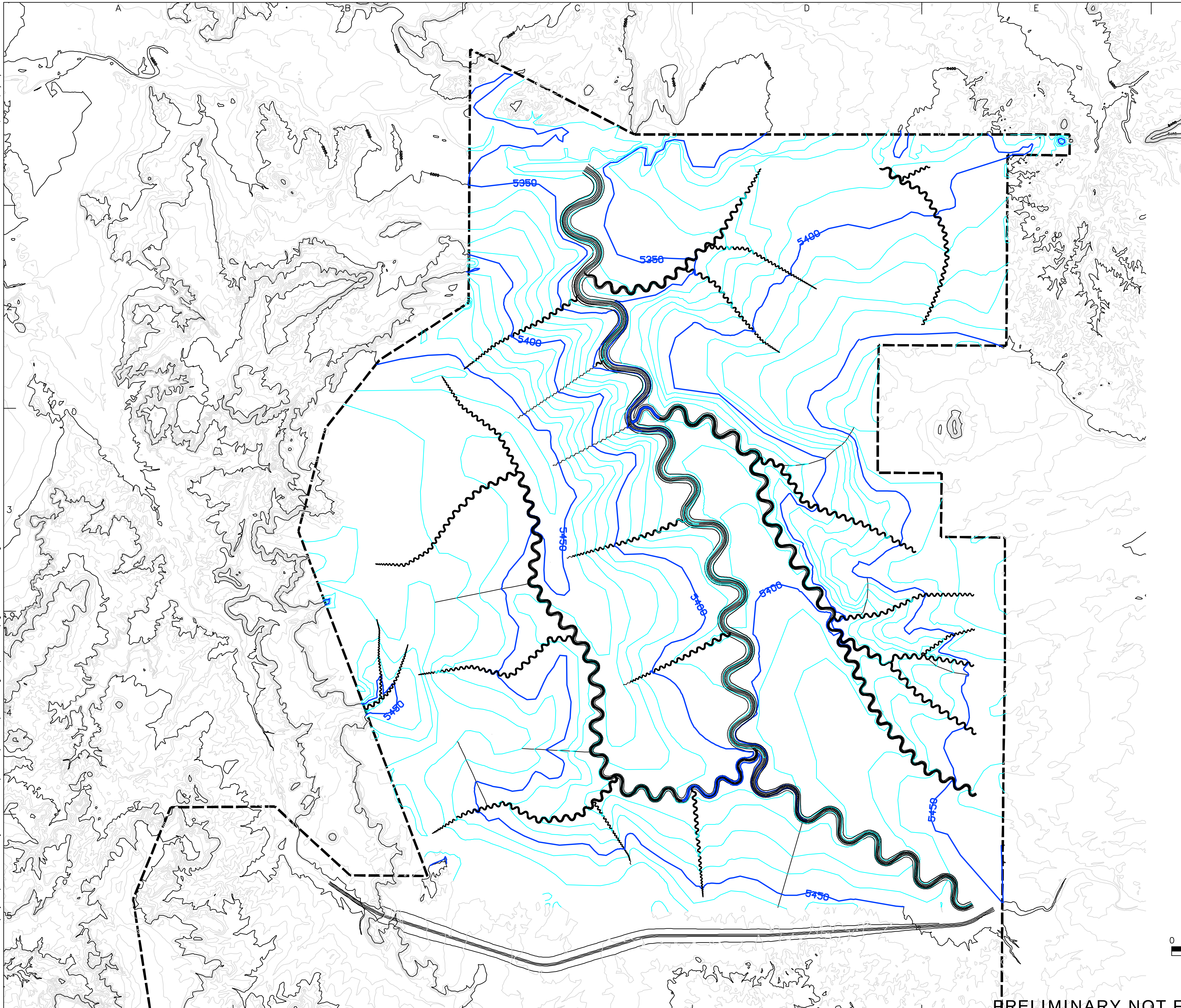


Figure 1. Navajo Mine Extension Project Field Reconnaissance Map

GUNN, BRIANA, 3/28/2008 11:44 AM

DRAWING PATH: T:\Projects\24342807_NovajoExtension_AOC\Sub_00\9.0_CAD\Natural Regrade\Final AOC\Figure 2-AOC Final.dwg



LEGEND

EXISTING CONTOURS

PROPOSED REGRADE CONTOURS

LEASE BOUNDARY

PROPOSED CHANNELS

NOTE:

1. THE SOURCE OF THE EXISTING TOPOGRAPHY IS A COMPOSITE OF A 1998 AERIAL FLIGHT AND USGS DTM DATA.

N

0 1000 2000 3000

SCALE IN FEET

PRELIMINARY NOT FOR CONSTRUCTION

URS

URS Center
8181 East Tufts Avenue
Denver, Co. 80237-2637
303 694-2770 (phone)
303-694-3946 (fax)

REVISIONS

NO.	DESCRIPTION	DATE
△		
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URS PROJECT NO:	24342807
DRAWN BY:	BWG
DESIGNED BY:	BWG
CHECKED BY:	SS
DATE CREATED:	3/21/2008
PLOT DATE:	3/28/2008
SCALE:	1"=1000'
ACAD VER:	17.1S (LMS TECH)

SHEET TITLE

APPROXIMATE ORIGINAL CONTOURS

FIG. 2

Attachment A

Technical Memorandum From URS To BHP Billiton Dated September 28, 2007

TECHNICAL MEMORANDUM

Date:	September 28, 2007
From:	Bud Brock, PE; Samrat Mohanty, PhD; URS Albuquerque; Briana Gunn, PE; Bill Sabatka, EIT; URS Denver
To:	Brent Musslewhite, Collete Brown, BHP Navajo Coal Company
Subject:	Baseline Channel Inventory and Drainage Density Survey for Pinabete and No Name Arroyos (NMEP Area IV South and northern section of Area V)

Introduction

From August 27 to August 29, 2007, two URS teams independently conducted a baseline channel inventory survey and a drainage density survey on the Pinabete and No Name Arroyos within the Navajo Mine Extension Project (NMEP) Area IV South and Area V. The Pinabete Arroyo is the main drainage path for Area IV South, bisecting the lease by flowing from the southeast corner to the northwest corner. The No Name Arroyo is the main drainage path for Area V, and flows from east to west along its northern boundary, just south of Area IV South. The Pinabete Arroyo is proposed to be diverted into the No Name Arroyo during the mining operation of Area IV South. Figure 1 is a map of the study area.

The baseline channel inventory was performed by the team of Bud Brock and Samrat Mohanty as part of the effort to obtain hydrologic information necessary for evaluation of Probable Hydrologic Consequences (PHC) of the proposed mining operations in Area IV South of the NMEP. The drainage density survey was completed by the team of Briana Gunn and Bill Sabatka to estimate input parameters for the development of the Approximate Original Contours (AOC) for Area IV South.

Baseline Channel Inventory

The specific objectives of the Baseline Channel Inventory effort are:

- Perform reconnaissance of Pinabete Arroyo and No Name Arroyo, including their major tributaries and associated floodplains to describe pre-mining conditions.
- Evaluate channel stability for both the major arroyos.
- Estimate channel characteristics, such as sinuosity and Manning’s n values, for use in later modeling efforts.
- Perform limited conceptual classification of bed and bank soils.

Field Reconnaissance Methodology

The URS team performed reconnaissance of the Pinabete Arroyo between the Upper Pinabete Monitoring Station, P-1, and Lower Pinabete Monitoring Station, P-6, and of the No Name Arroyo between Upper No Name Monitoring Station, NN-7, and Lower No Name Monitoring Station, NN-1, as well as their major tributaries and floodplains.

Key channel features identified included road crossings, culverts, dams, tributary junctions, bedrock outcrops, head cuts, bend points, and locations of convex segments within the channel flow path. The conditions of the channels along each course were described, including vegetative conditions in the channel and on the overbanks, the occurrence of steep bank slopes, evidence of bank failure, extent of scouring and deposition along the stream, and the classification of stream bed sediments. Photographs of the channel conditions were taken as part of the channel baseline survey for future reference during the Surface Water PHC project. A representative sample of the photos is presented in the text.

Limited soil classifications were performed on the channel bed and bank soils. Physical characteristics such as gradation, texture, moisture, plasticity, and density were noted for soils at selected locations. Locations were chosen based on their proximity to the monitoring stations, survey cross-sections, and any location with a perceived change in soil type.

Observations on No Name Arroyo

The No Name Arroyo is a fairly "young" arroyo, currently undergoing significant evolution. Overall, the No Name Arroyo is fairly straight for the reach located within the NMEP and flows in a general northwesterly direction. There are numerous small bends and turns in the channel, but they are minor and have little effect on the overall direction of the stream. The exception is the last major bend in the channel, approximately 900 feet upstream of NN-2. At this location, the channel takes a bend of approximately 30-degrees to the north. From here the channel continues on a north-by-northwesterly direction until the confluence point with Chaco River.

No Name Arroyo Low Flow Channel
Upstream of Burnham Road

The stream characteristics for No Name Arroyo can be divided into two distinct sections, upstream (east) of Burnham Road and downstream (west) of Burnham Road. For the majority of the stream reach upstream of the Burnham Road, there is a narrow, shallow, and discontinuous low flow channel with the capacity to convey runoff from the frequent storm events (1 to 5 year storm events). The low flow channel varies from 1 to 4 feet in dept and 2 to 10 feet in width. Bends in the channel are up to, and in a few locations exceed, 90-degrees. Flows resultant from the larger storm events overtop the low flow channel and are conveyed in a wide 'U' shaped shallow concentrated flow area. The shallow concentrated flow area ranges from approximately 50 to 100 feet wide, with some locations approaching 200 feet. The soil has minimal alluvial deposits consisting primarily of a clayey loam. Vegetation in the shallow concentrated flow area consists of low to medium grass with scattered low to medium brush for an effective ground cover of

60% to 80%. The Manning's n value for the channel is estimated to be 0.04. The two areas where the channel does not conform to these general statements are described below.

No Name Arroyo Shallow Concentrated Flow Area Upstream of Burnham Road

The area from NN-7 to approximately 500 feet downstream, the channel is incised at a depth of 2 to 4 feet and a width of 10 to 20 feet and has significant braiding. With the exception of the rare major storm events, flow is confined to the channel. The vegetation in the channel is consistent with the downstream section; however, the effective ground cover is approximately 50% in the channel resulting in an estimated Manning's n value of 0.035.

No Name Arroyo Upstream of NN-7

Immediately upstream of Burnham Road is the other location where the No Name Arroyo characteristics deviate from the typical channel section described above. Burnham Road acts as a retention structure creating a ponding area on the upstream side of the road. No crossing culverts were found. The gradient of the road slopes downward from north to south with a small dip in the road just south of the effective ponding area before the gradient of the road starts in an upward slope. This dip in the road acts as an overflow location for the ponding area and corresponds to a sandstone outcrop that limits the erosion of the roadway. The ponding area has an effective ponding depth of approximately 4 to 6 feet before flow will inundate the overflow location. It is assumed this ponding area was intentionally created to serve as a cattle watering pond. The bottom of ponding area is covered with clayey soil. There is little to no vegetation in the bottom of the ponding area; however, heavy brush is present on the upstream half of the pond overbanks. This heavy brush extends into and up the channel feeding the pond for

No Name Arroyo Ponding Area Upstream of Burnham Road Looking Upstream approximately 500 feet creating an effective ground cover of almost 100% resulting in an estimated Manning's n value for this part of the channel of 0.15.

Vegetation in the overbank area is fairly consistent along the stream reach and is composed primarily of low grass with interspersed low brush covering approximately 5% to 30% of the ground. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. There are few medium to large size rocks in the channel or overbank area. The Manning's n value is estimated to be approximately 0.035 for the overbank area.

The overbank areas consist of a gently sloping floodplain area leading to widely spaced rolling hills. The hills range up to approximately 100 feet high and are composed primarily of fractured sandstone gravel intermixed with loose soils. Tributaries in the area are typically shallow concentrated or sheet flow with only a few of the tributaries having incising at the main channel with a head cut depth of 1 to 3 feet. Upstream of the tributary head cut, the flow regime consists of shallow concentrated and sheet flow.

No Name Arroyo Sandstone Outcropping Upstream of NN-2

For the majority of the stream reach downstream of Burnham Road, the channel is well defined with incised depths up to 15 feet, steep to vertical side slopes, and bends ranging from 10 to 45-degrees. The soils in the channel banks are collapsible clayey silt. There is a significant amount of fractured sandstone in the bottom of the channel that has washed into the arroyo from the outcroppings to the north or from discrete outcroppings in the channel banks. There are a few scattered locations where fractured sandstone outcroppings are present in the channel banks, almost always on the north side. Sandstone outcroppings were noted in the channel bottom at two locations, approximately 200 feet upstream of NN-2 and approximately 1,500 feet downstream of NN-4. Vegetation in the overbank area is fairly consistent along the stream reach and is composed primarily of low grass with interspersed low brush covering approximately 5% to 30% of the ground surface. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. There are few medium to large size rocks in the channel and overbank areas. The Manning's n value is estimated to be approximately 0.035 for this overbank area. Vegetation and Manning's n values in the channel varies from upstream to downstream and are discussed per section below.

Immediately downstream of Burnham Road, the channel is difficult to discern due to the thick vegetation consisting of dense salt cedar, brush, and grass constituting an effective ground cover of approximately 100%. Approximately 500 feet downstream of Burnham

Road, the channel flairs out and becomes visible. The channel cross section in this area displays a benched condition. From the channel bank, it drops approximately 8 to 15 feet where it hits a small bench, roughly 5 feet wide. It then drops another 2 to 5 feet to the low flow portion of the channel, which is generally 2 to 5 feet wide. Overall, the channel width varies from approximately 15 to 40 feet wide. This general channel configuration continues downstream for approximately 500 feet to near the location of NN-4. The channel is fairly straight in the area with bends not exceeding 10 to 20 degrees. Due to the thick vegetation, the Manning's n for this portion of the channel is estimated to be 0.15.


No Name Arroyo at Approximately NN-4

From NN-4 to downstream approximately 1,000 feet, the channel is 10 to 12 feet deep and 10 to 20 feet wide. Vegetation in the channel is very thick constituting a ground cover of approximately 80%. Bends are more pronounced and frequent but do not exceed approximately 45 degrees. Due to the thick vegetation, the Manning's n value for this portion of the channel is estimated to be 0.10.

From approximately 1,000 feet downstream of NN-4 to approximately 500 feet downstream of NN-3, the channel is 8 to 10 feet deep and 10 to 20 feet wide. Vegetation in the channel still consists of salt cedar, brush, and low to medium grasses, but the density has decreased to an effective ground cover of approximately 50%. Bends are still fairly frequent but do not exceed approximately 45 degrees. The Manning's n value for this portion of the channel is estimated to be 0.05.

At approximately 500 feet downstream of NN-3, the channel dissipates over the course of approximately 200 feet as it exits a tight meander. The flow regime reverts to shallow concentrated and overland flow for a stretch of approximately 2,000 feet. Where a defined channel exists for this stretch of the arroyo, it is heavily braided, no more than 3 feet deep, and in excess of 30 feet wide. There are stretches where a definitive channel is not present and runoff reverts to sheet flow conditions. Vegetation in the channel and overland flow area is thicker than the downstream channel reaches, consisting of low to medium grasses and weeds, brush, and some salt cedar constituting a ground cover of approximately 50%. The Manning's n value for this portion of the channel is estimated to be 0.04. The overland flow terminates at a major head cut in the channel located approximately 1,000 feet upstream of NN-2. The head cut is approximately 30 feet wide and 12 feet deep. Downstream of the head cut, there is a definable channel as described in the following paragraph.

From the head cut to NN-2, braiding is frequent and the side slopes are vertical. The channel is approximately 8 to 12 feet deep and approximately 10 to 30 feet wide. The top edge of the channel banks tend to be sharp, indicating the channel is relatively new. Bends are fairly minor and range from less than 10 degrees to a maximum of 45 degrees. Vegetation in the channel consists primarily of low grass with some salt cedar and low brush constituting a ground cover of approximately 30%. The Manning's n value for this portion of the channel is estimated to be 0.03.

No Name Arroyo Head Cut Approximately 1,000 Feet Upstream of NN-2

From NN-2 to NN-1, the channel banks are vertical or nearly vertical in most locations. In the locations where the channel banks are not vertical, they range to a side slope of approximately 3H:1V. The top edge of the channel banks have been rounded over by erosion, indicating the incision has been in place for a few years. There is little to no braiding in the channel. Channel depths, widths, vegetative cover, Manning's n value, and bends are consistent with the preceding section.

No Name Arroyo from NN-2 to NN-1

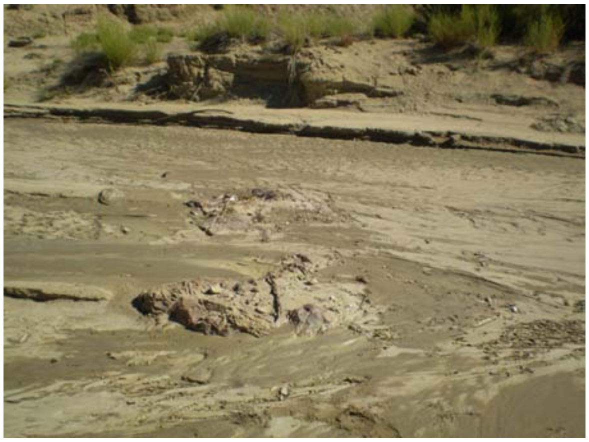
The overbank areas consist of a gently sloping floodplain area with a varied width from 50 to 200 feet leading to a fairly dense clustering of steep hills. The hills are generally up to approximately 100 feet high and are composed primarily of fractured sandstone overlain by loose soils. The majority of the hills have at least one side consisting of a vertical face of fractured sandstone. Tributaries in the area are typically incised at the main channel and upstream for up to 200 feet with a head cut depth of 2 to 5 feet. Upstream of the tributary head cut, the flow regime consists of shallow concentrated and sheet flow.

Observations on Pinabete Arroyo

The Pinabete Arroyo is a well defined and established channel. The overall trend of the channel is fairly straight through the NMEP area flowing in a general north-by-northwesterly direction. Right before the channel exits the mine area, there are a series of bends that result in an almost 90 degree change in the overall direction of the channel leaving it flowing in a west-by-northwesterly direction until its confluence with the Chaco River.

The stream characteristics for the Pinabete Arroyo are fairly consistent through the study area. Typically, the channel is 4 to 10 feet deep and 20 to 80 feet wide with side slopes in the range of 4H:1V to 10H:1V. At the bend points, the side slopes on the outside of the bend transition to vertical. Vegetation in the channel is almost solely confined to the channel banks and consists of low grass, some small brush, and the occasional salt cedar clump. The soil in the channel is primarily silty sand with very little to no clay content. There are a couple of locations where bedrock is exposed in the channel. These are at Burnham Road and approximately half way between P-1 and P-2. Otherwise, the channel is basically devoid of rock of any size, with the exception of the sandstone outcroppings at the bend points. The estimated Manning's n value for the channel is 0.022.

Pinabete Arroyo Typical Channel



Pinabete Arroyo Exposed Bedrock
Between P-1 and P-2

Although the general trend of the arroyo is fairly straight, the sinuosity of the channel is relatively high. There are numerous bend points with angles greater than 90 degrees, with a large percent of the bends approaching 180 degrees. Typically, between the major bend points the channel is fairly straight or has a gentle meander. There are a few locations on the stream reach where the sinuosity is very high, as one bend ties directly into the next and the bends approach or are in excess of 90 degrees. These areas are from P-1 downstream for 1,500 feet, upstream and downstream of P-3 for approximately 1,500 feet, and a 2,500 stretch of the channel centered approximately half way between P-5 and P-6.

Pinabete Arroyo Typical Bend Point
Upstream of Burnham Road

Tributaries to the Pinabete Arroyo are typically incised near the confluence point to the main channel. The incising extends up the tributary for no more than approximately 300 feet where it terminates in a small head cut of 2 to 5 feet deep.

Pinabete Arroyo Typical Bend Point Downstream of Burnham Road

The overbank area can be divided into two sections, upstream (east) and downstream (west) of Burnham Road. As with the No Name Arroyo, the overbank area upstream of Burnham Road consists primarily of gently rolling hills up to approximately 100 feet high composed primarily of fractured sandstone gravel intermixed with loose soils. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. Vegetation is composed primarily of low grass with interspersed low brush covering approximately 5% to 30% of the ground. There are few medium to large size rocks in overbank area. The Manning's n value is estimated to be approximately 0.035 for the overbank area.

Downstream of Burnham Road, the overbank area is also similar to that of the No Name Arroyo. Typically, a gently sloping floodplain area up to 200 feet wide leads to steep hills up to approximately 100 feet high. The hills generally have at least one vertical face of exposed sandstone with the other sides composed of fractured sandstone and soil. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. Vegetation is composed primarily of low grass with interspersed low brush covering approximately 5% to 50% of the ground. There are numerous medium to large size rocks in overbank area consisting of sandstone that has eroded off the nearby hills. The Manning's n value is estimated to be approximately 0.05 for this overbank area.

Drainage Density Survey

This 3-day effort included field reconnaissance of the Pinabete and No Name Arroyos and their major tributaries, developing drainage density data by measuring tributary lengths and areas, measurement of A-channel lengths, and head to ridge lengths.

Pinabete Arroyo near Confluence of Main Tributary Channel from Drainage Basin 18

Several drainage areas for the Pinabete and No Name Arroyos were identified prior to field survey where drainage parameters could be estimated. These locations were selected based on identified hydrologic features and soil types, as well as recommendations from environmental staff of BNCC. Pinabete Drainage Basins 18 and 21, and No Name Basin 1 were selected for reconnaissance. Drainage basin designations are based on a SedCAD model developed by BNCC, and are shown on Figure 1. A sampling of the photographs taken during the drainage density survey are presented in the text.

Day – 1

The URS team performed an overall reconnaissance of the area was performed by driving through the project area from north to south over the watersheds of both the arroyos. The first basin explored was Drainage Basin 18. This drainage basin is located immediately downstream of Burnham Road and drains to the Pinabete Arroyo directly downstream of cross section P-3. A GPS receiver was used to mark the drainage features of the tributary channels within Drainage Basin 18.

The tributary channels within Drainage Basin 18 are fairly flat and narrow, rectangular in shape, have a bottom width varying from less than 1 foot to over 10 feet, and side slopes from 1H:1V to 3H:1V. The main tributary channel within Drainage Basin 18 extends approximately 5,000 feet to the southwest from the confluence with the Pinabete Arroyo. The total length of all the tributary channels within the Drainage Basin 18 is 18,400 feet. The contributing drainage area is estimated to be 322 acres. The estimated drainage density is 60 feet per acre (ft/acre).

During the field investigation, the team observed that there were very few channels that could be classified as type A or B, with the majority of the channels consistent with type C. For this reason, only a few A-channel lengths were

Main Tributary Channel from Drainage Basin 18
near Confluence with Pinabete Arroyo

Top Segment of Drainage Basin 18
Main Tributary Channel

Top Ridge within Drainage Basin 18
Note Increased Gravel Content

measured within Drainage Basin 18. However, due to the flatness of the area and the small changes in grade between channels, none of the measured head to crest lengths were considered representative of the project area.

The soil within the tributaries is alluvial deposits with very few bedrock outcrops. The channel contains small to large fractured sandstone fragments along the channel bottom, extending into the channel side slopes. The channel bank is unstable, resulting in sustained erosion except for the areas with high rock concentrations.

Day – 2

During the second day, Drainage Basin 22 and the north end of Drainage Basin 21 were identified to have distinct ridges and valleys containing concave to convex channels where A-channel lengths could be evaluated, and the overall terrain contained a greater amount of elevation change.

In these areas, the tributary channel lengths were measured and coordinates were recorded along the tributary alignments to estimate elevation change and A-channel lengths. Within these areas a soil type that was slightly different than that within Drainage Basin 18 was identified. The soil type has less alluvial sands and a greater volume of gravel. These areas have a more stable channel configuration, which is narrower with a reduced amount of riling. The estimated average A-channel length and head to ridge length are approximately 30 feet and 150 feet, respectively; with one outlying head to ridge length of approximately 650 feet.

Towards the end of the second day, the southern portion of Pinabete Drainage Basin 21 and No Name Drainage Basin 1 were examined. Both these areas have

Center of Tributary Channel 18R1
in Drainage Basin 18

Channel 18 on South Bank of Pinabete Arroyo

Bedrock Outcrop within Main Tributary Channel
of Drainage Basin 18 after Rainfall Event

fairly flat topography with no measurable ridges and valleys, and were therefore not further evaluated.

Typical A-Channel in Drainage Basin 28

An attempt was made to identify additional contributing drainage areas in the Pinabete watershed that would be representative of the surface generated by the Natural Regrade model. During this process, Drainage Basin 28 was identified. This basin is approximately 1 mile downstream of Drainage Basin 18.

Day – 3

On the third day, measurements of the lengths of the tributaries within Drainage Basin 28 were conducted. The tributaries within this basin have slopes varying from 2 to 20 percent, which is steeper than tributaries measured in the preceding basins. The tributaries are more narrow in comparison to those within Drainage Basin 18. The tributary channels generally have a trapezoidal shape, a bottom width varying from 0.5 to 4 feet, and 1H:1V to 2H:1V side slopes. The main tributary channel extends approximately 1,080 feet to the confluence with the Pinabete Arroyo. The total length of all tributaries within Drainage Basin 28 is 2,350 feet. The contributing drainage area is approximately 16.8 acres. The estimated drainage density is 140 ft/acre.

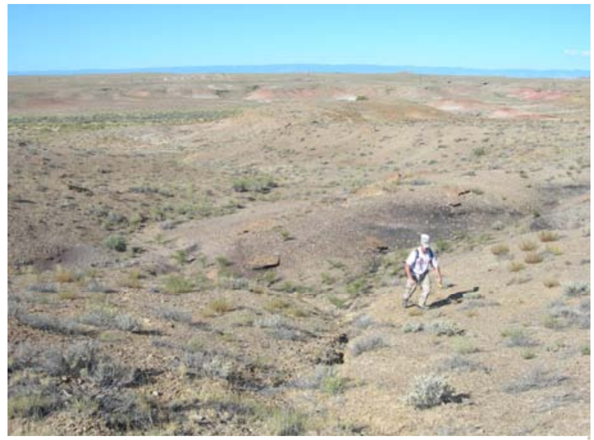
Typical Upstream Channel Segment
in Drainage Basin 28

The majority of the tributaries were found to contain an A-channel reach with a measurable head to ridge length. Measurements were taken along the tributary channels. The estimated average A-channel length and head to ridge length are approximately 20 and 100 feet, respectively.

Typical A-Channel in Drainage Basin 18

The soil type within Drainage Basin 28 is similar to Drainage Basin 22 with a lower amount of alluvial deposits and a large amount of gravel. For the majority of the tributaries, gravel is present at the transition between the concave to convex areas. Overall, this basin appears to be more stable than Drainage Basin 18.

GPS data were recorded at the estimated upstream and downstream elevation of the Pinabete Arroyo in the NMEP to be used as input in the Natural Regrade model. The upstream and downstream elevations are estimated to be 5,440 feet and 5,310 feet (Mean Sea Level), respectively.



Typical Geomorphologic Formations within Drainage Basin 28

Southern Boundary of the Regrade Area Looking North

Attachment B

Drainage Density Field Survey of Area 4S Photo Log

Photo 1: Pinabete Arroyo near Confluence of the Main Channel from Drainage Basin 18
(Looking Upstream)

Photo 2: Main Channel of Drainage Basin 18 near Confluence with Pinabete Arroyo
(Looking Upstream)


Photo 3: Top Segment of Drainage Basin 18 Main Channel (Looking Upstream)


Photo 4: Top of Ridge within Basin 18 (Looking towards the Channel); Note: Increased Gravel Content


Photo 5: Center of Channel 18 R1 in Drainage Basin 18 (Looking Upstream)

Photo 6: Channel 18 on South Bank of Pinebete Arroyo (Looking Upstream).


Photo 7: Bedrock Outcrop within Main Channel of Basin 18 (Flow after Rainfall Event)


Photo 8: Near Channel 18 (Looking North)


Photo 9: Near Channel 18 (Looking Northeast) at Likely Alluvial Deposits


Photo 10: Typical A-Channel (Looking Upstream towards Ridge)

Photo 11: Typical A-channel in Drainage Basin 28 (Looking Upstream towards Ridge)

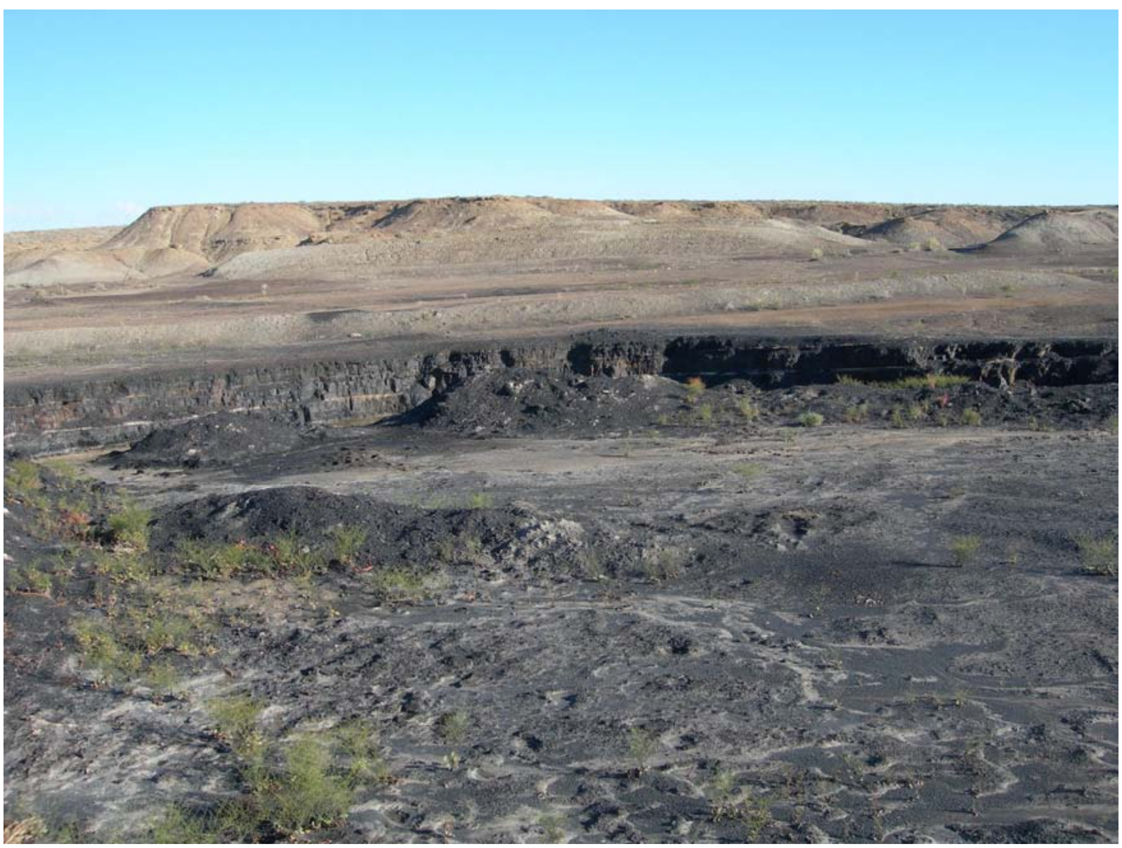


Photo 12: Coal Outcrop within a Tributary Basin of Pinabete Arroyo


Photo 13: Typical Upstream Channel Segment within Basin 28

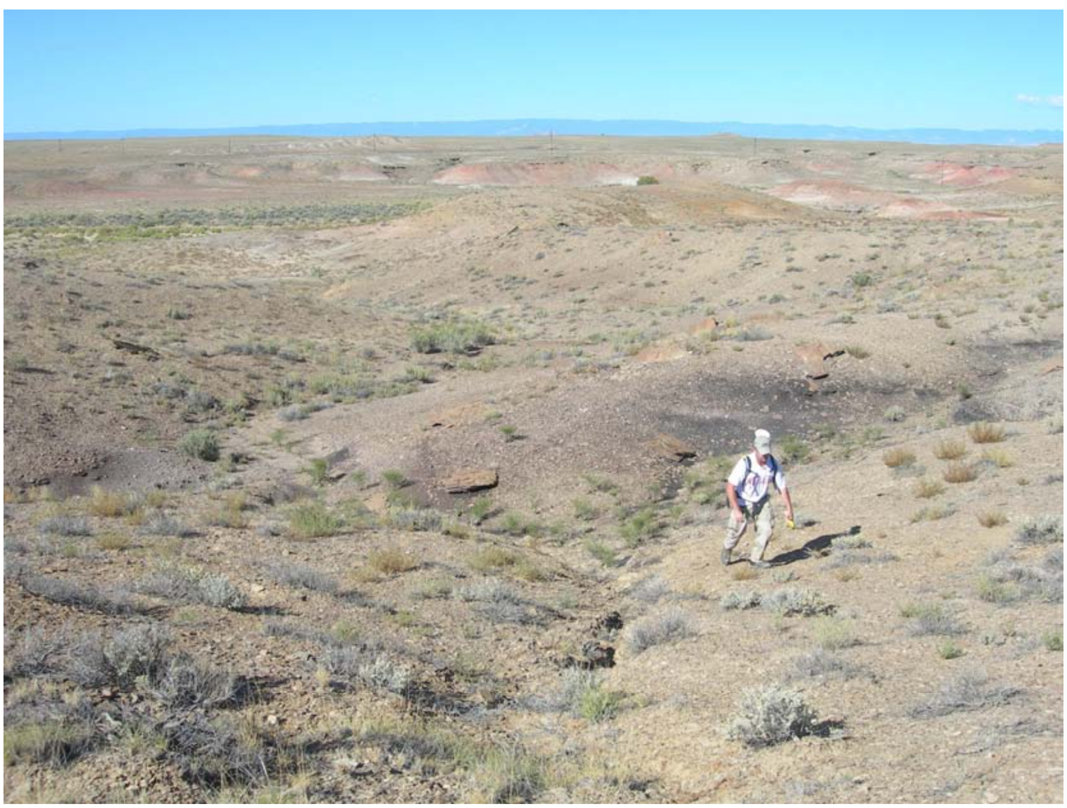


Photo 14: Typical Geomorphologic Formations within Basin 28


Photo 15: Southern Boundary of the Regrade area (Looking Upstream)