

APPENDIX D6 – HYDROLOGY

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The limestone mining operation is being developed to minimize impacts to the hydrologic regime of the permit area. All mining will be restricted to the upland areas and pit depths will normally not exceed 25 to 30 feet in total depth. The permit area is approximately 600 acres in size and the maximum area to be affected is 387 acres. Total annual disturbances will normally not exceed 16 acres. Therefore, impacts to groundwater and surface water systems is expected to be minimal.

D6.1 Groundwater

Geologic Setting

The geologic setting is discussed in Section D5.

Ground water is not expected to occur within 20 feet of the bottom of the pit in any of the areas to be mined. One stock well drilled in the SWSE, Section 26 is approximately 600 feet deep with a static water level at 600 feet. The other well located in Section 25 was drilled by the landowner in 2008 and the State Engineer hasn't received the completion notice so depths are not available at the time of submittal. This well will be utilized for mining activities.

A search of State Engineer's Office records indicated that no water wells were permitted within the affected area. Groundwater rights identified within the search area are presented Appendix E.

With all mining activities occurring well above known aquifers in the area, no baseline wells were established.

No known aquifers will be affected because of the shallow pit depths employed to recovery the limestone. Piezometric contour maps of affected aquifers were not developed.

Monitoring Program

No monitoring program was in place at the time this application was being prepared and no plan is proposed because of the lack of impacts to the groundwater.



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D6.2 Surface Water

Map E-1 provides the major and minor drainages surrounding the permit area. The two unnamed ephemeral drainages that flow through the permit area are tributary to Sundance Creek. Sundance Creek is a perennial stream located northwest of the permit area. The WDEQ classification for Sundance Creek is 3B. These streams are within the Belle Fourche River drainage area. All mining activities will be conducted outside of the drainages and surface runoff from disturbed lands will be contained within the pit limits. The second order eastern ephemeral drainage within the permit area has two first order drainages flowing into it within the permit area. Much of the channel sections of these drainages are very small and sections have been eliminated by the agricultural activities in the area. There is a small impoundment located on the lower reaches of the drainage. The drainage area immediately above this impoundment has been seeded to hayland and the impoundment itself is highly vegetated similar to the surrounding area. This impoundment has been cutoff from the drainage by previous mining operations but is not proposed for disturbance and may be able to be made functional again following mining. Other portions of this drainage will be impacted by mining and will need to be reestablished during reclamation. The second ephemeral drainage located in the southern and western portion of the permit area also has two first order drainages remaining that flow into it. Other small first order drainages may have been present prior to agricultural activities that have occurred on the south side of the drainage. There is a small impoundment on the lower reach of this drainage that will not be disturbed by mining. As shown in the Mine Plan, portions of this ephemeral drainage will be impacted by mining and will need to be reestablished during reclamation.

Monitoring Program

The two ephemeral drainages have very limited flow. No water was present at anytime during the baseline studies conducted in 2007 and 2008 so no monitoring was conducted. The pond located on the eastern drainage has not had any water to monitor and will not be removed under the current mine progressions. The pond on the southwest drainage will also be avoided by current mine p

D6.3 Water Rights

All surface and groundwater rights are presented in Appendix E and shown on Exhibit E-1.



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APPENDIX D-7 PRE-MINING SOILS ASSESSMENT

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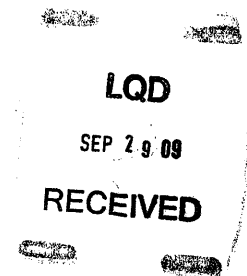
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APPENDIX D-7 PRE-MINING SOILS ASSESSMENT

D-7.1 INTRODUCTION

Croell Redi-Mix, Inc., of Sundance, Wyoming, currently operates a sand-and-gravel Limited Mining Operation (LMO), also known as an "ET" (Ten Acre Exemption), Permit #1396. The LMO is called "Roger's Pit" and is located in Crook County approximately six miles east of Sundance and immediately south of Interstate 90. Croell Redi-Mix proposes to expand the ET operation to a "regular mine" (WDEQ/LQD Form 1, Mining Permit). The identification and proper management of the topsoil resources in the Croell Redi-Mix Roger's Pit Quarry is essential for the success of reclamation in the mine area and the achievement of the post-mining land use. The information presented in this Section is designed to aid in formulating a practical and successful reclamation plan.

D-7.1.1 Location of the Proposed Area

The detailed Order 1-2 soil survey was conducted on approximately 600 acres located in portions of Sections 25, 26, and 35, T.52N., R.62W. The project area was later reduced to approximately 570 acres. The detailed Order 1-2 soil survey covered all portions of the project area. Please refer to the Introduction Section of the permit application package for the complete legal descriptions of the lands included within the proposed project area.

D-7.1.2 Topography of the Proposed Area

Please refer to the maps included at the end of this Section for an illustration of the topography of the proposed project area.

D-7.1.3 Vegetation of Proposed Area

Please refer to the Vegetation Section of the Permit Application for the vegetation types within the proposed project area.

D-7.1.4 Hydrology of the Proposed Area

Please refer to the Hydrology Section of the Permit Application for information concerning the hydrology of the proposed project area.

D-7.2 METHODOLOGY

Soils mapping, profile description, sampling, and taxonomic classification was conducted in accordance with the procedures and standards of the National Cooperative Soil Survey (Soil



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Survey Staff, 1993 and 1999; and Schoeneberger et al., 2002). Initial mapping units were identified using the USDA Natural Resources Conservation Service (NRCS) Order 3 air-photo base soil survey maps (Map Sheets 115 and 116) of the "Soil Survey of Crook County, Wyoming" (Elwonger, 1983), and the USGS 7.5' Sundance, Wyoming, topographic quadrangle map. The previous soil boundaries were used during initial field reconnaissance and observation.

The soil resources of the project area were investigated by Jim Nyenhuis, Certified Professional Soil Scientist/Soil Classifier (ARCPACS 2743), during the spring of 2008. The entire project area was mapped at the detailed Order 1-2 level of intensity. The project area was traversed by vehicle and on foot. Soil map unit boundaries were delineated by exposing soil profiles using a sharpshooter and bucket auger as well as observing surface conditions, vegetation, slope gradient and slope aspect.

Following soils mapping, representative locations were selected for all major soils within the project area and these sites were fully described and sampled. A total of thirty-six soil samples were collected from ten representative sample locations. The samples were sent to Colorado State University's Soil Testing Laboratory (CSU) in Fort Collins, Colorado, for standard analysis (WDEQ, 1996).

The soil laboratory analyses included: pH, electrical conductivity (EC); saturation percent; calcium, magnesium, sodium, and potassium (meq/l); calculation of Sodium Adsorption Ratio (SAR); organic matter percent (Walkley Black method); soil texture class (hand texture method); and several micronutrients including Phosphorus (P), Potassium (K), Zinc (Zn), Iron (Fe), Manganese (Mg), Copper (Cu), and nitrate-nitrogen (NO₃-N). A 10 percent duplicate analysis was conducted for quality assurance/quality control (QA/QC) purposes. Gypsum content (meq/100g) was also determined for soil sample site #10. In addition, a dryland fertilizer recommendation was generated for the upper foot of soil material of sample sites S1, S2, S3, S4, and S7. The results of the soil lab analysis are included with this report. See Table D-7.2.

D-7.3 RESULTS

The Croell Redi-Mix Roger's Pit project area in Crook County is located within a "mesic" soil temperature regime (average annual air temperature about 46 to 48 degrees F., 8 to 9 degrees C.), and an "ustic-aridic" soil moisture regime (mean annual precipitation about 12 to 16 inches, 305 to 407 millimeters). The frost free period is about 110 to 130 days.

The permit area is divided into two areas dominated by different types of bedrock (Love and Christiansen, 1985). The eastern portion of the permit area is underlain by the Permian age "Minnekahta" limestone and "Opeche" shale (geologic map symbol Pmo), whereas the western portion is underlain by the Triassic age "Spearfish" Formation (geologic symbol TrPs). The Spearfish Formation is composed of dark red, friable, fine-grained sandstone, maroon siltstone, interbedded shale, and several beds of gypsum in the lower part of the formation. The Minnekahta limestone, which immediately underlies the Spearfish Formation, is the target limestone bed being mined by Croell Redi-Mix at Roger's Pit Quarry.

The permit area is characterized by the presence of very shallow, shallow, moderately deep, and deep soils. Tilford and Nevee (Map Unit A) are deep soils with 40 inches or more of loam, silt loam, or clay loam soil material to the underlying limestone contact. Tilford is distinguished from Nevee by having a dark-colored surface layer with sufficient organic matter content and depth to

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qualify as a "mollic" epipedon. Both soils are located primarily in dryland fields that are in grass hayland at the present time. Nevee loam (Map Unit B) is mapped separately on gently sloping areas often near small ephemeral drainages. Laporte loam (Map Unit C) is a very shallow (4 to 10 inches deep) to shallow (10 to 20 inches deep) soil developing in thin residuum and colluvial slopewash derived from underlying limestone bedrock. Limestone Rock Outcrop, with a small percentage of Laporte loam inclusions, is mapped as Map Unit D. Rekop clay (Map Unit E) is a very shallow to shallow soil forming in thin residuum and colluvial slopewash derived from underlying gypsum bedrock. Gystrum loam is a moderately deep soil also mapped in Map Unit E. It is forming in gypsiferous, reddish-brown sediments weathered from gypsum bedrock and interbedded redbed shales and siltstones. Gypsum Rock Outcrop, with a small percentage of Rekop clay, is mapped as Map Unit F. Road corridors and small previously disturbed areas are mapped as Disturbed Land (Map Unit DL).

Figure D7-1 (Roger's Pit Quarry Soils Map) is attached to this report. It is the detailed soils map of the project area and is shown at a scale of 1"=400'. Soils mapping of some immediately adjacent area is also shown on the map. The map legend includes a list of all soil units and their recommended salvage depths. All ten soil profile description and sample site locations are plotted on the map as well. All of the sample sites are located within the "affected area boundary". Map production and determination of map unit acreages was completed by Mr. Tom Peterson of VCN.

Table D7-1 (List of Map Units and Mining Area Topsoil Salvage Summary) lists the soil map units within the Roger's Pit Quarry Project Area, their sample location numbers, and summarizes their salvage depths and limitations to deeper salvage. Soil map unit acreages and cubic yards of suitable soil recommended for topsoil salvage for project areas proposed to be disturbed by mining activities are listed in the project mine and reclamation plan.

The following text is a description of the project area soil map units and their component soils, as well as an evaluation of their topsoil suitability and salvage depths. The descriptions are presented in alphabetic order by map unit symbol:

3.1	Map Unit A	Tilford-Nevee complex, 2 to 10% slopes
3.2	Map Unit B	Nevee loam, 2 to 12% slopes
3.3	Map Unit C	Laporte loam, 2 to 35% slopes
3.4	Map Unit D	Limestone Rock Outcrop, Laporte inclusion, 2 to 50% slopes
3.5	Map Unit E	Rekop-Gystrum complex, 2 to 10% slopes
3.6	Map Unit F	Gypsum Rock Outcrop-Rekop inclusion, 2 to 18% slopes

D-7.3.1 Map Unit A: Tilford-Nevee complex, 2 to 10% slopes

Tilford-Nevee complex (Map Unit A) is mapped primarily on dryland grass hayfields scattered across the permit area. Tilford and Nevee are both deep soils (40 inches or more to the bedrock contact) and each comprises about 50 percent of the map unit. Tilford is distinguished from Nevee by having a dark-colored surface layer with sufficient organic matter content and depth to qualify as a "mollic" epipedon. In the Crook County soil survey, this area was mapped as Map Unit 117 (Nevee silt loam, 6 to 10% slopes) with Tilford listed as a "soil inclusion" (Elwonger, 1983). Portions of Map Unit A may be disturbed by mining activities and Tilford and Nevee soils were fully described and sampled at several representative sites. Each soil is described below.



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Tilford loam is a deep, well drained soil that is forming in "fine-silty" local alluvium and residuum from weathered reddish siltstones and shales on uplands, and is considered highly erodible. Tilford is classified as a "Fine-silty, mixed, superactive, mesic Torriorthentic Haplustoll", and is an established soil series of moderate extent mapped in eastern Wyoming and western South Dakota in a belt surrounding the Black Hills. The most recent official soil series description, dated November 1998, is on file with Jim Nyenhuis.

Typically in the project area, Tilford has a surface "Ap" horizon that is a brown to dark brown loam or silt loam about 5 inches thick. The upper cambic "Bw" subsoil is a brown loam to clay loam to a depth of about 10 to 12 inches. The lower cambic "Bw" subsoil is a brown clay loam to a depth of about 20 to 24 inches. The underlying "Bk" or "Ck" substratum layers are light brown to pink clay loam to clay to a depth of 40 inches or more.

Tilford loam is nonsaline and nonsodic and has moderate permeability (about 0.6 to 2 inches/hour). Available water capacity is moderate to high, and the effective rooting depth is 40 inches or more. On the project area, Tilford is typically noncalcareous in the upper horizons and calcareous in the lower parts of the profile. Coarse fragment content is typically less than 5 percent and consists of small siltstone or shale chips. The control section is loam, silt loam, or silty clay loam and has 18 to 35 percent clay. The ecological site (Range Site) is "Loamy". Land capability class (dryland) is "Ive-21".

Tilford loam was fully described and sampled at two representative sites within the Roger's Pit Quarry project area, sample sites **S2** and **S3**. Typical sample site S2 was described and sampled approximately 975' east, 250' north of the SW corner of Section 25, T.52N., R.62W. Additional typical sample site S3 was described and sampled approximately 425' west, 200' north of the SE corner of Section 26, T.52N., R.62W. Soil profile descriptions for both sampled pedons S2 and S3 follow below.

Tilford Sample Site S2 Profile Description: 6% slope; NW aspect; mixed grasses hayland vegetation; gently sloping field area; local alluvium over residuum from siltstone; stable surface with no to slight erosion in vicinity of sample site; described and sampled April 8, 2008.

Ap horizon – 0 to 5 inches; brown (10YR 4/2) loam, dark brown (10YR 3/2) moist; sod cover with moderate medium granular structure; soft, very friable, sticky and slightly plastic consistence; common fine and very fine and few medium roots, noneffervescent; from lab data: pH=7.1 (neutral), EC=0.3 (nonsaline), SAR=0.1 (nonsodic), Organic Matter (OM)=5.8%; gradual smooth boundary.

Bw1 horizon – 5 to 12 inches; brown (10YR 4/2) loam, dark brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic consistence; common fine and very fine and few medium roots; noneffervescent; from lab data: pH=7.6 (slightly alkaline), EC=0.2 (nonsaline), SAR=0.1 (nonsodic), OM=3.4%; gradual wavy boundary.

Bw2 horizon – 12 to 24 inches; brown (7.5YR 5/4) loam to clay loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky to massive structure; hard, friable, sticky and plastic consistence; few medium, fine, and very fine roots; noneffervescent in upper part to moderately effervescent in lower part; from lab data: pH=7.8 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.2 (nonsodic), OM=1.8%; gradual wavy boundary.



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B_{Ck} horizon – 24 to 34 inches; reddish yellow (7.5YR 6/6, 5YR 6/6) clay loam to clay with about 15% small limestone fragments, yellowish red (5YR 5/6) moist; massive structure; hard, firm, sticky and plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.2 (nonsodic), OM=1.4%; hit large limestone fragment (not considered bedrock yet), could not dig further.

Tilford Sample Site S3 Profile Description: 4% slope; South aspect; mixed grasses hayland vegetation; gently sloping field area; local alluvium over residuum from siltstone; stable surface with no to slight erosion in vicinity of sample site; described and sampled April 8, 2008.

A_p horizon – 0 to 5 inches; brown (7.5YR 4/4) loam, dark brown (7.5YR 3/4) moist; moderate medium granular structure; soft, very friable, slightly sticky and slightly plastic consistence; many fine and very fine, and few medium roots; strongly effervescent; from lab data: pH=7.5 (slightly alkaline), EC=0.2 (nonsaline), SAR=0.1 (nonsodic), OM=5.4%; gradual smooth boundary.

B_{w1} horizon – 5 to 10 inches; brown (7.5YR 4/4) loam to clay loam, dark brown (7.5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic consistence; many fine and very fine, and few medium roots; noneffervescent; from lab data: pH=7.7 (slightly alkaline), EC=0.2 (nonsaline), SAR=0.1 (nonsodic), OM=3.5%; gradual wavy boundary.

B_{w2} horizon – 10 to 20 inches; brown (7.5YR 5/4) loam to clay loam, dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic consistence; may fine and very fine, and few medium roots; moderately effervescent; from lab data: pH=7.9, (moderately alkaline), EC=0.2 (nonsaline), SAR=0.1 (nonsodic); OM=2.2%; gradual wavy boundary.

B_k horizon – 20 to 28 inches; light brown (7.5YR 6/4) clay loam to clay, brown (7.5YR 5/4) moist; massive structure; hard, friable, sticky and plastic consistence; few fine and very fine roots; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.2 (nonsodic), OM=1.9%; gradual wavy boundary.

C_k horizon – 28 to 40 inches; pink (7.5YR 7/4) clay loam to clay with about 15% small limestone fragments, light brown (7.5YR 6/4) moist; massive structure; very hard, firm, sticky and plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.5 (nonsaline), SAR=0.8 (nonsodic), OM=0.6%; gradual wavy boundary.

C horizon – 40 to 56 inches; pink (5YR 7/4) clay loam to clay with about 40% (screened) small, hard siltstone fragments; light reddish brown (5YR 6/4) moist; massive structure; very hard, firm, sticky and plastic consistence; no roots observed; strongly effervescent; from lab data: pH=7.8 (slightly alkaline), EC=1.1 (nonsaline), SAR=0.2 (nonsodic), OM=0.7%; gradual wavy boundary.

R (lithic contact) – 56" weathered siltstone bedrock.

Nevee loam to clay loam is a deep, well drained soil that is forming in "coarse-silty" local alluvium and residuum from weathered reddish siltstones and shales on uplands, and is considered highly erodible. Nevee is classified as a "Coarse-silty, mixed, superactive, calcareous, mesic Aridic Ustorthent", and is an established soil series of moderate extent mapped in and near the Black



Hills of eastern Wyoming and western South Dakota. The most recent official soil series description, dated October 1997, is on file with Jim Nyenhuis.

Typically in the project area, Nevee has a surface "Ap" horizon that is a brown to dark brown loam to clay loam about 5 inches thick. The cambic "Bw" subsoil is a brown loam to clay loam to a depth of about 12 to 14 inches. The underlying calcic "Bk" subsoil is a light brown clay loam to clay to a depth of about 24 to 30 inches. The "Ck" substratum layers are light reddish brown to reddish yellow clay loam to clay to a depth of 40 inches or more.

Nevee loam to clay loam is nonsaline and nonsodic and has moderate permeability (about 0.6 to 2 inches/hour). Available water capacity is moderate to high, and the effective rooting depth is 40 inches or more. Surface runoff is moderate and the erosion hazard is high. On the project area, Nevee is typically noncalcareous in the upper horizon and calcareous in the underlying parts of the profile. Coarse fragment content is typically less than 5 percent and consists of small siltstone or shale chips. The control section is loam, silt loam, or silty clay loam and has 18 to 35 percent clay. The ecological site (Range Site) is "Loamy". Land capability class is "IIIe-2", dryland and irrigated.

Nevee loam to clay loam was fully described and sampled at two representative sites within the Roger's Pit Quarry project area, sample sites **S1** and **S7**. Typical sample site S1 was described and sampled approximately 1300' east, 1250' north of the SW corner of Section 25, T.52N., R.62W. Additional typical sample site S7 was described and sampled approximately 1650' west, 500' north of the SE corner of Section 25, T.52N., R.62W. Soil profile descriptions for both sampled pedons S1 and S7 follow below.

Nevee Sample Site S1 Profile Description: 3% slope; north aspect; mixed grasses hayland vegetation; gently rolling upland field area; local alluvium over residuum from red siltstone; stable surface with slight erosion in vicinity of sample site; described and sampled April 7, 2008.

Ap horizon – 0 to 5 inches; brown (7.5YR 4/4) loam to clay loam, dark brown (7.5YR 3/4) moist; moderate medium granular structure; soft, friable, sticky and slightly plastic consistence; many fine and very fine and few medium roots; noneffervescent; from lab data: pH=7.4 (slightly alkaline), EC=1.3 (nonsaline), SAR=0.1 (nonsodic), OM=4.1%; gradual smooth boundary.

Bw horizon – 5 to 12 inches; brown (7.5YR 5/4) loam to clay loam, dark brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic consistence; many fine and very fine and few medium roots; slightly



effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.5 (nonsaline), SAR=0.1 (nonsodic), OM=2.5%; gradual wavy boundary.

Bk horizon – 12 to 24 inches; light brown (7.5YR 6/4) silt loam to clay loam, brown (7.5YR 5/4) moist; massive structure; hard, firm, slightly sticky and slightly plastic consistence; few fine and very fine roots; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.3 (nonsaline), SAR=0.2 (nonsodic), OM=0.4%; gradual wavy boundary.

Ck1 horizon – 24 to 38 inches; reddish yellow (7.5YR 6/6) clay loam to clay, strong brown (7.5YR 5/6) moist; massive structure; hard, firm, slightly sticky and slightly plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.2 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.3 (nonsodic), OM=0.7%; gradual wavy boundary.

Ck2 horizon – 38 to 54 inches; reddish yellow (7.5YR 6/6) clay loam to clay, strong brown (7.5YR 5/6) moist; massive structure; hard, firm, sticky and plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.4 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.3 (nonsodic), OM=0.4%; gradual wavy boundary.

Ck3 horizon – 54 to 72 inches; reddish yellow (7.5YR 6/6) clay loam to clay, strong brown (7.5YR 5/6) moist; massive structure; hard, firm, sticky and plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.5 (strongly alkaline), EC=0.3 (nonsaline), SAR=0.4, OM=0.4%; did not hit bedrock.

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Nevee Sample Site S7 Profile Description: 8% slope; northeast aspect; mixed grasses hayland vegetation; gently rolling upland field area; local alluvium over residuum from red siltstone; stable surface with none to slight erosion in vicinity of sample site; described and sampled April 17, 2008.

Ap horizon – 0 to 3 inches; brown (7.5YR 5/4) loam (field texture was loam although lab hand texture was reported as silty clay loam), dark brown (7.5YR 4/4) moist; moderate medium granular structure; slightly hard, friable, sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.4 (nonsaline), SAR=0.2 (nonsodic), OM=3.8%; gradual smooth boundary.

Bw horizon – 3 to 14 inches; brown (7.5YR 5/4) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), dark brown (7.5YR 4/4) moist; weak medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.1 (nonsodic), OM=2.6%; gradual wavy boundary.

Bk horizon – 14 to 30 inches; pink (7.5YR 7/4) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), light brown (7.5YR 6/4) moist; massive structure; slightly hard to hard, friable to firm, sticky and slightly plastic consistence; common fine and very fine roots; strongly effervescent; from lab data: pH=8.3 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.2 (nonsodic), OM=0.9%; gradual wavy boundary.

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Ck horizon – 30 to 46 inches; light reddish brown (5YR 6/4) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), reddish brown (5YR 5/4) moist; massive structure; slightly hard to hard, friable, sticky and slightly plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.6 (strongly alkaline), EC=0.3 (nonsaline), SAR=0.7 (nonsodic), OM=0.5%; gradual wavy boundary.

Ck/Cr horizon – 46 to 60 inches; light reddish brown (5YR 6/4) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), reddish brown (5YR 5/4) moist; massive structure; hard, friable, sticky and slightly plastic consistence; no roots observed; moderately effervescent; from lab data: pH=9.0 (strongly alkaline), EC=0.6 (nonsaline), SAR=3.0 (slightly sodic), OM=0.4%; gradual wavy boundary.

Tilford-Nevee complex (Map Unit A) Topsoil Suitability Evaluation and Salvage

Recommendation: Topsoil 24"

Both Tilford loam and Nevee loam (Map Unit A) are entirely "suitable" throughout the soil profile concerning soil reaction (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), soil texture, saturation percent, and coarse fragment content. However, the upper 24 inches (2') contains the better soil material with higher organic matter content, more roots, and slightly better soil texture. For the four sampled Tilford and Nevee pedons (S1, S2, S3, and S4), the weight-averages organic matter content for the upper 24 inches is 2.62 percent, compared to 0.65 percent for the underlying soil material. In addition, plant roots were generally not observed in the lower horizons of the Tilford and Nevee sampled pedons. As a result, the upper 24 inches of Tilford and Nevee soils in Map Unit A are recommended for topsoil salvage.

D-7.3.2 Map Unit B: Nevee loam, 2 to 12% slopes

Nevee loam (Map Unit B) is mapped separately as a consociation on gently sloping areas often near small ephemeral drainages. The map unit was previously mapped by NRCS as Map Unit 117 (Nevee silt loam, 6 to 10% slopes) (Elwonger, 1983). General information for Nevee loam

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was previously described in Map Unit A as does not change in Map Unit B. Refer to Map Unit A for this information. Nevee loam was fully described and sampled at one representative site in Map Unit B, **S4**, which is located approximately 725' west, 475' south of the NE corner of Section 35, T.52N., R.62W. The soil profile description for Nevee sampled pedon S4 follows.

Nevee Sample Site S4 Profile Description: 2% slope; NNW aspect; mixed grasses vegetation; local drainage alluvium over residuum from weathered gypsic red siltstone; small upland drainage and adjacent low terrace flat; no erosion on terrace, slight erosion spots in drainage channel; described and sampled April 4, 2008.

A horizon – 0 to 4.5 inches; brown (7.5YR 4/4) loam, dark brown (7.5YR 3/4) moist; moderate coarse granular structure; soft, very friable, slightly sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.6 (nonsaline), SAR=0.1 (nonsodic), OM=6.8%; gradual smooth boundary.

Bw1 horizon – 4.5 to 11 inches; brown (7.5YR 4/4) loam to clay loam (lab hand texture reported as clay), dark brown (7.5YR 3/4) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately effervescent; from lab data: pH=7.9 (moderately alkaline), EC=0.4 (nonsaline), SAR=0.1 (nonsodic), OM=3.7%; gradual wavy boundary.

Bw2 horizon – 11 to 21 inches; reddish yellow (5YR 6/6) clay loam (field texture was clay loam although lab hand texture was reported as clay), reddish yellow (5YR 5/6) moist; weak medium subangular blocky to massive structure; hard, friable, sticky and slightly plastic consistence; common fine and very fine and few medium roots; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.2 (nonsaline), SAR=0.2 (nonsodic), OM=1.6%; gradual wavy boundary.

Bk horizon – 21 to 34 inches; reddish yellow (5YR 7/6) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), reddish yellow (5YR 6/6) moist; massive structure; hard, firm, sticky and slightly plastic consistence; few fine and very fine roots; strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.6 (nonsaline), SAR=0.3 (nonsodic), OM=1.2%; gradual wavy boundary.



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Ck1 horizon – 34 to 50 inches; light red (2.5YR 6/6) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), red (2.5YR 5/6) moist; massive structure; very hard, firm, sticky and slightly plastic consistence; no roots observed; strongly to violently effervescent; from lab data: pH=8.3 (moderately alkaline), EC=5.6 (slightly saline), SAR=2.2 (nonsodic to slightly sodic), OM=0.5%; gradual wavy boundary.

Ck2 horizon – 50 to 65 inches; light red (2.5YR 6/6) clay loam (field texture was clay loam although lab hand texture was reported as silty clay), red (2.5YR 5/6) moist; massive structure; slightly hard, friable, sticky and slightly plastic consistence; no roots observed; strongly effervescent; from lab data: pH=8.3 (moderately alkaline), EC=4.8 (slightly saline), SAR=1.9 (nonsodic), OM=0.3%; gradual wavy boundary.

Cr (paralithic contact) 65+ inches; weathered, gypsic red siltstone.

Nevee loam (Map Unit B) Topsoil Suitability Evaluation and Salvage Recommendation: Topsoil 18"

All of Nevee loam (Map Unit B) is "suitable" throughout the soil profile concerning soil reaction (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), soil texture, saturation percent, and coarse fragment content. However, the upper 18 inches (1.5') contains the better soil material with higher organic matter content, more roots, and slightly better soil texture. For the one sampled Nevee pedon in Map Unit B (S4), the weight-average organic matter content for the upper 18 inches is 3.7 percent, compared to 0.70 percent for the underlying soil material. In addition, plant roots were generally not observed in the lower horizons of the Nevee sampled pedon. As a result, the upper 18 inches of Nevee loam in Map Unit B is recommended for topsoil salvage.

D-7.3.3 Map Unit C: Laporte loam, 2 to 35% slopes

Laporte loam (Map Unit C) is a very shallow (4 to 10 inches deep) to shallow (10 to 20 inches deep) soil developing in thin residuum and colluvial slopewash from underlying limestone bedrock. Laporte loam is mapped in the eastern part of the permit area where the Minnekahta limestone, which is the target limestone bed being mined by Croell Redi-Mix in the Roger's Pit Quarry,

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outcrops and subcrops. Laporte loam is mapped as a consociation in the small areas where the Minnekahta limestone subcrops, and in complex with Limestone Rock Outcrop (Map Unit D) where the limestone outcrops. Most of Map Unit C is projected to be disturbed by mining and the Laporte soil was fully described and sampled for laboratory characterization.

Laporte is classified as a "Loamy, carbonatic, mesic Lithic Hapustoll", and is an established soil series of large extent mapped in Wyoming, Colorado, Montana, and New Mexico. The most recent official soil series description for Laporte, dated January 2002, is on file with Jim Nyenhuis. Typically in the permit area, Laporte has a surface "A" horizon that is a dark grayish brown loam about 3 inches thick. The underlying "Bw" subsoil horizon is a brown loam to a depth of about 9 inches. The underlying "Bk" or "Ck" substratum is a highly calcareous loam with over 20 percent small limestone fragments. Hard, fractured limestone bedrock underlies the soil profile, generally from 4 to 20 inches in depth. The particle-size control section is "loamy" with 18 to 35 percent clay and 5 to 20 percent or more small limestone fragments.

Laporte loam is both nonsaline and nonsodic and has moderate permeability (about 0.6 in/hr) above the bedrock. Available water capacity is very low, the effective rooting depth is 10 to 20 inches depending on the thickness of the soil profile, surface runoff is rapid, and the erosion hazard is high. Laporte is typically calcareous at or within a few inches of the soil surface. The ecological site (Range Site) is "Shallow Loamy" and the land capability class (dryland) is "VIIIs".

Laporte loam was fully described and sampled at one representative site, **S6**, in Map Unit C, and at an additional representative site, **S8**, in Map Unit D. Sample site S6 is located approximately 1925' north, 2175' west of the SE corner of Section 25, T.52N., R.62W. Sample site S8 is located approximately 1775' east, 750' north of the SW corner also of Section 25. The soil profile description for sample pedon S6 follows.

Laporte Sample Site S6 Profile Description: 7% slope; NE aspect; mixed grasses vegetation; upland ridge – convex upper shoulder position; soil area on weathered limestone ridge; thin residuum from limestone; stable surface with slight erosion spots; described and sampled April 17, 2008.

A horizon – 0 to 3 inches; dark grayish brown (10YR 4/2) loam with about 10% small gravel-size limestone fragments, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, friable, slightly sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately effervescent; from lab data: pH=7.6 (slightly alkaline), EC=1.5 (nonsaline), SAR=0.1 (nonsodic), OM=13.5% (organic matter analyzed as "weight loss on ignition"; gradual smooth boundary.

Bw horizon – 3 to 9 inches; brown (10YR 5/3) loam with about 10% small gravel-size limestone fragments, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic consistence; many fine and very fine and few medium roots; strongly effervescent; from lab data: pH=7.9 (moderately alkaline), EC=0.4 (nonsaline), SAR=0.1 (nonsodic), OM=6.0%; gradual wavy boundary.

BC horizon – 9 to 15 inches; pale brown (10YR 6/3) to yellowish brown (10YR 5/4) loam with about 20% small gravel-size limestone fragments, brown (10YR 5/3) to dark yellowish brown (10YR 4/4) moist; massive structure; slightly hard to hard, friable, slightly sticky and slightly plastic consistence;



strongly effervescent; from lab data: pH=8.0 (moderately alkaline), EC=0.3 (nonsaline), SAR=0.3 (nonsodic), OM=3.3%; gradual wavy boundary.

R (lithic contact) 15+ inches; thin fragmental zone, then hard limestone bedrock.

Laporte loam (Map Unit C) Topsoil Suitability Evaluation and Salvage Depth Recommendation:

Topsoil 8"

Laporte loam (Map Unit C) is entirely "suitable" throughout the soil profile concerning soil reaction (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), soil texture, saturation percent, and coarse fragment content. The entire soil profile can be salvaged for use as topsoil during reclamation. Although the sampled pedon S6 is 15 inches to limestone bedrock, the average thickness for Laporte loam in Map Unit C is only 8 inches, and therefore the recommended soil salvage is 8 inches. In addition, there are scattered small spots of limestone rock outcrop in Map Unit C and these must be avoided during salvage operations.

D-7.3.4 Map Unit D: Limestone Rock Outcrop, Laporte soil inclusion

Limestone Rock Outcrop (Map Unit D) is located in the eastern part of the permit area and is underlain by "Minnekahta" limestone, which is the target limestone bed being mined by Croell Redi-Mix at the Roger's Pit Quarry. There is no soil where the limestone outcrops, but a very shallow Laporte soil inclusion occurs in small scattered areas across about 10 to 15 percent of the Map Unit D area. The Laporte soil has been previously described in Map Unit C. A very shallow pedon of Laporte loam, sample site S8, was fully described and sampled in Map Unit D and will be described below. Laporte pedon S8 is located approximately 1775' east, 750' north of the SW corner of Section 25, T.52N., R.62W.

Laporte Sample Site S8 Profile Description: 12% slope; north aspect; scattered mixed grasses vegetation; very thin residuum from limestone; limestone ridge convex upper shoulder position; stable surface with none to slight erosion in spots; described and sampled April 17, 2008.

AC horizon – 0 to 4 inches; brown (10YR 4/3) gravelly loam with about 25% gravel-size limestone fragments, dark brown (10YR 3/3) moist; moderate medium granular structure; slightly hard, friable, slightly sticky and slightly plastic consistence; many fine and very fine and few medium roots; moderately to strongly effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.3 (nonsaline), SAR=0.1 (nonsodic), OM=5.9%; gradual smooth boundary.

R (lithic contact) 4+ inches; hard, fractured limestone bedrock.

Limestone Rock Outcrop (Map Unit D) Topsoil Suitability Evaluation and Salvage Depth

Recommendation: LRO, 0"; Laporte soil inclusion, Topsoil 4"



Limestone Rock Outcrop has no soil available for salvage. The very shallow Laporte loam soil inclusion, existing in small scattered spots across about 10 to 15 percent of Map Unit D, is entirely "suitable" throughout the soil profile concerning soil reaction (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), soil texture, saturation percent, and coarse fragment content. If salvage operators are able to salvage the Laporte soil inclusion, the entire soil profile to the limestone bedrock, can be salvaged for use as topsoil. The average thickness for the Laporte loam soil inclusion in Map Unit D is only 4 inches, and therefore the recommended soil salvage is 4 inches.

D-7.3.5 Map Unit E: Rekop-Gystrum complex, 2 to 10% slopes

Rekop-Gystrum complex (Map Unit E) is mapped in the west-central and western part of the permit area, in the area underlain by the Triassic age "Spearfish" Formation. The formation is composed of dark red, friable, fine-grained sandstone, maroon siltstone, interbedded shale, and several beds of gypsum in the lower part of the formation. The "Minnekahta" limestone immediately underlies the Spearfish Formation. Rekop and Gystrum soils are developing in colluvial slopewash and thin residuum derived from the underlying gypsum bedrock. Rekop clay is a very shallow to shallow soil whereas Gystrum loam is moderately deep. Map Unit E also has "karst" features including scattered "sink holes" which were formed by dissolution of gypsum and anhydrite in the bedrock. Portions of Map Unit E are projected to be disturbed by mining operations, and both Rekop and Gystrum were fully described and sampled at representative sites. Each soil is described below.

Rekop clay is a very shallow (4 to 10 inches deep) to shallow (10 to 20 inches deep), well drained soil that is mapped on gently sloping to rolling uplands underlain by the Spearfish Formation, and is considered highly erodible. Rekop is classified as a "Loamy, gypsic, mesic, shallow Ustic Torriorthent", and is an established soil series of moderate extent mapped in northern and central Wyoming and extreme western South Dakota. The most recent official soil series description for Rekop, dated November 2005, is on file with Jim Nyenhuis.

Typically in the project area, the very shallow Rekop soil has an upper "AC" horizon that is a light brown clay about 4 inches thick. Weathered bedrock is encountered from 4 to 10 inches in depth. Rekop clay is nonsaline to slightly saline, nonsodic, has moderate permeability, low runoff, very low available water capacity, and the erosion hazard is high. Rekop is typically highly calcareous and gypsic and is forming in sediments derived from reddish brown gypsiferous siltstone. The ecological site (Range Site) is "Shallow Loamy" and the land capability class (dryland) is "Vlle".

Rekop was fully described and sampled at one representative site, **S5**, located approximately 425' west, 750' south of the NE corner of Section 35, T.52N., R.62W. The soil profile description for Rekop sample site S4 follows below.

Rekop Sample Site S5 Profile Description: 4% slope; south aspect; mixed grasses vegetation; very thin residuum from red siltstone; gently sloping upland; moderate erosion with severe spots; described and sampled April 8, 2008.

AC horizon – 0 to 4 inches; light brown (7.5YR 6/4) clay, dark brown (7.5YR 4/4) moist; weak medium granular over weak medium subangular blocky structure; slightly hard, friable, sticky and plastic consistence; many fine and very fine and few medium roots; from lab data: pH=7.8 (slightly alkaline), EC=1.8 (nonsaline), SAR=0.1 (nonsodic), OM=4.0%; gradual wavy boundary.



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Cr horizon (paralithic contact) 4+” weathered, calcareous, red siltstone bedrock.

Gystrum loam is a moderately deep (20 to 40 inches deep), well drained soil that is mapped in complex with Rekop clay on gently sloping to rolling uplands underlain by the “Spearfish” Formation, and is considered highly erodible. Gystrum is classified as a “Fine-silty, gypsic, mesic Ustic Haplocambid”, and is an established soil series of small extent in northern Wyoming and western South Dakota. The most recent official soil series description for Gystrum, dated November 2005, is on file with Jim Nyenhuis.

Typically in the project area, Gystrum has an “A” horizon surface layer that is a brown loam about 3 inches thick. The “Bw” subsoil layer is a dark brown clay loam to a depth of about 14 inches. The underlying “C” horizon substratum is a light reddish brown clay loam to a depth of about 27 inches. Gystrum loam is highly calcareous but both nonsaline and nonsodic. Gystrum has moderate permeability, medium runoff, medium available water capacity, and the erosion hazard is high. The ecological site (Range Site) is “Loamy” and the land capability class (dryland) is “VIIe”.

Gystrum was fully described and sampled at one representative site, **S9**, located approximately 925’ west, 725’ north of the SE corner of Section 26, T.52N., R.62W.

Gystrum Sample Site S9 Profile Description: 4% slope; east aspect; mixed grasses vegetation; residuum from siltstone; very gently sloping red siltstone-gypsum plain; no erosion to moderate erosion in spots; described and sampled April 17, 2008.

A horizon – 0 to 3 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; moderate medium granular structure; soft, very friable, slightly sticky and slightly plastic consistence; common fine and very fine and few medium roots; strongly effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.3 (nonsaline), SAR=0.3 (nonsodic), OM=6.2%; gradual smooth boundary.

Bw horizon – 3 to 14 inches; reddish brown (5YR 4/4) loam to clay loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic consistence; common fine and very fine and few medium roots; strongly effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.4 (nonsaline), SAR=0.1 (nonsodic), OM=4.4%; gradual wavy boundary.

C horizon – 14 to 27 inches; light reddish brown (5YR 6/4) loam to clay loam, reddish brown (5YR 5/4) moist; massive structure; slightly hard, friable, sticky and slightly plastic consistence; few fine and very fine roots; strongly effervescent; from lab data: pH=7.8 (slightly alkaline), EC=0.7 (nonsaline), SAR=0.2 (nonsodic), OM=1.7%; gradual wavy boundary.

Cr horizon (paralithic contact) 27+” weathered, gypsum bedrock.

Rekop-Gystrum complex (Map Unit E) Topsoil Suitability Evaluation and Salvage Depth

Recommendation: Topsoil 6”



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Technically, both Rekop and Gystrum soils are entirely "suitable" throughout the soil profile concerning soil reaction (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), soil texture, saturation percent, and coarse fragment content. However, there is a major difference in profile depth between the two soils (about 4" for Rekop and 27" for Gystrum) and they are located in a complex mosaic that can not be separated in the map unit. Although the Rekop sample pedon S5 was 4 inches deep, the average thickness of Rekop in Map Unit E is 6 inches. As a result, for the purpose of establishing a soil salvage depth, only 6 inches of soil is recommended for salvage. In the field, salvage of all soil to the underlying bedrock can be done, but any weathered siltstone or gypsum bedrock should be avoided.

D-7.3.6 Map Unit F: Gypsum Rock Outcrop, Rekop soil inclusion

Gypsum Rock Outcrop, Rekop soil inclusion (Map Unit F) is located in many, somewhat small occurrences (delineations) of gypsum outcrop that are scattered across the western part of the permit area in the area underlain by the "Spearfish" Formation. The gypsum outcrops are very gently sloping to nearly flat in appearance and are characterized by their white crusted surface with very little to no vegetation. Sparse vegetation is often limited to the edges of the outcrop. A few small spots of the very shallow Rekop soil (about 4 inches to bedrock) are interspersed with the Gypsum Rock Outcrop. The Rekop soil is considered a soil inclusion in Map Unit F because it only occupies about 10 to 15 percent of the map unit and can not be mapped separately at the 1"=400' scale of mapping. Rekop clay was described in Map Unit E.

For characterization purposes, the very shallow 2-inch weathered crust of Map Unit F was sampled for laboratory analysis. Map Unit F sample site **S10** is located approximately 250' east, 1400' north of the SW corner of Section 25, T.52N., R.62W.

Map Unit F Sample Site S10 Profile Description: 1% slope; south aspect; very little to no vegetation – scattered sparse forbs and a few small soil spots with mixed grasses; very thin weathered crust over gypsum bedrock; gypsum rock outcrop spot; severe erosion in vicinity of sample site; described and sampled April 18, 2008.

C/Cr horizon (paralithic contact) – 0 to 2 inches; pinkish white (5YR 8/2) weathered gypsum material (lab says sandy loam but the "sand" size particles are largely gypsum particles), pinkish gray (5YR 7/2) moist; weathered massive structure; soft dry consistence, very friable moist consistence, nonsticky and nonplastic wet consistence; no roots observed; moderately effervescent (calcareous); from lab data: pH=7.7 (slightly alkaline), EC=1.7 (nonsaline), SAR=0.1 (nonsodic), OM=0.9%; gypsum=3.6% (41.5 meq/100g); gradual wavy boundary; gypsum bedrock below about 2 inches in depth.

Map Unit F Topsoil Suitability Evaluation and Salvage Depth Recommendation: Topsoil 0"

Although the Rekop soil inclusion has about 4 inches of suitable soil, it occupies only 10 to 15 percent of the map unit and can not be separately salvaged within the unit. Gypsum



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Rock Outcrop has no soil for salvage. The 2-inch weathered crust that is on top of the gypsum rock is not recommended for salvage due to its very thin thickness, gypsum content, and the fact that it generally does not support vegetation and has few if any roots. The recommended salvage depth for Map Unit F is "0" inches.

D-7.3.7 Map Unit DL: Disturbed Land

Disturbed Land (Map Unit DL) is mapped on the Interstate 90 corridor road right-of-way, a small portion of which is within the proposed permit area. In addition, if the current permit application shows the currently disturbed "Limited Mining Operation" area of Roger's Pit, then this would be delineated as Disturbed Land. Some topsoil has already been salvaged and stockpiled from the LMO area. No additional topsoil is available for salvage. There are no other areas of Disturbed Land in the proposed permit area.

D-7.4 REFERENCES:

Elwonger, W.G. 1983. Soil Survey of Crook County, Wyoming. U.S.D.A. – Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service), in cooperation with the Forest Service and the Wyoming Agricultural Experiment Station.

Love, J.D. and Christiansen, Ann Coe. 1985. Geologic Map of Wyoming. U.S. Geological Survey (USGS), scale 1:500,000.

Robinson, Charles S., William J. Mapel, and Maximillian H. Bergendahl. 1964. Stratigraphy and Structure of the Northern and Western Flanks of the Black Hills Uplift, Wyoming, Montana, and South Dakota. USGS Geological Survey Professional Paper 404. US Government Printing Office, Washington D.C. 1964.

Schoeneberger, P.J., et.al. 2002. Field Book for Describing and Sampling Soils. Version 2.0. U.S.D.A.-Natural Resources Conservation Service-National Soil Survey Center. Lincoln, Nebraska.

Soil Survey Staff. 1993. Soil Survey Manual. Agricultural Handbook No.18. U.S.D.A.-Natural Resources Conservation Service.

Soil Survey Staff. 1999. Soil Taxonomy. Second Edition. Agricultural Handbook 436. U.S.D.A.-Natural Resources Conservation Service.



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USDA-Natural Resources Conservation. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

Wyoming Department of Environmental Quality-Land Quality Division (WDEQ). 1996. Guideline No.1, Topsoil and Overburden. Rules Update, August 1994. Selenium Update, November 1996.

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**TABLE D7-1
CROELL REDI-MIX, INC. – SUNDANCE, WYOMING
ROGER'S PIT LIMESTONE QUARRY PERMIT AREA (2008)
LIST OF MAP UNITS AND MINING AREA TOPSOIL SALVAGE SUMMARY**

Map Unit Symbol	Map Unit Name	Soil Sample Location Number	Total Soil Depth (In.)	Total Salvage Depth (In.)	Limitations to Deeper Salvage
A	Tilford-Nevee complex, 2 to 10% slopes	Tilford: S2, S3 Nevee: S1, S7	40+	24	Upper 24" is the better soil material. Lower soil could be salvaged to bedrock if needed.
B	Nevee loam, 2 to 12% slopes	S4	40+	18	Upper 18" is the better soil material. Lower soil could be salvaged to bedrock if needed.
C	Laporte loam, 2 to 35% slopes	S6	4-20	8	Salvage entire profile. Average profile depth is 8".
D	Limestone Rock Outcrop, Laporte soil inclusion	Laporte: S8	LRO=0 La: 4	LRO=0 La=4	LRO has no soil. Laporte averages only 4" to bedrock.
E	Rekop-Gystrum complex, 2 to 10% slopes	Rekop: S5 Gystrum: S9	Re:4-20 Gy: 20-40	6	Rekop average thickness is 6". Salvage Gystrum to bedrock if needed.
F	Gypsum Rock Outcrop, Repok soil inclusion, 2 to 18% slopes	Rekop: S10	GRO=0 Re: 4	0	GRO has no soil. Repok only occupies 10 to 15% of map unit.
DL	Disturbed Land	--	--	0	No soil

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CROELL Redi-Mix # Permit to Mine Table D-7.2

September, 2009

Croell Redimix, Inc

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Fort Collins CO 80525

Colorado State University
Soil, Water and Plant Testing Laboratory
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DATE RECEIVED: 04-11-2008
DATE REPORTED: 05-15-2008

(970) 491-5061 FAX: 491-2930

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RESEARCH SOIL ANALYSIS

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Lab #	Sample ID #	pH	paste mmhos/cm	EC	saturation %	Lime Estimate	OM %	NO ₃ -N	P	K	AB-DTPA ppm				Texture Estimate
											Zn	Fe	Mn	Cu	
R5342	S1 0-5"	7.4	1.3	59.5	Low	4.1	6.3	0.3	257	0.535	7.69	2.51	1.88	Clay Loam	
R5343	S1 5-12	7.8	0.5	53.2	High	2.5	1.7	0.6	140	0.182	7.17	1.42	2.02	Clay Loam	
R5344	S1 12-24	8.0	0.3	53.6	Very High	1.3	0.9	<0.1	84.1	0.150	6.41	0.77	3.41	Clay Loam	
R5345	S1 24-38	8.2	0.2	46.6	Very High	0.7	0.8	<0.1	85.8	0.068	5.97	0.62	1.34	Clay	
R5346	S1 38-54	8.4	0.2	39.2	Very High	0.4	0.6	0.3	91.1	0.069	5.56	0.34	0.96	Clay	
R5347	S1 54-72	8.5	0.3	46.6	Very High	0.4	0.5	0.3	100	0.075	6.55	0.32	0.88	Clay	
R5348	S2 0-5"	7.1	0.3	64.4	Low	5.8	7.9	0.6	449	0.839	11.6	2.60	1.83	Loam	
R5349	S2 5-12	7.6	0.2	57.8	Low	3.4	2.4	0.3	209	0.296	9.46	1.80	2.82	Loam	
R5350	S2 12-24	7.8	0.2	60.1	Low	1.8	1.4	0.3	163	0.157	10.1	1.15	1.60	Clay Loam	
R5351	S2 24-34	8.0	0.2	55.0	Very High	1.4	1.2	0.6	82.8	0.084	6.43	0.76	1.44	Clay	
R5352	S3 0-5"	7.5	0.3	59.2	Medium	5.4	3.6	0.6	255	0.533	7.94	2.66	1.99	Loam	
R5353	S3 5-10	7.7	0.2	54.2	Low	3.5	0.9	0.3	145	0.275	6.79	1.86	1.83	Clay Loam	
R5354	S3 10-20	7.9	0.2	55.7	Very High	2.2	1.1	0.9	116	0.121	7.36	1.11	1.88	Clay Loam	
R5355	S3 20-28	8.0	0.2	52.5	Very High	1.9	0.8	3.1	91.2	0.103	5.01	0.97	1.19	Clay	
R5356	S3 28-40	8.0	0.5	46.6	Very High	0.6	1.0	2.8	66.9	0.096	2.58	0.62	0.83	Clay	
R5357	S3 40-56	7.8	1.1	47.3	Very High	0.7	1.0	3.1	59.0	0.096	1.79	0.47	0.91	Clay	
R5358	S4 0-4 1/2"	7.8	0.4	66.8	High	6.8	7.6	4.0	361	0.817	5.09	2.58	1.44	Loam	
R5359	S4 4 1/2-11"	7.9	0.4	55.3	High	3.7	2.0	2.8	225	0.159	5.33	1.38	1.45	Clay	
R5360	S4 11-21	8.0	0.2	54.3	Very High	1.6	0.9	2.8	103	0.071	2.59	0.77	1.05	Clay	

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CROELL Redi-Mix # _____ Permit to Mine

September, 2009

Croell Redimix, Inc

Sundance Wyoming

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DATE RECEIVED: 04-11-2008

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BILLING:

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	pH	paste EC mmhos/cm	% saturation	Lime Estimate	% OM	AB-DTPA ppm				Texture Estimate		
							NO ₃ -N	P	K	Zn		Fe	Mn
R5361	S4 21-34	8.0	0.6	52.0	Very High	1.2	3.1	104	0.071	2.47	0.60	0.73	Silty Clay
R5362	S4 34-50	8.3	5.6	50.7	Very High	0.5	3.1	127	0.061	2.12	0.45	0.52	Silty Clay
R5363	S4 50-65	8.3	4.8	41.7	Very High	0.3	3.4	120	0.048	1.66	0.45	0.42	Silty Clay
R5364	S5 0-4"	7.8	1.8	64.7	Very High	4.0	2.8	58.3	0.205	2.84	1.28	0.44	Clay

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CROELL Red-Mix # Permit to Mine

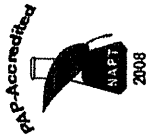
September, 20

Croell Redmix, Inc
Sundance Wyoming

Copy to **Jim Nyenhuis/Certified Professional Soil Scientist**
700 Ramah Drive
Fort Collins CO 80525

Colorado State University

Soil, Water and Plant Testing Laboratory
Natural & Environmental Sciences Bldg - A319
Fort Collins, CO 80523-1120



DATE RECEIVED: 04-11-2008
DATE REPORTED: 05-15-2008

(970) 491-5061 FAX: 491-2930

BILLING:

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	-----meq/L-----			K	SAR	Yield Goal T/A	crop to be grown	-----Fertilizer Suggestions-----		
		Ca	Mg	Na					irrigated	N	P ₂ O ₅
R5342	S1 0-5"	17.3	5.5	0.2	0.4	0.1	2	grass/hay	105	80	0
R5343	S1 5-12	4.7	1.6	0.2	0.1	0.1					
R5344	S1 12-24	2.2	1.4	0.2	0.1	0.2					
R5345	S1 24-38	1.3	2.0	0.3	0.1	0.3					
R5346	S1 38-54	0.7	2.7	0.4	0.1	0.3					
R5347	S1 54-72	0.6	3.6	0.5	0.1	0.4					
R5348	S2 0-5"	2.9	1.0	0.2	0.4	0.1	2	grass/hay	80	80	0
R5349	S2 5-12	2.4	0.7	0.2	0.1	0.1					
R5350	S2 12-24	2.1	0.6	0.2	<0.1	0.2					
R5351	S2 24-34	2.4	0.8	0.2	<0.1	0.2					
R5352	S3 0-5"	2.8	1.1	0.1	0.1	0.1	2	grass/hay	105	80	0
R5353	S3 5-10	2.4	0.7	0.1	<0.1	0.1					
R5354	S3 10-20	2.4	0.6	0.2	<0.1	0.1					
R5355	S3 20-28	2.3	0.7	0.2	<0.1	0.2					
R5356	S3 28-40	4.6	1.1	1.4	0.1	0.8					
R5357	S3 40-56	15.2	4.6	0.5	<0.1	0.2					
R5358	S4 0-4 1/2"	3.5	1.2	0.1	0.4	0.1	2	grass/hay	80	40	0
R5359	S4 4 1/2-11"	4.4	1.2	0.2	0.1	0.1					
R5360	S4 11-21	2.2	1.1	0.3	0.1	0.2					
R5361	S4 21-34	6.0	2.8	0.7	0.1	0.3					

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D-7 T. 4

CROELL Redi-Mix # — Permit to Mine

September, 2009

Croell Redimix, Inc

Sundance Wyoming

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700 Ramah Drive
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Soil, Water and Plant Testing Laboratory
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RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	Ca	Mg	Na	K	SAR
R5362	S4 34-50	20.5	32.7	11.4	0.5	2.2
R5363	S4 50-65	20.6	31.1	9.7	0.6	1.9
R5364	S5 0-4"	29.8	2.6	0.5	0.3	0.1

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CROELL Redi. Mix # Permit to Mine

September 2009

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Sundance Wyoming

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Fort Collins, CO 80523-1120

DATE RECEIVED: 04-25-2008
DATE REPORTED: 05-15-2008

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BILLING:

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	pH	EC	saturation	Lime Estimate	% OM	AB-DTPA				Texture Estimate			
							NO ₃ -N	P	K	Zn		Fe	Mn	Cu
R5449	S6 0-3"	7.6	1.5	73.6	Very High	13.5*	23.4	5.3	235	1.42	11.7	1.86	2.05	Loam
R5450	S6 3-9	7.9	0.4	67.2	Very High	6.0	8.1	2.5	209	0.217	9.70	0.79	1.36	Loam
R5451	S6 9-15	8.0	0.3	56.4	Very High	3.3	3.6	2.5	116	0.100	7.60	0.74	1.06	Loam
R5452	S7 0-3"	7.8	0.4	58.2	High	3.8	5.2	2.8	243	0.344	5.57	1.59	2.08	Silty Clay Loam
R5453	S7 3-14	8.0	0.2	55.3	Very High	2.6	1.2	2.8	102	0.131	5.52	0.84	2.46	Silty Clay
R5454	S7 14-30	8.3	0.2	51.7	Very High	0.9	0.6	3.1	77.3	0.124	5.93	0.43	1.87	Silty Clay
R5455	S7 30-46	8.6	0.3	51.3	Very High	0.5	2.2	2.8	84.6	0.047	6.32	0.26	0.95	Silty Clay
R5456	S7 46-60	9.0	0.6	45.1	Very High	0.4	0.9	3.1	85.7	0.059	6.44	0.30	1.01	Silty Clay
R5457	S8 0-4"	7.8	0.3	65.7	Very High	5.9	11.7	5.6	150	0.521	6.74	0.89	1.93	Loam
R5458	S9 0-3"	7.8	0.3	72.6	Very High	6.2	12.4	3.4	210	0.317	5.77	1.22	1.99	Loam
R5459	S9 3-14	7.8	0.4	64.1	Very High	4.4	2.7	3.1	141	0.136	6.70	1.05	1.91	Clay Loam
R5460	S9 14-27	7.8	0.7	59.4	Very High	1.7	1.2	2.8	217	0.065	3.01	0.53	0.56	Clay Loam
R5461	S10 0-2"	7.7	1.7	62.3	High	0.9	20.7	2.8	18.0	0.192	0.81	0.59	0.38	Sandy Loam

* Expressed as weight loss on ignition

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CROELL Redi-Mix # Permit to Mine

September, 2007

Croell Redimix, Inc

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Jim Nyenhuis/Certified Professional Soil Scientist

Colorado State University

Sundance Wyoming

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Fort Collins CO 80525

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Fort Collins, CO 80523-1120

DATE RECEIVED: 04-25-2008
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(970) 491-5061 FAX: 491-2930

BILLING:

RESEARCH SOIL ANALYSIS

Lab #	Sample ID #	-----meq/L-----				K	SAR	Yield Goal	crop to be grown irrigated	-----Fertilizer Suggestions-----			gypsum meq/100g
		Ca	Mg	Na	-----lb/A-----					N	P ₂ O ₅	K ₂ O	
R5449	S6 0-3"	22.9	4.4	0.5	0.5	0.1							
R5450	S6 3-9	4.2	1.1	0.2	0.3	0.1							
R5451	S6 9-15	3.4	1.1	0.5	0.1	0.3							
R5452	S7 0-3"	5.2	1.1	0.3	0.2	0.2	2T/A	grass/hay dryland	105	80	0		
R5453	S7 3-14	2.6	0.8	0.1	0.1	0.1							
R5454	S7 14-30	1.5	1.7	0.3	<0.1	0.2							
R5455	S7 30-46	1.6	2.3	0.9	0.1	0.7							
R5456	S7 46-60	2.4	1.6	4.2	0.1	3.0							
R5457	S8 0-4"	3.9	0.8	0.2	0.2	0.1							
R5458	S9 0-3"	3.7	0.6	0.4	0.2	0.3							
R5459	S9 3-14	4.8	0.6	0.2	0.1	0.1							
R5460	S9 14-27	26.0	10.3	0.7	0.6	0.2							
R5461	S10 0-2"	28.6	1.5	0.2	0.2	0.1							41.5

LOD

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D-7T.7

56/072

ADDENDUM D-7.1

MAPS

D-7.1-1



56/072

ADDENDUM D-7.2
SOIL MAP UNIT DESCRIPTIONS
FROM THE NRCS
FROM CROOK COUNTY

D-7.2-1



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D-7.2-2



56/072

Cushman loam, 0 to 20 percent slopes

Cushman is a well drained fine-loamy series on buttes, hills, fan remnants, piedmonts, ridges and terraces. The mixed super active soil is formed in slope wash alluvium and residuum from interbedded shale and siltstone, as well as fine-grained argillaceous sandstone. The average temperature is about 41 degrees F. Rock fragments can range from 0 to 15 percent. The rock fragments can consist of soft shale channers or semi rounded sandstone pebbles.

Typically, the surface is a light brownish gray fine sandy loam from 2 to 6 inches thick. It is common to have very fine to medium roots. The subsoil is a brown clay loam from 0 to 20 inches thick. The underlying material is a gray and brown, soft, calcareous shale that can extend to depths greater than 10 feet.

Permeability is moderate. Surface runoff is medium.

This unit is Sagebrush Grassland and wildlife habitat.

The plant community is a mixture of species found within the Sagebrush Grassland community. Plants found in this community include western wheatgrass, needleandthread, big sagebrush, and blue grama.

This community can be used as rangeland.

Kishona loam, 0 to 30 percent slopes

Kishona is a well drained fine-loamy series on alluvial fans, fan aprons, fan remnants, hills, ridges and terraces. The very deep super active soil is formed in alluvium made up of sandstones and shale. The elevations are 3,500 to 6,700 feet. The average temperature is about 45 degrees F. The frost free season can last, on average, between 105 and 130 days. Small areas of Rock outcrop make up 0 to 15 percent.

Typically, the surface is a brown loam from 1 to 6 inches thick. It is common to find fine root structure throughout. The subsoil is a very pale brown silty clay loam 0 to 30 inches thick. The underlying material is a pale brown loam with very few fine roots.

Permeability is moderate. Saline phases are recognized in this series. Surface runoff is slow to medium.

This unit is Sagebrush Grassland and wildlife habitat.

The plant community is a mixture of species found within the Sagebrush Grassland community. Plants found in this community include western wheatgrass, bud sagebrush, Gardner saltbush, and bottlebrush squirreltail.

This community supports native vegetation that is used for domestic livestock as well as by wildlife.



Zigweid loam, 0 to 20 percent slopes

Zigweid is a well drained fine-loamy series on fan aprons, fan piedmonts, alluvial fans, fan remnants, terraces, hills, ridges. The very deep well mixed soil is formed in alluvium from mixed sedimentary sources. The elevations are 3,500 to 6,600 feet. The average temperature is about 46 degrees F. The frost free season can last, on average, between 105 and 130 days. Small rock outcrops are typically less than 5 percent but can range from 0 to 15 percent.

Typically, the surface is a light brownish gray loam from 4 to 8 inches thick. It has many fine roots throughout. The subsoil is a brown clay loam with many fine roots throughout. 6 to 14 inches thick. The underlying material is a pale brown loam and it is common to have fine roots throughout the layer that is 7 to 24 inches thick.

Permeability is moderate. The effective rooting depth is 34 inches or more. Surface runoff is medium to rapid.

This unit is Grassland and wildlife rangeland.

The plant community is a mixture of species found within the Grassland community. Plants found in this community include western wheatgrass, blue grama, needleandthread, and green needlegrass.

This soil can be tilled for dry or irrigated crops but are mostly used as native rangeland.

Theedle loam, 0 to 75 percent slopes

Theedle is a well drained loam series on hills, ridges and fan remnants. The moderately deep to soft bedrock soils are formed in residuum and slope alluvium weathered from sort sandstone. The average temperature is about 45 degrees F.

The texture can be a loam, sandy loam, clay or clay loam. The mean soil temperature for the Theedle series is about 41 degrees F. Rock fragments can make up to 10 percent of the soil.

Typically the surface is a light brownish gray loam from 0 to 5 inches. It is common to have many very fine, fine and medium roots. The subsoil is a light gray loam and is common to have fine and medium roots. The underlying material is soft calcareous sandstone.

Permeability is moderate. Runoff can range from slow to rapid.

This unit is rangeland.

The plant community is Sagebrush grassland. Plants found in this community include: bluebunch wheatgrass, green needlegrass, needleandthread, and big sagebrush.

Shingle loam, 0 to 80 percent slopes

Shingle is a well drained loam series on hill slopes and ridges that are bedrock controlled. The very shallow soil is formed from residuum and colluviums derived from shale and sandstone or in alluvium of mudstone. The average temperature is about 45 degrees F.

The texture can vary between loam, silt loam, silty clay loam, clay loam, cobbly loam, and gravelly clay loam. The mean soil temperature for the Shingle series is between 47 and 53 degrees F. Rock fragments and shale channers vary from 0 – 35 percent.

Typically, the surface is a light brownish grey clay loam with calcium carbonate disseminated throughout. The subsoil is a light yellowish brown also with calcium carbonate. The underlying material is calcareous shale randomly imbedded with soft sandstone.



56/072

Worf loam, 0 – 30 percent slopes

Worf is a well drained loam found on upland hills, ridges, and rangeland. The very shallow or shallow to bedrock soils are formed in residuum and colluvial slope wash weathered from sedimentary rock. The mean annual temperature is about 45 degrees F. The elevation is 3,500 to 5,600 feet. The frost free season can last from 105 to 130 days. Rock fragments vary from 0 to 15 percent but are usually less than 5 percent.

Typically, the surface is a grayish brown loam from 2 to 4 inches that has many fine roots throughout. The subsoil is a yellowish brown loam from 4 to 11 inches thick. It also is common to have many fine and medium roots throughout. The underlying material is calcareous shale interbedded with limestone.

Permeability is moderate. Runoff, depending on slope, is medium or rapid.

This unit is rangeland.

The plant community is Sagebrush grassland. Plants found in this community include; blue grama, western wheatgrass, cactus, and sage.

This soil can be used as native pastureland.

D-Disturbed Area

Disturbed areas within the study area consist primarily of man-made disturbances such as roads. Many of these are linear features. The existing soil profile may remain in-place at the surface or is buried beneath fill material. No further characterization of these areas was made, due to the wide variability in such areas.

R-Rock Outcrop

Rock outcrop includes areas of exposed geologic features that were sufficiently large to be mapped. Vegetation is sparse or non-existent. Slopes may vary widely.



56/1072

ADDENDUM D-7.3
DESCRIPTIONS OF SAMPLED SOIL PROFILES

D-7.3-1



56/072

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D-7.3-2



56/072

KISHONA SERIES**SOIL MAPPING UNIT:** Kishona Loam, 0 to 6 percent slopes**SOIL SAMPLE LOCATION:** Falxa 17**TYPICAL PEDON:** Kishona sandy loam – utilized as rangeland. (Colors are for dry soil unless otherwise stated)

A--0 to 6 inches; brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; moderate medium and fine granular structure; soft, very friable, nonsticky and nonplastic; common fine roots throughout; non-effervescent; neutral (pH 6.9).

AC--6 to 18 inches; very pale brown (10YR 7/3) loam, brown (10YR 5/3) moist; weak medium and coarse angular structure; hard, friable, slightly sticky and slightly plastic; few fine and very fine roots throughout; non-effervescent; mildly alkaline (pH 7.5).

C1k--18 to 28 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slight sticky and nonplastic; carbonates are disseminated throughout; strongly effervescent; moderately alkaline (pH 7.9).

C2k--28 to 32 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slight sticky and nonplastic; carbonates are disseminated throughout; strongly effervescent; moderately alkaline (pH 7.9).

C3k--32 to 48 inches; pale brown (10YR6/3) sandy clay loam, brown (2YR 5/3) moist; massive; slightly hard, friable, slight sticky and slightly plastic; lithic contact at 48 inches; strongly effervescent; moderately alkaline (pH 8.3).

TYPE LOCATION: Johnson County, Wyoming; please refer to map.

RANGE IN CHARACTERISTICS (according to official NRCS description): Rock fragments ranges from 0 to 15 percent. The mean annual soil temperature ranges from 48 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 190 to 202 days. The depth to carbonates ranges from 0 to 10 inches. Saline phases are recognized. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F. and is never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 20 inches is 48 degrees F. or more. This soil is moist for 60 consecutive days when the soil temperature at a depth of 20 inches is 41 degrees F., which occurs April 21-27, but is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during that period.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torriorthents**SUITABILITY FOR TOPSOIL (according to WDEQ Guideline 1, 1994):** No unsuitable or marginal values were present. Estimated stripping depth is 32 inches.

GEOGRAPHIC SETTING (according to official NRCS description): Kishona soils are on dissected alluvial fans, fan remnants, fan aprons, hills, ridges and terraces. Slopes are typically 0 to 6 percent but range up to 30 percent on dissected slopes. The soils formed in alluvium derived from sandstones and shales. Elevation is 3,500 to 6,700 feet. The average annual precipitation ranges from 10 to 14 inches with over one-half falling in April, May and June and less than one inch falling in each month of July, August, September, and October. The mean annual air temperature is about 45 degrees F. but ranges from 43 to 51 degrees F. The frost-free season is about 105 to 130 days.

D-7.3-3



56/1072

ZIGWEID SERIES**SOIL MAPPING UNIT:** Zigweid loam; 0 to 6 percent slopes**SOIL SAMPLE LOCATION:** Martin 16**TYPICAL PEDON:** Zigweid clay loam - utilized as rangeland. (Colors are for dry soil unless otherwise stated)

A--0 to 2 inches; light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) moist; moderate fine and medium granular structure; slight hard, friable, slightly sticky and slightly plastic; many very fine and fine roots throughout; non-effervescent; neutral (pH 7.2).

Bw--2 to 6 inches; brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; moderate medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots throughout and few medium roots throughout; non-effervescent; neutral (pH 7.2).

Ck1--6 to 17 inches; brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots throughout; strongly effervescent; moderately alkaline (pH 8.0).

Ck2--17 to 27 inches; brown (10YR 5/3) loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots throughout; strongly effervescent; strongly alkaline (pH 8.6).

Ck3--27 to 40 inches; pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots throughout; strongly effervescent; moderately alkaline (pH 8.4).

Ck4--40 to 48 inches; pale brown (10YR 6/3) silty loam, brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots throughout; moderately effervescent; moderately alkaline (pH 8.1).

TYPE LOCATION: Johnson County, Wyoming; please refer to map.

RANGE IN CHARACTERISTICS (according to official NRCS description): Depth to carbonates ranges from 0 to 8 inches. Depth to the Bk horizon and the base of the cambic horizon ranges from 10 to 22 inches. The particle-size control section and soil profile are clay loam or loam. Clay ranges from 18 to 35 percent, silt from 20 to 55 percent, and sand from 15 to 50 percent with more than 15 percent but less than 35 percent fine sand or coarser. Rock fragments range from 0 to 15 but are typically less than 5 percent and are mostly soft shale chips. The moisture control section is usually dry in all parts for 90 cumulative days following the summer solstice and for 60 consecutive days during this period. The mean annual soil temperature is 47 to 53 degrees F. The soil temperature at a depth of 20 inches is 41 degrees F. or warmer for 175 to 192 days.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Ustic Haplocambids

SUITABILITY FOR TOPSOIL (according to WDEQ Guideline 1, 1994): A marginal pH value of 8.6 was found at Martin 16 (17-27). Estimated stripping depth is 40 inches.

GEOGRAPHIC SETTING (according to official NRCS description): These soils are on fan aprons, alluvial fans, terraces, fan piedmonts, fan remnants, ridges and hills. In many areas they are dissected. Slopes range from 0 to 20 percent. These soils formed in calcareous, moderately fine textured sediments derived from interbedded shale and soft sandstone. Elevations are 3,500 to 6,600 feet. The mean annual precipitation is 13 inches with over half of the annual precipitation falling in April, May, and June and less than one inch falling in each month of July, August, September, and October. Precipitation ranges from 10 to 14 inches. The mean annual temperature is about 46 degrees F., and ranges from 43 to 51 degrees F. The frost-free season is about 105 to 130 days.

D-7.3-4



56/072

SHINGLE SERIES**SOIL MAPPING UNIT:** Shingle loam, 0 to 6 percent slopes**SOIL SAMPLE LOCATION:** Martin 18**TYPICAL PEDON:** Shingle loam-utilized as rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 6 inches; light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate very fine granular structure; soft, very friable, slightly sticky and slightly plastic; non-effervescent; neutral (pH 7.0).

C--6 to 18 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, variable, moderately sticky and moderately plastic; strongly effervescent; moderately alkaline (pH 7.9).

TYPE LOCATION: Johnson County, Wyoming; please refer to map.

RANGE IN CHARACTERISTICS (according to official NRCS description): Depth to soft bedrock and paralithic contact ranges from 4 to 20 inches. The mean annual soil temperature is 47 to 53 degrees F. The soils commonly are calcareous throughout, but some pedons are leached to 6 inches. The particle size control section averages 20 to 35 percent clay and has more than 15 percent but less than 35 percent fine or coarser sand. The soil is usually dry. The moisture control section is usually moist in April, May and early June. It is dry for 60 consecutive days or more during the 90 day period following the summer solstice. EC is 0 to 2 mmhos throughout.

TAXONOMIC CLASS: Loamy, mixed, superactive, calcareous, mesic, shallow Ustic Torriorthents

SUITABILITY FOR TOPSOIL (according to WDEQ Guideline 1, 1994): No unsuitable or marginal values were present. Estimated stripping depth is 6 inches.

GEOGRAPHIC SETTING (according to official NRCS description): The Shingle soils occur on all hillslope positions. Slopes are 0 to 80 percent. These soils formed in colluvium and residuum weathered from soft, interbedded sandstone and shale or in alluvium from mudstone. Elevation is 3,200 to 6,500 feet. The mean annual precipitation is about 10 to 14 inches, most of which falls in April, May, and June. The mean annual temperature is about 45 degrees F but ranges from 43 to 51 degrees F. The frost-free season is about 105 to 130 days.

D-7.3-5



56/072

WORF SERIES**SOIL MAPPING UNIT:** Worf loam, 0 to 15 percent slopes**SOIL SAMPLE LOCATION:** Schoonover/Wardner 16**TYPICAL PEDON:** Worf loam- utilized as rangeland. (Colors are for dry soil unless otherwise stated.)

A--0 to 3 inches; grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; strong very fine granular structure; soft, very friable, slightly sticky and slightly plastic; many fine and very fine roots; non-effervescent; neutral (pH 6.6).

B--3 to 6 inches; grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; weak medium subangular blocky structure parting to moderate very fine granular; slightly hard, very friable, slightly sticky and slightly plastic; many fine and very fine roots; non-effervescent; neutral (pH 6.6).

BC--6 to 12 inches; brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; moderate fine subangular blocky; hard, very friable, moderately sticky and moderately plastic; many fine roots; non-effervescent; mildly alkaline (pH 7.6).

Ck--12 to 18 inches; light yellowish brown (2.5Y 6/3) sandy clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable, moderately sticky and slightly plastic; common fine and medium roots; strongly effervescent; mildly alkaline (pH 7.6).

TYPE LOCATION: Johnson County, Wyoming; please refer to map.

RANGE IN CHARACTERISTICS (according to official NRCS description): Depth to calcareous material ranges from 4 to 10 inches; depth to bedrock ranges from 8 to 20 inches. The soil is 90 to 100 percent base saturated. Rock fragments range from 0 to 15 percent but are typically less than 5 percent and are mostly soft shale fragments. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F., which occurs about April 21-27, and is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during this period. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 192 days.

TAXONOMIC CLASS: Loamy, mixed, superactive, mesic, shallow Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ Guideline 1, 1994): No unsuitable or marginal values were present. Estimated stripping depth is 12 inches.

GEOGRAPHIC SETTING (according to official NRCS description): These soils are on upland hills and ridges. Slopes range from 0 to 30 percent and are both simple and complex. Elevation is 3,500 to 5,600 feet. These soils formed in calcareous materials weathered from sedimentary bedrock. The mean annual precipitation is 12 inches with over half of the annual precipitation falling in April, May, and June and less than one inch falling in each month of July, August, September, and October. Precipitation ranges from 10 to 17 inches. The mean annual temperature is 43 to 51 degrees F. The frost-free season is about 105 to 130 days.

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CUSHMAN SERIES**SOIL MAPPING UNIT:** Cushman Loam, 0 to 15 percent slopes**SOIL SAMPLE LOCATION:** Schoonover/Wardner 18**TYPICAL PEDON:** Cushman sandy loam; utilized as rangeland. (Colors are for dry soil unless otherwise stated)

A--0 to 3 inches; light brownish gray (10YR 6/2) sandy loam, dark brown (10YR 3/3) moist; moderate medium granular structure; soft, friable, nonsticky and nonplastic; common very fine, fine, and few medium roots; non-effervescent; neutral (pH 7.1).

B--2 to 8 inches; brown (10YR 5/3) clay loam, dark yellowish brown (10YR 3/4) moist; moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine, fine and few medium roots; non-effervescent; neutral (pH 7.1).

Ck--14 to 21 inches; pale brown (10YR 6/3) sandy clay loam, yellowish brown (10YR 5/4) moist; massive; hard, firm, moderately sticky and moderately plastic; few fine roots; strongly effervescent; moderately alkaline (pH 7.8).

TYPE LOCATION: Johnson County, Wyoming; please refer to map.

RANGE IN CHARACTERISTICS (according to official NRCS description): Depth to a paralithic contact and bedrock is typically about 28 to 32 inches but ranges from 20 to 40 inches. Depth to continuous horizons of carbonate accumulation is 7 to 26 inches. Depth to the base of the argillic horizon ranges from 10 to 26 inches. Rock fragments range from 0 to 15 percent and are soft shale channers or semi-rounded sandstone pebbles. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F., which occurs about April 21-27, and is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during this period. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 192 days. EC ranges from 0 to 2 mmhos throughout.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Ustic Haplargids

SUITABILITY FOR TOPSOIL (according to WDEQ Guideline 1, 1994): No unsuitable or marginal values were present. Estimated stripping depth is 17 inches.

GEOGRAPHIC SETTING (according to official NRCS description): Cushman soils are on buttes, fan remnants fan piedmonts, hills and ridges. Slopes range from 0 to 20 percent. The soils formed in moderately fine textured slopewash alluvium and residuum. Surface erosion is common in overgrazed areas, and some thin eolian deposits overlie these soils in some areas. Elevations are 3,500 to 6,000 feet. The mean annual precipitation is 13 inches and ranges from 10 to 14 inches with over half of the annual precipitation falling in April, May, and June and less than one inch falling in each month of July, August, September and October. The mean annual temperature is 43 to 51 degrees F. The frost-free season is about 105 to 130 days depending upon elevation, aspect, and air drainage.

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