IN THE SUPREME COURT
STATE OF NORTH DAKOTA

Casey Voigt, Appellant, vs. North Dakota Public Service Commission and Coyote Creek Mining Company, L.L.C., Appellees.	))))))))))	Supreme Court Case No.: 20160046 Burleigh County District Court Case No.: 08-2015-CV-1056

Appeal from Judgment Entered on January 28, 2016
Case No. 08-2015-CV-1056
County of Burleigh, South Central Judicial District
The Honorable Bruce A. Romanick, Presiding

APPENDIX OF APPELLANT CASEY VOIGT

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EXHIBIT
10 Coyote Creek

STATE OF NORTH DAKOTA

PUBLIC SERVICE COMMISSION

Coyote Creek Mining Company, L.L.C
Permit NACC-1302
Application

Case No. RC-13-850

PERMIT TO ENGAGE IN SURFACE COAL MINING AND RECLAMATION OPERATIONS

October 22, 2014

Based on the application for **Surface Coal Mining Permit Number NACC-1302** submitted by Coyote Creek Mining Company, L.L.C. for the Coyote Creek Mine on November 1, 2013, and as revised through October 10, 2014, and all information and documentation contained therein, the North Dakota Public Service Commission (Commission) finds that the application meets all applicable requirements of Chapter 38-14.1 of the North Dakota Century Code (NDCC) and Article 69-05.2 of the North Dakota Administrative Code (NDAC). On the basis of the information set forth in the application or from that otherwise available and known by the applicant, the Commission finds that:

Finding No. 1. The permit application is accurate and complete and complies with the requirements of NDCC Chapter 38-14.1 and NDAC Article 69-05.2 [NDCC 38-14.1-21(3)(a)].

The applicant verified that all information included in the permit application is true and correct to the best of their knowledge. Permit NACC-1302 will allow surface coal mining and reclamation operations on 8,091.511 acres of land for the Coyote Creek Mine in Mercer County, North Dakota. Permit NACC-1302 includes the 84.24 acres of previously approved covered by Permit NACC-1301 for the mine's shop/office area. Commission staff conducted completeness and technical reviews to ensure that the required information was provided and the mining and reclamation plans meet all applicable requirements. The Reclamation Division sent completeness and technical review letters to the applicant on November 27, 2014, February 19, 2014, March 11, 2014, June 17, 2014, August 25, 2014, and October 3, 2014. Responses to each letter were received and appropriate changes were made to the application to address the concerns that were noted. The applicant provided leases and other documents showing that they have the right to mine the lands where coal removal is proposed and to disturb the surface of other lands in the permit area. The Commission concludes that the application is now accurate and complete.

The applicant published the required notices in the Hazen Star, Beulah Beacon, and Bismarck Tribune and the Commission sent notices to all surface owners that will be affected by Permit NACC-1302 and to numerous local, state and federal agencies. In addition, advisory committee members were provided copies of the application for their review and comment. No objections or requests for an informal conference were received on this application and no major issues were raised during the review of this application.

The applicant provided evidence that it has the right to disturb the surface of all lands within the proposed permit area. The applicant has these rights based on coal and surface leases, copies of which are included in the application. However, a coal lease was not obtained for Section 31 and therefore the mining plans do not show any coal mining in that section. In addition, the applicant has not obtained the right to mine coal on tracts where the United States of America owns the coal interest. No mining of the federal coal tracts is proposed at this time, only surface disturbances are proposed over these tracts. However, the applicant is planning to apply for federal coal leases in the future. Before overburden and coal removal is allowed to begin on any of the federal coal tracts, a federal coal lease must be issued and the Department of the Interior needs to approve the mine plan covering federal coal tracts that will be mined as required by 30 CFR 746.11. This section of federal regulations states no person shall conduct surface coal mining and reclamation operations on lands containing leased federal coal until the Secretary has approved the mining plans. Special Condition No. 1 attached to the approval of this permit prohibits overburden and coal removal from these tracts until the appropriate leases are issued, the permit is revised to provide the detailed operations and reclamation plans for mining the federal coal tracts, and the Department of the Interior approves the mine plan.

Finding No. 2. The applicant has demonstrated that reclamation as required by NDCC Chapter 38-14.1 and NDAC Article 69-05.2 can be accomplished under the reclamation plan contained in the permit application [NDCC 38-14.1-21(3)(b)].

Slightly more than half of the land in the permit area will be mined during the nearly 30-years of mining described in the permit. Additional areas will be disturbed for support activities including soil and overburden stockpiles, access and haulroads, and water management structures. Overburden from the coal removal areas will be removed using a truck/shovel fleet and one large dragline. Reclamation of disturbed areas will be carried out using reclamation procedures that have been successful in the past and satisfy the requirements of the North Dakota law and rules. Reclamation methods and practices that will be used by the applicant have proven effective in the past. Similar lands have been surface mined and successfully reclaimed at the former Indian Head and Glenharold Mines in Mercer County using comparable reclamation methods.

Mining activities will begin in the northeast portion of the permit in late 2014 following permit approval to the extent the construction season allows for the installation of utilities and continued construction of shop/office facilities. The construction of sedimentation ponds, haul roads, and a dragline walkway corridor will occur in 2015 along with topsoil and subsoil removal and stockpiling for the initial dragline pits. The actual mining will begin with dragline box cut pits in 2016. The applicant expects to start coal removal in 2016 with a projected production of 1.7 million tons for the first year of production.

Detailed design plans were provided for sedimentation ponds that will be constructed in the first year of the permit term as required by NDAC 69-05.2-09-09(1)(e). Coal removal from this permit is expected to continue until 2040. After 2016, the coal production rate will be approximately 2.5 million tons per year.

The applicant has demonstrated that sufficient soil materials are available to meet the soil redistribution requirements of NDAC 69-05.2-15 and the revegetation requirements of NDAC 69-05.2-22. The application includes information on sources of non-sodic glacial till material that may be selectively handled to cover sodic spoils or potentially used as other suitable strata to supplement subsoil materials in order to achieve the required respread thickness over sodic spoil material. The actual soil removal volumes and expected respread depths will be calculated annually and presented in an annual soils handling plan prepared by the applicant.

The proposed postmining topography that is shown for the mining that will occur through 2040 meets the requirements of NDCC 38-14.1-24(3) and NDAC 69-05.2-21-02. The average postmining slope proposed for the mining disturbance area is lower than the average pre-mine slope in this area. No thin overburden exists within this permit area. The reclaimed lands will be capable of supporting the premine uses, or higher or better uses, that existed prior to mining. The predominant premining land uses in the permit area are native grassland (6,572 acres) and cropland (198 acres for annual crops and 816 acres for hay crops). Lesser amounts are used for shelterbelts, fish and wildlife habitat (wetlands), woodlands, developed water resources, and roads. The acreage of each postmining land use will be somewhat similar to the premine conditions; however, the cropland acreage will increase by about 430 acres, while hayland will decrease by about 48 acres and the native grassland acreage will decrease by about 405 acres. There is one occupied farmstead located in the permit area. At this time the applicant does not propose to disturb the farmstead or to conduct mining operations within 500 feet of any farm building.

The applicant also evaluated premine lands that are not currently being used for cropland to identify areas with soils, slopes and size suitable to be considered potential cropland. The only potential cropland area identified in the permit area was found in Section 36, T143N, R89W. An equivalent sized area of potential cropland has been delineated on the postmining land use map within a tract that will be returned to native rangeland. The soil respread depth for the potential cropland area will be determined in the annual soils handling plan in a manner to ensure that the premine capabilities are restored as required by NDCC 38-14.1-24(2).

With regard to the reclamation schedule for the first five year permit term, the applicant has requested variances from the contemporaneous reclamation requirements that normally require rough grading to be completed within 180 days of coal removal, NDAC 69-05.2-21-01(2), and that all reclamation efforts through the initial seeding be completed within three years of completion of mining activities, NDCC 38-14.1-24(14). The requested variances described in the application are related to the backfill area required to accommodate pre-benching operations and to incorporate the box cut spoils into the postmining topography. The requested variances from the 180 day grading and three-year seeding requirements have been justified and are being approved by Commission as allowed by NDAC 69-05.2-21-01(2) and NDCC 38-14.1-24(14).

Finding No. 3. Based on the assessment of the probable cumulative impacts of all anticipated mining in the area, the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area [NDCC 38-14.1-21(3)(c)].

An assessment of the probable cumulative hydrologic impacts of all anticipated mining in the area has been made as required by NDCC 38-14.1-14(1)(o). The Commission finds that the proposed operation has been designed to maintain the quantity, quality, and hydrologic regime of surface and ground water systems in the area. The cumulative effects of all existing and proposed mining operations should not damage the hydrologic balance outside the permit area. The detailed cumulative hydrologic impact assessment is on file with Permit NACC-1302 in the Commission's offices.

Finding No. 4. Lands within the permit area are not within an area designated unsuitable for surface coal mining operations, nor within areas under study or administrative proceedings under a petition to have an area designated as unsuitable for surface coal mining operations [NDCC 38-14.1-21(3)(d)].

None of the lands in Permit NACC-1302 have been designated unsuitable for surface coal mining operations pursuant to NDCC 38-14.1-05, nor are they within an area under study or administrative proceedings under a petition to have an area designated as unsuitable for surface coal mining operations.

Finding No. 5. The proposed mining operations will not interrupt, discontinue, or preclude farming on alluvial valley floors that are irrigated or naturally sub-irrigated or materially damage the quantity or quality of water in surface or underground water systems that supply these alluvial valley floors [NDCC 38-14.1-21(3)(e)].

Based on an examination of the geologic and geomorphic characteristics, soils, land use, and the water quality and quantity of streams occurring within or adjacent to the permit area, it has been determined that there are no alluvial valley floors within or adjacent to the permit area. In addition, portions of Coyote Creek near the permit area were previously evaluated for alluvial valley floor potential and Commission staff determined that this creek does not have the characteristics to be considered an alluvial valley floor. Detailed alluvial valley floor investigation reports and determinations are on file with the Commission.

Finding No. 6. In cases where the mineral estate has been severed from the surface estate, the applicant complied with the requirements of NDCC 38-18 [NDCC 38-14.1-21(3)(f)].

The applicant included copies of the necessary leases and other documents in the permit application demonstrating compliance with the North Dakota Surface Owner Protection Act, North Dakota Century Code Chapter 38-18. This documentation included copies of notice that was given to the surface owners before the application was filed with the Commission.

Finding No. 7. Lands within the permit area are not subject to the prohibitions or limitations of NDCC 38-14.1-07 except for areas that receive specific approvals after complying the applicable review procedures of NDAC Chapter 69-05.2-04 [NDAC 69-05.2-10-03(6)(a)].

Lands in the permit area are:

a) Not on any lands within the boundaries of units of the North Dakota Park System, the National Park System, the National Wildlife Refuge Systems, the National System of Trails, the National Wilderness Preservation System, the National Wild and Scenic Rivers System, including study rivers designated under Section 5(a) of the Wild and Scenic Rivers Act, and national recreation areas.

b) Not on any federal lands within the boundaries of any national forest.

c) Not within 300 feet of any publicly owned park or places included in the State Historic Sites Registry or the National Register of Historic Places. A cultural resource survey and inventory of the area being permitted was conducted. All sites that were identified have been properly tested and evaluated. Several historic and prehistoric sites were identified and several prehistoric sites have been determined to be eligible for listing on the National Register of Historic Places. The field work for mitigation of one of the eligible sites, 32ME2350, was completed in 2013 and the mitigation report has been accepted by the State Historical Society and the site has been cleared for disturbance. All other eligible sites will be either avoided or mitigated. A cultural resource management plan and data recovery plan was developed for the remaining eligible sites with input from the State Historical Society and Native American consultation from the Three Affiliated Tribes. The cultural resource management plan was approved by the State Historical Society in a letter to Coyote Creek Mining Company dated May 27, 2014. Coyote Creek Mining Company has committed to reporting, testing and mitigating, if necessary, any previously unrecorded archeological, cultural, or historical materials that may be discovered as a result mining related activities.

d) Within 100 feet of the outside right-of-way line of public roads. However, no disturbances will occur within 100 feet of the outside right-of-way of any public road unless the road authority, Mercer County, has temporarily vacated the road right-of-way or granted permission to conduct mining operations within 100 feet of the road right-of-ways. The approvals previously obtained for public roads within the Permit NACC-1301 area have been included in Permit NACC-1302. The applicant will request additional road right-of-way closures in the future. Special Condition No. 2 is attached to the permit requiring Coyote Creek Mining Company to provide the Commission with copies of the road authority's approval documents within 30 days of the approval date and include the written findings made by the road authority. North Dakota Administrative Code Section 69-05.2-04-01.3 requires the Commission to make a written finding on protecting the interests of the public and affected landowners if this is not included in the road authority's approval process.

e) Includes an occupied dwelling that is part of a farmstead belonging to Casey and Julie Voigt in the SW¼ of Section 31, T143N, R88W. However, coal mining operations will not occur within 500 feet of the occupied dwelling, or within 500 feet of any farm building. In the future the applicant may exercise an option in the lease obtained from the building owners to purchase the buildings. No other occupied buildings are located within the permit area.

f) Not within 300 feet of any public building, school, church, community, or institutional building.

g) Not within 100 feet of any cemetery.

Finding No. 8. With respect to prime farmland within the permit area, the post-mining land use for the pre-mining prime farmland will be cropland, the reclamation plan was reviewed by the Natural Resources Conservation Service (NRCS) and their suggestions were considered, operations will be conducted in compliance with NDAC 69-05.2-26 and NDCC 38-14.1, and the applicant has the technological capability to restore the productivity on reclaimed lands [NDAC 69-05.2-10-03(6)(c) and NDCC 38-14.1-21(6)].

The applicant included a prime farmland reclamation plan with the submittal of the original permit that satisfies the requirements of NDAC 69-05.2-09-15 and the performance standards of NDAC Chapter 69-05.2-26. The postmining land use for the prime farmlands that will be disturbed is cropland. The prime farmland tracts in the permit area will be affected by associated disturbances only, not actual mining. Based on the type of disturbances no separate handling for soils from prime areas is planned. The NRCS provided review comments on the application and did not object to mixing prime and nonprime soils provided the selective handling plan for soil material as outlined in the application is followed. The selective soils handling plan in the permit application identifies soils and soil depths suitable for salvage and use in reclamation. The prime farmland areas will be reclaimed in the same location, with the same topography that existed prior to disturbance. The applicant is responsible for replacing soil materials and managing reclaimed lands as necessary to meet productivity standards. The reclamation methods that will be used by the applicant for associated disturbance areas have been proven to be successful in the past at other mines. Therefore, the Commission finds the technological capability exists to restore the productivity of reclaimed land to a level that is equal to or greater than non-disturbed prime farmland in the surrounding area under equivalent management practices.

Finding No. 9. The operations will not affect the continued existence of threatened or endangered species or result in the destruction or adverse modification of their critical habitats [NDAC 69-05.2-10-03(6)(d)].

Surface coal mining and reclamation activities will not affect the continued existence of threatened or endangered species or result in the destruction or adverse modification of their critical habitats. No federal threatened or endangered species or designated critical habitats were observed within or contiguous to the proposed permit area.

The permit area is located in the whooping crane (a listed species) migration corridor where mining and reclamation activities "may affect, but are not likely to adversely affect" this species. The likelihood of whooping cranes occurring in or adjacent the permit area is very low because desirable stop-over roosting habitat does not exist in the area. Whooping crane feeding sites area often found adjacent to roosting sites. Wetlands in and adjacent to the permit area are primarily associated with springs, seeps and ephemeral linear drainages. The permit and adjacent area does not contain any large (>5 acres) seasonal or more permanent wetlands and Coyote Creek is a highly incised perennial stream that ranges from 15 to 50 feet wide. Thus, the Commission finds that suitable whooping crane wetland stop-over habitat does not exist within or adjacent to the permit area. The U.S. Fish and Wildlife Service was consulted during the wildlife inventory process and concurred that there appeared to be limited suitable habitat for whooping cranes in the permit and adjacent area. (Refer to the comments in the U.S. Fish and Wildlife Service's July 16, 2012 letter regarding the applicant's pre-mine fish and wildlife inventory plan.)

The permit and adjacent area does not contain habitat for other listed species including the Black-footed ferret, Pallid Sturgeon, Interior Least Tern, Piping Plover or Western Prairie Fringed Orchid. The Gray Wolf could conceivably be an occasional migrant visitor to western North Dakota and the permit area.

Specific surveys were completed during baseline wildlife inventory for the Dakota skipper butterfly and Sprague's pipit which are Candidate species to the Endangered Species Act. Sprague's pipits were observed at eleven locations during the baseline wildlife survey in 2012, while none were observed in 2013. The Dakota skipper was not sighted on or near the permit area during 2012 and 2013 surveys. Suitable habitat obviously exists in the permit area for Sprague's pipit and it is unlikely that suitable habitat exist in the area for the Dakota Skipper. Surveys will continue to be conducted for these species and the Northern Long-eared Bat, which is also a Candidate species, if it is determined that the isolated woody draws in the permit area are suitable habitat for this species. The permit and adjacent area does not contain riparian forest or hibernacula so it is unlikely that the suitable habitat exists for Northern Long-eared Bat. Suitable habitat does not exist for the other Candidate species which includes Poweshiek Skipperling, Rufa Red Knot and Greater Sage Grouse.

Finding No. 10. The applicant will be required to pay all reclamation fees required by 30 CFR subchapter R [NDAC 69-05.2-10-03(6)(e)].

Since no mining has occurred at the Coyote Creek Mine, the applicant has not yet been required to pay the reclamation fees required by 30 CFR subchapter R. However, a standard condition is attached to the permit that will require the payment of these fees when coal is mined. The Office of Surface Mining's Applicant Violator System office in Lexington, Kentucky, was queried to verify that all fees have been paid by mining companies affiliated with the applicant.

Finding No. 11. The applicant has satisfied requirements for approving cropland as a post-mining land use [NDAC 69-05.2-10-03(6)(f)].

The applicant has satisfied the requirements for approval of a cropland post-mining land use under NDAC 69-05.2-22-01. Areas reclaimed to cropland will either be seeded directly to crops commonly grown in the area or to a tame grass/legume pre-cropland mixture. The post-mining topography and soils are suitable for cropland in the areas that will be cropped.

Finding No. 12. No existing structures will be used to support mining activities within the permit area and the requirements of NDAC 69-05.2-09-04 do not apply to the permit area [NDAC 69-05.2-10-04].

No existing structures in the permit area will be used to support mining activities. Design information for the support structures being constructed in Permit NACC-1301 is also included in this permit.

Finding No. 13. No drill holes, boreholes or wells will be retained for other uses [NDAC 69-05.2-14-03].

The applicant has not proposed to retain any drill hole, borehole, or well for other uses.

Finding No. 14. No spoil in the permit area is known to cause toxic mine drainage [NDAC 69-05.2-16-11].

The chemical characteristics of the overburden materials in the permit area are such that they do not produce toxic mine drainage. The analysis of overburden samples included in the permit application do not reveal any substances that would cause any chemical reactions or physical effects that are likely to kill, injure, or impair biota commonly present in the area.

Finding No. 15. The applicant will not conduct mining activities within or near perennial and intermittent stream channels that violate applicable water quality standards or adversely affect the quantity and quality of the water and other environmental resources of the stream [NDAC 69-05.2-16-20].

Mining activities are proposed within or near streams that have been identified as intermittent and perennial streams. The dragline walkway/access road that will cross Coyote Creek, a perennial stream, in one location and other associated disturbances will be within one hundred feet of Coyote Creek at another. Both areas are located in the S½ of Section 30. In addition, a coal haul road will cross Coyote Creek in the SW¼ of Section 19. No disturbances are planned for the remainder of the perennial stream located within the proposed permit area. No intermittent streams were identified in the permit area.

As required by subsection 1 of NDAC 69-05.2-16-20, the Commission sent a copy of the updated permit application to the State Engineer and North Dakota Department of Health on September 18, 2014 to specifically review and comment on the applicant's plan to conduct mining activities within one hundred feet of perennial and intermittent streams. Operation plans in the permit specifically discuss the associated mining disturbances that will take place within one hundred feet of the perennial stream. No concerns or objections to the proposed disturbances were received from the State Engineer or Department of Health. The buffer zones and areas where associated disturbance will occur within one hundred feet of the perennial stream are depicted on the pit layout and facilities map. The Commission finds that the proposed disturbances will not cause or contribute to the violation of applicable state and federal water quality standards and will not adversely affect the water quality of these intermittent and perennial streams. All runoff from disturbances planned within one hundred feet of the perennial stream will be controlled through the use of water management structures and best management practices. The applicant has made a commitment to properly mark the designated stream buffer zones that will not be disturbed to exclude mining related disturbance as required by NDAC 69-05.2-16-20(2).

Finding No. 16. The applicant does not propose to use any experimental practices in the federal coal tract area [NDAC 69-05.2-27-02].

There are no plans included in the application to use any experimental practices that may be allowed under NDAC 69-05.2-27-02.

Finding No. 17. The applicant does not control and has not controlled surface coal mining and reclamation operations with a demonstrated pattern of willful violations [NDAC 69-05.2-10-03(4)].

Commission records, and those in the Office of Surface Mining's Applicant Violator System, do not show that the applicant, nor any affiliated company, controls and has controlled surface coal mining and reclamation operations with a demonstrated pattern of willful violations of NDCC 38-14.1 or of other states' laws that are based on P.L. 95-87 (the Federal Surface Mining Control and Reclamation Act), of such nature, duration, and with such resulting irreparable damage to the environment as to indicate an intent not to comply with the provisions of these laws.

Finding No. 18. Neither the applicant, nor any affiliated companies, have unabated violations or unpaid civil penalties [NDAC 69-05.2-10-03(1)].

Commission records, and those in the Office of Surface Mining's Applicant Violator System, do not indicate that the applicant, nor any affiliated companies, have any unpaid civil penalties or unabated violations of NDCC 38-14.1 or any other federal or state laws, rules, or regulations pertaining to air or water environmental protection. Staff at the North Dakota Department of Health also verified that the applicant has no unabated violations with regard to air and water environmental protection standards.

Finding No. 19. A performance bond in the amount of $4,648,285 is sufficient for the surface coal mining operations proposed in the first bond increment for this permit [NDAC 69-05.2-12-07].

The Commission has determined that a performance bond in the amount of $4,648,285 is sufficient at this time to cover the required reclamation, restoration, and abatement work for the disturbances proposed in the first increment area in Permit NACC-1302. The first bond increment covers 2,088.8 acres and includes all disturbances that are expected to occur before January 1, 2016. A surety bond in the amount of $5,000,000 has been filed with the Commission for this first bond increment.

Subject to the right of any person with an interest that is or may be adversely affected to request a formal hearing under NDCC 38-14.1-30, **Surface Coal Mining Permit Number NACC-1302** is hereby granted to **Coyote Creek Mining Company, L.L.C.** to engage in surface coal mining and reclamation operations, on the following described areas subject to the applicable requirements of the original permit and conditions, Chapter 38-14.1 of the North Dakota Century Code, and the rules promulgated there under. (Attached is a copy of the metes and bounds description of lands included in the permit area.)

LOCATION

MINE	**ADDRESS**	**SECTIONS**	**TOWNSHIP**	**RANGE**	**COUNTY**
Coyote Creek	**Beulah, ND**	**6 and 7**	**142N**	**88W**	**Mercer**
		1, 2, 3, 11, and 12	**142N**	**89W**	**Mercer**
		19, 30 and 31	**143N**	**88W**	**Mercer**
		23, 24, 25, 26, 27, 34, 35, and 36	**143N**	**89W**	**Mercer**

Total – 8,091.511 Acres

PUBLIC SERVICE COMMISSION

Randy Christmann **Commissioner**	**Brian P. Kalk** **Chairman**	**Julie Fedorchak** **Commissioner**

Section 1.2.2 – Metes and Bounds Description for Entire Permit Area

A tract of land for a mining permit located in T142N and T143N, R88W and R89W, of the 5th P.M., Mercer County, North Dakota.

All bearings and distances are based on the North Dakota State Plane Coordinate System, South Zone, NAD 83.

All bound calls supersede any metes within this description.

Described as follows:
Beginning at the northeast corner of section 30, T143N, R88W;
thence S 00°46'11" W a distance of 2639.34', to the east 1/4 corner of said Section;
thence S 00°54'16" W a distance of 2639.62', to the southeast corner of said Section 30;
thence S 00°54'16" W a distance of 2639.61', to the east 1/4 corner of Section 31, T143N, R88W;
thence S 00°54'16" W a distance of 2639.61', to the southeast corner of said Section 31;
thence S 00°54'00" W a distance of 2649.62', to the east 1/4 corner of Section 6, T142N, R88W;
thence S 00°47'22" W a distance of 2638.46', to the southeast corner of said Section 6;
thence S 01°09'27" W a distance of 1308.63', to the N 1/16 corner of Section 7, T142N, R88W;
thence N 88°59'36" W a distance of 2627.51', to the CN 1/16 corner of said Section 7;
thence N 88°57'43" W a distance of 2627.09', to the N 1/16 corner of said Section 7;
thence N 89°18'06" W a distance of 2622.16', to the CN 1/16 corner of Section, 12, T142N, R89W;
thence N 89°12'46" W a distance of 2625.09', to the N 1/16 corner of said Section 12;
thence N 89°02'25" W a distance of 2625.57', to the CN 1/16 corner of Section 11, T142N, R89W;
thence N 89°05'11" W a distance of 2613.43', to the N 1/16 corner of said Section 11;
thence N 01°01'21" E a distance of 1315.76', to the northwest corner of said Section 11;
thence N 88°58'19" W a distance of 2612.33', to the south 1/4 corner of Section 3, T142N, R89W;
thence N 00°57'05" E a distance of 5265.85', to the north 1/4 corner of said Section 3;
thence N 00°48'24" E a distance of 5265.22', to the north 1/4 corner of Section 34, T143N, R89W;
thence N 00°51'14" E a distance of 5279.28', to the north 1/4 corner of Section 27, T143N, R98W;
thence S 88°55'24" E a distance of 2625.60', to the northeast corner of said Section 27;
thence N 00°48'41" E a distance of 1316.90', to the S 1/16 corner of Section 23, T143N, R89W;
thence S 89°19'20" E a distance of 2623.93', to the CS 1/16 corner of said Section 23;
thence N 00°49'38" E a distance of 1317.90', to the C 1/4 corner of said Section 23;
thence S 89°20'39" E a distance of 2625.40', to the east 1/4 corner of said Section 23;
thence S 89°14'25" E a distance of 2633.88', to the C 1/4 corner of Section 24, T143N, R89W;
thence N 00°54'35" E a distance of 1321.07', to the CN 1/16 corner of said Section 24;
thence S 89°13'35" E a distance of 2636.56', to the N 1/16 corner of said Section 24;
thence N 00°55'56" E a distance of 1320.44', to the northeast corner of said Section 24;
thence S 89°00'24" E a distance of 2551.86', to the north 1/4 corner of Section 19, T143N, R88W;
thence S 00°28'38" W a distance of 5276.35', to the south 1/4 corner of said Section 19;
thence S 89°07'41" E a distance of 2620.46', to the southeast corner of said Section 19, also being the point of beginning.

Said tract of land contains 8,091.511 acres.

STATE OF NORTH DAKOTA

PUBLIC SERVICE COMMISSION

Case No. RC-13-850

Coyote Creek Mining Company, L.L.C.
Permit NACC-1302
Application

SURFACE COAL MINING AND RECLAMATION PERMIT CONDITIONS

October 22, 2014

Surface Coal Mining Permit Number NACC-1302 has been issued to **Coyote Creek Mining Company, L.L.C.** subject to Chapter 38-14.1 of the North Dakota Century Code, all the rules promulgated thereunder, and the following standard and special conditions:

<u>STANDARD CONDITIONS</u>

1. Coyote Creek Mining Company, L.L.C. shall conduct surface coal mining and reclamation operations only on those lands specifically designated in the permit and only for the approved term of the permit and only in the manner or with the processes and techniques specified in the permit application and approved by the Commission.

2. Each of the reclamation or monitoring procedures, techniques, methods or descriptions specified in the permit application and approved by the Commission, or revision or renewal thereof, or by order of the Commission following such approval shall be deemed a "permit condition" for the purposes of enforcement under North Dakota Century Code Chapter 38-14.1.

3. Coyote Creek Mining Company, L.L.C. shall take all possible steps to minimize any adverse effects to the environment or public health and safety resulting from non-compliance with any term or condition of the permit, including, but not limited to: accelerated or additional monitoring necessary to determine the nature and extent of non-compliance, immediate implementation of measures necessary for compliance, and warning, as soon as possible after learning of such non-compliance, any person whose health and safety is in imminent danger due to the non-compliance.

4. Coyote Creek Mining Company, L.L.C. shall pay all reclamation fees required by 30 CFR subchapter R for coal produced for sale, transfer, or use.

5. Compliance with any design criteria or technical specifications, even where design criteria or the specifications have been approved by the Commission as a part of this permit shall not relieve Coyote Creek Mining Company, L.L.C. of the duty to redesign any criteria or technical specifications in order to comply with any applicable effluent limitation, applicable performance standard, water quality standard, ambient air quality standard, or any order issued by the Commission under North Dakota Century Code

Chapter 38-14.1, if such design criteria or technical specifications are later found to be inadequate.

6. Coyote Creek Mining Company, L.L.C. shall dispose of solids, sludge filter backwash, or pollutants removed in the course of treatment or control of waters or emissions to the air in the manner required by North Dakota Century Code Chapter 38-14.1 and North Dakota Administrative Code Article 69-05.2, and which prevents violation of any other applicable law.

7. Coyote Creek Mining Company, L.L.C. shall conduct its operations in accordance with any measures specified in the permit as necessary to prevent significant, imminent environmental harm to the health or safety of the public.

8. All applications for revisions to this permit must include a revision summary that describes the modifications that are proposed and indicates the pages, maps, or other parts of the permit that are revised or added. All revised and added pages, maps, designs, etc. shall be formatted for incorporation into the text of the permit and the revision number and date revised must appear on each revised and/or added document.

9. If a cessation order is issued under North Dakota Century Code Section 38-14.1-28, Coyote Creek Mining Company, L.L.C. must either submit the following information, current to the date the cessation order was issued, or notify the Commission in writing that there has been no change since the last submittal:

   a. Any new information needed to correct or update the information previously submitted under subdivision e of subsection 1 of North Dakota Administrative Code Section 69-05.2-06-01.

   b. If not previously submitted, the information required from a permit applicant by subdivision e of subsection 1 of North Dakota Administrative Code Section 69-05.2-06-01.

SPECIAL CONDITIONS

1. No overburden or coal removal may occur on federal coal tracts located within the permit area until Coyote Creek Mining Company, L.L.C. submits certified copies of the federal coal leases to the Commission and until the mine plan for the federal coal is approved by the United States Department of the Interior. Until a coal lease is issued and the mine plan is approved by the Department of the Interior, surface disturbances on the federal coal tracts are limited to those activities that the Commission determines are necessary for carrying out mining on the adjoining tracts where Coyote Creek Mining Company, L.L.C. has all of the rights necessary to mine the coal. Those activities and disturbances must not degrade the federal coal or impede any future mining on the federal coal tracts.

2. Coyote Creek Mining Company, L.L.C. must provide copies of the road authority's approval documents to the Commission that close or relocate any public road and other approval documents to conduct surface coal mining activities within one hundred feet of the outside right-of-way of any public road as required by subsection 4 of North Dakota Administrative Code Section 69-05.2-04-01.3. These documents must include written findings made by the road authority. If the road authority did not provide for a public comment period and make written finding as part of its approval process as specified in subsection 3 of North Dakota Administrative Code Section 69-05.2-04-01.3, no mining

activities may be conducted within one hundred feet of the outside right-of-way of a public road until the Commission provides public notice and makes the written finding.

PUBLIC SERVICE COMMISSION

Randy Christmann Commissioner	Brian P. Kalk Chairman	Julie Fedorchak Commissioner

STATE OF NORTH DAKOTA
PUBLIC SERVICE COMMISSION

Coyote Creek Mining Company, L.L.C.
Permit NACC-1302
Application

Case No. RC-13-850

AFFIDAVIT OF SERVICE BY CERTIFIED MAIL

STATE OF NORTH DAKOTA

COUNTY OF BURLEIGH

Esther Jangula deposes and says that she is over the age of 18 years and not a party to this action and on, **the 14th day of April, 2015**, she deposited in the United States Mail, Bismarck, North Dakota, 2 certified mail envelopes, postage prepaid, all securely sealed and each containing:

FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

The envelopes were addressed as follows.

Derrick Braaten
Attorney-at-Law
109 North Fourth Street Suite 100
Bismarck, ND 58501

Brian R. Bjella
Attorney-at-Law
100 West Broadway Suite 250
Bismarck, ND 58501

To the best of affiant's knowledge each address shown is the respective addressee's last reasonably ascertainable post office address.

Subscribed and sworn to before me
this 14th day of April, 2015

Notary Public

SEAL

GERALYN R. SCHMALTZ
Notary Public
State of North Dakota
My Commission Expires Oct. 5, 2016

STATE OF NORTH DAKOTA
PUBLIC SERVICE COMMISSION

Coyote Creek Mining Company, L.L.C. **Case No. RC-13-850**
Permit NACC-1302
Application

April 14, 2015

FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER

APPEARANCES

Commissioners Julie Fedorchak, Randy Christmann and Brian P. Kalk.

Derrick Braaten, Attorney-at-Law, 109 North Fourth Street, Suite 100, Bismarck, North Dakota 58501, on behalf of the Casey Voigt.

Brian R. Bjella, Attorney-at-Law, 100 West Broadway, Suite 250, Bismarck, North Dakota 58501, on behalf of Coyote Creek Mining Company, L.L.C.

Illona Jeffcoat-Sacco, General Counsel, Public Service Commission, State Capitol, Bismarck, North Dakota 58505, on behalf of the Public Service Commission.

Janet Seaworth, Administrative Law Judge, Office of Administrative Hearings, 1701 North Ninth Street, Bismarck, North Dakota 58501-1882, as Procedural Hearing Officer on December 19, 2014.

Wade Mann, Administrative Law Judge, Office of Administrative Hearings, 1701 North Ninth Street, Bismarck, North Dakota 58501-1882, as Procedural Hearing Officer on December 23, 2014 and January 2, 2015.

PRELIMINARY STATEMENT

On November 1, 2013, Coyote Creek Mining Company, L.L.C. (CCMC) applied for Surface Coal Mining Permit No. NACC-1302 for a new mine approximately ten miles southwest of Beulah, North Dakota. CCMC is a subsidiary of The North American Coal Corporation (NACCO) which is also the parent company of The Coteau Properties Company (Coteau) and The Falkirk Mining Company (Falkirk) that have been operating surface coal mines in North Dakota since the late 1970's. CCMC's permit application covers 8,091.511 acres of land located in all or portions Sections 6 and 7, T142N, R88W; Sections 1, 2, 3, 11, and 12, T142N, R89W; Sections 19, 30, and 31, T143N, R88W; and Sections 23, 24, 25, 26, 27, 34, 35, and 36, T143N, R89W, all in Mercer County.

On October 22, 2014, the Public Service Commission conditionally approved Permit No. NACC-1302. The Commission's conditional approval of the permit was subject to the right of any person with an interest who is or may be adversely affected to request a formal hearing on the decision.

On November 24, 2014, the Commission received a request for a Formal Hearing in the matter from Mr. Casey Voigt, a landowner in the permit area. In his written request, Mr. Voigt expressed concerns with the size of the permit area, the reclamation practices that would be used on land to be mined, and his loss in agricultural production due to the mining activities.

On November 25, 2014, the Commission issued a Notice of Formal Hearing scheduling the hearing for December 19, 2014. The hearing notice was served on the parties and it was also published in the Beulah Beacon, Hazen Star and Bismarck Tribune on December 4 and 11, 2014.

The hearing began on December 19, 2014 as scheduled and was continued on December 23, 2014 and January 2, 2015. The proceeding was further continued to allow the attorneys for Mr. Voigt and CCMC to submit written closing arguments and recommended orders following receipt of the hearing transcript.

Findings of Fact

1. The Commission issued Surface Coal Mining Permit No. NACC-1302 to allow CCMC to conduct surface coal mining and reclamation operations at the Coyote Creek Mine, a new mine that will supply lignite coal to the Coyote Power Station beginning in May 2016. Mr. Casey Voigt and his wife, Julie, either own or lease much of the land in the eastern half of the 8,092-acre permit area and these permitted lands encompass much of the Voigt family's ranching operation. The Voigt land includes native grassland that is used for livestock grazing, cropland primarily used for hay production, and an occupied farmstead where the family resides.

2. Mr. Voigt testified that he wants his land restored to the pre-mine conditions after mining and reclamation. He expressed concerns about native grass establishment on reclaimed lands, the nutrient value of the forage produced on reclaimed lands, the loss of future agricultural production, loss of mature trees, methods and equipment that will be used for spoil handling and land re-contouring after mining, compaction and limited rooting depth in soils that are replaced on reclaimed lands, road closures and mine signage. Mr. Voigt also discussed some issues about the coal lease he negotiated and entered into with CCMC.

3. Mr. Voigt further testified that he is familiar with coal mining operations and reclamation practices since he had worked at the nearby Beulah Mine for 12 years and he has also been haying reclaimed land at that mine.

4. Upon questioning, Mr. Voigt testified he wasn't trying to stop the progress of mining but he was "just trying to change the process and the way it's done".

Native Grassland Seed Mixtures and Diversity Standards

5. Subsection 17 of N.D.C.C. Section 38-14.1-24 covering revegetation success performance standards for native grassland requires that "a diverse, effective, and permanent vegetative cover must be established of the same seasonal variety native to the area to be affected and capable of self-regeneration, plant succession, and at least equal in extent of cover and productivity to the natural vegetation of the area." The Commission has adopted Standards for Evaluation of Revegetation Success, Exhibit CV-14, which provides more details and recommended methods for proving reclamation success on all agricultural lands and other land uses.

6. Mr. Voigt testified about his concerns with the native grasses that will be established on his reclaimed lands and that after mining, he wants his land restored to its pre-mine conditions.

7. Mr. Mark Anderson, a plant ecologist and conservationist formerly with USDA's Natural Resources Conservation Service and who now works for a consulting firm, testified about native grassland reclamation practices on behalf of Mr. Voigt. Mr. Anderson expressed concerns with the amount of tame grass species that are allowed on reclaimed native grasslands under the Commission's revegetation success standards, since he believes tame grass species will have lower production compared to native species. Mr. Anderson testified that he is also concerned that up to 35% of the species on reclaimed land could be non-native species and still meet the Commission's native grassland revegetation standards.

8. Mr. Anderson testified that Mr. Voigt's native grasslands are high quality and that Kentucky bluegrass, an invasive tame species, represents only 3% of the total production according to the pre-mine vegetation sampling that was conducted by CCMC and data that is included in the permit application.

9. Mr. Anderson testified that diversity on reclaimed native grassland is important for healthy and productive rangeland. He testified that in addition to grasses, forb species are also important on native grasslands and that some of these species add nitrogen to the soil. He also had concerns about noxious weeds on reclaimed lands and the quality of forage on reclaimed land. Mr. Anderson testified that Mr. Voigt wants his native grassland restored to the conditions that are present before mining and that Mr. Voigt does not want 60% Kentucky bluegrass after mining. Mr. Anderson also testified he does not believe CCMC will meet the performance standards of subsection 17 of North Dakota Century Code Section 38-14.1-24. Upon cross examination, Mr. Anderson also agreed that some of Mr. Voigt's native grassland in its current pre-mine condition would not meet the Commission's diversity requirement.

10. Mr. Anderson recommended that CCMC be required to restore 95% of the native species that are present on Mr. Voigt's pre-mine native grassland.

11. The native grassland seed mixture in Section 4.2.2 of Permit NACC-1302 shows that nine species of native warm and cool season grasses will be planted on reclaimed native grassland at the Coyote Creek Mine. This seed mixture also shows that a small percentage of forb species will be included in the mix and that weeds will be sprayed with herbicides as needed. No introduced species are included in the seed mix. In addition, plans for replacing and planting trees and shrubs are included in Sections 4.1 and 4.2.3 of the permit.

12. Ms. Sarah Flath, a range scientist and Senior Environmental Specialist for CCMC, testified that only native species will be seeded on reclaimed native grassland at the Coyote Creek Mine and that the seed mix was developed in consultation with the Natural Resources Conservation Service (NRCS) publications, data from the local NRCS office, and conversations with representatives with the United States Department of Agriculture Plant Material Center in Bismarck.

13. Ms. Flath stated CCMC will take measures to minimize the establishment of introduced grass species on the reclaimed native grassland. This includes delaying the seeding of native grassland a year after the soil has been respread so that introduced grass species that may have germinated from the seed present in the existing topsoil can be sprayed and eliminated. In addition, Ms. Flath testified that reclaimed native grassland will be closely monitored for introduced grasses and, if introduced grasses are observed after the first year or two, they can be controlled through herbicide application.

14. Ms. Flath also testified about baseline vegetation data that was collected for Permit NACC-1302 and CCMC plans to establish undisturbed reference areas that are representative of undisturbed native grassland in the permit area. Reference areas will be used to climatically adjust revegetation success standards that will be used to prove reclamation success at the time of final bond release. However, the plans in Permit NACC-1302 for selecting reference areas do not indicate that Mr. Voigt would be consulted when selecting the undisturbed areas that will be used to represent his native grasslands.

15. Requirements for diversity and seasonality in the Commission's Standards for Evaluation of Revegetation success, Exhibit CV-14, begin near the middle of page II-D-10. These provisions require:

> . . . that at least five native grass species are present on the reclaimed tract and that native plant species comprise at least 65% of the total composition by cover or weight. The relative composition of all warm season species must be at least 15%. Four native grass species must each contribute at least 3% relative live basal cover or at least 5% relative

composition by weight during the years sampling data is used for final bond release purposes.

16. Another provision in the Commission's revegetation success standards beginning near the bottom of page II-D-10 of Exhibit CV-14 allows the counting of Kentucky bluegrass to meet the native species composition requirement, but only up to its percent composition that is present on the approved reference area(s) located on undisturbed lands. Therefore, if Kentucky bluegrass represents only 3% of the production on Mr. Voigt's pre-mine native grassland, the reclaimed native grassland will not be allowed to have up to 60% Kentucky bluegrass as implied by Mr. Anderson's testimony. If the reference areas have 3% Kentucky bluegrass based on live basal cover at the time of final bond release, then only 3% Kentucky bluegrass on reclaimed native grassland can count towards meeting the total native species composition requirement. After reading the provision on page II-D-10 of the success standards about allowing Kentucky bluegrass on reclaimed native grassland, Mr. Anderson testified that "Mr. Voigt is fine with that."

17. While Subsection 17 of N.D.C.C. 38-14.1-24 requires mine operators to establish a diverse, effective and permanent cover on reclaimed native grassland, it does not require that the vegetation be "restored" to the exact conditions that were present before mining. However, it is reasonable for the Commission to request that CCMC consult with Mr. Voigt when selecting the undisturbed reference areas that will be used for proving reclamation success on his reclaimed native grasslands and for the management practices that will be used on those reference areas.

Productivity of Reclaimed Lands

18. Mr. Voigt testified he's heard concerns about the productivity of reclaimed lands from others, especially regarding cropland at Coteau's mine. He also stated he had concerns about the nutrient levels in grasses grown on reclaimed lands.

19. Mr. Anderson also expressed concerns about the productivity of reclaimed lands, especially on reclaimed native grasslands.

20. Subsection 17 of N.D.C.C. 38-14.1-24, requires mining companies to: "Restore lands affected by the surface coal mining operation which have been designated for postmining agricultural purposes to the level of productivity equal to or greater, under equivalent management practices, than nonmined agricultural lands of similar soil types in the surrounding area." Mining companies are required to demonstrate that the agricultural productivity of reclaimed lands is equal to or greater than the pre-mine level at the time of final bond release. Also, final bond release cannot be granted by the Commission until a minimum ten-year revegetation responsibility period after the date of initial seeding on the reclaimed lands has expired as required by Subsection 18 of N.D.C.C. 38-14.1-24.

21. Mr. Donn Steffen, Engineering and Environmental Manager for CCMC, testified about the productivity of reclaimed cropland, native grassland and hayland/tame pastureland at NACCO's former Indian Head Mine, a few miles north of the proposed Coyote Creek Mine. He testified that all of the mined lands that were permitted at the Indian Head Mine have received final bond release and that the required productivity standards were exceeded. Exhibit CC-2 contains summary data showing that the required productivity standards for this mine were exceeded when final bond releases were requested.

22. Ms. Flath testified about the yields from reclaimed cropland, rangeland (native grassland) and hayland yields that have received final bond release at Coteau's mine north of Beulah. Exhibit CC-3 contains summary data showing that the required productivity standards were exceeded for these final bond release tracts.

23. Ms. Flath also testified about an unscientific livestock weight gain study on reclaimed land at the Coteau mine compared to nearby undisturbed lands. Data from this study shows the average daily weight gain on reclaimed lands was slightly higher than that for the undisturbed grasslands. Exhibit CC-5 contains a summary of this data.

24. Mr. Jim Deutsch, director of the Reclamation Division, testified about the permit review process and the written findings that are part of the permit approval document. He stated that staff found that reclamation can be accomplished using the methods proposed by CCMC.

25. Mr. Voigt also stated that he believes the minimal amount of final bond release at coal mines, which he thought is about 2,000 acres, shows problems with reclaimed lands.

26. Mr. Deutsch also testified regarding the amount of reclaimed lands that have received final bond release in North Dakota. He stated that 20,800 acres of land have been released that were permitted after the federal reclamation act (SMCRA) was enacted. Exhibit PSC-7 shows that the final bond release acreage includes 4,046 acres of reclaimed cropland, 4,737 acres of reclaimed native grassland, and 1,684 acres of reclaimed hayland. Other lands that have received final bond release include undisturbed lands that had been permitted and mined lands that were reclaimed for industrial purposes, recreation, wildlife, woodlands and other land uses.

Spoil Grading and Soils Replaced on Reclaimed Lands

27. Mr. Voigt testified that he wants subsoil depths on reclaimed land that are consistent with the premine conditions, that overburden or spoil be put back in shallow lifts, that excess compaction should be avoided when handling the overburden, and soil experts should provide input in the reclamation process.

28. Mr. Anderson also testified he has concerns about soil compaction on reclaimed land.

29. Dr. Steven Merrill, a retired soil scientist who worked at the USDA Agricultural Research Service in Mandan, ND, testified about reclamation research in which he was involved in the 1970's and 1980's at the Indian Head and Glenharold Mines. He said the study results were used by the Commission to establish soil replacement standards in the reclamation rules. Dr. Merrill testified that he also participated in a follow-up study on the same research plots in the early 2000's and found that soil was functioning much better at that time compared to the late 1970's and 1980's and the overall soil health had improved over time at these two sites.

30. Dr. Merrill recommended that a soil scientist evaluate the soils on reclaimed land after four years following reclamation to check a number of soil health factors including stability, compaction, pH, salinity, root penetration and various aspects of soil biota. He said the top one foot of soil should be looked at more closely and this includes checking the organic carbon, microbial biomass carbon, infiltration, soil aggregate stability, and soil respiration. Dr. Merrill also recommended growing deep rooted crops on reclaimed lands such as sunflowers and safflower that will go to a depth of about six feet and to also use deep tillage if necessary to alleviate compaction. He recommended carrying out additional soil tests if problems arise. Commission rules do not require the sampling and testing of soils that are replaced on reclaimed lands for these parameters.

31. Mr. Steffen testified that he believes compaction on reclaimed soils is an isolated problem and that it can be alleviated by scarifying or ripping with blades or dozers.

32. Mr. Voigt also expressed concern that reclamation standards generally require 12 inches of topsoil and 36 inches of subsoil, while native grasses currently have a 78-inch rooting depth.

33. Ms. Flath testified that pursuant to Commission rules (that are based on the reclamation research discussed by Dr. Merrill), between 24 and 48 inches of suitable plant growth material (topsoil plus subsoil) must be respread depending on the properties of the mine spoil. She further stated that studies prepared by CCMC show that pre-mine topsoil and subsoil thicknesses on Mr. Voigt's land only average a total of 32 inches in depth, and that in order to achieve the required 48-inch total respread thickness, additional soil material of equivalent quality will have to be salvaged from between five and ten feet below surface to supplement Mr. Voigt's subsoil.

34. Plans for saving, storing and replacing the available topsoil and subsoil from lands to be disturbed by the proposed mining activities are described in Section 3.1.1.1 of Permit NACC-1302. These plans do not include provisions to test for compaction after the soil materials are replaced, nor are there any plans for alleviating soil compaction other than working the surface after the topsoil is replaced. Soils that have excessive compaction may not produce as well as they should and areas of excessive

compaction on reclaimed land should be identified within a few years after soil respreading is completed.

35. It is reasonable to request a mining company to conduct testing to determine if soils replaced on reclaimed lands are compacted and, if excessive compaction is present, to require actions to alleviate the compaction.

County Road Closures

36. Mr. Voigt testified that he had concerns about county road closures but did not provide any specifics about his issues.

37. The closure of county roads in the vicinity of the Coyote Creek Mine is under the jurisdiction of the Mercer County Commission, not the Public Service Commission.

Mine Signage

38. Mr. Voigt testified that he had concerns about the signs CCMC had placed at entrances to the permit area. He was particularly concerned about the "No Trespassing" markings on the mine entrance signs that to Mr. Voigt implied he could not go onto his own land.

39. The placement of mine entrance signs is required by subsection 3 of N.D. Admin. Code Section 69-05.2-13-04, but this rule does not require a "No Trespassing" statement on the signs.

Coal Lease

41. Mr. Voigt testified that he executed a coal lease in December 2010 that gives CCMC the right to mine his land and that he was represented by an attorney during the lease negotiations. Mr. Voigt further expressed concerns regarding certain leasing practices of CCMC and certain terms and conditions of the lease.

42. Mr. Jim Melchior, President of CCMC, testified about the coal lease that was executed by Mr. Voigt in December 2010 and about provisions in the lease for compensating Mr. Voigt for his loss of agricultural production due to mining activities.

43. While copies of coal leases must be included in mining permits to show the right to mine, coal leasing terms, conditions and practices are not under the jurisdiction of the Public Service Commission.

Alluvial Valley Floors

44. Although Mr. Voigt did not express any concerns about alluvial valley floors (AVFs) in his November 24th request for formal hearing, much of the testimony at the

hearing was about two AVF studies that were conducted for areas along Coyote Creek, a stream located in the eastern portion of the area covered by Permit NACC-1302. The studies were conducted to determine if segments of this creek were considered an "alluvial valley floor" as defined by North Dakota's reclamation law and the federal reclamation act.

45. The federal reclamation law, Section 701(1) of Public Law 95-87, and Subsection 1 of N.D.C.C. Section 38-14.1-02 define 'alluvial valley floors' as follows:

> "Alluvial valley floors" means the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of sediment from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation, and windblown deposits.

46. The federal regulations, 30 CFR 701.5, and Subsection 3 of N.D. Admin. Code Section 69-05.2-01-02 define 'agricultural activities' as:

> "Agricultural activities" means, with respect to alluvial valley floors, the use of any tract of land for the production of animal or vegetable life, where the use is enhanced or facilitated by subirrigation or flood irrigation associated with alluvial valley floors. These uses include the pasturing, grazing, or watering of livestock, and the cropping, cultivation, or harvesting of plants whose production is aided by the availability of water from subirrigation or flood irrigation. Those uses do not include agricultural practices which do not benefit from the availability of water from subirrigation or flood irrigation.

47. Subsection 2 of N.D. Admin. Code Section 69-05.2-08-13 requires the use of available data and, if necessary, an appropriate combination of studies adapted to the site-specific conditions to determine whether or not an AVF is present. An area must be identified as an AVF if:

1) Unconsolidated streamlaid deposits holding streams are present, and

2) There is sufficient water to support agricultural activities as shown by;
   (a) the existence of flood irrigation in the area or its historical use,
   (b) the capability to be flood-irrigated, based on streamflow water yield, soils, water quality, and topography; or
   (c) subirrigation of the lands from the ground water system of the valley floor.

48. Areas identified as AVFs are given additional protections under the reclamation law and rules, including protecting the essential hydrologic functions of the AVF. Also, in many instances, mining operations cannot interrupt farming activities on an AVF.

49. The federal Office of Surface Mining (OSM) also prepared draft AVF Identification and Study Guidelines in 1983, Exhibit CV-15, to assist regulatory authorities and mining companies in the identification of AVFs. Page II-1 of this document states that: "The ultimate goal of alluvial valley floor identification investigations is to identify stream valleys which have agricultural importance and where that importance is derived from the water available in those valleys. Stream valleys which do not have any agricultural importance or whose importance is not related to the greater water availability of the valleys are not alluvial valley floors." (*emphasis in original*)

50. In 1985, OSM issued a document with draft reconnaissance maps to assist in identifying AVFs in west-central North Dakota, Exhibit CV-2. A map in this document identified some areas along Coyote Creek as "potential" AVFs, including some of Mr. Voigt's hayfields.

51. A pre-application AVF study was prepared by the Dakota Westmoreland Corporation (DWC) in 2009 prior to DWC's submittal of a revision application to add additional areas to a mining permit for its Beulah Mine. A portion of that mine is located just northeast of the Coyote Creek Mine. DWC's AVF study report is Exhibit CV-3. A second AVF study was conducted by CCMC in 2013 for an additional segment of Coyote Creek and other downstream areas including a segment of the Knife River. The CCMC study report is Exhibit CV-5.

Unconsolidated Streamlaid Deposits for an AVF

52. Permit NACC-1302 identifies Coyote Creek as a perennial stream for the portion that is within and adjacent to the permit area. It contains unconsolidated streamlaid deposits, otherwise referred to as alluvium. Coyote Creek meets the geomorphic criteria for being considered an AVF.

Sufficient Water for Flood Irrigation for an AVF

53. The DWC and CCMC AVF studies found that no artificial flood irrigation was present in the areas studied along Coyote Creek. Discussion that begins near the bottom of Page 25 of DWC's 2009 AVF study report, Exhibit CV-3, states that the NRCS office in Mercer County was contacted about irrigation in Mercer County and the local office personnel reported they were not aware of any surface irrigation systems on Coyote Creek or other such stream valleys to the south of the Knife River. Section 2.2.1 of the permit states that, except for snowmelt and extreme precipitation events, flow and surface water availability in the channel is very limited. The DWC study also

indicates that natural flooding is rare along Coyote Creek and is only likely to occur during more extreme runoff events.

Flood Irrigation Potential for an AVF

54. Page 26 of DWC's 2009 AVF study report, Exhibit CV-5, discusses the potential for flood irrigation along Coyote Creek. The report states that placing a dam on the creek or pumping water to a storage facility would be needed to provide enough water for irrigating cropland. However, neither option was likely due to the lack of areas for storing the water, and the expense. As previously noted, artificial flood irrigation by diverting stream flows is not a common practice in Mercer County and surface water flows in Coyote Creek are very low most of the time. The potential for flood irrigation along Coyote Creek is very low. Also, the water quality in Coyote Creek is marginally suitable for limited or restricted irrigation based on salinity (electrical conductivity) information provided on Page 27 in the DWC 2009 AVF Report, Exhibit CV#3, and the related information provided on Pages 14 and 15 of the CCMC 2013 AVF Report, Exhibit CV#5.

Subirrigation

55. Mr. Charles Norris, a geologist/hydrologist with Geohydro, Inc. of Denver, CO, testified about the AVF determinations associated with Permit NACC-1302. Mr. Norris testified about his past consulting work that involved water issues related to surface mining and, more specifically, his work on AVF issues at three western mines including the proposed South Heart Mine in North Dakota. Mr. Norris said he believes the AVF section of the permit is deficient since enough data was not provided for the AVF determinations. He testified that the draft AVF reconnaissance study by the federal Office of Surface Mining (OSM) shows some areas along Coyote Creek as being subirrigated and likely an AVF. Mr. Norris said that if subirrigation occurs and hay production is enhanced in that area, such an area would be considered an AVF.

56. Mr. Norris testified that pre-application AVF studies and data requirements vary from state to state and from mine to mine depending on the site specific conditions. However, he believed that more data should have been collected for the Coyote Creek AVF determination, such as data from installing ground water monitoring wells to obtain measurements for water level profiles and daily water level changes to determine if subirrigation occurs along the creek.

57. Mr. Norris disagreed with the AVF determinations made by Commission staff that areas along Coyote Creek through Mr. Voigt's property are not an AVF. He especially disagreed about staff's finding that subirrigation does not occur along Coyote Creek.

58. Mr. Norris testified he never visited the site but, he believes subirrigation occurs along Coyote Creek and enhances the production of alfalfa on Mr. Voigt's hay field located on the Coyote Creek alluvium.

59. Mr. Voigt also testified about his hay yields in lowland fields along Coyote Creek and others in upland areas. Exhibit CV-7 contains those yield numbers for the past several years. He also testified that the water level in his wells near Coyote Creek are 15 feet and 17 feet from the surface, but he had been told that alfalfa roots will go down to 20 feet.

60. Dr. David Bickel, consultant and former hydrologist/geologist with the Reclamation Division, testified about AVF evaluation reports that he has prepared as a consultant, including one for CCMC. Dr. Bickel also testified about his experience in reviewing requests for AVF determinations, his use of the OSM AVF guidance documents, and writing related permit findings while employed at the Public Service Commission. Since retiring from the Commission, Dr. Bickel said he has prepared five AVF evaluation reports that have been reviewed and approved by the Reclamation Division.

61. Dr. Bickel said AVF evaluation reports are prepared well before mining since additional data may need to be obtained for making an AVF determination. He testified that adequate data was available to make the AVF determinations in the two reports that involved areas along Coyote Creek.

62. Dr. Bickel testified that he had reviewed the 2009 AVF evaluation report by Dakota Westmoreland Corporation for its nearby Beulah Mine and that study area included two of Mr. Voigt's hayfields in Section 31 along Coyote Creek. He agreed with the Reclamation Division's determination that no AVF's were present in the study area. Dr. Bickel testified he found no evidence of significant subirrigation during his investigation based on the vegetation and soil properties in the areas and on data from groundwater wells.

63. Dr. Bickel testified that he also prepared an AVF evaluation report for CCMC covering the portion of Coyote Creek that is downstream of Mr. Voigt's land and part of the Knife River. As the result of his study he also determined that no AVFs were present and the Reclamation Division agreed with his determination.

64. Dr. Bickel testified that any subirrigation along Coyote Creek was limited to very small areas adjacent to the stream bed and that these areas were only a few feet wide. He also said he had reviewed alfalfa production in Mr. Voigt's hayfields. While the water table was 8 to 10 feet below the surface in late summer and that some of the deep rooted plants such as alfalfa would reach it, Dr. Bickel testified that no subirrigation of significance was noted.

65. Dr. Bickel further testified that soils along Coyote Creek are classified as a "Straw" soil type and that soil type is not considered a subirrigated soil by the Natural Resources Conservation Service. He also said he believed that having groundwater monitoring well data with daily water level fluctuations was not necessary for the Coyote

Creek AVF determinations because sufficient data was otherwise available to make the AVF determinations.

66. Mr. Dean Moos, assistant director of the Reclamation Division and a registered professional soil classifier in North Dakota, testified that he participated in the 2009 AVF field review of areas along Coyote Creek and he visually examined the soil profiles at several locations to verify that the soil types along Coyote Creek were correctly mapped as "Straw". He said that Straw soils are a floodplain soil developed in stream-laid deposits and they are highly productive, high in organic matter, and make good cropland. He also said that the Straw soil is designated as a 'prime farmland' soil by the NRCS. Mr. Moos further testified that the depth to groundwater for a Straw soil is greater than 80 inches according to the NRCS, indicating the soil is not subirrigated.

67. Dr. Bickel also testified that the main reason AVF requirements are included in the federal reclamation act is to protect agriculture production along streams in the more arid regions of the United States where the production of hay and other crops along streams is essential to livestock production and other agricultural activities. While the AVF requirements apply to western North Dakota since this part of the State is west of the 100th meridian west longitude, he said that a classic area is along the Powder River (located further west in Montana and Wyoming). Dr. Bickel further testified that "regional climate in west central North Dakota enables areas, other than stream floodplains, to produce hay crops, including alfalfa, and thus regional livestock production is not dependent on stream valleys for hay production and other feed as is often the case in arid areas further to the west."

68. Ms. Flath testified that the expected alfalfa production on Casey Voigt's hayland in the mining permit area based on the pre-mine soil map units and the NRCS expected yields would be 75% higher on the lowland fields compared to the upland fields. She further testified that Exhibit CV-7, with yield values for Voigt lowland and upland hayfields, shows that the lowland hayfields averaged only 47% higher compared to the upland hayfields. In addition, during the relatively dry year of 2012, she said the production on the lowland fields was considerably less than the other five years. Ms. Flath testified if the lowland fields had received supplemental moisture from subirrigation separate from precipitation, the production should not have dropped off nearly as much as it did. She also noted that the yields of the first alfalfa cuttings in 2013 and 2014 from the uplands fields exceeded that of the lowland fields.

69. Mr. Bruce Beechie, geologist/hydrologist with the Reclamation Division, testified about the AVF review process used by Commission staff and the finding that no AVF exists along Coyote Creek. He said staff's field review that was conducted in 2009 for the Dakota Westmoreland permit revision focused on Mr. Voigt's field in Section 19 and the northern part of Section 30 along Coyote Creek since it was the most predominant tract of cropland along the creek.

70. Mr. Beechie testified that he is familiar with and uses OSM's AVF guidance documents and AVF reconnaissance maps of west-central North Dakota. He said that infrared photos were used by OSM to identify areas that are "potential" AVF's in the reconnaissance maps for west central North Dakota and that the OSM maps were used when he reviewed the AVF study reports that covered areas along Coyote Creek.

71. Mr. Beechie testified about the ground water level information along Coyote Creek that was available from the Oliver/Mercer Geologic and Water Resources Report (published by the North Dakota State Water Commission) and the water levels in wells near Mr. Voigt's home. The reported depths to the water table varied from 15 to 20 feet below surface.

72. OSM's AVF Study Guidelines, Exhibit CV-15, contains Table B-4 on page B-19 that lists a water extraction depth for alfalfa of five feet (or 60 inches). Elsewhere in that guideline, statements are included that some alfalfa roots can go much deeper than five feet. However, page C-11 of that guideline includes a statement that "subirrigation may provide enough water to maintain alfalfa but not enough to enhance its production." None of the evidence presented at the hearing indicates that subirrigation significantly enhances hay production on Mr. Voigt's fields along Coyote Creek. The overall higher hay production from those fields compared to his upland hayfields is due to the inherent high productivity of the Straw soils, which the NRCS classified as not subirrigated.

73. Mr. Beechie further testified that he is very comfortable with the negative AVF determinations that have been made for areas along Coyote Creek and that a positive AVF determination would have been indefensible.

OSM Infrared Photo Used to Identify 'Potential' AVFs

74. Late-filed Exhibit CV-18 is a copy of the infrared photo taken on September 8, 1978 that OSM used to identify potential AVF's along Coyote Creek that includes Mr. Voigt's hayfields. OSM's AVF Study Guidelines, Exhibit CV-15, states on page C-40 that red hues on infrared photos can indicate vegetation which may be subirrigated, but it is possible that the plant water could have been from another source. While some reddish colors are evident immediately adjacent to Coyote Creek and in a few nearby areas, there is very little reddish colors in the larger fields along Coyote Creek currently being hayed by Mr. Voigt. However, reddish colors are also present in non-irrigated upland fields on the photo about one mile southeast of Mr. Voigt's farmstead. Since the reddish color is also found on upland areas, there is no certainty that reddish color in a few areas along Coyote Creek represents water that was supplied to plants by subirrigation. The reddish colors in the uplands areas about a mile away from Coyote Creek were likely due to moisture in plants that followed a late summer rain event. The moisture in plants along Coyote Creek may have also been the result of a late summer rain, not subirrigation as Mr. Norris asserted in his affidavit regarding late filed Exhibit CV-18.

75. Mr. Norris also presented a schematic drawing, Exhibit CV-6, showing the saturated boundary, or water table, becoming closer to the ground surface as you move away from a creek or stream. He testified this would mean more water could be available for subirrigation as you move back from the creek channel. Upon cross examination, Mr. Norris testified that data had not been collected to show that Exhibit CV-6 actually represents the conditions along Coyote Creek.

76. The OSM infrared photo that includes Coyote Creek, late-filed Exhibit CV-18, does not depict any red colors on alluvium some distance away from Coyote Creek as would have been by hypothesized by Mr. Norris's schematic drawing of an Alluvial Flood Plain, Exhibit CV-6. That drawing indicated the water table would be much closer to the ground surface as you move away from a stream towards the upland, meaning there is a higher potential for subirrigation in those areas. If subirrigation was occurring along Coyote Creek as hypothesized by Exhibit CV-6, reddish colors should have been present in parts of the alluvium hayfields furthest from the creek, but this is not the case.

Proposed Mining Disturbances along Coyote Creek

77. Ms. Flath testified that none of Mr. Voigt's hayfields on alluvium along Coyote Creek will be disturbed by Coyote Creek's proposed mining activities.

78. Mr. Beechie testified that the valley floor of Coyote Creek is not going to be mined as proposed by CCMC and that the closest coal seam to be mined is at an elevation that averages 75 feet higher than the Coyote Creek valley floor. He said the only mine activities that will go across the valley floor are two mine roads.

79. No evidence was presented that the mining activities just west of Coyote Creek as proposed by CCMC will significantly impact the prevailing hydrologic balance along that creek.

Other Public Testimony

80. People attending the hearing provided public testimony. This testimony covered general topics about mining and reclamation including comments that reclaimed lands do not produce as they did before mining and reclaimed lands are not being bond released. Concerns were raised about settling features on reclaimed land and the amount of rock and compaction on reclaimed lands. Some testified that mining companies need to replace water supplies adversely affected by mining, including natural springs. One person discussed his positive experience with having a livestock water supply replaced that had been affected by mining activities. Others discussed concerns raised about royalty provisions in coal leases that were executed more than 40 years ago and insufficient compensation under the leases for loss of agricultural production when mining occurs decades later. Another concern pertained to the amount of land owned by some mining companies. Most of the public testimony

addressed mining and reclamation topics in general and did not directly pertain to Permit NACC-1302 issued to CCMC.

81. Subsection 9 of N.D.C.C. Section 38-14.1-24 requires mine operators to replace any water supply that is adversely affected by mining. Replacement of any water supply adversely affected by mining is considered part of reclamation and must be done at no cost to the surface owner.

82. There are no provisions in the state's reclamation law or other laws that give the Commission any authority over royalty payments or any other payments required or permitted by coal and surface leases.

From the foregoing Findings of Fact, the Commission now makes its:

CONCLUSIONS OF LAW

1. The Commission has jurisdiction over CCMC's planned mining and reclamation operations in North Dakota, including Permit No. NACC-1302.

2. CCMC's application for Surface Coal Mining Permit NACC-1302 meets all permit application standards under North Dakota Century Code Chapter 38-14.1 and North Dakota Administrative Code Article 69-05.2.

3. There is no basis for the Commission to rescind or revoke Permit NACC-1302.

4. It is reasonable to require Coyote Creek Mining Company to revise Permit NACC-1302 to describe the detailed methods that will be used to minimize compaction of topsoil and subsoil that is replaced on reclaimed lands and to provide a testing plan to determine if there is any excess compaction in the replaced topsoil and subsoil and describe measures that will be used to alleviate excessive compaction if detected.

5. It is reasonable to require Coyote Creek Mining Company to revise Permit NACC-1302 to state that Casey Voigt will be consulted when they select and establish management practices for undisturbed reference areas that will be used to demonstrate reclamation success on Mr. Voigt's reclaimed native grasslands.

6. The alluvium along Coyote Creek is not an alluvial valley floor as defined by subsection 1 of N.D.C.C. Section 38-14.1-02.

7. The Commission does not have any jurisdiction over coal or surface leasing terms, conditions or practices.

8. The Commission has no jurisdiction over the closure of county roads.

From the foregoing Findings of Fact and Conclusions of Law, the Commission now makes its:

ORDER

The Commission orders:

1. The Commission's October 22, 2014 conditional approval of Permit No. NACC-1302 is AFFIRMED;

2. Coyote Creek Mining Company shall submit a revision application to Permit NACC-1302 by July 1, 2015, to add plans for:

   a. Describing detailed methods that will be used to minimize compaction on the replaced subsoil and topsoil;

   b. Conducting testing to determine if there is any excess compaction in the topsoil and subsoil that are replaced on reclaimed lands and describe measures that will be used to alleviate excessive compaction if detected; and

   c. Consulting with Casey Voigt when selecting and establishing management practices for the reference areas on undisturbed native grasslands that will be used when demonstrating reclamation success on reclaimed native grasslands that Mr. Voigt owns.

PUBLIC SERVICE COMMISSION

Randy Christmann **Commissioner**	**Julie Fedorchak** **Chairman**	**Brian P. Kalk** **Commissioner**

Wade C. Mann
DIRECTOR

OFFICE OF ADMINISTRATIVE HEARINGS

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RECEIVED
JAN 23 2015
NORTH DAKOTA
PUBLIC SERVICE COMMISSION

January 21, 2015

Illona Jeffcoat-Sacco
General Counsel
Public Service Commission
600 East Boulevard Avenue, Dept. 408
Bismarck, ND 58505-0480

Re: Coyote Creek Mining Company, LLC, PU-14-689
Permit No. NACC-1302; Application RC-13-850
OAH File No. 20140505

Dear Ms. Jeffcoat-Sacco:

Enclosed is an exhibit list and the original exhibits from the above referenced hearings held on December 19, 2014, December 23, 2014, and January 2, 2015.

Sincerely,

Wade C. Mann
Director

WCM/lmw

cc: Derrick Braaten
Brian Bjella

51 **RC-13-850** Filed: 1/23/2015 Pages: 6
Letter enclosing exhibit list and exhibits
Wade Mann, ALJ - Office of Administrative Hearings

Filed - Clerk of District Court
6/29/2015 4:04:48 PM
Burleigh County, ND

EXHIBIT LIST							
Matter	Coyote Creek Mining Company, LLC Permit No. NACC-1302; Application RC-13-850						
Hearing	December 19, 2014; December 23, 2014; January 2, 2015 PSC = Public Service Commission CC = Coyote Creek CV = Casey Voigt						
No	Description	Mkd	Idd	Ofd	W/D	Adm	Note
CV1	Curriculum Vitae of Charles H. Norris, P.G.	X		CV		X	5 pages
CV2	Reconnaissance Maps to Assist in Identifying Alluvial Valley Floors for West-Central North Dakota	X		CV		X	Booklet
CVC3	Coyote Creek Alluvial Valley Floor Study – Dakota Westmoreland Corporation – October 2009 Revision	X		CV		X	17 pages
CV4	Memorandum from PSC re: CHIA of Coyote Creek Mining – Permit NACC-1302 dated 10/14/2014	X		CV		X	10 pages
CV5	Alluvial Valley Floor Evaluation Report; Coyote Creek Mine, March 2013, Revised August 2013	X		CV		X	13 pages
CV6	Upland Areas, Alluvial Flood Plain Diagram	X		CV		X	
CV7	Voigt Ranch Alfalfa Production Chart	X		CV		X	
CV8	Curriculum Vitae of Mark A. Anderson	X		CV		X	2 pages
CV9	Rangeland Similarity Index	X		CV		X	

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CV10	Ecosite Acres by Owner Chart	X		CV		X	
CV11	Ecosite Production Summary Chart	X		CV		X	
CV12	Root Systems Depth Illustration	X		CV		X	Admitted over objection for lack of foundation
CV13	Restoration and Reclamation Review; Vol. 5, No. 3, Fall 1999; Valerie Galajda Article	X		CV		X	4 pages Admitted over objection
CV14	ND PSC Standards for Evaluation of Revegetation Success and Recommended Procedures for Pre-and Post Mining Vegetation Assessments; Revised July 2003	X		CV		X	68 pages
CV15	Alluvial Valley Floor Identification and Study Guidelines	X		CV		X	3-Ring Binder
CV16	Soil Map – Mercer County, North Dakota including Voigt property	X		CV		X	3 pages
CV17	Map Unit Description for Soil Map covering Voigt property						4 pages
CC1	Surface and Coal Lease Agreement between the Voigts and North American Coal Royalty Company dated 12/29/2010	X		CC		X	10 pages

CC2	Indian Head Mine Reclaimed Land Productivity/Breakdown of Reclaimed Acres	X		CC		X	2 pages
CC3	Coteau Reclaimed Land Productivity	X		CC		X	
CC4	ND PSC Standards for Evaluation of Revegetation Success and Recommended Procedures for Pre-and Post Mining Vegetation Assessments; Revised July 2003	X		CC		X	135 pages
CC5	Livestock Weight Gain Study	X		CC		X	Admitted over objection of lack of foundation
CC6	Data from Application	X		CC		X	Exhibit 6 consists of hard copies of a portion of the final application which is contained in its entirety on the CD that is Exhibit 9
CC7	Range Nutrition Pamphlet	X		CC		X	10 pages
CC8	Grasses for the Northern Plains Publication; Volume 1 – Cool season & Volume 2 – Warm season	X		CC		X	2 books
CC9	Application of Coyote Creek Mining Company	X		CC		X	CD
CC10	Permit to Engage in Surface Coal Mining and Reclamation Operations and Surface Coal Mining and Reclamation Permit Conditions dated 10/22/2014	X		CC		X	2 parts 14 pages

CC11	OSM Annual Evaluation Report of ND PSC Regulatory Program for evaluation year 2013	X		CC		X	38 pages
CC12	OSM Annual Evaluation Report of ND PSC Regulatory Program for evaluation year 2014	X		CC		X	49 pages
CC13	Alluvial Valley Floor Evaluation Report, Coyote Creek Mine - March 2013	X		CC		X	45 pages Exhibit to be supplemented with a complete Ex. E to the report to be filed as a late-filed exhibit
CC14	Letter from James Deutsch approving Coyote Creeks August 2013 version of the Alluvial Valley Floor Evaluation Report dated 8/26/2013	X		CC		X	
CC15	Alluvium Coyote Creek Chart – ground water data from Voigt south well	X		CC		X	
CC16	Alluvium (CC)-Antelope Creek – ground water data from Voigt north well	X		CC		X	
PSC3	Curriculum Vitae of Bruce E. Beechie	X		PSC		X	2 pages
PSC4	Curriculum Vitae of Dean K. Moos	X		PSC		X	
PSC5	Curriculum Vitae of Commissioner Brian P. Kalk	X		PSC		X	

PSC6	Curriculum Vitae of James R. Deutsch	X		PSC		X	2 pages
PSC7	ND Final Bond Releases for Lands Permitted or Re-permitted after July 1, 1979	X		PSC		X	
PSC8	ND Permanent Program Mining Permits (post-July1979)	X		PSC		X	
PSC9	June 15, 2009, Memorandum re: Coyote Creek AVF Field Investigation	X		PSC		X	Late-filed exhibit
PSC10	October 20, 2014, Memorandum re: Application for Permit No. NACC-1302						

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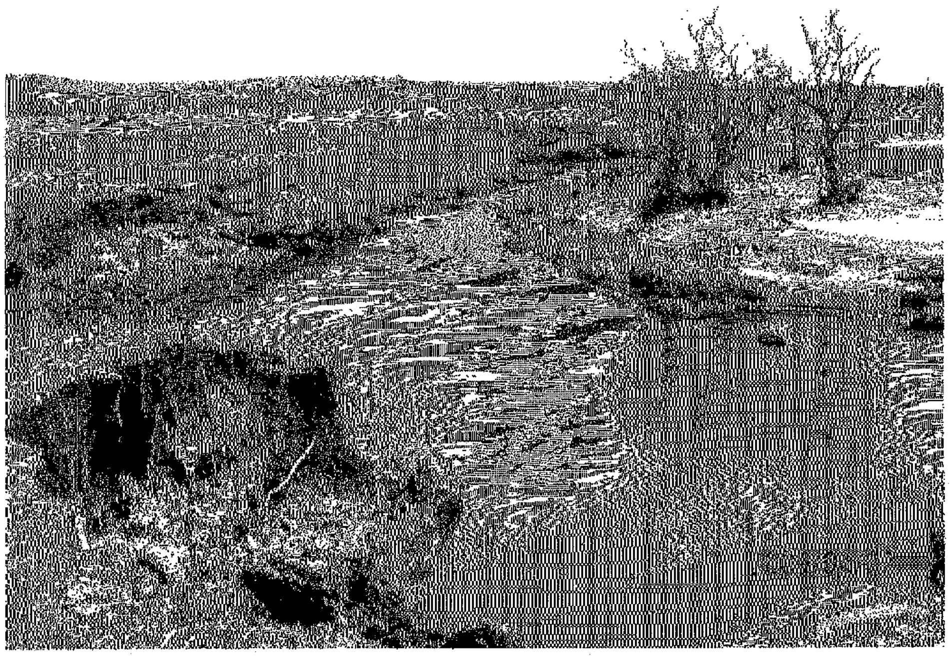


COYOTE CREEK

ALLUVIAL VALLEY FLOOR STUDY

Dakota Westmoreland Corporation

October 2009 Revision

0041

TABLE OF CONTENTS

INTRODUCTION

A. PURPOSE

In response to the North Dakota Public Service Commission's review of Dakota Westmoreland Corporation's (DWC) revision 22 to mining permit KRSB-8603, an initial investigation of stream valleys within and adjacent to the permit revision areas was undertaken to ascertain if alluvial valley floors may exist within any of the stream valleys. The eastern and western segments of the initial identification areas identified on Exhibit 1 include the permit revision areas and adjacent areas. The eastern segment includes all or portions of Sections 14, 15, 22, and 23, T.143N., R.88W. The western segment includes all or portions of Sections 18, 19, 20, 30, and 31, T.143N., R. 88 W., and Sections 13, 14, 24, and 25, T.143N., R. 89 W. Revision 22 encompasses all or portions of Sections 15, 19, 20, and 22, T.143N., R.88W .

The western segment of the initial investigation area contains several stream valleys of an ephemeral, intermittent, or perennial nature. All of the stream valleys with the exception of Coyote Creek have ephemeral or intermittent flow characteristics. It is doubtful that the ephemeral stream valleys have the alluvium, or streamlaid deposits, required for alluvial valley floors. None of these lesser stream valleys have any agricultural development such as that found along portions of Coyote Creek. Limited space for agricultural crops on valley bottoms and limited water volumes are certainly disincentives for agricultural development in these sites. Our initial investigation has therefore categorically excluded all areas except the Coyote Creek stream valley from consideration as alluvial valley floors.

Identical conclusions have been reached in the eastern segment of the initial investigation area, where Brush Creek is the only perennial stream. However, Brush Creek had previously been evaluated for alluvial valley floor (AVF) status. In October 1985, Knife River Coal Mining Company submitted an AVF study for Brush Creek as part of the application for mining permit KRSB-8603. The study area was not described specifically, but the study information was essentially derived from the area containing Quarternary alluvium (see Exhibit 2.9.1 in Permit KRSB-8603). Based on the study, the Public Service Commission found that the Brush Creek stream valley did not contain an AVF. Therefore, the eastern segment of the initial investigation area did not receive further attention. This study for Coyote Creek will consider the same issues as the Brush Creek study.

As a result of our initial investigation, the Coyote Creek stream valley has been identified as a potential alluvial valley floor lying adjacent to the permit area which may be influenced by mining activities within the permit area. This stream valley lies in an area adjacent to the western segment of the permit revision area. This focused study is a reconnaissance identification study aimed at determining if an alluvial valley floor exists within the Coyote Creek stream valley. The ultimate goal, as expressed by the Office of Surface Mining's Alluvial Valley Floor Identification and Study Guidelines (U.S. Office of Surface Mining, 1983) is "to identify stream valleys which have agricultural importance and where that importance is derived from the water available in those valleys." The area of study for Coyote Creek is shown on Exhibit 1 and encompasses all or portions of Sections 19, 30, and 31 T.143N, R.88W., and Sections 13, 14, and 24, T.143N., R.89W.

A reconnaissance-level study by the Office of Surface Mining Reclamation and Enforcement looked at stream valleys in west-central North Dakota and in other states to "identify surface irrigated and subirrigated sites in the West to develop an understanding, from a regional perspective, of the types of stream valleys that may be studied further for consideration as alluvial valley floors" (U.S. Office of Surface Mining, 1985). Coyote Creek was included in one of the study areas and classified as a major tributary to a large perennial stream (i.e., the Knife River). The study noted that water availability on these streams limits surface irrigation, if it is at all possible, and that natural flood irrigation and subirrigation are important features. The study concluded that portions of higher terraces along Coyote Creek could be flood irrigated by spreading and/or pumping water. Another conclusion was that deep-rooting alfalfa probably receives beneficial moisture through subirrigation. The study utilized field investigations, supplemented by interviews with agricultural producers, information from regulatory and land management agencies, from published reports, and from aerial photographs and Landsat imagery.

B. REGULATORY BACKGROUND

The Code of Federal Regulations (CFR) defines an alluvial valley floor as

> *the unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by concentrated runoff or slope wash, together with talus, or other mass-movement accumulations, and windblown deposits.* (30 CFR 701.5)

The study objective is to gather readily available information in order to determine if both geologic and hydrologic criteria defining alluvial valley floors can be satisfied. The criteria are satisfied when the following two points from Part 822 of Title 30 of the CFR are affirmed.

1. *Unconsolidated streamlaid deposits are present*

2. *Sufficient water is available to support agricultural activities, as evidenced by:*
   - *The existence of flood irrigation*
   - *The capability of an area to be flood irrigated, based on evaluations of typical regional agricultural practices, historical flood irrigation, streamflow, water quality, soils, and topography; or*
   - *Subirrigation of the lands in question derived from the ground-water system of the valley floor*

If an affirmative response is given to both criteria, the next step is to determine whether any statutory exclusions in Part 822 apply. If statutory exclusions do not apply, the permittee will provide permit application information to be used by the regulatory authority in its decisionmaking in the granting of a permit. Five points will be considered by the regulatory authority.

1. *The characteristics of the alluvial valley floor which are necessary to preserve the essential hydrologic functions throughout the mining and reclamation process;*

2. *Whether the operation will avoid during mining and reclamation the interruption, discontinuance, or preclusion of farming on the alluvial valley floor;*

3. *Whether the operation will cause material damage to the quantity or quality of surface or ground waters supplied to the alluvial valley floor;*

4. *Whether the reclamation plan is in compliance with requirements of the SMCRA, the Code of Federal Regulations (CFR), and North Dakota regulations,*

5. *Whether the proposed monitoring system will provide sufficient information to measure compliance with Part 822 during and after mining and reclamation operations.*

C. STUDY AREA

This study is a reconnaissance effort to provide information to aid in determining the existence of an alluvial valley floor within the Coyote Creek stream valley. The 560-acre study area is that portion coincident with the Coyote Creek stream valley floodplain as defined on Exhibit 1 within Sections 19, 30, and 31, T.143.N., R.88W., and Sections 13, 14, and 24, T.143N., R.89W. The floodplain was initially defined by referencing topographic contour resources and refined by groundtruthing that considered topography and evidence of streamworking and flooding. Evidence remaining after the major flooding this spring was also helpful in defining the study area.

1. GEOLOGIC INVENTORY

The following geologic data has been extracted from mine permit KRSB-8603 for the Beulah Mine. The data was last updated is November of 2008 (revision 22 to permit KRSB-8603). All exhibits referenced within this section can be found in mine permit KRSB-8603. The summarization of geology below represents a detailed characterization of the Brush Creek, Knife River, and Coyote Creek drainages. The permit area, as mentioned within the summary, can be found on Exhibit 1 (Area Map) within the AVF study report.

A. REGIONAL GEOLOGIC SETTING

1. Physiography and Topography

The permit area is located in the glaciated portion of the Missouri Plateau section of the Great Plains Physiographic Province. The topography in the area is characterized by gently rolling to hummocky upland surfaces with occasional prominent buttes rising as much as 200 feet above the surrounding land surface. These uplands are dissected by a series of generally northwesterly to southeasterly trending glacial meltwater channels which often contain small underfit intermittent streams which are tributaries of the Knife River. The Knife River is the master river in this area flowing northeasterly to its confluence with the Missouri River about twenty miles northeast of the town of Beulah. Maximum relief in the area is on the order of 400 feet.

2. Geology

The permit area lies within the southeastern portion of the Williston structural basin, and is underlain by 11,000 to 12,000 feet of sedimentary rocks which have a general regional dip of about one degree to the northwest. This sedimentary column consists of varying thickness of interbedded sandstone, shale, limestone, dolomite, and evaporites (Carlson and Anderson, 1970).

Paleozoic and Mesozoic units, including and underlying the Pierre Shale of late Cretaceous age, comprise about 80% of the sedimentary thickness in the area. Other than the Pierre, which reaches a thickness of about 2000 feet and forms an effective regional aquitard, these units are not relevant to the mining of the permit area nor the impacts of that mining.

Directly overlying the Pierre Formation are the youngest cretaceous units, the Fox Hills and Hell Creek Formations, which serve as important regional aquifers. The Fox Hills Formation was deposited in a very shallow sea with the uppermost member, the Colgate, being the last in this marine sequence. Subsequently, the seas retreated and, after erosion, the Hell Creek was deposited on stream flood plains and adjacent swamps, creating a series of sandstones and sandy shales, with some lignites. Occasional intrusions of brackish sea water resulted in the deposition of the Breien Member, a marine, glauconitic sandstone (Frye, 1969).

Cenozoic deposition began with the Ludlow Formation which is included with the other Tertiary Formations in the Fort Union Group. The Ludlow and Cannonball Formations represent the final sea transgression. These formations likely represent and intertonguing (Carlson, 1973), and a transition from the swamp deposits of the Ludlow to the marine-deposited Cannonball. As a consequence, the Ludlow consists of shales, siltstones, and lignites whereas the Cannonball varies from sandstones and shales to lenticular limestones (Carlson, 1973).

The Bullion Creek and Sentinel Butte Formations are the upper units of the Fort Union Group. The Toungue River Formation which represents the transition from the marine Cannonball below to the terrigenous Sentinel Butte above, consists of sandstones and shales with lignite, especially near its contact with Sentinel butte.

The Sentinel Butte Formation consists of interbedded sand, silt, clay and lignite and contains the most extensive coal deposits in the region. The sands are generally confined to basal and upper members. Of the lignite beds, the Beulah-Zap bed is the most persistent in quantity and quality in the Knife River area (Benson, 1952), and is currently being mined at the Knife River Coal Mining Company's Beulah Mine. Several other beds have been identified stratigraphically above and below the Beulah-Zap (Groenwold, et al., 1979). Among these is the Schoolhouse bed, which lies 45 to 50 feet above the Beulah-Zap and is also being mined at the Beulah Mine. Lignite from these beds is typically tough, compact and black to dark brown in color. Texture is often woody and fibrous, and carbonized logs and plant stems are common.

Erosion of the upland surfaces to the west and subsequent fluvial processes resulted in the deposition of the Golden Valley Formation at the top of the Fort Union Group. The Golden Valley Formation consists of siltstones and kaolinitic claystones grading upward to clayey sandstone.

Substantial erosion associated with Black Hills uplift removed much of the golden Valley Formation from the immediate vicinity of the permit area, but several outcrops have been observed to the west and the southwest (Carlson, 1973).

Surficial sediments in this region, other than bedrock, generally consist of till in the uplands, colluvium and alluvium along the valley slopes and meltwater channel bottoms, and scattered localized eolian sands and silts.

B. GEOLOGY OF THE PERMIT AREA

1. Stratigraphy

The coal seam of primary mining interest in the West Brush Creek Development Area as throughout the Beulah Mine is the Beulah-Zap bed of the Sentinel Butte Formation. The Sentinel Butte Formation of Paleocene Age is the only bedrock unit exposed in the permit area and is generally mantled by 10-20 feet of till except along sides of draws where the glacial sediment has been removed by erosion.

Exhibits 2.1.5a and 2.1.5b show diagrammatic cross sections including the permit area and adjacent area which depict the Beulah-Zap bed and its relationship to the overlying and underlying sediments. In an effort to present the maximum amount of information, the entire thickness drilled has been depicted for each drill hole. Due to the highly variable bottom hole elevations and the subtle variations in sediment type, however, no attempt has been made to correlate units from hole to hole below the lowest correlative lignite bed. Exhibit 2.1.7 shows the locations of these cross sections and the lithologic logs for these test holes are presented in Exhibit 2.1.2. All available geophysical logs for the permit area are contained in Exhibit 2.1.1.

Exploration drilling in the general area commonly penetrated the Spaer bed, the first lignite below the Beulah-Zap and also the first zone of significant permeability below the proposed mining disturbance. The following discussions of the site specific geology will focus on the stratigraphic intervals above and including the Spaer which will be disturbed or otherwise potentially affected by mining.

Moran, et al. (1978) established the practice of defining a lignite interval as those materials extending from the base of named lignite to the base of the next overlying named lignite. This practice will be followed here and discussion will begin with the Spaer interval deeper geologic units. Because of their potential as replacement water sources, will be discussed under Groundwater Hydrology (Section 2.3).

Spaer Interval

The Spaer Bed is traceable throughout the permit and adjacent areas where sufficient subsurface information exists. It occurs as a single continuous seam of lignite coal averaging two to four feet in thickness. Lithologically, the remainder of the Spaer interval is a highly variable mixture of moderately consolidated sediments ranging from silty-clay to sandy-silt with minor amounts of sand and limestone. Fine to very fine sandy-silt is probably the most predominant overall lithology. This interval appears to coarsen somewhat from north-south across the permit area. The Spaer bed as well as the overlying Beulah-Zap and Schoolhouse beds to be discussed below is a part of the Sentinel Butte Formation.

Beulah-Zap Interval

The Beulah-Zap bed is a thick and laterally continuous lignite which is present throughout the permit and general areas unless it has been removed by erosion. Within the permit area the Beulah-Zap bed averages an almost constant 12 feet in thickness with no splits or partings. The remainder of the Beulah- Zap interval is approximately 50 feet thick, where present in its entirety. This entire interval is present beneath most of the southern 2/3 of the permit area south of the line between test holes 965 and 969 (see Exhibit 2.1.7).

The lithology of this interval is a highly variable mixture of sandy silt-silty sand, clayey silt-silty clay, sand, and limestone. With the exception of the limestone, these sediments are moderately consolidated. Throughout most of the permit area sandy silt-silty sand is the predominant lithology and in most test holes an upward coarsening can be observed.

Schoolhouse Interval

The uppermost lignite bed within the permit area, the Schoolhouse, is believed to be of mineable quality only in the NE1/4 of Section 21 and NW1/4 of Section 22. The Schoolhouse lignite is commonly split into an upper and lower Seam averaging 3 and 4 feet in thickness respectively. These two seams are separated by 6 to 10 feet of sandy silt to silty clay.

The entire Schoolhouse interval was encountered near the southern boundary of the permit area and a good subsurface exposure of this interval is in the vicinity of test holes 1017-1019 where the total remaining thickness is about 65 feet. As with the underlying Beulah-Zap interval, a general upward coarsening from clayey silt-silty clay to sandy silt-silty sand or sand can be observed in these test holes.

The pebble-loam (till) of the Pleistocene Coleharbor Group unconformably overlies the Schoolhouse interval throughout the uplands of the general area and permit area as well. Within the permit area itself the thickness of this unit ranges up to 30 feet and averages about 20 feet. Lithologically, this pebble-loan contains a large portion of silt and clay and relatively few cobbles and boulders.

In general, the thickness of the entire overburden column increases uniformly across the permit area from northwest to southeast ranging from about 40 to 130 feet (See Exhibit 2.1.6).

2. Overburden and Coal Quality

The thickness of overburden to the top of the Beulah-Zap seam is depicted on Exhibit 2.1.6. The overburden within the permit area consists of the sediments of Beulah-Zap and Schoolhouse intervals and the pebble-loam of the Coleharbor Formation described above. During an exploration drilling program conducted in the summer of 1979, cuttings were collected at five-foot intervals from selected drill holes and analyzed for pH, EC, SAR, K, Na, P, net alkalinity, grain size distribution and nitrate nitrogen. The results of these analyses are presented in Exhibit 2.1.3 and sampling locations are shown on Exhibit 2.1.7. Table 2.1.1 presents the mean SAR value calculated for each of these test holes, including only those materials above the top of the Beulah-Zap lignite.

Table 2.1.1 Average SAR Values for Materials Above the Beulah Zap Lignite

Test Hole Number	Mean SAR
954	10.96
955	4.77
956	5.10
957	7.49
965	15.56
966	12.22
967	14.38
969	4.33
978	7.60
979	5.46
980	1.35
1005	18.35
1006	24.74
1007	16.62
1008	9.38
1009	14.28
1017	17.66
1018	19.35
1019	18.53
1020	15.25
1021	16.49

In general these mean SAR values increase from north to south across the permit area as the proportion of glacial sediment in the overburden column decreases in relationship to the proportion of bedrock sediment.

Analyses of the coal quality from selected drill holes are presented in Exhibit 2.1.4. These analyses indicate that the Beulah-Zap bed is of commercial quality throughout the permit area.

3. Structure

Exhibit 2.1.8 is a structure contour map drawn on the top of the Beulah-Zap lignite bed. An examination of this map reveals that the dip of the Beulah- Zap bed in the permit area averages about 1 degree and often less, approaching 2 degrees only at its steepest. As would be expected, the strike of the bed is highly variable, but a few general structural patterns are discernible.

Near the center of Section 16, in the area of the NE-SW box-cut pit, the bed strikes to the NE and dips to the SW at about 1 degree. A topographic high exists near the center of the NW1/4 of Section 21 with an elevation of 1970 feet. Dips are away from this high at about 1 degree, decreasing considerably to the north, west, and south. East of this high, through the NE1/4 of Section 21 and into the SE1/4 of Section 16, the Beulah-Zap bed strikes northerly, dipping at about 1 degree, with the strike gradually becoming northwesterly approaching the structural low in the SE1/4 of Section 16.

Exhibit 2.1.8 also shows the limit of the presently mineable coal (cropline) within the permit area. This boundary exists only at the north end of the proposed mining area where the Beulah-Zap bed has been removed by erosion. To the west, south, and east, this bed continues intact.

4. Geomorphology

The permit area is a gently rolling upland dissected in its northeast portion by a steep-sided draw which contains an intermittent tributary of Brush Creek. The heads of similar draws also extend into the permit area near its NW and SW corners, but provide far less relief (See Exhibit 2.1.8).

The highest elevation on the upland occurs near the SE corner of the permit area at about 2090 feet and from here the land slopes to the west and north at about 50-80 feet per mile. The head of the major draw originates near the south end of the centerline of Section 16 at an elevation of about 2000 feet and from here the draw runs north and then northwest, exiting the permit area near its northeast corner at an elevation of about 1860 feet. The side slopes of this draw in its steepest portions are on the order of 15 degrees.

This upland area has been mapped by Carlson (1973) as ground moraine ad further described by Clayton (1980) as "thin glacial sediment draped over and only slightly modifying the non-glacial topography existing before the last glacial advance." These descriptions are confirmed by the geologic cross sections which show that the glacial sediment does not create constructional topography. The pebble-loam has been removed along the sides of the draws where the sediments of the Sentinel Butte Formation are exposed, mantled with a foot or two of soil. Most of the upland area is veneered with wind-blown sand and silt of the Oahe Formation which is too thin to map or show in cross section.

C. INTERPRETATIONS RELATED TO COYOTE CREEK STREAM VALLEY

Stream valleys with the watershed size and other characteristics of the Coyote Creek stream valley are usually underlain by unconsolidated streamlaid deposits. For the purposes of this study, we assume this to be the case. Stream valley characteristics for Coyote Creek provide supporting evidence. For instance, oxbow lakes and truncated meanders are common throughout the length of the study area. Evidence of deposition of suspended and bed load was frequently observed during the site surveys throughout the length of the study area. Deposits of a foot or more of sediment were often found on points within and outside of the stream channel after the spring 2009 flood.

The general topography of the Coyote Creek stream valley and surrounding area is presented on the USGS topographic quad map composite appearing as Exhibit 2. A more detailed presentation of topographic contours for part of the area can be found in Exhibit 3. The cross-section in Exhibit 3 depicts a nearly level floodplain by scarp on one side and the toe of long, gradual slopes on the other side. The width of the study area (floodplain) varies considerably, but the most extensive arable portions, like that at the cross-section position, are in the vicinity of 1,200 to 1,500 feet wide. Similarly variable, channel width probably ranges from 50 to over 100 feet. The location and elevation of the nearest coal bed contours for the Beulah-Zap and Spaer coal beds and outcrop for the Schoolhouse coal bed has been developed from potentiometric maps in Permit KRSB-8603 and plotted on Exhibit 3.

2. GROUNDWATER HYDROLOGY

The following groundwater hydrologic data has been extracted from mine permit KRSB-8603 for the Beulah Mine. The data was last updated is November of 2008 (revision 22 to permit KRSB-8603), and includes additional information specific to the Coyote Creek drainage system. Watersheds for Coyote Creek, as well as Brush Creek and the Knife River, appear on Exhibit 1. All Exhibits referenced within this section can be found in mine permit KRSB-8603. The summarization of groundwater hydrogeology below represents a detailed characterization of the Brush Creek, Knife River, and Coyote Creek drainages. The permit area, as mentioned within the summary, can be found on Exhibit 1 (Area Map) within the AVF.

A. REGIONAL HYDROLOGY

The following narrative, synthesized mainly from Croft (1970), describes the hydrostratigraphy and hydrologic properties of the major water bearing units which represent potential replacement sources for water supplies which are adversely impacted by mining. A brief description of the geology of these units is contained in Section 2.1.A.

Upper Hell Creek and Lower Cannonball-Ludlow Aquifer

Fine to medium grained sandstones in the upper part of the Hell Creek and lower part of the Cannonball-Ludlow Formations form a regional aquifer in the Mercer County area. This aquifer underlies the permit area at a depth of about 800 feet. Transmissivity values on the order of $2.6(10^{-5})\ m^2{\cdot}s^{-1}$ to $6(10^{-4})\ m^2{\cdot}s^{-1}$ have been calculated for this aquifer, and wells tapping this unit should produce from 5 to 100 gpm. Chemically the water in this aquifer is very similar to that in the Fox Hills-Basal Hell Creek aquifer which lies beneath.

Fox Hills-Basal Hell Creek Aquifer

Sandstone units in the Upper Fox Hills and Basal Hell Creek Formations form an extensive regional aquifer which underlies the permit area at depths ranging from 1000 to 1300 feet. These fine to medium grained sandstones are interbedded with siltstones and claystones and the total aquifer thickness varies from about 150 to 350 feet (Croft, 1970).

Based on a series of recovery tests, a hydraulic conductivity ranging from $5.0(10^{-7})\ m{\cdot}s^{-1}$ to $5.6(10^{-5})\ m{\cdot}s^{-1}$ and averaging $7.4(10^{-6})\ m{\cdot}s^{-1}$ was calculated. Specific capacities for these wells average 0.3 gpm/foot, and the storage coefficient ranged from 0.0001 to 0.00001.

Water quality in the Fox Hills-Basal Hell Creek aquifer is a sodium bicarbonate type with a TDS range between 1200 and 2000 mg/l.

Lower Bullion Creek Aquifer

The last major regional aquifer of interest with respect to this permit is the Lower Bullion Creek aquifer. The areal extent of the Lower Bullion Creek aquifer zone is much more limited than that of the other major aquifers, being restricted largely to the Knife River Basin and adjacent areas to the north and south.

The lower part of the Bullion Creek Formation consists of numerous discontinuous sand units rather than a single widespread unit. The total composite thickness varies from 0-200 feet and includes sand units within the Hanson, Harmon, and Weller Slough intervals. This composite sand unit is referred to as an "aquifer zone" rather than as a distinct aquifer.

There is a very limited amount of data on the hydraulic properties of the Lower Bullion Creek aquifer zone within the Knife River basin. Several cores were analyzed from Dunn County and these cores showed an average hydraulic conductivity of $4.0(10^{-7})\ m^2 \cdot s^{-1}$. Water production from this zone seldom exceeds 10 gallons per minute.

The potentiometric levels in aquifers in the Sentinel Butte Formation are generally higher than those in the Lower Bullion Creek aquifer zone. The potentiometric levels in the Upper Hell Creek and Lower Cannonball-Ludlow aquifer are also generally higher than those in the Lower Bullion Creek aquifer zone. It is evident, therefore, that water flows downward into the Lower Bullion Creek from overlying aquifers and upward into it from underlying aquifers and that the Lower Bullion Creek aquifer zone functions as a regional groundwater sink.

B. HYDROGEOLOGY OF THE GENERAL, ADJACENT AND PERMIT AREA

1. Introduction

Hydrologic instrumentation of the permit and general area was initiated in 1979 in conjunction with the exploration program which provided much of the information presented in the geology section of this permit application. Monitoring wells in the 900 and 1000 series were installed at that time along with a water quality monitoring program for selected wells. Additional monitoring wells in the 1300, 1400, 1500, and 1700 series were installed during the years 1984, 1985, 1986, and 1990, respectively. Four wells (2001-2004) were installed in 2004 to monitor Section 15, T.143N, R.88W. Wells 2005 through 2014 were installed in 2005 to monitor the area added to this permit with Revision No. 19. In October, 2008, nine new wells (2020-2028) were installed to monitor both the groundwater quality and the static water levels in the area added to the permit via Revision No. 22. Wells 2020-2025 were drilled in two cluster locations in Section 22, T143N, R88W and wells 2026-2028 in one cluster in Section 21. Static water levels readings will begin in 2009 1st quarter and well quality sampling in the 4th quarter. Most wells have been sampled at least once for water quality and selected wells have had single well response tests performed in order to determine hydraulic conductivity. Their locations are shown on Exhibit 2.3.1, Groundwater Monitoring Sites. All of the wells shown in yellow on this exhibit have been mined through, destroyed, or abandoned due to casing or grout failure.

The geophysical logs, drilling logs and original completion reports for these wells are included in Exhibits 2.1.1 and Exhibit 2.1.2. Well completion summaries are presented in this section as Exhibit 2.3.2.

The hydrostratigraphy of those units which will be disturbed or otherwise potentially impacted by mining is defined by the geology of the lignite intervals as described in Section 2.1. In the permit and general areas, the fractured lignite beds are the most permeable near-surface units, sometimes providing water for domestic uses or livestock watering while the intervening sediments function as aquitards.

In general terms the permit area could be considered a recharge area as indicated by the falling potentiometric head with depth at the paired or nested piezometer locations. How much actual groundwater recharge (net addition of water to the zone of saturation) is actually occurring within the permit area is difficult to quantify; however, previous studies of groundwater recharge in western North Dakota have found that recharge is both spatially and temporally variable (Rehm et. al., 1980). The higher potentiometric levels to the south and west and the fact that the Beulah-Zap bed is unsaturated near the center of Section 16, suggest that groundwater recharge may be greater in the adjacent area than within the permit area itself.

Recharge to the Schoolhouse Bed is by vertical infiltration during exceptional precipitation or snowmelt events; the Schoolhouse Bed discharges where it outcrops to form springs or sloughs and by slow vertical leakage to the underlying sediments. The Beulah-Zap and Spaer Beds are recharged by direct infiltration and leakage from overlying saturated sediments. Within the permit area, the Beulah-Zap Bed discharges as spring flow and by vertical leakage. Due to its greater depth, no springs associated with the Spaer Bed have been observed in the general area; with the exception of spring 17ABB-W/SP (located ½ mile north of the permit boundary). Typically discharge from this bed is by slow leakage to the underlying sediments.

A series of single-well drawdown tests were used to define the hydraulic conductivities of the Schoolhouse, Beulah-Zap, and Spaer lignite beds. The results of these tests are discussed below for the individual beds.

No site specific testing was conducted to determine storativity or specific yield values within the permit area. Previous pump testing and computer modeling suggest that storativities of about 0.0005 to 0.00001 and specific yields of about 0.01 to 0.07 are reasonable for the lignite aquifers of the upper Great Plains (Rehm et. al., 1980).

2. Twin Buttes Bed

The Twin Buttes bed overlies the Schoolhouse Bed south of the permit area It reaches a maximum thickness of about 5 feet in T. 143 N. R. 90 W., and in scattered localities north and south of that area (R. A. Brant, 1953). Geologically, the bed is located between 90 and 110 feet above the Schoolhouse lignite. (C.G. Carlson, 1973). The Twin Buttes lignite is not present within the proposed permit area, and is located up gradient and isolated from mining activities.

3. Schoolhouse Bed

The Schoolhouse bed overlies the Beulah-Zap bed throughout most portions of the permit area, most specifically in the east halves of SE¼ of Section 16 and NE¼ of Section 21. It reaches a maximum depth of just over 90 feet near monitoring well 1441, in the extreme southeastern corner of the permit area and subcrops near the surface to form the slough in the SW¼ of the NW¼ of Section 21 (Weil Slough). This slough has not been mined through but has been replaced with Pond 87. Its outcrop is represented by springs in the area of the valley fill, as shown on Exhibit 3.6.4. Generally, the Schoolhouse bed ranges from about 20 to 50 feet in depth.

Due to its high permeability relative to the underlying sediments of the Beulah-Zap interval, the Schoolhouse bed is typically partially saturated, forming a perched water table. It is likely that this perched water table merges with the true water table (potentiometric surface) somewhere in the southeastern corner of the permit area where the Schoolhouse bed is found at greater depth; however, there is not sufficient instrumentation in place to substantiate this.

Piezometers were installed in the lower split of the Schoolhouse bed at selected locations. The October 1985 static water levels from those observation wells were used to produce the potentiometric map presented here as Exhibit 2.3.3. This map shows the highest potentiometric levels throughout most of the N½ of Section 21, with levels decreasing and the gradient steepening to the northeast away from a potentiometric high located near well 1447. Evidence collected since 1985 further supports this. Table 2.3.1 displays the groundwater potential above the top of the Schoolhouse bed at monitoring wells 1372, 1395, 1444, 1447, and 1448.

Table 2.3.1
Groundwater Potential of Selected Wells

Well	Top of Coal – BLS (ft)	(1979-2004) Average SWL – BLS (ft)	Average Water Level Above Top of Coal
1372	12.0	13.11	-1.11
1395	26.0	25.16	.84
1444	52.0	47.13	4.87
1447	31.5	26.72	4.78
1448	31.0	26.16	4.84

BLS – Below Land Surface
SWL – Static Water Level

The higher water levels above the coal at wells 1444, 1447, and 1448 indicate increased potentials south of the permit area where the Schoolhouse bed is deeper and the overlying saturated thickness is greater. All of the wells listed in Table 2.3.1 have since been either mined through or destroyed. The water levels for all wells within the permit area are shown in Exhibit 2.3.5.

Water quality within the Schoolhouse bed, as illustrated by a series of samples taken from well 1394, 1444, 1447, and 1448, varies greatly, even for sampling locations in relatively close proximity of each other. Total dissolved solids values for this group range from an average of 700 mg/l at well 1444 to 7713 mg/l at 1448. It is likely, however, that the samples from 1448 and 1394, while they were in existence prior to mining, were influenced by interaction with evaporation-affected water from the nearby slough; the analyses from wells 1447 and 1444 are probably more representative of the quality of water in the Schoolhouse bed. Well 1444 has an average TDS of 700 mg/l consisting of a sodium bicarbonate sulfate type water with an average SAR of 21, whereas well 1447 has an average TDS of 2814 mg/l consisting of calcium magnesium sulfate type water with an average SAR of 1.8 (see Exhibit 2.3.6).

Hydraulic conductivity and transmissivity values for three piezometers in the Schoolhouse bed show two orders of magnitude difference, ranging from $3.1(10^{-5})$ to $2.6(10^{-7})$ $(m{\cdot}s^{-1})$ and $2.4\ (10^{-5})$ to $3.2\ (10^{-7})(m^2{\cdot}s^{-1})$, respectively.

4. Beulah-Zap Bed

Hydrologically, the Beulah-Zap bed shows considerably more variation than the Schoolhouse, it occurs within the permit area as a confined aquifer, a partially saturated water table aquifer, and in a dry condition. Outside of and along the southern perimeter of the permit area, the Beulah-Zap bed is saturated, with potentiometric levels ranging from 2 to 33 feet above the top of the coal in the vicinity of well nos. 959, 2011, 1732, 1441, and 1445. Because the B-Z bed is saturated along the southern perimeter, sands located above this lignite bed typically act as an aquifer for the groundwater. If these sands are tapped by wells or are exposed to the surface, which then function as springs, they can serve as sources of stock, domestic, and possible irrigation water. To the north, along the west edge of the Red pit box-cut (wells 1358, 1359 and 1360), the coal is partially saturated; whereas near the northwestern (wells 2005, 2006, and 2007) and eastern (wells 2001, 2004, and 2013) areas of the permit, (wells. 1446, 1373 and 1371) the seam is dry.

The potentiometric contours on Exhibit 2.3.4 indicate that flow is generally to the east throughout most of the area, becoming more northeasterly in the NE¼ of Section 21. The highest potentiometric contour exists in S½ of Section 17 and N½ of Section 20. Caution should be exercised when interpreting flow directions from these contours; head loss and change from confined to unconfined conditions in the E½ of Sections 17 and 20 suggest a vertical component of flow in this area. The flow directions for the Beulah-Zap and Schoolhouse beds are similar throughout the NE¼ of Section 21 and the SE¼ of Section 16, although the gradient in the Schoolhouse steepens to the northeast, the potentiometric surface of the Beulah-Zap levels out probably due to the moderating effect of confined hydrostatic pressure in the Beulah-Zap bed.

Transmissivities and hydraulic conductivities for the Beulah-Zap bed were calculated based on bailer tests conducted at wells 1358, 1360 and 1443. These values show a variation of four orders of magnitude, suggesting that the calculated transmissivity and hydraulic conductivity values are largely a function of the degree of fracturing at the particular location. At these locations hydraulic conductivity values ranged from a high of $2.9(10^{-5})$ $m \cdot s^{-1}$ to a low of $3.0(10^{-9})$ $m \cdot s^{-1}$. Previous work (Rehm, et al., 1980) suggests that hydraulic conductivity values on the order of $3(10^{-6})$ $m \cdot s^{-1}$ to $3(10^{-7})$ $m \cdot s^{-1}$ are typical of North Dakota lignite. (See Table 2.3.2)

Chemically, the waters in the Beulah-Zap bed in the general area display both similarities and differences.

One of the most consistent parameters is pH, which usually ranges from about 6.5 to 7.5, except near the southern permit boundary where extremely high average pH values of 8.4 to 12.2 are found at well nos. 1441 and 1443, respectively. Well 1443 was abandoned in 1989 due to well grout failure which affected the pH and chemistry. Temperature is relatively consistent, around 8-12°C. Total dissolved solids are one of the more variable qualities, ranging from around 1,300 to 7,400 mg/l. Most TDS values fall in the 2000 to 4000 mg/l range with few exceeding 5000 mg/l

Sodium is the dominant cation in the Beulah-Zap waters, usually exceeding the combined concentrations of calcium and magnesium by an order of magnitude; sodium concentrations from 500 to 1000 mg/l are common. Sulfate and bicarbonate are the predominant anions having a combined concentration of approximately 2000 mg/l with one anion or the other occurring in the concentration by a factor of approximately 2 to 1. Sulfate concentrations as high as 4500 mg/l and bicarbonate concentrations as high as 1572 mg/l have been observed.

5. Spaer Bed

The Spaer lignite occurs throughout the permit area at a depth of between 20 and 40 feet below the base of the Beulah-Zap lignite. The interval, or aquatard, separating the Beulah-Zap and Spaer lignite consists of relatively tight silty clay with a permeability ranging between 10^{-8} and 10^{-9} cm/sec. Similar stratigraphy occurs east of the permit area in permit KRSB-8802.

Four piezometers in the Spaer Bed (wells 1440, 1442, 1526 and 1527) were used to define the hydrology of the next water bearing zone below the Beulah-Zap lignite. Wells 1440 and 1442 were destroyed in 1994 and 1990, respectively. Well 1731 was installed as a replacement of 1442 when it was destroyed in 1990. Wells 2008, 2012, and 2014 were installed in 2005 to further define the hydrologic properties of the Spaer. Exhibit 2.3.10 is a potentiometric map of the Spaer which shows the potentiometric surface declining from a high in the center of Section 20 declining in both westerly and easterly directions. The data essentially shows flow moving west and northwest towards Coyote Creek and east towards Brush Creek. (See Table 2.3.2.)

The Spaer lignite averages approximately three feet in thickness. The Spaer is not used as a water supply in this area. The source of recharge to the Spaer and all other water bearing strata within the area occurs to the south of the permit area. The Spaer is confined in the southern extension of the permit area as demonstrated in wells 1526, 2008, 2012, and 2014. To the north, the Spaer transitions to an unconfined or dry condition, as demonstrated by well 1527. North of the permit area, the Spaer outcrops, and should discharge in valleys located north (Sections 17 and 18) of the permit area. For the exception of Spring 17ABB-W/SP, there is no evidence of spring flow from this system within the tributaries located north of the permit area.

Possible impacts to the Spaer system would be infiltration of spoil water through the clay interburden, or aquatard, which could contribute water of the quality described in the PHC to the Spaer. The clay interburden may attenuate these impacts. Possible impacts would be limited in extent since the Spaer outcrops immediately north of the permit area.

The Spaer has been monitored and will continue to be monitored because it represents a logical stratigraphic location for potential groundwater impacts from mining. Water levels have remained relatively constant over time. Levels in well 1526 rose approximately 5 feet over the past 20 years. The remaining wells are relatively unchanged.

Water quality analyses for these wells are chemically similar, though of somewhat better quality than the overlying Beulah-Zap bed. TDS values vary from a low of 172 mg/l at well 1731 (only one sample over the past 15 years) to a high of 4501 mg/l at well 2003 (only one sample since installation). The water is a sodium sulfate and sodium bicarbonate sulfate type. Over the past 15 years, water quality data collected from the Spaer is very limited.

Dakota Westmoreland has added three existing wells as quality monitoring sites located south, within the confined sections of the aquifer. Wells 1526, 1527, and new well 2012 have been added to the annual water quality sampling schedule to augment the quality data for this system.

Should groundwater quality or quantity within the Spaer show a significant change over time, additional monitoring wells will be installed downgradient or within the northern portions of the permit area.

Table 2.3.2
Hydrologic Properties of the Schoolhouse
Beulah-Zap and Spaer Lignite Beds

Piezometer Number	Transmissivity ($m^2 \cdot s^{-1}$)	Hydraulic Conductivity ($m^2 \cdot s^{-1}$)	Stratigraphic Unit
1444	3.2×10^{-7}	2.6×10^{-7}	Schoolhouse
1447	2.4×10^{-5}	3.1×10^{-5}	Schoolhouse
1448	1.5×10^{-6}	1.1×10^{-6}	Schoolhouse
1358	9.1×10^{-9}	3.0×10^{-9}	Beulah-Zap
1360	2.7×10^{-5}	2.9×10^{-5}	Beulah-Zap
1443	1.0×10^{-8}	3.0×10^{-9}	Beulah-Zap
1440	8.6×10^{-7}	8.1×10^{-7}	Spaer
1442	3.2×10^{-8}	3.5×10^{-8}	Spaer

6. "Hazen B" Bed

The "Hazen B" lignite occurs throughout the permit area at a depth of between 80 and 150 feet below the Spaer lignite within the Sentinel Butte formation (Carlson, 1973). Very little is known of this coal seam because of its depth from surface. Wells 953 and 1514 intersect this coal seam. Wells 957 and 951 extend to the sands above this coal seam.

The Hazen B wells have been monitored and will continue to be monitored to assess potential groundwater impacts from mining. Water levels have remained relatively constant over time. Over the last 15 years, the static water elevation for wells 953, 1514, 957, and 951 have remaining essentially unchanged. The elevation of all of the wells have varied less than 0.5 feet, and appear to vary based on the relationship between precipitation and infiltration from the Spaer bed.

Water quality analyses for these wells are chemically similar, and of better quality than the overlying coal beds. TDS values were only collected from well 951 after installation (1435 mg/L. Over the past 15 years, water quality data collected from the Hazen B is very limited and not impacted by mining activities.

7. Spoils

The first monitoring well located on reclaimed land in Permit 8603, No. 2029, was installed on October 29, 2008. It was drilled at the exact location of pre-mining well 1373. Well 1373 monitored the groundwater within the Beulah-Zap bed, screened at an elevation of 1948.5-1938.5 feet. Spoil well 2029 now screens the overburden at the same elevation. Data from well 2029 will start being collected during 2009 1stquarter.

C. KNOWN USES OF GROUNDWATER

Several local domestic and stock watering wells and spring sources are located within the permit and adjacent areas. Their locations are shown on Exhibit 2.3.7. Table 2.3.3 summarizes their uses, intake depths and probable sources.

Table 2.3.3
Known Uses of Groundwater

Well Identification	Use	Intake Depth	Probable Source	Well/Spring Cert. Date
Fetch No. 1	Stock watering[1]	98-115	Beulah-Zap Coal	9-30-05
Fetch No. 2	Domestic supply[1]	35	Schoolhouse Coal	5-24-91
Fetch No. 3	Domestic supply[1]	45	Schoolhouse Coal	9-30-05
PVFCo* No. 1	Domestic supply[1]	18	Beulah-Zap Sand	9-30-05
PVFCo* No. 2	Domestic supply[1]	65	Beulah-Zap Coal	9-30-05
PVFCo* Spring No. 1	Stock watering	Spring	Beulah-Zap Sand	9-30-05
PVFCo* Spring No. 2	Stock watering	Spring	Beulah-Zap Sand	9-30-05
PVFCo* Spring No. 3	Stock watering	Spring	Beulah-Zap Sand	9-30-05
Unruh No. 1	Domestic supply[1]	30	Twin-Buttes Coal	5-24-91
Unruh No. 2	Stock Watering	40	Twin-Buttes Coal	10-17-05
Unruh No. 3	Stock Watering	46	Twin-Buttes Coal	10-17-05

Unruh No. 4	Stock Watering	30	Twin-Buttes Coal	10-17-05
Reich/Unruh	Domestic supply	1450	Fox Hills Fm.	10-17-05
Reich No. 2	Stock Watering	37	Twin-Buttes Coal	10-17-05
S. Winkler (Weil) No. 1	Stock/Domestic[1]	382	Bullion Creek Fm.	9-30-05
S. Winkler (Weil) No. 2	Stock/Domestic[1]	50	Beulah-Zap Coal	9-30-05
Welk	Domestic Supply	70	Beulah-Zap Coal	9-26-05
Endreson	Domestic Supply	120	Beulah-Zap Coal	9-26-05
M. Gunsch Spring	Stock watering	Spring	Schoolhouse Coal	9-27-05
R. Gunsch Spring No. 1	Stock watering	Spring	Schoolhouse Coal	9-27-05
R. Gunsch Spring No. 2	Stock watering	Spring	Beulah-Zap Coal	9-27-05
R. Gunsch Well No. 1	Stock watering	71	Beulah-Zap Coal	9-27-05
R. Gunsch Well No. 2	Irrigation	86	Beulah-Zap Sand	9-27-05
Reich	Stock/Domestic	62	?	9-30-05
Erickson Well No. 7	Stock Watering	272	Bullion Creek Fm.	10-17-05
Erickson Spring No. 3	Stock watering	Spring	?	10-17-05
L. Winkler Spring No. 1	Stock Watering	Spring	?	9-26-05
L. Winkler Spring No. 2	Stock Watering	Spring	?	9-26-05
Voigt Spring No. 1	Stock Watering	Spring	?	9-30-05
Voigt Spring No. 2	Stock Watering	Spring	?	9-30-05
17ABB-W/SP	Stock Watering	Spring	?	No cert.
17DAC-W/SP	No Flow	Spring	?	No cert.

*PVFCo = Pleasant Valley Farming Co.
[1]Presently unused

A discussion of the Gunsch spring located in the SE¼ of Section 16 can be found in Section D-2. Probable Hydrologic Consequences, Impacts to Known Sources. Further information regarding the Gunsch spring and valley fill may be found in Section 3.6 Backfilling and Grading – Special Considerations. Section 3.6-D contains a discussion regarding groundwater management within the valley fill area.

The following discussion relates to wells and springs in and adjacent to the revision area. In October 1985, Water Supply, Inc certified and sampled these water sources to determine the quality and quantity of water available at that time.

Water Supply, Inc. re-certified the sites listed in Table 2.3.3 in the fall of 2005. The results of this certification program are presented in Exhibit 2.3.8. Most of these wells and springs are shallow and low yielding (<5 gpm) sources which tap either the Beulah-Zap or Schoolhouse coal beds.

In general these wells provide water which is of satisfactory quality for its intended purpose and although most of it is not desirable as a domestic source, it is typical of the waters often utilized in western and central North Dakota. The following is a synopsis of the water supplies listed in Table 2.3.3. These sites may be found on Exhibit 2.3.7 – Water Supply Locations.

Fetch Farmstead

Fetch well No. 1 is located inside a corral and has high nitrate content. Fetch well No. 2 was the sole source for the abandoned farmstead. It was classified by the State Health Department as usable, but not desirable for a domestic supply. Well No. 2 is located inside the pump house as shown on the certification photo. The well was drilled in 1935 and is screened in the Schoolhouse, its use was discontinued some time prior to 1991. Fetch well No. 3 was drilled in 1985 and is screened within the Schoolhouse. Use of the well was discontinued prior to 1991.

The Fetch Pond was a dugout excavated into the Schoolhouse within a small coulee. It is a saline slough used for stock watering. The area where the dugout is located has not been disturbed by mining. All of the Fetch sites are located up-gradient of the permit area and are not anticipated to be affected by mining.

Pleasant Valley Farming Co. (PVF) Farmstead

PVF well No. 1 is the sole domestic source for the house which was rented out by the Pleasant Valley Farming Co. This water is not considered potable and drinking water was hauled from Beulah. PVF well No. 2 is presently unused. PVF wells No. 1 and No. 2 will be removed as mining progresses through the area. Because the house will be removed during mining (and not replaced post-mining), mining will not impact the use of wells No. 1 and No. 2.

PVF spring numbers 1, 2 and 3 were piped into adjacent stock water tanks in the past. All three springs are functioning as of this writing; however, they are no longer utilized for stock watering. Since 1986, mining has proceeded through the NW¼ of Section 21 (T.143N, R.88W) northeast of the two wells and three spring sites with no observed impacts. The local groundwater gradient for both the Beulah-Zap and Schoolhouse in this area is from the west and north moving to the south. See Exhibits 2.3.3 and Exhibit 2.3.4. All three springs were certified in 1986 and recertified in the fall of 2005 (Exhibit 2.3.8). Springs 1, 2, and 3 will be impacted by mining as mining progresses South. Because the springs originate from the Beulah-Zap sand, impacts to the springs should be limited to the time in which an open pit is unfilled north of their location. Once the final pit has been reclaimed, the springs should re-establish in the vicinity of their original location based on the post-mine topography. These springs are different than other springs impacted because of mining due to the fact that their source is not coal that is being removed. Likewise, the impacts will be minimal simply because the stock pond located downstream (surface fed) is the major source of water for livestock in the area. The downstream stock pond will not be impacted by mining.

Reich/Unruh Farmsteads [formerly Altavilla/Unruh (Erdman/Neuberger)]

Reich/Unruh well is a deep (Fox Hills), high yield well which provides domestic water for two residences which share this farmstead site. The Unruh well No. 1 is suitable but not a desirable domestic source. This well is not presently utilized.

The Reich/Unruh domestic well is screened within the Fox Hills, far too deep to be affected by mining. The Fox Hills represents the best of several possible replacement sources for any shallower wells impacted by mining.

There are several shallow wells located at both the Reich/Unruh farmsteads, which are used for purposes other than household use. The wells are shallow with depths ranging from 30 to 50 feet. All are screened within the Twin Buttes lignite.

The Twin Buttes bed outcrops in drainage divides in the western part of the county. It reaches a maximum thickness of about 5 feet in T. 143 N. R. 90 W., and in scattered localities north and south of that area (R. A. Brant, 1953). Geologically, the bed is located between 130 and 150 feet above the Beulah Zap lignite. (C.G. Carlson, 1973)

The Twin Buttes lignite is not present within the proposed permit area. The Bed is located up gradient and isolated from mining activities. No adverse effects to the aquifer system from mining are possible.

Weil Farmstead (Sharon Winkler)

Weil well No. 1 is a potential wintertime livestock watering source. The well has a total depth of 382 feet. Well No. 2 is likely screened within the Beulah-Zap lignite. The Weil farmstead is presently not occupied and has not been occupied for nearly twenty years. Pond 87 is located where the Weil slough was located, which was not disturbed by mining. The pond is currently recharged by the Schoolhouse and is a reliable source for livestock watering. Since all of the Weil sites are located up-gradient of mining, no impacts have been observed or are anticipated.

Welk Farmstead

The Welk well is located approximately 1 mile SE of the permit area. The well is screened within the Beulah-Zap coal and is used as a domestic source. No impacts are anticipated due to its location.

Roger Endreson

The Endreson well is located SW of the Welk farmstead. The well is screened within the Beulah-Zap coal and is used as a domestic source. No impacts are anticipated due to its location.

Martha Gunsch Spring

This spring is located in the NW¼ of Section 22 south of the permit area within a minor tributary to Brush Creek. It consists of a concrete spring box piped to a water tank. It appears to be screened in the Schoolhouse lignite. The spring is currently not functioning and is ~~but~~ in need of repair to assess whether or not it could function in the future. This spring will be removed due to mining, but because the spring is not used for stock watering or any other purpose, the impact from mining will not effect its potential use.

R. Gunsch Springs 1 & 2

Spring No. 1 consists of an undeveloped spring feeding a dug-out stock pond located in the SW¼ of Section 28, or approximately 1 mile south of the Permit area. At the time of certification, no free flowing water was observed but the down stream pond was holding water. Impacts to this site are not anticipated due to its location. Spring No. 2 is a developed spring discharging to a minor tributary to Brush Creek. The spring is in good condition with a discharge rate of 1.4 gpm at the time of inspection. This site it is located approximately 1 mile NW of where mining is scheduled to occur between 2008 through 2016 (See Exhibit 3.1.1). Since Spring No.2 is located down-gradient of mining, it is possible this site may be impacted by mining. Alternate groundwater sources are available as a replacement source, if needed.

Gunsch Wells 1 & 2

Well No. 1 is located in the NW¼ of the SW¼, Section 18 approximately 1.5 miles from the western boundary of mining. It is screened within BZ lignite with a total depth of 71 feet. The well produced approximately 15 gpm at the time of certification. Well No. 1 may be impacted by mining; however, due to its location impacts may only be negligible. Alternate groundwater supplies are available if necessary.

Well No. 2 is located in the NW¼ of SW ¼ of Section 7 and is screened in the Beulah-Zap Sand. The well is permitted for 656.5 acre feet to irrigate 125.5 acres at 566.7 gpm. Impacts to this well from mining are not anticipated. The B-Z Sand is recharged from the Knife River alluvial aquifer system.

Gunsch Spring located in SE ¼ of Section 16

Detailed discussions regarding the Gunsch Spring may be found below in Section D, Probable Hydrologic Consequences. Further discussion relating to this spring may be found in Section 3.6 Backfilling and Grading – Special Considerations. In the event the Valley Fill Drainage System fails to provide the necessary quantities for the intended post mining land use at the time of bond release, alternate groundwater sources are available for use at this location.

DWC Monitored Springs

Springs 17ABB-W/SP and 17DAC-W/SP are located in the NE½ of section 17. Both springs are monitored as part of DWC's approved ground water monitoring program under permit KRSB-8603. Spring 17ABB-W/SP is suitable for livestock watering and has a developed concrete watering tank. Spring 17ABB-W/SP has maintained an average flow of approximately 1.2 gpm over the past 25 years. Results of sampling at the spring located at 17ABB reported TDS values ranging from 129 to 4496 mg/l with an average of 1778 mg/l with a sample size of 62. No impacts are expected to this spring from mining. This spring is fed by the Spaer lignite, located below the Beulah-Zap coal bed.

Spring 17DAC-W/SP sporadically produces flow, the last of which was recorded in March of 2000. Alternate water supplies are available for these sites if necessary.

D. PROBABLE HYDROLOGIC CONSEQUENCES

1. General Quality and Quantity Changes

Possible impacts to the surface and groundwater systems within the permit, adjacent and general areas involve the issues of water quality and water quantity. Whereas these systems are highly interdependent, the probable hydrologic consequences for both systems will be addressed together in this section. Other than as noted above, minimal impacts to surface waters of the extended mine plan area are expected to result from the proposed mining activities. This statement is based on mining and hydrologic monitoring experience conducted in the area for over the past forty years.

Pond No. 81 is proposed to remain as a permanent impoundment; likewise, Pond No. 86 will be removed during final mine reclamation. Because Pond No. 81 is located in the upper reaches of its respective drainage basins and intercepts only a small portion of the receiving basins total runoff, its effect on the quantity of surface water available downstream following mining will be minimal. Although DWC does not expect spring flow to reestablish to historical quantities, Pond No. 81 has been designed to allow flow-through of spring discharges. Spring flows from the Valley Fill drainage system (Gunsch premining spring located in the SE¼ of Section 16) into pond 86 are currently in a range between 1.0 to 1.5 gpm. Historical data shows an average discharge of between 60 and 70 gpm from this pond system (Pond 86 & 81) over the past 20 years. Although spring flows from the Beulah-Zap coal bed have been mostly eliminated, average flows from the Ponds 86 & 81 remain due mainly to pit dewatering activities discussed below (and, to a lesser extent, the 1 to 1.5 gpm of spoil spring flow). Over the past 10 years of mining in the area, average discharges from pond 81 have increased from 60 gpm in the early 1980's to 70 gpm in the early 2000's. Average conductivity values from Pond 81 are 2337 umhos/cm for the period of 2000 through 2002. Average conductivity values for the receiving stream (Brush Creek) is 2900 umhos/cm at site 15 BBD-W/ST. All other discharges from the West Brush Creek mining area are insignificant (less than 1 gpm average annual flow) due to the low quantity discharged

Spring flows from the Gunsch spring (16ADA-W/SP) have diminished while mining has been, and currently is, occurring in the immediate area. Thus, pre-mining water levels are not expected to re-establish to pre-mining levels as discussed below. Currently, groundwater originated from the south, and discharges into the Red Pit. The groundwater is then intercepted and pumped to the 86 and 81 pond system. Discharge quantities from Pond 81 (NDPDES discharge point 081) over the past 18 months average 40 gpm, excluding water used for dust suppression. Due to the limited drainage area above Pond 86 & 81, most of this flow is intercepted groundwater from the Red Pit.

After mining in the West Brush Creek area is completed, a small percentage of the groundwater emerging from south of the Red Pit (up gradient), will migrate through the spoils and will eventually reach the springs located down gradient, i.e. the Valley Fill drainage system. The remaining, larger portion of the groundwater will infiltrate through the spoil material into the Spaer coal bed aquifer. Groundwater levels within the spoils will be less variable than observed in the lignite due to a relatively consistent texture of the spoil materials versus the fractured nature of the lignite. Most wells within both lignite seams are either dry or contain little groundwater prior to mining.

Regarding groundwater quantity, in summary, DWC expects flows to increase in relation to current spring flows (1 to 1.5 gpm), but decrease in relation to pre-mining flows (60 to 70 gpm). DWC does not expect flows to return to pre-mining levels.

Regarding groundwater quality, studies at other mines in North Dakota (Groenewold, et al., 1983) indicate that water levels in the spoils approach pre-mining levels within a few years after mining and that these resulting spoils aquifers show a range of hydraulic conductivities similar to the coal aquifers in the pre-mining setting. The Company's experience at the Beulah Mine (KRSB-8802) indicates that water quality in the spoils was found to be approximately 2 to 3 times as mineralized as prior to mining and enriched in sodium and sulfate. (Refer to the PHC section, Permit KRSB-8802.)

Due to both the decrease in groundwater quantity, and the expected increase of mineralized post-mining groundwater quality, DWC will replace the pre-mining Gunsch spring with a well in the SE¼ of Section 16; likewise, DWC will replace a well in the N1/2 of Section 16 to provide a source of water for livestock watering. Wells installed in an aquifer below mining disturbance will provide the most viable source of water for livestock. As mentioned on page 2.3.1, the Upper Hell Creek and Lower Cannonball-Ludlow Aquifer is the next hydrostratigraphic unit whose transmissivity values make it capable of supporting wells when tapped. However, DWC is not aware of any wells within the area that are drilled into this aquifer. This, coupled with the fact that there are wells drilled down to the Fox Hills Aquifer in this region [Reich Farmstead (see Table 2.3.3) – 1450' ; Dale Neuberger residence (NE1/4, Section 8 T143NR87W) – 1455'], suggest that this aquifer is the most likely hydrostatigraphic unit that will be used to replace the pre-mining Gunsch spring. The Reich Farmstead well was sampled for quality during a round of well recertifications in October 2005. Exhibit 2.3.8 contains the lab analysis (titled M & S Altavilla) of the sample taken from this Fox Hills well. Immediately following this analysis is a page listing the constituents measured and parameter levels needed to meet U.S. Public Health Service Drinking Water Standards. It also displays the North Dakota State Health Department's Classification System relating to those same constituents. All the well sample constituents, with the exception of TDS (1300 mg/l), are well below the USPHS drinking water standard limits. The 1300 mg/l is shown as being within the Average range in the NDSDOH Classification System. For livestock consumption, TDS levels below 3000 mg/l are considered satisfactory (Boyles, 1988). Wells tapped into the Fox Hills aquifer are also capable of meeting production (quantity) requirements for human and livestock consumption. Most well owners limit their well flows to 5 to 10 gpm. Fox Hills wells generally flow at unrestricted rates of 10 to 25 gpm (Croft, 1973).

In June of 1979, the Beulah Mine drilled two wells in coal that were never mined (outcrop coal). These two wells represent baseline wells that are used to compare pre-mining and post-mining groundwater quality. In August 1984 the Beulah Mine installed four base-of-spoils wells to monitor spoil water quality after coal extraction. These four wells represent post-mining wells used to compare water quality and static water levels in the spoils, versus pre-mining water quality and static water levels. Exhibit 2.3.9 presents the water quality analyses for the two baseline wells (929 and 930), and the four base-of-spoil wells (1352, 1354, 1355 and 1357). By comparing the baseline wells to the base-of-spoil wells, the data supports the conclusion that the post-mining water quality will be approximately 2 to 3 times more mineralized than the pre-mining water quality. Three of these four wells however, show enrichment in Ca and Mg relative to Na, as well as elevated SO4 levels.

When reviewing the historical data from baseline well 930, it appears as though the first two readings of TDS concentrations are skewed high due to drilling. In some instances after drilling, TDS readings are artificially high from downhole disturbance related to the drilling process.

2. Pit Water Inflows

The following discussion was an attempt to predict initial pit in-flows using analytical methods written in 1986. The final predicted results of inflows have proven quite reasonable based on observed flows since 1986.

McWhorter (1982, pgs 60-66) presents an analytical solution which allows the calculation of inflows to the first cut and to the extent to which the potentiometric surface is lowered in affected aquifers, for the case where a surface mine is initiated by a box cut into aquifer materials, which extend laterally to great distances from the area to be mined.

This solution is applicable to the N-S box cut proposed in this permit and its attendant hydrologic impacts; analysis of those impacts based on the results of pre-mining hydrology investigations is presented below:

The discharge to one side of the pit is given by;

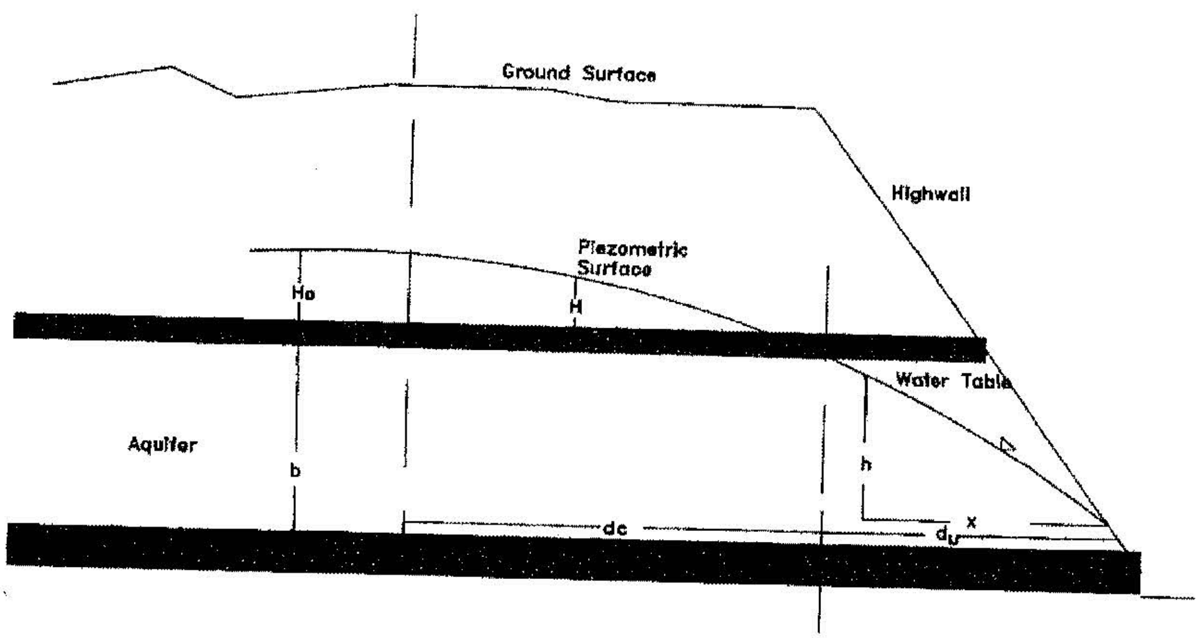
$$Q = 2R \quad \frac{S_{ya}\ Tb^2}{12} + \frac{STH_O^2}{4} \quad ½\, t^{½},\ t \leq \frac{L}{R} \qquad (1)$$

which holds for all times during the advancement of the pit (i.e., for $t \leq L/R$, where L is the maximum length of the pit).

Figure 2.3.1 is a definition sketch for this analytical solution, and the terms defined therein and in equation (1) are:

S_{ya} = apparent specific yield
S = storage coefficient (storativity)
b = aquifer thickness (saturated)
H = height of water table above floor of aquifer
H_O = piezometer height above top of aquifer
d_U = extent of unconfined zone
d_C = distance between the boundary of the confined and unconfined zones and the point at which $H = H_O$
R = average rate of pit advancement
T = transmissivity
L = maximum length of pit
Q = total discharge to the pit
t = time since initiation of pit

Figure 2.3.1
Definition Sketch for Flow to Box Cut Pit



a. Flows To Box Cut Pit

Inflows to the box cut pit are expected from both the Beulah-Zap and Schoolhouse beds. Because field data indicates that both coals contain significantly more water at the south end of the pit, flows for the southern one-third and northern two-thirds of the pit are calculated separately.

Aquifer parameters and other terms used in this calculation are as follows:

S_{ya} = 0.1
b = Beulah-Zap N2/3:0.6m,S1/3:2.3m — Schoolhouse N2/3:0.6m,S1/3:1.2m
R = 15 m·day^{-1}

T_1 = Beulah-Zap North $1.8 \times 10^{-7}\ m^2 \cdot s^{-1}$
T_2 = Beulah-Zap South $6.9 \times 10^{-7}\ m^2 \cdot s^{-1}$
T_3 = Schoolhouse North $6.6 \times 10^{-7}\ m^2 \cdot s^{-1}$
T_4 = Schoolhouse South $1.3 \times 10^{-6}\ m^2 \cdot s^{-1}$
L_1 = North 2/3 975m
L_2 = South 2/3 488m

Maximum discharge will occur at $t = \frac{L}{R}$ therefore from equation (1)

$$Q_1 = 2R \frac{S_{ya}\ Tb^2}{12} \quad \tfrac{1}{2} t^{1/2} \quad \text{for } H_O = O$$

$$Q_1 = 2 \cdot 15\ m \cdot day^{-1} \quad 0.1\ 1.8 \times 10^{-7}\ m^2\ s^{-1}\ (0.6m)^2 \quad \tfrac{1}{2} \quad 65\ days^{1/2}$$

$$Q_1 = 2\ m^3 \cdot day^{-1} \quad \text{(Beulah-Zap North)}$$

Calculations for Q_2, Q_3 and Q_4 are performed in a similar manner using the appropriate numbers yielding: $Q_2 = 50\ m^3 \cdot day^{-1}$ (Beulah-Zap South)
$Q_3 = 3\ m^3 \cdot day^{-1}$ (Beulah-Zap North)
$Q_4 = 36\ m^3 \cdot day^{-1}$ (Beulah-Zap South)

Total inflow for one side of the pit therefore equals $91 m^3 \cdot day^{-1}$, and for both sides equals $182 m^3 \cdot day^{-1}$ or 33 gpm.

E. GROUND WATER MONITORING PLAN

Figures 2.3.2 through 2.3.11 are Piper trilinear chemistry plots for wells historically monitored for ground water quality. With the exception of wells 1359 and 1443, these wells show virtually no water quality variation since monitoring was begun in 1985. Revised Exhibit 2.3.6 contains the complete water quality analyses for these wells for the period of record. Groundwater levels and quality will be monitored according to the schedule presented in Table 2.3.4. Water levels will be measured quarterly and reported to the Commission by the end of the month following the close of the quarter. In the event that severe climatic conditions, which prevent access for water level measurement persist throughout the quarter, documentation to this effect will be submitted along with the quarterly report.

Revision No. 22 will implement the following changes to the monitoring program. Eight of the nine new wells mentioned earlier in the narrative of Section 2.3.B will supplement the documentation of the effects mining has on the three lignite beds in this permit. Wells 2022, 2025, and 2028 will be added to the Schoolhouse bed wells; 2021, 2024, and 2027 to the Beulah-Zap wells; 2020, 2023, and 2026 to the Spaer wells.

The current active wells to document the effects of mining on the Beulah-Zap bed are: 959, 1358, 1359, 1441, 1445, 1528, 1732, 2001, 2003, 2004, 2005, 2006, 2007, 2009, 2010, 2011, and 2013. The Schoolhouse bed will continue to be monitored by current active wells 1394 and 2002. The current Spaer bed wells are 1526, 1527, 1731, 2008, 2012, and 2014.

Water quality samples will be collected annually and analyzed according to the schedule outlined above for the parameters required by NDAC 69-05.2-08-06.e. The analytical results will be reported to the Commission by the end of the month following the sampling quarter. Those wells which produce sufficient water are sampled using a dedicated WaTerra sampling system. Prior to sampling, approximately three well volumes are removed. The non-pumping wells are evacuated with a bailer, allowed to recover overnight and sampled the following day. Because of water level fluctuations, some of the wells scheduled for sampling contain insufficient water to allow for collection of a representative sample. When this occurs it will be specifically stated in the quarterly monitoring report.

As mining progresses, some of the monitoring wells will be destroyed and additional base-of-spoils wells will be installed as close as possible to previous monitoring well locations and added to the monitoring program. DWC submits an annual Ground Water Monitoring Performance Standard Report each year as required by NDAC 69-05.2-16-14(3). This report includes a listing of all the monitoring wells which were mined through, destroyed, abandoned due to casing or grout failure, or lost by any other means during the previous year. Within this report, recommendations will be presented for replacement of wells deemed unusable. The groundwater monitoring plan contained herein will be updated as needed by a permit revision at the midterm review and prior to renewal.

Exhibit 2.3.1 depicts the locations of the groundwater monitoring wells. It is not intended that this map represent all wells, but only those wells in the approved monitoring program. The wells in the approved monitoring program are listed in Table 2.3.4.

Prior to abandonment, these wells will be cut off below plow depth and filled with grout by a North Dakota certified monitoring well contractor. All test holes drilled to date have been reclaimed by plugging potential aquifer zones with coarse bentonite. Any monitoring wells subsequently drilled within the permit area which will not be disturbed by mining will be reclaimed to those same standards.

Exhibit 2.3.7 also depicts two springs that are monitored annually for water quality and quantity. Water quality and quantity results from the two springs can be found in Exhibit 2.2.4 and Exhibit 2.2.8. Spring sites will be sampled in the fall during low flow, which should be worst case.

Table 2.3.4
Groundwater Monitoring Plan

Well/Spring Number	Quarterly Water Levels	Water Quality	Screened Bed
949	X		Brush Creek Alluvium
951	X		Sand below B-Z
953	X		Hazen B
957	X		Sand below B-Z
959	X		B-Z
1009	X		Spaer Sand below B-Z
1358	X	X	B-Z
1359	X	X	B-Z
~~1360~~	~~X~~	~~X~~	~~B-Z~~
1394	X		SCH
1441	X	X	B-Z
1445	X		B-Z
1514	X		Hazen B
1526	X	X	Spaer
1527	X	X	Spaer
1528	X		B-Z
1731 replacement	X	X	Spaer
1732 replacement	X	X	B-Z
2001	X	X	B-Z
2002	X	X	SCH
~~2003~~	~~X~~	~~X~~	~~B-Z~~
~~2004~~	~~X~~	~~X~~	~~B-Z~~
2005	X		B-Z
2006	X		B-Z
2007	X		B-Z
2008	X		Spaer
2009	X		B-Z
2010	X		B-Z
2011	X		B-Z

2012	X	X	Spaer
2013	X		B-Z
2014	X		Spaer
2020	X	X	Spaer
2021	X	X	B-Z
2022	X	X	SCH
2023	X	X	Spaer
2024	X	X	B-Z
2025	X	X	SCH
2026	X	X	Spaer
2027	X	X	B-Z
2028	X	X	SCH
2029	X	X	Spoil
17ABB-W/SP	N/A (Spring)	X	Spaer
17DAC-W/SP	N/A (Spring)	X	B-Z

F. INTERPRETATIONS RELATED TO COYOTE CREEK STREAM VALLEY

Coal removal within the permit area is usually restricted to the Beulah-Zap bed in most locations because it is the only seam considered commercially recoverable due to adequate thickness and quality. The approximate disturbance boundary for mining activities is displayed on Exhibit 1. The Schoolhouse bed will likely only be removed in any quantity from the southeastern extent of the permit area. One or both of these potential aquifers may outcrop within or near the southern permit boundary in Sections 19 and 20. Several springs and seeps in this vicinity feed tributaries to the tributary to Coyote Creek that flows westward through these sections. Flows in this tributary have been observed to vanish in mid to late summer in recent years; no groundwater flow has been observed entering the stock pond in the SW¼ of Section 20 during several surveys of the area conducted during these periods.

Flow direction in the Schoolhouse and Beulah-Zap coal beds has been characterized as easterly to northeasterly, although difficult to define precisely in some portions of the permit. Flow generally appears to be away from Coyote Creek. Flow in the Spaer bed that emanates from a high in the center of Section 20 is apparently directed west and north, in the general direction of Coyote Creek and eastward toward the Brush Creek area. Mining of the Beulah-Zap bed in the NE¼ of Section 19 and in Section 20 will remove springs in these areas. The flows contributed by these springs is relatively minor and water quality is poor because of high specific conductivity (salinity). The receiving tributary often dries up in mid to late summer and any flow enters Coyote Creek downstream of almost all of the agricultural fields in the study area.

Little is known about the specific geology and groundwater flow characteristics of the Coyote Creek stream valley. Croft (1973) estimated that the sandy silt and clay alluvium of Elm Creek in southwest Mercer County, a few miles southwest of Coyote Creek, at up to 40 feet thick. The depth of the sandy silt and clay alluvium of Goodman Creek in northwest Mercer County was estimated at 38 feet, based on a single sample. With a watershed of similar size, the alluvial thickness of the Brush Creek stream valley could reasonably be assumed to have a similar range. Absent data on potentiometric surfaces within the valley, we assume that groundwater flow is directed toward the Knife River.

In the reclaimed landscape, rejuvenation of groundwater supplies in the manner predicted for the Brush Creek area is expected. Re-establishment of pre-mining water levels in the graded spoils is expected after a few years. The Pleasant Valley Springs along the east quarterline of Section 20 are expected to return as well. Recharge to the Spaer coal bed will resume in time as groundwater works its way down through the spoil fill and undisturbed overburden.

As a result, the relatively minor current spring flow contributions to Coyote Creek are expected to return. Reshaping of the postmining surface will resemble premining conditions, allowing surface flows to return.

3. SOILS

The predominant soil map units occupying the agricultural fields of the Coyote Creek AVF Study Area are Shambo loam (map symbol 40), Straw silt loam (51), channeled Straw soils (67), and Straw loam (91). The locations and general information of these and other soils in the study area can be found in Exhibit 4A. Exhibit 4B has soil map unit descriptions. Straw loam is the principal soil found in the flood plain agricultural fields of the study area. Gradients range up to 2 percent and natural flooding may occur rarely for brief periods. Flood irrigation is constrained by the erodibility of constructed terraces and diversions. Locations in the study area contain oxbows, sloping areas greater than 2 percent, and a small amount of terraces.

The channeled Straw soils comprise the next largest proportion of the study area soils, but have limited current or potential agricultural use because of slopes, woody development, flood debris deposition, and small acreages of arable area. The Straw silt loam is found on about 2 percent of the area of interest defined on Exhibit 4A. This soil is suitable for irrigation, but erodibility of terraces and diversions is a concern. Most of this unit has a land use of native grassland and its single location is transgressed by Coyote Creek. A minor portion is cropped annually, but stream terraces and oxbow depressions exist in both small fields. Present in the smallest proportion, the Shambo loam is currently used primarily for cropland and hayland. Oxbow depressions punctuate portions of the cropland. This map unit has the most favorable qualities for irrigation.

4. LAND USE AND VEGETATION

Land uses in the study area consist of native grassland (including the Coyote Creek channel), cropland, hayland, and tame pastureland in descending order when considering areal coverage. Other land uses such as woodlands, wetlands, and shelterbelts have not been segregated from these primary uses, which are displayed on Exhibit 5. Native grassland is the predominant land use within the study area. Approximately 350 acres of native grassland are found in the study area. It appears that all of the native grassland is grazed annually, probably seasonlong, although use is probably reduced in the NW¼ of Section 24. Grazing paddocks include both the valley floor and adjoining uplands. The composition of the native grassland has been somewhat tainted by introduced grasses in the vicinity of the creek. The 89 acres of hayland is composed of alfalfa and appears to be under an annual harvesting routine. The 83 acres of cropland show evidence of rotation between grain and row crops. The tame pastureland (38 acres) is dominated by tamegrasses, probably smooth bromegrass or a close relative.

5. IRRIGATION

A. EXISTING FLOOD IRRIGATION

Artificial flood irrigation is currently not practiced within the study area. Conversations with the agricultural producer involved in cropping the fields in the study area confirmed that flood irrigation was not practiced. The local office of the Natural Resources Conservation Service was queried on irrigation occurring in Mercer County. The county Soil Conservationist reports that a few surface irrigation systems are established in the north and east reaches of the county in close proximity to Lake Sakakawea, Knife River, and the Missouri River, but they were not aware of any systems on Coyote Creek or other such stream valleys to the south of the Knife River.

Natural flood irrigation occasionally occurs in portions of the study area; the major flooding that occurred in April 2009 is ample evidence. However, even the exceptionally high water levels did not cover all portions of the agricultural fields. Woody debris ranging up to tree trunk dimensions was scattered over fields, silt was deposited in low lying areas and downstream-facing slopes, and sheet washing resulted in the pedestaling of perennial crop plants and wholesale surface soil loss in many areas. Given the magnitude of this year's flood, it appears that most floods would transcend too little acreage too rarely to benefit the agricultural operations in the floodplain. Large floods akin to this year's may actually have a negative effect by reducing crop yields as a result of soil loss in some locations and sedimentation in others.

B. FLOOD IRRIGATION POTENTIAL

1. Soils Potential

The preceding Soils section described the soils present in the agricultural fields of the study area. The Shambo and Straw soil map units generally possess few inherent chemical or physical limitations to the application of flood irrigation. If terraces or diversions are employed in a flood irrigation system, the erodibility of the Straw soils can be problematic.

2. Water Quantity

Flow data for Coyote Creek is limited. Streamflow data was gathered by the U.S. Geological Survey from October 1977 through the end of 1983 (USGS, 2009) on the east side of the county road bridge in Section 13. Excluding the 1982 flows which exceeded all other years by a multiple of at least four, average streamflow for June was 1.72 cubic feet per second (cfs) and July registered 1.14 cfs. These rates would provide roughly 102 and 70 acre-feet of water for June and July respectively. If 83 acres of irrigable cropland are assumed, capture of half of the streamflow in June and July would be necessary to provide an acre-foot of flood irrigation water in an "average" year. In 1978, July flows would have provided roughly 6 inches of water for the cropland acreage if the entire flow was utilized. Two years later, no flow existed for the month of July.

Generally speaking, the greatly reduced flows present on such streams after the conclusion of spring runoff requires that water storage be accomplished by damming the stream or pumping to a storage facility in the floodplain in order to provide an ample volume of water when needed. Damming is an unlikely option and there are no impoundments present in or near the study area agricultural fields that could be utilized for storage. Impoundment construction or modification of existing natural features to store water pumped water is not likely due to expense and area limitations.

3. Water Quality

The amounts of soluble salts and sodium in water are of primary concern when the quality of irrigation water is considered. Salt content is commonly measured by determining electrical (specific) conductivity (EC) or total dissolved solids (TDS) content. Excessive salt content results in a physiological drought condition whereby plants are unable to extract sufficient water from the soil even though saturated conditions may exist. Sodium content is measured in relation to the concentrations of calcium and magnesium ions and expressed as the sodium adsorption ratio (SAR). High SAR water brings about structural changes to the soil, decreasing permeability and resulting in physical drought conditions. Analysis of water samples will focus on EC and SAR levels.

The tributary to Coyote Creek that coalesces with Coyote Creek near the middle of Section 19 was sampled at a point in the SE¼ of Section 20-143-88 in May 2008 to determine water quality in this perennial drainageway. EC was measured at 4,777 µmhos/cm and SAR at 6.60. A couple hundred yards to the northwest of the tributary sampling site lies the outcrop of the three Pleasant Valley springs that empty into the tributary a little further downstream. When sampled in the fall of 2005, the electrical conductivity of water from the three springs in this area all had levels of 2,200 µmhos/cm or greater, equating to high to very high salinity levels. Based on the criteria in the following table, tributary water quality has salinity levels that render it's utility doubtful, if not unsuitable. This information can be useful when evaluating the consequences of mining that will disturb this area within a few years.

Coyote Creek water was sampled in mid-May of this year at the county road bridge. Specific conductance of the single sample came in at 1,784 µmhos/cm. Snowmelt runoff had concluded prior to sampling and all flow is assumed to have a groundwater discharge origin.

Many authorities agree that water with high salinity levels (≥2,000 µmhos) should not be used continuously on soils with restricted drainage. Use should be sporadic – one year in several. Water with very high salinity is limited to special crops under special management. Coyote Creek water has a conductivity level classifying use as "permissible", but leaching would be necessary. Conductivity in the Coyote Creek sample is approaching the conductivity level of 2,000 µmhos/cm – a level at which these restrictions begin to come into play.

Table 3.1 Suggested criteria for irrigation water use based upon conductivity.

Classes of water	Electrical Conductivity (dS/m)*
Class 1, Excellent	≤0.25
Class 2, Good	0.25 - 0.75
Class 3, Permissible[1]	0.76 - 2.00
Class 4, Doubtful[2]	2.01 - 3.00
Class 5, Unsuitable[2]	≥3.00

*dS/m at 25°C = mmhos/cm, 1,000 µmhos = 1mmhos
[1]Leaching needed if used.
[2]Good drainage needed and sensitive plants will have difficulty obtaining stands.

The sodium hazard of the tributary water is low. In the case of the three springs, sodium adsorption ratios of 7.39, 8.88, and 15.6 translating to a low to medium sodium hazard for all springs. The May 2009 Coyote Creek sample had an SAR of 5.74, classified as a low sodium hazard.

Table 3.2 General classification of water sodium hazard based on SAR values.

SAR values	Sodium hazard of water	Comments
1-9	Low	Use on sodium sensitive crops must be cautioned.
10-17	Medium	Amendments (such as gypsum) and leaching needed.
18-25	High	Generally unsuitable for continuous use.
≥26	Very High	Generally unsuitable for use.

Tables from Colorado State University Cooperative Extension Bulletin No. 0.506

4. Irrigable Acreage

Flood irrigation on the Coyote Creek stream valley floodplain has many impediments. Flood irrigation common to the region typically involves supplying water to canals bordering fields. It is often necessary to pump the water into the canals, wherefrom the water is distributed to fields where gentle slopes at up to roughly 2 percent carry water downslope. Water may flow into furrows or across level terrain bounded by boundary berms to constrain and direct flows. Flood irrigation fields often require precision grading and careful management of fields and water application. Large fields are usually necessary to realize benefits, even with high value crops.

The characteristics of the study area fields, whether annual or perennial crops exist, argue against the use of flood irrigation. Oxbow lakes and/or truncated meanders exist in all fields, severely restricting water distribution uniformity. Slopes can exceed the optimal gradient, and are sometimes complex. The configuration and topography of most fields would require construction of an irrigation canal through the field, eliminating potential production acres. Unlike most flood-irrigated fields in locations like the Yellowstone River valley of eastern Montana, the perimeter of most study area fields is very irregular, posing additional challenges related to water distribution. All single field acreages within study area boundaries are roughly 60 acres or smaller. Given the fragmentation of these generally small fields by surface features that limit pragmatic flood irrigation, along with other limitations involving soils and configuration, the lack of present-day flood irrigation systems is understandable.

5. Flood Irrigation History and Regional Practices

In 2007, there were only 2,348 irrigated acres in Mercer County (2007 Census of Agriculture). This was a modest increase from the 1,676 acres irrigated in 2002. Only 22 Mercer County farms harvested irrigated crops in 2007 and almost 90 percent of the harvested acreage was represented by 16 farms with a cropping acreage of 500 acres or more on each farm. It is likely that the vast majority of these farms capitalized on water resources available in the broad floodplains of the Knife River and Missouri River. Irrigated acres were reported for only four farms cropping 100 acres or less.

There is no anthropomorphic evidence that flood irrigation has been practiced in the study area. Neither the current landowner or Mercer County Soil Conservationist are aware of any instances of historic flood irrigation. As previously reported, stream valleys like Coyote Creek typically are not developed for flood irrigation purposes, especially in areas within Mercer County south of the Knife River.

C. EXISTING SUBIRRIGATION

Subirrigation is defined by the CFR as *the supplying of water to plants from underneath or from a semi-saturated or saturated zone where water is available for use by vegetation* (30 CFR 701.5). The Office of Surface Mining's guidelines for Alluvial Valley Floor Identification and Study Guidelines states that the focus of the potential influence of subirrigation on stream valley vegetation should be on agricultural plants, since they play a significant role in determining the value of agriculture in the Coyote Creek valley.

Some insights into the quality and levels of groundwater and the potential for subirrigation in the Coyote Creek stream valley can be gained from the groundwater studies conducted by Croft (1970). The studies contain data for two wells in the area of the farmstead in the S½ of Section 31, now occupied by Casey Voigt. One well had a depth of 22 feet and reported a water level at 16 feet below ground level. Electrical conductivity of this stock well was

2,500 µmhos/cm. A nearby domestic service well with a depth of 20 feet expressed a water level of 18 feet and an EC of 2,200 µmhos/cm.

The static water depths in the Voigt wells correspond to recently observed levels of the Coyote Creek soon after the passage of flood stage flows caused by snowmelt runoff. It is assumed that Coyote Creek influences the stream valley water table in the same manner as observed with Brush Creek, i.e., water table levels reflect nearby stream levels. The elevation of creek flows in mid-May of this year was estimated to be at least 12 feet below the lowest adjacent fields and roughly 20 feet below the highest fields. The landowner has also reported well water levels at 15-20 feet. Root systems of the annual crops and forage grasses grown in Sections 19, 30, and 31 typically would not tap water resources at such depths to significantly increase yields, nor would rangeland plants subjected to grazing.

The floodplain of Coyote Creek was walked in the spring of 2009 to determine the abundance of phreatophytic plant species – those plants that like to have their feet in water. These plants are particularly useful as an indicator of subirrigation conditions. Habitats such as streambanks, terraces adjacent to the creek, and oxbows received concerted attention due to their closer proximity to the water table, which would enable enterprising phreatophytes to take advantage of any subirrigation potential. Populations of plant species such as prairie cordgrass (Spartina pectinata), willows (Salix spp.), and cottonwood and aspen (Populus spp.) were keyed on because they are considered among the most reliable indicators of significant subirrigation. No phreatophyte communities, or even individuals, were noted during surveys, suggesting that the depth to the water table was too great for these plants to profit. Generally speaking, riparian woodland growth was present in these areas, but extensive, dense woodland growth was not found. The banks and most adjacent low-lying areas of Coyote Creek are densely covered by smooth bromegrass and punctuated by individuals and small colonies of woody species such as chokecherry, box elder, American elm, and green ash. Grazing of much of the floodplain and a deeply incised streambed are no doubt contributors to this condition. The lack of phreatophytes in the low-lying landforms investigated strongly suggests that subirrigation is not contributing to any increased yields for agricultural crops, most of which are grown at slightly higher elevations in the floodplain.

Following the direction of the OSM guidelines, the other plant group that received attention was the agricultural field crop group. The assessment of field crops was limited to observations of early growth alfalfa and tamegrass in the hay and tame pastureland fields respectively. Standing crop (production), plant densities, and vigor were visually assessed by walking across sections of fields. The appearance of alfalfa was considered particularly important due to its deep-rooted morphology. Surveys revealed that those plants nearest to the creek which should have the best access to subirrigation were, if anything, in poorer condition and/or had poorer population densities than the average plant in the field. The most productive plants were the beneficiaries of additional surface water, not ground water, by virtue of their location in or near the footslope position. Native grassland surveys did not uncover anything contrary to the aforementioned observations. The landowner of lands where the fields reside indicates that yields exceed those on the uplands, but do not appear to be benefitting from subirrigation.

CONCLUSIONS

Based on the information provided, we believe the following conclusions can be drawn:

1. The geologic criterion for alluvial valley floors – streamlaid unconsolidated deposits – is assumed. Stream path configuration and streamload deposition are strong indicators supporting the assumption.

2. Flood irrigation is currently not practiced in the study area or anywhere on Coyote Creek. The following factors enter in to the flood irrigation potential in this location:

   - Water quantity may be limiting in many years.
   - Surface water quality is marginal in terms of salinity; some special mitigating practices such as leaching may be necessary at slightly higher conductivity levels.
   - Fields, sometimes small, contain oxbow depressions, complex and/or steeper slopes, irregular boundaries, and other characteristics militating against the economic feasibility of flood irrigation practices.

3. There is no evidence of historical flood irrigation in the study area or any portion of Coyote Creek. The potential for flood irrigation is considered remote considering the factors previously cited.

4. Subirrigation is not playing a role in enhancement of crop production in the study area. This conclusion is evidenced by a depth to the water table that exceeds 15 feet, absence of phreatophytes, and absence of field crop production enhancement. Further, the water table in the vicinity of the Voigt farmstead has high salinity, limiting the agricultural producer to sporadic use and the implementation of a leaching program.

In summation, these conclusions on the judgment criteria for evaluation of a potential alluvial valley floor lead us to a summary conclusion that the Coyote Creek stream valley does not contain an alluvial valley floor within the study area.

The OSM draft study summarized in the introduction section noted that water availability on streams such as Coyote Creek limits surface irrigation, if it is at all possible, and that natural flood irrigation and subirrigation are important features. The study concluded that portions of higher terraces along Coyote Creek could be flood irrigated by spreading and/or pumping water. We have concluded that the limited water quantity in some years and other factors such as marginal water quality make surface irrigation unlikely. Absence of historical surface irrigation in similar stream valleys in the area also discount consideration of surface irrigation. Another conclusion of the OSM report was that deep-rooting alfalfa probably receives beneficial moisture through subirrigation. Absence of phreatophytes, poor groundwater quality, water table depth exceeding 15 feet, and lack of evidence of plant growth benefitting from additional water provided by subirrigation lead us to conclude that deep-rooted crops such as alfalfa are not being subirrigated.

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EXHIBIT
PSC 9

PUBLIC SERVICE COMMISSION
Reclamation Division
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Memorandum

TO: File

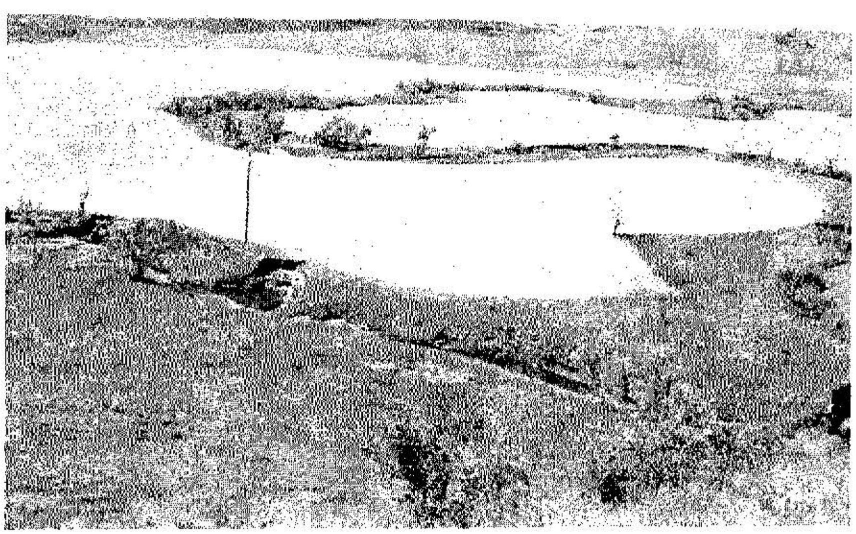
FROM: Dean Moos, Guy Welch, Bill Gunnerson, and Bruce Beechie

DATE: June 15, 2009

SUBJECT: Coyote Creek AVF field investigation

On June 11, 2009 the PSC personnel listed above met with representatives of Dakota Westmoreland Corporation to conduct a field review of potential alluvial valley floor (AVF) areas that lie within the terraces and floodplains delineated in the 2009 Coyote Creek Alluvial Valley Floor Study area. In particular, observations were recorded for areas along Coyote Creek in Sections 19 and 30, T143N, R88W in Mercer County. Areas proposed for mining operations by Dakota Westmoreland Corporation with Revision 22 to Permit KRSB-8603 are located within ¼ mile of the Coyote Creek drainage. Dakota Westmoreland Corporation representatives on site for the field investigation were Greg Smestad and Jeff Frohlich. The field review was conducted between 10:45 a.m. and 1:00 p.m. on June 11, 2009. The skies were clear and the temperature was near 60°F. Access to the study area was good.

General overview of cropland along Coyote Creek, S1/2 of Section 19



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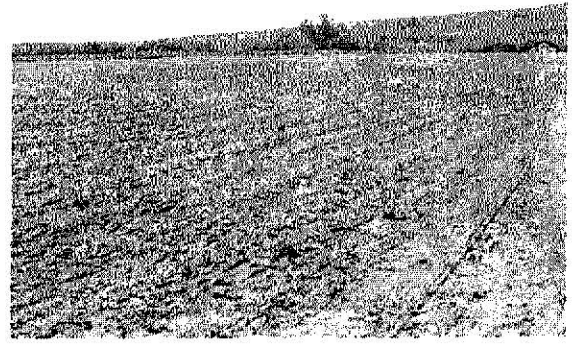
The primary focus of the field investigation was cropland areas adjacent to Coyote Creek in the S1/2 of Section 19 and the N1/2 of Section 30. The areas of cropland adjacent to Coyote Creek are currently seeded to corn and encompass approximately 125 acres of land broken into three distinct tracts. The largest tract is located south and west of Coyote Creek and two smaller tracts separated by an eastern ephemeral tributary drainage to Coyote Creek are located on the north side of the creek. All areas were accessible during the field investigation with vehicular access gained through pasture and cropland trails to the north and the ability to cross Coyote Creek by vehicle in the SW1/4 of Section 19.

Generally, those cropland areas located directly adjacent to Coyote Creek are considered to be within a developed floodplain and assumed to be underlain by alluvial deposits beneath the valley floor. Based on surface topography and soils delineation, the cropland area located south and west of Coyote Creek in the SW1/4 of Section 19 and the NW1/4 of Section 30 appears to be in a transition area from alluvium to residuum. The areas of higher ground and increasing slope gradient to the west and southwest are contained within the larger field that is planted to corn.

Coyote Creek begins as an intermittent stream with headwaters originating in the SW1/4 of Section 28, T141N, R87W about 15 miles southeast of the South Beulah Mine. Coyote Creek gains status from intermittent to perennial within the SE1/4 of Section 31, T142N, R87W. The reach of Coyote Creek that is located within the alluvial valley floor study area and which is the focus of this field investigation is perennial. Generally, Coyote Creek runs in a southeast to northwest direction and its confluence with the master drainage Knife River is located within the NE1/4 of Section 14, T143N, R89W, about 2 ½ miles northwest of the study area.

As mentioned earlier the focus study area is cropland and was seeded to corn approximately 3 weeks previous to the field investigation. The corn is generally at the 3-5 leaf stage and averages about 6 inches in height. Historically, this area has been cropland for as long as landowner Casey Voigt can recall. Evidence of the late March and early April, 2009 spring snow melt flooding event was apparent. Mr. Voigt apparently expended a great deal of time and effort in collecting and disposing of drift wood and other water-borne debris carried by the floodwaters and deposited on the flood plain/valley floor.

Corn crop that was planted approximately 3 weeks prior to field review
Photograph location is the NE1/4 of the SW1/4 of Section 19



Within the study area Coyote Creek is substantially incised and occupies an under-fit drainage system. Coyote Creek is a meandering low-gradient drainage that has formed many oxbows along its course. Remnant or abandoned oxbows have provided utility as cropland on the north side of the creek. The average water depth of Coyote Creek within the study area appeared to be 3-4 feet and the stream was actively flowing. Elevation of the flood plain varied with geographic position compared with the position to Coyote Creek. The flood plain/terrace elevation averaged about 5-8 feet above the surface of the water for areas north of Coyote Creek and the flood plain/terrace elevation averaged about 12-15 feet above the surface of the water for those areas south of Coyote Creek. In the field, the elevation difference between terrace levels south of Coyote Creek and terrace levels north of Coyote Creek is readily visible and marked.

View looking north across Coyote Creek to corn field in the SE1/4 of Section 19
Terrace elevation on north of Coyote Creek averages about 7 feet lower than south side

Soil samples to a depth of approximately 18 inches were excavated by shovel and analyzed at several representative locations throughout the flood plain/cropland portion of the study area. Generally, soils associated with cropped areas were of the Straw loam series that is typical of flood plains, and also the Shambo loam series that is typical of terrace soils. Soils were also analyzed for indications of redox, or reducing/oxidizing conditions associated with subirrigation. No indications of redox or soil mottling were observed in the 6 or so soil samples that were analyzed. Soil stratification indicated evidence of historic flooding events on the flood plain/terrace and indications of recent flooding events were noted for areas immediately adjacent to Coyote Creek with sand and coarser materials dominating the upper soil horizon.

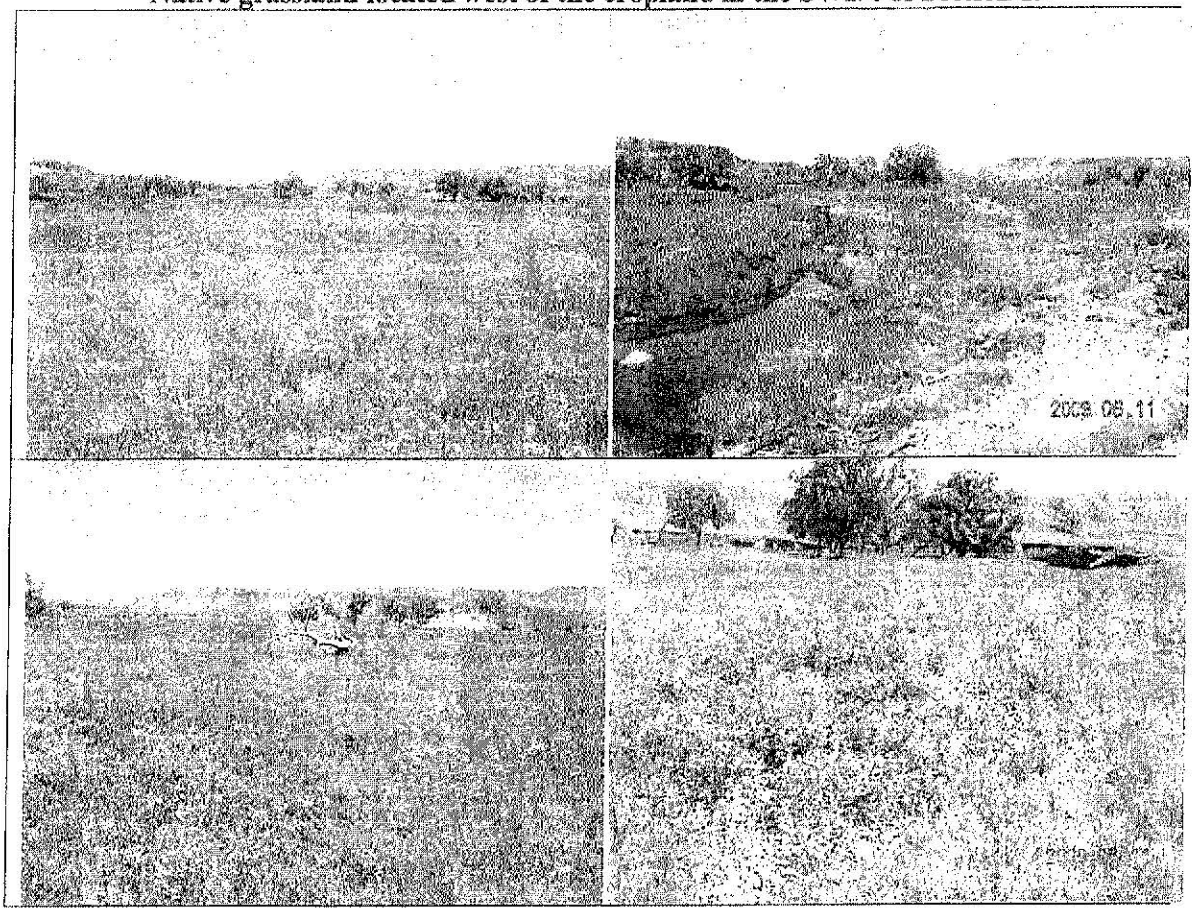
Analyzing soil sample in the NE1/4 of Section 30

A vegetative survey of riparian areas associated with Coyote Creek was conducted along an approximate 2 mile segment of the creek channel and no indications of phreatic or hydrophilic vegetation were observed beyond the creek channel. Phreatophytes with tap roots having the ability to utilize ground water associated with a high water table include cottonwood, saltcedar, willows and various species of rushes. Hydrophyte communities represented by such species as cattails were also not observed. Scattered trees and shrubs along the creek course consisted primarily of Box elder, Green Ash, American elm, peachleaf willow and hawthorn. Secondary drainage ways and grass buffer zones adjacent the cropland field and Coyote Creek were dominated with smooth bromegrass and buck brush.

View to the north of Coyote Creek with an observed water depth of about 3-4 feet. Phreatic vegetation along the creek is essentially non-existent.

The native grassland floodplain terraces adjacent Coyote Creek located west of the cropland fields in the SW1/4 of Section 19 are zeric sites. The upper terraces are dominated with western wheatgrass, blue grama, Prairie junegrass, needle and threadgrass, needleleaf sedge and crested wheatgrass. Forb species present include green sage, dandelions, wild onions, Indian wheat, bastard toadflax, fringed sagewort and penstemon and oxytropis species. The lower terrace or those closest to the creek are dominated with smooth bromegrass, Kentucky bluegrass, western wheatgrass and buckbrush. Cudweed sagewort, common dandelion and scarlet globemallow were some of the forbs present on this site. This terrace is 5-10 feet above the bottom of the channel of Coyote creek and there was evidence that the lower terrace had flooded with snow melt runoff this past spring. Floodwaters deposited soil and an accumulation of smaller rocks or cobbles in places on the floodplain and there was head cutting and scour erosion along the banks of the channel of Coyote Creek.

Native grassland located west of the cropland in the SW1/4 of Section 19



The general consensus at the conclusion of the field review was that those areas adjacent to Coyote Creek that fall within the 2009 study area do not fit the description of an AVF. There are no artificially developed flood irrigation systems in place and sprinkler or drip irrigation systems have not been developed either. Flood irrigation does occur along this portion of Coyote Creek as was recently evidenced, although periods of overbank flooding generally occur during early spring during snow melt events. Spring flood episodes generally provide no benefit to cropland with the possible exception of a temporary addition to subsoil moisture, providing the ground is not frozen at the time of flood. Spring floods normally restrict access to affected crop fields during the early portion of the planting season. No evidence of subirrigation was observed. Mr. Smestad reported that corn is historically the predominant crop raised by the landowner within the study area and Mr. Voigt reported to Mr. Smestad that he felt crop production was generally better within the flood plain along Coyote Creek because of increased soil quality and landform run-on characteristics associated with the terrace topography as opposed to upland areas and not because of ground water availability through subirrigation.

Additional photographs taken during the field review are on file with the Reclamation Division. A GPS track log showing the route traveled is also on file with the Reclamation Division.

R:BEB\reclamation\DWC\KRSB-8603\Coyote Creek AVF\Coyote Creek AVF Investigation Report

Public Service Commission
State of North Dakota

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October 26, 2009

Mr. Jeff P. Frohlich
Manager, Engineering and Environmental
Dakota Westmoreland Corporation
Beulah Mine
P.O. Box 39
Beulah, ND 58523-0039

Dear Mr. Frohlich:

The Reclamation Division has conducted a review of Dakota Westmoreland Corporation's October 15, 2009 response to technical review deficiencies of the Coyote Creek Alluvial Valley Floor Study associated with proposed additional mining areas at the Beulah Mine with Revision No. 22 to Surface Coal Mining and Reclamation Permit KRSB-8603. The responses to technical review deficiencies were deemed adequate.

The Reclamation Division has completed its review and evaluation of the possible presence of alluvial valley floors within the AVF study area. Based upon review of your investigation information, as well as information obtained during a field investigation conducted by several members of the Reclamation Division on June 11, 2009, we have determined that those areas included within the East and West Segment Study Areas, as well as the valley of Coyote Creek within the study area, do not constitute an alluvial valley floor as defined in NDCC 38-14.1-02 and as outlined in NDAC 69-05.2-08-13.

As required by the Reclamation law and rules, please incorporate a copy of this determination into the final version of the application for Revision 22 to Permit KRSB-8603.

If you have any questions, please contact this office.

Sincerely,

James R. Deutsch
Director
Reclamation Division

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Alluvial Valley Floor Evaluation Report
Coyote Creek Mining Company, L.L.C.
Coyote Creek Mine
Mercer County, North Dakota
March, 2013
Revised August, 2013

Prepared by
Dr. David Bickel
Bickel Consulting, LLC
P.O. Box 993
Bismarck, ND 58502

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Evaluation of the Soil Resources as related to Alluvial Valley Floors along a Portion of the Knife River in Mercer County, North Dakota. Mike Ulmer and C.J. Heidt.

Alluvial Valley Floor Evaluation Report
Coyote Creek Mining Company
Coyote Creek Mine
Mercer County, North Dakota

February, 2013

Introduction

Scope and objectives

This report was prepared in accordance with Section 69-05.2-08-13 of the North Dakota Administrative Code. The area of this report includes Sections 3, 4, 5, 6, 7, 8, 9, 16, 17 and 18, T142N, R88W; Sections 1, 2, 3, 4, 9, 10, 11, 12, 13, 14, 15 and 16, T142N, R89W; S½ Section 3, S½ Section 4, S½ Section 5, S½ Section 6, Sections 7 and 8, portions of W½, NE¼ Section 9, NW¼ Section 10 and N½ Section 16 defined by an irregular boundary around the valley of Brush Creek as drawn by the Reclamation Division of the North Dakota Public Service Commission (PSC), portions of NW¼ Section 16, N½ Sections 17 and 18 excluding permitted areas of KRSB-8603, Sections 32, 33, 34 and 35, T143N, R88W; S½ Section 1, SE¼ Section 2, E½ Section 11, Section 12, N½ Section 13, N½, SW¼ Section 14, Section 15, E½ Section 16, Sections 20, 21, 22, 23, SW½ (diagonal) Section 24, Sections 25, 26, 27, 28, 29, 32, 33, 34, 35 and 36, T143N, R89W, Mercer County, North Dakota (Exhibit A). The report area, while contiguous, represents two tracts in terms of future development. The northeast area encompasses possible haulroad routes around existing permitted acreage of the Dakota Westmorland Corporation's Beulah Mine. Coal removal is not planned for this tract or the possible haulroad corridor. Both report segments are adjacent to areas that have received prior Alluvial Valley Floor (AVF) determinations associated with mining permit approval findings for the Beulah Mine. The present study area and previously determined areas provide continuous coverage of AVF evaluation over the area of existing mining, proposed new mining, and likely future permitting as shown in Exhibit A. These AVF study area boundaries shown in Exhibit A were reviewed on two separate occasions prior to report preparation, modified to required specifications and finally agreed to with Reclamation Division staff.

The report is based on existing information available in published work, approved mining permits, and related data in the public domain from the surface mining reclamation and regulatory process. However, observations made by environmental professionals involved in the acquisition of baseline data for future Coyote Creek Mining Company permit applications are incorporated and attributed to the individuals where appropriate. Preliminary observations from baseline data acquisition for other aspects of mine permitting are occasionally referred to and are noted as such.

The record of Alluvial Valley Floor evaluation, reporting and PSC findings at the Beulah Mine is somewhat unclear because AVF studies, permits and permit findings documents in early work usually focused on named streams in or adjacent to proposed permit areas and often omitted comprehensive references to areas covered by the studies or determinations. Revision 22 of Dakota Westmoreland Corporation mining permit KRSB-8603 provides a review to help clarify the history of AVF studies for the Beulah Mine. Exhibit A outlines those areas covered by previous AVF studies based on information in the approved Beulah Mine permits and their findings documents. There is some overlap among these areas and the present study. The proper language concerning AVF is present in all findings documents for awarded permits for the Beulah Mine, and permitted acreage must be considered evaluated for AVF potential. Inspection of available aerial photography and other data presented here confirm that all of the previously studied and determined areas as outlined in Exhibit A are not AVF.

This study accepts existing findings in several Beulah Mine permits that the valleys of Coyote Creek, Brush Creek, short segments of the Knife River floodplain traversed by these creeks, and the Main Drainage traversing eastern portions of Beulah Mine are not AVF. This study addresses the AVF status of the Knife River drainage within the present study area. While not directly addressing the determined status of previously studied adjacent areas, this report will provide additional evaluation of existing data that supports these findings.

The OSM Guidelines state that geologic, geomorphic and water resources criteria form the regulatory definition of an AVF. An AVF must be an area with water availability sufficient for subirrigation or flood irrigation to support agricultural activities. They go on to clarify the meaning of water availability (*OSM Guidelines, p. II-9)* by stating that the water availability criteria are met if:

> (a) water is available by surface-water irrigation or subirrigation and is being or has successfully been used to enhance production of agriculturally useful vegetation; or
>
> (b) surface water is available in sufficient quantities to support agricultural activities.

Item (b) could be seen as suggesting that agricultural activities mean the entire range of rural water supply needs including household use and livestock watering. However, in spite of very broad technical summarization in many sections of *The OSM Guidelines*, nowhere is it implied or stated that uses of surface water supplies other than for enhancing crop production serve to meet the AVF criterion. Thus, this item refers to supporting plant productivity. Irrigation with ground water, even if located on a stream floodplain, does not make the stream reach an AVF.

Previous Studies and Findings

Late in 1985, Knife River Coal Mining Company submitted a study to the Reclamation Division of the Public Service Commission (PSC) demonstrating that the valley of Brush Creek was not an AVF. On November 20, 1985, the PSC issued a determination that the Brush Creek valley is not an AVF. Confusion about the AVF concept and the power of the 1985 OSMRE draft reconnaissance map, *Draft Reconnaissance Maps to Assist in Identifying Alluvial Valley Floors West-central North Dakota, OSM/TM-3/85*,

(Exhibit B) probably contributed to the status of the Knife River valley not being addressed in the earliest Knife River Coal report other than to note that it is a potential AVF.

The 1985 OSMRE reconnaissance map has been subsequently found to have numerous false positive AVF areas indicating AVF potential where it does not exist. However, the report recognized correctly the deeply incised channel and lack of AVF potential of the Knife River valley from Elm Creek to Spring Creek. Elm Creek is a southern tributary of the Knife River that enters it about 5 miles west of the study area of this report, and Spring Creek confluences with the Knife River about 1.5 miles northeast of the study area. Thus, the Elm Creek to Spring Creek reach described in the 1985 OSMRE report encompasses all of the Knife River within the present AVF study area. The OSM narrative (p. 12) observes:

> From Elm Creek to Spring Creek (pl. 2), the river is deeply incised (15 to 25 feet), and no Knife River water is used for irrigation. However, one system utilizes tributary water, and a center pivot system pumps alluvial ground water. Subirrigation is precluded by the depth of channel incision, and natural flood irrigation rarely occurs below Brush Creek.
>
> Below the confluence of the Knife River and Spring Creek, three operations use pumped sprinkler systems to irrigate alfalfa and small grains. Annual flooding does not generally reach the main valley floor, which is 20 feet or more above the channel. Subirrigation does not occur under the main valley floor (fig. 7).

Revision 22 to KRSB-8603 included an AVF study that addressed Coyote Creek. The PSC issued a determination on October 26, 2009 that the valley of Coyote Creek within that study area is not an AVF in the sense of SMCRA. The study area of that report is included within the shaded area of previously determined acreage shown in Exhibit A. An AVF study and negative determination associated with Revision 27 to KRSB-8603 covered an area between Coyote and Brush Creeks as shown on Exhibit A.

Geology and Geomorphology

The geologic and geomorphic concept of an alluvial valley floor serves to define a very large class of landscape features to which Alluvial Valley Floors, in the restricted regulatory sense of SMCRA, belong as a subset. In other words, an alluvial valley floor by a geologic and geomorphic definition includes all such features while the restricted definition of SMCRA is intended to afford protection to a subset of alluvial valley floodplains that are critical to the agricultural economy in certain areas of the arid western USA. *The OSM Guidelines, p. II-7,* cite the following to clarify the regulatory definition of AVF.

> Of special importance in the arid and semiarid coal mining areas are alluvial valley floors which are the productive lands that form the backbone of the agricultural and cattle ranching economy of these areas. For instance, in the Powder River Basin of eastern Montana and Wyoming, agricultural and ranching operations which form the basis of the existing economic system of the region could not survive without hay production from the naturally subirrigated

and flood irrigated meadows located on the alluvial valley floors. (U.S. House of Representatives, Committee on Interior and Insular Affairs, 1976).

This quote not only clarifies the restricted regulatory definition of AVF but also conveys the whole intent of the AVF concept in SMCRA.

The study area is within the Glaciated Missouri Plateau section of the Great Plains Physiographic Province. The area was glaciated, and as a result is mantled with till and outwash deposits. Reworked glacial material occurs within all drainage courses. The most notable geologic features of the area are the glacial debris-filled stream valleys which are deeply incised in bedrock. These channels were cut by glacial outwash streams or the diversion courses of proglacial streams that filled with water borne sediment. The valley of the Knife River and those of its major tributaries were established prior to or during glaciation and interglacial periods and are now filled with glacial-fluvial sediment of the Coleharbor formation which is being reworked by the present-day drainages.

The major tributary drainage areas south of the Knife River are shown in Exhibit C. The main perennial stream in the study area is the Knife River. Principal tributaries of the Knife River within the study area, from west to east, are Mud Creek, Coyote Creek and the mouth and one ephemeral tributary of Brush Creek. Several smaller and unnamed tributaries of the Knife River also drain the study area.

The principal northern tributary of the Knife River in this portion of Mercer County is Spring Creek which enters the Knife River about 1.3 miles north of the study area. Its course is generally eastward and about 7 miles from the Knife River channel at the west end of the AVF study area. Smaller, unnamed northern tributaries of the Knife River drain the narrow area between the Spring Creek drainage and the Knife River. A few of these smaller streams are in the AVF study where they enter onto and cross the Knife River floodplain. These will be discussed only where appropriate and generally in terms their presence on the Knife River floodplain. These drainages are mostly ephemeral, have no or poorly developed floodplains and are isolated from future hydrologic effect of mining in the proposed permit area. The northern tributaries of the Knife River will not be considered further in this report.

The Knife River is a meandering perennial stream deeply incised in a narrow but well-developed flood plain. Meander scars, oxbows, and bar deposits are common in the floodplain area. Terrace levels occur on the flood plain but are discontinuous, and detailed geomorphic research could reveal additional stages of terrace formation. The transition from valley floor to upland is fairly distinct on both sides of the Knife River valley. The Knife River has an average gradient of 1.9 feet/mile over the study area. Gradients of tributary stream channels are typically low. The characteristic fill deposits in the Knife River valley are silt to clayey silt with very fine- to coarse-grained sand, interbedded with clay and fine gravel. The coarse sand and gravel intervals in the valley fill reach thicknesses of up to 60 feet in drilling southwest of Beulah as reported in Croft, 1973. Plate 2 and Figure 22 (Exhibit D) from Croft (1973) show a cross section through the Knife River alluvium just below the mouth of Coyote Creek, the extent of the Knife River Aquifer in the study area, and depths of alluvium under the Knife River floodplain.

Holocene alluvium makes up a very small portion of the valley fill. These recent deposits are up to 10 feet thick but are usually less than 5 feet thick. They consist of lag gravel, silty sand and clay. Some colluvium has been deposited along the valley sides but its distribution and thickness is variable and not a factor in land use and floodplain topography. Small deposits of sandy silt may occur on the valley floors where ephemeral tributaries have emptied into the Knife River, Coyote Creek, Mud Creek and other drainages in the area.

A little less than 930 acres of the Brush Creek drainage is within the AVF Study Area in Sections 34 and 35, T143N, R88W and Section 3, T142N, R88W. Additionally, a small segment near its mouth in Section 9, T143N, R88W is located on the Knife river floodplain and is considered part of that feature. The upstream area is drained by western ephemeral tributaries of Brush Creek only one of which has its main channel within the study area. This stream channel lacks a developed floodplain and flows through rangeland. Tracts of cropland and hay land in the area occur on more gently sloping areas of uplands. This portion of the Brush Creek drainage is not a logical candidate for AVF status and will not be considered further in this report.

A little over 3 linear miles of the Coyote Creek channel and floodplain extend across the southern portion of the AVF study area in Sections 7, 8, 16 and 17, T142N, R88W. Over four linear miles of the channel and floodplain north of the study area to its mouth have been determined not to be AVF. Within the study area, Coyote Creek has a floodplain that varies in width from about 0.1 to 0.4 miles. This upstream reach of Coyote Creek appears to occupy an ancestral valley with terrace remnants formed by a larger stream. In general, the floodplain of Coyote Creek is less easily differentiated from features from ancient stream activity here than further north. Many flat-lying areas along the valley are at significantly higher elevations than water levels in the Coyote Creek channel. Investigation of the geomorphic history of the area is beyond the scope of this study. Since Coyote Creek within this AVF study area possesses a floodplain, its AVF potential will be evaluated.

Mud Creek, with a drainage area covering about 7800 acres, is the smallest drainage of the named streams in the AVF study area. It is about one third the area of the Brush Creek drainage and a little more than one ninth the area of the Coyote Creek drainage. It has a narrow floodplain ranging from about 600 to 900 feet in width extending from the center of Section 4, T142, R89W to where it empties into the Knife River about 2.5 miles to the northwest. There are no flow data for Mud Creek, but flows can be assumed to be proportionately less than those of the larger drainages. Steeper terrain and fewer significant catchments in the drainage probably mean shorter retention times for runoff from the Mud Creek drainage. The principle shallow lignite aquifers in the area evidently crop out upstream of Section 4, T142, R89W, so intermittent flow may occur within the two and one half miles from Section 4 to its mouth. As with most small streams in the region, the transition from ephemeral to intermittent flow probably shifts up and down the stream yearly depending upon the influence of precipitation on groundwater and surface inflow.

There are areas within the AVF Study Area that are drained by small streams that flow directly into the Knife River. These occur in areas between Gold and Mud Creeks, between Mud and Coyote Creeks, and between Coyote and Brush Creeks. These areas are labeled "Knife River Small Drainages" in Exhibit C. These drainages are ephemeral and small, generally extending over 1.5 miles or less before dropping onto the Knife River floodplain. None of them have developed floodplains and they are not candidates for AVF status. Their downstream portions crossing the Knife River floodplain are considered as part of that floodplain in this report. These streams and their contributing drainages are not considered further in this report.

In general, drainageways are well defined and form pronounced valleys or draws on the upland. Relief and depth of stream down-cutting is more pronounced in the western one-half of the area. Remnants of surficial glacial deposits are widespread outside the study area to the east of Brush Creek, are generally confined to the upland areas between Brush Creek and Coyote Creek, and are even more restricted to smaller upland areas west of Coyote Creek. Areas with slopes conducive to cultivated crops and hay production are mostly found in the eastern one-third of the study area. Within the rolling terrain of the western portions of the area, suitable slopes for hay production are more commonly found on upland interfluvial locations. The steeper slopes of drainage networks are used primarily for livestock grazing. There is a general correspondence between the gentler slopes of glaciated upland areas and sites suitable for crop cultivation or hay production.

Natural water catchments are limited to reaches of drainageway channels and the area is generally well-drained. Effective drainage and limited surface water retention on the landscape is likely a factor in limiting local ground water recharge. Consequently, relatively low hydraulic heads in shallow bedrock aquifers do not produce exceptional groundwater discharge to seeps or alluvial aquifers and do not provide areas of enhanced crop production on floodplains or upland seep areas.

Stratigraphy

From oldest to youngest strata, the study area consists of the Bullion Creek Formation, Sentinel Butte Formation, Golden Valley Formation, Coleharbor Formation, and the Oahe Formation. The Sentinel Butte Formation, of Paleocene Age, forms the upland areas and it and the Bullion Creek Formation comprise the shallow bedrock of the study area and contain the lignite sequences of interest. The Eocene Golden Valley Formation occurs on drainage divides between Mud and Elm Creeks and Coyote and Brush Creeks on the southern edge of the study area. These formations are of non-marine fluvial origin. Significant lignite beds in the study area are the Schoolhouse, Upper Beulah, Lower Beulah, Jim Creek and Antelope Creek seams. The Upper Beulah Lignite is the main lignite to be mined. Glacial drift deposits of the Coleharbor Formation of Pleistocene Age mantle the bedrock in places and fill older valleys and glacial trenches. Alluvial deposits of the Oahe Formation of Holocene Age are the near-surface deposits in the creek drainages. Colluvial deposits of the Oahe Formation, consisting of reworked glacial, bedrock and topsoil material, may occur locally. The Pleistocene Coleharbor Formation and the Holocene Oahe Formation are commonly undifferentiated in mapping of the channel fill deposits and can be collectively referred to as Quaternary Alluvium (Qal).

Climate and Hydrology

Because of its location in the center of North America, Mercer County, North Dakota experiences temperature extremes characteristic of a continental climate, with cold winters and mild to hot summers. One feature of a continental climate is that short-term weather, on a scale important in human affairs, can be variable and only reliably predictable on a scale of hours. Long-term patterns, on annual to decadal scale, can be more predictable. Temperature and precipitation can vary widely. Hot weather, though usually confined to June, July, and August, can sometimes begin as early as April or May, and may continue through September. The 181 F (83 C) variation between North Dakota's highest and lowest temperature is the 3rd largest variation of any U.S. state, and the largest of any non-mountainous state. In the Beulah area, the lowest temperatures occur in December through February with the highest in June through August. Months of highest precipitation are May, June and July. Table 1 summarizes local long-term climate averages.

Table 1
Climatic summary, Beulah, ND

Beulah, North Dakota - Monthly Averages & Records - F°

Month	Average Low	Average High	Record Low	Record High	Average Precip.
January	0°	22°	-42° (1968)	59° (1981)	0.31"
February	9°	30°	-42° (1994)	68° (2002)	0.42"
March	19°	41°	-32° (1998)	81° (2007)	0.73"
April	30°	58°	-11° (1975)	97° (1980)	1.71"
May	41°	71°	11° (2005)	99° (1980)	2.21"
June	50°	79°	27° (1998)	105° (2002)	3.3"
July	55°	85°	30° (1957)	109° (2002)	2.35"
August	54°	85°	30° (1982)	106° (2003)	1.53"
September	43°	73°	13° (1974)	108° (1978)	1.6"
October	32°	60°	-12° (1991)	96° (1997)	1.35"
November	18°	39°	-25° (1985)	82° (1999)	0.7"
December	5°	26°	-46° (1983)	65° (1979)	0.38"

Source: www.intellicast.com/Local/History

Winter through spring precipitation is significant in the hydrologic regime. Late winter and spring runoff from snowmelt generally produce the highest stream flows of the year. Most recharge to the ground water saturated zone occurs in this period of time. Once vegetation is growing, water retention on the landscape and plant uptake of water increase, and relatively intense precipitation events are needed to produce significant runoff or infiltration. West-central North Dakota is considered semi-arid but long-term climatic records show the region has had significantly more years dominated by wet conditions than have states to the west and south.

Most of the study area is an upland consisting of bedrock unconformably overlain by a mantle of glacial deposits. The surface drainage is well integrated, and water from snowmelt or heavy rainfall events is concentrated into established ephemeral stream channels. Surface water from snowfall entrapment and melting recharges wetland catchments in these channels and provides infiltration to the saturated zone. Groundwater seep discharge from perched saturated zones augments surface water supplies in wetlands and pools of ephemeral and a few intermittent streams. These smaller drainageways have not formed significant floodplains or terraces. In general, favorable slope development and the presence of surface water catchments are more prevalent in the eastern one-third of the study area and annual fluxes of groundwater recharge from local surface infiltration are assumed to be greater there.

Streams in the AVF Study area can be classified as perennial, intermittent or ephemeral based their regime's permanence of flow. The boundaries between perennial, intermittent or ephemeral tend to be indistinct. NDAC 69-05.2-01-02 defines ephemeral stream as a stream which flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice, and which has a channel bottom that is always above the local water table. An intermittent stream is a stream or part of a stream that flows continuously for at least one month of the calendar year as a result of ground water discharge or surface runoff. A perennial stream means a stream or part of a stream that flows continuously during all of the calendar year as a result of ground water discharge or surface runoff. Ambiguities inherent in these definitions are overcome with logical application of regional climate and hydrology.

The main stem Knife River throughout the AVF Study Area is a perennial stream. The main stems of Brush Creek and Coyote Creek have been classified in various Dakota Westmoreland Corporation (DWC) and prior Knife River Corporation AVF studies and permits for Beulah Mine as perennial streams. The segment of Coyote Creek's main channel within the AVF Study Area is presumed to be perennial based on DWC investigations to the north and periodic observations by Kelly Krabbenhoft in the course of 2012 field work. Reaches of the channel near the south end of the study area probably have intermittent flow, but detailed investigation is beyond the scope of this report.

Flow characteristics of Mud Creek are uncertain. It is considered an intermittent stream in this report with the possibility that some or all of its lower reach may have perennial flow. Reliable determination of a stream's flow as perennial or intermittent is dependent upon field data acquisition periodically over a typical water year, and field investigation of this nature was beyond the requirements of this study. Use of commonly available topographic, soils and geologic information alone to infer stream flow has been attempted mostly in areas of high precipitation the eastern US and with uncertain success. Mud Creek, from about the center of Section 4, T142, R89W to its mouth, is underlain by Channeled Straw Loam soils which typify hydric conditions. In the eastern US, a stream with a contributing drainage of 12.2 square miles could be assumed perennial. Semiarid conditions and the limited groundwater resources that evidently crop out in its drainage suggest that Mud Creek does not maintain perennial flow.

In terms of AVF potential, the remaining streams of the AVF Study Area lack developed floodplains and are typically ephemeral or nominally intermittent. They are not potential candidates for AVF status.

USGS summaries of monthly flow records for the Knife River at stations along its main stem demonstrate the streams' characteristics. Summaries of available data at these sites are shown in Tables 2 and 3 below, and the original USGS data are in Exhibit E. The average monthly mean discharge at USGS Station 06340010 near Beulah, ND has been about 340 cfs; however, the median of these monthly discharge rates is 96 cfs. High discharges during a few infrequent runoff events produce the high average. The median and percentiles are less affected by anomalous values and are more characteristic of stream flow when a few extreme values are present. These data are biased because the station is only operated spring through late summer and maximum annual runoff events from snow melt are missed. USGS Station 06340500 at Hazen, ND is further from the study area and also contains recording gaps, but it has a longer run of data that include fall and winter low flow periods and late winter runoff events. It has a long-term mean value of 167 cfs and a median of monthly means of 33 cfs. The maximum and minimum flow values for the Hazen station range from 0 to 24,000 cfs. These data better represent the variance in Knife River flows than do data from the site near Beulah.

Ranges in gage heights at the Beulah and Hazen stations and their quartile values reflect the variance in water levels and the magnitude of normal and extreme events in the Knife River. Of course, gage height does not proportionately increase with discharge since once flows exceed bank-full stage, large volumes of discharge can be accommodated by the larger cross-sectional area of the river floodplain. The data confirm that flow tends to be confined to the deep channel and general flooding of the Knife River floodplain is a rare occurrence.

Base flow conditions refer to those extended dry periods between significant rainfall runoff events when stream flow is maintained largely by contributions from groundwater and other long-term storage in the contributing drainage. The inter-quartile ranges of flows in the Knife River are greatest from March through July, and inspection of the data shows the infrequent and variable occurrence of months with high mean discharges. Inspection of the data from USGS Station 06340500 at Hazen, ND suggest that the 10 percentile value, 10 cfs, is a reasonable estimate of its base flow value. Comparison of a base flow of 10 cfs to a median monthly flow rate of 33 cfs suggests that groundwater contributions from bedrock and alluvial aquifers are a significant part of the characteristic flow of Knife River. They also show that the quantity of surface water available for withdrawal for major water uses such as irrigation at points along the stream may be limited.

Table 2

USGS 06340010 Surface Water Station - Knife River near Beulah, ND

	Gage height (ft)	Mean Discharge (cfs)
Period of Record 3/14/2010 to 10/3/2012 (not operational October-February)		
Number of Records	563	593
Maximum	67.8	5290
Minimum	53.3	17
Range	14.6	5273
Mean	55.5	340
Median	54.5	96
75th %tile	55.9	273
25th %tile	54.1	50
Lowest 10%	53.5	28
USGS 06340010 KNIFE RIVER NEAR BEULAH, ND Latitude 47°15'14", Longitude 101°47'08" NAD83 Mercer County, ND, Hydrologic Unit 10130201 Drainage area: 1,880 square miles Datum of gage: 1,700 feet above NGVD29		

The OSM Guidelines, P.II-9 clarifies the concept of subirrigation as:

> The term "subirrigation" is understood to mean the supply of water to plant roots from an underlying alluvial ground-water system such that the vegetation is more productive than in other areas and that the vegetation continues to grow during the moisture-stress portion of the growing season. **Some low-lying areas have greater vegetation productivity than adjacent uplands merely because of better soils, snow drift accumulation, or occasional flood overflow. These areas are not considered to be subirrigated**, and one of the tasks of identification studies is to distinguish those valley areas whose productivity is a result of subirrigation, and not a result of water from some other source. **The water availability criterion excludes areas that could be developed for subirrigation; e.g., by establishing deep rooting alfalfa to tap ground water not presently used by native vegetation.** [emphasis added]

Table 3
USGS 06340500 Surface Water Station – Knife River at Hazan, ND

	Temperture (°C)	Daily Mean Discharge (cfs)	Mean Suspended Sediment (t/d)	Mean Suspended Sediment (mg/l)	Gage height (ft)
Period of record: 4/1/1929 to 10/8/2012					
Number of Records	2482	29045	297	292	4623
Maximum	32	24000	29400	6900	26.5
Minimum	0	0	2	29	0.5
Range	32	24000	29399	6871	26.1
Mean	10	167	631	441	2.0
Median	9	33	17	116	1.6
75th %tile	19	78	102	300	2.1
25th %tile	0	18	6	75	1.2
Lowest 10%	0	10	4	55	0.9
USGS 06340500 KNIFE RIVER AT HAZEN, ND Latitude 47°17'07", Longitude 101°37'18" NAD27 Mercer County, ND, Hydrologic Unit 10130201 Drainage area: 2,240 square miles Datum of gage: 1,712.35 feet above NGVD29.					

The emphasized sentences above are important because they provide a reasonable limit to the regulatory definition of subirrigation. *Appendix C Subirrigation* of the guidelines also emphasizes that the saturated zone must be in reach of the normal rooting depths of shallow rooting hayland and cropland plants under common cultivation in the area rather than only exceptionally deep rooted species such as alfalfa.

The presence of subirrigation, or the occurrence of the saturated zone at depths in the soil that are reached by the normal rooting depths of natural vegetation, is generally non-existent on the floodplain of Knife River in the study area. Croft (1973, Figure 25) shows an unconfined alluvial aquifer on the Knife River floodplain near Hazen, ND in Section 18, T144N, R86W downstream of the study area with water levels ranging from about 16.5 to 21.5 feet below ground surface. Two monitoring wells, CM12-22B and C completed to date in the Knife River alluvium for the proposed permit, had water levels about 29 feet below ground surface on September 13, 2012. These wells in the NW1/4NW1/4 Section 23, T143N, R89W are about 104 feet from water's edge of the Knife River.

State Water Commission records have a water level reading on December 5, 2001 of 29 feet below the surface from a domestic well in the Knife River aquifer in Section 21, T143N, R89W. Without more exact location, the well is likely associated with the farmstead in the NE1/4 of Section 21 about 1.3 miles west of the monitoring wells, CM12-22B and C. Aerial photography suggests that the well is probably within 100 to 300 feet of water's edge of the Knife River. An irrigation well in the NW¼SW¼

Section 7, T143N, R88W and about 250 feet from the Knife River had a water level of 19.5 feet below the surface on September 10, 1980. Again, no exact location is given in the State Water Commission permit, but the well was located during a field review on April 30, 2013 with Reclamation Division staff. The well supplies alluvial ground water to center pivot irrigators located in Sections 7 and 18.

The water table aquifers in the Knife River alluvium are typically at their lowest hydraulic head in fall and winter in response to limited recharge. They can be expected to recharge and gain head during spring from infiltration of winter snow melt. Significant water level increases will occur in response to significant spring snowmelt or spring precipitation. These water level increases will still be below normal rooting depths of crop and rangeland plants common to the Knife River floodplain. In the study area, the saturated zone in the Knife River alluvium occurs at depths of 20 to 30 feet below the surface and may rise to depths of 10 to 20 feet during significant recharge fluxes. These depths indicate that hydraulic head in the unconfined system is controlled, as expected, by the elevation of surface water in the deeply incised river channel and is well below the normal rooting depths of commonly cultivated crops and hay land plants. Any subirrigated areas that may be present along the Knife River in the study area are small, on the scale of a few acres or fractions thereof, and are not significant to agriculture.

Flow data for Coyote Creek are limited. USGS Surface Water Site 06339550 was operated near its mouth in the SW¼ of Section 13, T143N, R89W from October 1, 1977 to December 21, 1983. Daily mean discharges for this site are summarized in Table 4. Flows are typical of larger tributary streams in the region. Daily flows range from an extreme high of 1600 cfs to no flow. The mean shows the influence of extreme events. The median of daily averages is less than 1 cfs and 75% of the daily records are 2.4 cfs or less. Except for snowmelt and extreme precipitation events that generally occur before the plant growing season, flow and surface water availability in the channel is very limited. The base flow contribution is probably in the range of 0.2 to 0.5 cfs and responsible for most of the characteristic flow.

In the course of baseline data acquisition, the low hydraulic heads observed in bedrock aquifers in the general permit area in 2012 suggest that groundwater discharge has potential for maintaining only low volumes of base flow in area streams. This inference is supported by the historic flow characteristics of area streams. Groundwater discharge seepage above stream water elevations tends to be utilized by vegetation during the growing season and retained in a variety of ways in the vadose and surface environments during cold months. Highest groundwater discharge contributions to stream flow likely coincide with and follow spring runoff. The degree of below-grade interchange between the shallow alluvium in the channels of larger tributary streams and bedrock aquifers is beyond the scope of this study. But, it is likely that a significant component of the limited base flow in some reaches of these streams comes through groundwater discharge into their underlying alluvium. The perennial classification of Coyote Creek, Brush Creek, and possibly downstream reaches of Mud Creek are best viewed as nominal. Usable surface water resources of these streams are limited and not significantly different from those of intermittent streams in the region.

Surface water quality is not a central issue in AVF determination but is important in assessing water suitability for irrigation. Water quality information is available from USGS Station 06340500 on the Knife River at Hazen and for DWC monitoring sites on Coyote Creek in the SW¼ Section 13, T143N, R89W near its mouth and in SE¼ Section 31, T143N, R88W about 0.5 miles north of the southern portion of the AVF study area. A DWC monitoring site on Brush Creek in the SE¼ Section 25, T143N, R88W less than a mile east of the AVF study area, while beyond the AVF study area, provides information on the upper reaches of that stream. The Coyote Creek and Brush Creek monitoring sites are within stream reaches that have previously been determined to not be AVF. Summary statistics and locations for these sites are given in Table 5 and the complete data are available in Exhibit E. The data show reasonable similarity between the sites, and greater variance in many parameters in the tributary streams than in the main stem which is typical of stream chemistry.

Median SAR values of all three streams range from 5.49 to 7.63 with a lowest 25th percentile value of 5.09 occurring in the Knife River data. Median specific conductivity values range from 1500 to 2457 mMOHS/cm with a lowest 25th percentile value of 1190 mMOHS/cm. Irrigation suitability of the surface waters in Knife River proper and its tributaries, Coyote and Brush Creeks, are similar with all having low sodium hazard but high to very high salinity potential. The Knife River surface water samples at Hazen represent water integrated over the upper area of the Knife River drainage and more variable surface water quantity and quality can be expected over the tributary drainages of the basin as evidenced by the Coyote Creek and Brush Creek data. The somewhat lower SC and SAR values in the Knife River compared with its tributaries may reflect local infiltration, storage and subsequent base flow contribution of less mineralized waters from floodplain infiltration and the alluvial aquifer of the main stem channel. Surface water in any portion of the Knife River or its tributaries would be marginally suitable for limited irrigation.

Table 4

USGS 06339550 Surface Water Station – Coyote Creek Near Zap, ND

USGS 06339550 COYOTE CREEK NR ZAP, ND Period of Record 10/1977 to 12/1983	
	Monthly Mean Discharge (cfs)
Number of Records	75
Maximum	185.20
Minimum	0.00
Range	185.20
Mean	11.70
Median	1.18
75th %tile	6.05
25th %tile	0.36
Lowest 10%	0.13
Mercer County, North Dakota Hydrologic Unit Code 10130201 Latitude 47°11'57", Longitude 101°54'42" NAD27 Drainage area 65.2 square miles Gage datum 1,809.75 feet above NGVD29	

Table 5

Coyote Creek, Brush Creek and Knife River surface water quality

	Fld-pH	SC	SAR	TDS	Ca	Mg	Na	K	Cl	SO4	Total Fe
13CCC-W/ST Coyote Creek - SW1/4 Sec. 13, T143N, R89W, about 1 linear mile of its its mouth											
Maximum	8.7	3,681	10.10	2,910	208.0	589.0	530	14.0	18.0	1,620	0.80
75th %tile	8.6	2,479	8.38	2,140	131.5	123.0	436	13.5	14.4	1,100	0.49
Median	**8.4**	**2,425**	**7.63**	**1,930**	**97.9**	**77.5**	**412**	**11.8**	**12.5**	**951**	**0.41**
25th %tile	8.1	2,285	6.31	1,905	75.3	54.1	374	10.3	10.5	783	0.27
Minimum	7.8	1,316	4.03	954	61.6	43.7	172	8.9	7.6	520	0.18
31DBD-W/ST Coyote Creek - SE1/4 Sec. 31, T143N, R88W, about 0.25 miles north of AVF study area											
Maximum	8.6	3,707	12.00	2,920	212.0	153.0	546	14.5	17.7	1,600	1.34
75th %tile	8.5	2,554	8.89	2,185	123.8	94.7	457	12.4	11.6	1,116	0.57
Median	**8.4**	**2,457**	**6.98**	**1,960**	**84.5**	**61.8**	**438**	**10.7**	**9.6**	**887**	**0.40**
25th %tile	8.1	2,175	6.44	1,850	74.5	51.5	344	9.9	9.3	842	0.36
Minimum	7.7	1,400	3.92	871	52.8	44.5	171	8.6	7.6	554	0.18
25DCC-E/ST Brush Creek - SE1/4 Sec. 25, T143N, R88W, ca. 0.75 miles E. of tributary in AVF study area											
Maximum	9.0	6,610	20.00	7,120	239.0	298.0	1,850	47.7	67.9	4,000	0.98
75th %tile	8.3	2,719	6.40	2,225	147.5	130.0	406	16.5	24.0	1,125	0.71
Median	**8.1**	**2,318**	**5.49**	**1,830**	**94.1**	**96.7**	**338**	**15.0**	**16.4**	**925**	**0.33**
25th %tile	7.8	1,991	4.94	1,550	87.7	86.5	277	11.7	12.7	755	0.23
Minimum	6.5	442	1.56	357	23.8	15.1	40	11.1	4.0	113	0.13
USGS Surface Water Station 06340500 Knife River at Hazen, ND											
Maximum	9.2	3,100	9.8	1,890	130.0	70.2	410	15	21.5	860	7.00
75th %tile	8.4	1,835	6.7	1,290	77.5	47.0	300	9.6	7.9	520	0.95
Median	**8.2**	**1,500**	**5.89**	**1,035**	**63.0**	**39.0**	**240**	**8.8**	**6.3**	**423**	**0.44**
25th %tile	7.9	1,190	5.09	883	51.0	30.0	195	7.8	4.3	320	0.16
Minimum	7	170	1.27	128	14.0	2.2	17	0.3	0.5	26	0.00

Data on Coyote Creek floodplain alluvium are limited. Two monitoring wells drilled in the summer of 2012 by Coyote Creek Mining Company characterize the alluvium. CM12-08B in the NE¼, Section 31, T143N, R88W, 45 feet from the Coyote Creek channel and screened in the base of the alluvium at a depth of 20 feet, had a static water level of 9.3 feet below ground surface on September 14, 2012. About ¾ miles south and downstream, CM12-20C in the SE¼ Section 31, T143N, R88W, about 70 feet from the Coyote Creek channel and screened at the base of the alluvium at a depth of 15 feet, had a static water level of 8.5 feet below ground surface on September 14, 2012. Four older groundwater monitoring wells to the south and close to the Coyote Creek channel are apparently screened in lignite based on their depths and lower static water levels. The alluvium under Coyote Creek is shallow and has static water levels below the rooting depths of common range vegetation and cultivated crops in the area. The saturated zone is characterized by low hydraulic head that has very limited potential as a ground water supply for significant irrigation.

Soils

The project area is in the Missouri Plateau section of the Northwestern Great Plains ecoregion (Bryce et. al., 1996). They describe the region as:

> *"......a semiarid rolling plain of shale, siltstone, and sandstone punctuated by occasional buttes and badlands. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring wheat and alfalfa over most of the ecoregion. Agriculture is limited by erratic precipitation patterns and limited opportunities for irrigation. On the Missouri Plateau, west of the Missouri River, the topography is largely unaffected by glaciation and retains its original soils and complex stream drainage pattern. A mosaic of spring wheat, alfalfa, and grazing land covers the shortgrass prairie ....."*

Most of the soils in the area are classified as Mollisols (Haplustolls, Calciustolls, Argiustolls, and Natrustolls), and Entisols (Ustorthents). The temperature regime is Frigid and the moisture regime is Typic Ustic. Soils on summit or convex landscape positions lack or have thinner mollic epipedons, while backslopes through toeslopes have thicker mollic epipedons. Glacial erratics, consisting of large stones, commonly occur. An Order Two soil survey has been completed by the USDA-SCS (Weiser, 1975). Exhibit F shows the NRCS soils map within the study area and Exhibit G shows a map legend for soils occurring within the AVF study area. Mean annual precipitation is 15 to 17 inches and frost-free days are 95-130.

Most of the study area is glacially modified bedrock controlled upland. It drains into the Knife River, a tributary of the Missouri River. The upland primarily consists of Tertiary-aged deposits. A thin mantle of Quaternary-aged glacial till is found on stable interfluves. In most areas the surface drainage is well integrated, and excess precipitation is concentrated into established ephemeral stream channels. Excess surface water also recharges wetland catchments in these channels and provides infiltration to the saturated zone. Groundwater seep discharge from perched saturated zones augments surface water supplies in wetlands and pools of ephemeral streams. These drainageways have not formed significant floodplains or terraces. Many of the soils occurring in the alluvium filled valleys and tributary drainageways tend to be saline.

The Soil Survey of Mercer County, North Dakota was used to evaluate the soils in the study area (Exhibits F and G). The most commonly occurring soils within the study area based on acreages of mapped units in Exhibit F are Cabba Loams with 15-35% slopes (6143 acres) occurring generally over the area but with greater coverage in the southern one-third of the area. Rhoads-Daglum soils (2992 acres) are found mostly west of Coyote Creek and in the southern and western portions of the study area. Flaxton fine sandy loam (2088 acres) occurs primarily in the northern two-thirds of the area. Straw loam (1605 acres) is the primary soil on floodplains of the Knife River and Coyote Creek, and its distribution is a good indicator of floodplain areas. Channeled Straw loam (877 acres) is characteristic of headwaters reaches with narrow and less developed floodplains such as Coyote Creek and Mud Creek near the west margin of the study area. Noonan-Flaxton, Cabba loams with 9-15% slopes, and Flaxton-Williams complex soils (1460, 1336 and 1107 acres, respectively) are other soils covering more than 1000 acres. They are found largely in the southern and eastern portions of the study area

Mr. Mike Ulmer and Mr. C. J. Heidt, Soil Scientists and Soil Classifiers, are mapping soils within the area for an upcoming permit application. They prepared a report on their observations along the Knife River over its extent in the AVF study area from the western border of Sec. 29, T143N, R89W to the eastern border of Sec. 3, T143N, R88W including the previously determined segment in Section 14, T143N, R89W (Appendix A) They concluded that the soil resources and imagery in this area did not reveal any conclusive areas of subirrigation. Two small areas were identified with potential subirrigated landscape characteristics, but both areas are very small, covering 14 and 15 acres, are not managed uniquely, and do not significantly influence crop or range production in the area. No artificial flooding or water spreading areas were identified.

There is no soil evidence of any subirrigation of consequence occurring along the Knife River, Coyote Creek, Mud Creek or other smaller tributaries of Coyote Creek, Mud Creek or the Knife River within the study area. As with most drainageways in West-central North Dakota, there are probably scattered low areas of shoreline or low meander terraces of a few acres or less in size where the saturated zone may be available to the rooting depths of normal vegetation during the growing season. The deeply incised channels of the Knife River and other streams in the study area suggest that shoreline fringes with patches of subirrigated plants are less common here than along many other streams in the region. Cut banks are common features of streams with developed floodplains in the area. Productive soils do occur on floodplain areas but their productivity is due to slope and soil genesis and not to subirrigation.

Land Use and Vegetation

The OSM Guidelines, p.II-12, emphasize that the key criterion of an AVF is having an important, if not critical, economic role in the success of local agricultural cropping practices by noting,

> ... it is important to understand the style of agricultural land use in an area, and the way, if there is one, that stream valleys are important to agriculture. As previously noted, if certain stream valleys do not serve a special role in agricultural land use in a particular coal region, or if their special role is not a function of water availability, then these streams are not alluvial valley floors in that region. [underlining is in the original text]

Scale, significance and negligible impact are issues addressed in the *The OSM Guidelines, Chapter III* under permit data needed when an AVF is present and may be affected by mining. However, the physical scale and geometry of potential AVF areas and their significance in the economics of individual agricultural operations are issues that must be addressed in an analysis leading to an AVF determination.

There are significant differences in land use over the AVF study area. Cattle raising is the dominant land use but crop production is more common in the eastern east one-third of the area with Coyote Creek being a convenient dividing line.

The Knife River floodplain provides an extensive area of relatively flat agricultural land that is from 0.75 to 1.5 miles wide but commonly broken into smaller land use tracts by the sharply meandering river channel.

Floodplain development on Coyote Creek is most pronounced from its mouth through Section 31, T143N, R88W in areas already determined not to be AVF. It continues southward into Section 6, T142N, R88W in the study area where it is still about 0.4 mile wide. It is used as rangeland as is the rest of Section 6. Section 5 to the east has significant tracts of crop land and hay land on suitable upland slopes. In section 7, 8, 16 and 17 to the south the Coyote Creek floodplain narrows to about 0.25 mile. Over the area, cropland and hay fields on the creek floodplain tend to extend from near the channel onto adjacent upslope areas. Clearly, favorable slope generally unrelated to floodplain development controls the occurrence of crop and hay production in this area.

Beaver Creek enters Coyote Creek in Section 17, T142N, R88W. Its floodplain set in a broader valley suggests that the Beaver Creek valley may have been formed by an earlier drainage pattern. The geomorphic history of this area is beyond the scope of this study. However, field patterns near the stream have taken advantage of the broad valley and the gentle slopes on surrounding uplands. Cropland and hay land tracts show the strong control of slope on their location and shape. There is no evidence of water availability controlling the location of cropland or hay land tracts in this area.

Two unnamed tributaries of Coyote Creek enter it near the west quarter corner of Section 8, T142N, R88W. These tributaries have poorly developed floodplains and are not candidate AVF areas. Mud Creek which flows into the Knife River in Section 29, T143N, R89W has a poorly developed floodplain. These drainagways are within rangeland tracts and are used as rangeland. Hay and other crop production along these drainages tends to be on flatter areas that tend to occur on uplands rather than on valley floors. These are not candidate AVF areas.

Within the study area shown in Exhibit A, land uses of tracts interpreted from NAIP color photography and within sections were grouped as cropland, hay land, rangeland, farmstead and industrial to evaluate the relationships between land use on the Knife River floodplain and uplands in the area (Exhibit H). No attempt was made to generate detailed categorization of land use or the boundary precision characteristic of pre-mining land use studies for permitting actions. However, that portion of the map area within the proposed permit boundary is based on land use categories generated by KDK Consulting for baseline analysis in an upcoming application by Coyote Creek Mining Company.

Land use tracts shown in Exhibit H and occurring within or extending onto the Knife River floodplain were grouped and then compared with all other tracts in the study area. Tracts extending between floodplain and upland areas are counted in both groups rather than partitioning them since the comparison is intended as an approximation. When the overlap was small, generally about 5 percent or less of the tract, the tract was placed in only one group as a matter of judgment. Results are shown in Table 5.

Table 5
Land Use Comparison between Knife River Floodplain and Other Portions of AVF Study Area

Land Use	Knife River Floodplain (percentage)	Other Areas (percentage)
Cropland	11.8%	8.4%
Farmstead	1.1%	0.7%
Hay Land	12.9%	9.1%
Rangeland	74.2%	81.8%
	100.0%	100.0%

The higher percentage of cropland and hay land on the floodplain reflects the flat terrain and favorable soils rather than natural irrigation. The slightly higher incidence of farmsteads probably relates to the historic importance of surface water, wood supplies, access to transportation and aesthetic values of the valley. Land use on the Knife River floodplain is integrated into land uses of larger agricultural units. Agricultural practices on the floodplain are not distinct from those on upland areas, and the area does not have a special role in local agriculture. There is not pronounced differences in land use between the Knife River floodplain and adjacent uplands that would be expected with a true AVF area. In comparison with other North Dakota areas that have been evaluated for possible occurrence of AVF, the predominant rolling terrain and steeper slopes of the western half of the study area have weighted the percentages for upland areas in Table 5 toward rangeland usage far more so than would be expected in central North Dakota.

The uses and irregular shape of cropland and hay land tracts that occur along drainageways and around steeper slopes in the study area evidently evolved in the first half of the 20th Century or earlier to accommodate topographic limitations to agriculture. In terms of floodplain usage, with one exception, there is no evidence in the study area of remnants of water spreading, irrigation dikes or dams, or other cultural features suggesting that floodplain irrigation has ever been a part of farming practice in the area or influenced tract boundaries. The single instance is discussed below and is a system of water spreading dikes originally intended to enhance alfalfa production by spreading runoff from two ephemeral drainages on about 43 acres of Knife River floodplain. In general, the shape of cropland and hay land tracts that occur along drainage floodplains in the study area are commonly influenced by land slope more than by soil type and water availability. The limited water resources, including groundwater which is not an AVF value, of major stream valleys in the study area give those areas little if any added value over the whole area for crop and hay production. Favorable growing conditions provided over the entire area by regional climate and soils place a premium on gentle slopes that support modern cropping and haying practices.

Mr. Kelly Krabbenhoft made the following observations on haying within the study area during his baseline field work in 2012 that show floodplain areas are not regarded as special resources for hay production but are integrated into haying practices applied by operators to the whole area.

> Haying initiated in early to mid-June as vegetation was ahead of normal with the warm dry growing conditions encountered in 2012. This haying activity was not only seen within the permit and surrounding lands, but in numerous western counties. Activity increased during late June and early July as most hayland vegetation began to regress through senescence with moisture stress. Activity continued into late July and early August. By that time, most of the prime haylands had been cut and activity turned to road ditches and ancillary areas as dry conditions persisted. Ranchers attempted to make up for shortages in their primary fields by cutting all prospective areas. Most of which likely had not been cut during the previous 3 seasons which were cool and had above average moisture. The only observation of a second cutting, to date, came from the SE4 Section 31, 143-88 near the Casey Voigt ranch. It did not appear there was a difference in timing of cutting between areas adjacent to creeks and rivers versus upland sites.

Key indicator grass species of Subirrigated ecological sites are Big Bluestem, Switchgrass, Indiangrass, Prairie Cordgrass, and Little Bluestem. Mr. Krabbenhoft has also observed that, within the proposed permit area, there appears to be no significant difference in the abundance of these species between the Knife River and Coyote Creek floodplains and the surrounding uplands. No Similarity Indices were assessed within the current study specific to the potential AVF areas. However, similar low percentages relative to the Historic Climax Plant Community and decreased yields due to management were observed within the native ecological sites.

Irrigation History and Potential

Topographic conditions make unfeasible the diversion of the Knife River or its major tributaries including Coyote Creek, Brush Creek and Mud Creek onto their floodplains to develop gravity-feed water spreading systems. The meandering channel and steep cut banks prevent the feasible development of upstream diversions to irrigate downstream areas.The channels of these streams are deeply incised in the valley floor and meander from side to side in their valleys, creating steep cut banks; however, the floodplain appears to be less terraced by meander scarring than other larger streams in the region and generally more accessible with farm machinery. The deep channel and low flow regime limit natural flooding to rare events. Natural flooding of lowlands over the region tends to occur during brief and exceptionally high runoff events in late winter and spring before the growing season giving no opportunity for irrigation by water spreading.

State Water Commission water permit records were searched for past and current water use permits in T142N, R88W; T142N, R89W, T143N, R88W and T143N, R89W. Two permits were located. Archie Wanner holds a permit to 225 acre-feet of water from the Knife River aquifer in Section 29, T143N, R89W with a priority date of 3/18/2008. There has been no reported water use of record and the site was not investigated further. Ronald Gunsch holds a permit with three locations for water withdrawal from the Knife

River groundwater aquifer with a priority date of 8/1/1974. Only the site in the SE¼, Section 7, T143N, R88W has reported use that ranges from 1981 to the present. The majority of the acreage under irrigation with this water is in the NW¼ of Section 18 south of the floodplain and the withdrawal site.

An area of surface water spreading covering about 43 acres north of the Knife River in the NW¼ Section 14, T143N, R89W diverts and spreads water during high water stages of spring run-off on two unnamed tributary streams. These streams converge to within about 0.1 to 0.25 of one another on the Knife River floodplain before discharging into the Knife River. The area does not utilize Knife River water. This site was not considered further because of its small size, unusual geomorphic setting that allows for limited water spreading, and its location north of the Knife River opposite and hydrologically isolated any foreseen mining or associated disturbance at Coyote Creek Mine.

However, the Reclamation Division of the Public Service Commission requested more information on this unusual site, and Mr. Tom Buechler whose family owns the land was contacted for that information. He said the spreading system was built by his father in 1965 or 1966 for the purpose of enhancing alfalfa hay production. It may have been funded in part by an NRCS program then in place. He noted that it was effective at providing early cuttings of alfalfa hay only during years of sufficient spring runoff. He had no thoughts on whether or not it provided any benefit to the tract's current use for more shallow rooted crops since the land has been leased to operators for many years. The tract has been used for corn production the past one or two years. He commented that it has been several years since there has been sufficient spring runoff to operate the system, and he noted that 60-70% of the water comes from the west drainageway.

Utilization of flow from small tributary streams for pre- or early growing season enhancement of soil moisture on floodplains or suitably flat uplands has apparently not been practiced elsewhere in this portion of the Knife River basin and is questionably feasible and effective. It did not become an irrigation practice for the area even with government support that may have been available. The OSMRE (1985, p. 25) report made the following observations about the small spreader dike systems in North Dakota that succinctly summarize their economic status.

> There are several reasons why these small spreader dike systems are not considered a regional practice. First, there are so few of them used that most farmers and ranchers obviously do not consider them a viable development strategy. Second, the small drainages where spreader dikes would be built are not as crucial to operations as perhaps similar drainages would be in more arid coal regions. Uplands in west-central North Dakota have good soils. Rainfall averages about 16 inches annually, falls mainly during the growing season, and is adequate for dry land crops. Thus, the uplands are chosen for additional cropland over the small valley bottoms.

Coyote Creek and Mud Creek main channels within the AVF study area show no evidence of surface water spreading, flood irrigation, catchments for irrigation or other mechanisms to enhance hay or crop production on their floodplains. Floodplain areas are mostly used for rangeland. Crop and hay production occurring on the Coyote Creek floodplain is controlled by slope rather than water availability. Crop and hay land tracts on the floodplain extend onto areas above the floodplain and upland fields continue onto floodplain areas for maximum field size to the degree allowed by terrain and ownership.

Agricultural interests in an area are always striving to innovate and optimize agricultural production. Over 100 years of striving for optimum agricultural production in the Knife River drainage basin has not produced any significant amount of past or current irrigated cropland or hay land on the river floodplain or on the floodplains of its major tributaries.

Wording in the OSM AVF guidelines serves to limit speculation about the future potential for irrigation to past or present uses common in the area. The guidelines state that an AVF must be an area with water availability sufficient for subirrigation or flood irrigation to support agricultural activities and that "water is available by surface-water irrigation or subirrigation and is being or has successfully been used to enhance production of agriculturally useful vegetation."*(OSM Guidelines, p II-9)*

The base flow in the Knife River interpreted from flows recorded from 2010 to 2012 at USGS gauging station 06340010 near Beulah, ND in the late summer and late winter months of minimum precipitation suggest ground water contributes generally about 30 cfs to the stream. The station was not operated October through February over the period of record, and base flow had to be assumed from the lowest 10% of monthly discharges. Its median monthly flow is 96 cfs. Gaged height has a range of 14.5 feet. The base flow of the Knife River is probably closer to 10 cfs based on records at USGS Station 06340500 located at Hazen, ND. Although more removed from the study area, the Station at Hazen has a longer record and provides more records over fall and winter periods when most if not all flow is from groundwater contributions. These data suggest that 10 to 30 cfs of Knife River flow is from ground water sources, or approximately 30% of the median of monthly discharges.

Table 6

Irrigation requirements of typical North Dakota crops.

System Capacity in gallons per minute per acre (gpm/acre) for different soil textures needed to supply sufficient water for each crop in 9 out of 10 years. An application efficiency of 80% and a 50% depletion of available soil water were used for the calculations.

Crop	Root Zone Depth (ft)	Coarse Sand and Gravel	Sand	Loamy Sand	Sandy Loam	Fine Sandy Loam	Loam and Silt Loam
POTATOES**	2	8.2	7.5	7	6.4	6.1	5.7
DRY BEANS	2	7.9	7.1	6.4	6.1	5.7	5.4
SOYBEANS	2	7.9	7.1	6.4	6.1	5.7	5.4
CORN	3	7.3	6.6	5.9	5.5	5.3	4.9
SUGARBEETS	3	7.3	6.6	5.9	5.5	5.3	4.9
SMALL GRAINS	3	7.3	6.6	5.9	5.5	5.3	4.9
ALFALFA	4	6.8	5.9	5.6	5.1	5	4.5

**Adjusted for 40% depletion of available water

Source: http://www.ag.ndsu.edu/pubs/ageng/irrigate/ae91w.htm

Table 6, specific to North Dakota irrigated crop conditions, suggests that Knife River flows would be capable of providing surface water needed to irrigate a modest acreage of cropland. Given the seasonal irregularity in quantity of runoff from these streams, irrigation potential based on surface water availability is far less than the maximum suggested by USGS average flows.

Assume a reliable flow rate in the range of 10-30 cfs (4,440 to 13,460 gpm) for the Knife River in the months of June, July and August. Assume 5 gpm per acre is needed for sufficient irrigation of corn, small grains and alfalfa. The Knife River surface flow could provide water for 889 to 2693 irrigated acres, with total permitted withdrawals likely to total less than one-half this maximum volume and acreage. Withdrawals of this magnitude during the irrigating season could significantly impact livestock watering capacity and stress aquatic communities along the river. Livestock watering along the river remains a significant value to local agriculture.

Significant flood irrigation potential does not exist along the Knife River without resorting to pump lifting. Small tract size, irregularity of the topography and meandered channel course combine to make water spreading and flood irrigation systems unfeasible. Tillable acreage is limited in size and scattered among areas only suitable as grazing land that offer minimum potential for expanding tillable field size to accommodate even large-scale groundwater use with center pivot irrigation. State Water Commission records show no interest in surface water irrigation. This lack of interest on the part of operators confirms a very low potential for irrigation along this reach of the Knife River and its tributaries including Coyote Creek, Brush Creek and Mud Creek. While irrigation with pumped surface water from the Knife River is feasible, the one instance of center pivot irrigation in proximity to the Knife River aquifer uses that more economical and reliable ground water resource rather than surface water from the Knife River channel.

Summary and Recommendations

The environmental and agricultural properties of the Knife River floodplain, the Coyote Creek drainage (upstream from previously determined areas) and all other portions of the study area were investigated relative to their status as Alluvial Valley Floors. Findings are summarized as follows:

1. In the study area of this report, two streams have developed floodplains sufficient in size to warrant evaluation of their AVF potential. The Knife River has a well-developed floodplain and is a perennial stream over its length in Mercer County. Coyote Creek is a perennial to intermittent stream with a narrower floodplain that still merits evaluation.
2. All downstream portions of Coyote Creek floodplain, within T143N, R88W and T143N, R89W, have been determined to not be AVF in prior permit findings associated with Beulah Mine permit KRSB-8603. The floodplain narrows in its upstream reaches evaluated in this report, and these reaches are found to not be AVF.
3. Mud Creek, a smaller drainage in the western portion of the study area, has a very narrow floodplain in its downstream reach of about 2 miles in length. It is predominately range land, and hay production in the contributing drainage comes mostly from gently sloping upland areas. Mud Creek has no AVF values or potential.
4. The main channel of Brush Creek is outside this AVF study area and those main stem reaches of the stream in close proximity to this study area have been determined to not be AVF in prior determinations related to mine permitting at Beulah Mine. An ephemeral or nominally intermittent tributary drainage of Brush Creek occurs within the AVF study area in Sections 34 and 35, T143N, R88W. This drainage lacks a floodplain and the shallow valley is rangeland. It is not an AVF.
5. The Knife River has not been evaluated for AVF status except for a short segment in Section 14, T143N, R89W that was evidently considered along with the mouth of Coyote Creek in determinations made relative to Beulah Mine permitting.
6. The OSMRE publication, *Draft Reconnaissance Maps to Assist in Identifying Alluvial Valley Floors, West-Central North Dakota, OSM/TM-3/85, 1985* correctly identified the key features that remove the Knife River floodplain in this area from AVF status, primarily its deeply incised channel with the floodplain being 15 to 20 feet above water level and the lack of historic or current irrigation that meets the criteria for AVF irrigation. The report observes the similarity in crop production between the floodplain, higher terraces and uplands along the river that is made possible by favorable climate, soils and slope. It also concludes that the very limited number of irrigated lands along the river is influenced by the marginal economic advantage of irrigation to dry-land farming and ranching in the area.
7. In the study area, only the valley fill of the Knife River is recognized as a significant aquifer in the Mercer-Oliver County Ground Water Study. Alluvial deposits in the valleys of Coyote Creek and other tributary streams in the area are too shallow and narrow to be significant water resources. Saturated zones of about 5 to 10 feet thick are probably characteristic of Coyote Creek alluvium.
8. The Knife River and Coyote Creek floodplains in the study area are not subirrigated. The water table on the floodplains range from 8 to 30 feet below the

ground surface. The normal rooting depth of natural vegetation and typical North crops is generally less than 3 feet.

9. Soils on floodplains in the study area are dominated by Straw loam. Soil series associated with subirrigation are not present, and the stream floodplains are not subirrigated in the opinions of C.J. Heidt and Mike Ulmer, both Professional Soil Classifiers.
10. Rangeland is the largest land use by acreage on both the Knife River floodplain and all other parts of the study area. Cropland tracts tend to overlap floodplain and upland areas with slope being the primary control of their location. Crop selection and farming practices on the floodplains are comparable to those on adjacent upland areas and are dictated by slope and topography rather than water availability. Based on land use and productivity, crop production on floodplains does not receive special management practices or priority that would indicate it is a critical aspect of area agriculture. Mike Ulmer, C.J. Heidt and Kelly Krabbenhoft in their observations felt that the Knife River floodplain shows no evidence of agricultural management significantly different from upland areas.
11. Kelly Krabbenhoft found no subirrigated sites or plant communities indicative of subirrigation in the study area during field inventories of ecological sites in 2012. Also he concluded that floodplain rangeland sites were not significantly more productive than rangeland on the surrounding uplands.
12. State Water Commission historic records show no past, present or planned agricultural irrigation on the Knife River or Coyote Creek floodplains utilizing surface water. One small area of center pivot irrigation is located both on the Knife River floodplain and its side slopes, and it utilizes groundwater from the Knife River aquifer. A small 43 acre area of water spreading uses high stage flows from two small unnamed northern tributaries of the Knife River to enhance soil moisture on Knife River floodplain sediments.
13. The Knife River typically has its highest flows in late winter and early spring before the plant growing season. It tends to be near base flow conditions during the growing season. Base flow median discharge of about 10-30 cfs is also a likely characteristic range for reliable flows during the growing season months of May, June and July. This base flow indicates the maximum volume of water available for withdrawal during the growing season. This supply could irrigate a. maximum of 889 to 2693 acres based on typical needs of North Dakota crops, but maximum withdrawals could impact usage for livestock watering. Coyote, Brush and Mud Creeks lack the surface water quantities needed to support any significant irrigation.
14. Surface water quality in the Knife River, Coyote Creek and Brush Creek poses high to very high salinity hazard that limits the potential for using these resources for significant irrigation.
15. The limited resource of growing season flows in the Knife River, the relatively small and irregular areas of adjacent cropland and the necessity of pump lifting make future irrigation with Knife River water unlikely. Like the one small 180-acre example of sprinkler irrigation in the study area, any future irrigation attempts will rely on groundwater from the Knife River aquifer.
16. Mining and reclamation at Dakota Westmorland's Beulah Mine has taken place in close proximity to the Knife River, Coyote Creek and Brush Creek for over 35 years and has not harmed the environmental or agricultural values of these streams. Future permit applications will provide the necessary mining and

reclamation plans to assure that the environmental or agricultural values of the Knife River, Coyote Creek and other streams in the AVF study area will be maintained and no material damage will occur to these drainages.

This study finds that the contribution of floodplains in the Knife River drainage of Mercer County to crop and hay production is not a factor in local agriculture. There is no evidence that the Knife River and Coyote Creek or other drainages within or adjacent to the AVF study area meet any of the criteria essential for determining them to be AVF. Their agricultural usage is not different from adjacent upland areas, nor are they critical to crop or livestock feed production as are the true AVF areas in the arid west. They have no history of surface water irrigation or economically feasible irrigation potential for enhancing current or foreseeable agriculture in the area. They are not subirrigated. Water, soil and wildlife resources of these floodplain areas are more directly, stringently and effectively protected by the surface and groundwater protection requirements of SMCRA and North Dakota regulations than by inappropriate designation of the valleys as Alluvial Valley Floors.

It is recommended that a determination be made that no Alluvial Valley Floors occur within the study area of this report as delineated in Exhibit A. It is also recommended that, for clarification, the findings specifically reaffirm or find that the Knife River floodplain segment previously determined in Section 14, T143N, R89W is not an AVF. Land use, geologic, hydrologic and related data are presented here to reaffirm prior findings that this small stream segment is not an AVF. It is similarly recommended that the determination reaffirm that all of Coyote Creek, from its mouth to the southern boundary of this AVF study area, including reaches evaluated in previous AVF determinations, is not an Alluvial Valley Floor. Since a non-candidate tributary of Brush Creek is within this study area, it is recommended that it be reaffirmed that Brush Creek is not an AVF. It is also recommended that the determination state that Mud Creek is not an AVF.

References

Bryce, S.A., Omernik, J.M., Pater, D.A., Ulmer, M., Schaar, J., Freeouf, J., Johnson, R., Kuck, P., and Azevedo, S.H., 1996, Ecoregions of North Dakota and South Dakota, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Carlson, C. G. 1973. Geology of Mercer and Oliver Counties, North Dakota. Bull. N.D. Geol. Surv. 56, Pt. 1; N.D. State Water Comm. Co. Groundwater Studies 15, Pt. 1.

Croft, M. G. 1973. Ground-water Resources Mercer and Oliver Counties, North Dakota. Bull. N.D. Geol. Surv. 56, Pt. 3; N.D. State Water Comm. Co. Groundwater Studies 15, Pt. 3

OSMRE. 1983. Alluvial Valley Floor Identification and Study Guidelines, Draft of August, 1983.

OSMRE. 1985. Draft Reconnaissance Maps to Assist in Identifying Alluvial Valley Floors, West-Central North Dakota, OSM/TM-3/85.

PUBLIC SERVICE COMMISSION
Reclamation Division
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Memorandum

TO: NACC-1301 proposed permit file

FROM: Randy Kowalski, Environmental Scientist - Reclamation Division
Bill Gunnerson, Environmental Scientist – Reclamation Division
Bruce Becchie, Hydrologist – Reclamation Division

DATE: May 16, 2013

SUBJECT: Coyote Creek Mine Alluvial Valley Floor field investigation

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On April 30, 2013 the PSC personnel listed above conducted an alluvial valley floor (AVF) field investigation covering selected portions of an approximate 33,000-acre AVF Study Area that was submitted in anticipation of the proposed initial application of Permit NACC-1301 for the Coyote Creek Mine in Mercer County, North Dakota. Sarah Flath, Environmental Specialist of Coyote Creek Mining Company, L.L.C. and Dr. Dave Bickel, Bickel Consulting, LLC, participated in the field investigation.

As required by NDAC 69-05.2-08-13-1, before applying for a permit to conduct operations within a valley holding a steam, or in a location where the adjacent area includes any stream, the applicant shall either affirmatively demonstrate the presence of an alluvial valley floor, or submit the results of a field investigation of the permit and adjacent areas. On March 20, 2013 the Coyote Creek Mining Company submitted the *Alluvial Valley Floor Evaluation Report* that was prepared by Dr. Bickel in preparation of a proposed small permit application to be located in the E1/2 SE1/4 of Section 30 and E1/2 NE1/4 of Section 31, T143N, R88W. Permit application NACC-1301 will consist of approximately 84 acres and will be the location of the Coyote Creek Mine shop/office complex and dragline erection site. An additional permit application for a much larger mining area is expected to be submitted in the future and the AVF Evaluation Report study area encompasses the NACC-1301 permit area as well as the proposed future permit application area that is anticipated to incorporate approximately 10,000 acres. The AVF Evaluation Report study area includes portions of the major drainages to the Knife River consisting of Brush Creek, Coyote Creek, Mud Creek and other smaller tributary drainages to the Knife River within the evaluation area.

The purpose of the PSC field review was to evaluate stream characteristics, vegetation, evidence of subirrigation, flood irrigation and other land uses at stream valley sites contained within the Coyote Creek Alluvial Valley Floor Evaluation Report study area. As depicted on attached Figure 1, six stream valley sites within the Knife River drainage basin were investigated during the field review. These six sites were chosen for investigation because they contained unconsolidated stream laid deposits (alluvial flood plains/terraces) holding a stream or streams and/or contained adjacent tracts presently being used as cropland and/or hayland. Undeveloped rangeland adjacent to streams is not candidate as alluvial valley floors.

The Office of Surface Mining Reclamation and Enforcement (OSM) *Alluvial Valley Floor Identification and Study Guidelines*, as well as North Dakota Century Code Chapter 38-14.1-02(1) defines an alluvial valley floor as "the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of sediment from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation, and windblown deposits." As described in the OSM Guidelines, legislative, judicial, and administrative interpretation of alluvial valley floors indicate that the water availability criteria are met if: (a) water is available by surface-water irrigation or subirrigation and is being or has successfully been used to enhance production of agriculturally useful vegetation; or (b) surface water is available in sufficient quantities to support agricultural activities. The term "flood irrigation" means natural flood overflow or irrigation using surface water in the methods typical for a given region, and the term "subirrigation" is understood to mean the supply of water to plant roots from an underlying alluvial ground-water system such that the vegetation is more productive than in other areas and that the vegetation continues to grow during the moisture-stress portion of the growing season. The OSM Guidelines also notes that the water availability criterion excludes areas that could be developed for subirrigation; e.g., by establishing deep rooting alfalfa to tap ground water not presently used by native vegetation.

Figure 1 shows the AVF Study Area boundary comprising approximately 33,000 acres outlined in black. The April 30, 2013 GPS point track log of the field investigation route is shown in red. Sites 1-5 are all located near or adjacent to the Knife River and several of those sites are at locations where tributary drainages to the Knife River confluence. Site 6 is located at the southern end of the study area boundary and represents the confluence location of Beaver Creek and Coyote Creek. Photographs of the Sites and additional Site descriptions are described below. As depicted in the attached photographs, the perennial Knife River and all of the ephemeral and intermittent streams inspected that confluence with the Knife River within the AVF study area are substantially incised. Cut banks along the Knife River and its tributaries range from about 12-40 feet in height above the stream channels. No evidence of subirrigation was observed during the field investigation. However, the AVF Evaluation report sites two small tracts of rangeland having soils indicative of potential subirrigation located within dead loops of the Knife River in portions of the N1/2 of Section 14 and the NW1/4 of Section 21, T143N, R89W.

As noted below, Site 3 depicts a cropland tract in which spreader dikes have been constructed to divert surface water flow from two unnamed (assumed ephemeral) tributaries to the Knife River. This site represents two stream channels that do not appear to be unconsolidated stream laid deposits holding a stream. The streams however, do appear to border alluvial deposits of the Knife River and that area of floodplain/terrace has been developed for artificial flood irrigation by construction of a spreader dike system. The unnamed ephemeral streams providing the surface water for the spreader dike system cannot by definition be classified as AVF. At the conclusion of the field review, it was the general consensus of the PSC inspectors that the stream valleys at Sites 1 through 6 located within the AVF Evaluation Report study area do not meet the criteria of an AVF for flood irrigation and subirrigation defined by NDAC 69-05.2-08-13-2(b). The two small tracts of possible subirrigation depicted in the report and the 43-acre spreader dike flood operation described would not represent "productive lands that form the backbone of the agricultural and cattle ranching economy of the area" (OSM Study Guidelines, page II-7).

FIGURE 1

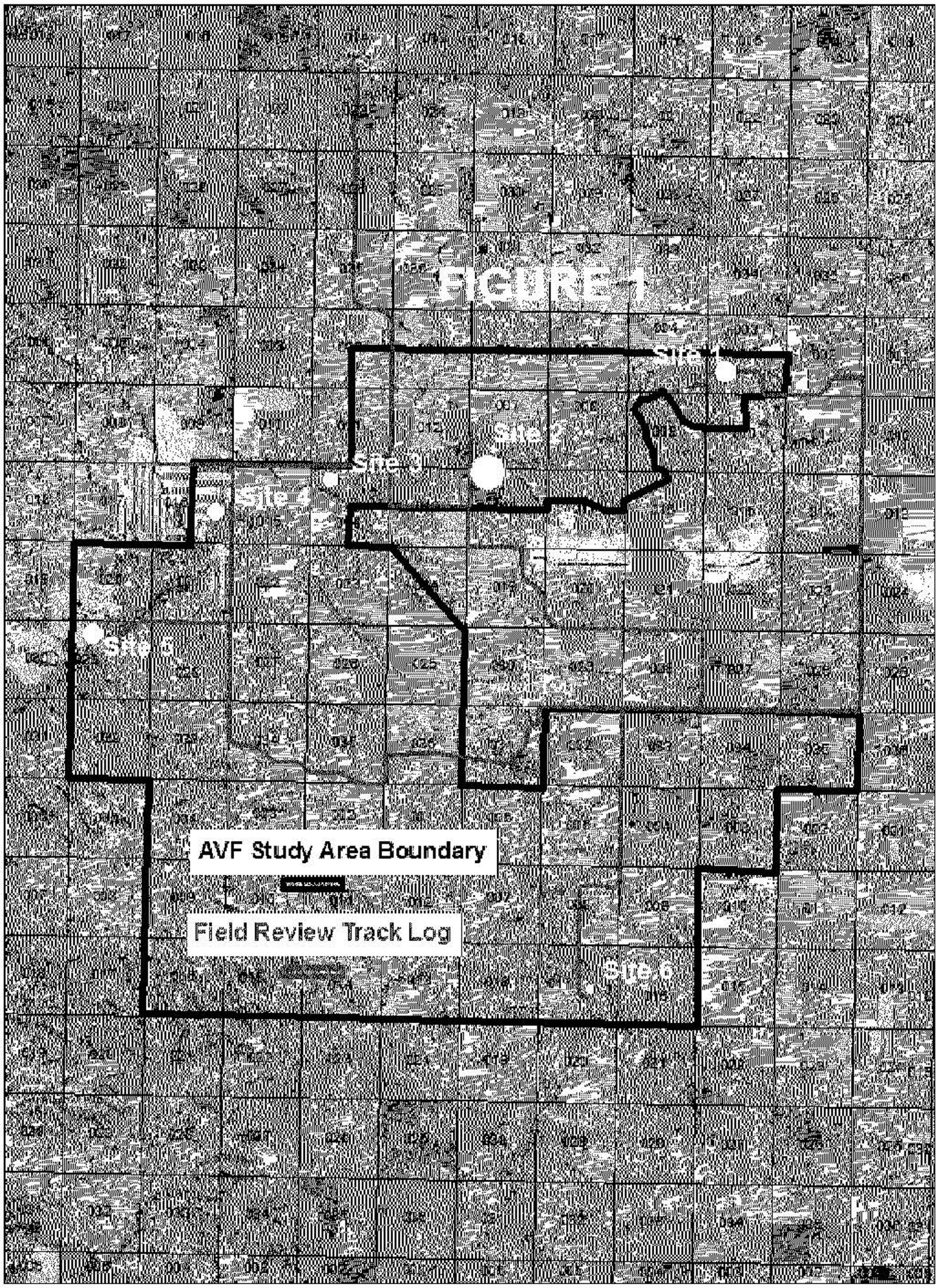
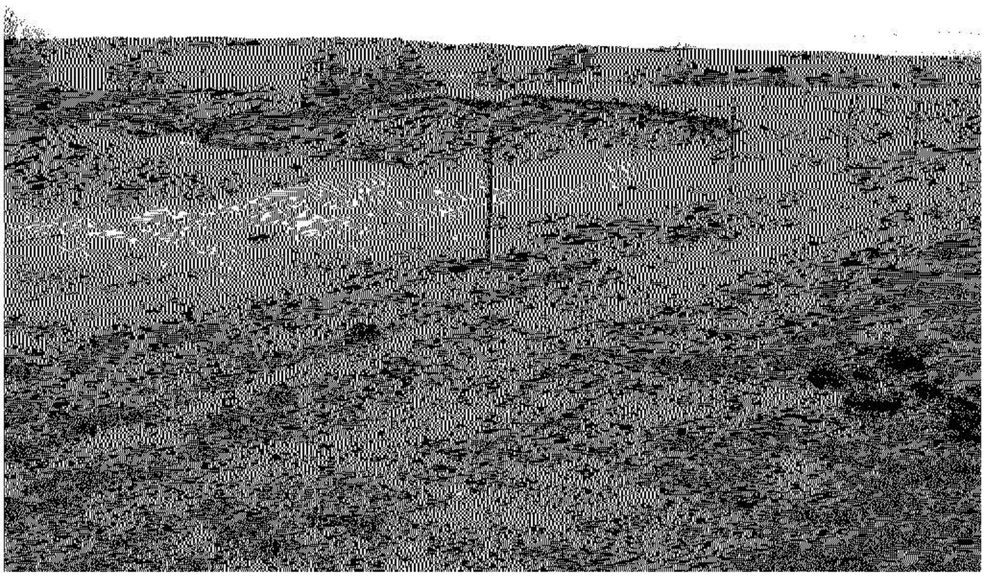


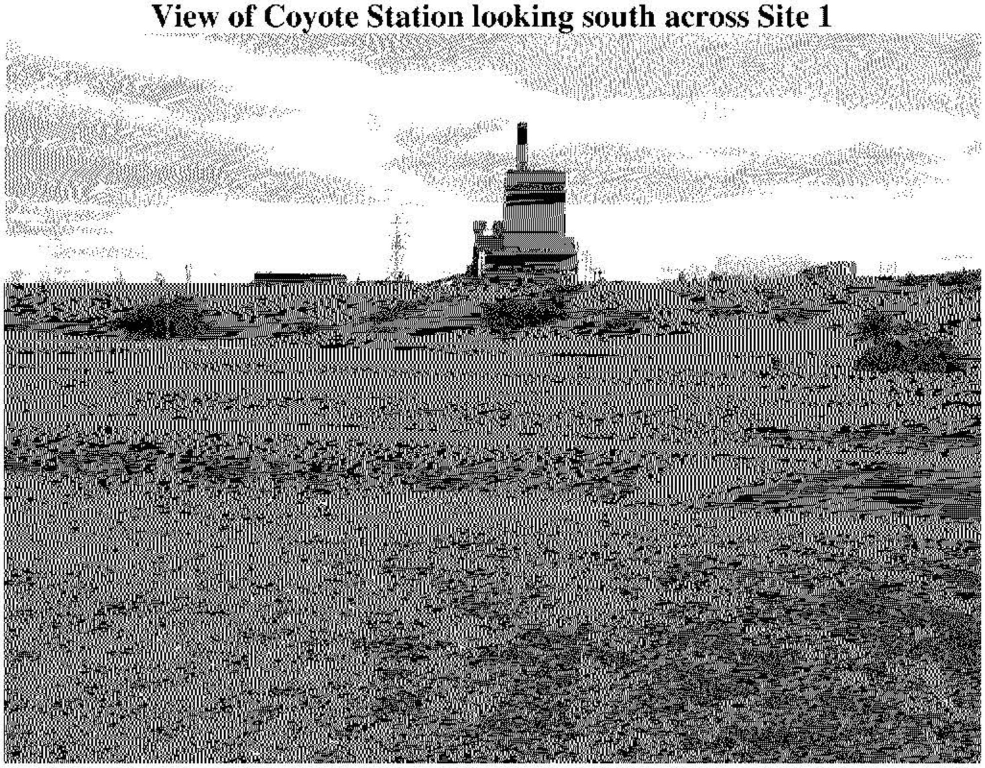
FIGURE 1
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
AVF Study Area Boundary
Field Review Track Log

Site 1 is generally located at the northeastern corner of the study area and represents a 160-acre tract of cropland at the west end of the tract and hayland at the east end of the tract adjacent to, and on the south side of the Knife River where the Knife River leaves the AVF study area. This particular site is located within the S1/2 of Section 3, T143N, R88W approximately 1 mile down-gradient of the confluence of Brush Creek and Knife River.

View of Knife River looking northwest from Site 1

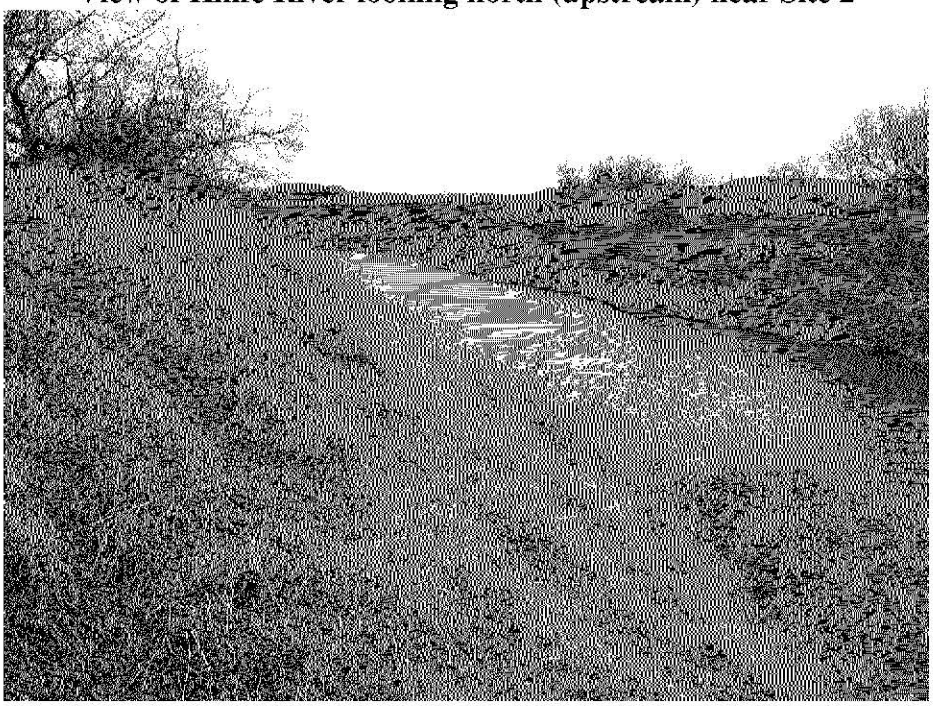


View of Coyote Station looking south across Site 1



Site 2 represents two cropland tracts that are irrigated with separate center pivot sprinkler irrigation systems, each tract encompassing approximately 80-90 acres. The southern-most irrigated field is located wholly within the NW1/4 of Section 18, T143N, R88W and the northern-most irrigated field is located within the SW1/4 of Section 7 and NW1/4 of Section 18, T143N, R88W, and within the SE1/4 of Section 12 and NE1/4 of Section 13, T143N, R89W. Both irrigation systems are supplied by alluvial ground water from the Knife River Aquifer and the well is located north of the tracts about 250 feet from the Knife River in the SW1/4 of Section 7, T143N, R88W.

View of Knife River looking north (upstream) near Site 2

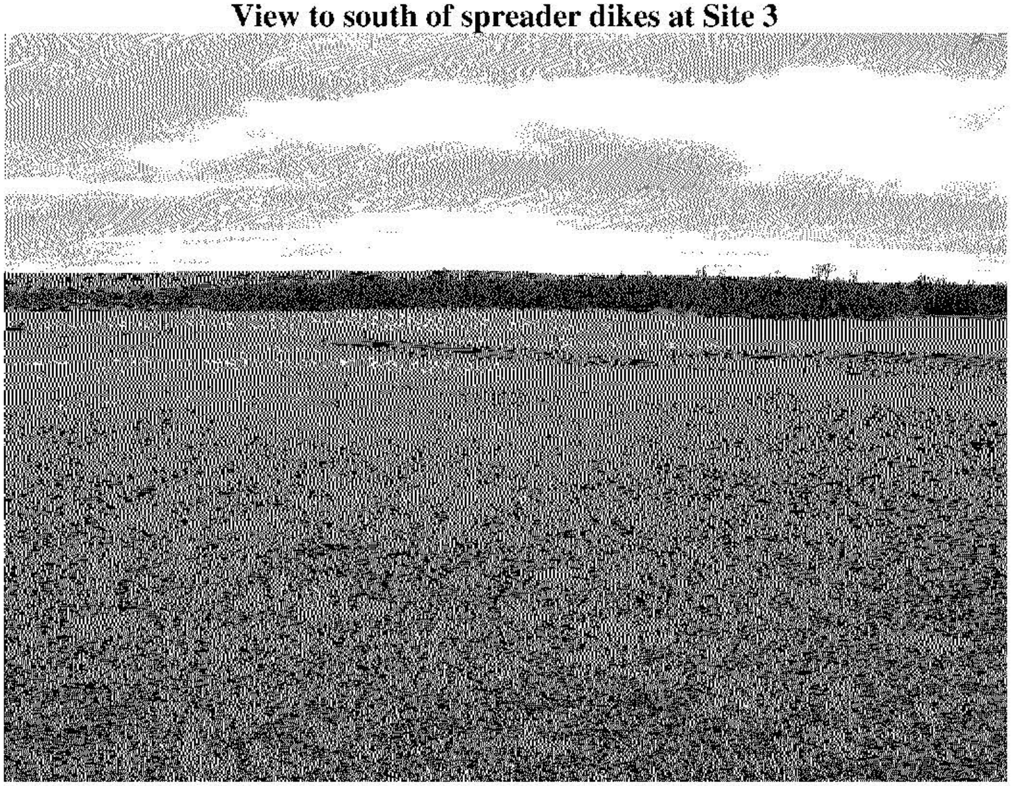


View to north of irrigated cropland (corn) within Site 2

Site 3 depicts a an approximate 40-acre cropland tract that has been developed into a spreader dike system and is situated between two unnamed tributaries to the Knife River in the NW1/4 of Section 14, T143N, R89W. Within the 40-acre tract there appeared to be approximately a half-dozen spreader dikes constructed within the tract to divert surface water runoff from the two unnamed tributaries for artificial flood irrigation. The cropland tract appeared to be located on a floodplain within an abandoned oxbow/meander loop of the Knife River.

Culvert gate valves and stops within stream channel of north tributary at Site 3

View to south of spreader dikes at Site 3



Site 4 is a series of cropland tracts located along the west side of a bridge crossing of the Knife River along 69th Ave. SW within the W1/2 of Section 15, T143N, R89W. Approximately 1400 acres of cropland tracts are located adjacent to, and to the north and west of Site 4.

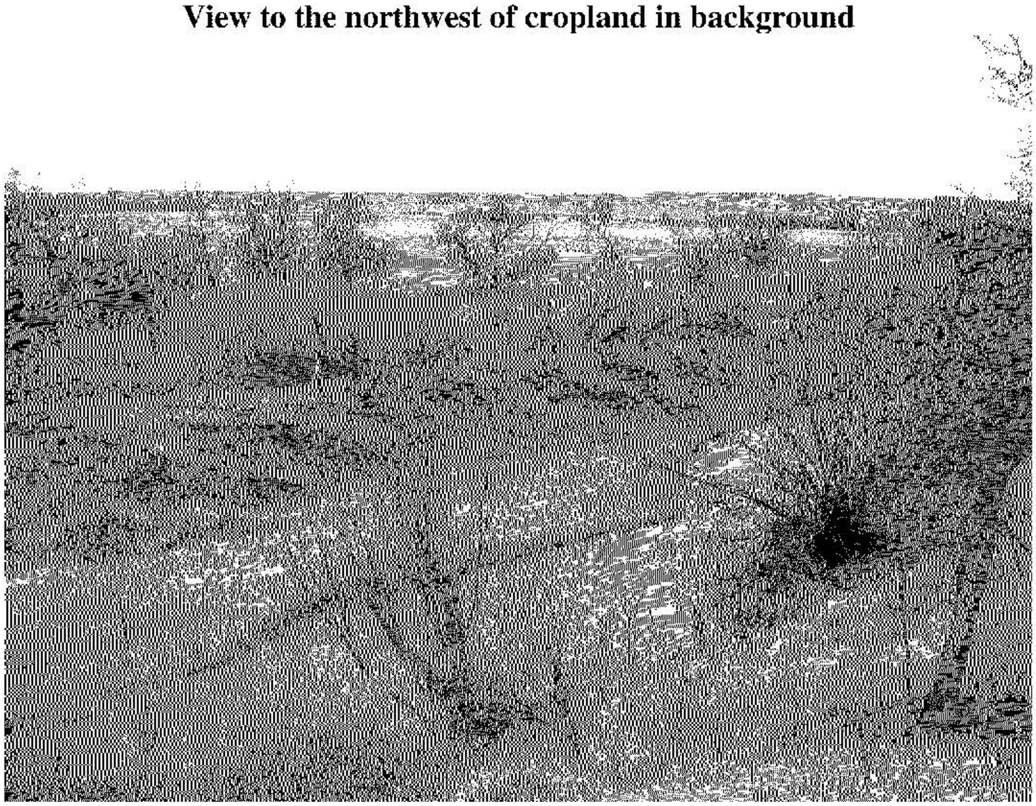
View of Knife River from bridge crossing looking upstream to northwest of Site 4

View to northwest of cropland adjacent to Knife River at Site 4

Site 5 depicts cropland tracts north and west of the confluence of Mud Creek and the Knife River within the NW1/4 of Section 29, T143N, R89W.

Confluence of Mud Creek and Knife River at Site 5
View is toward the west (Mud Creek at bottom center of photo)

View to the northwest of cropland in background



Site 6 depicts cropland at the confluence of Beaver Creek and Coyote Creek at the furthest southeastern portion of the AVF study area in the E1/2 and portions of the W1/2 of Section 17, T142N, R88W.

Confluence of Beaver Creek and Coyote Creek at Site 6
View is toward the southwest (upstream of Coyote Creek)

Cropland to the north of Beaver Creek/Coyote Creek confluence at Site 6

EXHIBIT
Coyote Creek
14

Public Service Commission
State of North Dakota

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August 26, 2013

Ms. Sarah Flath
Senior Environmental Specialist
Coyote Creek Mining Company, L.L.C.
2000 Schafer Street, Suite D
Bismarck, ND 58501-1204

Dear Ms. Flath:

The Reclamation Division has completed its review of the Alluvial Valley Floor Evaluation Report for drainage systems located within and adjacent to North American Coal Corporation's proposed Coyote Creek Mine in Mercer County, North Dakota. The Coyote Creek Mining Company's Alluvial Valley Floor Evaluation Report provides geologic, hydrologic, soils, vegetation and landuse data and information covering an area of approximately 33,000 acres and includes the 84 acres in Permit Application No. NACC-1301 which is currently under review by the Reclamation Division. Additionally, the AVF evaluation report area incorporates lands proposed for a future larger mining permit (NACC-1302) that is expected to contain approximately 10,000 acres.

Based upon review of the information required by NDAC 69-05.2-08-13 in your March 20, 2013 submittal and subsequent updates to the report with your August 20, 2013 submittal, in addition to other information obtained during a field investigation conducted by members of the Reclamation Division on April 30, 2013, we have determined that those areas of the AVF evaluation report study area do not constitute alluvial valley floors as defined by NDCC 38-14.1-02 and as described in the 1983 OSM Alluvial Valley Floor Identification and Study Guidelines. The study area includes lands located adjacent to Brush Creek, Beaver Creek, Mud Creek, Coyote Creek and Knife River as well as their contributing drainages included within the AVF Study Area Boundary of the report that is provided as Exhibit A.

Coyote Creek Mining Company's August 20, 2013 version of the Alluvial Valley Floor Evaluation Report is approved as submitted. Since track changes of new and updated information were not incorporated into the August 20th version of the report, no additional or cleaned-up CD's of the evaluation report will need to be submitted to us.

As required by the Reclamation law and rules, please incorporate a copy of this determination letter into the applications for Permit NACC-1301 and NACC-1302.

If you have any questions, please contact this office.

Sincerely,

James R. Deutsch
Director
Reclamation D

Minedata/CoyoteCreek/GenCorr/2013/AVF_det_ltr_8-26-13

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CR Exhibit 51 Hrg Exhibit CV 4

EXHIBIT
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4

PUBLIC SERVICE COMMISSION
Reclamation Division
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Memorandum

TO: Permit NACC-1302 Correspondence File

FROM: Bruce Beechie, Hydrologist – Reclamation Division BB
Randy Kowalski, Environmental Scientist – Reclamation Division RK

DATE: October 15, 2014

SUBJECT: **Cumulative Hydrologic Impact Assessment (CHIA) of Coyote Creek Mining Company - Permit NACC-1302, Mercer County, North Dakota**

SUMMARY

The Reclamation Division of the Public Service Commission has made an assessment of the probable cumulative hydrologic impacts of all anticipated mining in the area as required by NDCC 38-14.1-21-(3)(c) and the Commission finds that mining and reclamation operations proposed with Coyote Creek Mine Permit NACC-1302 have been designed to minimize disturbance to the hydrologic balance within the permit area and prevent material damage to the hydrologic balance outside the permit area.

As specified in NDCC 38-14.1-14(1)(o), this assessment was based in part, on review of the determination by the permit applicant of the probable hydrologic consequences (PHC) of the mining and reclamation operations, both on and off the mine site, with respect to the hydrologic regime, quantity and quality of water in surface and ground water systems and particularly upon water availability. This assessment incorporates the permit applicant's hydrologic reclamation plan (HRP) as required by NDAC 69-05.2-09-12(2), that specifically addresses any potential adverse impacts identified in the probable hydrologic consequences determination and contains the preventative and remedial measures for those impacts.

Coyote Creek Mine Permit NACC-1302 is located on 8091.51 acres within portions of Sections 6 and 7, T142N, R88W; Sections 1, 2, 3, 11, and 12, T142N, R89W; Sections 19, 30, and 31, T143N, R88W; Sections 23, 24, 25, 26, 27, 34, 35, and 36, T143N, R89W, of Mercer County. The permit area includes an 84.24 acre tract on the east side of Coyote Creek in Sections 30 and 31, T143N, R88W that was initially permitted as Permit NACC-1301 as a site to erect the dragline and contains the shop/office facilities that will be used in support of mining operations.

55 RC-13-850 Filed 01/23/2015 Pages: 19
Exhibit CV-4
Baumstark Braaten Law Partners - Attorneys for Casey Voigt
Filed Clerk of District Court
6/29/2015 4:14:54 PM
Burleigh County, ND

The Beulah Mine is operated by Dakota Westmoreland Corporation and is located on land just to the east of this permit. However, coal removal operations conducted at the Beulah Mine and Coyote Creek Mine are physically separated by Coyote Creek. The Coyote Creek Mine will replace most of the lignite coal production from the Beulah Mine beginning in 2016. Permit NACC-1302 is located adjacent to the southwest corner of Dakota Westmoreland's active mining Permit KRSB-8603 at the Beulah Mine. The Reclamation Division approved Revision No. 27 to Permit KRSB-8603 in 2014 that added approximately 900 acres contiguous with, and to the south of the Beulah Mine's active permit area. The planned mining and reclamation disturbance associated with the Beulah Mine along the west side of Permit KRSB-8603 is located within a subwatershed that enters the Coyote Creek Mine permit area and Coyote Creek proper in the SW1/4 of Section 19, T143N, R88W. Any potential impacts to this drainage are described in Permit KRSB-8603 and the accompanying CHIA for the permit area. No significant cumulative hydrologic impacts as a result of combined Beulah Mine and Coyote Creek Mine operations are foreseen.

As shown in **Figure 1**, the area of possible impact evaluated, defined as the Cumulative Impact Area and covered by this assessment includes that portion of Mercer County, North Dakota within the drainage basin of the Knife River from Coyote Creek downstream to the confluence with Antelope Creek east of Hazen. This area includes all existing and foreseeable operations at the Coyote Creek Mine and adjacent Beulah Mine, and all groundwater and surface water systems which may be logically impacted by those operations. Possible impacts are more reasonably limited to the Coyote Creek and Knife River drainages which include the permit and adjacent areas. Much of the assessment necessarily focuses on potential impacts within the permit and adjacent areas.

DISCUSSION

Material Damage by mining is here defined for the purpose of cumulative impact assessment as permanent and unmitigated degradation of the hydrologic environment outside permit areas, in excess of regulatory standards, which significantly affects beneficial economic uses of water resources, including maintenance of environmental and wildlife values.

The hydrologic standards used to assess the probable cumulative impacts of mining in this area and North Dakota coal producing areas in general are derived from four sources: 1) the baseline state as documented in all permit applications and in the county ground water study (the Mercer County Ground Water Study, N.D. Geol. Surv. Bull. 56, Parts I-III consisting of Geology, Ground Water Basic Data, and Ground Water Resources), 2) the probable hydrologic consequences and hydrologic reclamation plan in all relevant permits, 3) NDAC 69-05.2-16 Performance Standards - Hydrologic balance, and 4) NDAC 33-16-02.1 Standards of Quality for Waters of the State. These sources also provide the performance standards and environmental parameters which will be used to evaluate final bond release applications for individual tracts of permitted land.

The State Department of Health - Standards of Quality for Waters of the State establishes parameter-specific standards for water quality in surface and ground water, and NDAC 69-05.2-

16-04(1)(g) makes them part of the hydrologic protection performance standards for mining operations. These standards are consistent with the federal Safe Drinking Water Act of 1974 and the established North Dakota anti-degradation policy, and they accommodate situations where preexisting water quality exceeds established standards. The rules generally require that discharges into the waters of the state not cause concentrations of substances in the receiving water body to exceed the established or preexisting limits. Ground water classifications and standards are defined as well as aquifer exemption requirements under North Dakota's underground injection control program that was established under the Environmental Protection Agency's Safe Drinking Water Act and is now regulated in North Dakota by the State Health Department.

GENERAL HYDROGEOLOGY

The permit area is located within the Missouri Plateau Section of the Great Plains Physiographic Province which is characterized by glaciated terrain of moderate relief, stream dissected bedrock, ephemeral and intermittent streams, and the intermittent to perennial Coyote Creek that drains to the Knife River and ultimately, the Missouri River. Over much of this portion of the Knife River drainage, ground moraine is thin, usually less than 20 feet thick but up to about 45 feet thick in places, glacial features are few and bedrock topography controls landforms away from larger stream channels. Portions of the permit area are located within the valley and upland breaks of Coyote Creek. Coyote Creek enters the southeastern corner of the permit area in the NE1/4 of Section 7, T142N, R88W and flows north a distance of approximately 5 miles along the eastern edge of the permit area. The confluence of Coyote Creek and the perennial Knife River is located in the SE1/4 of Section 14, T143N, R89W, approximately 1.5 miles northwest of where Coyote Creek leaves the permit area. At its widest point within the permit area, the Coyote Creek valley is approximately 0.5 miles wide. Most of the permit area is an elevated upland that prominently rises more than 200 feet above the Coyote Creek floodplain elevation and in some areas rises to more than 260 feet above the flood plain.

The geologic formations of significance to the study area are the Quaternary, Coleharbor Group of Pleistocene age sediments which represent glacially constructed and modified landforms and the stratigraphically lower Sentinel Butte Formation, which constitutes the bedrock stratigraphic unit of the permit area. The overburden lithology of the Coleharbor Group includes unconsolidated glacial till/drift (pebble-loam) with occasional glacial erratics, gravel, sand and clay. Glacial outwash channels filled with variable depths of Pleistocene age till and Holocene age alluvium characterize the drainage channels of Coyote Creek and the Knife River. Alluvium in the Coyote Creek channel generally ranges between 20-25 feet thick in places and alluvium of the Knife River channel varies between 60 or 70 feet nearest the permit area up to about 240 feet east of Beulah. The developed flood plain and terrace system along Coyote Creek within the permit area will not be mined-through, although two crossings will be constructed over Coyote Creek by the operator to provide access to the mine on the east side of Coyote Creek with the shop/office facilities that are located on the west side of Coyote Creek.

The Sentinel Butte Formation is a terrestrial/non-marine deposit of Paleocene age sediments and consists of interbedded silts, clays, sands, as well as the lignites of the assessment area.

Overburden characteristics of the Fort Union Group sediments as well as the overlying glacial materials are variable throughout the Williston Basin sedimentary sequence and similar to those characteristics encountered within the permit area. However, in reviewing the data, some generalities can be made. Values of pH are fairly uniform ranging between 7 and 9 and pH tends to increase slightly with depth. Values of electrical conductivity vary considerably among samples spatially and with depth. Higher ratios of sodium adsorption ratio (SAR) were encountered frequently, although low SAR values were common in all depths to coal in several samples. As expected, overburden texture varied from relatively coarse loamy sands to fine textured clays. Generally, overburden properties varied with depth and are similar to overburden characteristics at other North Dakota coal mines. Underlying the bedrock Sentinel Butte Formation throughout the permit area is the Paleocene Bullion Creek Formation. There are three general hydrostratigraphic units of significance in the general mine plan area; Quaternary alluvium along Coyote Creek that is composed of silts, sands and gravels; the Upper Beulah lignite seam that will be mined by the Coyote Creek Mining Company; and a lower lignite seam which is termed the Lower Beulah 3 lignite. As described later, other thin lignite seams above the Upper Beulah serve as localized minor hydrostratigraphic units that serve as discharge zones as seeps and springs along major drainages within the permit.

The uppermost geohydrologic unit in the area is the Pleistocene, Coleharbor Group of Wisconsinan age consisting mostly of silty-clay glacial till, but with occasional lenses of sand and silty-sand that may locally contain nominal quantities of ground water as perched aquifers and is not significant to the hydrologic regime within the permit area. Pebble-sized to boulder-sized igneous and metamorphic rocks, typically granites and gneisses are frequently encountered in the glacial till overburden and the presence of Pleistocene age glacial erratics are common on the soil surface of rangeland throughout the permit area. Infrequent, hard cemented sedimentary sandstone ledges and/or concretions averaging about 2 feet thick have been identified in the Sentinel Butte strata below the Coleharbor Group sediments through Coyote Creek's drilling program within portions of the permit area. Cemented sandstone and sandstone/mudstone concretions up to 20 feet thick are typical in Sentinel Butte sediments; however, deposits of those thicknesses have not been encountered within the permit. The use of explosives is not planned at Coyote Creek Mine and heavy equipment will likely be used to break up any cemented sandstone deposits or concretions encountered during mining operations.

Coyote Creek Mining Company has identified a total of 27 separate and distinct, named coal seams within the permit area. Many of these attain thicknesses of only 1-2 feet and are insignificant in terms of water resources and insignificant in terms of coal production regarding the proposed mining operation. Thirteen of these coal seams have had their elevations correlated and the cropline locations (outcrops and subcrops) of these prominent seams are mapped and those locations are provided in the permit. Major coal seams identified within the permit area include in descending order; Harnisch, Twin Buttes, Schoolhouse, Upper and Lower Beulah, Jim Creek, Antelope Creek, and other significant rider and kicker seams associated with those named coal beds. The Upper Beulah Lignite is the only coal seam planned for extraction within the permit area although Coyote Creek Mine has not ruled out potentially removing localized thicker lignites higher in the stratigraphic column (Twin Buttes or Schoolhouse) when encountered and deemed economically feasible to mine. The Upper Beulah generally ranges between 9 to 12 feet in thickness and averages about 11 feet thick within the permit area. The NACC-1302 permit area encompasses approximately 8,100 acres and the estimated coal production rate is expected to average 2.3 million tons/year, and the life of mine coal production from the permit area is estimated at 58.7 million tons through 2040. Overburden thickness to the top of the Upper Beulah averages about 100 feet in most areas of the permit except near outcrop areas, and increases to about 160 feet thick in some areas within the central and southern portions of the permit area. Strike and dip of the Upper Beulah is variable with a general dip from northwest to southeast in northern portions of the permit area and away from central portions of the permit area toward the croplines. The Upper Beulah reserve outcrops within the permit area along the northern and eastern portions of the permit and both outcrops and subcrops in southern portions of the permit area. Small scale structural features are observable on the Upper Beulah Structural Contour Map as provided in the permit and may produce localized grade reversal to the dip and strike. The Upper Beulah is classified as Lignite-A, with an average in-place heat value rating of 6,950 BTU/lb., an average of 36% moisture content, 7.5% sodium, 1% sulfur, and 7.6% ash content. Quality of the weathered coal along croplines (Leonardite) is considered poor and will not be mined.

Coal seams above the Upper Beulah include the Harnisch, Twin Buttes, and Schoolhouse. Harnisch and Twin Buttes lignites are present as localized deposits in higher elevation areas of the permit and range in thickness from 1 foot to about 6 feet thick. The Schoolhouse lignite is prominent throughout much of the permit area and ranges in thickness from 1 foot to about 3.5 feet. In places, all of these higher elevation coal seams may serve as local ground water sources with discharge zones as seeps and springs along croplines and where mined, those seeps and springs will be destroyed.

Several named coal seams and splits of those coal seams are located below the Upper Beulah. The Lower Beulah 3 seam averages about 20-25 feet below the Upper Beulah and is generally about 1-2 feet thick. The Lower Beulah 3 is a confined aquifer and in most areas of the permit is deemed the next viable water-bearing unit below depth of mining, and numerous ground water monitoring wells have been screened into this zone. Major lignite beds below the Lower Beulah 3 in descending order are major splits of the Lower Beulah 3 followed by the Jim Creek, Antelope Creek, Kinneman Creek, Hagel, and Tavis Creek beds. Correlation and seam naming convention for the Coyote Creek Mine general follows the seam correlation and names of Groenewold, et al. (1979) *"Geology and Geohydrology of the Knife River Basin and Adjacent Areas of West-Central North Dakota"*; however, one notable exception is that the Lower Beulah 3 bed and its splits are correlative with the Spaer bed in *Groenewold, et al. (1979)*. The nearby Beulah Mine uses the Spaer bed nomenclature for this coal seam as provided by Groenewold, et al and the Coyote Creek Mine refers to this seam as the Lower Beulah 3.

The assessment area is an established lignite mining district that includes abandoned surface and underground mines as well as active, large scale surface mines including the nearby Beulah Mine operated by Dakota Westmoreland Corporation. The western portion of the Beulah Mine drains to a tributary that empties into Coyote Creek at the northeast end of Permit NACC-1302 on the east side of Coyote Creek in the SE1/4 of Section 30, T143N, R88W. The Beulah Mine represents the only active mining within the assessment area south of Knife River at this time.

The Freedom Mine operated by the North American Coal Corporation, is the only active surface mining operation located north of the Knife River and is located about 8 miles north of the permit area. The PSC Abandoned Mine Lands Division lists 24 inactive lignite mines in the assessment area. All but 5 of these were very small mines that operated for local use prior to 1950 and had maximum production of less than 1,000 tons per year. At the larger old sites with underground workings, collapse has caused localized safety problems. The Dakota Collieries Mine was wholly a surface mine started in 1922 and the predecessor to the Indian Head Mine. The Dakota Star, later Truax-Traer, Mine operated entirely as a strip mine from 1940 to 1967, and this old mine is included in or adjacent to the area under permit for the Freedom Mine. Evidence from over 30 years of hydrologic analysis and monitoring by mines and power plants in the assessment area indicates that effects of these old mine sites on surface and ground water systems are localized and not significant factors in the hydrologic regime. The only abandoned coal mine identified within Permit NACC-1302 is a small .5-acre surface cut located at the base of the western breaks to Coyote Creek within the SE1/4SW1/4 of Section 30, T143N, R88W and the presence of this feature will have no impact to surface or ground water systems within the permit area or the assessment area.

Agriculture is a significant activity in the assessment area in terms of economic importance and hydrologic impact, but it is a historically established cultural activity and its environmental effects are considered part of the baseline state of the area. The majority of agricultural activity within the NACC-1302 permit area is livestock production on native range; however, crop and hay production make up a minor, yet important component to the total land utilization. The Major Land Resource Area 54 in which Mercer and Oliver Counties are grouped within the 2002 USDA-NRCS inventory system has water erosion of soil from cropland averaging 3.6 tons/acre/year while statewide losses average 2.1 tons/acre/year; however, losses to wind erosion are less than the statewide average. In 1977-1980, the U.S. Geological Survey gaging stations on Spring Creek at Zap and Knife River at Hazen reported mean Total Suspended Solids values of 90.87 and 144.05 mg/l and average sediment discharge loads of .26 and .19 tons/acre/year, reflecting the acreage under cultivation in the contributing drainages. Extensive soil conservation and water quality preservation practices are permit requirements, and all surface water leaving the Coyote Creek Mine and other mining permits in the assessment area must meet NDPDES daily average and maximum total suspended solids values of 35 mg/l and 70 mg/l, respectively.

GROUNDWATER ASSESSMENT

The ground water database for Permit NACC-1302 has been acquired from a total of 83 ground water monitoring wells as depicted in **Figure 2** and these have been monitored for water levels and sampled for water quality since August, 2012. Details of acquiring water level and water quality data in the premine, mining, and postmine setting are outlined in Coyote Creek Mining Company's ground water monitoring plan and are provided in the permit. Previous scientific investigations, ranging from the study of fundamental ground water questions to landowner complaints about specific water wells, surface water bodies, and springs and seeps has served to verify the geologic and hydrologic data which have been acquired by mine operators in North Dakota since the mid-1970's, including the North American Coal Corporation. These data have been compared and used in analysis along with data which have been acquired by diverse, independent sources such as the U.S. Geological Survey, North Dakota Geological Survey, State Water Commission, State Health Department, private well drilling contractors, and consultants performing spring and water well certifications. Close scrutiny of the data and information has found no inconsistencies attributable to careless or improper data acquisition. In addition to technical use, data are periodically audited by the Reclamation Division and Office of Surface Mining, Casper Field Office, for completeness of acquisition and monitoring sites are frequently checked during mine inspections. The Coyote Creek Mine and adjacent area is considered in hydrologic terms to be data rich, attributable to the fact that substantially more ground water monitoring points have been installed than required by regulation.

Mining operations within the general mine plan area will remove the Harnisch, Twin Buttes, and Schoolhouse seams/lignite beds where present, the Upper Beulah seam and all coal stringers and minor water-bearing sand units in the overburden that may contain nominal quantities of ground water as a perched aquifer or saturated zone. In mined-through areas, these lignite seams and all overburden will be replaced with a single pit-bottom spoils saturated zone. Historic data shows that water quality in this saturated zone will show some degree of increased mineralization with total dissolved solids (TDS) concentrations generally 1.5 to 2 times higher than those of waters in the lignites that were mined. The increase will depend on the degree of vertical infiltration and lateral recharge into the spoils. Saturated zones at the base of spoils are not considered groundwater resources because of their uncertain productivity, reduced transmissivity in the short term, and expected lower water quality due to increased soluble salt content, characterized as electrical conductivity or TDS. Geochemical reactions of oxygen with fresh, regraded spoil matrix results in spoil water ionic composition comparable to undisturbed units, but at higher initial concentrations. Over time, water quality in the base of spoils saturated zone will show improvement; however, this process may take years or decades, particularly in areas of low hydraulic heads and transmissivity and is considered an expected consequence of coal removal and reclamation processes in western North Dakota.

Recharge of ground water resources in western North Dakota is infrequent and only occurs during spring runoff or intense precipitation events since potential evaporation exceeds precipitation over most of the year. Plant uptake is a significant consumer of precipitation during the growing season which limits the amount of water that infiltrates to greater depths. However, low-gradient ephemeral and intermittent drainages and wetlands tend to be effective groundwater recharge areas because of snowmelt concentration and retention, while well-drained uplands are less effective recharge sites. Tracts of reclaimed spoil will likely have increased porosity and infiltration capacity compared with the soils and parent materials they replace due to the destruction of orderly, fine-grained and semi-lithified sediment encountered in the stratigraphic column, normally considered to be aquitards. The Center Mine, which is operated by BNI Coal, Ltd., and is located less than 30 miles east of Coyote Creek Mine, was one of several research sites in the 1980's that confirmed these observations on mined areas. Ground water level rebound and maintenance of saturated zones at the base of reclaimed spoils and within water levels in units below mining is further evidence of adequate recharge occurring in the post-mining landscape. Groundwater recharge after mining should approximate the pre-mining recharge rate since land use, runoff, retention and infiltration on the post-mining topography will approximate that of the pre-mine topography. The planned construction and reconstruction of post-mining stock ponds, wetlands, drainage channels, linear catchments and other developed water resources will enhance ground water recharge to the base of spoils. Plans and design details regarding wetlands and other developed water resources, along with all surface water management reclamation plans, are incorporated into the permit. Plans are in the permit for placement and construction of base of spoils post-mining ground water monitoring wells to properly monitor recharge in the mined spoils block as well as in the Lower Beulah 3 hydrostratigraphic unit, and several other deeper units.

The Upper Beulah coal seam and all of the lignite hydrostratigraphic units within the permit area, under natural conditions, typically contains sodium-sulfate to sodium-bicarbonate type waters with total dissolved solids ranging from about 700 mg/l to over 3200 mg/l. Values of pH are predominantly alkaline, but generally range from 6.5 to 8.5 and sodium adsorption ratios (SAR) tends to be high. Sodium adsorption ratios of the Lower Beulah 3 Lignite, Upper Beulah Lignite, and higher lignite hydrostratigraphic units have a median SAR value of about 40. Below the Lower Beulah 3, the Lower Jim Creek, Antelope Creek, Kinneman Creek and Hagel lignites have SAR values ranging from low to high. Data collected from monitoring wells installed in alluvium adjacent to Coyote Creek typically contain sodium-sulfate type waters with TDS ranging from 1880 mg/l to 2870 mg/l and a median value of 2025 mg/l.

The shallow ground water flow systems in the permit area which includes the Upper Beulah seam and Lower Beulah 3 seam can best be described as sluggish. Groundwater movement in the Coyote Creek Mine area is generally downward through fine grained silts and clays which recharge the lignites and deeper sands. Ground water movement and hydraulic gradient within the lignites in the permit area is variable, but generally laterally toward discharge zones. Hydraulic head data indicate recharge to the Upper Beulah hydrostratigraphic unit is from interior portions of the permit, but data also indicate significant contributions from off-permit upland areas to the southwest in Sections 11 and 12, T142N, R88W. Ground water of the Upper Beulah is under confined conditions in southern portions of the permit area nearest the recharge areas with hydraulic heads exceeding 25 feet in places, and transitions to unconfined or water table conditions along the west and east sides of the permit toward discharge zones associated with major drainages in the area. Continuing to the north, head values further decline to nearly dry or dry conditions within the Upper Beulah.

Potentiometric contours of the Lower Beulah 3 lignite show similar hydraulic gradients to the Upper Beulah lignite. The Lower Beulah 3 lignite is considered the next viable hydrostratigraphic unit below depth of mining and recharge areas are concentrated in central and southern portions of the permit area and discharges are toward major drainages to the north, west, and east. Movement of ground water within the topographically higher Schoolhouse bed is generally from east to west across the permit area. Hydraulic gradient of ground water within the stratigraphically lower Jim Creek and Antelope Creek lignites is similar to head gradients of ground water in the Upper Beulah with prominent recharge areas being located in upland areas to the south of the permit area. The Harnisch lignite, where it occurs within the permit, is generally dry and not considered a hydrostratigraphic unit in the area. Several monitoring wells are screened within the Twin Buttes lignite and monitoring data indicate ground water to be under confined conditions in those areas monitored. Other hydrostratigraphic units monitored include the Upper and Lower Kinneman Creek lignites and the Hagel Lignite. Both of these hydrostratigraphic units are located substantially deeper than the Upper Beulah and all other monitored units; however, several wells are monitoring these units at locations near the Knife River and Coyote Creek as these lignites occur below the elevation of those alluvial aquifers.

Significant alluvial hydrostratigraphic units within the permit and adjacent area include the alluvial aquifers of the Knife River and Coyote Creek. Ground water monitoring wells near the Knife River indicate about 70 feet of alluvium with about 40 feet of hydraulic head. Nested wells screened in differing elevations of the alluvial column indicate unconfined or water table conditions of the alluvial aquifers. Potentiometric gradient of the Knife River alluvial aquifer which is located a significant distance from the permit, has not been measured and is logically assumed to flow downstream. Alluvial ground water along the valley of Coyote Creek is also under unconfined conditions with hydraulic heads in the range of only 6 to 8 feet. Multiple monitoring wells along the course of Coyote Creek confirm that potentiometric gradient of the alluvial aquifer follows the stream gradient to the north, as could be expected. Baseline static water level data collected in 2012 and 2013 from Coyote Creek alluvial ground water monitoring wells CM12-08B, CM12-20B & 20C compared with Coyote Creek surface water elevation indicates Coyote Creek to be a losing stream. Static water levels in Coyote Creek alluvium average 8-9 feet below the surface water elevation of Coyote Creek, meaning that surface water flow recharges, or supplies the alluvial aquifer with water. Throughout the reach of Coyote Creek within the permit, the Antelope Creek lignite is a buried subcrop and through much of the course rides directly below or nearly so, of the Coyote Creek alluvial aquifer. Elevation of the Upper Beulah lignite to be removed by mining is above the Coyote Creek flood plain and contributes minimal quantities of water in support of base flow.

Slug test analyses of permit and adjacent ground water monitoring wells were attempted on 77 of the 83 monitoring wells in determination of aquifer hydraulic properties. Of those 77 wells tested, only 52 had sufficient water levels in which to conduct the single well response tests. Hydraulic conductivities of the Coyote Creek and Knife River alluvial aquifers ranged from .4 feet/day to 1.2 feet per day and transmissivity ranged from 4.6 square feet/day to 20.5 square feet/day, with the highest transmissivity value coming from the Knife River alluvial aquifer due to increased saturated thickness of Knife River alluvial deposits. Hydraulic conductivities and transmissivity of Twin Buttes and Schoolhouse lignites were highly variable. Hydraulic conductivity values ranged from .001 to 11.93 feet/day and transmissivity ranged from .001 to 47.7 square feet/day.

Hydraulic conductivity of the Upper Beulah was highly variable ranging several orders of magnitude from .001 to 4.37 feet/day with a median value of .027 feet/day. Transmissivity of the Upper Beulah ranged from .007 to 48 square feet /day with a median value of .293. The next lowest hydrostratigraphic unit below the Upper Beulah is the Lower Beulah 3 lignite and both hydraulic conductivity and transmissivity values were much less variable than all other higher stratigraphic units. Hydraulic conductivity ranged from .0004 to .874 with a median value of .005 feet/day. Transmissivity ranged from .001 to 1.75 with a median value of .010 square feet/day. Well response/aquifer testing was also conducted on wells monitoring the Lower Jim

Creek Lignite, Antelope Creek Lignite, Upper and Lower Kinneman Creek Lignites and the Hagel Lignite. Hydraulic testing results for those and all of the units are available in the permit.

Hydraulic conductivity values of the target Upper Beulah coal seam and hydraulic conductivity values of most lignite coal seams in North Dakota are highly variable due to secondary permeability caused by fracture flow. Variable fractures, joints and cleating distribution in North Dakota lignite is generally attributed to coalification processes at the time of deposition, sediment loading and unloading after deposition; and in some cases depending on the specific location-glacial loading and unloading. Shallower coal seams generally trend toward having increased fracture flow development and hydraulic conductivity lending to increased well production or yield, while deeper coal seams generally trend toward reduced fracture development and more sluggish hydraulic conductivity values resulting in reduced yields or production to a well.

Loss of ground water contributions in the form of base flow to Coyote Creek to the east and other ephemeral drainages to Knife River west of the permit is expected to be minimal during the mining process. Ground water produced from active pits will make a small addition to the volume of surface water flows to Coyote Creek and Knife River. The base of the Upper Beulah seam is above Coyote Creek alluvial aquifer grade in all areas with the exception of the extreme southeast portion of the permit area in the E1/2 of Section 6, T142N, R88W, most of which will not be disturbed by mining. Coyote Creek Mine has calculated that the springs along Coyote Creek contribute a total of 0.045 cfs to the flow of Coyote Creek. Adequate ground water monitoring systems in place at all mine permits in North Dakota since the mid-1970's has typically documented an average aquifer drawdown radius of influence from the cone of depression to be about 1000 feet. In those instances where private, in-use water wells are predominantly located down-gradient of coal removal operations and are screened in the target coal seam or a stratigraphically higher water-producing zone, effects of aquifer drawdown may be experienced up to about 1000 feet away and are addressed with replacement options as described in the permit.

Due to inadequate quantity and quality of shallow ground water resources within the permit area and the lack of reliable wetlands and properly-sized stockponds in other areas, an elaborate system composed of wells and pipelines used to deliver water to several stock tanks across the permit and adjacent area has been installed by major landowners Unruh and Voigt to support their livestock operations.

The S. Unruh system is supplied by a nest of three alluvial wells (#1, #2, #3) located ½ mile to the west of the permit in the SW1/4 of Section 22, T143N, R89W. A pipeline system from those wells supplies 12 stock tanks located in portions of 6 sections within the permit area, all located west of County Road 13. Those wells have been certified by Coyote Creek Mining Company and the alluvial aquifer which supplies the wells will not be affected by mining. Depth of the Unruh alluvial wells #1, #2, and #3 are 55, 53, and 44 feet, respectively.

The C. Voigt system is separated into North and South distribution systems. These systems are supplied by water from two separate wells in the deep Cretaceous, Fox Hills aquifer. The North system is supplied by water from the C. Voigt Well #1 that is located in the NW1/4 of Section 25, T143N, R89W, within the permit area and will be mined through. Plans in the permit indicate the well will either be salvaged or replaced. Pipelines from the North system deliver water to 7 stock tanks all located within the permit. The South system is supplied by water from the C. Voigt Well #7 that is located in the SE1/4 of Section 31, T143N, R89W, just south of the Voigt farmstead. This well and pipeline system also supplies seven stock tanks and combined, the North and South systems supply water to portions of 6 sections within the permit area, all located east of County Road 13. This well has also been certified by Coyote Creek Mining Company and the well will not be disturbed. Depth to these Fox Hills wells and the other two Fox Hills wells on Voigt property average about 1300 feet below surface. Coyote Creek Mine is committed to partial and/or ongoing replacement of water resources as mining progresses to allow the landowners and individual producers to maintain full usage of available pasture in support of grazing plans for their livestock operations.

Two center pivot sprinkler irrigation systems owned by the same producer are located ½ mile to the north of the permit boundary in portions of Sections 7 and 18, T143N, R88W, and within portions of Sections 12 and 13, T143N, R89W. It has been observed over the years that the irrigated cropland has generally been planted to row crops, usually corn. The north irrigation system is sized to provide water to an 80-acre circle tract and is located within the floodplain of the Knife River. The south irrigation system is sized to provide water to a 100-acre circle tract and is located along a gentle gradient that is sloping up to the south and away from the Knife River floodplain. One well provides the water supply for both systems and the well is screened in shallow alluvium adjacent to the Knife River and is located within the NW1/4SW1/4 of Section 7, T143N, R88W, approximately 250 feet west of the Knife River. Mining and reclamation operations proposed at Coyote Creek Mine will not affect the producers' cropland, irrigation operation or the quantity or quality of the shallow Knife River alluvial ground water that supplies the irrigation system.

Coyote Creek Mining Company has an established groundwater monitoring plan for Permit NACC-1302, and its parent company the North American Coal Corporation, has a policy of certifying and periodically re-certifying private wells and springs in its North Dakota mining operations that, together, should detect any changes in groundwater quality or quantity which may occur as the result of mining. A total of 13 private production water wells and 8 springs have been certified within the permit area or within a distance of about 1/2 mile of the permit boundary. Of the 13 wells certified, one is expected to be replaced, two have been previously abandoned, and the remaining nine wells are not expected to be affected. Wells within the permit and adjacent area typically yield 1 to 10 GPM and the only exception to that is one of the S. Unruh alluvial wells having a measured production rate of 18.8 GPM. Wells in the Fox Hills aquifer may produce flows up to 50 GPM, but most well owners throughout the assessment maintain flows of 10-25 GPM or less, much of that depending on the pump size and rating.

A total of 8 springs have been certified within the permit area. Of those 8 certified springs, seven will either be mined through or experience noticeable drawdown and the water supply will be replaced or reestablished after mining. The other remaining certified spring is not expected to be affected. Water quality of the certified springs ranged from fair to poor. Total dissolved solids concentrations of the certified springs ranged from 800 mg/l to over 6000 mg/l, with a median value of 1430 mg/l. Most agricultural publications provide warning statements to producers of livestock usage of water with TDS concentrations of 2000 mg/l or more, and some publications provide the same cattle consumption warning statements for TDS concentrations of 1000 mg/l or more. Mine-wide, well over a hundred spring/seep areas have been identified. Of those, well over 50% emanate as discharge from the Harnisch, Twin Buttes, and Schoolhouse lignites positioned above the Upper Beulah lignite. Only 15 of the springs identified within the permit were documented with a flow rate greater than 1 GPM, and are best described as seeps. Those springs and seeps whose source is from a hydrostratigraphic unit above the base of the Upper Beulah will be destroyed and will likely not be restored, with the exception of those located along unmined croplines. As could be expected, locations of the spring/seep zones are along unit source outcrop areas of major drainages to Coyote Creek, Mud Creek, and Knife River. The remaining spring/seep source units include the Upper Beulah, Lower Beulah, Antelope Creek, and Lower Jim Creek lignites. Measured spring flow rates at the point source from all identified spring and seeps in both the Knife River and Coyote Creek Watershed drainages, including about a dozen located on the east side of Coyote Creek that will not be disturbed, conservatively range from less than about 50 GPM to a high of 178 GPM, equal to a flow rate that ranges from 0.11 to about 0.4 cfs. However, much of the described spring/seep flow does not reach either Knife River or Coyote Creek and is retained in stock ponds and wetlands, lost to soil retention, provides some contribution to ground water recharge and most is lost to evapotranspiration. Location information, water quality sampling, seasonality, flow rate and possible source unit information data from the springs and seeps were collected, compiled, analyzed, and that information is incorporated into the permit.

The probable hydrologic consequences sections of the Coyote Creek Mine Permit, as well as the nearby Beulah Mine, discuss the specific locations and owners/operators of the wells and developed springs that may be affected by mining. Should any in-use water supply be contaminated, diminished or destroyed, Coyote Creek Mining Company has committed in the permit to replacement of water supplies as required by North Dakota's reclamation law and rules. Replacement wells are of better construction and generally significantly more productive than the pre-mining wells they replace. Commonly, a single replacement well can produce more water than several older pre-mine wells on the same tract. Mining and reclamation is not expected to negatively affect availability of post-mining groundwater resources at Coyote Creek Mine.

In general, the Lower Beulah 3 lignite, which is situated below and hydraulically separated from the Upper Beulah lignite, is a minor source of shallow ground water that should not be affected by mining and is not used by producers in the permit area. The ability of the Lower Beulah 3 to supply water quantities suitable for modern uses is variable over the area and unlikely, in particular because of the low transmissivity of the Lower Beulah 3 and the availability of more transmissive, productive aquifers in the area. The alluvial aquifers associated with Coyote Creek and the nearby Knife River, in addition to nearby well-documented deeper sand units in the Lower Hell Creek/Upper Fox Hills Formations are proven replacement sources for destroyed wells near them. A water supply well, or well system that will produce water from the deep Fox Hills Formation regional aquifer is planned for installation in the permit area to supply a low volume of water to the Coyote Creek Mine shop/office complex to provide non-potable and equipment washing water needs of the facility. Depth to the Fox Hills aquifer ranges from about 1270-1300 feet below surface in the permit area and water facility requirements are expected to be on the order of approximately 3 million gallons per year. The well system will be designed to yield approximately 30 GPM and this nominal production rate, drawdown, and estimated water usage from the Fox Hills aquifer should not adversely affect other producing wells in the area.

A piped rural water system that has been available to rural Mercer County and surrounding areas for many years is a viable water replacement alternative for homeowners and producers. On-site surface and ground water resources, rather than the rural water system, will likely remain the appropriate post-mining water replacement supply for most livestock and similar agricultural uses in established water system areas because of their more favorable cost and accessibility. However, necessary water supply replacement by mining companies in North Dakota has typically entailed diligent response by the mining company and consultation in close relationship with the affected user. Water supply replacement options are discussed between mine operators and affected users, and replacement generally proceeds after concurrence with both parties regarding the water supply source, required quantity, quality, and delivery method.

North American Coal Corporation has responded quickly and positively to landowner concerns about water supply problems and has cooperated fully with PSC investigations of water supply complaints in the past. Complaints and inquiries relative to the effects of mining on wells increased throughout North Dakota's coal mining areas in the late 1980's and early 1990's during a drought period but declined with wetter conditions of the mid 1990's. Complaints are typically few in number and usually concern water quantity. Most complaints, after investigation, have been found to be unrelated to mining, but operators have responded quickly with appropriate remedies in instances where diminution of in-use supplies or any water-related issues by mining was evident. In the assessment area, there has been no evidence to date of improperly designed or executed mining operations, reclamation activities or hydrologic monitoring causing permanent damage to the hydrologic regime not addressed in probable hydrologic consequences assessments and hydrologic reclamation plans of approved permits.

The relative scarcity of water in western North Dakota, the reclamation rules taken collectively, and the very limited degradation of water quality by surface coal mining in the coal-bearing strata of North Dakota impart special emphasis on water quantity, more properly the conservation of flow systems and hydrostatic heads, in adjacent areas of permits. Lowering of potentiometric surfaces near mine pits by ground water flow into pits is generally recognized in mining permits as a probably hydrologic consequence of mining. Where hydrostatic head loss is due only to mine pit inflows, nearly full recovery of shallow aquifers after its closure and reclamation has been documented at several North Dakota mines and can be logically expected in the normal North Dakota surface mine setting. Recovery to approximate pre-mining conditions is a reasonable standard for water quantity in undisturbed strata near reclaimed mine pits and is expected at Coyote Creek Mine.

Coyote Creek Mining Company is fully committed to restoration and replacement of any in-use ground water supply that may be adversely affected by its operations and has committed to the water supply replacement requirements of the North Dakota reclamation law and rules. The mine plan incorporates modern best management practices to control and minimize water pollution. In addition to the Reclamation Division's permit review, all aspects of the operator's ground water and surface water management plans and systems were allowed to be reviewed by the State Water Commission and State Health Department as members of the Reclamation Division's advisory review committee and no issues or concerns were brought forward regarding water management operations from either of those reviewing agencies. Utilizing the best technology currently available and as required by NDAC 69-05.2-16-01(a), the Coyote Creek Mine has been designed to minimize disturbance of the hydrologic balance within the permit and adjacent areas and prevent material damage outside the permit area.

SURFACE WATER

The Coyote Creek Mine is located on a topographic divide between the Knife River and Coyote Creek. The eastern half of the mine drains to Coyote Creek and the western half drains to the Knife River via ephemeral drainage ways. Coyote Creek flows along the east side of the permit area and eventually drains into the Knife River at a location approximately 1.5 miles northwest of the permit area. The Knife River has its headwaters in west-central North Dakota near Fairfield and drains predominantly agricultural lands throughout its length over a drainage basin of 2,240 square miles, as measured at Hazen, ND. Spring Creek is a substantial tributary that empties into the Knife River just to the west of Beulah North Dakota. Seasonal variations in flow for the Knife River and its tributaries are primarily influenced by snowmelt runoff and summer thunderstorms. Base flows are generally very low and periods of no flow occur on most streams in the area, including the Knife River.

The only perennial or intermittent stream in the permit area is a portion of Coyote Creek. Several ephemeral drainages are cut into the upland breaks and flow to Coyote Creek or to the Knife River within the study area. Baseline information for surface water features was provided in the permit to support the stream flow classifications. Mining will begin on the upland west of Coyote Creek and progress in a westward direction. The upland (coal producing area) is bound on the northwest by the Knife River valley. The office/shop site is located east of Coyote Creek necessitating a stream crossing over Coyote Creek. Another crossing is planned for the coal haulage route. The Commission consulted with the State Health Department and the State Water Commission in regard to these disturbances planned within 100 feet of a perennial stream in accordance with NDAC 69-5.2-16-20. Coyote Creek Mining Company plans to remove the road and crossings once mining is complete and restore the stream crossing areas to the approximate original contour and vegetative ground cover.

There are no large bodies of standing water in the assessment area, and surface water use is largely ponds or stock dams on smaller drainages for livestock watering. There are 17 stock ponds located in the permit area considered to be reliable. Five additional stock ponds were inventoried that do not hold water for extended periods of time due to erosion, siltation or small size. Water for livestock is also provided by a pipe system supplying water to stock tanks from wells within the permit. Coyote Creek Mining Company will be required to replace or supplement any supplies that are diminished by mining on the adjacent permit areas.

A summary of the available data for Coyote Creek has been included in, and reviewed as part of the application for this permit. Coyote Creek has also been monitored by the Beulah Mine as part of their surface water monitoring program. A USGS gaging station (06339550) located on Coyote Creek near the confluence with the Knife River was operated from October 1, 1977 through December 21, 1983. Extensive ambient monitoring records are available for the Knife River at Hazen and Golden Valley, USGS gaging stations 06340500 and 06339500 respectively. Coyote Creek Mine intends to monitor eight surface water sampling sites as part of their surface water monitoring program. The monitoring sites are located on the Knife River and Coyote Creek both upstream and downstream of the mine area and four ephemeral drainages in the mine area. Pre-mining baseline monitoring information for the years 2012 and 2013 is included in the permit application. Data collection at the monitoring sites has continued with data provided to the Commission in quarterly surface water monitoring reports.

The applicant conducted sampling for heavy metals as part of their baseline surface water monitoring program and all of the samples results were below the respective acute water quality standard as provided in NDCC 33-16-02.1. Coyote Creek and nearby tributaries to the Knife River are subject to a Total Maximum Daily Load (TMDL) for fecal coliform bacteria, finalized in September 2010 *(Fecal Coliform Bacteria TMDLs for the Knife River Tributaries in Mercer County, North Dakota; September 2010; North Dakota Department of Health).* The Knife River from its confluence with the Branch Knife River (upstream of the permit area) to the Missouri River is identified as a water body requiring a TMDL to address fecal coliform/Escherichia coli bacteria impairments in the 2012 Section 303(d) TMDL list for North Dakota. Coal mining activity and runoff is not a significant source of bacteria to the TMDL water bodies. The septic system planned for the facility is subject to approval by local authorities and requirements specified in a NDPDES permit for any wastewater discharge.

The permit area will have several sedimentation ponds and associated diversions that will control runoff from the permit area. The designs for the surface water management structures are included in the permit application. The proposed facility plans indicate a waste stabilization pond system will be built to store and treat wastewater from the shop and office facilities. The design for the wastewater treatment system must be approved by the State Health Department and/or local health unit. The operation of the ponds and more specifically the quality of the water released from the ponds is subject to NDPDES permit requirements. The surface water leaving the Coyote Creek Mine and other mining permits in the assessment area must meet NDPDES daily average and maximum total suspended solids values of 35 mg/l and 70 mg/1, respectively. The sediment concentration in water released from the mining operations in the state is typically less than suspended sediment levels found in streams in the area.

The ephemeral drainages within the permit area commonly contain linear wetlands. The wetland drainages are often times enhanced by flow from springs or seeps. The flow from the springs is described as typically being less than 1 gpm. The mining disturbance will remove the springs and they will be absent in the reclaimed setting. The design for replacement wetlands and stock ponds will be based on surface flow volumes. While the reclaimed wetlands will be in a different form than the linear wetlands the acreage and function will be replaced.

The permit application adequately evaluates the probable consequences of mining and the post-mining environment on the surface hydrologic regime. The land included in Permit NACC-1302 is primarily located on a topographic ridge with well-defined pre-mine drainages in close proximity to the Knife River and Coyote Creek. Surface water management during mining will primarily be achieved with sedimentation ponds. Interception of storm runoff and ground water discharged from all mining pits by the total surface water management system will result in a net reduction in peak flows from controlled drainage areas. Changes in peak flows in the Knife River and Coyote Creek immediately below the Coyote Creek Mine (downgradient) will be insignificant. Ground water produced from active pits will make a very small addition to the volume of surface water flows. Thus, the operations will produce no significant diversion of water from the surface or ground water flow systems of the Knife River and Coyote Creek. Reclamation to approximate original contours minimizes diversion of water from surface or ground water flow from pre-mining drainages. The post-mining watershed divides will be situated near pre-mining divides between the Knife River and Coyote Creek, including the respective tributaries, so no significant change in the proportions of watershed yield to these streams is anticipated.

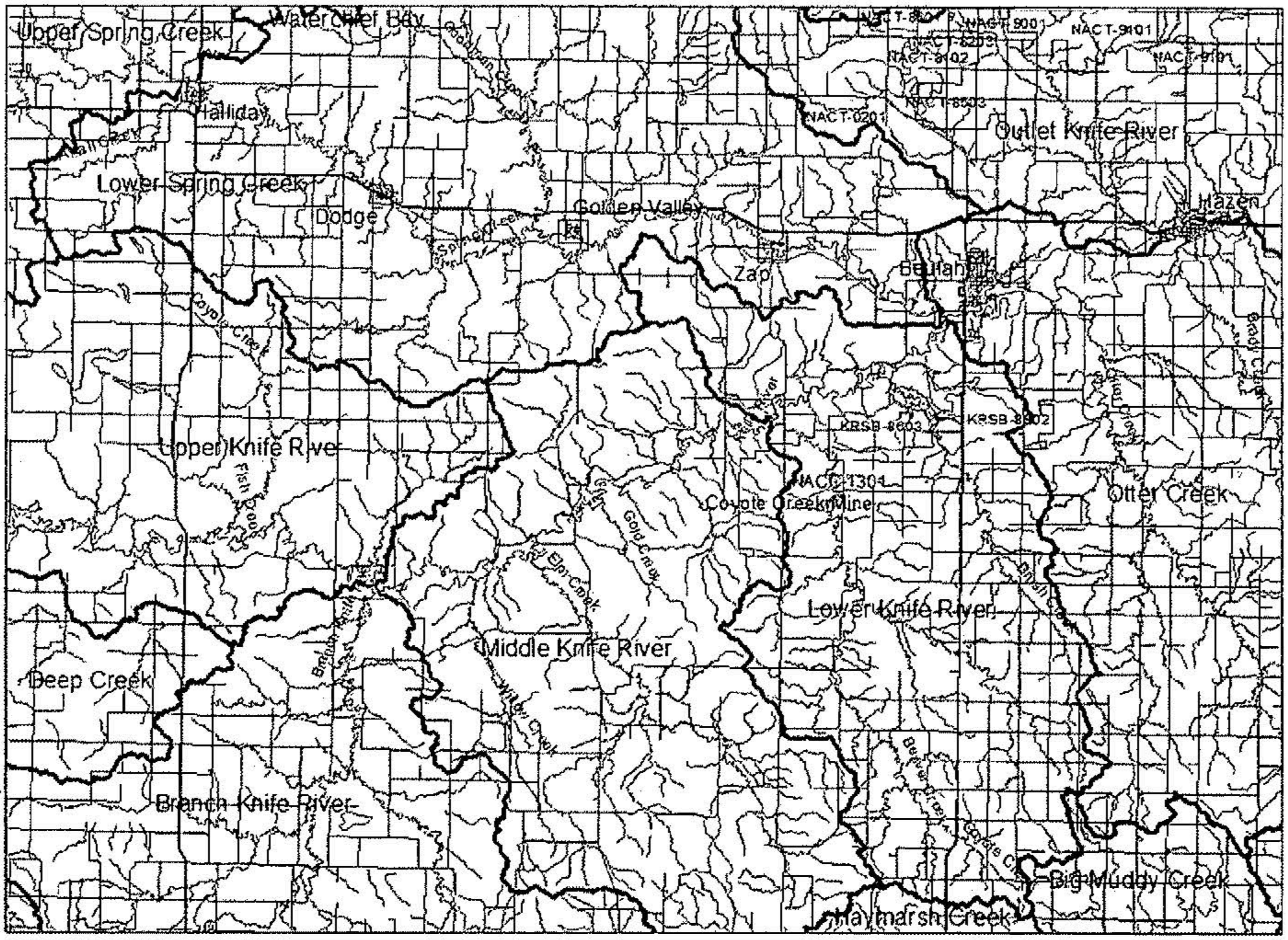
ALLUVIAL VALLEY FLOOR

As required by NDAC 69-05.2-08-13(2) the Reclamation Division provided a written determination detailing the absence of alluvial valley floors within and adjacent to the proposed Coyote Creek Mine permit area associated with Permit NACC-1302 that now incorporates previously approved Coyote Creek Mine Permit NACC-1301. Based on review of the *Alluvial Valley Floor Evaluation Report – Coyote Creek Mining Company, L.L.C. – Coyote Creek Mine* prepared by Bickel Consulting, LLC, for the Coyote Creek Mining Company, the Alluvial Valley Floor Evaluation Report was approved by the Reclamation Division on August 26, 2013, affirming the non-existence of AVF within the study area.

A previously approved Alluvial Valley Floor report and negative determination is applicable to a portion of the Coyote Creek Mine area. The determination made for Dakota Westmoreland Company's Revision No. 22 to Permit KRSB-8603 for the Beulah Mine encompasses the area included in Coyote Creek Mining Company's Permit NACC-1301, which has now been absorbed into Permit NACC-1302. The PSC issued a determination on October 26, 2009 that the valley of Coyote Creek within the Revision No. 22 to Permit KRSB-8603 study area is not an AVF. A discussion of the 2009 determination and maps depicting the study area are included with the Alluvial Valley Floor Evaluation Report approved for the Coyote Creek Mine.

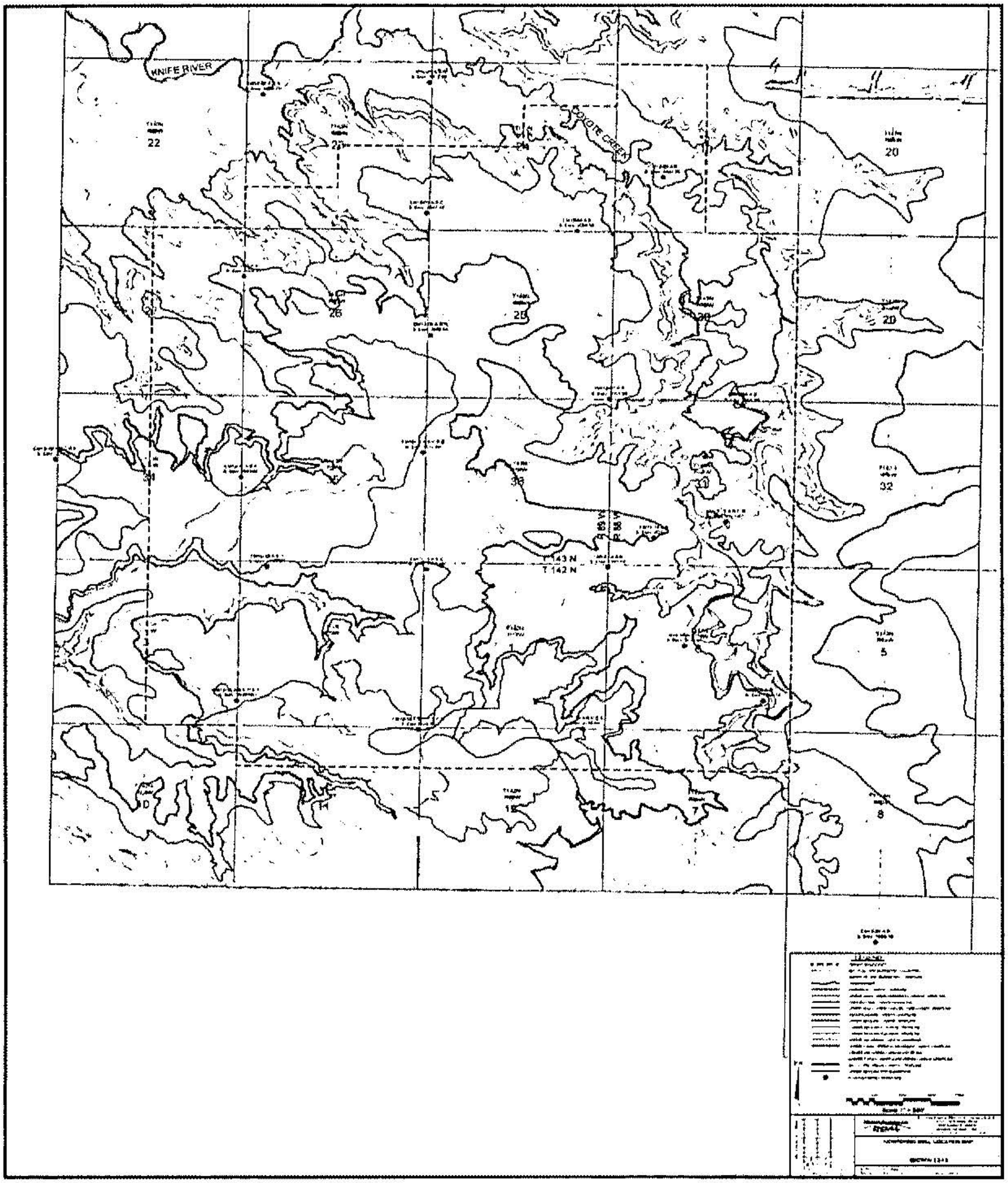
The Coyote Creek AVF report information was based on existing information available in published work, approved mining permits and related data in the public domain from the surface mining reclamation and regulatory process, and observations of professionals involved in the acquisition of baseline data for application of Permits NACC-1301 and NACC-1302. Based on the geologic, hydrologic, soils, vegetation and landuse data and information provided in the *Alluvial Valley Floor Evaluation Report – Coyote Creek Mining Company, L.L.C.* and observations made during a field investigation conducted by the Reclamation Division in April, 2013, it was determined that the Knife River floodplain adjacent to the Knife River channel, Coyote Creek and its associated floodplain, Brush Creek, Beaver Creek, Mud Creek and the remaining stream channels and drainage areas included within the 33,000 acre AVF Study Area do not constitute an alluvial valley floor as defined in NDCC 38-14.1-02 and described in NDAC 69-05.2-08-13.

Figure 1: Hydrologic Map depicting the Cumulative Impact Area



Pink – Freedom Mine
Blue – Beulah Mine
Tan – Coyote Creek Mine

Figure 2: NACC-1302 Ground Water Monitoring Sites Location Map As provided in Permit NACC-1302



United States Department of the Interior

OFFICE OF SURFACE MINING
Reclamation and Enforcement
WASHINGTON, D.C. 20240

JULY 26, 1983

Dear Reader:

Enclosed for your review is a copy of the draft Alluvial Valley Floor Identification and Study Guidelines Handbook for lands west of the 100th Meridian. The handbook has been developed to assist the Regulatory Authority, coal industry, Indian tribes and State and Federal agencies in the identification of alluvial valley floors as defined in sections 701.5, 785.19 and 822.0 of the permanent regulatory program final rules dated June 26, 1983. A copy of these rules can be found in the appendix of this handbook.

Your comments on this document are solicited by OSM. All comments must be received within 45 days of the date on the postmark. If, from your comments, OSM determines that changes should be made in the handbook, only those pages requiring changes will be reprinted. A copy of all necessary corrections will be mailed to each recipient of the handbook. Please retain this draft handbook.

Please send your comments to Allen Klein, attention John Lovell, Western Technical Center, Office of Surface Mining, Brooks Towers, 1020 15th Street, Denver, Colorado 80202.

Sincerely,

Lewis M. McHat
Assistant Director, Technical
Services and Research

ALLUVIAL VALLEY FLOOR IDENTIFICATION AND STUDY GUIDELINES

U.S. DEPARTMENT OF THE INTERIOR

Office of Surface Mining Reclamation and Enforcement

August 1983

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INTRODUCTION

This handbook reviews regulatory and technical aspects of alluvial valley floors, important issues to coal mining in the semiarid and arid parts of the Western United States. The information contained in this handbook should be helpful to the coal mine operator, interested citizen, regulatory agency, and land mangement agency in identifying, studying, and predicting impacts to alluvial valley floors. In developing this handbook, the Office of Surface Mining used the experience gained by this office and the States in dealing with alluvial valley floors since the passage of the Surface Mining Control and Reclamation Act of 1977. The handbook uses this experience to guide the reader toward certain study approaches. However, it is emphasized that this handbook is solely an advisory document and the only fixed requirements relating to alluvial valley floors are contained in the statute itself or in the adopted regulations.

This handbook is designed to review (1) the regulatory process, (2) the identification of alluvial valley floors, (3) studies of alluvial valleys necessary for inclusion in permit applications, and

(4) the technical literature related to selected pertinent topics. The study of alluvial valley floors is a particularly difficult issue on which to provide clear guidance. The natural environment of the West is highly diverse, and the characteristics of alluvial valley floors differ widely from North Dakota to New Mexico. Studies necessary to allow a regulatory agency to make its required findings range from simple to complex, depending on the characteristics of the valley and the particular mining proposal. This handbook attempts to outline the types of questions which need to be considered and the study methods available. Any particular study plan, however, must be developed for a site-specific area.

No handbook can eliminate the need for close communication between a permit applicant and the regulatory authority. Specific study areas and plans should be reviewed prior to full-scale commitment by the applicant to a study program. Good communication can avoid many problems and encourage efficient decisionmaking.

Understanding of the roles of both the applicant for a mining permit and the regulatory authority is important to ensure efficient mine permitting. The applicant has the responsibility to develop the data to support any determination, be it a designation of an alluvial valley floor or the definition of essential hydrologic functions. These data must be accurate, analyzed, and presented in such a manner as to facilitate the decisionmaking of the regulatory agency. The role of the regulatory authority is to review data presented by the applicant or obtained from other sources and to make defensible written determinations within a reasonable timeframe.

CHAPTER I

ALLUVIAL VALLEY FLOOR REGULATORY PROCESS

Under provisions of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), (1) certain types of stream valleys in the Western United States are prohibited from disturbance by coal mining activities, whereas (2) some other types of stream valleys in the West may be mined but must meet higher standards for reclamation than those required for other types of mined areas. Both of these types of stream valleys are referred to as alluvial valley floors. The regulatory process for the alluvial valley floors issue is more complex than for most other reclamation issues because of the sequential nature of the studies and decisions which must be made by the applicant and the regulatory authority.

The provisions of the SMCRA include specific prohibition from mining certain alluvial valley floors, stringent reclamation standards for those alluvial valley floors not prohibited from mining, and requirements that mining operations not materially damage the hydrologic functions of any alluival valley floors that would otherwise be prohibited from mining.

Provisions of the SMCRA which apply to alluvial valley floors are found in three sections. Section 701 contains the definition of alluvial valley floors. Section 510(b)(5) requires that an applicant for a mine permit affirmatively demonstrate that the proposed operation will not interrupt, discontinue, or preclude farming on alluvial valley floors (with two exceptions) and that the proposed operation will not materially damage the water supply of those alluvial valley floors not excepted. Section 515(b)(10)(F) requires preservation of the hydrologic functions of all alluvial valley floors outside the mine area and the reclamation of all alluvial valley floors disturbed by mining.

The prohibitions to mining an alluvial valley floor are outlined in Section 510(b)(5)(A) of the Act. This section generally states that no coal mining operation may "interrupt, discontinue, or preclude farming" on alluvial valley floors. This means that a mining operation is banned from disturbing any portion of an alluvial valley floor, except for those alluvial valley floors specifically excluded from this prohibition. The term "preclude" was included in the statute to ensure that a mining company does not take land out of production in order to avoid compliance with this section.

There are two types of alluvial valley floor areas which are provided exemption to the prohibition of mining. The first exemption is given to "undeveloped rangelands not significant to farming" and the second to "lands of such small acreage that their mining would have negligible impact on the farm's production." In addition, lands identified in approved reclamation plans from which coal was produced in commercial quantities or for which permit approval was obtained in the year preceding the passage of the SMCRA are exempted, or grandfathered, from the alluvial valley floor provisions.

Protection is also mandated in Section 510(b)(5)(B) to the hydrologic systems associated with the alluvial valley floors which are banned from mining. A mining operation cannot materially damage the quantity or quality of water in surface- or ground-water systems which supply these alluvial valley floors. Therefore, it is possible that additional areas not designated as significant alluvial valley floors might be banned from mining if mining the area would cause adverse impact to a designated alluvial valley floor and adequate mitigation measures could not be taken in the mine plan to eliminate the adverse impact.

Section 515(b)(10)(F) requires that the essential hydrologic functions of all alluvial valley floors be preserved throughout the mining and reclamation process. This section mandates that all alluvial valley floors be protected during mining and reclamation. Some may be mined and reclaimed, whereas others must be protected during mining.

Section 515(b)(10)(F) also establishes the reclamation standards for those alluvial valley floors not excluded from mining under the provisions of Section 510(b)(5). Under the reclamation standards, a coal mine must minimize the disturbances to the prevailing hydrologic balance by restoring the essential hydrologic functions of mined valleys.

Regulations implementing SMCRA were adopted March 13, 1979, as 30 CFR, Parts 700 and 800 (U.S. Department of Interior, 1979). Provisions applying to alluvial valley floors are included in:

30 CFR 701.5	Definitions
30 CFR 785.19	Requirements for Permits for Special Categories of Mining: Surface coal mining and reclamation operations on areas or adjacent to areas including alluvial valley floors in the arid or semiarid areas west of the 100th meridian.
30 CFR 822	Special Permanent Program Performance Standards: Operations in alluvial valley floors

Following adoption of the final Federal regulations, Peabody Coal and several States sued the Federal Government on numerous aspects of the regulations. The decision by the United States District Court for the District of Columbia, Civil Action No. 79-1144 (1980), known as the Flannery decision, shed light on several aspects of the alluvial valley floor regulatory program. The court sustained the OSM interpretation that alluvial valley floors may be found along perennial, intermittent, or ephemeral streams. The court noted:

> An alluvial valley floor must satisfy geologic criteria (unconsolidated stream-laid deposits meeting the regulation's dimensions) <u>and</u> hydrologic criteria (water sufficient to sustain agriculture). Hence, those ephemeral or dry streams incapable of

> supporting agriculture by natural or artificial means fail to qualify as an alluvial valley floor.
>
> The Senatorial exchange (between Senators Bartlett and Metcalf) * * * demonstrates that dry water streams without surface or subirrigation capability are excluded from the definition of an alluvial valley floor, whereas dry water streams with irrigation capability are subject to the Act's protections. The key is water availability. Congress' concern was the preservation of agriculture. This concern is protected whether the alluvial valley floor contains natural subsurface irrigation or is capable of irrigation by surface means.
>
> (p. 47-48)

Thus, the court emphasized the basis of an alluvial valley floor as containing both geomorphic and water availability attributes and which, together, have agricultural importance.

The regulatory requirements to collect detailed sets of geologic, hydrologic, soils, vegetation, and agricultural data were also upheld by the courts:

> The informational requirements of 30 CFR 785.19 are consonant with the Act. * * *. The Act thus commands an operator, who seeks to mine coal in or around an alluvial valley floor, to provide additional information in the permit application specific to the values underlying alluvial valley floor preservation. The regulations at issue merely implement these informational requirements.
>
> As to the agricultural information of Section 510(b)(5), if an alluvial valley floor fails to encompass agricultural activities, then the permit application need only present rudimentary evidence of lack of farming. * * *. However, hydrologic information must still be provided. If the permit area encompasses an alluvial valley floor, the hydrologic protections of sections 510(b)(3) and 515(b)(10)(F) apply regardless of whether farming occurs.
>
> (p. 49-50)

The court mandated minor changes, such as remanding the requirement that a full year's hydrologic data be collected but basically upheld the notion that alluvial valley floors required detailed study.

The regulatory procedure presently followed by OSM in reviewing proposed operations on or adjacent to alluvial valley floors is a multistep process. Figure 1 is a flow chart depicting the successive investigations and determinations which must be made before permit approval can be given. In considering alluvial valley floors, the following major decisions must be made by the applicant:

1. Are there alluvial valley floors in or near the proposed permit area?
2. Are any of those alluvial valley floors subject to prohibition from mining?
3. What will be the effect of proposed mining on those nearby alluvial valley floors?
4. Can those alluvial valley floors proposed for mining be successfully reclaimed?

In order to answer each of these questions, specific data and analyses are needed. Since the answers to some questions dictate responses to other questions, it is advisable to complete the identification phase of alluvial valley floor studies prior to submittal of a formal mining and reclamation plan. Satisfactory answers to all questions must be made prior to permit approval.

Experience has shown that the identification of alluvial valley floors is best accomplished in two phases:

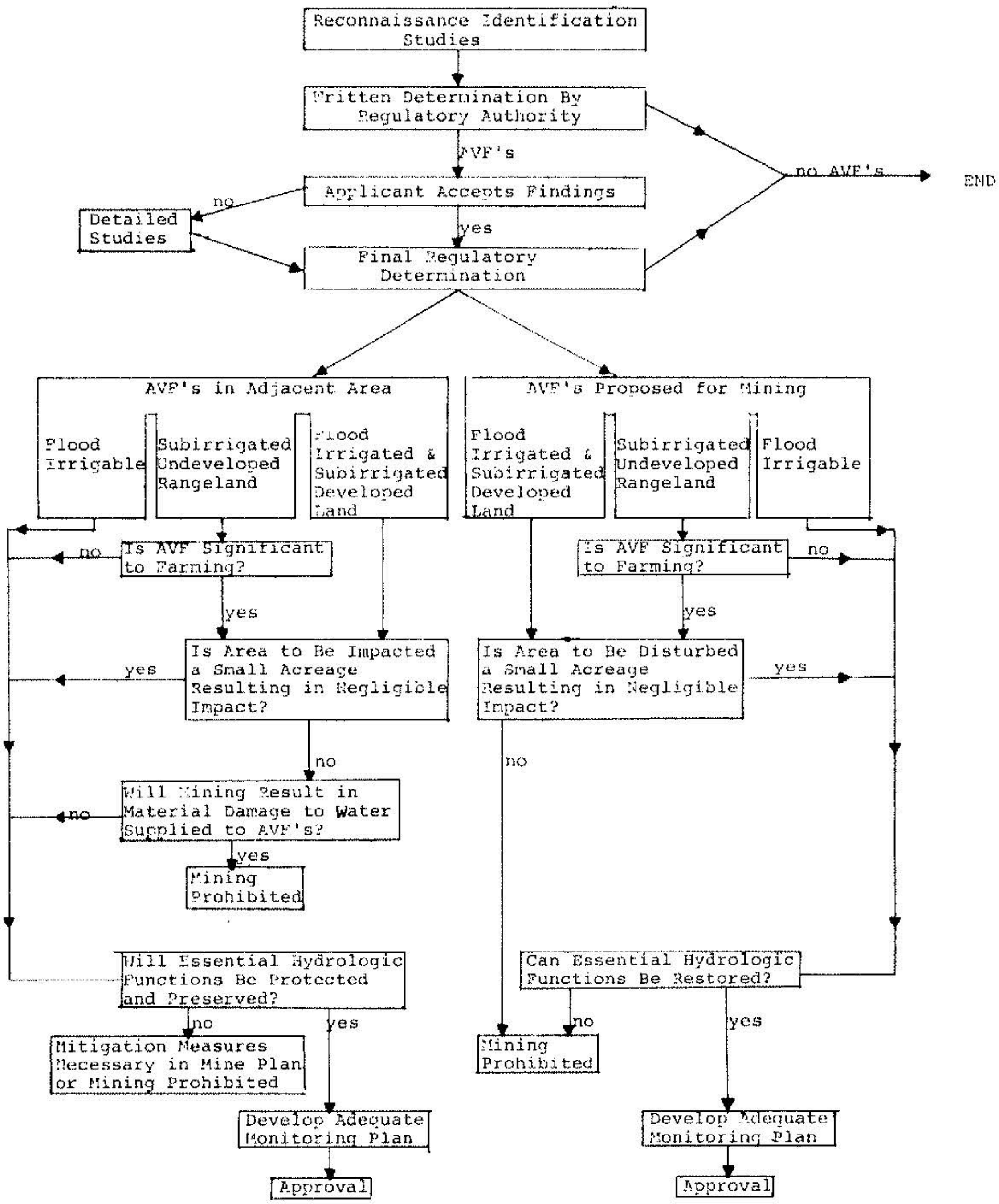

Fig. 1 Flowchart of alluvial valley floor regulatory process

1. A reconnaissance phase allows the applicant or land management agency to identify areas clearly not alluvial valley floors, as well as probable alluvial valley floors, without conducting costly and time-consuming studies; and

2. Detailed studies can then be conducted if the applicant wishes to demonstrate that any probable alluvial valley floors should not have that status.

The details of identifying alluvial valley floors are discussed in chapter II.

Whether alluvial valley floors can be mined depends on their significance to agriculture. Statutory language exempts certain portions of an alluvial valley floor from the mining prohibition and hydrologic protection provisions. The first exemption differentiates undeveloped rangeland which is not significant to farming, and the second differentiates small acreages which, if disturbed, would cause negligible impact to a farming operation. If neither condition is met, then the alluvial valley floor is significant. The proposed mine cannot disturb these "significant" areas and cannot materially damage the water which supply these "significant" alluvial valley floors.

For all designated alluvial valley floors, whether significant or insignificant to farming, a determination must be made that the essential hydrologic functions of the valley will be protected. If mining or disturbance of the alluvial valley floor is allowed, the adequacy of the reclamation plan to restore the essential hydrologic functions must be demonstrated. Finally, for all alluvial valley floors, a monitoring program must be designed which will document that the alluvial valley floor protections afforded by the Act are being complied with during the approved mining and reclamation operation.

Chapter III discusses further the issues of significance, essential hydrologic functions, material damage, reclamation, and environmental monitoring.

CHAPTER II

IDENTIFYING THE OCCURRENCE OF ALLUVIAL VALLEY FLOORS

In a general sense, alluvial valley floors are areas in the Western United States which (1) are located in those topograhic valleys having an associated stream channel, (2) are underlain by unconsolidated deposits whose surface usually has the landform appearance of flood plains or terraces, and (3) have an agricultural importance derived from the availability of surface or ground water. The ultimate goal of alluvial valley floor identificaton investigations is to identify stream valleys which have agricultural importance and where that importance is derived from the water available in those valleys. Stream valleys which do not have any agricultural importance or whose importance is not related to the greater water availability of the valleys are not alluvial valley floors. Because the environmental characteristics, agricultural uses, and irrigation practices of stream valleys vary in the different regions of the West, the specific rationale used for identifying or determining the role and character of alluvial valley floors may vary from region to region. A regional understanding of irrigation and agricultural practices is a prerequisite to making assessments of alluvial valley floor status.

Experience has shown that a phased approach to the identificaton of alluvial valley floors is often desirable (table 1). In such a phased approach, readily available data are used to make initial determinations of land status as alluvial valley floors, and increasing amounts of detailed data are collected to resolve any uncertainties. The needs of various agencies and industry also differ in the certainty of decisions needed. Land management agencies usually wish to make initial identifications on the basis of readily or easily obtainable data. Surface mine permit applications, on the other hand, often require more specific characterization of the environment.

A three-step process is suggested in this handbook for identifying alluvial valley floors. First, the applicant, or land management agency, uses readily obtainable data, including regional data collecting, to make initial identifications. Second, for permit applications the regulatory authority can make an initial determination of the existence of alluvial valley floors on the basis of the data submitted by the applicant. Third, the applicant has the opportunity to conduct more detailed studies if there is disagreement with the regulatory authority's findings. This step is optional. If no contest of the initial findings is made, the identification based on readily obtainable data can be sufficient for identification purposes.

At the identification stage discussed in this chapter, precise boundaries may not be able to be assigned to all parts of an alluvial

TABLE 1

SUGGESTED PHASING OF ALLUVIAL VALLEY FLOOR IDENTIFICATION STUDIES

Study level	Potential users	Data requirements
Initial studies (including initial regulatory decisions)	Land management agencies -- land use planning	Available data
	Land management agencies --leasing studies	Regional studies
	Mine operators--preliminary planning	Reconnaissance and historical site data
Further studies	Mine operators--permit applications	Site data to resolve uncertainties of initial studies

valley floor nor may they be necessary. Precise boundaries must, however, be established before permit approval can be granted. Studies suggested later in this guideline may provide the needed definition for the boundaries. The primary goal of the identification process should be to establish whether alluvial valley floors exist.

Interaction Between Applicant and Regulatory Authority

All coal mining regulatory authorities agree that continuing interaction between the applicant and the reviewing agency is essential. No statute, regulation, or guidelines can address every issue concerning a proposed mining site. Nor can a guideline anticipate ongoing policy development within agencies which might affect study plans. Prior to developing a study program, the applicant is therefore urged to consult with the appropriate regulatory authority about the proposed project and its projected impacts. As the applicant's study progresses, continuing contact and communication with regulatory personnel can help avert problems of interpretation, scope, and detail.

What is an Alluvial Valley Floor?

Although "alluvial valley floor" has a technical meaning, particularly to a geologist, in the context of the Surface Mining Control and Reclamation Act (SMCRA), the term has a regulatory meaning. Failure to understand that "alluvial valley floor" is a regulatory term, definied in statute and clarified in legislative history, court decisions, regulations, and ongoing administrative decisions, can result in incomplete or misdirected studies. The SMCRA defines alluvial valley floor as:

> the unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by unconcentrated runoff or slope wash, together with talus, or other mass-movement accumulations and windblown deposits.

The term is, therefore, an integration of concepts in geology, hydrology, and agricultural land use (fig. 2). Alluvial valley floors are not merely those valleys filled with alluvium.

"Alluvial valley floor" is a term that was first mentioned in the context of coal mining by the National Academy of Sciences (1974) in a report concerning reclamation of Western lands. The Academy noted the susceptibility to erosion of unconsolidated alluvial deposits and the relationship of gullying to declining ground-water levels and lost productivity of affected lands. The Academy suggested that "alluvial valley floors and stream channels be preserved" (p. 45). The Academy used the term as would a geologist and did not distinguish types of valleys or their relative importance to agriculture.

During congressional debates concerning coal mine reclamation in the mid-1970's, focus turned to protection of certain types of valleys--those of most importance to agricultural operations:

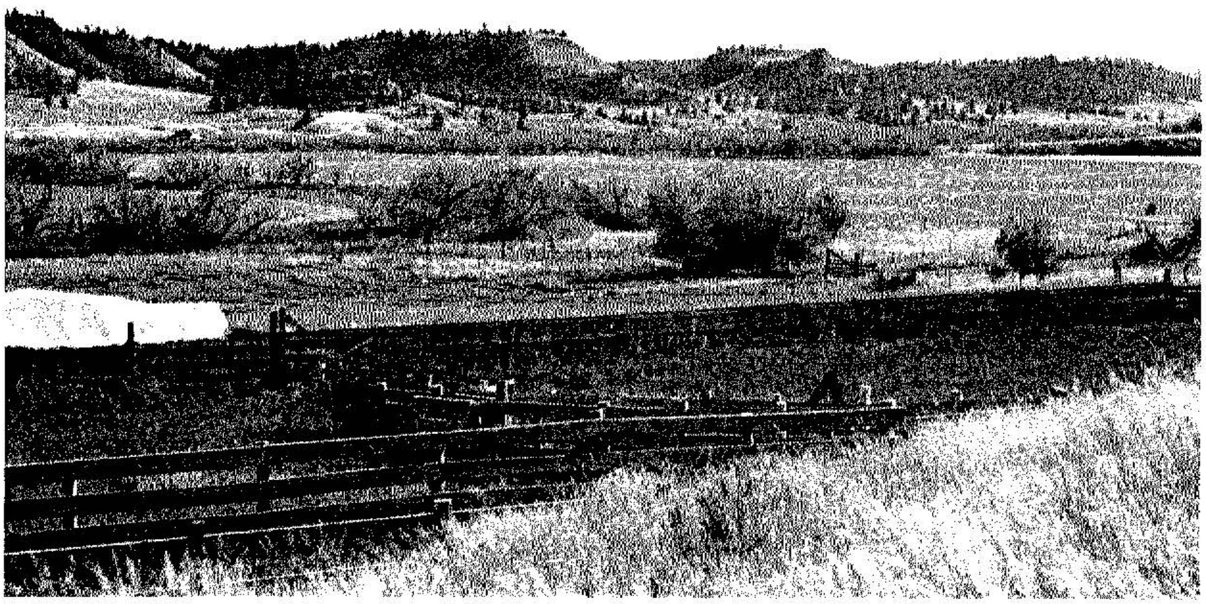

Fig. 2 View of Rosebud Creek near Slough Grass Coulee, southeastern Montana. Hay meadows are subirrigated.

> Of special importance in the arid and semiarid coal mining areas are alluvial valley floors which are the productive lands that form the backbone of the agricultural and cattle ranching economy of these areas. For instance, in the Powder River Basin of eastern Montana and Wyoming, agricultural and ranching operations which form the basis of the existing economic system of the region could not survive without hay production from the naturally subirrigated and flood irrigated meadows located on the alluvial valley floors. (U.S. House of Representatives, Committee on Interior and Insular Affairs, 1976).

The understanding of an alluvial valley floor is well described in this statement and has been consistently understood in the subsequent passage and implementation of the SMCRA.

The two major aspects of an alluvial valley floor--geology and water resources--are discussed more extensively in the following sections.

A. Geology. As already noted, one of the two fundamental aspects of an alluvial valley floor is its geologic character. Regulations, judicial review, and administrative decisions have expanded and clarified the statutory definition. The geologic criteria of an alluvial valley floor are understood to be:

> (a) A TOPOGRAPHIC VALLEY WITH A CONTINUOUS PERENNIAL, INTERMITTENT, OR EPHEMERAL STREAM CHANNEL RUNNING THROUGH IT; AND

(b) WITHIN THAT VALLEY, THOSE SURFACE LANDFORMS THAT ARE EITHER FLOOD PLAINS OR TERRACES IF THESE LANDFORMS ARE UNDERLAIN BY UNCONSOLIDATED DEPOSITS; AND

(c) WITHIN THAT VALLEY, THOSE SIDE-SLOPE AREAS THAT CAN REASONABLY BE SHOWN TO BE UNDERLAIN BY ALLUVIUM AND WHICH ARE ADJACENT TO FLOOD PLAIN OR TERRACE LANDFORM AREAS.

Areas which are not alluvial valley floors include (1) terrace landforms not found in topographic valleys with stream channels in them, (2) lake deposits, (3) windblown deposits not meeting the criteria of (c) above, (4) residual deposits, and (5) bedrock. A description of each of these deposit types is included in appendix A.

The criteria of an alluvial valley floor place greatest emphasis on identification of alluvial landforms and secondary importance on detailed stratigraphic descriptions of deposits. Only in these valleys where the sloping land adjacent to terraces can be shown to be underlain by the same deposits that underlie the terraces is the knowledge of stratigraphy important in the identification process. Because the kind of stratigraphic data needed for the criteria of (c) is often not available during initial studies, these criteria are usually not applied until formal permit application review is completed.

B. Water Resources. An alluvial valley floor is not merely an area meeting geologic criteria. It is also an area with water availability sufficient for subirrigation or flood irrigation agricultural activities. Most of the confusion and disagreement in identifying alluvial valleys is a function of different perspectives on whether water availability in a specific valley is actually sufficient for agricultural activities. Apendix B describes surface-water irrigation practices in the West, and appendix C describes subirrigation and its evaluation.

Legislative, judicial, and administrative interpretation of alluvial valley floors indicate that the water availability criteria are met if:

> (a) WATER IS AVAILABLE BY SURFACE-WATER IRRIGATION OR SUBIRRIGATION AND IS BEING OR HAS SUCCESSFULLY BEEN USED TO ENHANCE PRODUCTION OF AGRICULTURALLY USEFUL VEGETATION; OR
>
> (b) SURFACE WATER IS AVAILABLE IN SUFFICIENT QUANTITIES TO SUPPORT AGRICULTURAL ACTIVITIES.

The term "flood irrigation" means natural flood overflow or irrigation using surface waters in the methods typical for a given region. Not all styles of surface-water irrigation are appropriate for all Western coal regions. Appendix B outlines typical Western irrigation practices.

The term "subirrigation" is understood to mean the supply of water to plant roots from an underlying alluvial ground-water system such that the vegetation is more productive than in other areas and that the vegetation continues to grow during the moisture-stress portion of the growing season. Some low-lying areas have greater vegetation productivity than adjacent uplands merely because of better soils, snow drift accumulation, or occassional flood overflow. These areas are not considered to be subirrigated, and one of the tasks of identification studies is to distinguish those valley areas whose productivity is a result of subirrigation, and not a result of water from some other source. The water availability criterion excludes areas that could be developed for subirrigation; e.g., by establishing deep rooting alfalfa to tap ground water not presently used by native vegetation.

The identification process described in the next section suggests a method of assessing water availability using regional and site-specific data.

DEFINITION OF AN ALLUVIAL VALLEY FLOOR

AN ALLUVIAL VALLEY FLOOR IS DEFINIED BY THE EXISTENCE OF FLOOD PLAINS AND TERRACES UNDERLAIN BY UNCONSOLIDATED STREAM-LAID DEPOSITS, THE AVAILABILITY OF WATER BY FLOOD IRRIGATION OR SUBIRRIGATION, AND THE USE, OR POTENTIAL USE, OF THAT WATER AND LAND FOR AGRICULTURAL PURPOSES. THE STUDIES DESCRIBED IN THIS SECTION ARE AT A RECONNAISSANCE LEVEL AND ARE USED TO IDENTIFY THE EXISTENCE OF THESE COMPONENTS OF ALLUVIAL VALLEY FLOORS. AN ALLUVIAL VALLEY FLOOR IS DETERMINED TO EXIST WHEN THE FOLLOWING CRITERIA ARE MET:

1. GEOLOGIC CRITERIA:

   a. A TOPOGRAPHIC VALLEY WITH A CONTINUOUS PERENNIAL, INTERMITTENT, OR EPHEMERAL STREAM CHANNEL RUNNING THROUGH IT; AND

   b. WITHIN THAT VALLEY, THOSE SURFACE LANDFORMS THAT ARE EITHER FLOOD PLAINS OR TERRACES IF THESE LANDFORMS ARE UNDERLAIN BY UNCONSOLIDATED DEPOSITS; AND

   c. WITHIN THAT VALLEY, THOSE SIDE-SLOPE AREAS THAT CAN REASONABLY BE SHOWN TO BE UNDERLAIN BY ALLUVIUM AND WHICH ARE ADJACENT TO FLOOD PLAIN OR TERRACE LANDFORM AREAS.

2. WATER AVAILABILITY CRITERIA:

   a. WATER IS AVAILABLE BY SURFACE-WATER IRRIGATION OR SUBIRRIGATION AND IS BEING, OR HAS SUCCESSFULLY BEEN, USED TO ENHANCE PRODUCTION OF AGRICULTURALLY USEFUL VEGETATION; OR

   b. SURFACE WATER IS AVAILABLE AND COULD BE USED TO ENHANCE PRODUCTION OF AGRICULTURALLY USEFUL VEGETATION.

Initial Identification Study of Alluvial Valley Floor

As previously noted, initial studies can be used by agencies interested in land use planning or leasing evaluation and by companies interested in initial mine planning. The purpose of an initial identification phase is to permit identification of areas which clearly are <u>not</u> alluvial valley floors, so that detailed studies can be focused only on areas which might reasonably be expected to be alluvial valleys. The other purpose of initial studies is to permit a level of identification on the basis of readily available or easily collected data.

The final result of the initial study programs would be identification of areas which clearly are alluvial valleys, areas which clearly are not alluvial valleys, and areas of uncertain status. The use of readily available or easily collected data means that these data usually should not be plotted on maps of a scale larger than 1:24,000.

Depending on the outcome of these studies, the mine operator, for instance, can focus detailed studies on other regulatory issues, begin detailed characterization of the essential hydrologic functions of an alluvial valley floor, or collect more detailed data on those areas of uncertain status.

The following steps (table 2) are suggested to the applicant in conducting an initial investigation of alluvial valley floors:

<u>A. Regional evaluation of agricultural practices</u>. Before beginning a site-specific evaluation of the mine area, it is important

to understand the style of agricultural land use in an area, and the way, if there is one, that stream valleys are important to agriculture.

TABLE 2

COMPONENTS OF INITIAL IDENTIFICATION STUDY

1. Regional evaluation of agricultural practices.
2. Establish mine site study area.
3. Determine water availability.
    A. Map presently irrigated lands.
    B. Map all lands which appear to have the capability of being flood irrigated.
    C. Map subirrigated areas.
4. Map areas meeting geologic criteria.

As previously noted, if certain stream valleys do not serve a special role in agricultural land use in a particular coal region, or if their special role is not a function of water availability, then these streams are not alluvial valley floors in that region. At least some types of stream valleys do play that special role in parts of each major coal region in the interior West, however.

The types of data that can be collected are illustrated in a case study in appendix D. Generally, the focus of these studies should be mapping flood irrigated and subirrigated areas and identifying the style of agricultural water utilization in valleys. Within the region around the proposed minesite, the following kinds of data should be collected:

1. The types of streams and valleys developed for surface-water irrigation or spreader dike systems.

2. The physical characteristics of those valleys.

3. The role of subirrigated land in hay or crop production and grazing.

These data can later be used in assessing those valleys with the capability to be irrigated.

An attempt should be made to distinguish subirrigated areas that are agriculturally important in ranch management. Subirrigated, cropped areas are an obvious feature, and the size of these areas can be noted. More uncertain, however, is the pattern of use of subirrigated rangeland. During the regional agricultural land use evaluation, data can be collected on the kinds of subirrigated rangeland that are of some importance to ranchers. Some subirrigated areas may be too small, too narrow, or too difficult to reach to be reasonably used for grazing operations. Subirrigated areas of nonagriculturally useful vegetation do not qualify as alluvial valleys.

The Office of Surface Mining is presently collecting some of these types of data in its regional alluvial valley floor mapping program. Reports from this program will be available in early 1984.

B. Establish minesite study area. A mine permit application should identify alluvial valley floors and the impacts of proposed mining and reclamation operations within the proposed permit area and the area adjacent to the permit area. The "adjacent area" is a regulatory term definied as encompassing all areas which may be adversely affected by the proposed mine. The "adjacent area" and the permit area thus constitute the study area. For purposes of alluvial valley floor studies, identification of an adjacent area in terms of possible adverse impacts to ground-water and surface-water resources is necessary.

Regulatory authorities and industry often ask, "What area should a study encompass?" It is difficult to establish a regionwide standard for study area size because the geohydrology of Western mine areas differs widely. In conceptual terms, a study must encompass all areas possibly affected by proposed mining activities. This area of possible impact is defined at the application stage through analyses of ground-water, surface-water, geologic, and other environmental baseline data. Where an applicant does not have those kinds of data available at the time of the initial alluvial valley floor studies, information about adjacent area size at nearby mines and conversations with the regulatory authority can be used to establish the study area size.

Although it is clearly at the discretion of the applicant to choose an appropriate study area, it is obviously to the applicant's benefit to initiate study on any lands which reasonably might be included in formally designated adjacent areas.

C. Water Availability. The following steps can be completed in any order:

1. Map all presently irrigated lands. These lands may already have been identified during the regional study, but if not, they should be identified and mapped within the study area. It is also helpful to identify the locations of diversions, ditches, dams, spreaders, and any other structures used to manipulate surface waters.

2. Map all lands which appear to have the capability of being flood irrigated. The capability of an area to be flood irrigated has been a difficult and sometimes controversial aspect of the identification process. Experience has shown the value of considering regional irrigation practices when considering site-specific irrigation capability. The applicant should try to answer the question, "Are the kinds of undeveloped stream valleys within the study area typically developed for irrigation elsewhere in the region?" If the answer is no, then the valleys in question within the study area can be rejected as alluvial valley floors.

Obviously, there is great latitude in the term "developed in similar type valleys". Valleys may be similar in terms of channel character, incision, and basin area but differ in soil type or water quality. Valleys that appear at first notice to be similar to developed valleys may be shown to be dissimilar after further evaluation. At the initial study stage, the applicant will usually rely on easily collected data, such as channel character, size, slope, depth of incision, and basin area. However, more detailed data may be collected at the applicant's discretion. Factors considered in assessing irrigation capability are discussed more extensively in Appendix D.

Data concerning the success of presently abandoned irrigation structures is also helpful in assessing capability. Administrative decisions to date show a clear pattern of rejecting capability where abandoned irrigation systems clearly failed due to lack of water or poor quality water or soils.

One of the reasons for evaluating regional irrigation practices is that some western valleys have not been developed because of land ownership or water rights factors, and not the physical character of the valley. Administrative decisions show that in these situations, the capability of an area to be irrigated should be evaluated solely on physical characteristics.

3. Map potentially subirrigated areas. Subirrigation is another difficult and sometimes controversial topic. Its identificaton at the

initial study stage is usually dependent on color infrared air photo interpretation, which is available for all Western mine areas (appendix C). Well and soil moisture data which can confirm subirrigation is usually not available to the applicant at this stage. The interpretation of air photography in delineating subirrigation is discussed in appendix C.

The kinds (in terms of area and width) of potentially subirrigated areas that should be mapped should be based on the findings of the regional assessment, as well as on conversations with land managers of the immediate study area. The question often arises, "How small or narrow an area should I map?" The answer to this question is site specific to each region. Those potentially subirrigated areas that are viewed by the regional agricultural community as being important to grazing patterns should be identified. If there is consensus in a region that certain types of areas are too small to matter in grazing land use, or are characterized by unpalatable species, they need not be identified.

4. Map areas meeting geologic criteria. As already noted, aluvial valley floors are both a geologic and an agricultural water-use feature. Surficial geologic data (appendix A) should be collected and flood plain or terrace areas mapped. Areas overlain by slopewash or aeolian deposits, and which might reasonbly be expected to be underlain by alluvium, should be identified as areas of

uncertain status. Any areas meeting the geologic criteria which also meet one of the water availability criteria can be considered alluvial valley floors for purposes of initial identification.

Further Studies

Revised regulations of the Office of Surface Mining provide discretion to the applicant to request an alluvial valley floor status determination prior to formal permit application submittal. If such a request is made, the regulatory authority will make such a determination, based on the data presented and other data available. If the applicant adequately characterizes the regional agricultural use practices; describes the physical character of the study area, valleys, and stream channels; and interprets available color infrared photography, consistent with the previous section, the regulatory authority should be able to make an initial interpretation of alluvial valley floor status. If the applicant concurs with the initial determination, then the identification process can end.

In this case, the applicant can proceed with detailed studies appropriate for a permit application for those areas that are or might be alluvial valleys (chapter III). Areas of uncertain status can be resolved with detailed stratigraphic data for areas covered with slopewash or aeolian deposits. Areas that the applicant and regulatory authority agree do not meet geologic or water availability criteria can be eliminated from any alluvial valley floor related detailed studies.

However, disagreement between applicant and regulatory authority may arise, particularly with respect to water availability. Color infrared air photo interpretation will sometimes result in identification of areas whose water source to vegetation is not ground water. Development of wells, soil pits, and other studies discussed in appendix C would provide additional data to resolve this issue. Also, regulatory authorities and applicants may disagree on the interpretation of regional irrigation patterns in terms of the capability of study area streams for surface-water development. In this case, detailed studies of water yield, water quality, soil type, or other considerations in irrigation development (appendix B) should be conducted. Whatever the disagreement, the applicant and regulatory authority should agree on the points of contention and the studies needed to resolve the issue.

The identification phase should end when agreement is reached on status of all stream valleys in the study area. Precise boundaries of the designated alluvial valleys may not be drawn until other detailed data collected for the permmit application are submitted.

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CHAPTER III

PERMIT APPLICATION DATA SUBMITTALS

Introduction

If alluvial valley floors have been identified within the permit or adjacent area, certain types of data and analyses must be contained in the permit application. If the initial or further identificaton studies show that no alluvial valley floors occur in the study area, then the identifcation study data should be presented, or the negative determination written by the regulatory authority should be referenced. The data and analyses contained in the permit application for an operation affecting a designated alluvial valley floor should allow the regulatory authority to make a determination of:

1. The significance of the alluvial valley floor and its affected area of the agricultural activities of the farming operation [510(b)(5)(A)] and whether the operation would interrupt, discontinue, or preclude farming on a significant alluvial valley floor [510(b)(5)(A)].

2. The characteristics of the alluvial valley floor which are necessary to support its essential hydrologic functions during and after mining, and whether these essential hydrologic functions will be preserved and/or restored [515(b)(10)(F)].

3. Whether the operation will cause, or presents, an unacceptable risk of causing, material damage to the quantity or quality of surface or ground waters that supply alluvial valley floors signficant to farming [510(b)(5)(B)].

4. The effectiveness of proposed reclamation with respect to requirements of the Act (if mining is proposed) [515(b)(10)(F)].

5. The adequacy of proposed environmental monitoring designed to document compliance with alluvial valley floor performance standards during and after mining and reclamation operations [510(b)(5) and 515(b)(10)(F)].

In developing a detailed study plan, the applicant should keep in mind that the regulatory authority is under statutory requirement to satisfy certain questions and to make specific written findings. With this in mind, the applicant can develop an appropriate and efficient study program to provide the necessary data. The following section reviews these regulatory considerations.

The Question of Significance

The significance of alluvial valley floors to farming operations is a critical aspect of the regulatory process because the SMCRA exempts certain portions of an alluvial valley floor from the mining prohibition and hydrologic protection provisions of Section 510(b)(5)(A) and (B). The basis for these exemptions is that some land can be removed from agricultural production without adversely affecting agricultural operations. Undeveloped rangeland that is determined to be insignificant to a farming operation is one exemption; the other exemption allows disruption of a small acreage of a signficant alluvial valley floor. It is suggested that alluvial valley floors be assumed to be either significant or insignificant in the manner outlined below. With this basis, a regulatory decision focuses on the area that can be disrupted while creating only a negligible impact on a ranching operation.

Alluvial valley floors having only the capability to be surface irrigated can be assumed to be insignficant and need not be evaluated further. All alluvial valley floors which are currently* flood irrigated or subirrigated are assumed to be significant. For these significant valleys, the central question to be addressed is: What constitutes an insignificant acreage whose loss would have negligible impact on the particular ranching or farming operation?

Negligible impact is based on the relative importance of vegetation and water of the alluvial valley floor to the individual farm's production. Some loss in production is acceptable, and the issue concerns the point at which losses cease to be negligible.

A simple way to consider negligible impact or significance is in terms of production, because production from alluvial valley floor lands can be compared to production for the rest of the farm. Production can be measured by tons of hay, by animal unit months (AUM's), by bushels of wheat, or by whatever main crop or livestock is produced. For example, in the State of Wyoming, all significance and

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*Currently, in this context, means the most developed level of irrigation in use on or after August 3, 1977.

negligible impact determinations are made in terms of AUM's. In parts of North Dakota, it might be more appropriate to make calculations in terms of bushels of wheat produced. Determining production is terms of monetary value is not recommended because of the annual fluctuations of farm product prices. In any case, only income or production from farm-related activities should be considered. Although comparing production is relatively simple, other factors which make alluvial valley floors important in specific situations should also be considered and may override a simple comparison of production. An example illustrates this point:

> A ranch in the Powder River Basin grows all its hay needed as winter feed for the ranch's herd of cattle. The hay is the only crop grown on the alluvial floor. The production of the hay crop can be compared to the vegetative production of the rest of the ranch's rangeland to determine relative importance, but this comparison would ignore the fact that the amount of hay grown for winter feed is the limiting factor on the size of the herd. Therefore, in determining the small, insignificant acreage of the hayed alluvial valley floor, comparison should be made of the hay production lost to the hay production remaining.

Negligible impact must be determined for each alluvial valley floor on the basis of the importance of portions of the alluvial valley floor to the specific ranching or farming operation to which a parcel belongs. Five acres of irrigated hayland may be significant to a small ranch, whereas 20 acres of similar land may not be significant to a much larger ranch. For regulatory purposes, an entire subirrigated undeveloped rangeland valley used only in summer may be insignificant to a large operation. A farm is generally considered to be the combination of land units with acreage and boundaries in existence prior to August 3, 1977, or, if established or modified after this date, with those boundaries based on enhancement of the farm's agricultural productivity and not related to surface coal mine operations.

The kinds of data that can be collected in making a signficance evaluation are listed in table 3.

TABLE 3

KINDS OF DATA USEFUL FOR SIGNIFICANCE DETERMINATIONS

1. Information on total farm production:

   A. An inventory of typical livestock numbers.

   B. A cropland/hayland use summary for typical production and marketing years, including the following:

      (1) Acreage of each crop grown;

      (2) Yield per acre;

      (3) Total production harvested;

      (4) Estimated carrying capacity of aftermath (AUM's);

      (5) Disposition of crops (percentage);

         (a) Amount fed to farm's livestock; and

         (b) Amount sold.

   C. Acreage and estimated carrying capacity (AUM's) of the range and pasture resources of the farm under typical weather conditions, excluding crop production and carrying capacity of the crop aftermath.

2. Information for farm's developed lands within affected alluvial valley floor, including the following:

   A. Information as requested in 1.B. and C. above;

   B. A history of land uses and production; and

   C. Maps showing:

      (1) History of ownership/tenancy of the affected alluvial valley floor and adjacent lands.

      (2) History of land uses and management practices within and adjacent to the affected alluvial valley floor; e.g., fencing, irrigation structures, haylands, croplands, pasturelands, etc.

      (3) Extent of subirrigation.

      (4) Extent of affected alluvial valley floor.

Although the Office of Surface Mining has not adopted a regulatory definition of "negligible impact," the State of Wyoming has done so, and their approach may be useful in other States. The quantitative definition (table 4) was developed after numerous interviews were held in the State with ranchers concerning income cycles and acceptable losses. Although no loss of income is appreciated by an operator, the nature of agricultural business is one of cyclical trends of good and bad times. Some amount of losses are experienced occasionally as part of any operation. The State of Wyoming estimated a range of productivity losses depending on ranch size--from 3 percent for a very small operation to 10 percent for a large one--that operators considered sustainable without affecting their overall operation. In other words, ranchers were asked what amount of loss in productivity would really affect their overall operation.

The quantitative definition of negligible impact developed in Wyoming cannot automatically be transfered to other States. Acceptable losses in other regions may differ from the data for Wyoming. However, the process used by Wyoming to develop its definition is instructive and can be used by operators and regulatory authorities elsewhere in establishing threshold values for negligible impact.

As additional background on this issue, a review of regulatory decisions is helpful. In one decision in Montana, the regulatory authority determined that a 2 percent loss in hay production measured in equivalent AUM's for an overwintering herd of 500 head was less than a negligible loss.

TABLE 4

WYOMING DEFINITION OF NEGLIGIBLE IMPACT

Where developed lands are involved in a proposed mining operation and where agricultural use of such developed lands would be interrupted, discontinued, or precluded during mining, the loss of such lands from a farm's production capabilities must be assessed. If it is determined that the loss to farm production would only cause a negligible impact upon total production, then a permit to mine may be granted. The equation of:

$$P = 3 + 0.0014X,$$

Where: P = productive loss in percent, and
X = number of animal units in excess of 100,

is used to estimate allowable farm production loss less than 10 percent. "P" (up to 10 percent) is the percentage of productive loss considered to be of a negligible impact to a Wyoming farm. The equation is a result of the following assumptions: (1) that a 3 percent loss in production to a very small viable farming operation (100 AU's) would constitute a production loss in excess of that which could be absorbed through management changes; and (2) that production loss which can be absorbed by viable farming operations will generally increase as total farm production must be converted to animal units. Any loss greater than 10 percent is considered to exceed a negligible impact to both small and large Wyoming farming operations.

Essential Hydrologic Functions

"Essential hydrologic functions" is a term used in the SMCRA [515(b)(10)(F)]. Mining and reclamation operations, in order to gain permit approval, must preserve the essential hydrologic functions of alluvial valley floors not proposed for mining and must restore the functions of valleys proposed for mining. The purpose of regulatory focus on essential hydrologic functions is to ensure that the goal of environmental protection or reclamation is met: restore or protect the essential hydrologic roles of the valley which give the valley its agricultural value. These roles include the collection, storage, and regulation of water flow which results in water being usefully available from streams or alluvial aquifers for agricultural purposes. Each alluvial valley floor in the West has unique characteristics, but the function of providing water for agriculture is common to all valleys.

Section 515(b)(10)(F) of the Act requires that the essential hydrologic functions of all alluvial valley floors be preserved during mining and reclamation operations. The term "preserve" is understood (based on legislative history) to have two meanings, depending on whether the alluvial valley floor is within or outside the affected area. For alluvial valley floors within the affected area, the term "preserve" means that the essential hydrologic functions must be reestablished during reclamation. For alluvial valley floors offsite, the essential hydrologic functions must be "preserved"--that is, maintained--at all times. To allow the regulatory authority to make a determination that essential hydrologic functions will be maintained or reestablished, the hydrologic functions of the specific valley and the characteristics of the valley which create those functions should be identified. Every alluvial valley floor is unique, and the geologic, hydrologic, and biologic characteristics which combine to supply water for agricultural activities are unique.

Studies of essential hydrologic functions should focus on the unique character of a specific alluvial valley resulting in making surface water, ground water, or both usefully available to plants. Once the characteristics are understood, the operator can propose mitigation of impacts or a reclamation plan which restores the same functions, although not necessarily with the same characteristics. The degree of detail needed to describe each characteristic should be related to the likelihood of that characteristic being disturbed or affected and the importance of the characteristic to the basic functions. Most detail is required when the alluvial valley floor is proposed for mining and the reestablishment of the essential hydrologic functions must be accomplished.

It is impossible to give one study outline for all alluvial valley floors. In studying a specific valley, the important hydrologic functions should be broadly identified, and then the specific characteristics supporting each function should be identified and defined. The functions and characteries of any alluvial valley floors will probably be a subset of those listed in table 5. Appropriate studies which can be carried out and included in a permit application are outlined in tables 6 and 7.

TABLE 5

ESSENTIAL HYDROLOGIC FUNCTIONS OF ALLUVIAL VALLEY FLOORS AND FREQUENTLY OCCURRING CHARACTERISTICS RELATED TO THOSE FUNCTIONS

1. Typical characteristics supporting the function of collecting water:

   A. The amount and rate of runoff and a water balance analysis, with respect to rainfall, evapotranspiration, infiltration, and ground-water recharge.

   B. The relief, slope, and density of the network of drainage channels.

   C. The infiltration, permeability, porosity and tranmissivity of unconsolidated deposits of the valley floor that either constitute the aquifer associated with the stream or lie between the aquifer and the stream.

   D. Other factors that affect the interchange of water between surface streams and ground-water systems, such as depth to ground water, the direction of ground-water flow, and the extent to which the stream and associated alluvial ground-water aquifers provide recharge to, or are recharged by, bedrock aquifers.

2. Typical characteristics supporting the function of storing water:

   A. Surface roughness, slope, and vegetation of the channel, flood plain, and low terraces that retard the flow of surface waters.

   B. Porosity, permeability, water-holding capacity, saturated thickness, and volume of aquifers associated with streams, including alluvial aquifers, perched aquifers, and other water-bearing zones found beneath valley floors.

   C. Moisture held in soils or the plant-growth medium within the alluvial valley floor, and the physical and chemical properties of the subsoil that provide for sustained vegetation growth or cover during extended periods of low precipitation.

TABLE 5

ESSENTIAL HYDROLOGIC FUNCTIONS OF ALLUVIAL VALLEY FLOORS
AND FREQUENTLY OCCURRING CHARACTERISTICS RELATED TO THOSE FUNCTIONS
(Continued)

3. Typical characteristics supporting the function of regulating the flow of water:

   A. The geometry and physical character of the valley, expressed in terms of the longitudinal profile and slope of the valley and the channel, the sinuosity of the channel, the cross-section, slopes, and proportions of the channels, flood plains and low terraces, the nature and stability of the streambanks, and the vegetation established in the channels and along the streambanks and flood plains.

   B. The nature of surface flows as shown by the frequency and duration of flows of representative magnitude including low flows and floods.

   C. The nature of interchange of water between streams, their associated alluvial aquifers, and any bedrock aquifers as shown by the rate and amount of water supplied by the stream to associated alluvial and bedrock aquifers (i.e., recharge) and by the rates and amounts of water supplied by aquifers to the stream (i.e., baseflow).

4. Typical characteristics which make water available:

   A. The presence of landforms including flood plains and terraces suitable for agricultural activities.

   B. The presence of valley soils which support agriculturally useful species.

   C. The resistance of the valley to erosion by floods.

   D. The extended availability of surface and ground water.

TABLE 6

TYPICAL KINDS OF STUDY NECESSARY TO CHARACTERIZE ESSENTIAL HYDROLOGIC FUNCTIONS FOR PERENNIAL AND INTERMITTENT STREAMS WITH OR WITHOUT SUBIRRIGATED AREAS

1. Geomorphology:

   A. Map and describe the channel, flood plain, and terraces at a scale of 1" = 400'. Survey representative channel cross-sections at approximately 1,500-foot intervals. Determine meander characteristics.

   B. Map the surficial geology of the valley and describe the recent geomorphic history of the valley floor.

   C. Survey the longitudinal profile of the thalweg and the valley slope.

   D. Identify the texture of channel bed and banks, and describe bedforms, if present. Estimate channel roughness.

   E. Collect sediment samples and separate bedload and washload fractions.

2. Surface Water:

   A. Collect continuous streamflow records upstream and downstream from the affected alluvial valley floor. Estimate mean annual and monthly streamflow.

   B. Develop floodflow estimates, estimate stream velocities, and estimate inundated areas on surveyed cross-sections for the 2-, 10-, 25-, and 100-year floods.

   C. Collect streamflow records on tributaries affected by mining operations.

   D. Collect precipitation and snowfall data and relate it to stream hydrographs.

   E. Estimate runoff and sediment-yield contribution from mining areas to the alluvial valley floor.

   F. Measure and describe the water quality charcteristics of the valley floor stream and significant mining-affected tributaries.

TABLE 6

TYPICAL KINDS OF STUDY NECESSARY TO CHARACTERIZE ESSENTIAL HYDROLOGIC FUNCTIONS FOR PERENNIAL AND INTERMITTENT STREAMS WITH OR WITHOUT SUBIRRIGATED AREAS (Continued)

3. Geohydrology: Geohydrologic studies for alluvial valley floors without subirrigated areas can be less intensive but the relationship between streamflow and aquifers must be determined.

   A. Identify the configuration, location, and strata of the alluvial aquifer and develop geologic cross-sections; use backhoe pits and drillhole data.

   B. Describe the capillary fringe for the different materials in which it is found.

   C. Map geology and structure of the study area and develop representative geologic cross-sections.

   D. Describe the connection of the alluvial saturated zone with adjacent aquifers.

      (1) Define potentiometric surfaces in all aquifers.

      (2) Perform pump tests to determine aquifer properties.

      (3) Identify faults or other hydrologic boundaries.

   E. Monitor alluvial ground-water levels within and adjacent to the alluvial valley floor to adequately define the dynamic interrelationship of the system.

   F. Describe seepage run to identify areas where streamflow is lost to, or gained from, the ground-water system.

4. Soils and Vegetation:

   A. Prepare a soil survey to develop an understanding of the characteristics of soils which make it irrigable or which permit subirrigation.

   B. Prepare a vegetation inventory, providing special attention to varying vegetation patterns on terraces, subirrigated areas, and cropland.

TABLE 7

TYPICAL KINDS OF STUDY NECESSARY TO CHARACTERIZE ESSENTIAL HYDROLOGIC FUNCTIONS FOR EPHEMERAL STREAMS WITH NO SUBIRRIGATED AREAS

1. Geomorphology:

   A. Map and describe the channel, flood plain, and terraces at a scale of 1" = 400'. Survey representative channel cross-sections at approximately 1,500-foot intervals.

   B. Map the surficial geology of the valley and describe the recent geomorphic history of the valley floor.

   C. Survey the longitudinal profile of the thalweg.

   D. Identify the texture of channel bed and banks. Estimate channel roughness.

2. Surface water:

   A. Collect streamflow records for the valley stream and tributaries affected by mining. Estimate peak flow and mean annual and monthly streamflows.

   B. Develop floodflow estimates, estimate stream velocities, and estimate inundated areas on surveyed cross-sections for the 2-, 10-, 25- and 100-year floods.

   C. Estimate runoff and sediment yield contribution from mining areas to the alluvail valley floor.

   D. Measure and describe the water quality characteristics of the valley floor stream and significant tributaries to be affected by mining.

3. Soils and Vegetation:

   A. Describe the characteristics of valley bottom deposits from backhoe pits.

   B. Prepare a soil survey to develop an understanding of why the soils are irrigable.

   C. Prepare a vegetation inventory, providing special attention to varying vegetation patterns on terraces and cropland.

Material Damage

Section 510(b)(5)(B) of the Act prohibits a mining operation from materially damaging the waters supplied to those alluvial valley floors signficant to agricultural operations. Material damage is defined in regulation as degrading or reducing water quantity or quality to the extent that changes would significantly decrease the capability of an alluvial valley to support agricultural use dependent on that water.

Thus, material damage to water supplies is to be evaluated in terms of the effect of that change on the usefulness of the area to agriculture and not merely in terms of a measured change in water supply or quality alone.

Analyses concerning material damage must obviously be predictive in nature, using baseline data collected to characterize essential hydrologic functions and the specific mining and reclamation plan proposals. The major difficulties in such an effort are (1) to predict change in hydrologic and other parameters, and (2) to estimate the effect of those changes on agricultural use. The kinds of changes which might be considered in a material damage assessment are listed in table 8. The kinds of predictive studies which should be considered in a material damage assessment are listed in table 9.

As with "negligible impact" (the term of importance when deciding how much land can be disturbed by mining), material damage must be quantified in terms of the degree of acceptable change. There is a threshold, below which change is considered acceptable and above which is considered material damage.

Although quantitative regulatory standards for material damage have not been proposed, consistency dictates that threshold numbers developed for negligible impact analyses are appropriate for material damage assessments. In other words, if a predicted decrease in agricultural usefulness of an alluvial valley (such as a decrease in productivity, as measured in AUM's) due to mining-induced impacts would be considered neglible under a significant evaluation, then material damage would not occur.

The guidance offered in developing threshold numbers for significance determinations applies in this case. The State of Wyoming has offered specific guidance in this topic, whereas other States have developed more fluid standards. In States without fixed standards, interviews with ranchers and farmers in the region can help fix an "acceptable-loss" threshold value.

TABLE 8

POSSIBLE HYDROLOGIC CHANGES WHICH MIGHT MATERIALLY DAMAGE AGRICULTURAL ACTIVITIES ON ALLUVIAL VALLEY FLOORS

1. Diversion or alteration of streamflow of valley stream or tributaries.

2. Change of runoff characteristics of affected land in drainage basin.

3. Change of streamflow through mine area due to evaporation or dewatering.

4. Reduction of sediment load caused by impoundments.

5. Increase in sediment yield from reclaimed lands.

6. Disruption of the alluvial aquifer or other aquifers hydraulically connected to the alluvial aquifer.

7. Drainage of the alluvial aquifer to an adjacent mined area.

8. Alteration of the water quality of the stream or alluvial aquifer due to surface discharge, seepage, or ground-water movement.

TABLE 9

PREDICTIVE STUDIES FOR MATERIAL DAMAGE ASSESSMENTS

1. Hydrologic Assessment:

   A. Drawdown analysis for each aquifer in or adjacent to a mine pit.

   B. Model ground-water flow patterns for mining and postmining periods, given the estimated changes in aquifer characteristics.

   C. Model streamflow for mining and postmining periods, given the estimated changes in drainage density, runoff characteristics, drainage area, and channel characteristics of the reclaimed area.

   D. Estimate postmining ground-water quality of spoils water and determine effect on adjacent surface and ground waters.

   E. Estimate postmining surface-water quality of streams draining the reclaimed area and determine effect on adjacent surface and ground waters.

   F. Develop a water balance of the entire study area encompassing the cummulative effects of the studies mentioned above.

2. Vegetation and Agricultural Assessment:

   A. Compute loss of irrigated acreage due to reduced streamflow.

   B. Estimate reduction in crop yield due to degraded water quality.

   C. Estimate loss of productivity of subirrigated species due to lowered water table.

   D. Estimate loss of agricultural land due to a rise in the water table.

Reclamation of Alluvial Valley Floors

Reclamation of alluvial valley floors should be approached with the intent of reestablishing the essential hydrologic functions of the original alluvial valley floor. Commonly, reestablishing these functions can be accomplished most completely by restoring all components of the valley floors to their preexisting condition. In reality, it is not always possible to do this, and alternate design of some components is necessary owing to the drastic disturbance of the original alluvial valley materials. The test of reclamation success is whether the functions of the valley are reestablished.

A good understanding of the characteristics of the existing, undisturbed system is a prerequisite to developing the plan. Appendix E discusses concepts in reclamation related to flood irrigation and subirrigation. Obviously, for flood irrigation, the major focus of reclamation is on the stream channel, the availability and quality of surface water, and the topography and soil characteristics of areas to be irrigated. Stability of the reclaimed stream channel is of primary concern, and, as discussed in appendix E, a geomorphic approach to reclamation planning is encouraged to ensure stability of the valley floor over the long term.

For subirrigated valleys, the characteristics of the reconstructed aquifer, the volume and quality of the restored ground water, its annual fluctuations, the nature of the reestablished vegetation communities, and their expected productivities are all issues which must be addressed. The science of aquifer reconstructon is in its infancy; therefore, less guidance can be given in appendix E for reclamation of subirrigated valleys than is given for stream channel reclamation. Perhaps of most value to the reclamation planner is the discussion of proposed reclamation plans for subirrigated valleys.

Developing a Monitoring System

Ongoing monitoring programs must be proposed at the time of permit application submittal. The monitoring program is designed to demonstrate compliance with the performance standards of the SMCRA. Monitoring studies are usually continuations of some of the studies undertaken in the considerations of significance, material damage, essential hydrologic functions, and reclamation. The level of monitoring of various aspects of an alluvial valley floor will depend on the degree of importance of the agricultural lands and the sensitivity of the agricultural or hydrologic systems to effects of mining. Some or most of the monitoring requirements needed for alluvial valley floor protection will probably be the same as those required by other regulations concerning hydrologic protection. The following phases of a monitoring program should be considered:

1. Continuation of baseline studies. Frequently baseline monitoring initiated for studying alluvial valley floors would be continued during the permitting and initial mine development periods. Although an understanding of the agricultural and hydrologic systems of an alluvial valley

floor must be developed for a permit application, longer term records can provide a better understanding of such factors as seasonal variation. This greater knowledge can help clarify the meaning of later monitored changes in the alluvial valley floor system and can aid reclamation planners to "fine tune" valley floor or alluvial aquifer reconstruction plans.

2. Monitoring during mining. Most important during mining is the monitoring of the essential hydrologic functions and agricultural utility of the alluvial valley floor to document that protected valley floors remain unaffected.

3. Monitoring after mining. Monitoring of protected alluvial valley floors must continue after mining because of the commonly significant hydrologic changes which occur as ground- and surface-water systems readjust to the cessation of mining operations. Additional monitoring must be started to demonstrate compliance of reclaimed alluvial valley floors with appropriate performance standards.

It is best for the applicant to discuss these studies with the regulatory authority to determine which studies ought to be continued during and after mining and reclamation.

APPENDIX A

ALLUVIAL DEPOSITS AND GEOMORPHOLOGY

Introduction

Alluvial valley floors are composed of "unconsolidated stream-laid deposits" but are not composed of "upland areas which are generally overlain by a thin veneer of colluvial deposits" (30 CFR 701.5). Virtually all stream valleys in the semiarid and arid West are filled with unconsolidated deposits, and, thus, most stream valleys meet this criterion. The task of the geologist mapping alluvial valley floors is to map the areal and vertical extent of these deposits, describe their characteristics and make interpretations of their origin.

Collectively, the unconsolidated deposits of Western valleys are called valley fills. The deposits are actually composed of the debris left by several processes, such as streamflow, slopewash, wind, and/or landsliding. These processes also shape the valley floor, and recognition of particular landforms--terraces, flood plains, alluvial fans, for example--aids the geologist in describing the underlying deposits. Thus, the task of the geologist, in terms of the alluvial valley floor issue, is to identify those deposits and landforms whose origin is a function of streamflow. This appendix gives an overview of the current state of knowledge about unconsolidated stream-laid deposits in the interior West, as well as a summary of geomorphic principles applicable to reclamation planning for those valley floors proposed in mining.

As emphasized in this section, identificaton of deposits and landforms related to stream, or fluvial, processes is not always clearcut, particularly at the margins of the valley. The quickest way to identify alluvial deposits is through mapping of stream terraces and flood plains. The easiest type of alluvial deposit to recognize, either in an outcrop or in drill cuttings, is gravel or well-sorted sand. However, older stream terraces may be masked by a mantle of colluvium, and some fine-grained alluvial deposits are indistinguishable from other unconsolidated deposits. Therefore. when questions arise concerning the lateral extent of stream-laid deposits, various types of evidence need to be evaluated bv a qualified geologist or geomorphologist.

Alluvial Deposits

Several classifications of alluvial deposits have been proposed (Fisk, 1947; Allen, 1965), and that outlined by Happ and others. (1940) is reviewed here. These authors recognized six types of denosits which may underlie the alluvial floor of a valley (fig. A-1):

1. Channel fill deposits are primarily bed-load materials.
2. Vertical accretion deposits consist largely of suspended load materials and are deposited from overbank floodflows.

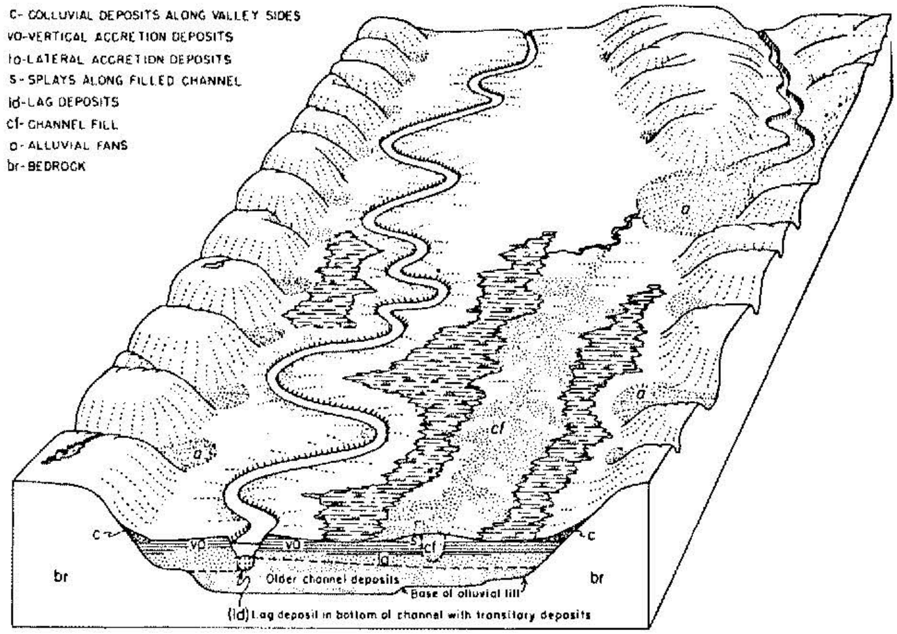

Fig. A-1 Types of alluvial deposits. (After Happ and others, 1940; Thornbury, 1969).

3. Flood plain or crevasse splay is a term applied to deposits spread over the flood plain through a restricted low section, along distributary channels, or through breaks in natural levees.

4. Latéral accretion deposits, such as point bar materials, occur at the sides of channels as channels migrate laterally.

5. Lag deposits are coarse materials which have been sorted out and left behind on the streambed.

6. Colluvium deposits consist of debris carried by slopewash and small rills into the valley. Such material is generally unsorted.

Typically, coarse-grained materials, such as gravel, make up the channel fill and lag deposits, whereas the vertical and lateral accretion deposits are generally finer grained. However, differentiation of the origin of various alluvial deposits cannot be made solely on the basis of grain size. Sedimentary structures and features seen in cross-sections of the deposits provide a better understanding of origin.

Different river flood plains have varying amounts of deposits formed by lateral and vertical accretion. The fact that flood plain deposits of many streams in subhumid areas are comprised mostly of silt with a thin, irregular layer of basal gravel has led some observers to believe that flood plains are comprised principally of overbank deposits (Stene, 1980; Schumm and Lichty, 1963; Everitt, 1968). Paleosols and cultural horizons found within the upper, fine-grained alluvium indicate that overbank deposition is responsible for alluvium above these horizons. Wolman and Leopold (1957), however, were of the opinion that vertical accretion deposits make up only a minor component of most flood plain deposits chiefly because the continued lateral shifting of the channel eliminates areas with overbank deposits. Geologists should be aware that the stratigraphy of stream-laid deposits varies from stream to stream.

The types of alluvial deposits discussed above are generally better developed and more easily distinguishable on perennial streams. Ephemeral and intermittent streams tend to have poorly developed alluvial deposits owing to the varying size of runoff events responsible for transporting and depositing the sediment. In the semiarid West the alluvium underlying ephemeral drainages is usually a heterogeneous mixture of sediment ranging from gravel to fine clay (Hadley and King, 1978).

Terrace Formation

The most distinctive landforms showing stream processes are the terrace and the flood plain. Stream terraces are flat surfaces along the valley sides of stream courses marking the level of former valleys (fig. A-2). They are vestiges of former flood plains formed by streams which were higher in elevation than the present stream. The flat floor of a valley is constructed by the stream during lateral migration of the stream channel(s). As the stream simultaneously erodes one bank and deposits sediment on the other, older landforms are elmininated, and the new flood plain is built. At some time in

Fig. A-2 Terraces along Dutch Creek, near Sheridan, Wyoming. The flat-lying terraces in the valley bottom are haylands, and the valley slideslopes (foreground) are planted in small grains.

Fig. A-3 Flood plain and terraces of the Powder River near Arvada, Wyoming. The flood plain extends between the trees on both sides of the river.

the past, the stream has occupied each and every position on the flat valley floor.

A stream's flood plain (fig. A-3) is developed in response to the relative rates of transport of both water and sediment. The longer these rates remain fairly uniform through time, the broader the flood plain becomes as the stream migrates laterally. A change in climatic or watershed conditions which alters the water or sediment availability in the drainage basin can result in net aggradation or downcutting by the stream as the stream creates a new valley flat or flood plain at an elevation appropriate for the new conditions. In such a circumstance, the flood plain level previously associated with the stream is either abandoned by downcutting or is covered as aggradation occurs. During downcutting, the previous flood plain is dissected, and portions may remain as continuous benches bordering the stream, or, more often, as remnants of flat, or nearly flat, spurs jutting into the valley. Sediment deposited by aggrading streams covers older landforms and masks the former flood plain position.

A valley floor may contain several different terrace levels. The erosional and depositional history of terraces can usually be deciphered by looking at the geology of the underlying deposits. Figs. A-4 and A-5 diagram various scenarios of terrace development.

The progressive sequence of channel migration and consequent flood plain construction is portrayed in fig. A-6. The coarsest

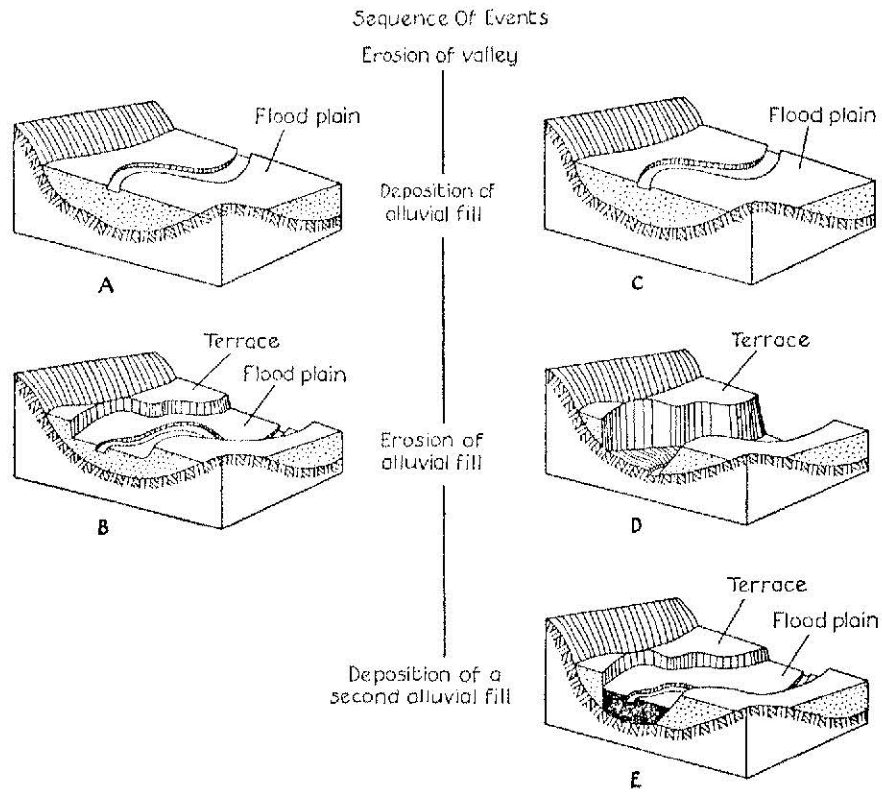

Fig. A-4 Block diagrams illustrating the stages in development of a terrace. Two sequences of events leading to the same surface geometry are shown in diagrams A, B, and C, D, E, respectively. (Leopold, Wolman, and Miller, 1964.)

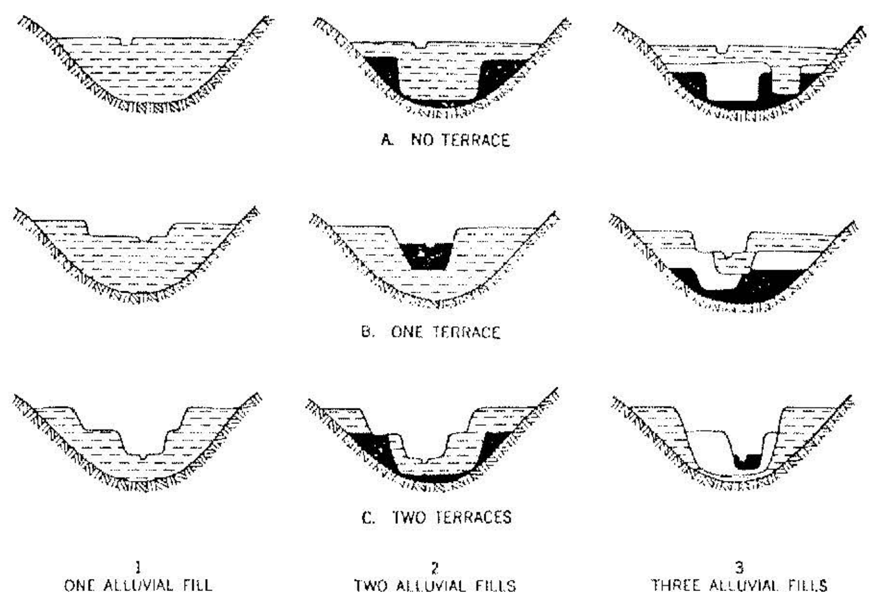

Fig. A-5 Examples of valley cross-sections showing some possible stratigraphic relations in valley alluvium. A, No terrace. B, One terrace. C, Two terraces. (Leopold, Wolman, and Miller, 1964.)

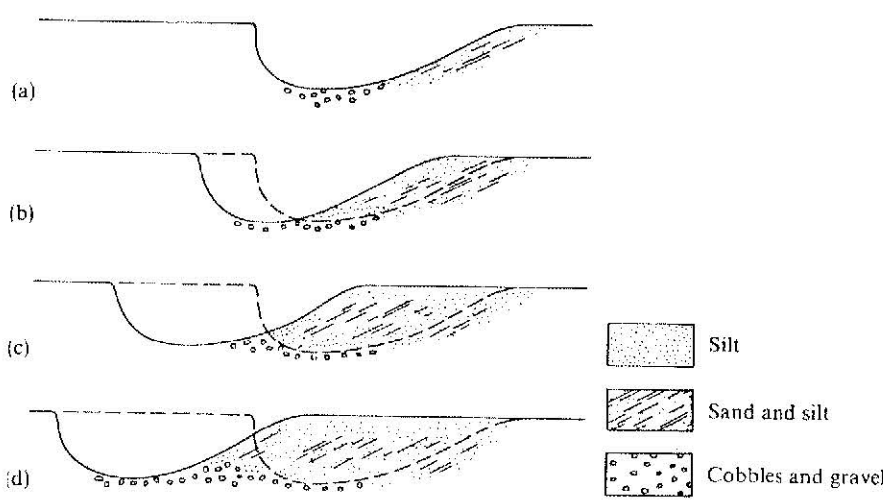

Fig. A-6 Four sequential stages in progressive construction of a flood plain as stream moves laterally, diagrammatically shown. (a) Initial stage showing gravel and sand on streambed. (b) Stream erodes left bank as it deposits on point bar to right of diagram. (c) Later stage showing streambed gravel covered over with sand and silt, finer material deposited near the top of the point bar. (d) Still later stage indicating how progressive lateral movement builds flood plain with cobble or coarse material at base and finest material near surface. (Dunne and Leopold, 1978.)

material, usually gravel, is deposited only on the channel bed. This coarse bed material tends to be covered with finer sand and silt which forms the channel bank. Deposition of additional fine-grained material occurs on top of the flood plain as overbank deposits during floods. As the material in the channel bed and banks is continually eroded from one bank, transported downstream, and redeposited on another, the characteristic features of unconsolidated stream-laid deposits or alluvium which underlie terraces and flood plains are created.

Flood plains and terraces generally tend to have flat surfaces; however, portions which are near valley sides are subject to local deposition of slopewash, and, therefore, the flat surface tends to curve upward to meet the valley side. This process occurs not only after formation of the flat flood plain or terrace but also during the depositional buildup of a flood plain. Sediment eroded from valley sides is deposited in the valley by local wash, tributary rills, and mass movement. These slopewash deposits are called colluvium and, in some cases, may be preponderant in the valley fill. In summary, flood plains and terraces have flat surfaces which are blurred at edges where they merge gradually with valley-side colluvium.

Alluvial Fans

In some valleys alluvial fans must be distinguished from stream terraces, particularly where a smaller valley joins a larger valley or large basin. Alluvial fans form where a stream, heavily loaded with sediment, emerges from highlands onto a lowland (fig. A-1). At this juncture, there is a significant change in gradient, which reduces the stream's capability to transport sediment. The deposited sediment typically accumulates in a semicircular area with the coarser material at its head and the finer material downslope. The down-fan profile of an alluvial fan is typically concave, whereas the cross-fan profile is convex. A series of adjacent fans may, in time, coalesce to form an extensive piedmont surface or bajada. Alluvial fans are generally underlain by gravelly detritus that is poorly sorted and stratified and that usually do not contain deposits comparable to overbank or vertical accretion deposits of flood plains.

Difficulty has been encountered in some alluvial valley floor studies in distinguishing alluvial fans from stream terraces. If at the junction of two streams, the main stream can transport the entire sediment load of the tributary, no alluvial fan forms. Rather, the current flood plains of both streams are graded to each other. Similarly, terraces (former flood plains) tend to be graded to each other. Remnants of terraces along valley margins can be recognized and distinguished from alluvial fans because the terrace remnant is part of a terrace level mappable along the valley, because the underlying deposits do not vary in grain size in a direction perpendicular to the valley wall, and because of the surface morphology of the terrace.

Alluvium and Colluvium

As already noted, alluvial valley floors are those portions of topographic valleys underlain by stream-laid deposits. Geologists use the term alluvium to describe these kinds of deposits. To the geologist, colluvium is "a general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity" (American Geological Institute, 1974). Colluvium may be found in valley floors, but its identification is only possible if differences can be recognized between the material in transport in the stream and in transport on the slopes. Detailed stratigraphic data is also necessary.

As with most regulatory exercises, it becomes necessary to establish boundaries, even where natural processes have yielded gradational change. Colluvium is not always easily differentiated from alluvium in a field situation. Some key indicators in specific instances may provide the necessary distinctions; however, in other cases, the two deposits may not be readily distinguishable. In their work on alluvial valleys of eastern Wyoming, Leopold and Miller (1954, p. 13) stated that "alluvial terraces * * * characteristically do not exhibit a sharp textual break between deposits of the main stream and slopewash. In fact, the materials are generally so nearly identical that the criteria usable in the Big Horn Basin (Mackin, 1937) cannot be applied" (in our study).

The typical stratigraphy of alluvium in smaller drainages of the Powder River Basin and elsewhere is basal gravels overlain by silt and clay material. The fine-grained deposits tend to be more extensive laterally than the gravels. The gravels can be as much as 40 feet thick, with the total alluvium thickness ranging up to 70 feet. The great thickness and sorted nature of the gravel deposits clearly indicate their fluvial origin. Therefore, a map showing the extent of the basal gravel in the valley fill often indicates the minimum extent of alluvial deposits in the valley.

Fine-grained alluvial and colluvial deposits, however, are difficult to distinguish. Both are generally composed of clay, silt, and sand. Distinguishing features of alluvium are sometimes rounded particles and massive layering, with the stratigraphy less variable and the units thicker than in colluvium. Colluvium can have more angular grains and, where it has been transported along a slope by sheetwash, can be more thinly bedded with more variable stratigraphy. These features are relative and are not absolute guides to differentiating the deposits. Deposits may be distinguished by finding distinctive rock types in the deposit which could have been transported to the valley fill by only the stream or by only slopewash processes.

The deposits are generally examined in backhoe pits or as they are retrieved during a drilling operation. Neither method is ideal and does not offer as good a view of the deposits as that offered in stream or roadcuts. Lithologic descriptions of drill cuttings do not indicate the type of lateral stratification of the deposits and vertical stratification can be partially or completely masked owing to mixing of the cuttings during drilling. Backhoe pits seldom exceed 15 feet in depth and, therefore, may not intersect deeper alluvial deposits.

Given the difficulty in distinguishing the two types of deposits, the geologist must use not only the evidence afforded by the deposits but also the evidence provided by the landform. Emphasis on landform data has been made by regulatory authorities because such data are more easily collected. As a general rule, all unconsolidated deposits beneath terraces and flood plains are considered to meet the criteria of an alluvial valley floor. Uplands, such as the middle and upper portions of hillslopes, are clearly not alluvial valley floors. Along the margins of valley floors, where the land surface slopes gently upward and underlying deposits are unconsolidated, the geologist must use all available evidence in determining the extent of alluvial deposits. The data for such distinctions are usually not available until the formal permit application stage.

Surficial Geologic Mapping

The U.S. Geological Survey has mapped surficial geology of Campbell County, Wyoming, at a scale of 1:100,000 (Reheis, 1982; Reheis and Coates, 1982; Reheis and Williams, 1979) and has also mapped much of the county at a scale of 1:24,000 (fig. A-7). This effort represents the most comprehensive surficial mapping program in a Western coal region, and the data collected in this effort are very useful in initial alluvial valley floor identification studies. Table A-1 lists the mapping units used in the study, as well as deposit description, common thickness, origin, typical landscape position, and common slope. Those mapping units which meet the geologic criteria of alluvial valley floors are flood plain alluvium (fa), stream terrace alluvium (ta), and minor stream alluvium (aa). It is also possible that portions of the sheetwash alluvium (sa), fan, apron, pediment, and sheetwash alluvium (fs), and dune sand and windblown silt (ed) mapping units are underlain in part by alluvium, where these deposits are adjacent to alluvium-filled valleys.

Fig. A-8 shows a portion of the Turnercrest NE quadrangle and indicates of those mapping units or portions of mapping units which may meet the geologic criteria for purposes of initial identification.

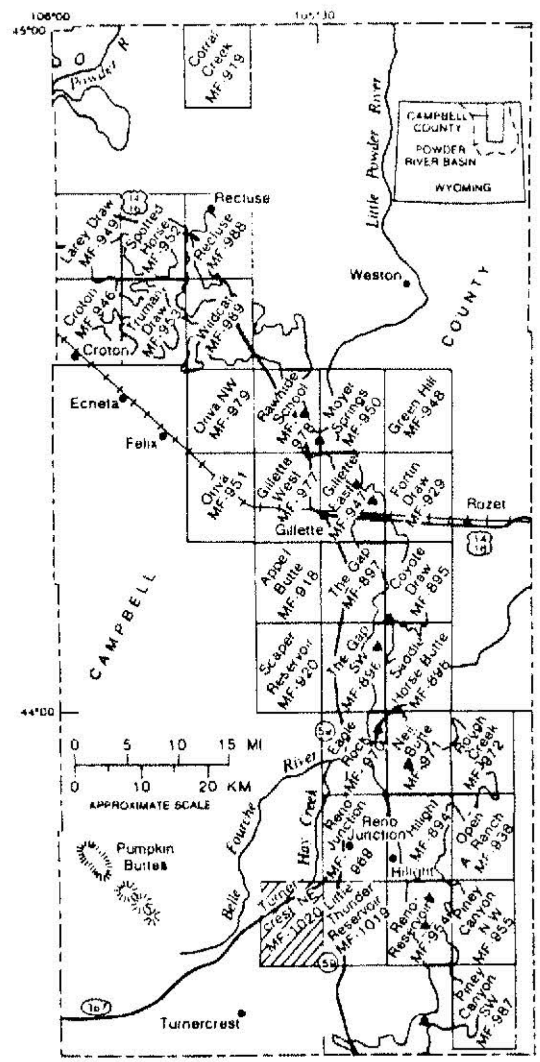

Fig. A-7 Index of recently published U.S. Geological Survey surficial geologic maps in Campbell County, Wyoming. Approximate area of strippable coal shaded (Keefer and Schmidt, 1973). Triangles indicate active or proposed coal strip mines.

TABLE A-1

CHARACTERISTICS OF MAP UNITS

(Used on U.S. Geological Survey surficial geologic maps in Campbell County, Wyoming)

Symbol, name, and age of unit	Materials	Origin	Typical position in the landscape	Common thickness (feet)	Common slope (percent)
		ALLUVIAL DEPOSITS			
fa FLOOD PLAIN ALLUVIUM (HOLOCENE)	Sand and silt, locally containing bedded clay or fine gravel. Isolated pebbles and cobbles of sandstone, porcellanite, and ironstone common locally.	Stream channel and overbank deposits in areas that are flooded.	Channel and flood plain of major stream. May include parts of lowest terrace.	5-10	0-2
ta STREAM TERRACE ALLUVIUM (HOLOCENE)	Massive to well-bedded sand, silt, and clay containing rare thin gravel beds and widely scattered pebbles, most of which are porcellanite.	Stream channel and overbank deposits that are now above the level of stream flooding.	Terraces (benches) along a major valley bottom above the usual level of flooding and below the	5-25	0-2
aa MINOR STREAM ALLUVIUM (HOLOCENE)	Silt and sand locally interbedded with clay or gravel. Isolated pebbles and cobbles of porcellanite, sandstone, and ironstone common locally.	Stream channel and overbank deposits of small ephemeral streams; may include flood plain sediments, deposits on low terraces, and sheetwash alluvium.	Valley bottom of small ephemeral streams.	1.5-10+	0-4

TABLE A-1

CHARACTERISTICS OF MAP UNITS--CONTINUED

Symbol, name, and age of unit	Materials	Origin	Typical position in the landscape	Common thickness (feet)	Common slope (percent)
		ALLUVIAL DEPOSITS			
sa SHEETWASH ALLUVIUM (HOLOCENE)	Mostly reworked local debris from higher parts of slopes. Consists of poorly sorted to well-sorted irregularly bedded to laminated sand, silt, and clay, and minor interbeds of fine gravel.	Sediments deposited chiefly by overland flow of unchanneled water (sheetwash) in nearly level areas.	In swales and depressions, commonly adjoining ephemeral lakes or ponds.	1-5	1-4
fs FAN, APRON, PEDIMENT, AND SHEETWASH ALLUVIUM (HOLOCENE)	On alluvial fans and aprons the upper 1-5 ft is massive to faintly bedded sheetwash alluvium, similar to unit sa, grading downward into poorly sorted to well-sorted sand and silt containing small beds of angular to subangular gravel.	Deposited by ephemeral streams and sheetwash either as a buildup of sediment (alluvial fan or alluvial apron deposits) or as a thin discontinuous deposit on an erosional surface (pediment alluvium).	Gentle to moderate slopes between valley bottoms below and steeper slopes above.	3-10	1-5
		LAKE AND POND DEPOSITS			
lc LAKE AND POND SEDIMENTS (HOLOCENE)	Generally massive gray clay and silt; no pebbles. Some deposits are alkaline.	Sediments deposited in ephemeral lakes and ponds formed in depressions eroded by wind.	Locally low-lying parts of flat to rolling terrain.	3-15	0-1

TABLE A-1

CHARACTERISTICS OF MAP UNITS--CONTINUED

Symbol, name, and age of unit	Materials	Origin	Typical position in the landscape	Common thickness (feet)	Common slope (percent)
		WINDBLOWN DEPOSITS			
ed DUNE SAND AND WINDBLOWN SILT (HOLOCENE)	Crossbedded, parallel-bedded, or massive well-sorted to poorly sorted, mostly medium and fine, generally arkosic sand; locally coarse sand. Includes some windblown silt (loess).	Windblown sand with dune form preserved; commonly includes minor beds of windblown silt.	Small patches on uplands and in some valleys.	1.5-15+	0-15
		RESIDUAL DEPOSITS			
rW RESIDUUM ON WASATCH FORMATION (HOLOCENE AND (PLEISTOCENE?)	Generally sandy and silty material containing variable amounts of clay. Uper 1-3 ft may include a well-developed soil. Grades downward into unweathered Wasatch Formation. Upper 3 ft generally includes minor amounts of sheetwash alluvium, windblown sand and silt, and colluvium.	Products of in-place weathering of Wasatch Formation (Tw). On slopes sheetwash and soil creep move some material downhill. In most places wind periodically erodes and redeposits meterial of the upper 1-4 in.	Moderately to steeply rolling terrain.	3-15+	0-15

TABLE A-1

CHARACTERISTICS OF MAP UNITS--CONTINUED

Symbol, name, and age of unit	Materials	Origin	Typical position in the landscape	Common thickness (feet)	Common slope (percent)
		MIXED DEPOSITS			
Rs RESIDUUM AND SHEETWASH ALLUVIUM (HOLOCENE AND PLEISTOCENE?)	Residuum (rW) and sheetwash alluvium (sa). Mapped where boundaries are indistinct or cover of slopewash alluvium (sa) over residuum is thin and discontinuous.	See origin of residuum (fW) and sheetwash alluvium (sa).	Gentle lower slopes of hills.	1-10	2-10
cr COLLUVIUM AND RESIDUUM (HOLOCENE AND PLEISTOCENE?)	Colluvium generally consists entirely of unsorted and crudely bedded to massive sand, silt, and clay; may contain isolated angular to rounded pebbles, cobbles, and boulders; may be very stony, or may be mainly chaotic rubble; reflects composition of local bedrock.	Colluvium is bedrock debris, weathered bedrock, and soil that have been transported significant distances on moderate to steep slopes chiefly by down-mass-wasting processes. Residuum has not been transported.	Steep upper slopes of hills a capped by baked and fused bedrock and coal ash (bf).	3-20	10-75
re RESIDUUM AND LOESS (HOLOCENE AND PLEISTOCENE?)	Residuum (fW) and windblown sand and silt (ed). Mapped where windblown sand and silt forms a thin discontinuous cover over residuum (rW).	See origin of residuum and windblown deposits (ed).	Gently rolling terrain.	3-15+	0-5

TABLE A-1

CHARACTERISTICS OF MAP UNITS--CONTINUED

Symbol, name, and age of unit	Materials	Origin	Typical position in the landscape	Common thickness (feet)	Common slope (percent)
		BEDROCK			
bf BEDROCK AND FUSED BEDROCK AND COAL ASH	Mostly baked shale and siltstone (porcellanite) that is hard, dense, and mostly brick red to bright orange but locally white or gray mottled with green. In some places rock has melted, forming a black bubbly rock (buchite) that is glassy and resembles some volcanic rocks. Buchite forms veins, flows, and chimneys with porcellanite. The coal ash (clinker) is gray or white and is generally 2 in. to 2 ft thick at the base of or within a porcellanite zone.	Bedrock has been baked and fused by near-surface burning of coal beds in the Wasatch Formation. Thick coal beds have burned hundreds of feets back from the outcrop, producing large areas of baked and fused bedrock and coal ash.	Hilltops and low hummocks.	10-30+	5-50
Tw WASATCH FORMATION	Drab-brown and gray claystone and siltstone containing thick lenses of sandstone.	Deposits laid in streams, swamps, and lakes.	Steeper slopes and ridgetops.	0-200	0-40

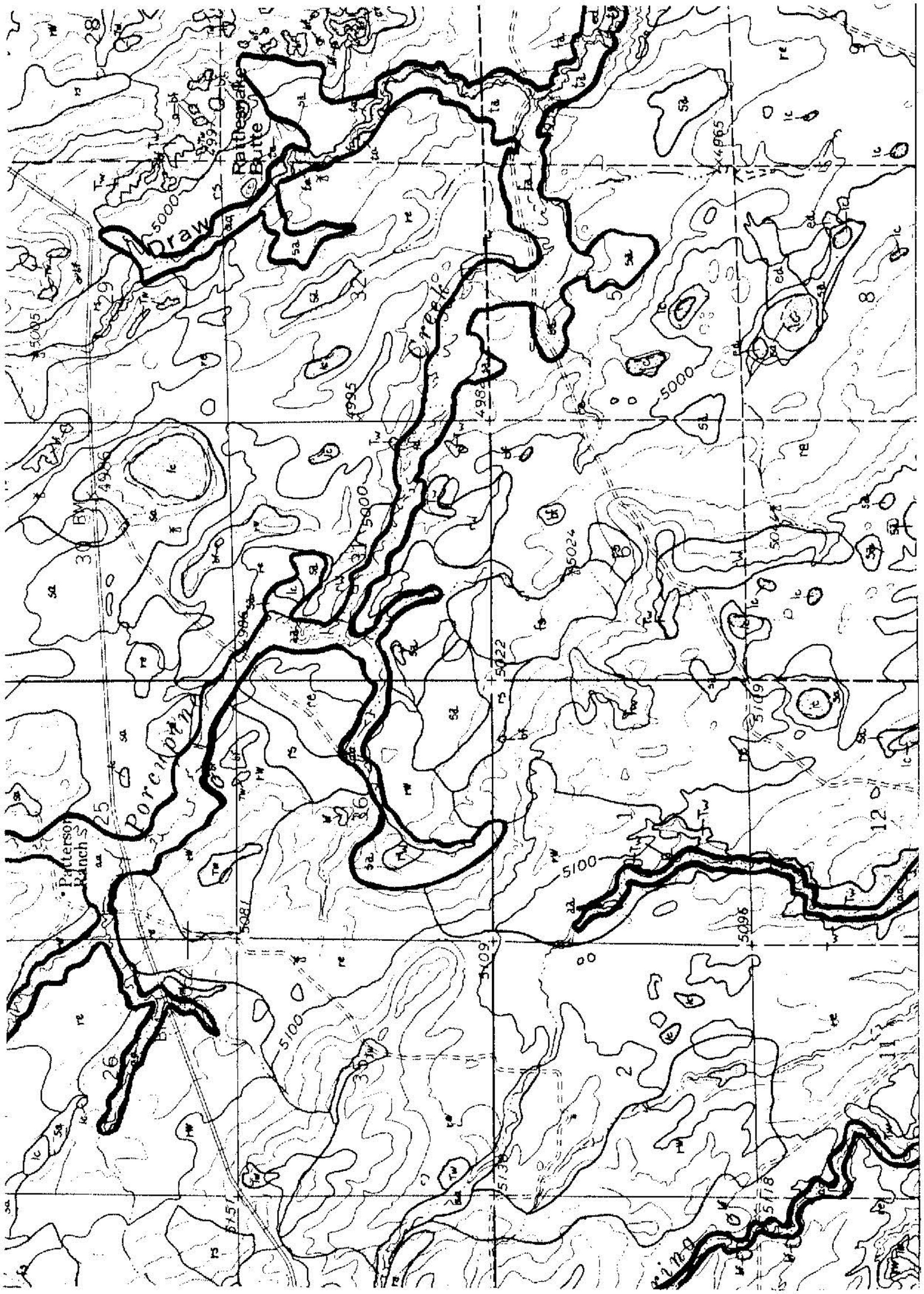

Fig. A-8 A portion of the surficial geologic map of the Turnercrest NE 7 1/2' quadrangle (Wyoming). Heavy lines indicate those mapping units of table A-1 which may include unconsolidated stream-laid deposits. Geology by D. A. Coates. Map scale is 1:36,000.

Bankfull Characteristics of Streams

The physical characteristics of streams are of interest in terms of alluvial valley floors as an aid to estimating hydrologic characteristics of ungaged streams and as an aid in developing reclamation plans for stream channels. The first is discussed briefly in appendix B and the latter in appendix E. This section discusses baseline identification of physical channel characteristics and some other uses of that data.

The identification of channel size characteristics is important because it is generally assumed that channel size is a function of the flows which occur in the channel, particularly a formative or dominant discharge to which other flow characteristics are related. In other words, a channel is a self-forming feature, and its size is determined by the amount of water and sediment it must carry. Thus, for the many small streams in the West which have no gaging record, channel size can be used to estimate the stream's flow regime. Several studies have correlated stream size with hydrologic data from gaging stations and have extrapolated this information to ungaged streams within areas of common hydrology and geology. Hedman and Osterkamp's (1982) summary of some of these studies is outlined in table A-2.

Two terms are used by geologists to describe physical channel characteristics: bankfull stage and active channel (fig. A-9). Bankfull stage is a term intimately related to the concept of the active flood plain because the active flood plain is formed as channels which

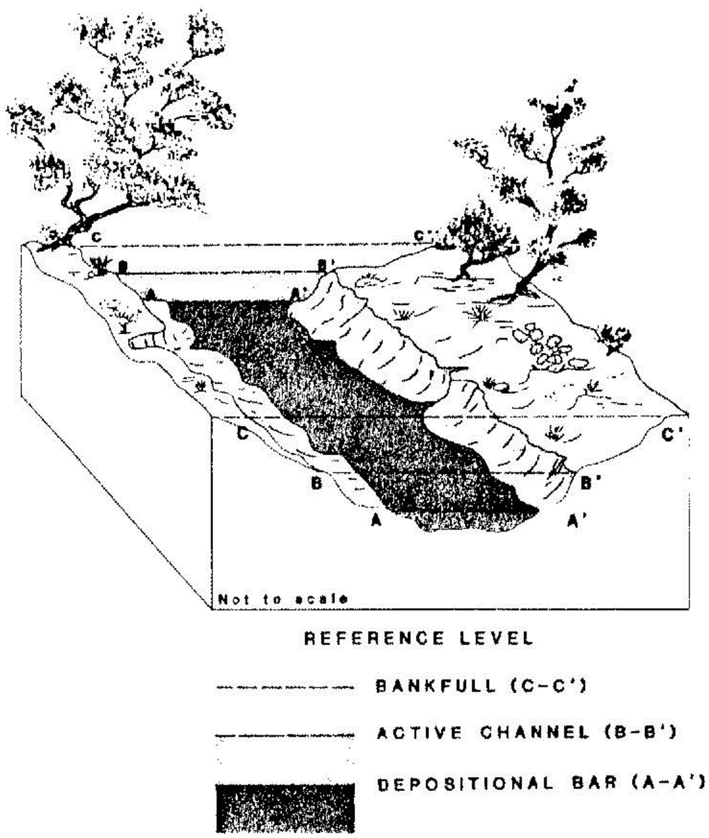

Fig. A-9. Commonly used reference levels for determining channel size.

TABLE A-2

EQUATIONS FOR DETERMINING MEAN ANNUAL RUNOFF FOR STREAMS IN WESTERN UNITED STATES

Flow Frequency	Areas of Similar Regional runoff characteristics	Percentage of time having discharge	Channel material characteristics[a]	Equation[b]	Standard error of estimate (percent)
Perennial	Alpine	More than 80	Silt-clay and armored	$Q_A = 64W_{AC}^{1.88}$	28
Intermittent	Plains north of latitude 39° N.	10 to 80	Silt-clay and armored	$Q_A = 40W_{AC}^{1.80}$	[c]50
			Sand	$Q_A = 40W_{AC}^{1.65}$	[c]50
	Plains south of latitude 39° N.	10 to 80	Silt-clay and armored	$Q_A = 20W_{AC}^{1.65}$	[c]50
			Sand	$Q_A = 20W_{AC}^{1.55}$	[c]50
Ephemeral	Northern and southern plains	6 to 9	Silt-clay and armored	$Q_A = 10W_{AC}^{1.55}$	(d)
			Sand	$Q_A = 10W_{AC}^{1.50}$	(d)
	and intermontaine areas	2 to 5	Silt-clay and armored	$Q_A = 4.0W_{AC}^{1.50}$	[c]40
			Sand	$Q_A = 4.0W_{AC}^{1.40}$	[c]40
	Deserts the Southwest	1 or less	Silt-clay and armored	$Q_A = 0.0W_{AC}^{1.75}$	[c]75
			Sand	$Q_A = 0.0W_{AC}^{1.40}$	[c]75

[a]Silt-clay channels--bed material d_{50} less than 0.1 millimeter or bed material d_{50} equal to or less than 5.0 millimeters and bank silt-clay content equal to or great than 70 percent.

Sand channels--bed material d_{50} = 0.1-5.0 millimeters and bank silt-clay content less than 70 percent.

Armored channels--bed material d_{50} greater than 5.0 millimeters.

[b]Active channel width, W_{AC}, in feet; discharge, Q_A, in acre-feet per year.

[c]Approximate--standard error of estimate of the basic regression equation.

[d]Standard error or estimate not determined; graphical analyses.migrate laterally across the valley flat (fig. A-6). Bankfull stage is commonly

defined as the point at which streamflow just begins to overflow its banks onto the flood plain. Because the flood plain is not always the most prominent portion of the valley flat, care must be taken not to identify bankfull stage on the basis of its association with a terrace.

Development of the idea of the active channel came after investigators, particularly in the West, realized that bankfull stage was sometimes difficult to recognize in the field and that a smaller channel size, or in-channel reference level, for discharge-channel geometry correlations might indicate recent, rather than historic, stream dynamics. The most common in-channel reference level used is the active channel, which is defined by Osterkamp and Hedman (1977) as

> "a short geomorphic feature subject to change by prevailing discharges. The upper limit is defined by a break in the relatively steep bank slope of the active channel to a more gently sloping surface beyond the channel edge. The break in slope normally coincides with the lower limit of permanent vegetation so that the two features, individually or in combination, define the active channel reference level. The section beneath the reference level is that portion of the stream entrenchment in which the channel is actively, if not totally, sculptured by the normal process of water and sediment discharge."

Williams (1979) summarized some of the different criteria that investigators have used to identify channel size:

1. The topographic break in slope from a vertical bank to the flat flood plain.

2. The topographic break in slope from a vertical bank to a gentler slope.

3. The elevation of the lower limit of perennial vegetation (usually trees or shrubs).

4. The elevation of the upper limit of fine-grained stream-deposited debris.

5. The elevation of the "active flood plain".

6. The elevation at which the width/depth ratio of a measured cross-section is at a minimum.

Clearly, one field definition of bankfull stage has not been developed. In the same channel cross-section, different bankfull levels can be identified, depending on which definition or combination of definitions is used. The term "active channel" has also been used by some investigators when using some of the above criteria. Therefore, when using an existing report on bankfull stage or active channels, it is important to use the method specified in the report actually being used. Otherwise, regression equations used in these reports will be misapplied.

The most questionable use of bankfull and active channel interpretations is in ephemeral streams. Unfortunately, these streams are also the most common ones for which such interpretations would be helpful. Some important reasons for the hesitation in use of these data are

1. There are very limited data about ephemeral streams, and therefore, correlations with hydrologic data are subject to wide error.

2. The limited occurrence of flow in these channels may mean that there is no relationship between hydrology and channel characteristics--there may be no "average" discharge in these streams.

3. Several diagnostic features useful in identifying bankfull stage may not be present in some small channels owing to the limited occurrence of flow.

Investigations by Schmidt (unpublished data) in southeastern Montana showed that on small ephemeral streams, there is no apparent relationship between drainage basin characteristics and channel size. Investigations by Curry and Weber (1976) showed some relationship betweeen bankfull size and infrequent large precipitation events at small stream gaging sites in the same region. Such a finding may be of use elsewhere and may imply that channel size in small ephemeral streams may be more closely related to the recent precipitation and runoff history of a basin than to any "average" hydrologic feature of the stream.

Apley (1976) found that in small ephemeral streams of the Powder River Basin in Wyoming with drainage basins less than 2.5 square miles, streams usually do not experience flow more than 3 to 5 days a year. It is not surprising that in these size streams, there may not be a flood plain or an active channel. These stream valleys may, however, have a larger feature, which NERCO (1981) termed the valley trench. Although this larger feature is clearly unrelated to the modern hydrologic regime, it may be a feature worth preserving in reclamation since it is a common feature of many streams (fig. E-3).

Osterkamp and Hedman (1982) collected channel geometry, channel sediment and discharge data for 252 perennial stream gaging stations in the Missouri River basin. Results of their data analysis show that channel width is the best variable to use in regression equations to determine discharge. Further improvement in the equations results from inclusion of channel sediment properties and channel gradient. The authors suggest that the equations developed are applicable outside the Missouri River basin.

Other studies which relate channel geometry to hydrologic characteristics done in individual States are listed on page B-21 in appendix B.

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APPENDIX B

SURFACE IRRIGATION PRACTICES IN THE WEST

Introduction

Surface irrigation plays a vital part in sustaining the agricultural economy of all Western States. Water distribution is accomplished on irrigated lands by means ranging from uncontrolled flooding to highly engineered and elaborately equipped automated systems. Surface water has been the primary source of irrigation in all the Western coal regions, but, within each region, irrigation practices vary with the different environmental conditions. Factors affecting irrigation use patterns include water availability and quality, the degree of Government subsidy, distribution of water rights, and the different management decisions of individual farmers and ranchers.

Flood irrigation methods have traditionally been considered the most economical use of surface water primarily because the initial capital investment of these systems is generally the lowest. The low initial investment is frequently accompanied, however, by a high labor requirement during the irrigation season. Most lands naturally adapted to flood irrigation can receive water from gravity flow sources or require pumping only to the extent of lifting water to the highest point in the field. Natural limitations to effective irrigation by surface methods are steep slopes and soils with very high intake rates (permeability). Inefficiencies generally attributed to surface irrigation systems include water losses from the primary and secondary distribution layouts and unnecessary water losses caused by a lack of understanding of the intake rate and water-holding capacity of the soil being watered.

The remainder of this appendix explains the various methods of surface irrigation found in the West, discusses the factors to be considered in choosing a system, and outlines the typical irrigation practices of each coal region.

Types of Application Methods

The different styles of irrigation practices are important to observe when conducting regional agricultural use surveys and assessing the capability of undeveloped lands to be irrigated. Styles of irrigation not characteristic of a region should not be considered potential methods for purposes of alluvial valley floor studies.

Surface irrigation methods can be classified as either flood, drip, or sprinkler methods. Flood irrigation is practiced by flooding the surface with water. Sprinkler irrigation involves spraying water into the air above the ground. Drip irrigation provides a continuous water supply from pipes. More detailed information on these methods can be found in irrigation guides published for each Western State by the Soil Conservation Service or in standard irrigation textbooks (Hanson and others, 1980, Hagan and others, 1967).

A. Sprinkler irrigation is conducted with many different types of equipment and methods. In general, water is sprayed into the air and allowed to fall on the land surface in a uniform pattern at a rate approximately equal to, or less than, the infiltration rate of the soil. This method simulates rainfall, and efficiencies of 65 to 75 percent can be achieved. Water losses using this method are due to evaporation of the sprinkler spray, evaporation from wetted leaves, nonuniform distribution caused by sprinkler pattern, and wind. Common sprinkler systems are lateral pipes moved by hand or mounted on wheels, single high-capacity nozzles which rotate, and center-pivot irrigation systems. Sprinkler irrigation is adaptable for a very wide variety of crops and soils. The water supply for many sprinkler irrigation systems in the West is either pumped from ground water or is supplied through large-scale irrigation diversion systems. Because both of these water sources can supply water to agricultural land located away from stream valleys, sprinkler irrigation is the most common irrigation method on upland areas. However, some farms and ranches have converted traditional flood irrigation systems to sprinklers on valley bottom fields to reduce labor costs. In most of these cases, surface water is still the source of irrigation.

B. Drip irrigation is the frequent and slow application of water to soil through mechancial outlets. The objective is to continuously supply each plant with enough moisture to meet evapotranspiration needs. Water wastage is reduced considerably.

Drip irrigation is used where water is expensive and crops provide high monetary return on small acreage. Orchards are a typical crop irrigated by this method. Drawbacks to this technique are initial capital costs and high maintenance requirements.

C. Flood irrigation methods can be broken down into two broad classifications--flooding and furrow. All modifications of the flooding method involve covering the entire field surface with water for a period of time and letting it percolate downward into the soil profile. Furrow irrigation wets only a part of the soil surface and results in less loss to direct evaporation than full flooding methods. Movement of water into the soil using the furrow method is both lateral and downward. Different types of flood irrigation methods are described below.

1. Border irrigation is a controlled surface flooding method of water application. The irrigated field is divided into strips, usually 20 to 60 feet wide, separated by parallel dikes or "border ridges." Each strip is irrigated separately. Water is introduced at one end and progressively covers the entire strip. Border irrigation is practiced on either level or graded fields.

a. Level border irrigation applies water by ponding. Each strip of the field in this case has no slope and is enclosed by border ridges. All water applied is retained and absorbed into the soil. This type of irrigation is best suited to soils that have moderate to extremely low intake rates. Advantages of level border irrigation are that many different kinds of crops can be grown in sequence without making major changes in design, layout, or operating procedures. High application efficiency can be obtained easily. The method is well suited to mechanization, can be adapted easily to automation, and can be operated efficiently by inexperienced workers. There are almost no crops that cannot be grown with level border irrigation. It is widely used for close-growing crops, such as alfalfa and other legumes, grasses, and small grains.

b. In graded border irrigation water is applied at the uphill end of each strip and is absorbed into the soil as it flows down the sloped field. The stream of water is such that the desired volume of water is applied at the upper end of the strip in a time equal to or slightly less than that needed for the soil to absorb the net amount required. The stream is turned off after application of the desired volume of water. The water temporarily stored on the ground surface then flows down the strip and completes the irrigation. Uniform and efficient water application is dependent upon use of irrigation streams of the proper size. Field application efficiencies of 60 to 75 percent usually are possible if systems are properly designed and managed. Labor requirements are low, and border strip dimensions can be designed for efficient operation of farm machinery. Fields best suited for this type of irrigation have a slope of 0.1 to

2.0 percent with zero cross-slope. The maximum length of run depends on the soil and stream size but is normally limited to 1,300 feet. Border strips generally require relatively large stream sizes, uniform soil, and uniform land slopes. The graded border method of water applicaion is suitable for close-growing, noncultivated, sown or drilled crops. Legumes, grasses, and small grains are commonly irrigated by this method.

2. Furrow and corrugation irrigation involves directing streams of water into furrows or corrugations graded with a shallow slope in a field. Water is usually pumped or siphoned from an irrigation ditch or other water source. There will be surface runoff, and drain ditches are necessary to carry water off the lower end of the field. This water can be returned to a head ditch, to another field, or to the source. Furrow irrigation is used for row crops, such as corn and sugar beets, whereas corrugation irrigation is used for close-growing crops, including pasture grass, alfalfa, and small grains. Either irrigation system requires relatively little capital investment and complements other cultural practices, such as cultivating. The method works well with stream diversions because high pressures are not required, and large or small flows can be utilized by varying the number of furrows watered at one time. Skilled labor is required for operation and annual touch-up grading is necessary.

3. Contour ditch irrigation generally consists of a series of ditches on a suitable grade following the general contour of the land (figs. B-1, B-2). These ditches are usually designed with spacing of 200 to 500 feet between ditches on fields with slopes of up to 6 percent. The fields in between are then irrigated by controlled flooding. Runoff water usually collects in the next ditch downslope and is used to supplement the water subsequently applied to irrigate the next elevation. The contour ditches either have many openings or canvas or plastic check dams are periodically moved to permit water to flow from the ditch to adequately maintain waterspread for the entire breadth of the field. Land smoothing will improve the water distribution. Field application efficiencies should be between 40 and 60 percent for properly designed and operated systems which reuse tailwater on successive closely spaced contour ditch areas.

4. Field flooding irrigation is the oldest form of irrigation water distribution (fig. B-3) and is used when an abundance of water is available, and the crops grown are principally hay and pasture. It is a common but usually wasteful practice. Irrigation ditches are generally located without much planning, and few are used. This method may be as elementary as diverting the flow of a stream or ditch to a field area and letting the water run wild. One man can handle large amounts of water and irrigate large acreages under favorable conditions where the land is comparatively level and

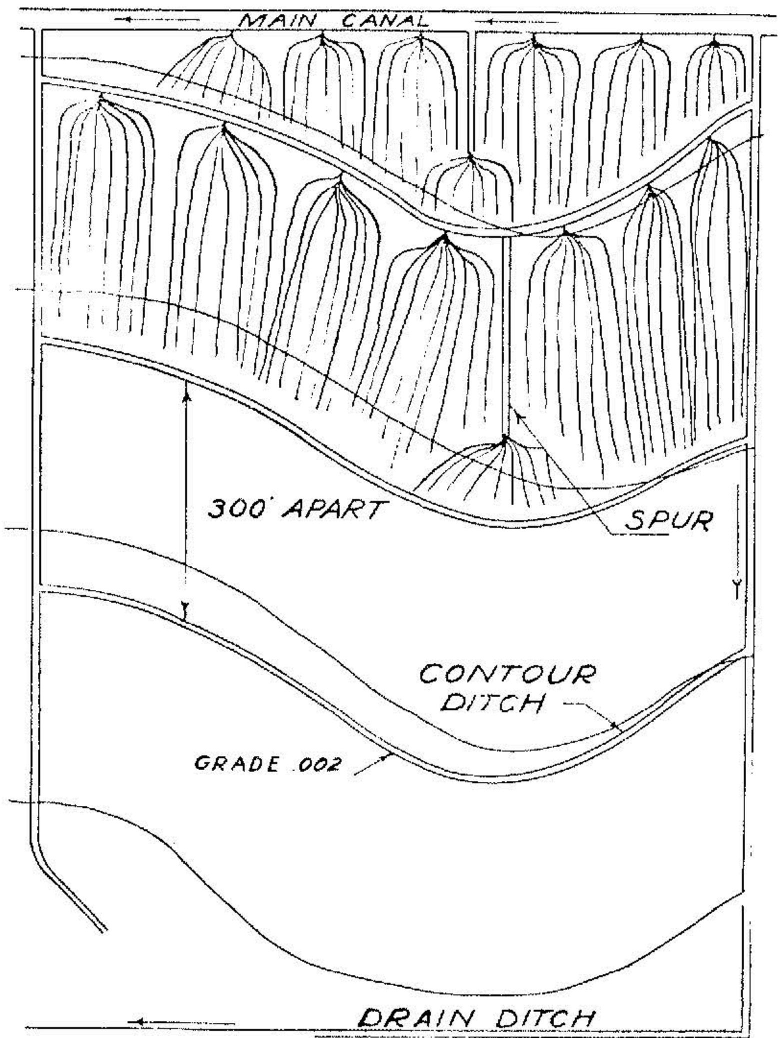


Fig. B-1 Typical contour ditch system for irrigating steep irregular fields. (Dusenberry, 1950.)

Fig. B-2 Contour ditches in alfalfa field along Prairie Dog Creek near Sheridan, Wyoming.

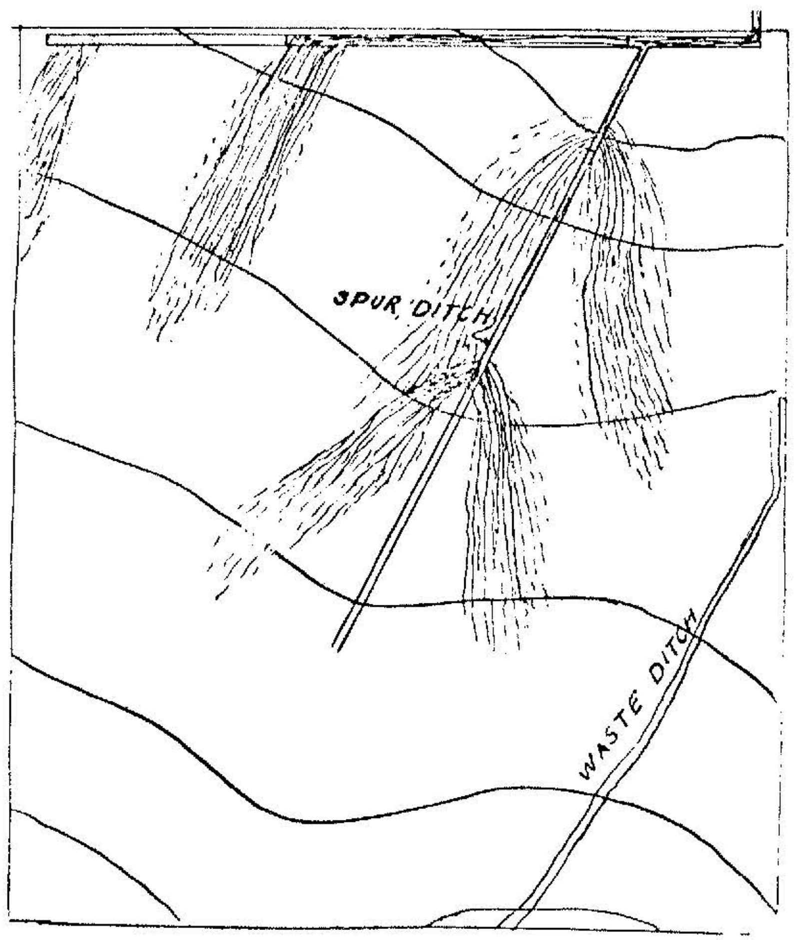


Fig. B-3 Wild flooding method of irrigation. Note scarcity of ditches. (Dusenberry, 1950.)

easily flooded. This method often gives poor control of water and results in high runoff and, frequently, waterlogging of certain areas.

Surface flooding by use of spreader dikes is commonly practiced on low-lying terraces in drainage basins of relatively small size (less than 50-100 square miles). An earthen dam is built across the stream and part of the terrace to be flooded (fig. B-4). A series of dams is sometimes built along a reach of stream. Floodflows caused by annual snowmelt or large rainfall events are ponded by the dams and forced to spread out over the terrace. Dikes built in the field retain water on the field and then direct it to other parts of the field. When used on larger streams, a culvert is placed in the dam to allow low-flow drainage, but the earthen berms are still occasionally washed out by large floods. Spreader dikes are most common on ephemeral drainages in which more extensive irrigation structures are not feasible due to the unpredictability of the size and timing of floodflow and the very short duration of the floodflow.

D. Artificial subirrigation is not a surface irrigation method but is mentioned here for the sake of completeness. It is used in a few localities where natural soil and topographic conditions are favorable to the applicaion of water to soils directly under the surface. A permeable loam or sandy loam surface soil, a very permeable subsoil, an impervious layer below the subsoil 6 feet or more below

Fig. B-4 Spreader dike across Dry Creek, tributary to the Powder River, near Interstate 90, Johnson County, Wyoming. The valley bottom has aggraded somewhat in response to spreader dikes on this drainage.

the surface, uniform topographic conditions, and moderate slopes favor artificial subirrigation.

Considerations in Choosing and Developing an Irrigation System

This discussion outlines considerations in developing irrigation systems, and its application in alluvial valley floor studies is in developing detailed studies of irrigation capability. As explained in chapter II, regional evaluations will lead to an apparent pattern of irrigation development. If an applicant questions this pattern, detailed studies might be undertaken in order to show why irrigation is not feasible in a particular valley. Thus, site data may be used to show that specific factors used in designing irrigation systems could preclude, within the valley in question, the kind of development characteristic of the region.

The factors which are considered in choosing or changing irrigation systems include the soil type, topography, water supply, water quality, climate, crops, labor supply, economic feasibility, and finances. Many of these parameters are interrelated and consideration of all of them can reach such complex levels that decisionmaking approaches intuition. Thus, for any specific situation, different individuals may well make different choices about the best irrigation system or even about whether irrigation is feasible.

A. Soil. The type of soil is a major factor in choosing an appropriate irrigation system and in planning the system. Soil serves as a reservoir for water and nutrients and gives physical support to plants. The rate at which water can infiltrate the soil and the storage capacity of the soil are fundamental characteristics, and the irrigation system must match these characteristics (table B-1). Generally, soils with very high intake rates are not suited to surface irrigation methods, and soils with very low intake rates normally should not be sprinkled. To make any irrigation system practical, the soil must be capable of storing moisture between water applications, and the soil must be deep enough for adequate root development.

Topography is of prime importance in determining the feasibility and correct method of irrigation. Some methods require level fields (e.g., level border irrigation), others are designed for specific slopes (e.g., furrow irrigation), and some, such as sprinkler irrigation, work on flat or undulating fields (table B-2). Land leveling is required for some irrigation systems to ensure proper distribution of water. Most methods have greater efficiency when fields are leveled because the water is more evenly distributed over the entire field. Erosion is a potential hazard when irrigating, especially on sloped fields, and soil structure can be damaged by flowing water. Therefore, topography which concentrates surface flows should be avoided or eliminated by grading.

TABLE B-1

WATER-HOLDING CAPACITIES OF SOILS

Soil texture	Range of available moisture (inches per foot)
Sands and fine sands	0.5 - 1.0
Very fine sands, loamy sand, and loamy fine sand	0.7 - 1.4
Sandy loam and fine sandy loam	1.2 - 1.7
Loam and very fine sandy loams	1.7 - 2.2
Silty loams and silts	1.9 - 2.4
Clay loams, sandy clay loams	1.4 - 1.9
Silty clay loams	1.7 - 2.2
Clay and silty clay	1.3 - 1.8
Heavy clays	1.2 - 1.7

Source: Colorado Irrigation Guide (SCS, undated).

TABLE B-2

SLOPE LIMITATIONS FOR IRRIGATION METHODS

	Design slope (percent)							
Method	Level	0 1	0.2	0.4	0.75	1.5	3.0	6.0
Level border	X	--	--	--	--	--	--	--
Graded border	--	X	X	X	X	X	X[1]	--
Furrow	--	X	X	X	X	X	--	--
Contour ditch	--	--	--	--	X	X	X[1]	X[2]
Sprinkler	X	X	X	X	X	X	X	X[2]
Maximum nonerosive furrow stream (gpm)	--	50	50	25	13	7	--	--

[1]Sod crops only.

[2]Srinkler adaptable to slopes to 15 percent. Slopes greater than 8 percent require stable soils and sod crops.

Source: Colorado Irrigation Guide (SCS, undated).

County soil surveys by the Soil Conservation Service provide good information about the general nature of different combinations of soils and topography and their suitability for irrigation. Information provided in a soil survey of a specific area provides a starting point; however, a more detailed field assessment is useful. Soil surveys have data on the depth, drainage characteristics, water capacity, and slope of all soils mapped and also provide an indication of the suitability of each soil for irrigation diversions.

B. Water Quantity. Irrigation systems are typically designed to provide sufficient water to meet crop needs during the growing season, particularly during periods of peak consumptive water use by crops. In drainages which have a limited runoff season and in which storage is not practicable, surface irrigation can still produce a beneficial increase in production. Table B-3 indicates critical growth periods for various crops and table B-4 indicates crop adaptations for the various irrigation methods. Water requirements of crops for various climatic conditions are usually determined from estimates of potential evapotranspiration made from equations, such as the Blaney-Criddle formula, or from field experiments. Water requirement for specific crops is listed in irrigation guides for each State published by the Soil Conservation Service and in other references, such as Jensen and others (1974), Doorenbos and Pruitt (1974), and SCS (1970).

TABLE B-3

CRITICAL GROWTH PERIODS FOR MAJOR CROPS

Crop	Indications of moisture stress	Critical growth period	Other considerations
Alfalfa	Darkening color, then wilting.	Early spring and immediately after cuttings.	Normally 3-4 inches of water are needed between cuttings. Fall irrigation is desirable.
Corn	Curling of leaves by midmorning.	Tasseling, silk stage until grain is fully formed.	Needs adequate moisture from germination to dent stage for maximum production.
Sorghum	Curling of leaves by midmorning.	Boot, bloom, and dough stages.	Yields are reduced if water is short during seed development.
Sugar beets	Leaves wilting during heat of day.	Post thinning.	Excessive fall irrigation lowers sugar content.
Beans	Wilting.	Bloom and fruit set.	Yields are reduced if water is short at bloom or fruit set.
Small grains	Dull green color, then firing of lower leaves.	Boot and bloom stage.	Last irrigation at milk stage.
Potatoes	Wilting during heat of day.	Tuber formation to harvest.	Moisture stress during critical period may cause cracking of tubers.
Onions	Wilting.	Bulb formation.	Keep wet during bulb formation, let soil dry near harvest.
Tomatoes	Wilting	After fruit set.	Wilt and leaf rolling can be caused by disease.
Cool season grass	Dull green color, then wilting.	Early spring, early fall.	For seed production, critical period is boot to head formation.
Fruit trees	Dulling of leaf color color, and drooping of growing points.	Any point during growing season.	Stone fruits are sensitive to moisture stress during last 2 weeks prior to harvest.

Source: Colorado Irrigation Guide (SCS, undated).

TABLE B-4

CROP ADAPTATIONS TO IRRIGATION METHODS

Crop	Water extraction depth (ft)	Furrow spacing (in.)	Maximum furrow capacity (gpm)	Adapted Irrigation Methods				
				Level border	Graded border	Contour ditch	Furrow	Sprinkler
Alfalfa	5	---	---	X	X	X	---	X
Beans (dry)	3	22	25	---	---	---	X	X
Beets (sugar)	4	22	25	---	---	---	X	X
Corn (silage)	4	36	50	X	X	---	X	X
Corn (sweet)	3	36	50	X	X	---	X	X
Grain (spring)	4	---	---	X	X	X	---	X
Grain (winter)	4	---	---	X	X	X	---	X
Grass	3	---	---	X	X	X	---	X
Orchards	5	---	---	X	X	---	---	X
Peas	3	22	25	---	---	---	X	X
Potatoes	2	36	50	---	---	---	X	X
Sunflowers	3	36	50	---	---	---	X	X

Source: Colorado Irrigation Guide (SCS, undated).

Determining the actual amount of surface water available for irrigation use in a drainage in many cases is not necessary because all the water has been appropriated. A prospective irrigator commonly either owns the water rights to a certain amount of water or must attempt to acquire rights to the water needed. If the surface flows are not totally appropriated or used, the amount of water available can be estimated from gaging records or by various other means. Some perennial streams are gaged by the U.S. Geological Survey and records of average daily discharge are available for as many as 30 or more years for some streams. However, in the semiarid West, there are few perennial streams. These few large perennial streams provide the main component of surface irrigation water in stream valleys in the West.

For small perennial streams and ephemeral and intermittent streams, long-term gaging records generally are not available. Estimates of discharge must then be made by various methods of regional analysis. These methods utilize available gaging records for streams in an area and extrapolate estimates to ungaged streams on the basis of similarity with other physical factors (drainage basin characteristics and channel characteristics, for example). Most of these techniques give estimates of magnitude and frequency of floods, low flows, and mean annual discharge. Although these techniques do not give average daily or monthly streamflows during the irrigation season, comparison with gaging records of nearby streams can at least permit estimates of monthly flows.

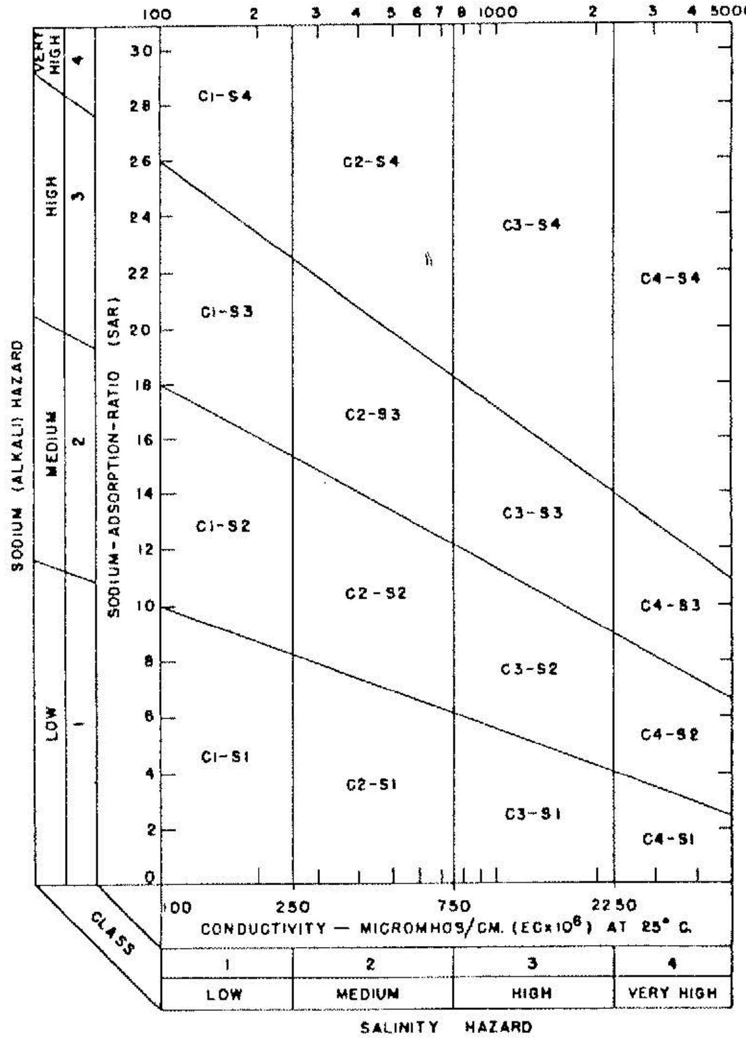
Riggs (1973) provided a good overview to the topic of regionalization of streamflow data, and Hedman and Osterkamp (1982) reviewed empirical equations developed for Western stream channels to estimate streamflows from channel geometry. Estimation methods which relate mean annual discharge and magnitude and frequency of floods with drainage basin characteristics and stream channel geometry have been completed by the USGS in the following Western States: North Dakota (Crosby, 1975); Montana (Parrett and Omang, 1981); Wyoming (Craig and Rankl, 1978; Hedman and Kastner, 1977; Lowham, 1976); Colorado (Hedman and others, 1972; McCain and Jarrett, 1976); New Mexico (Borland, 1970; Kunkler and Scott, 1976; Thomas and Dunne, 1981); and Utah (Eychaner, 1976; Fields, 1975). Estimation of flows from channel characteristics is discussed further in appendix A.

C. Water Quality. Water of suitable quality is important for proper irrigation. Plants can extract more water from a salt-free soil than from the same soil with high salt content. All water contains some dissolved salts or minerals. Without leaching, salts accumulate in the soil as the water is drawn off through evapotranspiration. A favorable salt balance is reqired for successful irrigation over the long term. The output of salts in water draining through the soil must exceed the input of salts in the irrigation water. Where soils do not drain well or where high water tables exist, the removal of salts is impeded, and soils can become saline.

Salinity can affect plants in many ways physiologically. However, overt injury symptoms, such as leaf necrosis, seldom occur except under extreme saline conditions. Plants affected by salinity usually appear normal but have decreased rates of water absorption and, hence, reductions in yields. As salt concentration increases above a threshold level for a given plant species, both the growth rate and the ultimate size of most plant species will progressively decrease. Top growth is often affected more than root growth (Maas and Hoffman, 1977). In addition to reductions in yields, plants grown under high salt conditions often have reductions in the quality of yield as well. For areas where salinity is a problem, crops which produce satisfactorily under existing saline conditions can be selected. In selecting such crops, it is important to be aware that certain crops are more sensitive to saline conditions during germination and much more tolerant during later stages of growth. Field crops with good salt tolerance include barley, sugar beets, alfalfa, and sweetclover (SCS, 1977).

The suitability of water for irrigation depends on the amount and composition of the solids dissolved in it. Salinity (as measured by total dissolved solids) and sodium are the two most commonly used indicators for irrigation water classification (fig. B-5). Table B-5 suggests criteria for classifying the TDS hazard of waters in arid and semiarid regions, and table B-6 presents similar criteria developed by McKee and Wolf (1974) on the basis of an extensive survey of the

Fig. B-5. SAR--Conductivity classification of irrigation water. Source: U.S. Salinity Lab (1954).



CONDUCTIVITY

- C1 Low-salinity water: Can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop.
- C2 Medium-salinity water: Can be used if a moderate amount of leaching occurs.
- C3 High-salinity water: Cannot be used on soils with restricted drainage. With adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
- C4 Very high salinity water: Is not suitable for irrigation under ordinary conditions.

SODIUM

- S1 Low-sodium water: Can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.
- S2 Medium-sodium water: Will present an appreciable sodium hazard in fine-textured soils having a high cation-exchange capacity, especially under low-leaching conditions.
- S3 High-sodium water: May produce harmful levels of exchangeable sodium in most soils and will require special soil management — good drainage, high leaching, and organic matter additions.
- S4 Very high sodium water: Is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity.

TABLE B-5

DISSOLVED-SOLIDS HAZARD FOR IRRIGATION WATER

Total dissolved-solids content of water (mg/L)	Remarks
500	Water from which no detrimental effects will usually be noticed.
500 to 1,000	Water which can have detrimental effects on sensitive crops.
1,000 to 2,000	Water that may have adverse effects on many crops and requires careful management practices.
2,000 to 5,000	Water that can be used for tolerant plants on permeable soils with careful management practices.

Source: U.S. Environmental Protection Agency, (1976); National Academy of Science (1973).

TABLE B-6

SUMMARY CLASSIFICATION OF IRRIGATION WATERS

	Water class[1]		
	I	II	III
Boron (mg/L)	Less than 1.0	Less than 2.0	Less than 3.0
SAR	Less than 1.0 to 4.2[2]	1.0 to 11.6	Greater than 9.0 to 11.6
Chlorine (meq/L)[3]	Less than 2.0 to 5.5	2.0 to 16.0	Greater than 6.0 to 16.0
Sulfate (meq/L)	Less than 4.0 to 10.0	4.0 to 20.0	Greater than 12.0 to 30.0
Specific conductance	Less than 500 to 1,000[4]	500 to 3,000	Greater than 2,500 to 3,000
TDS (mg/L)	Less than 700	350 to 2,100	Greater than 2,500 to 3,000
Salinity hazard	Low to medium	Medium to very high	Very high

[1]The water classes are defined for two purposes: first, in relation to overall soil/climate management, as:

I (excellent to good; suitable under most conditions).
II (good to injurious; harmful under certain conditions of soil, climate, and practices).
III (injurious to unsatisfactory; unsuitable under most conditions).

and, second, in relation to plants, as:

I (suitable for irrigation of all or most plants, including salinity- and boron-sensitive species).
II (not suitable for most salinity- and boron-sensitive plants; suitable for all tolerant and many semitolerant species).
III (unsatisfactory for most plants except those that have a high tolerance for saline conditions and high boron levels).

[2]Recent work favors the upper limit.
[3]meq = milliequivalents.
[4]In μmhos/cm at 25°C.

Source: Mckee and Wolf (1974).

literature. Other studies have determined the tolerance of individual plant species to water of different qualities (Gough and others, 1979; Christiansen and others, 1977; Ayers, 1977; Maas and Hoffman, 1977). Ultimately, the suitability of water for irrigation depends on the type of crop, the type of soil, and acceptable yield reduction. In some localities high-salinity- or high-sodium-hazard water from streams or wells is used for irrigation, usually because of the lack of better water. Soils in these fields can be adversely affected or accumulations of salts can be leached by excessive irrigation. Application of any water quality criteria must be tempered with the knowledge that the criteria may have been developed in regions with different climatic conditions and that site-specific conditions may make any individual criterion too stringent or lenient.

D. Climate determines the need for water, the crops grown, and influences the choice of irrigation method. Total annual precipitation and its seasonal distribution are the most important climatic characteristics relating to the need for irrigation. Temperature, wind, and hours of sunshine also affect plant growth and irrigation requirements.

E. Crops. The crop(s) to be irrigated in one field is an important parameter in choosing an irrigation system (table B-4). Different crops need different amounts of water. The amounts of water needed vary with the length of the growing season and the portion of the plant which is harvested. Rooting depth controls the frequency and amount of irrigation applications.

F. Labor availability and costs are becoming increasingly important in choosing an irrigation method. All methods can be automated, but sprinklers adapt most readily. If an abundance of cheap labor is available, or if irrigation can be interspersed between other farm chores, surface irrigation may be best. Initial low-capital investments generally buy systems requiring the most labor. A greater capital investment and less labor is required when more costly methods are chosen.

Methods of Obtaining Surface Water

Various methods are used to obtain surface water for surface irrigation systems. Diversion systems used on ephemeral or smaller perennial streams are developed where construction of reservoirs is not suitable (fig. B-6). Streamflows are diverted by earthen, metal, or concrete dams built across the channel into ditches which convey water to irrigated fields, which may be several miles from the diversion point. On larger perennial streams, it is usually more practical to build an impoundment because suitable damsites may be available and economies of scale allow for lower unit cost for water delivered from larger systems. Impoundment and ditch systems utilize water storage behind a dam to supply water to fields through sometimes

Fig. B-6 Metal diversion dam on Prairie Dog Creek near Sheridan, Wyoming. Headgate for the diversion ditch is located on the far side of the stream.

very extensive ditch systems throughout the growing season. In some instances, water is pumped from a stream to a ditch because the pump system is cheaper than constructing and maintaining a long ditch, which would be required for a gravity flow sytem (fig. B-7). Spreader dikes, as mentioned under irrigation methods, impound water temporarily until flow can spill out of the channel and flow overland across fields on low-lying terraces.

Summary of Regional Practices

Surface irrigation practices in each of the coal regions of the West vary due to differences in climate and demand for various crops. The irrigation methods described in this paper can be used in any region; however, specific methods are more predominant in certain regions due to various environmental factors. After OSM completes a study of regional irrigation practices in Western coal regions (early 1984), more complete summaries of regional irrigation practices can be developed. The following briefly summarizes regional practices and available irrigation data. It is strongly recommended that any published irrigation survey be field checked because discrepancies may exist due to the age of survey, variable mapping units, and the degree of care taken by the particular mappers.

A. Fort Union Coal Region. Alfalfa and grass hay are the major irrigated crops grown on valley floors in the Fort Union coal region (fig. B-8); however, other crops, particularly sugar beets, are

Fig. B-7 Irrigation water is supplied to contour ditches (beyond telephone poles) by pumping from Dutch Creek near Sheridan, Wyoming. Pump (foreground) has been pulled from stream and pipeline moved, both readied for winter storage.

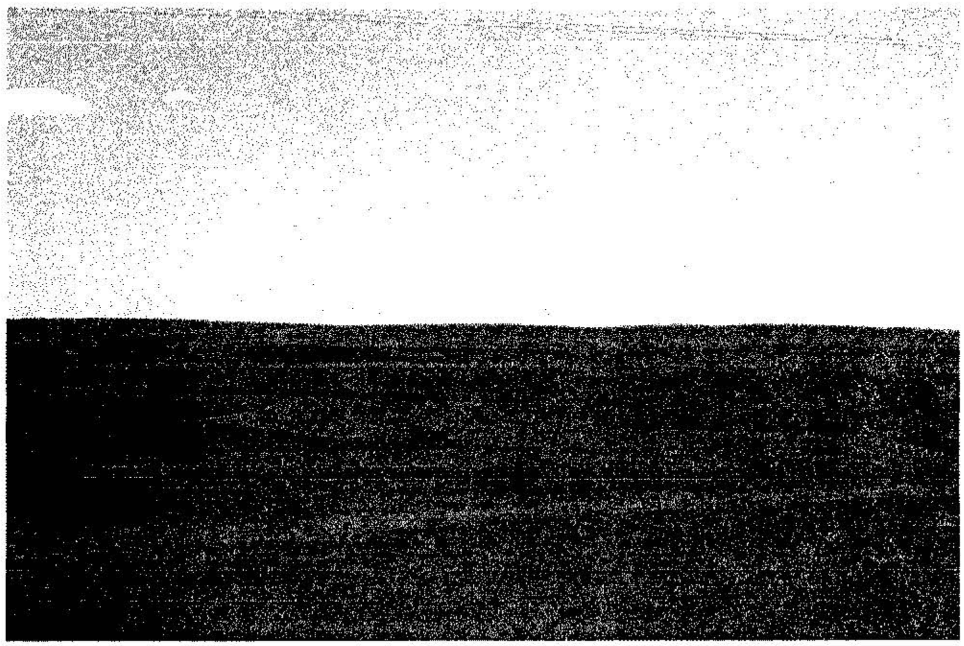


Fig. B-8 Flood-irrigated alfalfa fields along the Redwater River, Dawson County, Montana.

irrigated along the Yellowstone River of Montana and the Missouri River of North Dakota. Irrigated acreage has been mapped in east-central Montana by Schmidt (1977), in southeastern Montana by Druse and others (1981), in Carter County, Montana, by Yellowstone-Tongue A.P.O. (1977a), and in all counties of Montana by the Department of Natural Resources in published water resource surveys and published and unpublished land classification maps. The State of North Dakota has identified irrigated areas of Dunn County.

B. Powder River Basin Coal Region. Diversion ditches, reservoir-ditch systems, and spreader dikes are the three most popular methods of surface irrigation on valley floors of the Powder River Basin coal region in Montana and Wyoming. The predominant irrigated crop is alfalfa and grass hay, although other crops (corn, sunflowers) are grown along the major rivers.

Spreader dikes are used on ephemeral and intermittent streams in the upper parts of drainage basins where flood runoff is not large enough to wash out the dikes (fig. B-4). Spreader dikes are most frequently used on ranches not owning irrigated hayland along perennial streams. The inconsistent development of irrigated hay meadows on some major streams may be due to land ownership patterns, lack of water rights, or poor water quality in some perennial streams. The diversity of irrigation paractices is illustrated in the following examples:

1. In the Powder River drainage in Montana, the ranches tend to be small and those without land along the Powder River have developed spreader dike systems on smaller streams.

2. Along Crazy Woman Creek in Johnson County, Wyoming, very few ranches have water rights for the stream and, instead, use spreader dikes to divert flow from tributary ephemeral tributaries into the larger terraces of Crazy Woman Creek (fig. B-9).

3. The suspended sediment load of the Powder River in Johnson County, Wyoming, is so high that the water is not suitable for flood irrigation, even though the valley is large (fig. A-3). Therefore, ranches in this area use spreader dikes both along tributaries and on Powder River terraces, where the tributaries join the river.

Intermittent and small perennial streams frequently are diverted into ditches several miles long. These ditches typically feed contour ditch or wild-flooding irrigation systems on fields on valley floors. Such systems are developed, for example, along Squirrel Creek near Decker, Montana, and along Wild Horse and Spotted Horse Creeks in northwestern Campbell County, Wyoming. Flow is diverted during spring runoff and may continue into late spring or summer if there is sufficent flow. Major rivers, such as the Tongue River, Prairie Dog Creek (fig. B-2), and Clear Creek, have storage reservoirs which release water to the river during the irrigation season. Water is either diverted to ditches or pumped to ditches which lead to irrigated fields. Some sprinkler irrigation is practiced by pumping from the river or ditch.

Irrigated acreage in the Powder River Basin has been mapped by Druse and others (1981), in southeastern Montana by Yellowstone-Tongue

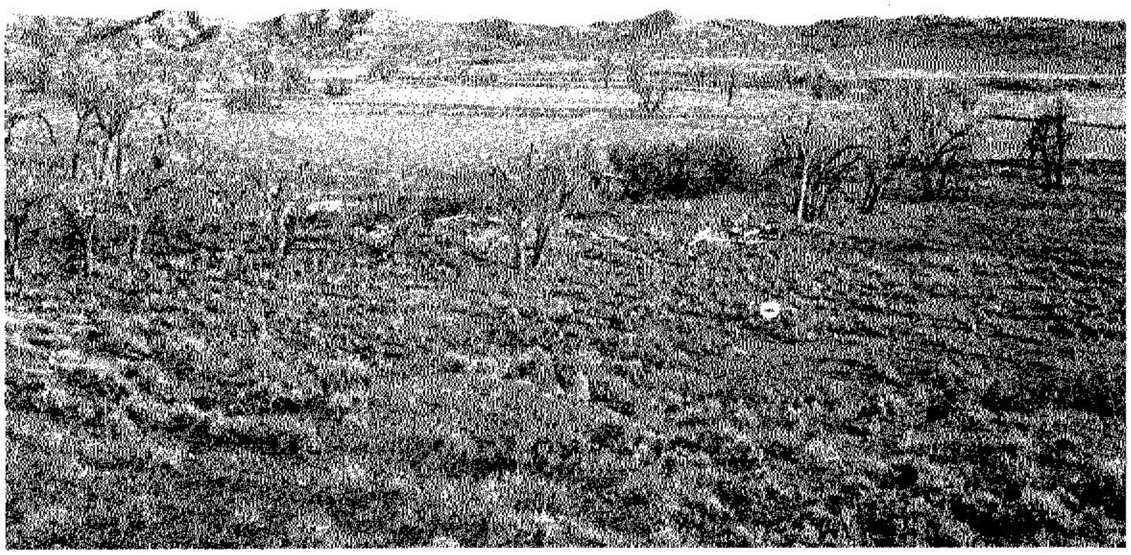


Fig. B-9 Dikes on terraces of Crazy Woman Creek, Johnson County, Wyoming, spread water from tributaries. This rancher does not have water rights on Crazy Woman Creek, a perennial stream.

A.P.O. (1977b), and in Wyoming by the Wyoming State Engineer's Office (1971). Inventories by the Montana Department of Natural Resources are available for all Montana counties.

C. Green River-Hams Fork Coal Region. Irrigated valley floors in this area of Wyoming and Colorado are primarily used for hay production. At higher elevations on streams draining mountains, spring snowmelt is diverted to flood irrigate native grasses, alfalfa, or other hay grass grown on mountain meadows. In high-elevation areas with many perennial streams, such as the Upper Yampa River basin, ditch development can be extensive. Natural subirrigation is usually a supplemental source of water later in the growing season. Larger impoundment/ditch and diversion structures are used on the lower lying major rivers.

D. Unita Coal Region. Two major irrigation methods are used in the Uinta coal region in Colorado and Utah. Mountain meadows typically produce hay irrigated by diversion of spring snowmelt floodflows. Along large rivers having broad valleys, such as the Gunnison, Green, and White Rivers, large irrigation diversion systems supply water for irrigation of many diverse crops. Crops irrigated include hay, small grains, row crops, and orchards. Irrigated land has been mapped in some Colorado counties by the SCS (1980). Along the Book Cliffs and Wasatch front of Utah, virtually every perennial stream has been diverted to irrigated crops in the Grand and Castle valleys.

E. San Juan Coal Region. The only irrigated farmland in valley bottoms in the San Juan coal region occurs along the larger perennial streams that head in alpine areas. These rivers have sustained flow through the growing season and are easily diverted with large-scale systems. In smaller drainages, sizeable floodflows occur but are not easily diverted because of their size and infrequency. Some streams may have been diverted decades ago but cannot be now, owing to recent incision of the stream channels. Diversions and irrigated land in New Mexico has been mapped by Cornelius and others (1978) and by Love and others (1981).

F. Southern Utah. Schmidt (1980) identified the major surface irrigation practice in southern Utah to be diversion of streams heading on high plateaus (fig. B-10). Hay is the dominant irrigated crop.

Fig. B-10 Flood-irrigated and flood-irrigable area on Johnson Wash, Kane County, Utah. Designated alluvial valley floor.

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APPENDIX C

SUBIRRIGATION AND ITS ASSESSMENT

Introduction

The identification of subirrigated areas (fig. C-1) is important in identifying alluvial valley floors, since alluvial valley floors include areas where water is "sufficient for subirrigation * * * agricultural activities." This appendix is intended to provide the user with an understanding of what subirrigation is, how it can be identified, how it can be mapped, and what references are available on the topic.

General Definitions

Subirrigation, in terms of the alluvial valley floor regulatory program, is "the supplying of water to plants from underneath or from a semi-saturated or saturated zone where water is available for use by vegetation" (30 CFR 701.5). The U.S. Soil Conservation Service (SCS) definition of a naturally subirrigated area is land "with an effective subsurface ground-water table and water rarely over the surface during the growing season" (Zacek and others, undated). Implicit in the SCS definition is that ground water is useable for the entire growing season, or a sizeable portion of it.

When considering subirrigation, biologists are more inclined to consider the plants and plant communities growing in a particular area

Fig. C-1 North Fork Burns Creek, Dawson County, Montana. Narrow, lower terrace is subirrigated. Broad, upper terrace may have the capability to be flood irrigated.

than the physical attributes of the substrate. Several terms commonly used by vegetation specialists to characterize plants which grow in the presence of ground water are phreatophyte, riparian vegetation, and hydrophyte. Phreatophytes are plants that depend upon ground water for their water supply (Robinson, 1958). Examples of phreatophytes are alfalfa, saltcedar, cottonwood, and giant wildrye. Hydrophytes are plants which grow in water or depend upon being partially immersed in water at all times (Billings, 1970). Examples include water lilies and cattails. Riparian vegetation is a term for a plant community inhabiting the banks and adjacent areas of lakes, streams, and springs (Warner, 1979). Riparian vegetation is dependent on surface or ground water transported to the site to provide the extra soil moisture not available in other areas. A riparian community is composed of phreatophytes and upland plants and, thus, includes species such as Western wheatgrass or silver sage, which can utilize available ground water but will also grow on upland sites.

Robinson (1958) compiled a list of phreatophytes which occur in the West. Most of these species, however, are not valuable either as range or cultivated plants, but they are important as indicators of subirrigated sites. Their presence, in conjunction with other observations, can be used to assist in defining the extent of an alluvial valley floor. Table C-1 presents a list of phreatophytes known to occur in coal regions of the West. Those with economic value as livestock forage are noted.

TABLE C-1

SOME PHREATOPHYTES OF THE COAL REGIONS OF WESTERN UNITED STATES

(Data from Robinson (1958) unless otherwise noted)

Scientific name	Common name	Occurrence as a phreatophyte	Relation to ground water: Depth to water below land surface (feet)	Relation to ground water: Quality[1]	Remarks (*Indicates species is agriculturally useful)
Acacia greggii A. Gray	Catclaw, devilsclaw, una de gato	Southern California to western Texas	--	1	Uses more water than mesquite (McGinnies and Arnold, 1939, p 236). Forms thickets along streams and washes.
Acer negundo Linnaeus	Boxelder	Canada to Oklahoma	--	--	Occurs in moist places and along streams, chiefly in mountains. Also common in riparian zone of prairie streams (Daubenmire, 1978).
Allenrolfea accidentalis (S. Watson) Kuntze	Pickleweed, Iodinebush	California to western Texas	1-20	3	Found on moist saline areas.
Anemopsis californica (Nuttall) Hooker and Arnott	Yerba mansa	Southern California, southern Nevada to Utah and Texas	Shallow	3	Common in saline and wet lowlands.
Artemisia cana Pursh	Silver sagebrush	Montana to New Mexico	12+	2	Normally associated with lowland areas but on occasion can be found also on upland sites. Often associated with greasewood.
Atriplex canescens (Pursh) Nuttall	Fourwing, saltbush, chamiso, chamiza	South Dakota to Oregon, south to Mexico	8-62[2]	1-2	Tolerates alkali. Valuable browse plant. Useful in erosion control. Taproots 30-40 ft. deep (Van Dersal, 1938, p. 65). May not always occur as a phreatophyte.

TABLE 1

SOME PHREATOPHYTES OF THE COAL REGIONS OF WESTERN UNITED STATES (Continued)

(Data from Robinson (1958) unless otherwise noted)

Scientific name	Common name	Occurrence as a phreatophyte	Relation to ground water: Depth to water below land surface (feet)	Relation to ground water: Quality[1]	Remarks (*Indicates species is agriculturally useful)
Atriplex (cont'd.)					
lentiformis (Torrey) Watson	Quailbrush, lenscale, Nevada saltbush	Southern Utah and Nevada and Sonora, Mexico	6-15	3	High tolerance for alkali and saline soil (Benson and Darrow, 1954, p. 121; Magistad and Christiansen, 1944, p. 10). Fair browse plant. Reaches height of 10 ft. where water table is shallow (Kearney and Peebles, 1951, p. 259).
Cnilopsis linearis Sweet	Desert willow	Western Texas to southern Nevada, Arizona, southern California	To 50	--	May not always occur as a phreatophyte (Bryan, 1925).
Distichlis stricta (Torrey) Rydberg	Saltgrass, or desert saltgrass	All Western States (Hitchcock, 1951, p. 178)	2-14	1-3	*Associated with capillary fringe which reaches land surface.
Elymus condensatus Presl.	Giant wildrye	All Western States except New Mexico	1-12	1-2	(Fair forage. Killed by overgrazing Extensive root system.
cinererus Scribn. and Merr.	Great Basin wildrye	Western United States	To 11	1-2	*Good to fair forage. Found roots associated with capillary fringe in Montana (Consolodation Coal, 1981).

TABLE C-1

SOME PHREATOPHYTES OF THE COAL REGIONS OF WESTERN UNITED STATES (Continued)

(Data from Robinson (1958) unless otherwise noted)

Scientific name	Common name	Occurrence as a phreatophyte	Relation to ground water: Depth to water below land surface (feet)	Relation to ground water: Quality[1]	Remarks (*Indicates species is agriculturally useful)
Fraxinus velutina Torrey	Velvet ash, Arizona ash	Southwestern Utah, southern Nevada, California, Arizona, New Mexico, and western Texas	--	1	Prominent streambank and canyon tree; restricted to areas with a permanent ground-water supply (Benson and Darrow, 1954, p. 237, 274).
Juncus balticus Willdenow	Wirerush, wiregrass	Western United States	--	--	*Grows in wet sites where ground-water is shallow, also in shallow ponds. Appears to occur both as phreatophyte and hydrophte. Deep root system. Fair to good forage.
Juncus cooperi Engelmann	Desertrush	Southern Utah to California	--	2-3	Occurs on the margins of salt marshes and alkaline meadows, common in Death Valley, CA, along the edge of the playa often associated with saltgrass.
Leptochloa fascicurlaris (Lamarck) A. Gray	Sprangletop	Western United States	--	1-3	Occurs along ditches and in moist waste places, often in brackish marshes (Kearney and Peebles, 1951, p. 123(; most places in alkali plains (Tidestrom, 1925, p. 83).

TABLE L

SOME PHREATOPHYTES OF THE COAL REGIONS OF WESTERN UNITED STATES (Continued)

(Data from Robinson (1958) unless otherwise noted)

Scientific name	Common name	Occurrence as a phreatophyte	Relation to ground water: Depth to water below land surface (feet)	Relation to ground water: Quality[1]	Remarks (*Indicates species is agriculturally useful)
Medicago satiya Linneaus	Alfalfa	Western United States	4+	1-2	*See case study in this appendix.
Populus spp.	Cottonwood	Western United States	--	1-2	Riparian species found along watercourses.
Populus tremuloides aurea Tidestrom	Quaking aspen	Mountainous areas of Western United States	--	1	Considered a phreatophyte when it grows along streams, around springs, and in other wet areas. Shallow root system.
Potentilla fruticosa Linneaus	Bush or scrubby cinquefoil	Locally in Idaho but widespread in Oregon, Washington, Utah, Nevada, and Arizona	Shallow	--	Occurs as a phreatophyte in Pahsimerol Valley, Idaho (Meinzer, 1927, p. 60). Grows in subalpine meadows, along streams, about cold springs in peaty, sandy or clayey loam
Salicornia rubra Linnaeus	Glasswort	Colorado, New Mexico, Nevada, Utah	--	3	Some value as waterfowl feed.
Salix spp.	Willow	Western United States	--	--	Riparian species found along watercourses.
Sarcobatus vermiculatus (Hook) Torrey	Big greasewood	Western United States	60+	--	Roots found on contact with ground water along Squirrel Creek, Montana (Consolidation Coal 1981). Generally associated with shallow ground water. Alkaline tolerance.

TABLE C-1

SOME PHREATOPHYTES OF THE COAL REGIONS OF WESTERN UNITED STATES (Continued)

(Data from Robinson (1958) unless otherwise noted)

Scientific name	Common name	Occurrence as a phreatophyte	Relation to ground water: Depth to water below land surface (feet)	Relation to ground water: Quality[1]	Remarks (*Indicates species is agriculturally useful)
Spartina perctinata Link	Cordgrass	Montana to New Mexico	--	1-2	Requires water table close to the surface. Is often considered a hydrophyte.
Sporobolus airoides Torrey	Alkali sacaton	Western United States	5-25+[2]	1-3	*Most common in the Southwest, where it is important as forage; deep, coarse root system. Prefers moist alkali flats.
Suaeda depressa Watson	Seepweed, saltwort	Southwest	--	3	Browsed when other forage is scarce. Occurs on saline or saline-alkali soils.
Tamarix aphylla Linneaus	Athel tree	Southwest	--	1-3	Introduced species found where water table is close to the surface.

[1]The quality of the ground water with respect to its suitability for crop growth is indicated by numerals, as follows: 1, excellent to good; 2, good to poor; 3, poor to unsatisfactory.

[2]Meinzer, 1927.

In mapping vegetation communities, the Soil Conservation Service classifies rangeland according to climax vegetation, soil, and climate. Four types of range sites can be considered potentially subirrigated. These rangesites produce more herbage than ordinary range uplands because of superior soil moisture availability and are defined (after Zacek and others, undated):

WETLAND: Lands where seepage, ponding, etc., raise the water table above the surface during only a part of the growing season. Too wet for cultivated crops, but too dry for common reed, cattails, or true aquatics.

SUBIRRIGATED: Lands which have an effective subsurface ground-water table and water rarely over the surface during the growing season.

SALINE LOWLAND: Subirrigated and overflow lands, where salt and/or alkali accumulations are apparent and where salt-tolerant plants occur over a major part of the area.

OVERFLOW: Areas regularly receiving more than normal soil moisture because of run-in or stream overflow.

Each of these rangesites frequently have plant species which may be subirrigated.

Regulatory Considerations

Subirrigation can occur under a range of conditions with a corresponding range of plant productivity induced by available ground water. The interplay of fluctuating water table elevations, land surface elevation, soil properties, and annual water supply variations causes changes in water availability from place to place in different years. The best subirrigated areas are those where plant roots have ground water accessible to them during the entire growing season. These plants experience limited moisture stress, and their life cycles tend to be longer than those of upland plants.

In other areas plants may benefit only a little from subirrigation because available water is only accessible for a short time. In terms of the alluvial valley floor regulatory program, subirrigation occurs if enough water is available for a long enough time to have a recognizable effect on the species type and the productivity of a plant community. Agricultural crops or rangeland must receive enough subirrigation that the community is notably more productive or more agriculturally useful when compared to dryland areas.

Various problems have been encountered in the past by regulatory and industry personnel in defining subirrigated and non-subirrigated areas. These difficulties, some of which are described below, have been experienced because the regulatory process requires that areas of marginal or occasional subirrigation must be classified as either subirrigated or not subirrigated. The regulatory process necessitates a definite delineation of subirrigation and non-subirrigation areas, when, in fact, such arbitrary delineation of these areas is not definitively accurate.

Water supplied by subirrigation is recharged by ground water and not by local infiltration of precipitation, surface runoff, or snowmelt. Areas which are naturally wet because of poor drainage conditions or because of extra snow accumulation may be exceptionally productive but are not subirrigated. Sometimes, subirrigated areas are also flood irrigated, and determining the relative importance of each can be difficult. For identification purposes, the distinction of water source between surface and ground water is not important, because either fits the regulatory definition of water availability. For puposes of understanding essential hydrologic functions, however, an estimate of relative surface- and ground-water contributions is important.

The timing of water availability affects the usefulness of subirrgation. High water tables tend to coincide with periods of seasonal high runoff or high precipitation. Thus, at times when the potential for subirrigation is at its highest, a plant's entire moisture requirement may be met by shallow water recharged from rainfall or diverted floodflows. By the time this water in the upper soil zone is depleted, the water table may have dropped below the root zone. In this case, the only benefit of a raised water table is that soil moisture in the lower root zone has been recharged for later use by plants. In a regulatory sense, subirrigation would not be demonstrated here unless the species composition or annual productivity could be substantially differentiated from those in other areas.

In some situations, subirrigation may provide enough water to maintain alfalfa but not enough to enhance its production. In years when above average precipitation or surface irrigation is available, the alfalfa may have significant production; however, in drier years, it may not be important. For example, subirrigation ensures that the plant does not die, but it does not contribute to the plant's useful production. In this case, subirrigation would not exist in a regulatory sense because no increased production would result from the available ground water.

The value of subirrigated land and even the existence of subirrigated land should thus be evaluated by comparing vegetative production data. However, getting production data which yield meaningful analyses can be difficult. For instance, production data provided by a rancher usually are given on a per field basis and may not differentiate production from different parts of a field covering different terrace levels. Vegetative sampling by clipping is a standard technique used by botanists that may be helpful. Production data collected in one sampling year can be compared to average historic data for the farm or region, but a nonaverage precipitation year may result in uncertain (inaccurate) comparisons.

Mechanics of Subirrigation

To fully understand subirrigation, one must consider the various components and processes of the soil/water system and how these components and processes are interrelated. Ideally, subirrigation occurs because plant roots penetrate the soil zone recharged by ground water. Downvalley flow of ground water in the alluvial aquifer supplies a continuous source of water. Capillary rise of the ground water increases the soil moisture reservoir in the soil above the water table. Roots within the saturated (or partially saturated) soil zones supply additional water to plants supplementing near-surface water supplied by surface infiltration (fig. C-2).

The following discussion describes these soil/plant/water interactions and how each affects subirrigation and productivity of the plant. First, the hydrology of the soil system is discussed in terms of saturated flow in the ground-water system and the capillary rise of water above the water table. Second, the characteristics of soil which hold and supply water to the plant are described. Third, the physiology of roots is discussed in terms of water uptake. Fourth, evapotranspiration and the plant growth cycle are reviewed. The discussion attempts to highlight issues which have been important in recent alluvial valley floor determinations.

A. Alluvial Ground Water. The source of water for subirrigation is the ground water which flows through the unconsolidated alluvial deposits of the valley. This ground water flows under saturated conditions downstream, parallel to the valley. This ground water is found at the base of the unconsolidated deposits, and the geologic deposits in which the water is found is called an aquifer. The compositions of these deposits are discussed in appendix A. Depending on the stratigraphy of the deposit, alluvial ground water may or may not be confined in the aquifer. If the water is unconfined, then the

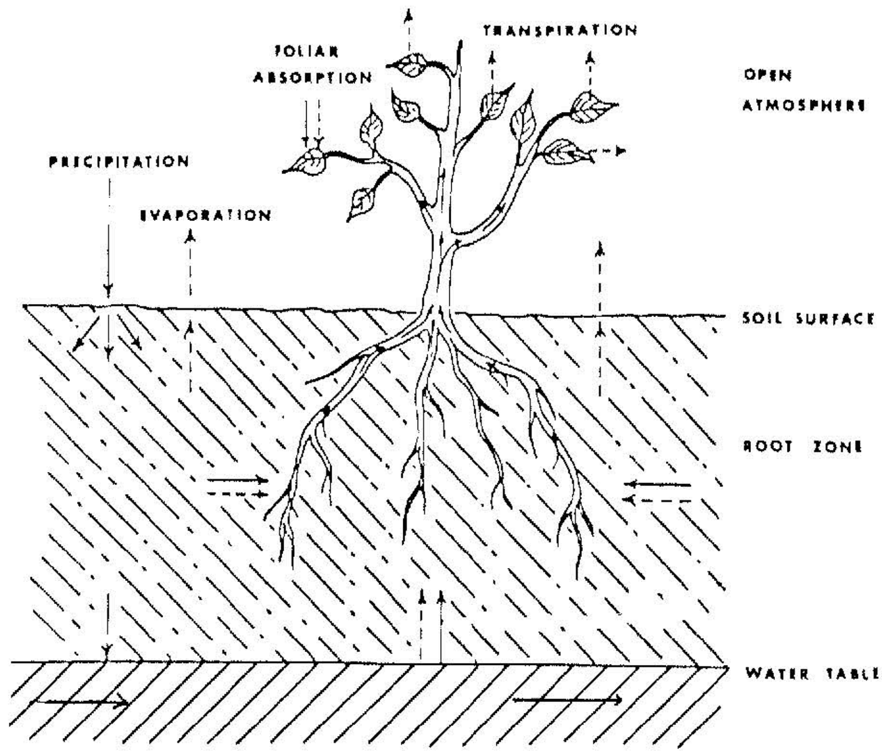


Fig. C-2 Water flux pathways in the soil-plant-atmosphere continuum. Solid arrows represent liquid water fluxes; dashed arrows represent vapor fluxes.

water level rises and falls with changes in volume of flow. If the water is confined (for example, by a layer of clay), then the water level may not change with changes in flow volume.

The source of alluvial ground water at any specific location may be from any one of the following:

1. Infiltration of surface flow through the channel bed and banks to the alluvial material.
2. Lateral or upward ground-water flow from bedrock aquifers which bound the alluvium.
3. Infiltration from manmade structures, such as irrigation ditches or impoundments.
4. Infiltration of rainfall, snowmelt, or surface runoff.
5. Ground-water flow through the alluvial aquifer from upstream areas, whose source of water is one of the previously mentioned items.

In many alluvial systems, the quantity of ground water decreases during the dry summer months (fig. C-3). As the ground-water volume decreases, the thickness of the saturated zone may decrease; thus, the depth from the surface to the saturated zone may increase. If the depth to water increases enough, water that was once available to plant roots may no longer be so. Therefore, subirrigation may cease.

An example of an alluvial aquifer and its characteristics is that of Squirrel Creek, tributary to the Tongue River, in Big Horn County, Montana. Fig. C-4 illustrates a cross section which is typical of

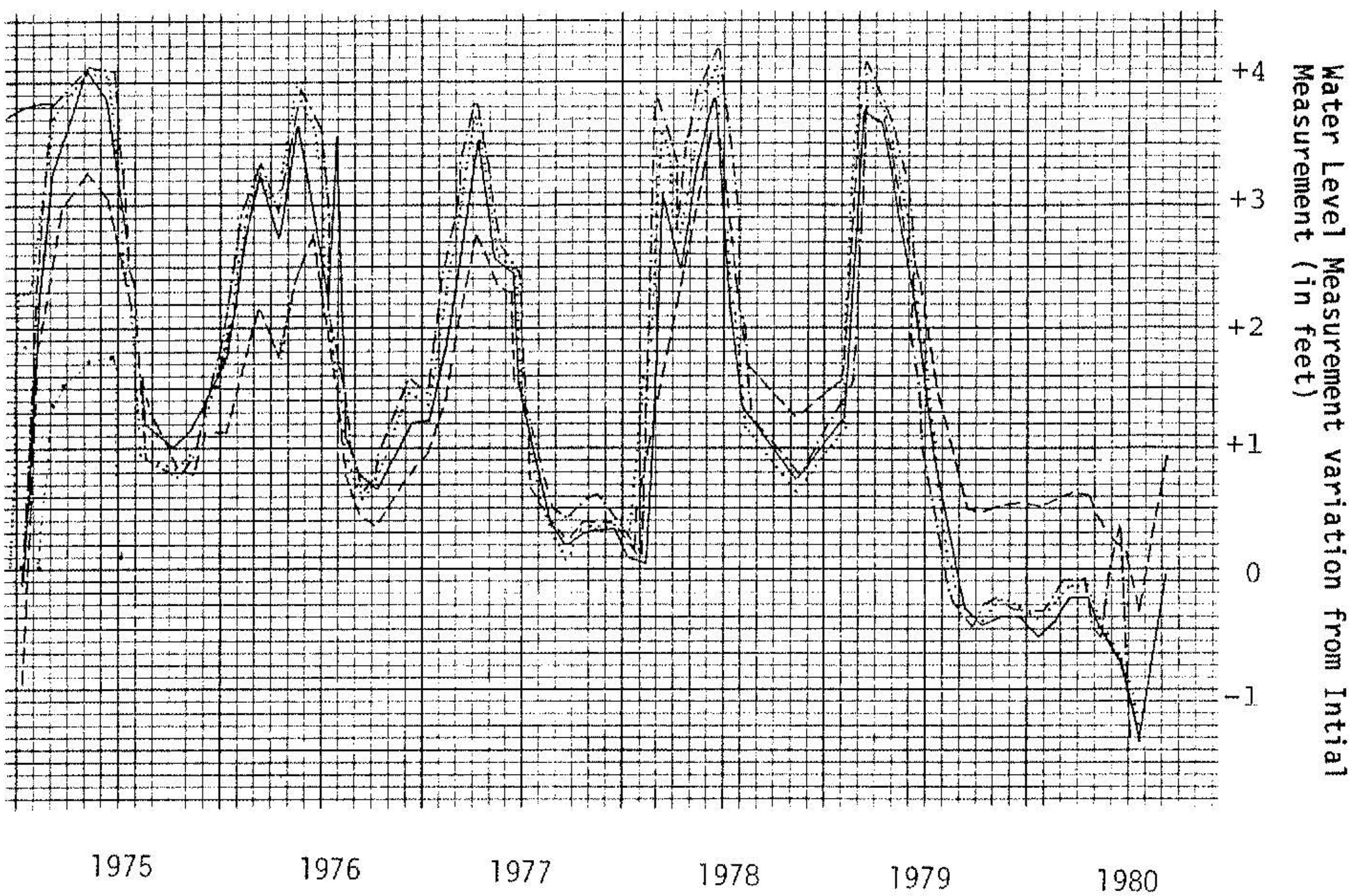


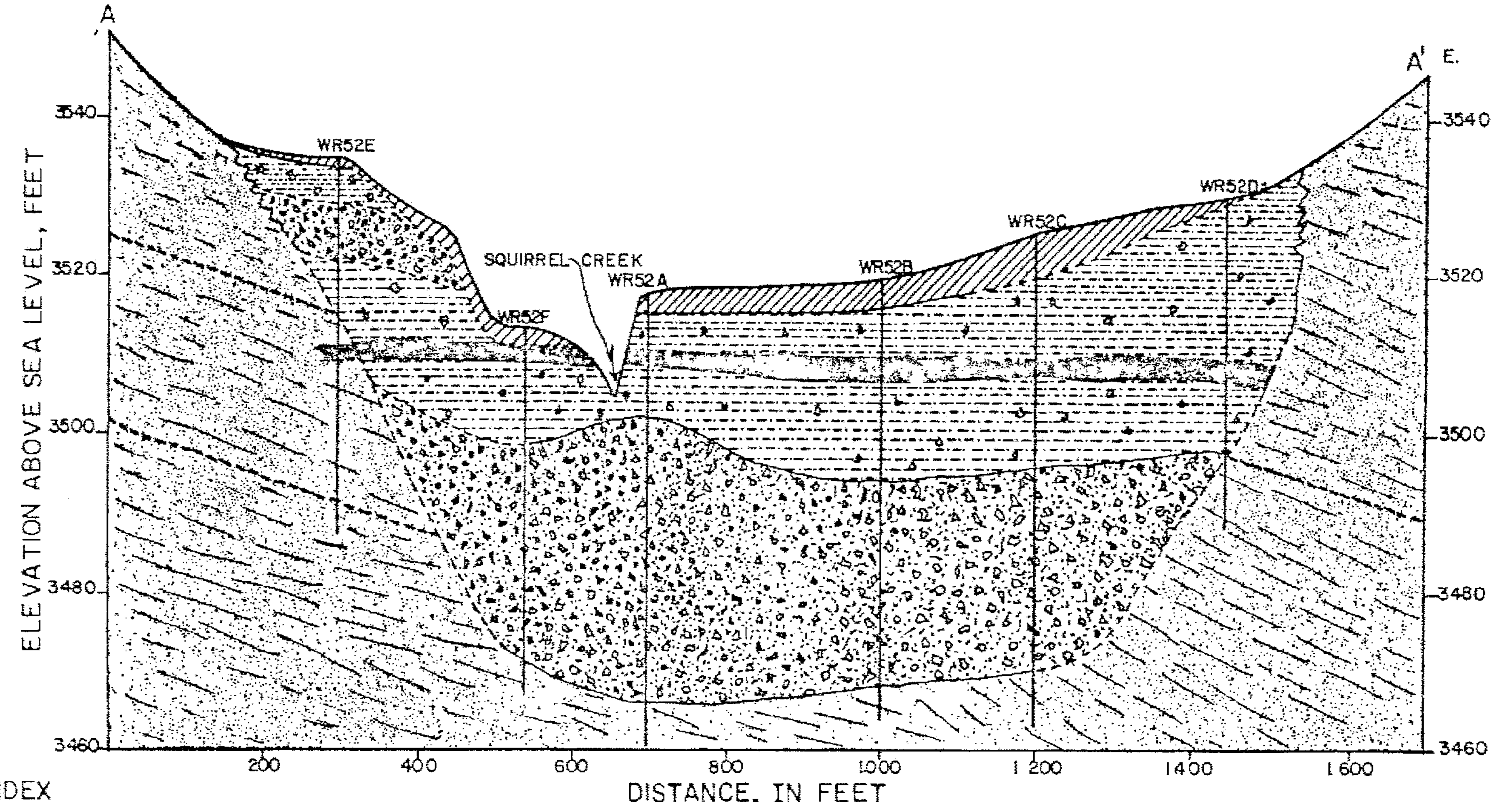
Fig. C-3. Hydrographs from alluvial wells in alluvium of East Fork Armells Creek, Colstrip, Montana. Note seasonal fluctuation of water table (Western Energy Co.).

this alluvial aquifer. The basal alluvial gravel unit is up to 35 feet thick, and most of the ground water in the alluvial aquifer flows through this gravel layer. Ten to thirty feet of fine-grained deposits overlie the gravel. The elevation of the water table fluctuates seasonally but is always within the fine-grained unit. Subirrigation occurs where the land surface is low enough to allow root penetration to the capillary fringe above the water table.

B. Soil Moisture. Soil moisture is recharged by infiltration from the ground surface and by capillary rise of water upward from the water table. Subirrigation occurs if plants use soil moisture moving upward from the saturated ground-water zone. The area of unsaturated, but available, water above the ground water is called the capillary fringe. Capillary water occurs in this area as continuous films around soil particles with the water held by surface tension. Water molecules are drawn upward from the saturated zone by the attractive force, called capillarity, between the soil particles and water molecules. This attractive force exceeds the force of gravity and, therefore, results in upward movement of water. Because capillary water is held by the soil particles under tension, it is more properly called soil moisture and not ground water.

The height of capillary rise of water is dependent on the size of pores between individual soil particles. Large pores, as found in sand, give the least rise. The small pores of clay soils give the

Fig. C-4. Geologic cross-section through Squirrel Creek valley, Decker, Montana, (Consolidated Coal Co.).



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STRATIFIED FINE-GRAINED SANDSTONES AND SHALES OF THE FORT UNION FORMATION.

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VERTICAL SCALE IS 1"=20'
HORIZONTAL SCALE IS 1"=200'

greatest rise. The importance of the different heights of rise is somewhat offset by the tendency for clay soils to hold water more strongly, preventing moisture from becoming available for uptake by plant roots. Silt-sized pores give the greatest effective height in terms of both absolute height and availability (Dollhopf and others, 1981a). Height of capillary rise has been calculated by Kohnke (1968) and Slatyer (1967) for various soils.

As the attractive force between soil and water in the capillary fringe becomes greater with increased height above the water table, plant roots have more difficulty drawing water. Also, water is supplied at a slower rate to the top of the capillary fringe. For both reasons, then, the upper part of the capillary fringe is less useful to plants than the lower part. This principle has been demonstrated by Wind (1960) and Gardner (1965).

Gardner (1965) demonstrated that in a sandy loam soil, capillary rise of water was able to supply about 0.8 cm of water per day when roots are within 90 cm of the water table. This amount is about equivalent to the daily evapotranspiration (ET) requirement of alfalfa in the Central Great Plains (Blad and Rosenberg, 1974; Rosenberg, 1969a, b). As the distance between the root zone and the water table increases, the amount of water supplied by capillary rise decreases (fig. C-5).

The rate of rise of capillary water has been calculated by Wind (1961) (fig. C-6). In a coarse-textured soil he calculated that capillary rise could supply 5 mm of water per day to a height of 57 cm and 1 mm/day to 87 cm. A very fine-textured soil supplies 2 mm/day to only 40 cm above the water table. The plant's ability to utilize this soil moisture is of course dependent on the depth at which the capillary fringe terminates and the quantity of roots present.

Several degrees of soil moisture content are generally recognized in relation to agricultural and laboratory studies of soil. The wilting point is that moisture content at which permanent wilting of plants occurs. Experiments have proved that this is not a unique value; rather, it depends upon the plant, the climate, the root system, and the volume of soil tested. Branson and others (1976, 1979) have documented the variability of the wilting point of different species found in the semiarid West. The soil moisture tension at which wilting occurred in 12 species ranged from 7 bars (atmospheres) to as high as 96 bars, depending on the rate of consumptive use of water, soil salinity, and soil texture. Typically, 15 bars is used as the wilting point when more specific information is not available for a specific species (Brady, 1977) (fig. C-7).

Field capacity is defined as the amount of water held in the soil after excess water has drained from the soil by gravity. This water is held by capillary forces in narrow spaces between soil grains and

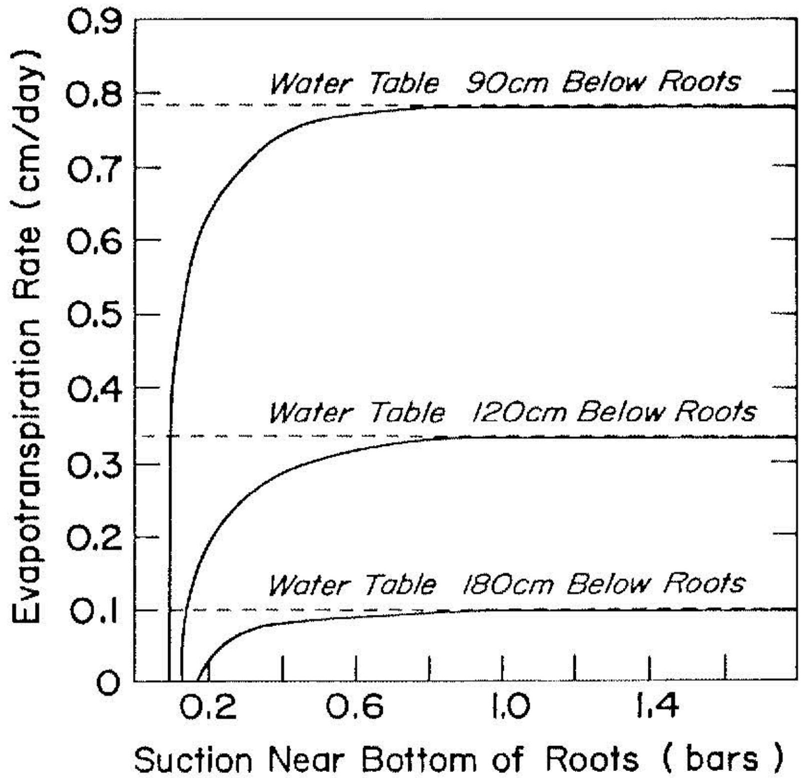


Fig. C-5 Rate of capillary rise, i.e., evapotranspiration, from a water table as a function of the suction near the bottom of the root zone (after Gardner, 1965).

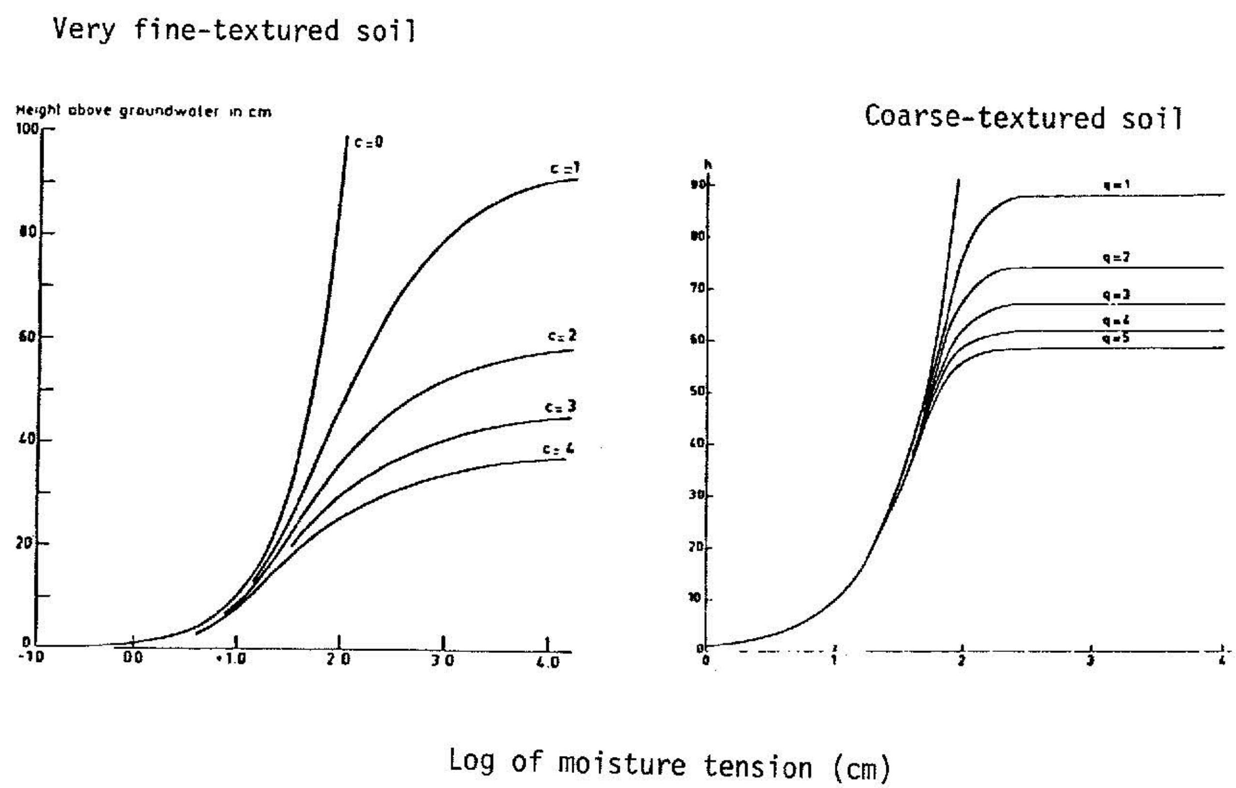


Fig. C-6. Rate of capillary rise to various heights for two different soils. q is equal to rate in min/day. (Wind, 1961.)

by adhesion of very thin films coating the grains. The tension on soil water at field capacity is usually between 0.1 and 0.3 bars. As roots exert suction through evapotranspiration processes, water is removed from around the soil particles until the wilting point is reached.

The water which can be removed from a soil profile by plants or evapotranspiration as the moisture content is lowered from the field capacity to the wilting point is called available water. Available soil water can be expressed in terms of soil water potential which is a measure of the force with which the water is held by the soil and the force the plant must overcome to obtain the water. The amount of available water is dependent on the soil texture. Sandy soils have less available water than do fine-textured soils (fig. C-7). Thus, laboratory tests are usually done to determine the percent soil moisture in any soil of a particular texture under certain suction potentials.

C. Evapotranspiration. Evapotranspiration is the collective loss of water from the land surface and from plants. That portion which is lost from the ground surface and from rainwater intercepted and held by the above-ground part of plants is called evaporation. Transpiration is the loss of water from the cuticle or the stomatal openings on the leaves of plants and can be considered a biological evaporation process. Evaporation involves a change from liquid to

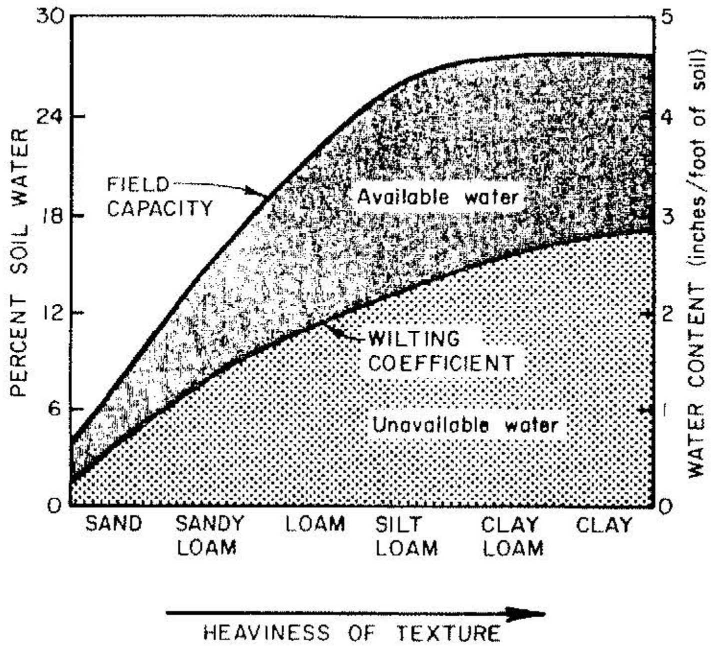


Fig. C-7. Relationship between soil moisture, soil texture, and available water (Brady, 1976).

vapor, and this change requires an input of energy normally supplied by solar radiation. Evapotranspiration is an important concept in understanding subirrigation because it is the upward water loss which occurs in the soil/plant/water budget.

Potential and actual evapotranspiration are terms used to describe water loss from plants. Potential evapotranspiration is the water loss which would occur if there is no water deficiency in the soil. Potential evapotranspiration gives an estimate of the total amount of water which should be supplied by rainfall and irrigation to maximize plant growth. Actual evapotranspiration is the actual water loss from a plant and is usually less than potential evapotranspiration in the West because of the scarcity of water.

The rate at which water is returned from the soil to the atmosphere by evapotranspiration is controlled by two factors: atmospheric demand and soil-water availability. If soil water at the surface or in the root zone is not limiting, ET is equal to the potential rate as determined by air temperature, wind speed, relative humidity, solar radiation, and other meterologic conditions. Most evaporation data have been obtained using evaporation pans placed on the ground, such as the U.S. Weather Bureau's class A pan. The relation between pan evaporation and ET of well-watered crops has been studied for various conditions. A summary of the results is presented by Doorenbos and Pruitt (1974). Results from these studies indicate that plant transpiration represents roughly 35 to 85 percent of the potential value depending on wind speed, relative humidity, upwind conditions, convection, and pan environment.

Numerous techniques for estimating potential ET in addition to class A pans have been developed, ranging from empiricial equations to physical equations. The latter have been derived from the energy balance of the soil and plant surface, the mass transport of water vapor above the soil and plant surface, or a combination of the two. These methods have been reviewed by Jensen (1973).

Potential ET for vegetated areas is reached only if soil water is not limiting and if plants are actively growing and fully covering the soil. When full cover has not yet been attained, ET will be less than potential ET. As a crop reaches maturity, ET becomes less than the potential ET because the crop no longer is actively growing. Exceptions, of course, are forage crops and other plants that continue to grow actively after full cover is reached.

With continued evapotranspiration, soil-water content declines until it reaches a level where the plant roots can no longer extract the water. The lower limit of soil-water availability to plant roots is the wilting point. Volumetric water content at the wilting point ranges from about 2 percent or less for sands to 30 percent or more for clays. Plants differ in their reaction to decreasing water contents. For some plants, ET remains essentially at potential rate until the wilting point is reached and then suddenly reduces to almost zero. Other plants show a more gradual reduction in ET as the wilting point is reached. The wilting point will be reached first in the upper part of the root zone, from where it can be expected to advance downward as the deeper roots continue to take up water.

The literature on evapotranspiration is voluminous, and the reader is referred to reviews by Sosebee (1976), Jensen (1973), and Horton (1973).

D. Plant Growth Cycle and Physiology. Probably few environmental factors are as important to the survival of plants as is adequate water availability. Water is the principal consitutent of cell protoplasm, comprising 80 percent of the fresh weight of herbaceous vegetation and over 50 percent of that of woody plants (Brown, 1977). Water is an important component of all plant biochemical reactions, a carrier of nutrients and wastes within the plant, and is essential for the maintenance of cell turgidity and the absorption and dissipation of heat. Numerous discussions of plant-water relationships have been compiled and are readily available (Kozlowski, 1964, 1968a, b, 1972; Taylor and Ashcroft, 1972; Kramer, 1969).

Distribution and movement of water between various constituents of the environment, such as soil, plant, and atmosphere, occur in both the liquid and gaseous phases. A gradient of free energy (or water potential) between these constituents provides the force behind water movement. Water movement in the soil-plant-atmosphere continuum proceeds from higher to a lower free energy. This gradient is steepest in the soil and decreases progressively through the plant system through the leaves and into the atmosphere (Gardner, 1965). The essential feature in plant-water relationships is the internal water balance in plant tissues because the internal water balance controls the physiological processes responsible for growth.

Water absorption by plant roots is generally a passive process. Through this process water is absorbed from the soil in response to transpiration by aerial parts of the plant. As water is lost to the atmosphere by transpiration, leaf-water potential declines and, in turn, develops a gradient down the vascular system to the roots. When the root-water potential falls below that of the soil, water enters the root.

As transpiration proceeds, the gradient between the soil and the plant's root system steepens, and absorption eventually lags behind transpiration. This lag in absorption is due to the resistance to water movement by root cells (Kramer, 1969). With continued transpiration, soil moisture decreases, and the capillary conductivity of the soil declines, causing even greater absorption lags. Plants can and do control transpiration losses to minimize absorption deficits. The ability to control transpiration rates is one of several adaptive responses to arid conditions. Bliss (1962) found transpiration losses well controlled in alpine plants subject to extreme temperature and solar fluxes. Phreatophytes, dependent on root-ground-water contact for growth and survival, have relatively little ability to control transpiration losses.

Plant-water stress is initiated by the lag in transpiration versus absorption rates. If adequate soil moisture is present, the plant will undergo maximum stress during the day and will reduce this stress (e.g., increase leaf water potentials) at night, when transpiration decreases. If soil moisture becomes limiting, the plant cannot recover from this moisture stress, and leaf potentials will continue to decrease. Eventually, decreasing leaf water potentials result in loss of leaf turgor and increases in transpiration resistance.

Unless additional moisture is provided to the plant, severe stress will eventually occur. The ability of plant species to cope with water stress is another adaptation to arid environments. In all situations, however, water stress causes reduced growth rate, protein synthesis, and reductions in other biochemical mechanisms. Under severe stress, biochemical processes will stop, the cell protoplasm will collapse, and ultimately death will occur. From the perspective of evaluating moisture stress in subirrigated plant species, a loss of soil moisture to these plants will cause growth losses and, ultimately, plant death more readily than in their counterparts on upland sites adapted to soil moisture stress.

Quantitative Assessment of Subirrigation

The amount of ground water used by vegetation has been evaluated with various techniques. Major issues which this research has addressed are the consumption of scarce water resources by flood plain phreatophytes in the arid Southwest, productivity of commercial crops in relation to depth of water, and percent use of ground water by subirrigated species. These studies are usually undertaken for purposes other than to identify areas of subirrigation but may be used to quantify the subirrigation component supplied to a plant community. As such, these techniques are usually used in detailed scientific research, and their application in the study of alluvial valley floors would be limited to detailed assessments of the importance of subirrigation to a specific plant community. Techniques for studying these topics are reviewed below.

A. Lysimeters. Lysimeters are used to obtain a direct measurement of evapotranspiration. A block of soil is held in a porous-bottomed tank, called a lysimeter, and buried in the ground. Water-table depths and net input or drainage of water from the soil block can be measured. Evapotranspiration is evaluated by measuring the decrease in weight of the soil block or by measuring the water added to maintain a specific water-table depth (McDonald and Hughes, 1968; Robinson, 1970). Lysimeter studies are applicable to studies determining the water consumption and productivity of plants grown under varying soil moisture and water-table conditions. Productivity data from lysimeter studies and from valley bottom vegetation can be compared to make inferences about the water available to the valley bottom vegetation. Such studies should be carried out with containers in the same environment as that of the actual phreatophytes to minimize advective energy loss, or clothesline effect, which could greatly increase the water use of the plants in the lysimeters. Even then, the results are not always transferable to flood plains with different types of phreatophyes with varying rooting depths and different soil profiles.

B. Water Balance Approach. Field techniques to evaluate ground-water use by phreatophytes on flood plains have included measurement of the various components of the hydrological balance. All inflow and outflow components of a certain reach of stream and its flood plain are measured or calculated. The water loss to evapotranspiration is then the difference between the total inflow and outflow. The disadvantages of this method are that large areas are required to obtain a measurable difference between inflow and outflow, and that the errors of the individual components accumulate in the calculated value of the water use (Van Hylckama, 1974).

Dollhopf and others (1979, 1981a) have used the water balance approach to calculate the amount of subirrigation in alfalfa and wheat crops located at various heights above the water table. The water budget developed in this study was for the inputs and consumption of water by the vegetation and not for the hydrologic system.

C. Color Infrared Photography. Jones (1977) presented a method for efficiently measuring evapotranspiration rates over large areas. The method involves correlating optical densities of vegetation on color infrared photography with ET data derived from field study of that vegetation. ET rates for other valley bottom vegetation can then be determined by comparing optical densities with the reference areas. This method thus quantifies various hues of the photography and is useful to extend detailed field study from a limited area to a much larger area. The degree of subirrigation can be determined from photographs taken during normal moisture stress periods and knowledge of the water budget of the plant community.

D. Other Methods. Other field techniques consist of calculating ground-water uptake by phreatophytes from decreases in ground-water flow (measuring gradients and transmissivities in the aquifer); from measurements of the fall of the water table or of decreases in water content of the unsaturated soil zone; and from increases in ground-water salinity. Reasonable agreement between the results of these methods has been reported (Gatewood and others, 1950).

Case Study of a Subirrigated Alfalfa Field

A study was made of an alluvial valley to determine the importance of subirrigation to agriculturally significant crops and illustrates the type of analyses possible in alluvial valley studies. Dollhopf and others (1979, 1981a) related the yields of alfalfa and wheat to varying amounts of subirrigation as a function of location in the valley and its sideslopes. Of particular interest is their work on alfalfa grown for forage and for seed because of the alfalfa's naturally deep roots and the importance of this crop throughout the coal regions of the West.

The root distribution of an alfalfa plant is important in the plant's ability to tap deep ground water. Dryland alfalfa plants in Montana will generally root in the upper 10 feet of soil and extract the bulk of its water requirements from the upper 13 feet of soil (Brown, 1971, 1972). Although the majority of roots are within the top 4.6 feet of soil, the tap root, which extends deeper, is characteristically covered with small root hairs which give a large effective surface area for uptake of soil moisture and nutrients. Alfalfa roots have been noted at depths of 65 feet, 66 feet and 129 feet by Meinzer (1927, p. 54) and 30 feet by Hughes and others (1962), but these examples are atypical and do not indicate normal root patterns.

Dollhopf and others (1979, 1981a) studied alfalfa growth near Colstrip, Montana. The presence or absence of subirrigation was documented by measurement of the soil-water content of the profile and observation of diurnal fluctations of ground-water level. Further confirmation and quantification of subirrigation was provided by evaluation of the hydrologic budget. The hydrologic budget in this study was made by measuring the difference between inputs, such as precipitaion, and outputs (losses) due to evapotranspiration, runoff, and deep drainage. Because all components of the water balance except subirrigation could be measured, the amount of water used by alfalfa derived from subirrigation could be calculated.

Hydrologic balance calculations for alfalfa at sites with water table depths of 18 feet, 40 feet, 44 feet, and 60 feet indicated no reliance on subirrigation. These water table depths are well beyond the normal rooting depth of alfalfa. At other sites with ground water 5 to 12 feet below the surface, alfalfa extracted at least one-third of its water requirement from ground water. On the average, subirrigation supplied a large portion of the water requirements of alfalfa at these sites not supplied by precipitation. At one intermediate site, which had ground water at 15.8 feet and an effective capillary fringe bringing water to 11.3 feet of the surface, seed alfalfa had 25 percent of its water deficit satisfied. The yields from this intermediate site were found to be between those from the subirrigated sites and those from dryland sites (Dollhopf and others, 1979, 1981a). Results from the 1979 Dollhopf study are summarized in fig. C-8.

Dollhopf and others (1981a) developed a hydro-yield relationship (fig. C-9) which can be used to estimate the yield variation of alfalfa in an alluvial valley system if ground-water level fluctuations occur. The hydro-yield relationship suggests that when the ground-water level is deeper than 15.8 feet, or when the effective capillary rise plus ground-water level is deeper than 15.8 feet from the surface, alfalfa will not be subirrigated. Although these results were developed in Colstrip, Montana, they may be applicable to other sites in the Northern Great Plains (Dollhopf and others, 1981a).

Mapping and Studying Subirrigated Areas

The regulatory need to designate alluvial valley floors with definable boundaries results in the necessity of mapping subirrigated areas. Natural systems do not usually yield clearly fixed boundaries, as are desired for regulatory purposes. In subirrigated areas, a frequently observed pattern is an area of clearly subirrigated vegetation, a zone of clearly not subirrigated uplands, and a zone of limited subirrigation, which decreases in importance as one moves away from the stream channel. The greatest difficulty in mapping subirrigated areas is in drawing a line in the midst of the zone of uncertainty.

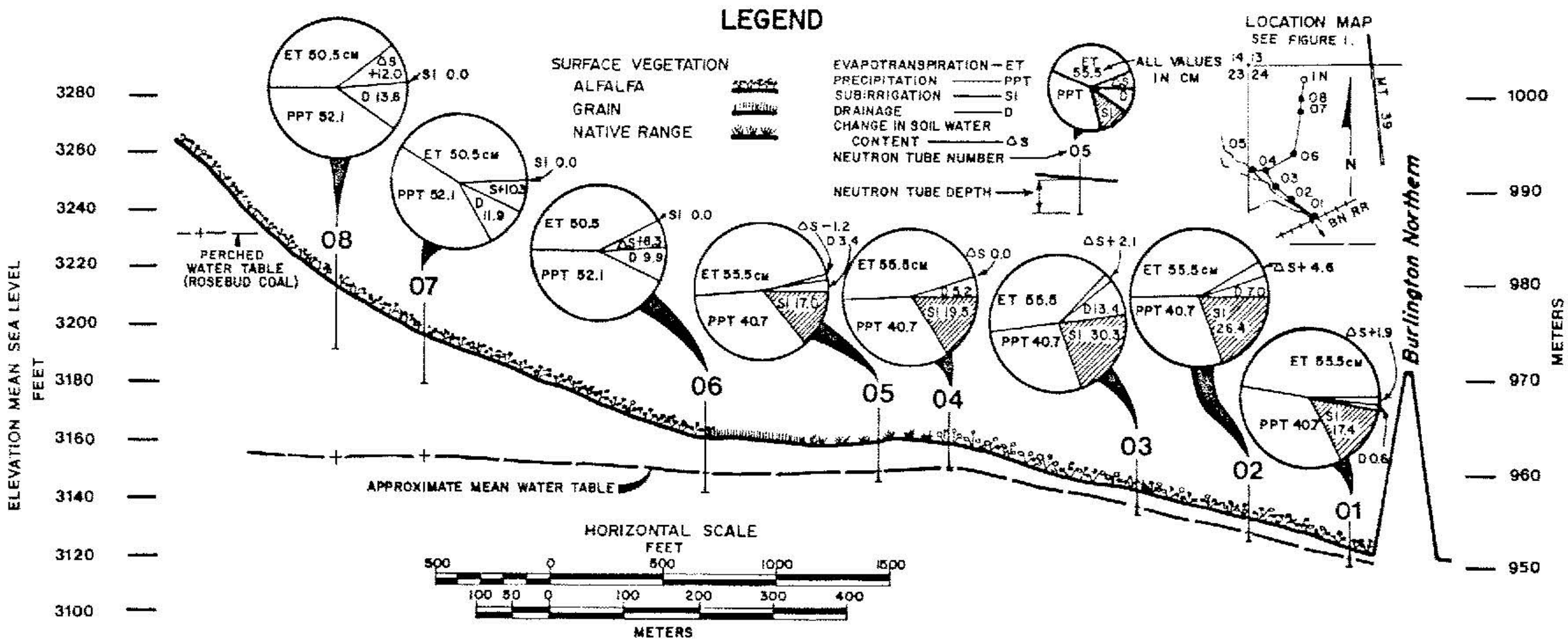
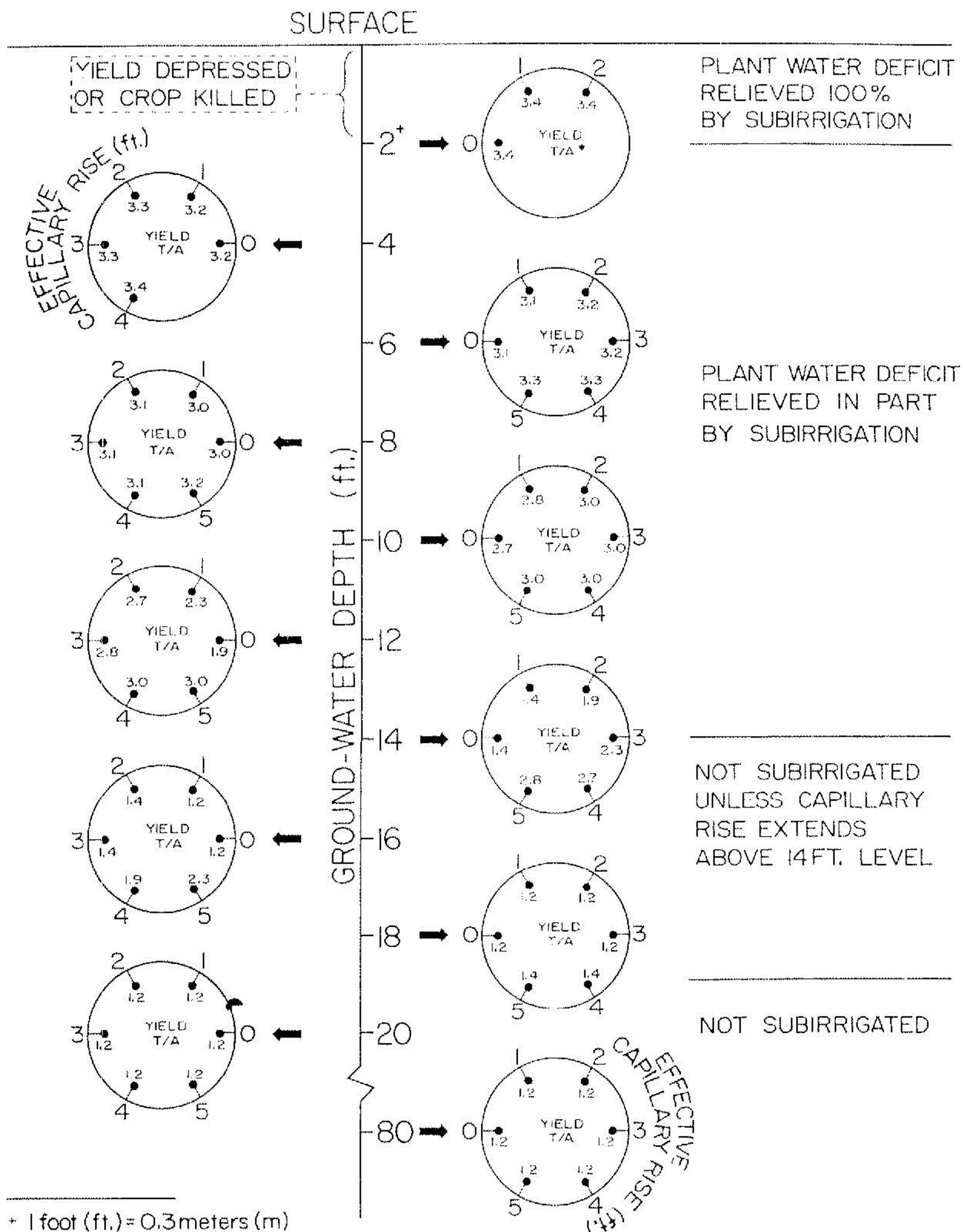


Fig. C-8. Hydrologic budget for the cropland area in Coalbank Coulee watershed as a function of depth to ground water. Sites 01-05 represent a 4-year summary (1975-78), whereas sites 06-08 represent only the 1978 hydrologic year. (Dollhopf and others, 1979).



+ 1 foot (ft.) = 0.3 meters (m)

* 1 ton/acre (T/A) = 2,242 kilograms/hectare (kg/ha)

Fig. C-9. Relationship between alfalfa yield, ground-water level, and effective capillary rise in an alluvial valley system. (Dollhopf and others, 1981.)

This section describes some methods frequently used to identify and study subirrigation and some of the questions which must be asked before boundaries of subirrigation can be drawn. There is no easy answer in assessing subirrigation. Drawing conclusions about subirrigation should be based on an analysis of several lines of evidence and cannot always be based on a single factor, such as the depth to the water table or an office inspection of color infrared photographs.

As the distance between land surface and water table increases, usually in a direction perpendicular to the channel, the amount and rate of water which can be supplied to plants decreases. The number of days during the growing season when useful subirrigation occurs also decreases. As the amount of water supplied decreases, the amountof ground water available for plant growth decreases, and subirrigation may simply keep plants alive. However, subirrigated areas must still be mapped. Many studies of subirrigation use a combination of several methods to differentiate subirrigated areas from non-subirrigated areas. The following methods are described in this section:

A. Color infrared photography.
B. Identification of roots within the capillary fringe.
C. Vegetation mapping (community types or indicator species).
D. Agricultural or vegetative production.

E. Rooting depth determination.

F. Maximum water table depth.

G. Soil mottling.

H. Streamflow increase or ground-water rise after the first killing frost.

I. Diurnal fluctuation of the water table.

Color infrared photography is the most useful method for reconnaissance identification and mapping of subirrigated areas. The other methods can be used to verify the existence of subirrigation. These studies can also aid in the determination of essential hydrologic functions in subirrigated valleys to sort out ground-water contributions from other water sources, and to establish the mechanisms of subirrigation in order to develop adequate reclamation.

A. Color Infrared Aerial Photographs. Aerial photographs taken with color infrared film can distinguish actively transpiring plantcommunities from those which are senescent. The advantage of color infrared film over other film types for vegetation analysis is the high reflectivity of actively growing plants in the near infrared wavelength range (0.70 to 0.90 micrometers). This high reflectance in the near infrared range is, in part, a function of the water content of the leaves, which, in turn, is a function of the water available to the plant's roots. Due to the three dye layers used in the film, the film yields "false" colors--near infrared radiance generally appears red, red may appear green, and green may appear blue. The red hues of infrared photography give an indication of both the relative concentration of transpiring plants and the degree to which the plants are not under moisture stress.

Interpretation of color infrared photography can be done visually for the qualitative analyses necessary for alluvial valley floor identification studies. Rigorous interpretation, which might attempt calculation of rates of evapotranspiration, involves classification of colors which must be done with instruments capable of measuring optical densities of the film. This type of work (Jones, 1977) should remain in the realm of academic endeavor, although quantification of subirrigation in studies done for material damage assessments might effectively use it.

A single series of photographs taken late in the growing season or a sequential series taken at intervals during the growing season can indicate vegetation which may be subirrigated. Late-season color infrared photography for all Western coal regions is available from the EROS Data Center in Sioux Falls, South Dakota. To positively identify areas with red hues on infrared photography as subirrigated, the possibility of the existence of any other water sources must be eliminated. This can only be done by field checking the interpretations. If other forms of irrigation, such as flood irrigation, are practiced, then subirrigation cannot be positively identified and other study methods must be used. Perched water tables, recent rainstorms or other localized contributions to elevated soil moisture may cause plant growth which confuses aerial photograph interpretation of the extent of subirrigation.

B. Identification of Roots Within the Capillary Fringe. Finding a significant portion of a plant's roots within the capillary fringe above the water table is considered evidence of subirrigation. The capillary fringe is normally identified from soil moisture data collected by the neutron-scattering technique (neutron probe). Rooting depths are typically measured in pits dug with a backhoe or similar device. Problems with this technique include inherent drawbacks of the neutron-scattering technique, depth limitations for installing access tubes and digging pits, and difficulty in knowing and identifying a signficiant portion of the roots. If this technique is used carefully, it can provide useful information. As mentioned previously for alfalfa and other plant species with taproots, total rooting depth may not reflect the existence of a signficant portion of the root mass.

Rooting depths can be determined in backhoe pits, although the rooting depths of some phreatopytes (e.g., alfalfa) may exceed the usual depths of pits. What constitutes a significant portion of roots to be found in the capillary fringe depends on the rooting morphology of the specific species. For instance, most of the root biomass of dryland alfalfa is found within 9.8 feet of the surface, and about 80 percent of these roots are within 4 feet of the surface. However, alfalfa grown for seed production would ideally be grown in a soil in which the top 4 feet of soil becomes depleted of water late in the growing season, thus triggering the plant into a reproductive state and in which the lower profile (6 to 12 feet) contains available moisture to sustain a dense stand of alfalfa (Dollhopf and others, 1981a).

The neutron-scattering technique is based on the principle that hydrogen atoms are the only major cause reducing the kinetic energy of fast neutrons. Hydrogen atoms are assumed to be present primarily in water, and the activity of neutrons is assumed to be proportional to soil moisture content (Shirazi and Isobe, 1975). Use of the neutron probe technique involves calibration of the measuring probe for varying soil textures and moisture contents (Rawls and Asmussen, 1973) and for determination of soil-water desorption characteristics of each soil profile. Thin-walled aluminum access tubes are installed in predrilled holes which are usually about 12 feet deep. Initial measurements made with a neutron moisture probe are compared to the volumetric moisture content samples measured in a laboratory to calibrate the measuring probe for future measurements in the same tube. To determine the relationship between soil moisture content and moisture availability to plants for a specific soil profile interval, the desorption characteristics of the soil interval must be measured by laboratory techniques (U.S. Salinity Lab, 1954). Error is introduced here because, at the 0.3- and 15-bar tension levels, a different amount of water may be contained in the in situ soil than in the laboratory sample whose original soil structure has been disturbed. Estimation of desorption characteristics is sometimes made from the textural analysis of the sample. Problems encountered in using data collected from neutron probes in alluvial valley floor studies are detailed by Dollhopf and others (1981a, b).

Results of measurement of soil moisture in a soil profile during the growing season are depicted in fig. C-10. Effective capillary fringe water lies in the suction range of gravitational water--that is, between field capacity (-0.3 bar) and saturation (0.0 bar). Capillary fringe height can be estimated as the distance between the ground-water level (measured in an adjacent piezometer) and the level at which soil-water content becomes less than field capacity (Dollhopf and others, 1979, 1981a).

Methods have been devised to determine the actively functioning portion of the root structure. The radioactive phosphorus techniques of Lipps and others (1957) and Fox and Lipps (1955) have proved to be successful in studying root activity zones in alfalfa. The technique involves injecting radioactive P_2O_5 near the root structure at various depths and monitoring the labelled material in the leaf samples. This technique could be expanded to determine root activity zones for other phreatophytes of interest.

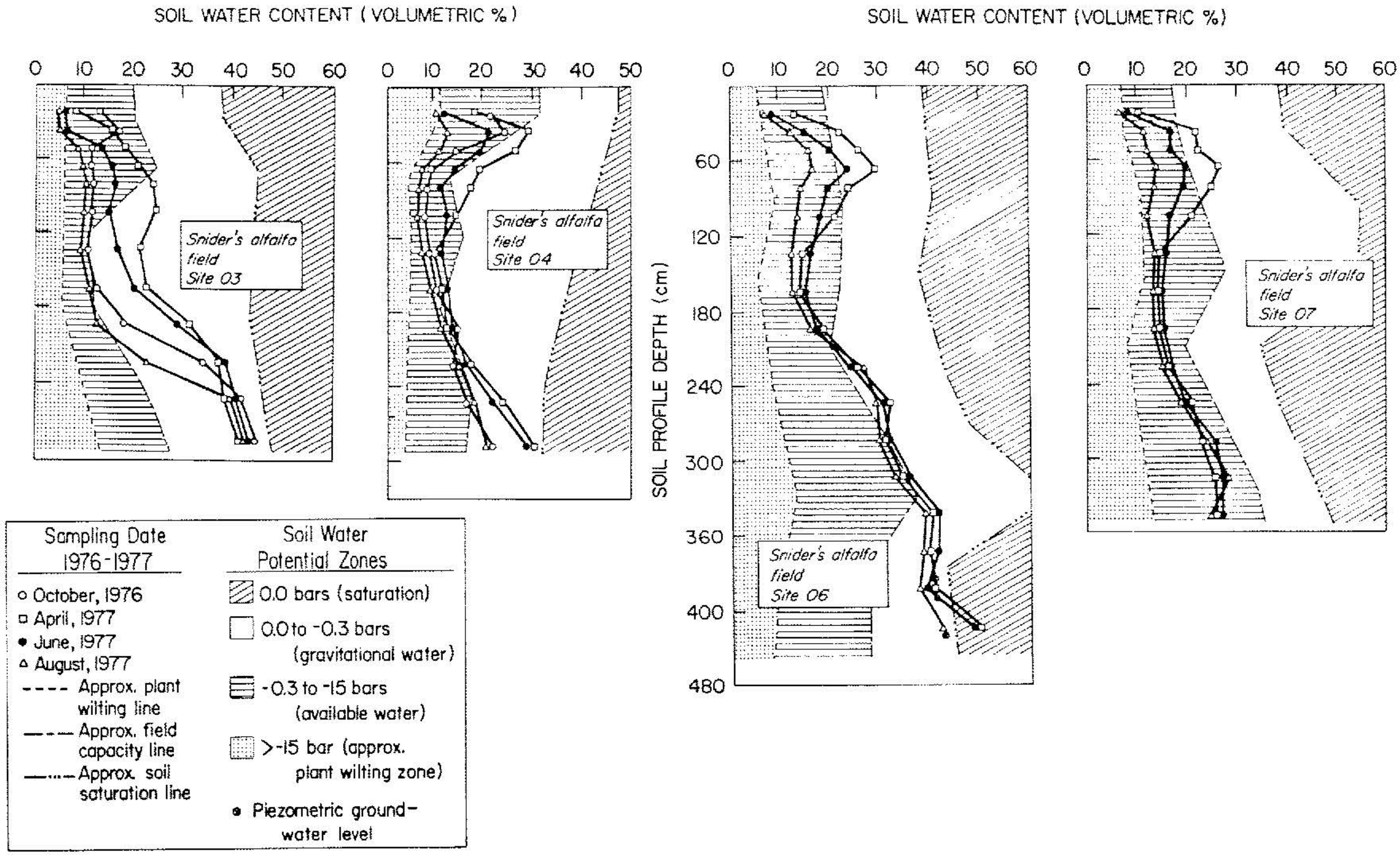


Fig. C-10. Foot zone soil water content as a function of time during the 1977 hydrologic year in alfalfa cropland area of Coalbank Coulee water-shed, Colstrip, Montana. Sites 03, 04, and 06 are subirrigated; site 07 is not subirrigated. Source: Dollhopf and others (1979).

C. Vegetation Mapping. Mapping species which are known phreatophytes produces a vegetation map distinguishing between subirrigated and non-subirrigated species. Use of specific species as indicator species can be misleading, however, because some species, such as silver sage, Western wheatgrass, and alfalfa, occur in both dryland and subirrigated conditions. Sometimes, production data can separate the small yields produced under dryland conditions from the higher yields which would only result from subirrigated conditions. The existence of a plant community which consists of several phreatophytes gives more convincing evidence of subirrigation than the existence of a single phreatophyte.

D. Agricultural Production. Enhanced productivity of sub-irrigated agricultural crops over dryland crops takes place because of increased soil moisture during all or some part of the growing season. For alfalfa, Bauder and others (1978) have determined that plant water use is a linear function of dry matter production. This relationship can be used to study the amount of subirrigation provided to an area.

Measurements of production of dryland areas versus potentially subirrigated areas are made, and an analysis is made of differences between sites. Comparable values would indicate that subirrigation has a minimum effect on the area in question.

Limitations in this method of analysis pertain to the comparability between sites in terms of crop spacing, age of crop, and crop management differences, such as fertilizer application and harvesting methods. In applying this method to investigate the existence of subirrigation in an area, care should be exercised in comparing only upland and lowland sites with similar crop histories.

E. Rooting Depth Determination. Rooting depths of native and agricultural crops are not always constant across different soil and subsoil conditions. Weaver (1920), in his classic paper on root development and formation, found that there is a certain amount of plasticity to root development under different soil conditions. He noted that alfalfa roots are normally dominated by a single taproot with few lateral branches, but, under heavy clay conditons, the branching habit of the plant becomes much more developed. Because of this plasticity, accurate site information is more important than literature searches in determining the rooting characteristic of potentially subirrigated plant species.

Methods for determining rooting depths and other rooting characteristics are normally accomplished by excavating a trench near the plant in question. Excavating the entire root structure, as Clements (1920) did, is too costly and time consuming. Once trenching is completed, the levels of rooting depths associated with various root diameters can be determined by making root depth-to-surface measurements.

In using this trenching technique it must be kept in mind that the plant's root structure is not going to be completely exposed; rather, the trench will be merely making a longitudinal cut into the soil through which plant roots pass. Therefore, care must be exercised in determining trench placement and the location of the root structures.

Several methods have been devised to quantify root structures at various depths. The SCS method divides roots at fixed intervals into classes representing root density and thickness (table C-2). Another method used in an analysis of rooting depths in the Squirrel Creek, Montana, drainage (Consolidation Coal Co., 1980) describes rooting depths as percentages of root structure biomass found at variable depths (table C-2).

TABLE C-2

ROOTING DEPTH CLASSIFICATIONS

Depth internal	Root density	Thickness
1 foot	M = many roots	VF = very fine roots
	C = common roots	F = fine roots
	F = few roots	M = medium roots
	C = coarse roots	
(Source: Soil Conservation Service)		VC = very coarse roots

Depth interval	Root structure biomass
v feet	10% above v feet
w feet	25% above w feet
x feet	50% above x feet
y feet	75% above y feet
z feet	100% above z feet

(Source: Consolidation Coal Co.)

It is also possible to simultaneously determine other characteristics of the soil and subsoil during pit excavation. Evidence of soil mottling, increases in soil moisture and texture, and water-table depths may be determined and allow empirical relationships to be made between rooting depths and these variables.

Although roots within the water table or capillary fringe are considered evidence that subirrigation may exist, the importance of subirrigation in terms of enhanced production also needs to be considered. Each plant species will provide a different answer to this question, on the basis of root morphology, soil characteristics, and other physiological requirements. The presence of a water table in contact with some part of the root structure does not, in itself, constitute subirrigation.

F. Maximum Water-Table Depth. If maximum depth of the water table below which subirrigation does not occur is known for a specific species, then the areal extent of subirrigation can be determined by mapping that water-table distance below ground surface, using water-level data collected from observation wells. For instance, Montana Department of State Lands (MDSL, 1981) determined for the Squirrel Creek valley that alfalfa is subirrigated where the water table is within 19 feet of the surface. Data from the extensive array of monitoring wells allowed a 19-feet-to-water line to be drawn to outline subirrigated areas. The 19-foot figure was determined by a

14.5-feet-to-water limit interpreted from research by Dollhopf and others (1979, 1981a) plus the existence of a 4.5-foot capillary fringe in the heavy-textured alluvial soils.

G. Soil Mottling. The existence of soil mottling is used to indicate soils which experience high water tables or which have horizons which impede downward percolation of water. Poor water drainage or constant saturation creates low oxygen content in soils and leads to reducing conditions. Iron and manganese are in the reduced state, and the compounds formed give the typical gray and bluish colors of gleyed (poorly drained) horizons. A fluctuating water table or water content causes variable reducing and oxidizing conditions. Some iron will be oxidized and yellow-brown, brown, and red compounds will be formed. The characteristic colors of reducing and oxidizing conditions, when found together, are described as mottling. Gleying conditions can occur throughout a soil if the water table is high or can be restricted to only a part of the profile if water drainage is impeded (Birkeland, 1974).

Determining the exact cause of soil mottling makes its use as an indicator of subirrigation difficult. Mottling can be caused by a high water table, which would establish the possibility of subirrigation. However, excessive flood irrigation and horizons impeding drainage may also cause mottling. Mottling may also be a relic feature related to hydrologic conditions which no longer exist.

H. Streamflow Increase or Ground-Water Rise After the First Killing Frost. The abrupt halt of evapotranspiration caused by the first killing frost in the fall can cause streamflow to increase and ground-water levels in the alluvial aquifer to rise if vegetation along the valley is subirrigated. This method is useful for determining whether subirrigation occurs in a valley but not for determining the areal extent of subirrigation in the valley.

I. Diurnal Fluctuation of Water Table. The daily fall and riseof the water table in an alluvial aquifer caused by consumptive use of ground water by phreatophytes during the day and subsequent recharge from the upgradient part of the aquifer at night can be measured in a piezometer (fig. C-11). A continuous recorder is normally used to measure water level, and the resulting hydropgraph is corrected for changes in barometric pressure. A diurnal rise and fall of the water table is normally considered evidence of subirrigation. The drawback for assessing subirrigation is that the diurnal fluctuation is most strongly influenced by the areas that are clearly known to be subirrigated; for instance, the central riparian zone of the valley. If the observation piezometers are installed in areas of marginal subirrigation, it may not be clear what the hydrographs mean. Information on diurnal fluctuations may be equivocal. Diurnal fluctuations may sometimes be due to neighboring subirrigated areas, or subirrigation may exist but not be obvious from piezometer measurements, owing to the very low permeability of some fine-grained alluvial soils.

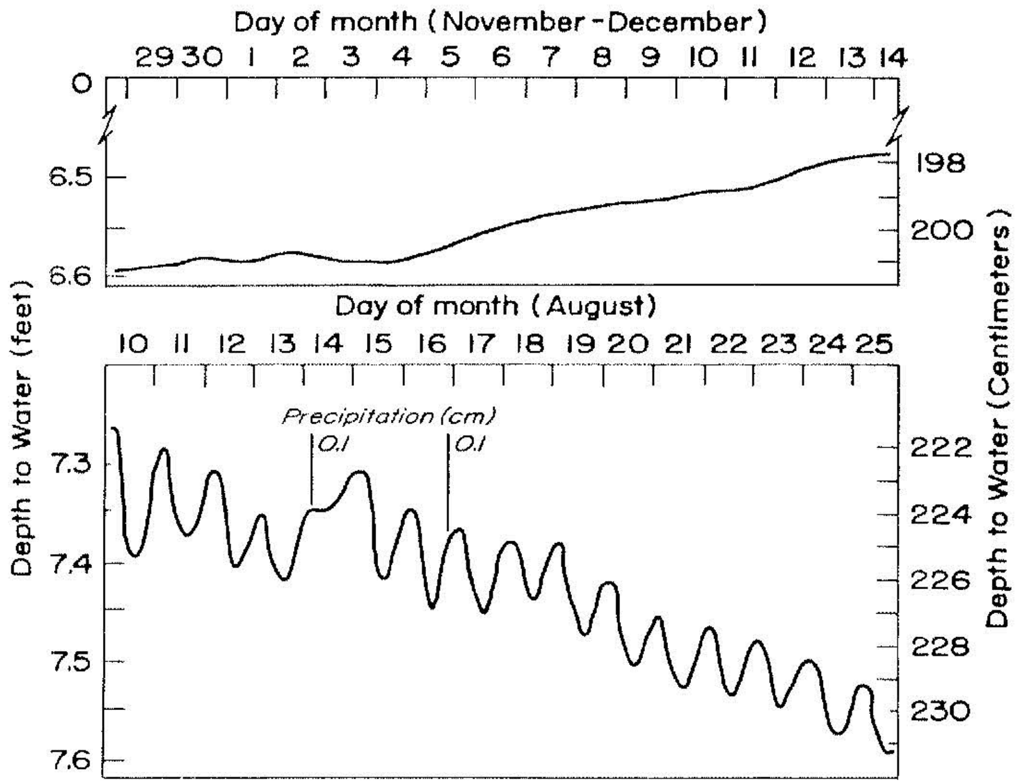


Fig. C-11 Daily ground-water-level fluctuations during two periods of 1978 in the subirrigated cropland area of Coalbank Coulee watershed. (Dollhopf and others, 1979.)

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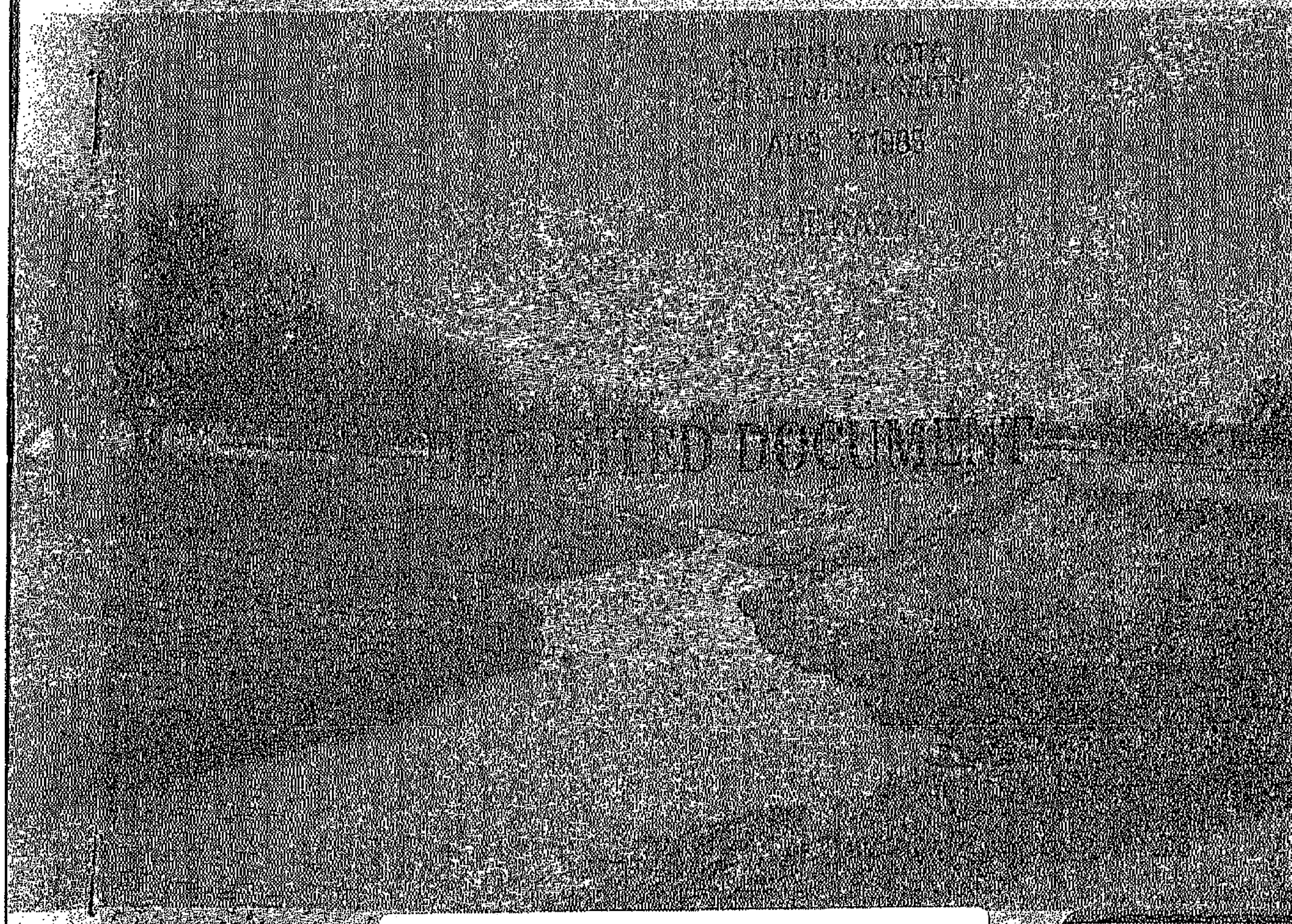
United States Department of the Interior
Office of Surface Mining Reclamation and Enforcement

DRAFT

OSM/TM-3/85

RECONNAISSANCE MAPS TO ASSIST IN IDENTIFYING ALLUVIAL VALLEY FLOORS

WEST-CENTRAL NORTH DAKOTA



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RECONNAISSANCE MAPS TO ASSIST IN IDENTIFYING ALLUVIAL VALLEY FLOORS, WEST-CENTRAL NORTH DAKOTA

Office of Surface Mining Reclamation and Enforcement
UNITED STATES DEPARTMENT OF THE INTERIOR

June 1985

ACKNOWLEDGMENT

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INTRODUCTION

Alluvial valley floors are defined by the Surface Mining Control and Reclamation Act of 1977 as:

> ...the unconsolidated streamlaid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation and windblown deposits [Section 701(1), Public Law 95-87].

With the passage of this act, Congress provided for the preservation of alluvial valleys in the semiarid West. Generally, alluvial valley floors are areas in the Western United States which (1) are located in topographic valleys having an associated stream channel, (2) are underlain by unconsolidated deposits whose surface usually has a landform appearance of flood plains or terraces, and (3) have an agricultural importance derived from water availability. Environmental characteristics, agricultural uses, and irrigation practices within stream valleys vary in the different coal regions of the West. Therefore, the specific rationale used for identifying the role and character of alluvial valley floors may vary from one area to another.

The objective of this study was to identify surface irrigated and subirrigated sites in the West to develop an understanding, from a regional perspective, of the types of stream valleys that may be studied further for consideration as alluvial valley floors. Further, potentially surface irrigable sites which also meet the geomorphic criteria were also identified on the basis of regional agricultural practices. This information was compiled onto 1:100,000-scale maps for all or part of four coal regions in the Western United States. Areas studied include the Fort Union coal region in west-central North Dakota, the Powder River Basin coal region of southeastern Montana and northeastern Wyoming, the Yampa and Danforth Hills coal fields of northwestern Colorado, the Book Cliffs, Grand Mesa, and Somerset coal fields of west-central Colorado, and the Book Cliffs and Wasatch Plateau coal fields of central Utah.

These maps represent only a reconnaissance-level effort in identification of areas which are likely to meet this definition, and these areas, therefore, are called potential alluvial valley floors. The intent of this mapping effort is to identify areas which might, at a future date, be designated as alluvial valley floors. Because reconnaissance-level data have been used in this study, it is recognized that detailed data collected for any specific area may more conclusively prove or disprove the alluvial valley floor findings made in this report. The following text outlines the basis for the alluvial valley floor mapping. If further site-specific study is necessary, information contained in this report can help identify those issues requiring additional study.

Mapping was conducted consistent with the method described in chapter II of the "Alluvial Valley Floor Identification and Study Guidelines" (U.S. Office of Surface Mining, 1983). The data on which these maps are based were obtained primarily by field investigation and supplemented with information from regulatory and land management agencies, from published reports, and from aerial photographs and Landsat imagery.

The study area encompasses parts of the Fort Union coal region in west-central North Dakota, specifically coal fields in parts of Dunn, Mercer, Oliver, McLean, Stark, and Billings Counties. Figure 1 shows the location of the study area, as well as the location of the individual maps of potential alluvial valley floors which accompany this text.

PHYSIOGRAPHY AND CLIMATE

Except for the area north and east of the Missouri River, the study area is located in the Missouri Plateau section of the Great Plains physiographic province. The gently rolling upland surface of the area is dissected by east- and southeast-flowing drainages, which have eroded valleys as much as 200 feet below the plateau surface. Scattered buttes, capped by resistant bedrock, rise above the upland surface. Elevations range from about 3,300 feet (1,000 m) above sea level in the Killdeer Mountains to 1,650 feet (500 m) at the point where the Missouri River leaves the study area.

Although the Knife River basin in the study area was glaciated, most glacial sediment has been eroded away, and the physiography is similar to the unglaciated Dickinson area. Several deep flat-floored valleys carved by glacial melt water cut the present drainages in a northwest to southeast direction.

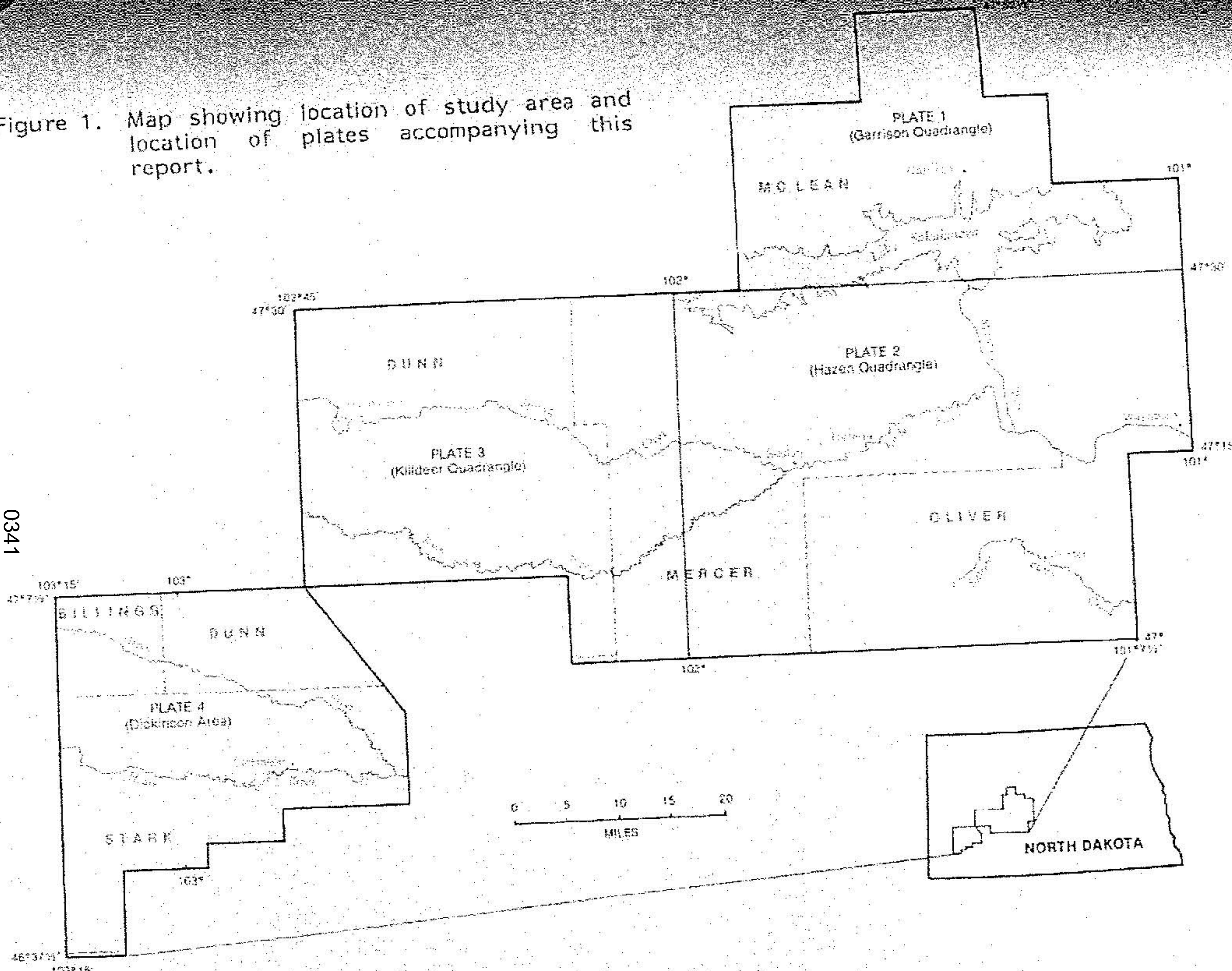
The portion of the study area north and east of the Missouri River is part of the Missouri Coteau of the Central Lowland physiographic province. The bedrock is covered by dead-ice ground moraine which has created a hummocky and irregular surface, quite distinct from the rest of the study area. Elevations range from 1,900 to 2,200 feet (580 to 670 m).

The climate of the study area is uniformly cool and semiarid. Mean annual temperature is about 40°F. Mean annual precipitation is about 16.5 inches, approximately 75 percent of which falls between April and September.

DATA COLLECTED

Detailed information regarding the areas included in this study was compiled through field investigation and an intensive review of published reports, interpretation of aerial photography and Landsat

Figure 1. Map showing location of study area and location of plates accompanying this report.



imagery, review of geologic and soils data, and evaluation of irrigation and agricultural practices for each region. Potential alluvial valley floors were classified and delineated on maps at a scale of 1:24,000, and the information was transferred to the 1:100,000-scale maps that accompany this text. Essentially, the areas mapped are the parts of valleys underlain by unconsolidated deposits: (1) where surface-water irrigation is practiced; (2) where natural flood irrigation occurs, or (3) where ground water occurs at sufficiently shallow depths that vegetation can tap this available supply. Reconnaissance-level data have been collected on each of these topics.

Identification of unconsolidated deposits found in valleys was based on interpretation of aerial photography, topographic maps, bedrock and surficial geologic maps, and field observations. Bureau of Land Management color-infrared aerial photography (scale 1:24,000) flown in August 1980 (Knife River area) and in June and July 1981 (Dickinson area) was utilized. Surficial geologic maps at various scales were consulted (Bluemle, 1971; Carlson, 1973; Clayton, 1969; Trapp and Croft, 1975). Soil surveys are available for the study area (U.S. Soil Conservation Service, 1975, 1978, 1979, 1982). Collectively, these data permitted identification of flood plains, terraces, outwash channels, and some gently sloping areas where colluvium is interpreted to overlie alluvium.

Interviews with local farmers and ranchers as well as resource professionals played a key role in our collection of agricultural data. Data were collected concerning the location and use of irrigated fields, agricultural practices, the importance of stream valleys to farms and ranches, and general perceptions of local agriculture and economics. Attempts were made to talk to as many farmers and ranchers in the study area as possible. Approximately 80 interviews were conducted in the study area.

Data on surface-water irrigation practices were collected from various sources. Unpublished maps of irrigated lands were available from the Soil Conservation Service (SCS) field offices in Dunn and McLean Counties. Unpublished maps showing the location of water permits for irrigation use and water permit records were available at the North Dakota State Water Commission in Bismark. Aerial photograph interpretation, field checks, and interviews with farmers and ranchers, as well as with SCS and Agricultural Stabilization and Conservation Service (ASCS) personnel, further refined and updated the assembled data. To the authors' knowledge, these compiled data represent the most nearly complete surface-water irrigation assessment available for west-central North Dakota.

Areas of subirrigation and natural flood irrigation overlap in many valleys in the study area. The net result of both is increased vegetative production on bottomlands, but distinguishing the relative importance of either at the reconnaissance level of these maps is often not possible. Therefore, one mapping unit is used to indicate one or the other, or both. The reader is referred to the description of each drainage for any additional information not indicated on the maps.

Data on the extent of natural flood irrigation were collected at specific valley sites through interviews with farmers, ranchers, and SCS personnel. Mapping of natural flood irrigation involved extrapolation of these data throughout the valley system, based on correlation with geomorphic surfaces. Natural flooding occurs in any stream in the Western United States, but in this study area, farmers and ranchers consistently emphasized the value of natural flood irrigation to the productivity of their valley-bottom crops and pastures. Therefore, these naturally irrigated lands have been specifically delineated in this study. The actual width of natural flooding is obviously different every year and, thus, not precisely mappable. Our map unit reflects the area reported by area residents and by resource professionals as frequently inundated. Review of hydrologic data and interviews indicate that this area is flooded approximately 3 years in 5. Because this study is a reconnaissance, it did not involve surveys of cross sections and slopes or detailed flood-height analysis. Therefore, the mapped extent of the natural flood irrigation areas should be considered approximate. Furthermore, areas of natural flood irrigation and subirrigation often are difficult to distinguish. Mapping of this unit is helpful, however, in the sense of indicating those valleys where the phenomenon is important.

Subirrigation was interpreted from Landsat imagery taken during the moisture-stress period of the late growing season in 5 different years (1975-76, 1978-80). Mean annual precipitation ranged from 25 percent above normal to 24 percent below normal in these 5 years. Near-infrared color composites and black-and-white images of Landsat's Band 5 were used because these bands indicate the relative moisture content of vegetation. This approach was necessary because different years vary in moisture regime. This effort is directed at mapping areas which consistently reflect subirrigation, with subirrigated areas being interpreted as those valley-bottom areas which indicated vegetation growth during the late growing season of most of the years of evaluated Landsat imagery. Areas which were apparently subirrigated only in the wettest year have not been mapped. The smallest size area which can be seen on Landsat imagery is limited by the 80- x 80-m size (1.6 acres) of a pixel, or piece of Landsat datum. Areas of subirrigation smaller than this size could not be distinguished and were not mapped. Ground-water-level data from coal mine permits and published reports (Croft, 1970; Klausing, 1971, 1976; Trapp, 1971; and Groenewold and others, 1979) were also used to correlate Landsat imagery with known depths to water. Generally, subirrigated areas have ground-water depths of 15 feet or less.

The crop rotation practice prevalent in the study area--alternating deep-rooting alfalfa with shallow-rooting crops--results in a pattern where, in any 1 year, certain fields may be subirrigated while adjacent fields may not. In subsequent years, the pattern will change as deep-rooted alfalfa is grown in other fields. Because the time span covered by the Landsat images used is less than the normal rotation cycle, the area of subirrigation is likely to be more extensive than indicated on the maps.

AGRICULTURAL LAND USE

Cattle ranching and grain farming are the two main types of agriculture in west-central North Dakota. The chief crops are wheat, barley, corn, hay, and cattle. In some areas there is greater crop diversity, particularly where highly developed irrigation exists. Several small dairies are scattered throughout the study area. For most operators, though, raising some combination of wheat and cattle provides their main livelihood.

The proportion of each crop grown by a farmer or rancher depends on several factors, the most important of which is the topography of the land controlled by the operation. Individual management preferences and the market demand for agricultural commodities are also important factors. Wheat farming is more suited to flat, upland areas. Cattle ranching is preferred where drainages cross the land (fig. 2). Upland areas, which cover most of the study area, are extensively farmed with dryland grains and some hay. Sporadic fields are in pasture. Valley bottoms, with their better soils, irrigation potential, and water supply for stock watering, are well suited to the various needs of raising cattle. Hay, silage, and small grains are the three crops which are grown in rotation in valley-bottom fields. Good pastureland is found nearby along stream channels and on side slopes, but the familiar "breaks" country which surrounds many drainages is useful only for grazing. Over the years, as cattle prices have declined and as cash crops have become more important, more pasture and hayland has been broken and planted to grains.

The main types of irrigation traditionally used in west-central North Dakota are spreader dikes and pumped sprinkler systems. Contrary to what is possible in much of the West, alfalfa can be grown in upland areas due to good soils and the approximately 16 inches of annual precipitation. This fact, plus the strong reluctance to change traditional practices (which do not include irrigation) has minimized the role of irrigation in the study area.

Spreader dikes are used to spread either tributary or main stem water onto main stem terraces. Most spreader systems completely impound water behind the dikes, and water is released when a headgate in the dike is manually opened. Commonly, water flows through a series of diked fields (fig. 3). Water is diverted to fields with spreader dikes by direct diversion by a dike, by overbank floodflows, or by pumping from the stream. An approximate doubling in production in these irrigated fields over dryland fields was reported in many interviews. The irrigation season is generally short because most systems are used only during high runoff periods. Generally, irrigation is practiced throughout the growing season only on larger streams, such as the Missouri and lower Knife Rivers. Sprinkler

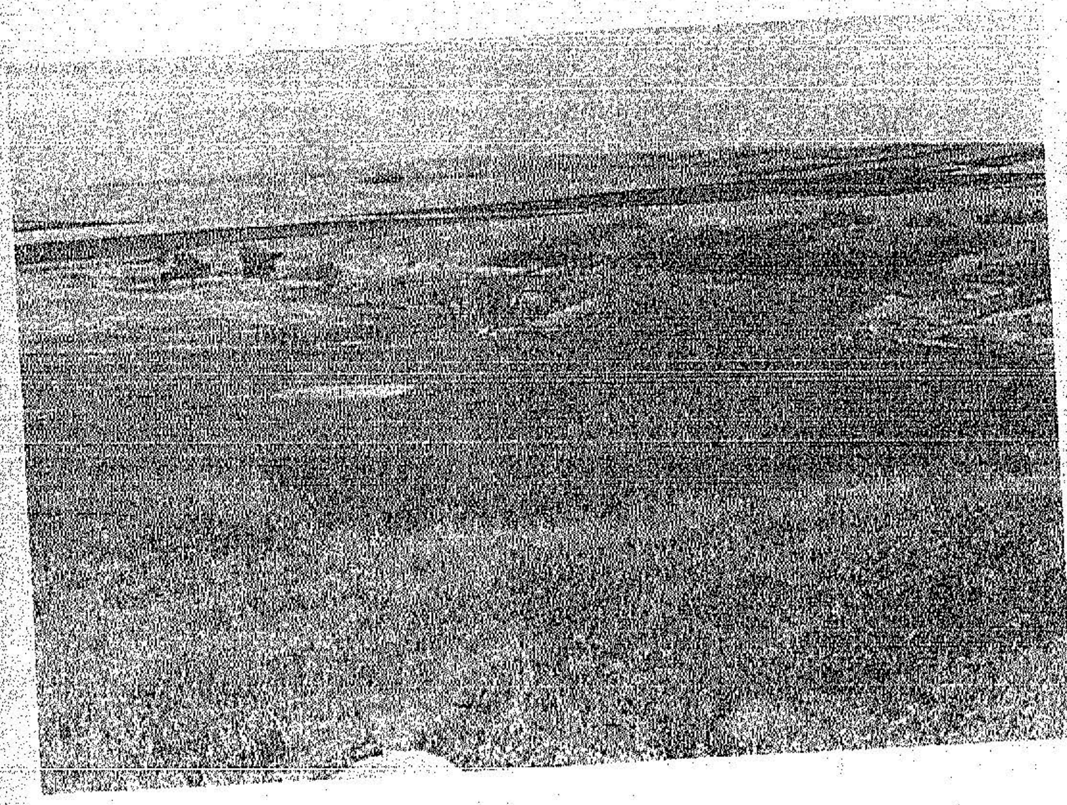


Figure 2. View of Coyote Creek (near Beulah) showing hayfields on the valley bottom, grazing land on valley slopes, and dryland farming on uplands (in distance).

Figure 3. Spreader dike system on a tributary to Branch Douglas Creek, McLean County. Water diverted from the stream by dikes is impounded by dikes in the hayfield. Headgates are opened to release water from upper fields (on the left) to lower fields. Because streamlaid deposits do not underlie these fields, the area is not an alluvial valley floor.

systems with center pivots have begun to be used on both upland areas and valley bottoms within the past 10 years. However, their use is not common.

Irrigation exists along the major drainages but is not generally extensive. Very few small streams have any irrigation development. These smaller tributaries have the potential for more extensive irrigation development, particularly with spreader dikes. This potential is not indicated on the alluvial valley floor maps because irrigation on these small drainages is not considered a regional practice. (See discussion under Minor Drainages.) On the basis of extrapolation from irrigated parts of specific valleys in the study areas, significantly more acres in the larger valleys could be irrigated with either surface or ground water.

The smaller stream valleys are very important to ranchers. They provide stock water, which is commonly springfed, shelter from sun and wind, and highly productive pasture, which is commonly subirrigated or naturally flood irrigated (fig. 4).

IDENTIFICATION OF REGIONS

Part of the process of designating alluvial valley floors is to identify valley floors which are capable of being flood irrigated. One dilemma in this effort is that physically similar valleys experience different use patterns in different parts of the West. Other aspects of the regional physical geography (e.g., proximity to major rivers) and social geography (e.g., agricultural methods) help determine what types of stream valleys are developed in one particular region of the West. Therefore, an assessment of regional agricultural practices within the study area was made. This method is consistent with the method outlined in chapter II of the "Alluvial Valley Floor Identification and Study Guidelines" (U.S. Office of Surface Mining, 1983).

The agricultural land use practices described previously are similar throughout west-central North Dakota. Although the use of any valley is dependent on its size, soils, water availability, and other factors, on a regional basis, the use of any valley is largely dependent on the size of the drainage basin. In evaluating the potential for irrigation development in undeveloped valleys, comparison of developed and undeveloped valleys has been undertaken only in relation to others of similar size. In other words, large valleys have been compared with other large valleys. The following groups of drainages have been formulated:

1. Large perennial streams. The Missouri, Knife, Green, and Heart Rivers and Spring Creek are the main drainages of the study area. Sufficient water for irrigation at many sites is available in each. Depending on the specific reach of stream, zero to 90 percent of the valley may be irrigated currently.

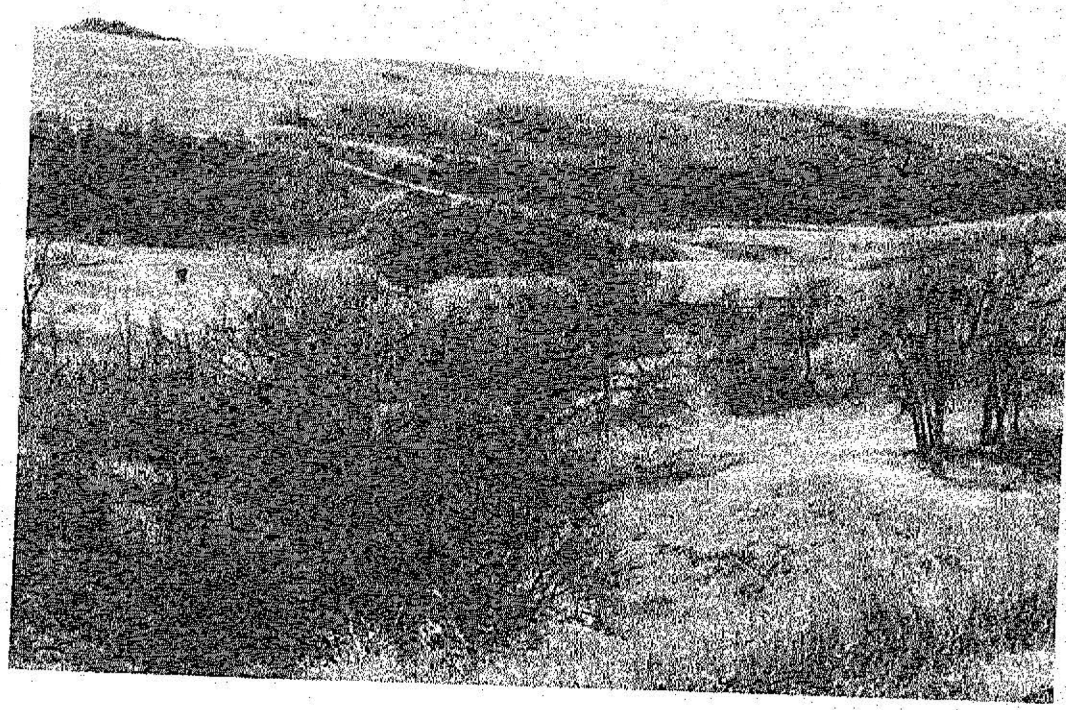


Figure 4. Headwater tributary to Elm Creek. This type of drainage, sometimes called a woody draw, is important to cattle operations due to its subirrigated grasses, stock water supply, and shelter.

2. Major tributaries. Major tributaries to the five large perennial streams are also perennial and generally have drainage areas of over 40 square miles. Examples include Square Butte, Otter, and Crooked Creeks. Irrigation water is usually available for at least one development in each valley, although not all major tributaries are irrigated. Subirrigation and natural flood irrigation are important.

3. Former outwash channels. Glacial outwash channels that no longer have large streams associated with them contain large amounts of ground water but are generally dryland farmed. Upper Antelope and Goodman Creeks are examples. Except for subirrigated areas, these valleys generally are not alluvial valley floors.

4. Minor drainages. The small streams not included in the other three groupings are, for the most part, undeveloped. Subirrigation and natural flood irrigation are sometimes important.

SUMMARY OF RESULTS

All irrigated and subirrigated valleys underlain by unconsolidated deposits were identified as potential alluvial valley floors. Within each grouping of drainages, nonirrigated valleys and nonirrigated parts of valleys with irrigation were also designated potential alluvial valley floors if other valleys of similar size are developed. Further site-specific study may provide data which might indicate that certain valleys or portions of valleys may not be considered alluvial valley floors due to unsuitable soils, topography, or water supply.

LARGE PERENNIAL STREAMS

The major drainages in the study area, while not extensively developed, have numerous irrigation systems. All sites are irrigated during spring runoff, and fewer sites are irrigated during the summer. Pumped sprinkler systems and diversion by pumping or gravity flow to fields with contour dikes are the common methods of surface irrigation.

Missouri River. The terraces along the Missouri River (pl. 2) provide the cropland base for many farms. Alfalfa, grass hay, and silage are grown for livestock or dairy cattle, or else for sale. Row crops are also important. The first and second terraces (10 to 25 feet) are occasionally irrigated by pumping from the river. On the west side of the river south of Stanton, the second and third terraces are irrigated by a canal system. Fields as much as 60 feet above the river are irrigated here. All three terraces are designated as flood irrigable.

Knife River. At its upstream end at the western edge of the study area (above Crooked Creek), the Knife River (pl. 3) is incised approximately 10 feet into a broad, low terrace. Hay production on this terrace is enhanced by natural flood irrigation that occurs during spring runoff and other large runoff events in most years. Alfalfa hay may also be subirrigated. A second terrace is occasionally present about 5 feet above the first terrace; it experiences floods very rarely and is not specifically utilized in the way that the lower terrace is. No irrigation development exists in this reach of the Knife River, although several operators have applied to the SCS for construction of spreader systems.

From approximately 2 miles west of Emerson upstream to the confluence with Crooked Creek, the river (fig. 5) is more deeply incised (15 feet). The valley floor is not as intensively utilized as it is upstream. Native grass, pasture, and dryland grains are the predominant crops grown. This change in use is probably a result of limited natural flood irrigation due to the deeper channel incision.

Between Crooked Creek and Elm Creek, the Knife River is intensively irrigated. The broad valley flat is a terrace approximately 15 to 20 feet above the river channel. Higher, nonirrigated terraces also exist. Most spreader systems developed on this terrace divert and/or impound the naturally occurring floodwaters (fig. 6); some spreader systems have water pumped to them. Tributary water from Coyote Creek (near Marshall) and North Schaffner Creek is also used. Parts of undeveloped fields receive beneficial moisture from natural flood irrigation. The amount of natural flooding is less below Marshall. The additional runoff contribution from Crooked Creek is probably the primary factor influencing the extent of natural flooding that occurs in this reach of the Knife River. Hay is grown in irrigated fields, whereas grain crops may be planted in the undeveloped higher parts of the terrace.

From Elm Creek to Spring Creek (pl. 2), the river is deeply incised (15 to 25 feet), and no Knife River water is used for irrigation. However, one system utilizes tributary water, and a center pivot system pumps alluvial ground water. Subirrigation is precluded by the depth of channel incision, and natural flood irrigation rarely occurs below Brush Creek.

Below the confluence of the Knife River and Spring Creek, three operations use pumped sprinkler systems to irrigate alfalfa and small grains. Annual flooding does not generally reach the main valley floor, which is 20 feet or more above the channel. Subirrigation does not occur under the main valley floor (fig. 7).

All first and second terraces of the Knife River are considered flood irrigable on the basis of existing irrigation on these terraces in the drainage.

<u>Spring Creek</u>. All irrigation systems in the Spring Creek valley (pls. 2 and 3) pump water and utilize either contour dikes or sprinklers. The main irrigation occurs for 2 weeks in the spring,

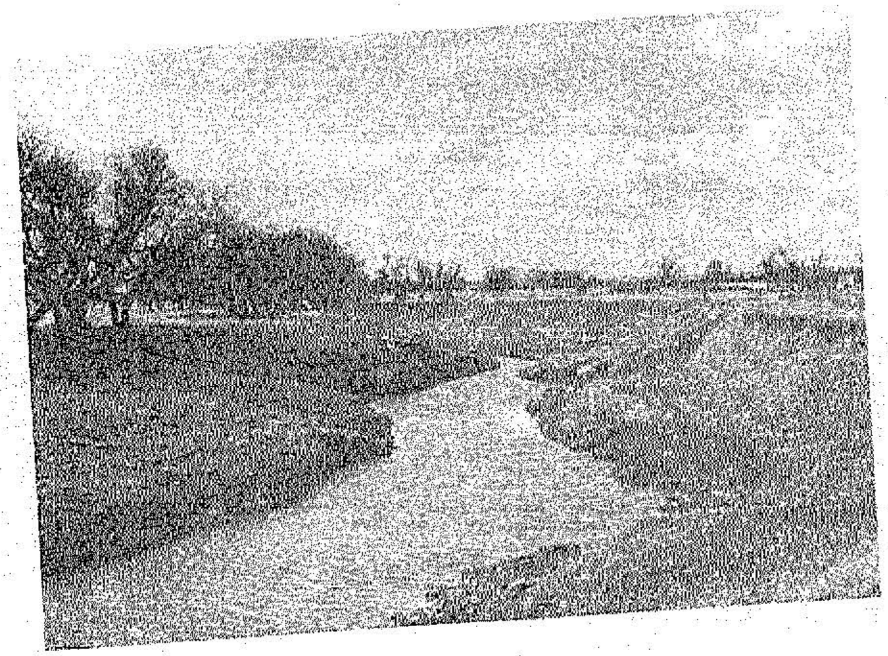


Figure 5. View of the main terrace (15 feet) used for sporadic irrigation on a reach of the Knife River downstream from Crooked Creek. This photograph was taken in T. 143 N., R. 93 W., sec. 31.

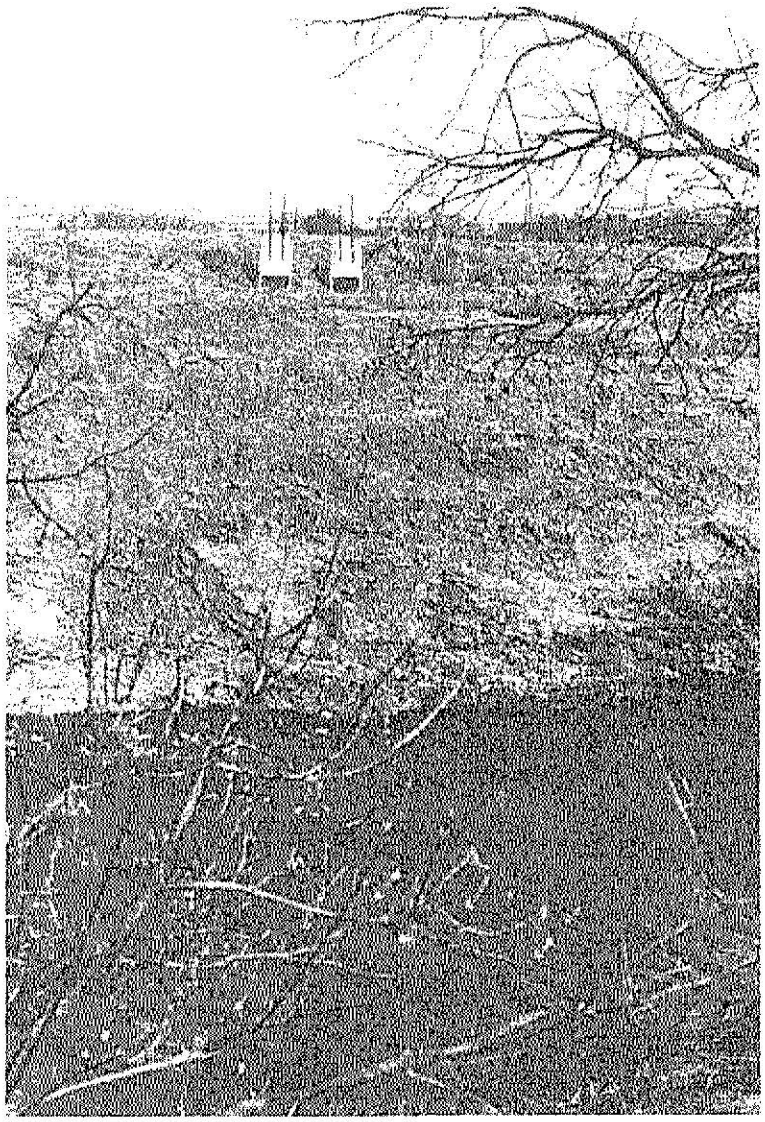


Figure 6. Headgates used to divert floodwaters of the Knife River to fields irrigated by spreader dikes. Floodwaters annually rise to the height of these gates, which are located in T. 143 N., R. 94 W., sec. 23, downstream from Crooked Creek.

Figure 7. The Knife River downstream from Beulah is incised 20 feet or more into a broad valley which is used primarily for dryland crops. This valley is considered potentially flood irrigable on the basis of several pumped sprinkler systems along this reach of the river.

during runoff, and a second irrigation is used if summer streamflow is high. Water quality is adequate for irrigation during runoff. Some operators irrigate during low-flow periods even though water quality is considered poor. Additional systems could physically be developed; however, as elsewhere in the study area, management styles, capital, and the short irrigation period are probable reasons for the lack of additional irrigation. Two main terrace levels exist along Spring Creek (fig. 8). Both irrigated and nonirrigated portions are designated irrigable. A higher terrace occurs, more commonly below Goodman Creek, and is not irrigated or considered irrigable.

Natural flood irrigation increases yields on the lower terrace and lower parts of the second terrace (8 to 12 feet). Subirrigation probably also provides some water to deep-rooted crops. These areas are mapped as naturally flood irrigated and/or subirrigated.

Heart River. The Heart River (pl. 4) provides Dickinson with municipal water, and water permits, therefore, no longer exist for irrigation upstream from the city. Several fields between South Heart and Dickinson used to be irrigated; therefore, the valley upstream from Dickinson is designated flood irrigable. Several pump/dike and pump/sprinkler systems still exist downstream from Dickinson and are used throughout the growing season. The second terrace contains the irrigated fields, and the Heart River is designated as irrigable as far upstream as Norwegian Creek. A higher terrace (35 to 45 feet) is not irrigated or designated irrigable.

The second terrace is generally lower above Dickinson (8 to 12 feet) than it is downstream (10 to 15 feet); therefore, natural flood irrigation of this extensive terrace surface is more common upstream. Natural flooding and subirrigation occur in the lower parts along the entire valley.

Green River. At their confluence, the Heart and Green Rivers (pl. 4) are similar in size, and agricultural practices on their valley floors are also similar. The Green River flows through a broad valley, which has several irrigated fields. In stretches, there are broad areas of subirrigated fields. Irrigation development includes some spreader dike systems which catch flood runoff from both the Green River and its tributaries. Most of the irrigation involves pumping water from the river.

MAJOR TRIBUTARIES

The major tributaries of the large perennial streams contain important crop and pasturelands. Although the streams are perennial, water availability usually limits surface irrigation to one or just a few operations on each stream. Some slightly smaller tributaries in this category do not have sufficient water for any irrigation. Generally, the drainage area of these streams is greater than 40 square miles. Natural flood irrigation and subirrigation are important features of these valleys.

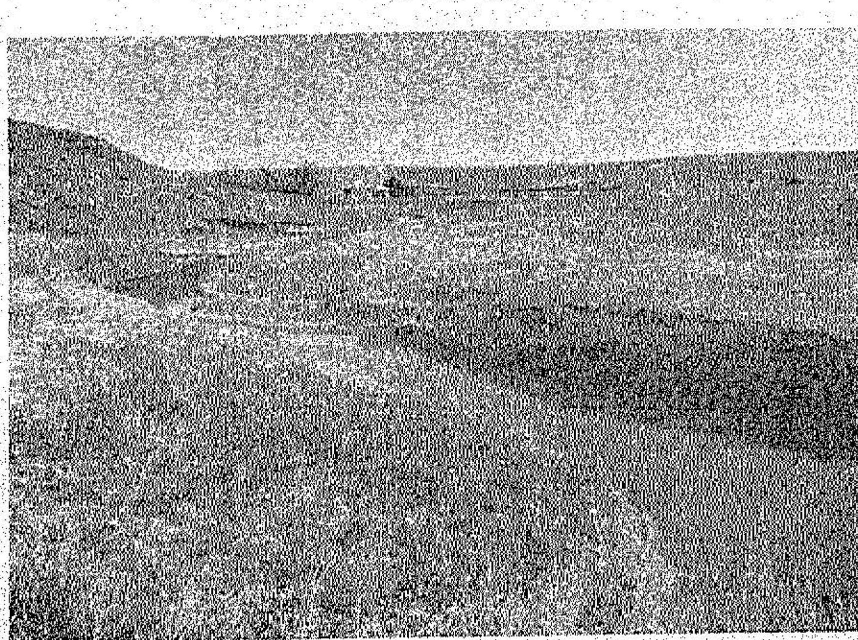


Figure 8. View of Spring Creek valley near Dodge. Most of the valley floor is subirrigated, and some pumped sprinkler irrigation systems exist.

A. Missouri River Drainage

Douglas Creek. The three branches of Douglas Creek (pl. 1) are the only major streams north or east of Lake Sakakawea within the study area. The Middle Branch is the largest drainage and has two terrace levels (2 feet and 5 feet). The stream is incised into bedrock in the lower part of the drainage. The broader, second terrace is used primarily as pasture with lesser amounts in hay and grain crops. Alfalfa could be subirrigated on the second terrace of the Middle Branch. Though no irrigation is practiced in this drainage, the character of the stream is similar to the major irrigated drainages of the Knife River. Therefore, Douglas Creek is designated as flood irrigable.

Square Butte Creek (pl. 2). All water rights were acquired by the powerplant near Center during the 1960's, and no irrigation has been practiced since that time. According to our interviews, no one irrigated along the stream prior to the 1960's despite the existence of water permits. Because there is sufficient water for irrigation in the stream and because the valley is similar in size to other major tributaries which are irrigated, the valley is designated as irrigable.

Natural flood irrigation and subirrigation reportedly double yields of alfalfa crops on the main terrace (6 to 10 feet). Croft (1970) reported eight wells along the stream with water levels between 5 and 15 feet; these data, as well as inspection of Landsat imagery, confirm the existence of subirrigation.

B. Knife River Drainage

Antelope Creek. The lower 5 miles of Antelope Creek (pl. 2) have several fields of flood irrigated alfalfa. The potential exists for more development in this portion of the valley. The two main branches of the stream above this portion are primarily dryland farmed. All people interviewed along these two forks claimed the water supply was insufficient for flood irrigation or that the soil was too saline.

Brady Creek. Brady Creek (pl. 2) flows through a small canyon with walls 30 to 50 feet high. The low terraces are small and frequently dissected by the stream. There are numerous springs at the base of the cliffs and the terraces are often subirrigated. This valley floor provides critical pasture for ranches along the stream. Two reaches are irrigable.

Otter Creek. Otter Creek (pl. 2) is a perennial stream with wide terraces throughout most of its length. The upper portion of the valley has subirrigated hayfields and supports some dairy operations. Farther downstream, subirrigated fields also occur. Only one irrigation system has been installed on the stream (fig. 9). Water is pumped into a series of fields bordered by spreader dikes. This new system's success has prompted its operator to enlarge the system, and irrigation

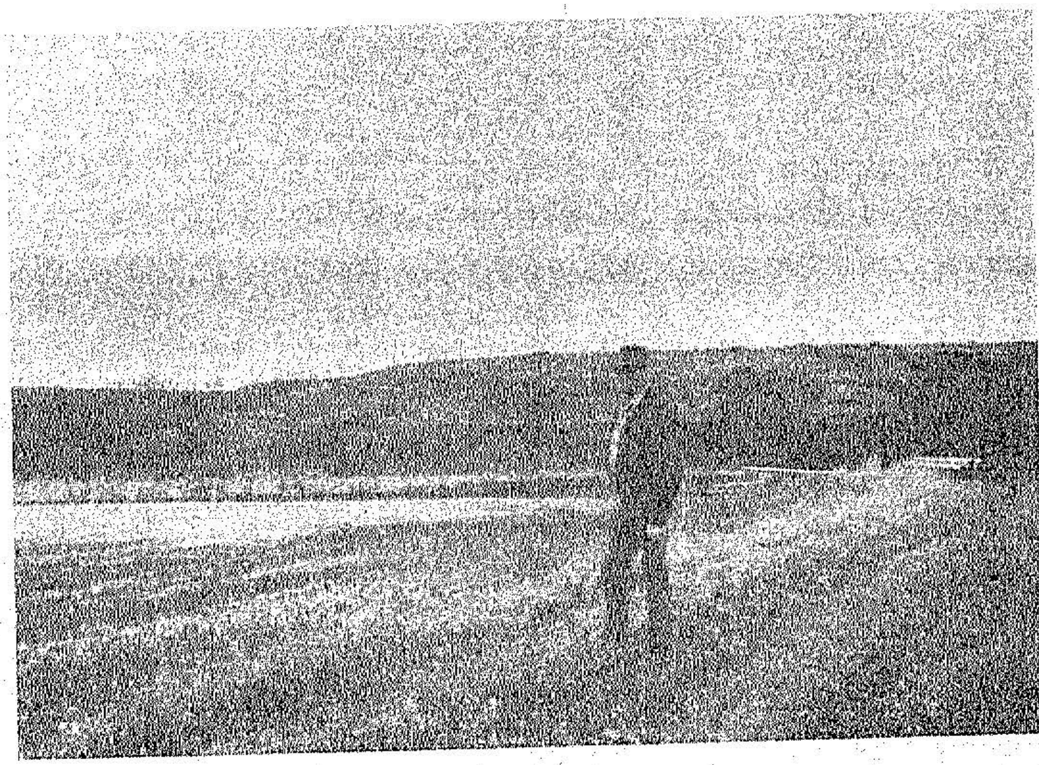


Figure 9. One spreader dike in the spreader dike system on Otter Creek. The pipes (right side) are used to pump water from the stream into the fields bordered by dikes. Three terrace levels are irrigated.

occurs on all three terraces of the valley. On the basis of this example, the terraces of Otter Creek are designated as flood irrigable. The traditional uses of the valley, however, are dryland hay and pasture. These uses alone make the valley floor critical to the success of the bordering ranches.

Brush Creek. Brush Creek (pl. 2) is a perennial stream with a baseflow contribution from springs. No irrigation development occurs in the drainage; however, the valley is considered irrigable on the basis of its similarity to adjacent valleys. Only one terrace is present in the upper reach (2 to 5 feet). Pasture use is predominant, although hayfields and cropland are present. Floodwaters will inundate lower parts of the terrace; subirrigation is evident in some areas.

Two terraces are present in the lower reach of Brush Creek. The lower terrace is 4 to 5 feet above the channel and is usually covered by floodwaters; pasture is the primary use. The second terrace (8 to 10 feet) is used for pasture and hay production.

Coyote Creek. Coyote Creek (pl. 2) (near Beulah) is a perennial stream without any irrigation development (fig. 2). The lower reach (below Beaver Creek) is characterized by several terrace levels. The first terrace (5 feet) normally floods, but it is too small for any use other than pasture. The broad second terrace (7 to 10 feet) is extensively used for pasture and hayfields. The lower parts of this terrace flood during high runoff; the other parts could be flood irrigated by spreading and/or pumping runoff water. Deep-rooting alfalfa probably receives beneficial moisture through subirrigation. A higher terrace is occasionally present but is not flood irrigable.

The upper reach of Coyote Creek has a single terrace level 3 to 5 feet above the stream. Lower parts of the terrace will occasionally flood, and all of it is flood irrigable.

Beaver Creek. Beaver Creek (pl. 2) is a perennial tributary to Coyote Creek. A low terrace is present 3 to 5 feet above the channel and is occasionally flooded. Pasture is the primary use. A broad second terrace (6 to 10 feet) is used for pasture, hayfields, and some grain crops. Though not naturally flooded, this terrace could be flood irrigated through use of spreading and/or pumping systems. The valley bottom does not appear to be as intensively used as those in some other drainages.

Mud Creek. Mud Creek (pl. 2) is a small perennial stream that is partially sustained by springs. There is only one major terrace, approximately 4 to 5 feet above the stream channel. Terraces are intensively used as pasture and hayfields. There is no irrigation development in the drainage. However, floodwaters cover parts of the terrace and could be spread or pumped to other parts of the terrace.

Elm Creek. The lower reach of Elm Creek (pl. 3) is characterized by a narrow, deeply incised channel. There is a sporadic terrace (3 to

5 feet) within the primary incision which regularly floods but is too narrow to be developed. A broad second terrace ranges from 7 to 20 feet above the channel; only the lower parts of this terrace are naturally flooded. Hay production and grain crops are the predominant uses of this terrace.

One irrigation development on the second terrace utilizes tributary flow for its spreader system. No other irrigation occurs; however, the second terrace is potentially flood irrigable.

The upper reach of Elm Creek has a channel shallowly incised into a broad outwash surface (fig. 10). There is no preferential use of land adjacent to the stream, probably due to the limited water available in this upstream reach.

Willow Creek. Willow Creek (pl. 3) is slightly different from other northwest-flowing tributaries of the Knife River in Mercer County. The channel gradient is steeper, and the width of the second terrace is narrower. The first terrace (2 to 5 feet) is reported to flood during some spring floods; it is narrow and only used for grazing. The second terrace level (5 to 10 feet) does not flood. Primarily grazing land, this terrace is broad enough in some places for cropland use. There is no irrigation development on Willow Creek. It is not designated as potentially flood irrigable owing to the reported lack of water availability and small terrace areas. There is some subirrigation along the lowest terrace.

Branch Knife River. The channel of this stream (pl. 3) is deeply incised (15 to 20 feet) into a broad valley floor. The land use here is either dryland farming or rangeland. No spreader systems have been installed, although one is planned. The valley floor is potentially flood irrigable.

Crooked Creek. Crooked Creek (pl. 3) is a perennial stream with some irrigation development, primarily on the broad second terrace. Natural flood irrigation occurs on the lowest terrace and the lower parts of the main terrace. Alfalfa hay may receive some subirrigation on both terraces.

C. Spring Creek Drainage

There are no major tributaries in the Spring Creek drainage basin.

D. Heart River Drainage

Ash Creek. The valley bottom soils along this perennial stream reportedly are unsuitable for farm machinery, and the basin is too small to provide sufficient water for irrigation. The valley is, therefore, used for pasture and is naturally flood irrigated and/or subirrigated.

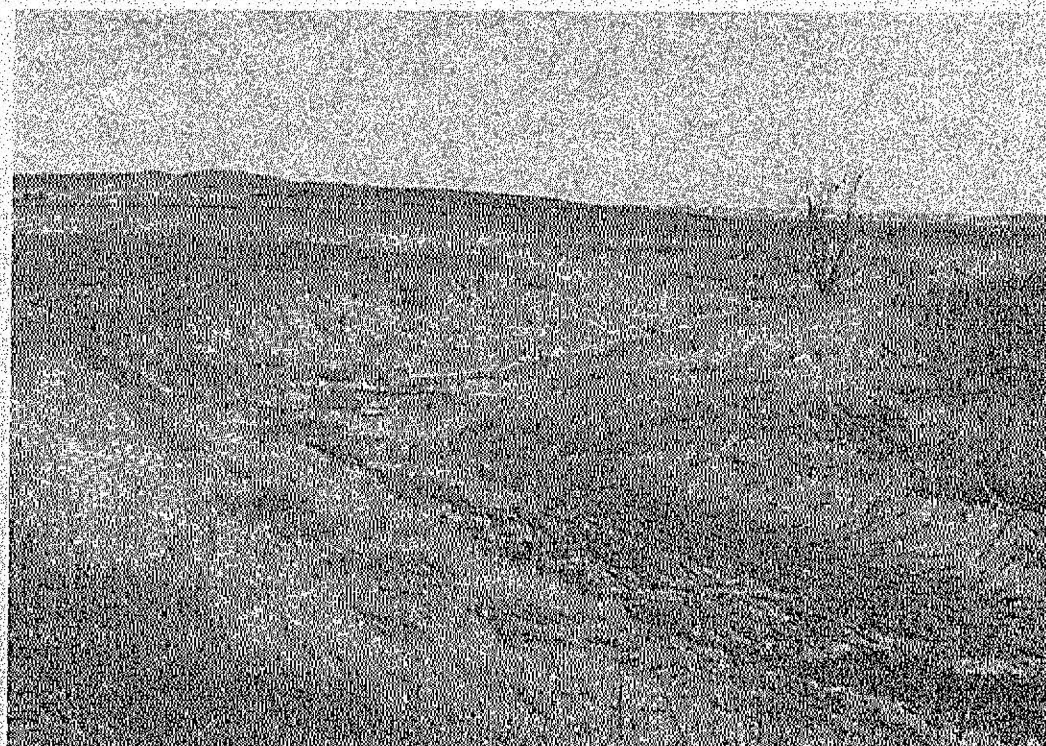


Figure 10. The upper reach of Elm Creek flows through a former outwash channel. This underfit stream is not used for irrigation.

Duck Creek. Ranchers report the water quality to be poor, and no irrigation is used. Natural flood irrigation and/or subirrigation are recognized as being important in the lower reaches of the valley.

South Branch Heart River. This stream is similar to the main stem at their confluence. The valley flat is a second terrace (10 to 15 feet) that is naturally flood irrigated on its lower areas. No irrigation development is currently used, although a system may have existed historically near the confluence with the Heart River. About 5 miles upstream, the South Branch valley changes character. The first terrace (2 to 3 feet) becomes more prominent and is utilized as pasture. The second terrace (12 feet) is still present but is rarely flooded, owing to the increased area of the lower terrace. Designation of flood irrigability extends upstream to the mouth of Bull Creek and includes all of the second terrace.

E. Green River Drainage

Russian Spring Creek. This stream (pl. 4) is spring fed and has extensive subirrigation and/or natural flood irrigation. Some areas are used for hay but many areas are permanent pasture. No ranchers were interested in developing irrigation because the good grazing and subirrigation make it unnecessary.

FORMER OUTWASH CHANNELS

Melt water from Pleistocene ice sheets carved broad valleys through west-central North Dakota. These valleys contain as much as 200 feet of glacial outwash deposits and younger alluvium and are important ground-water reservoirs. These melt-water valleys, which do not contain major streams, have small ephemeral drainages and are not surface irrigated. Natural flood irrigation and subirrigation are locally present. Dryland farming is their chief use (fig. 11).

Goodman Creek. The valley floor is used for dryland farming and pasture (pl. 3). Some subirrigation and/or natural flood irrigation exists along the stream channel.

Unnamed tributary to Antelope Creek. This valley northeast of Zap (pl. 2) is dryland farmed or is pasture. Ground water is used for irrigation in the valley, but surface water is not.

MINOR DRAINAGES

Most of the study area is drained by small streams, the vast majority of which are not developed. Generally, they are ephemeral or intermittent, and the upper reaches of many, where wheat farming takes place, have been plowed over. Some spreader dike development has occurred, mostly in response to cost-sharing programs sponsored by the ASCS. Although 11 spreader dike systems do exist on small drainages in or near the study area, they are not considered a regional

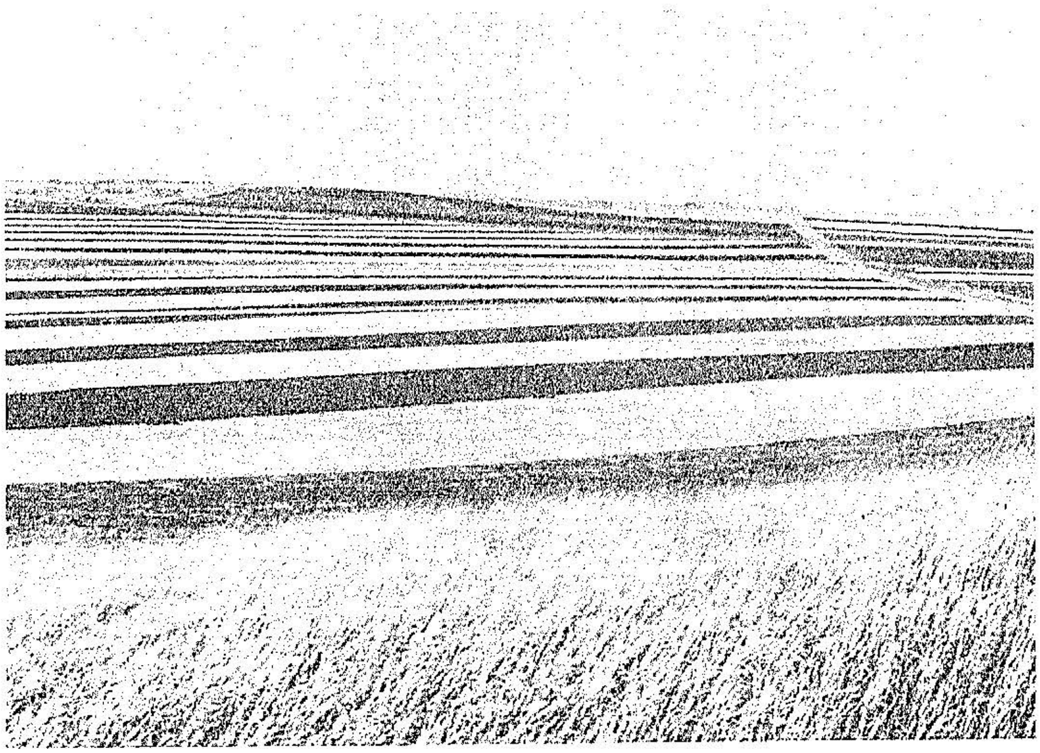


Figure 11. View of strip cropping across an outwash channel. This valley is too dry for irrigation and subirrigation, and the stream channel is only an obstacle to farming. The valley is an unnamed tributary to Crooked Creek in T. 142 N., R. 94 W., sec. 9.

practice and are not used as a criterion for designating flood irrigable valleys.

Four of the 11 systems are located on hillslopes and are not mapped. The rest are on alluvial soils (as mapped by the SCS) and are indicated on our maps. There are five systems on alluvial soils in Dunn County within a small area east and northeast of Killdeer; two in Oliver County (one is in T. 141 N., R. 82 W., sec. 22, just east of the study area); and one is planned for construction (T. 145 N., R. 85 W., sec. 32) in 1983 in Mercer County. About half these systems reportedly work well and are satisfactory to the landowners. The others are less satisfactory. All are used to irrigate haylands.

There are several reasons why these small spreader dike systems are not considered a regional practice. First, there are so few of them used that most farmers and ranchers obviously do not consider them a viable develoment strategy. Second, the small drainages where spreader dikes would be built are not as crucial to operations as perhaps similar drainages would be in more arid coal regions. Uplands in west-central North Dakota have good soils. Rainfall averages about 16 inches annually, falls mainly during the growing season, and is adequate for dryland crops. Thus, the uplands are chosen for additional cropland over the small valley bottoms.

On the north and east side of the Missouri River (pl. 2), none of the small tributary drainages are developed. These drainages are used primarily for grazing and occasionally for calving and winter feeding. They are important to ranchers because they provide shelter and good water. Several drainages appear subirrigated on Landsat imagery.

Some of the small tributaries on the south and west side of the Missouri River (pl. 2) are large enough to have agricultural development. These include Alderin Creek, the unnamed drainage which crosses Highway 48, and the unnamed tributary south of Mandan Lake. Alderin Creek appears subirrigated on Landsat imagery. The Highway 48 valley is perennial, and four agricultural operations use its bottomland. Based on field observation, the hayfields and pasture appear to be subirrigated in part. The Mandan Lake drainage is not subirrigated, and the productivity of the bottomland pasture is not enhanced by water availability.

In the southwestern part of the study area (pl. 4), specifically in the Heart and Green River drainages, many small tributaries appear to be subirrigated based on inspection of Landsat imagery. This indicated late-season vegetative productivity, however, is probably a result of increased soil moisture due to natural flooding rather than subirrigation (Horak, oral commun., 1984).

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________. 1979. Soil survey of McLean County, North Dakota.

________. 1982. Soil survey of Dunn County, North Dakota.

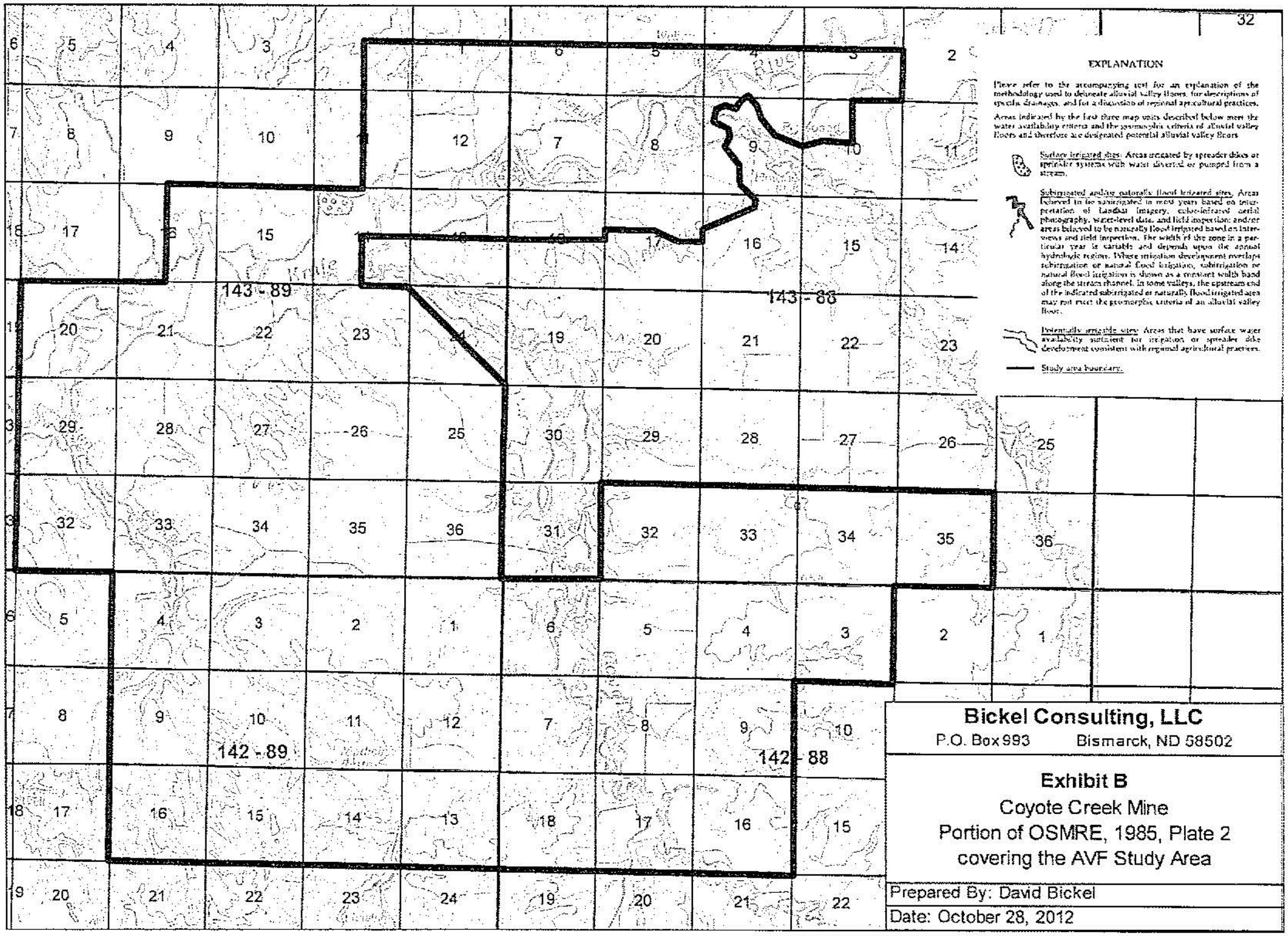

EXPLANATION
Please refer to the accompanying text for an explanation of the methodology used to delineate alluvial valley floors, for descriptions of specific drainages, and for a discussion of regional agricultural practices.
Areas indicated by the last three map units described below meet the water availability criteria and the geomorphic criteria of alluvial valley floors and therefore are designated potential alluvial valley floors.
Surface irrigated sites: Areas irrigated by spreader dikes or sprinkler systems with water diverted or pumped from a stream.
Subirrigated and/or naturally flood irrigated sites. Areas believed to be subirrigated in most years based on interpretation of Landsat imagery, color-infrared aerial photography, water-level data, and field inspection; and/or areas believed to be naturally flood irrigated based on interviews and field inspection. The width of the zone in a particular year is variable and depends upon the annual hydrologic regime. Where irrigation development overlaps subirrigation or natural flood irrigation, subirrigation or natural flood irrigation is shown as a constant width band along the stream channel. In some valleys, the upstream end of the indicated subirrigated or naturally flood irrigated area may not meet the geomorphic criteria of an alluvial valley floor.
Potentially irrigable sites: Areas that have surface water availability sufficient for irrigation or spreader dike development consistent with regional agricultural practices.
Study area boundary.
143 - 89
143 - 88
142 - 89
142 - 88
Bickel Consulting, LLC
P.O. Box 993 Bismarck, ND 58502
Exhibit B
Coyote Creek Mine
Portion of OSMRE, 1985, Plate 2
covering the AVF Study Area
Prepared By: David Bickel
Date: October 28, 2012

EXHIBIT
Voigt
7

Voigt Ranch Alfalfa

	House		Scoria		Branding Corrals (North)		Branding Corrals (South)	
	Bales	Pounds per Acre	Bales	Pounds per Acre	Bales	Pounds per Acre	Bales	Pounds per Acre
2009								
1st Cutting	228	7057	206	5951	76	3952	95	3859
2nd Cutting	68	2105	54	1560	0	0	0	0
2010								
1st Cutting	201	6500	144	4160	83	4316	104	4225
2nd Cutting	95	2940	45	1300	0	0	0	0
2011								
1st Cutting	165	**Cut Early** 5107	209	6038	83	4316	109	4428
2nd Cutting	119	3683	68	1964	10	520	19	772
2012	**Extreme Drought**							
1st Cutting	95	3167	44	1369	**Grazed**		**Grazed**	
2nd Cutting	58	1933	**Short of Pasture Grazed**		0	0	0	0
2013	**Dry Until End of May**							
1st Cutting	102	3400	97	3018	89	4984	122	5338
2nd Cutting	69	2300	88	2738	18	1008	22	963
3rd Cutting	27	900	15	467	0	0	0	0
2014								
1st Cutting	107	3567	121	3764	68	3808	101	4419
2nd Cutting	67	2233	56	1742	22	1232	24	1050
3rd Cutting	**Fields Flooded- Grazed**		**Fields Flooded- Grazed**		****Mine Damaged 2nd Cutting (Core Drilling)****			

EXHIBIT
Voigt
1

Charles H. Norris, P.G.••

SUMMARY OF QUALIFICATIONS

Thirty plus years of professional experience in geology, hydrogeology and management in the applied and theoretical geosciences. Experience includes performance, oversight review, or management of site assessment; RI/FS; computer modeling of fluid flow, contaminant transport, and geochemistry (applications and code development); policy and rule making procedures; aquifer evaluation; resource development; and litigation support; nationwide and internationally.

PROFESSIONAL EXPERIENCE

Geo-Hydro, Inc., (1996-present), Principle, CEO

Hydro-Search, Inc., (1992-1996), Director of Hydrogeology

University Of Illinois at Champaign, (1987-1992), Research Associate; Manager, Industrial Consortium for Research and Education for the Laboratory for Supercomputing in Hydrogeology

Consulting Hydrogeologist/Geologist, Champaign, Illinois and Denver, Colorado, (1980-1992)

MGF Oil Corporation, (1985 - 1986), Manager Geological Engineering

Emerald Gas and Oil, (1980 - 1986), President and Owner

Petro-Lewis Corporation, (1980), District Geologist

Tenneco Oil Company, (1977-1980), Senior Geological Engineer

Amoco International Oil Company, (1975-1977), Senior Geologist

Shell Oil Company, (1972-1975), Exploration Geologist

PROFESSIONAL REGISTRATIONS, MEMBERSHIPS, AND AFFILIATIONS

Professional Geologist: Illinois (No. 196-001082), Indiana (No. 2100), Kentucky (No. KY-2470), Missouri (No. 2011012527), Pennsylvania (PG003994), Utah (No. 5532631-2250), Virginia (No. 2801 001834), Wisconsin (No. 924), Wyoming (No. 2989)

Registered Environmental Professional (#5350), State of Colorado, Petroleum Storage Tank Fund

National Ground Water Association

Colorado Groundwater Association (Vice President 1999, President 2000, Past-President 2001)

Phi Beta Kappa, Phi Kappa Phi, Sigma Xi

EDUCATION

B.S., Geology, University of Illinois, High Honors and Distinction in Geology, 1969

M.S., Geology, University of Washington, National Science Foundation Fellow, 1970

University of Illinois, all but dissertation completed for Ph. D., Hydrogeology, 1992

Select Project Experience

RI/FS and Site Investigations

- Manager for technical assistance through a Technical Assistance Program (TAP) grant from PRPs to local citizens' group. Assistance through grant to provide assessment and feedback on site work products as they are developed and implemented, explain the remediation processes and activities to the citizens, and serve as technical liaison between citizens and remediation team.

- Modeler and hydrogeologic consultant at industrial tank farm adjacent to the Chicago Sanitary and Ship Canal in northeastern Illinois. Assess hydrogeologic data, interpret aquifer testing, and model groundwater flow in soil and fractured carbonate bedrock in area of DNAPL accumulation as part of site characterization and voluntary remediation design.

- Manager and Hydrogeologist of groundwater investigation at an industrial dump site adjacent to the Illinois River in north Central Illinois. Investigated fate and transport of 3-4 decades of disposal of mixed, hazardous industrial wastes at a non-engineered floodplain dump site. Expert testimony and legal support. Pre-trial settlement provided for installation of monitoring system in lieu of site characterization.

- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the preliminary remedial designs. The site is a Superfund site involving both organic and metals contaminants at a wood treating facility in an urban area in Alabama adjacent to a major commercial waterway.

- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the 90% and final remedial designs. The site is a high profile Superfund site involving both organic and metals contaminants at a wood treating facility in Northern California.

- Technical Advisor assisting in the evaluation of aquifer properties and well performances for an extraction well field near Sacramento CA. A high volume pump and treat system for chlorinated solvents showed strong and anomalous decline in productivity. Detailed evaluation identified both possible causes and recommended operations changes to alleviate the problems.

- Technical Advisor assisting in the evaluation of aquifer properties and well performances for initial installation of a high volume extraction well field in Southern California. The chlorinated solvent plume associated with a Superfund site impacted a large area in a layered, heterogeneous groundwater basin managed intensively for public water supplies.

- Senior oversight and review in the evaluation of aquifer and soil properties, and the remediation of the soils contamination and groundwater impacts associated with compressor facilities of interstate gas transmission companies. Various projects and sites in western Colorado, Wyoming, and the Texas panhandle.

- Technical Advisor for the Remedial Investigation/Feasibility Study (RI/FS) of the Landfill Solids and Gases Operable Units at the Lowry Landfill CERCLA site located near Denver, Colorado. This project involves the characterization of the extent of potential contamination within the unsaturated zone adjacent to this high profile site. Work involves extensive coordination and interaction with multiple PRP groups as well as various regulatory agencies.

- Project Manager for independent oversight of a proposed low-level radioactive waste disposal site. Task was to develop technical and legal program for governmentally funded intervener's case as part of adjudicatory hearings on a high-profile, proposed disposal facility and involved identifying, retaining and educating legal staff, retaining a team of technical experts, negotiating fees, coordinating work product and presentations, providing liaison with citizen's groups, responding to press and integrating personal testimony on hydrogeology and modeling. Expert testimony and legal support.

Landfill Services

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of existing water quality and off-site migration from existing licensed landfill near Joliet IL. Work includes groundwater flow modeling of remedial alternatives and groundwater impact assessments of various alternatives for submittal to IEPA.

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed expansion for a hazardous waste landfill in Peoria County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed contamination on facility property, and inappropriate modeling design and implementation.

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Ogle County, Illinois. Expert testimony and legal support. Review identified in errors application, unaddressed existing leakage, and potential risk to public water supply. (Three hearings)

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Kankakee County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed existing off-site leakage, and inappropriate modeling design and implementation. (Two hearings)

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill in Will County, Illinois. Expert testimony and legal support. Research documented numerous errors in application which resulted in underestimation of infiltration rates and potential migration rates. Identified evidence of sub-karstic migration pathway from site to nearby stream.

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill expansion at East Peoria, Illinois. Research documented current leakage from the existing landfill into the regional unconfined aquifer within the cone of depression of the municipal water supply wells. In part as a result of the evaluation, the proposed expansion has been abandoned. Expert testimony and legal support.

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill at Ottawa, Illinois. Provided testimony at county hearings identifying and documenting site-specific conditions that invalidated part of the ground water evaluation testing, necessitating the need to re-evaluate the groundwater flow system and redesign the monitoring system. Expert testimony and legal support.

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of existing municipal landfills and a proposed landfill redesign and expansion at Salem, Illinois. Provided testimony at city hearings documenting existing landfill leakage and identifying site-specific conditions that complicate the design of a reliable monitoring system. Expert testimony and legal support.

- Project Manager and Hydrogeologist for site evaluations of the geology and hydrogeology of several proposed municipal landfills and a landfill expansion in Bartholomew County, Indiana. The review of the expansion demonstrated inadequate monitoring of the existing facility. One proposed site showed possible, current ground water usage from under the proposed facility and conditions that may preclude state-level site approval.

- Project Manager and Hydrogeologist serving in consultation to the Board of Wayne County, Illinois, regarding a proposed expansion to a regional landfill. Investigation and oversight established viability of the physical site and improvements that were needed in operating procedures and monitoring efforts. Expert testimony and legal support.

- Project Manager and Hydrogeologist for an assessment of an existing regional municipal landfill at Urbana, Illinois. Principle problems included ground water contamination, unplugged well(s) within the facility boundary that penetrated the aquifer serving public water supplies and a monitoring system inadequate to evaluate the contaminant migration. Results of the evaluation include an expanded system of monitoring wells, improved protocols for ground water sampling and revised statistical procedures to determine background water chemistries.

- Project Manager and Hydrogeologist for a site assessment of a proposed municipal landfill expansion in west central Indiana. Established feasibility of using the engineering and design features of the expansion to prevent contamination from the pre-existing non-engineered facility.

- Project Hydrogeologist for a site assessment of a proposed saturated-zone, regional balefill in central Illinois. Principal problems involved the evaluation of the hydrogeologic characteristics of the strip mine spoils within which excavation would occur, the blasted mine bottom upon which the liners would be built and the materials available for liner construction. Expert testimony and legal support.

- Project Manager and Hydrogeologist for a site assessment of a proposed municipal landfill expansion in Livingston County, Illinois. Principal problems involved the evaluation of the impact of shallow coal tunnel mining beneath the site and reaction of waste leachate with unusual clay mineralogy important to waste isolation at the site. Expert testimony.

- Technical Reviewer of site assessment and re-assessment of a proposed inter-governmental regional landfill in central Illinois. Verified unanticipated, politically unacceptable risks to major aquifer system serving public water supplies. Assisted in drafting of technical policy statement that permitted new siting efforts to proceed in the jurisdiction. Expert testimony.

WATER RESOURCE EVALUATION & DEVELOPMENT

- Manager for ground water modeling effort associated with the development of a high-volume ground-water supply and delivery project in Colorado. The effort included investigating and evaluating a previously used, court-accepted model, adapting and updating the model, and applying the model to assess the impacts of a proposed private ground-water diversion project that would be the largest in the United States. Ongoing effort includes subsequent review of alternative proposed model and further litigation support.

- Manager for review of an application for an expansion of a large long-wall mine in southeastern Ohio. The review identified extensive unrecognized mining-related impacts to water supplies from historic mining and identified hydrologic risks to a unique old-growth forest adjacent to the proposed expansion, and resulted in an appeal of the application. Expert testimony and legal support.

- Manager for ground water modeling effort associated with the development of a surface reservoir designed for conjunctive use of ground and surface water to reduce peak ground water pumping demands in Denver metro area. The effort included investigating and evaluating a previously used, model, adapting and updating the model, and applying the model to assess the impacts of project on other water rights. Study is a component of the EIS.

- Project Manager for multi-company effort to model thermal loading of northern Nevada surface waters as a result of mine dewatering project. Successful liaison among technical staffs and regulators and modeling work for a high profile EIS resulted in approval of discharge permit.

- Project Hydrogeologist for the feasibility study of a small lake for a northern Illinois nursery, to be used for recreation, fishing and irrigation. Evaluated shallow and intermediate ground water and surface run-off, reviewed engineering design and directed ground and surface water sampling program to determine nutrient levels.

HYDROCHEMISTRY

- Principal Investigator for grant to research the geochemical implications of using alkaline addition as one means for preventing and/or remediating inorganic contamination resulting from acid mine/rock drainage. Empirical and modeling evidence showed conditions under which alkaline addition can cause or exacerbate contamination of some constituents of concern.

- Project Manager, hydrogeologist, geochemist for ongoing investigation of metals contamination of a trout stream in West Virginia. Impacts from natural and industrial sources , present and past, evaluated to segregate relative significance of various sources. Includes expert testimony and legal support.

- Project Geochemist and Hydrogeologist for evaluation and critique of modeling protocols used by USEPA for risk assessments performed as part of regulatory determinations for various solid wastes. Identified errors in methodology and input that had caused previous modeling to mischaracterize risks for settings with observed damage cases. Computer modeling.

- Geochemist and Hydrogeologist for evaluations of inorganic groundwater chemistry at an industrial RCRA site near Joplin MO. Federal lawsuit filed pursuant to PRP contribution and sources and timing of contamination. Was able to use geochemical interpretations to establish significant elements of aquifer characteristics and implications for contamination routes. Expert testimony.

- Project Hydrogeologist and Geochemist for evaluations of proposed coal combustion waste disposal as part of reclamation activities at surface coal mines in Southwestern Indiana. Ongoing efforts are targeted toward refining regulatory framework for disposal efforts, establishing effective characterization and monitoring programs and determining appropriate operation and engineering practices. Project involves extensive interdisciplinary effort and expert testimony.

- Project Geochemist for the investigation of the impacts of remediating acid mine drainage by installing bulkheads to flood exhausted mine working. Predictively modeled water chemistries in situ, within flooded mine, along flow paths and upon surface discharge. Assisted in preparation of testimony that resulted in permit approval for the San Juan County, Colorado project.

- Project Manager and Project Geochemist/Hydrogeologist for investigation of potential environmental impacts of disposal of coal combustion wastes (CCW) as part of a reclamation plan at a surface coal mine in northern New Mexico. Performed or directed geochemical, infiltration and flow modeling of the proposed project to identify optimum disposal methods and worst case impacts. Presentation to State resulted in approval of this precedent-setting project.

- Project Manager, Geochemist and Hydrogeologist for an investigation of a proposed disposal/construction project to build a central Illinois ski mountain from fly ash produced by a co-generating plant operated by a major food products manufacturer. The investigation involved overseeing an engineering review of project plans, a site investigation and evaluation, geochemical modeling of initial and final mineralogical composition of the mass and of the leachate chemistry and evolution and the impact on the hydrogeologic and structural integrity of the project. Expert testimony and legal support.

PETROLEUM INDUSTRY EXPERIENCE

- Project Manager for the environmental assessment of 82 Texas producing properties targeted for acquisition. Evaluations included site walk-overs, surface soil and liquid sampling, radiological monitoring and geoprobe sampling of soils and ground water. The assessments documented a multitude of impacts from both exempt and non-exempt wastes that, unrecognized, could have resulted in substantial financial exposure to the client.

- Project Geologist and Petrophysicist for an investigation of resource potential of coal bed methane in San Juan Basin of New Mexico and Colorado. Study focused on innovative log analysis techniques; formation water chemistries, production rates and disposal problems; well drilling, completion and re-completion practices; and detailed subsurface facies and structural mapping and stratigraphic correlation in shallow coal beds of Kirtland/Fruitland/Pictured Cliffs shoreline complex and relationships to overlying Tertiary sandstones.

- Developed a successful play in the Hunton and Mississippi Lime formations of northwest Oklahoma. The play recognized the secondary porosity systems of both formations (dolomitization and fracturing, respectively) and the genetic significance to each of the buried topography at the intervening unconformity.

- Managed a detailed reservoir study of a Cotton Valley gas field in east Texas that resulted in RRC approval of non-standard spacing based upon the recognition of secondary porosity and a dual-conductivity system that resulted from drape-induced fractures. The revised spacing both protected resource ownership and conserved the costs of infill drilling. Expert testimony and legal support.

- Project Geologist, Petrophysicist and Expert for various contested adjudicatory hearings apportioning oil and gas ownership. Cases involved primary recovery of both oil and gas and secondary recovery of oil. Accepted as expert (geology, hydrogeology, and/or geological engineering) in Oklahoma, Texas, and Wyoming.

ADDITIONAL PROFESSIONAL EXPERIENCE

- Invited presenter to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes.

- Appointed member of a Quality Assurance Committee under the West Virginia Department of Environmental Protection. The committee, comprised of representatives of state and federal regulators, industry , and interveners, was charged with a year-long review of state mining applications and approval practices relative to mining under the state and federal surface mining laws.

- Invited presenter to National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments.

- Project Manager and Hydrogeologist for the review of Proposed and Revised Proposed Criteria for the Siting of a Low Level Radioactive Waste Disposal Facility in Illinois. Evaluation was targeted toward both technical content and processes of selection. Testimony and written comments led to significant improvements and flexibility in the Criteria as finally published.

- Project Hydrogeologist testifying at hearings before the Illinois Pollution Control Board on regulatory language for the Illinois Ground Water Protection Act. Contributed major conceptual and specific language changes to the final promulgated rules for Ground Water Quality Standards and Regulations for Existing and New Activities with Setback Zones and Regulated Recharge Areas. Expert testimony and legal support.

- Project Hydrogeologist and Log Analyst for three applications to U.S. EPA for permits to continue deep well disposal of hazardous wastes in east central Illinois and southern Ohio. Project required evaluation of geophysical logging data to determine injection zone and confining layer properties, regional flow systems, chemical interactions of the waste stream with the native rock and the ability of the injection system to isolate the waste from the environment.

REPORTS, PRESENTATIONS, AND PUBLICATIONS

Norris, Charles H., 2005, "Water Quality Impacts from Remediation Acid Mine Drainage with Alkaline Addition", draft version released to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Geo-Hydro, Inc., Denver CO, July 3, 2005

Norris, C. H., "notes from the front. . . Overview of three sites", invited paper before National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Evansville IN, March 2005.

Norris, Charles H., 2004, "Environmental Concerns and Impacts of Power Plant Waste Placement in Mines", Presented at Harrisburg PA, May 4-6, 2004. Published in Proceedings of State Regulation of Coal Combustion By-Product Placement at Mine Sites: A Technical Interactive Forum, Kimery C Vories and Anna Harrington, eds, by U. S. Department of Interior, Office of Surface Mining, Alton IL, and Coal Research Center, Southern Illinois University, Carbondale IL.

Norris, C. H., "Developing Reasonable Rules for Coal Combustion Waste Placement in Mines. Why? When? Where? How?", USEPA Contract 68-W-02-007, IEI Subcontract 7060-304, Invited paper at USEPA MRAM meeting, Rosslyn VA, September, 2003.

Norris, C. H., "So, You Think You're a Geologist? (F. Kafka to A. Liddell, In Wonderland)", Colorado Ground Waster Association Monthly Meeting,, Denver CO, September, 2002.

Norris, C. H., "Assessment of the Anker Energy Corporation proposal for mining and reclamation, Upshur County, West Virginia." Independent evaluation on behalf of Anker Energy Corporation and West Virginia Highlands Conservancy, July, 2002.

Norris, C. H., "Coal Combustion Waste: Coming soon to a neighborhood (and maybe a faucet) near you." Colorado Ground Waster Association Monthly Meeting,, Denver CO, May, 2001.

Norris, C. H., "Slurry-to-ashes, and ashes-to . . . A case of a coal company and citizens working together to evaluate alternatives." Invited paper before National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments, St. Louis MO, June, 2001.

Norris, C.H., and C. E. Hubbard, "Use of MINTEQA2 and EPACMTP to Estimate Groundwater

Pathway Risks from the Land Disposal of Metal-Bearing Wastes", for Environmental Technology Council, submitted as public comment to USEPA on regulatory determination for Fossil Fuel Combustion Wastes, May, 1999.

Norris, C.H., "Report on the Determination of Intermittent Streams and the Potential Impacts of Valley Fill on Area Drainages, Southern West Virginia", expert report for litigation prepared for Mountain State Justice, Inc, Charleston WV, March, 1999.

Norris, C.H., "Report on the Geology and Hydrogeology of the Caterpillar Levee Site with an Evaluation of Potential Pathways on- and off-site for the Movement of Solid and Hazardous Wastes", expert report for litigation prepared for Citizens for a Better Environment, Chicago IL, March, 1998.

Norris, C.H., "Dr Pepper, Biorhythms, and the Eight-Hour Pumping Test ", Colorado Ground Waster Association Annual Meeting, Golden CO, December, 1997.

Norris, C.H., "Characterizing Ash Composition and (vs.) Projecting Environmental Impact for Purposes of Permitting CCW Disposal ", Coal Combustion By-Products Associated with Coal Mining - Interactive Forum, Southern Illinois University at Carbondale, Carbondale IL, October, 1996.

Norris, C.H., "Geochemical Modeling". Co-instructor for Short Course on Hydrogeologic Issues Related to Mine Permitting, Reclamation and Closure, SME Annual Convention, Phoenix AZ; March, 1996.

Norris, C.H., An Improved Method for Middle Time Analysis of Slug and Bail Test. Unpublished. 1994.

Norris, C.H., "Evolution of the Landfill", presentation as part of a Telnet program, *Garbage Dilemma Educational Series*, sponsored by Illinois Farm Bureau and Cooperative Extension Service of the College of Agriculture, University of Illinois, Urbana, Illinois, April 20, 1992.

Norris, C.H., "Technical Analysis or Political Acceptability: The Domesticated Fowl or its Ovum", Solid Waste Management and Local Government Workshop, sponsored by Institute of Government and Public Affairs, University of Illinois, Urbana, Illinois, Jan-Apr, 1992.

Norris, C.H., Report on the Geology and Hydrogeology [of the] SWDA Proposed Landfill Site, Township 8 North, Range 6 East, Section 31, Bartholomew County, Indiana, for Central States Education Center, Champaign, Illinois, 1991.

Norris, C.H., Hydrogeology and Modeling of the Proposed Illinois Low Level Radioactive Waste Disposal Site at Martinsville, Illinois; testimony before the LLRW Siting Commission, October and November, 1991, Martinsville, Illinois.

Norris, C.H., Ground Water Quality Standards for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois; February, May, October and December, 1990; May, 1991.

Norris, C.H., Hearing on a Petition for a Special Use Permit for the Construction of a Ski Mountain in Oakley Township, Macon County, Illinois; testimony before the Macon County Zoning Board of Appeals; February 16, 1990.

Norris, C.H., Hearing on a Solid Waste Disposal Permit for the Siting of a Municipal Landfill for Streator, Illinois; testimony before the Livingston County Board; August 6, 1990.

Norris, C.H., In the matter of the Gallatin National Company Proposed Balefill, Fulton County, Illinois, written comments to the Illinois Environmental Protection Agency, Springfield, Illinois, 1990.

Norris, C.H., 1990, Log Analysis of the Allied Chemical Corporation Waste Injection Well, Danville, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., 1989, Log Analysis of the Cabot Corporation Waste Disposal Wells, Tuscola, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., Regulations for Existing and New Activities Within Setback Zones and Regulated Recharge Areas for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois, June, 1989.

Norris, C.H., and C.M. Bethke, (Abstract) "Mathematical Models of Subsurface Processes in Sedimentary Basins", Conference on Mathematical and Computational Issues in Geophysical Fluid and Solid Mechanics, Society for Industrial and Applied Mathematics Annual Meeting, Houston, Texas, September 28 (invited paper), 1989.

Norris, C.H., "An Evaluation of the Geology and the Monitoring Well Data [at the] City of Urbana Regional Landfill", report submitted to the City of Urbana, Champaign County, Illinois, for Central States Education Center, Champaign, Illinois, 1989.

Norris, C.H., Gallatin National Proposed Balefill/Landfill [at] Fairview, Illinois; testimony before Fairview Town Council, Fairview, Illinois, November, 1988.

Norris, C.H., "Evaluation of the Hydrogeologic Factors Influencing Risk [at the] ISWDA Regional Landfill Site B", report submitted to the Inter-Governmental Solid Waste Disposal Association, Champaign County, Illinois, 1988.

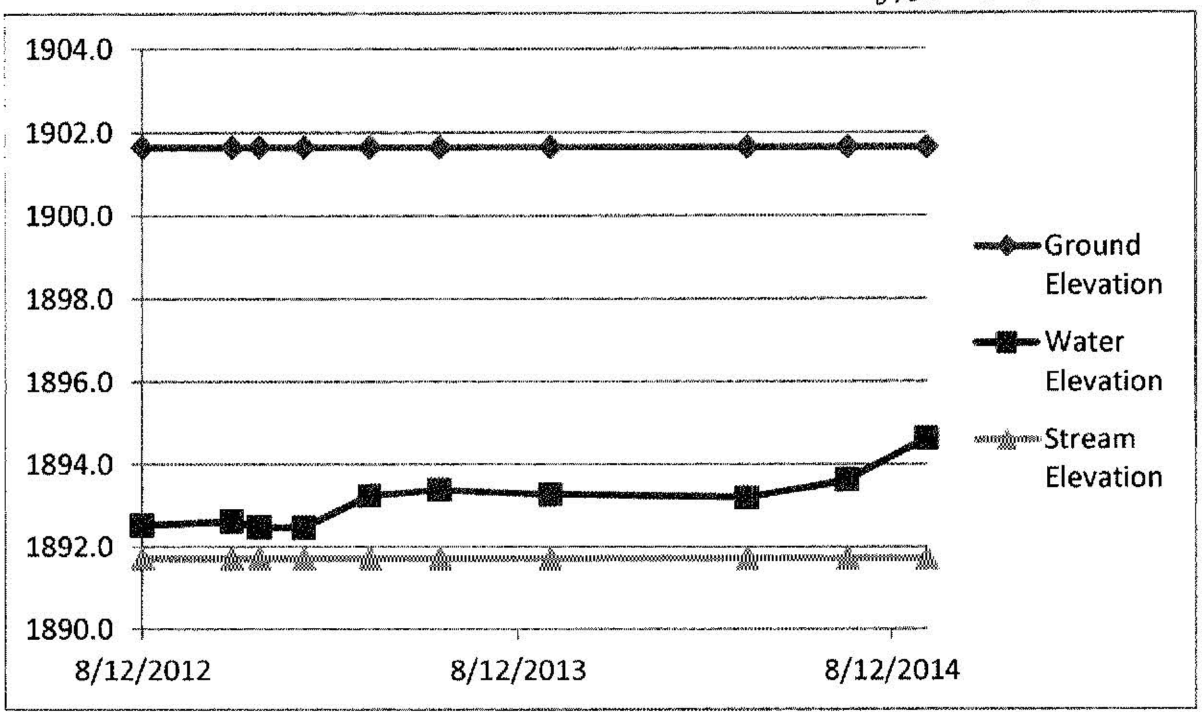
Norris, C.H., and C.M. Bethke, "Status and Future Directions of Quantitative Flow Modeling in Sedimentary Basins", Workshop on Quantitative Dynamic Stratigraphy (QDS), Colorado School of Mines, Lost Valley Ranch, Colorado, February 14-18, 1988.

EXHIBIT Coyote 16 Creek

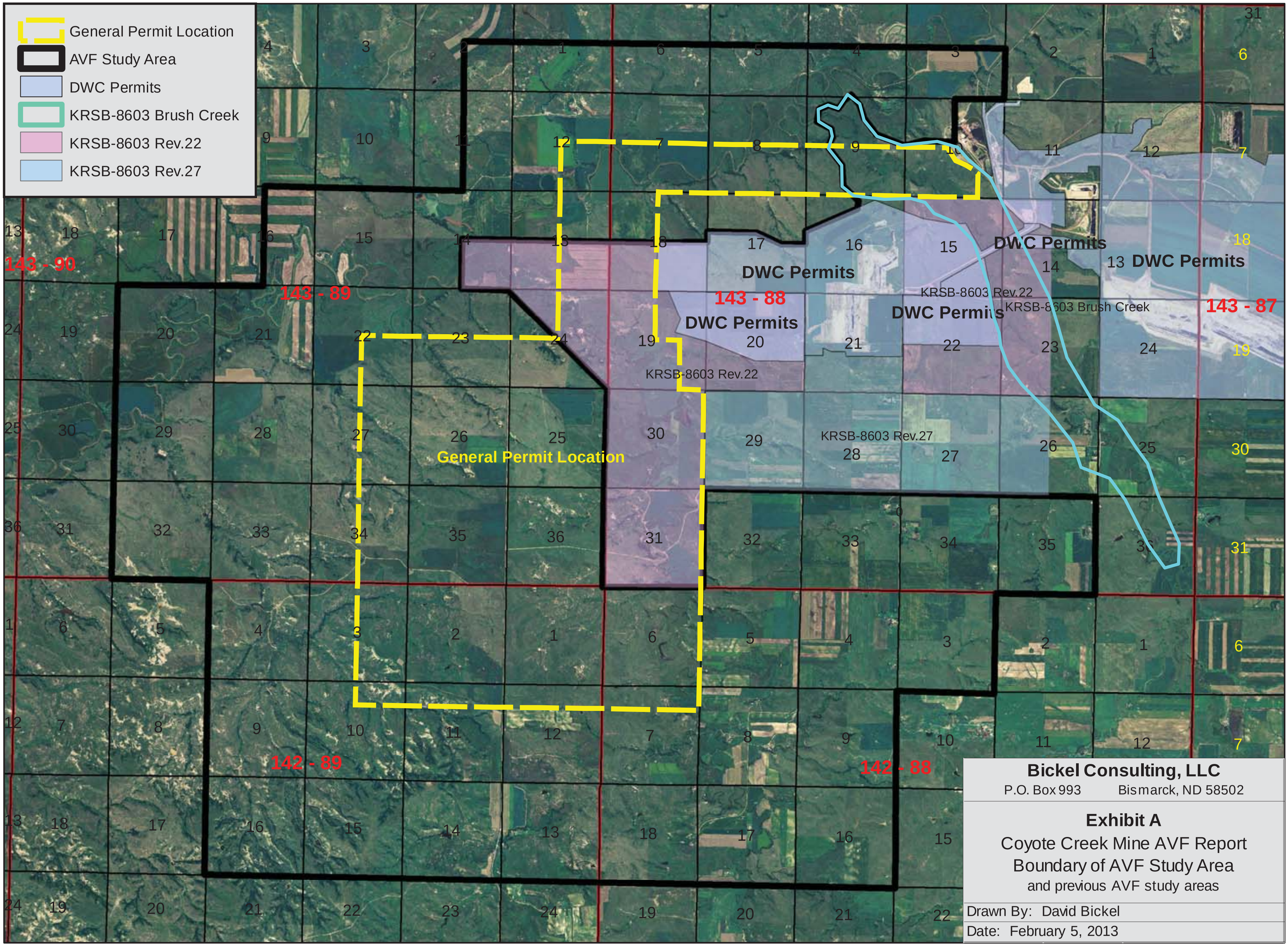
Alluvium (CC)-Antelope Creek

CM12-08B	Ground Elevation	Water Elevation	Stream Elevation	Top of Casing	Depth to Water
8/12/2012	1901.65	1892.54	1891.72	1903.32	10.78
11/7/2012	1901.65	1892.63	1891.72	1903.32	10.69
12/4/2012	1901.65	1892.49	1891.72	1903.32	10.83
1/16/2013	1901.65	1892.48	1891.72	1903.32	10.84
3/21/2013	1901.65	1893.25	1891.72	1903.32	10.07
5/28/2013	1901.65	1893.39	1891.72	1903.32	9.93
9/13/2013	1901.65	1893.28	1891.72	1903.32	10.04
3/24/2014	1901.65	1893.20	1891.72	1903.32	10.12
6/30/2014	1901.65	1893.62	1891.72	1903.32	9.70
9/15/2014	1901.65	1894.64	1891.72	1903.32	8.68

8.68 – 10.84



Coyote Creek Mining Company, LLC


General Permit Location
AVF Study Area
DWC Permits
KRSB-8603 Brush Creek
KRSB-8603 Rev.22
KRSB-8603 Rev.27
143 - 90
143 - 89
143 - 88
143 - 87
142 - 89
142 - 88
DWC Permits
KRSB-8603 Rev.22
KRSB-8603 Brush Creek
KRSB-8603 Rev.27
General Permit Location
Bickel Consulting, LLC
P.O. Box 993 Bismarck, ND 58502
Exhibit A
Coyote Creek Mine AVF Report
Boundary of AVF Study Area
and previous AVF study areas
Drawn By: David Bickel
Date: February 5, 2013

RC-13-850 **Coyote Creek Mining Company, LLC** Status: Open

Description: **Permit No. NACC-1302**

Case Type:	Application	Portfolio:	Randel D. Christmar
Date Filed:	11/1/2013	Advisory Staff:	Randy Kowalski
Catagory:	?	Docket Count:	132

Doc	Filed	Description	Pages:	Exhibit:	Cerified to Court
1	11/1/2013	**Permit application submitted to permit 8,091.51 acres for the proposed Coyote Creek Mine** By: Coyote Creek Mining Company, LLC by Donn Steffen	5		Yes
2	11/5/2013	**Receipt #8636 $81,415.10 Permit Application** By: Coyote Creek Mining Company, LLC	1		No
3	11/27/2013	**Completeness deficiency letter sent to the applicant** By: Public Service Commission by Randy Kowalski	10		Yes
4	2/3/2014	**Response to the completeness deficiency letter filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	4		Yes
5	2/19/2014	**Second completeness deficiency letter sent to the applicant** By: Public Service Commission by Randy Kawolski	2		Yes
6	2/28/2014	**Response to the second completeness deficiency letter received from the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	2		Yes
7	3/11/2014	**Third completeness deficiency letter sent to the applicant** By: Public Service Commission by Randy Kawolski	2		Yes
8	3/17/2014	**Response to the third completeness deficiency letter filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	1		Yes
9	3/21/2014	**Permit application was deemed complete** By: Public Service Commission by Randy Kowalski	1		Yes
10	3/26/2014	**Notice of Receipt of Permit Application** By: Public Service Commission	2		Yes
11	3/27/2014	**Copies of the application sent to advisory agencies for review and comment** By: Public Service Commission by Randy Kowalski	8		Yes
12	3/27/2014	**Letter of consultation sent to OSM regarding mining activities over unleased federal coal** By: Public Service Commission by Jim Deutsch	2		Yes
13	4/28/2014	**Comments received from the Natural Resource Conservation Service** By: Natural Resource Conservation Service by Mary Podoll	1		Yes
14	6/4/2014	**Copies of cultural resource reports filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	1		Yes
15	6/6/2014	**Letter to applicant about no objections or informal conference requests being filed during the public comment period** By: Public Service Commission by Jim Deutsch	1		Yes
16	6/17/2014	**Technical review letter sent to the applicant** By: Public Service Commission by Randy Kowalski	30		Yes
17	7/31/2014	**Response to the technical review letter filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	9		Yes

Doc	Filed	Description	Pages:	Exhibit:	Cerified to Court
18	8/25/2014	**Second technical review letter sent to the applicant (Randy Kowalski)** By: Public Service Commission	12		● Yes ○ No
19	9/15/2014	**Comments received from the Bureau of Land Management on disturbances over unleased federal coal** By: Bureau of Land Management by Phil Perlewitz	9		● Yes ○ No
20	9/17/2014	**Response to the second technical review letter filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	18		● Yes ○ No
21	9/22/2014	**Copy of the application to the Corps of Engineers for a Regional General Permit filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	4		● Yes ○ No
22	10/3/2014	**Third technical review letter sent to the applicant** By: Public Service Commission by Randy Kowalski	6		● Yes ○ No
23	10/8/2014	**Additional comments received from the Bureau of Land Management on disturbances over unleased federal coal** By: Bureau of Land Management by Phil Perlewitz	2		● Yes ○ No
24	10/8/2014	**Response to the third technical review letter filed by the applicant** By: Coyote Creek Mining Company, LLC by Sarah Flath	8		● Yes ○ No
25	10/13/2014	**Bond amount determination letter sent to the applicant** By: Public Service Commission by Randy Kowalski	1		● Yes ○ No
26	10/13/2014	**Request to update the ownership and control information sent to the applicant** By: Public Service Commission by Randy Kowalski	1		● Yes ○ No
27	10/16/2014	**E-mail response to ownership and control update received from the applicant** By: Coyote Creek Mining Company, LLC by Joe Friedlander	2		● Yes ○ No
28	10/16/2014	**Additional changes made by the applicant in response to BLM comments** By: Coyote Creek Mining Company, LLC by Sarah Flath	1		● Yes ○ No
29	10/20/2014	**Concurrence received from the Bureau of Land Management on proposed disturbances over unleased federal coal** By: Bureau of Land Management by Phil Perlewitz	2		● Yes ○ No
30	10/20/2014	**Memorandum** By: Public Service Commission Staff by Jim Deutsch, Dean Moos, Randy Kowalski	4		● Yes ○ No
31	10/22/2014	**Commission Motion issuing Surface Coal Mining Permit** By: Public Service Commission	1		● Yes ○ No
32	10/22/2014	**Permit to Engage in Surface Coal Mining and Reclamation Operations** By: Public Service Commission	11		● Yes ○ No
33	10/22/2014	**Surface Coal Mining and Reclamation Permit Conditions** By: Public Service Commission	3		● Yes ○ No
34	10/22/2014	**Notice of Permit Approval** By: Public Service Commission	1		● Yes ○ No
35	11/24/2014	**Request for hearing** By: Casey Voigt	1		● Yes ○ No
36	11/25/2014	**Commission Motion issuing Notice of Formal Hearing** By: Public Service Commission	1		● Yes ○ No

Doc	Filed	Description	Pages:	Exhibit:	Cerified to Court
37	11/25/2014	**Notice of Formal Hearing** By: Public Service Commission	1		Yes
38	11/25/2014	**Request for Administrative Law Judge** By: Public Service Commission	4		Yes
39	12/1/2014	**Notice of Appearance of Counsel** By: Baumstark Braaten Law Partners by Derrick Braaten, Attorney	2		Yes
40	12/1/2014	**Letter designating Administrative Law Judge** By: Office of Administrative Hearings by Wade C. Mann, Director	1		Yes
41	11/26/2014	**Affidavit of Service, Cert. Mail – Notice** By: Public Service Commission	1		Yes
42	12/10/2014	**Letter re Court Reporter** By: Public Service Commission	1		Yes
43	12/12/2014	**Request for documents** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt by Derrick Braaten, Attorney	1		Yes
44	12/19/2014	**Docketed in error** By: Public Service Commission	1		Yes
45	12/18/2014	**Letter changing designation of Administrative Law Judge** By: Office of Administrative Hearings by Wade C. Mann, Director	1		Yes
46	12/17/2014	**Affidavits of Publication received for the Notice of Formal Hearing** By: North Dakota Newspaper Association by Colleen Park	8		Yes
47	12/19/2014	**Electronic record of December 19, 2014 formal hearing** By: Public Service Commission	1		Yes
48	12/23/2014	**Electronic record of December 23, 2014 formal hearing** By: Public Service Commission	1		Yes
49	1/2/2015	**Electronic record of January 2, 2015 formal hearing** By: Public Service Commission	1		Yes
50	1/19/2015	**Late-filed Exhibit E to Coyote Creek Exhibit #13** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	306		Yes
51	1/23/2015	**Letter enclosing exhibit list and exhibits** By: Wade Mann, ALJ - Office of Administrative Hearings	6		Yes
52	1/23/2015	**Exhibit CV-1** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	9		Yes
53	1/23/2015	**Exhibit CV-2** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	33		Yes
54	1/23/2015	**Exhibit CV-3** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	34		Yes
55	1/23/2015	**Exhibit CV-4** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	19		Yes
56	1/23/2015	**Exhibit CV-5** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	26		Yes

Doc	Filed	Description	Pages:	Exhibit: Cerified to Court
57	1/23/2015	**Exhibit CV-6** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
58	1/23/2015	**Exhibit CV-7** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
59	1/23/2015	**Exhibit CV-8** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	4	● Yes ○ No
60	1/23/2015	**Exhibit CV-9** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
61	1/23/2015	**Exhibit CV-10** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
62	1/23/2015	**Exhibit CV-11** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
63	1/23/2015	**Exhibit CV-12** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	1	● Yes ○ No
64	1/23/2015	**Exhibit CV-13** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	8	● Yes ○ No
65	1/23/2015	**Exhibit CV-14** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	136	● Yes ○ No
66	1/23/2015	**Exhibit CV-15** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	300	● Yes ○ No
67	1/23/2015	**Exhibit CV-16** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	3	● Yes ○ No
68	1/23/2015	**Exhibit CV-17** By: Baumstark Braaten Law Partners - Attorneys for Casey Voigt	4	● Yes ○ No
69	1/23/2015	**Exhibit CC-1** By: Coyote Creek Mining Company, LLC	11	● Yes ○ No
70	1/23/2015	**Exhibit CC-2** By: Coyote Creek Mining Company, LLC	2	● Yes ○ No
71	1/23/2015	**Exhibit CC-3** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
72	1/23/2015	**Exhibit CC-4** By: Coyote Creek Mining Company, LLC	137	● Yes ○ No
73	1/23/2015	**Exhibit CC-5** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
74	1/23/2015	**Exhibit CC-6** By: Coyote Creek Mining Company, LLC	2	● Yes ○ No
75	1/23/2015	**Exhibit CC-7** By: Coyote Creek Mining Company, LLC	10	● Yes ○ No
76	1/23/2015	**Exhibit CC-8** By: Coyote Creek Mining Company, LLC	154	● Yes ○ No

Doc	Filed	Description	Pages:	Exhibit: Cerified to Court
77	1/23/2015	**Exhibit CC-9** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
78	1/23/2015	**Exhibit CC-10** By: Coyote Creek Mining Company, LLC	14	● Yes ○ No
79	1/23/2015	**Exhibit CC-11** By: Coyote Creek Mining Company, LLC	39	● Yes ○ No
80	1/23/2015	**Exhibit CC-12** By: Coyote Creek Mining Company, LLC	49	● Yes ○ No
81	1/23/2015	**Exhibit CC-13** By: Coyote Creek Mining Company, LLC	46	● Yes ○ No
82	1/23/2015	**Exhibit CC-14** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
83	1/23/2015	**Exhibit CC-15** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
84	1/23/2015	**Exhibit CC-16** By: Coyote Creek Mining Company, LLC	1	● Yes ○ No
85	1/23/2015	**Exhibit PSC-3** By: Public Service Commission	2	● Yes ○ No
86	1/23/2015	**Exhibit PSC-4** By: Public Service Commission	1	● Yes ○ No
87	1/23/2015	**Exhibit PSC-5** By: Public Service Commission	1	● Yes ○ No
88	1/23/2015	**Exhibit PSC-6** By: Public Service Commission	2	● Yes ○ No
89	1/23/2015	**Exhibit PSC-7** By: Public Service Commission	1	● Yes ○ No
90	1/23/2015	**Exhibit PSC-8** By: Public Service Commission	1	● Yes ○ No
91	1/23/2015	**Exhibit PSC-9** By: Public Service Commission	6	● Yes ○ No
92	1/23/2015	**Exhibit PSC-10** By: Public Service Commission	4	● Yes ○ No
93	2/6/2015	**Electronic record of Jan. 16, 2015 work session** By: Public Service Commission	1	● Yes ○ No
94	2/6/2015	**Letter request to admit late-filed exhibits & opportunity to file response** By: Casey Voigt by Derrick Braaten, Attorney	3	● Yes ○ No
95	2/9/2015	**Response to request to admit late-filed exhibits and for opportunity to respond** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	12	● Yes ○ No
96	2/12/2015	**Transcript of Dec. 19 & 23, 2014 and Jan. 2, 2015 formal hearings** By: Emineth & Associates Court Reporters	821	● Yes ○ No

Doc	Filed	Description	Pages:	Exhibit: Cerified to Court
97	2/13/2015	**Order on Late-filed Exhibits** By: Office of Administrative Hearings by Wade Mann	4	● Yes ○ No
98	2/20/2015	**Affidavit of Charles Norris Regarding Three Late-Filed Exhibits** By: Casey Voigt by Derrick Braaten, Attorney	14	● Yes ○ No
99	2/23/2015	**Affidavit of Bruce Beechie** By: Public Service Commission by Illona Jeffcoat-Sacco, General Counsel	3	● Yes ○ No
100	2/26/2015	**Late-filed Exhibit - Voigt Exhibit 18** By: Casey Voigt by Derrick Braaten, Attorney	1	● Yes ○ No
101	2/26/2015	**Late-filed Exhibit - Voigt Exhibit 19** By: Casey Voigt by Derrick Braaten, Attorney	1	● Yes ○ No
102	2/26/2015	**Late-filed Exhibit - Voigt Exhibit 20** By: Casey Voigt by Derrick Braaten, Attorney	9	● Yes ○ No
103	2/27/2015	**Letter changing Administrative Law Judge** By: Office of Administrative Hearings by Wade C. Mann, Director	1	● Yes ○ No
104	2/19/2015	**Request to admit Oct. 26, 2009 AVF Determination as late filed exhibit** By: Casey Voigt by JJ England, Baumstark Braaten	3	● Yes ○ No
105	2/26/2015	**Affidavit of David Bickel and Objection to admission of part of Norris Affidavit and attachments** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	10	● Yes ○ No
106	2/27/2015	**Request for extension to file response** By: Public Service Commission by Illona Jeffcoat-Sacco, General Counsel	3	● Yes ○ No
107	2/27/2015	**ALJ Approval of extension of time to file** By: Wade Mann, ALJ - Office of Administrative Hearings	3	● Yes ○ No
108	3/2/2015	**Second Affidavit of Bruce Beechie and Response to Objection** By: Public Service Commission by Illona Jeffcoat-Sacco, General Counsel	5	● Yes ○ No
109	3/3/2015	**Objection and Response to Coyote Creek and PSC filings and objections** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	1	● Yes ○ No
110	3/4/2015	**Request for Extension** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	2	● Yes ○ No
111	3/4/2015	**Grant of Extension** By: Wade Mann, ALJ - Office of Administrative Hearings	2	● Yes ○ No
112	3/6/2015	**Order admitting Exhibits with partial exclusions** By: Wade Mann, ALJ - Office of Administrative Hearings	5	● Yes ○ No
113	3/6/2015	**Voigt Closing Argument** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	22	● Yes ○ No
114	3/6/2015	**Voigt Proposed Findings of Fact, Conclusions of Law and Order** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	14	● Yes ○ No
115	3/6/2015	**Affidavit of Service via Electronic Delivery** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	1	● Yes ○ No
116	3/17/2015	**Late filed Voigt Exhibit 21** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	1	● Yes ○ No

Doc	Filed	Description	Pages:	Exhibit: Cerified to Court
117	3/17/2015	**Late filed Voigt Exhibit 22 – Redacted** By: Casey Voigt by Derrick Braaten, Baumstark Braaten Law	13	● Yes ○ No
118	3/17/2015	**Late filed Coyote Creek Exhibit 17 - Redacted** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	8	● Yes ○ No
119	3/17/2015	**Late filed PSC Exhibit 11** By: Public Service Commission	2	● Yes ○ No
120	3/17/2015	**Late filed PSC Exhibit 12 - Redacted** By: Public Service Commission	4	● Yes ○ No
121	3/20/2015	**Proposed Findings of Fact, Conclusions of Law and Order** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	15	● Yes ○ No
122	3/20/2015	**Closing Argument** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	20	● Yes ○ No
123	3/20/2015	**Certificate of Service** By: Coyote Creek Mining Company, LLC by Brian Bjella, Crowley Fleck, PLLP	1	● Yes ○ No
124	4/14/2015	**Commission Motion adopting Findings of Fact, Conclusions of Law and Order** By: Public Service Commission	1	● Yes ○ No
125	4/14/2015	**Findings of Fact, Conclusions of Law and Order** By: Public Service Commission	17	● Yes ○ No
126	4/20/2015	**December 19, 2014 formal hearing - attendance signup sheets** By: Public Service Commission	11	● Yes ○ No
127	4/20/2015	**Letter closing OAH file** By: Wade Mann, ALJ - Office of Administrative Hearings	1	● Yes ○ No
128	4/23/2015	**Electronic record of April 02, 2015 work session** By: Public Service Commission	1	● Yes ○ No
129	4/23/2015	**Electronic record of April 07, 2015 work session** By: Public Service Commission	1	● Yes ○ No
130	4/23/2015	**Electronic record of April 13, 2015 work session** By: Public Service Commission	1	● Yes ○ No
131	4/14/2015	**Affidavit of Service, Cert. Mail – Findings of Fact, Conclusions of Law and Order** By: Public Service Commission	18	● Yes ○ No
132	5/15/2015	**APPEAL - Notice of Appeal and Specifications of Errors** By: Casey Voigt & Julie Voigt by Derrick Braaten & JJ England, Attorneys	8	○ Yes ○ No

Register of Actions

Case No. 08-2015-CV-01056

Casey Voigt vs. North Dakota Public Service Commission and Coyote Creek Mining Company, LLC	Case Type: **Administrative Appeal**
	Date Filed: **05/14/2015**
	Location: **-- Burleigh County**
	Judicial Officer: **Romanick, Bruce A**
	Supreme Court Docket Number: **20160046**

Party Information

		Attorneys
Appellant	**Voigt, Casey**	**Derrick Lance Braaten** *Retained* 701-221-2911 x0000(W)
Appellee	**North Dakota Public Service Commission and Coyote Creek Mining Company, LLC**	**Brian R Bjella** *Retained* 701-223-6585 x0000(W) Illona A Jeffcoat-Sacco *Retained* 701-328-2400 x0000(W)

Events & Orders of the Court

DISPOSITIONS

01/28/2016 **Judgment / Order Entered** (Judicial Officer: Romanick, Bruce A)
Comment (Appeal Dismissed)

OTHER EVENTS AND HEARINGS

05/14/2015 Notice **Doc ID# 1**
Notice of Appeal and Specification of Errors
05/14/2015 Service Document **Doc ID# 2**
Certificate of Service
05/15/2015 Notice of Assignment and Case Number **Doc ID# 3**
06/08/2015 Motion **Doc ID# 4**
Appellant's Motion to Amend Notice of Appeal and Specifications of Error
06/08/2015 Affidavit **Doc ID# 5**
Affidavit of JJ England in Support of Motion to Amend Notice of Appeal and Specifications of Errors
06/08/2015 Service of Motion **Doc ID# 6**
Certificate of Service
06/09/2015 Exhibit **Doc ID# 7**
Exhibit 1
06/11/2015 Notice **Doc ID# 8**
Notice to Appellant of Estimated Costs
06/11/2015 Service Document **Doc ID# 9**
Certificate of Service
06/29/2015 Exhibit **Doc ID# 10**
CR Exhibit 1 Permit application
06/29/2015 Exhibit **Doc ID# 11**
CR Exhibit 2 Completeness deficiency letter to CCM
06/29/2015 Exhibit **Doc ID# 12**
CR Exhibit 4 Second completeness deficiency letter to CCM
06/29/2015 Exhibit **Doc ID# 13**
CR Exhibit 5 Response to second deficiency letter from CCM
06/29/2015 Exhibit **Doc ID# 14**
CR Exhibit 6 Third completeness deficiency letter to CCM
06/29/2015 Exhibit **Doc ID# 15**
CR Exhibit 7 Response to third deficiency letter from CCM
06/29/2015 Exhibit **Doc ID# 16**
CR Exhibit 8 Permit application deemed complete
06/29/2015 Exhibit **Doc ID# 17**
CR Exhibit 9 Notice of receipt of permit application
06/29/2015 Exhibit **Doc ID# 18**
CR Exhibit 10 Copies of application sent to advisory agencies
06/29/2015 Exhibit **Doc ID# 19**
CR Exhibit 11 Letter of consultation to OSM
06/29/2015 Exhibit **Doc ID# 20**
CR Exhibit 12 Comments from Natural Resource Conservation Service
06/29/2015 Exhibit **Doc ID# 21**
CR Exhibit 13 Cultural resource reports filed by CCM
06/29/2015 Exhibit **Doc ID# 22**
CR Exhibit 14 Letter to CCM regarding no objections or informal conference requests
06/29/2015 Exhibit **Doc ID# 23**
CR Exhibit 15 Technical review letter to CCM
06/29/2015 Exhibit **Doc ID# 24**
CR Exhibit 16 Response to technical review letter by CCM
06/29/2015 Exhibit **Doc ID# 25**
CR Exhibit 17 Second technical review letter to CCM
06/29/2015 Exhibit **Doc ID# 26**
CR Exhibit 18 Comments received from BLM
06/29/2015 Exhibit **Doc ID# 27**
CR Exhibit 19 Response to second technical review letter from CCM

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CR Exhibit 19 Response to second technical review letter from CCM
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CR Exhibit 20 CCM s app. to Corps of Engineers for a Regional General Permit
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CR Exhibit 21 Third technical review letter to CCM
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CR Exhibit 22 Comments received from BLM
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CR Exhibit 23 Response to third technical review letter from CCM
06/29/2015 Exhibit **Doc ID# 33**
CR Exhibit 24 Bond letter to CCM
06/29/2015 Exhibit **Doc ID# 34**
CR Exhibit 25 Request to update ownership information
06/29/2015 Exhibit **Doc ID# 35**
CR Exhibit 26 Response ownership information from CCM
06/29/2015 Exhibit **Doc ID# 36**
CR Exhibit 27 Changes by CCM in response to BLM comments
06/29/2015 Exhibit **Doc ID# 37**
CR Exhibit 28 Concurrence from BLM
06/29/2015 Exhibit **Doc ID# 38**
CR Exhibit 29 Staff Memorandum
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CR Exhibit 30 Motion issuing Surface Mining Permit
06/29/2015 Exhibit **Doc ID# 40**
CR Exhibit 31 Permit
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CR Exhibit 32 Permit Conditions
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CR Exhibit 33 Notice of Permit Approval
06/29/2015 Exhibit **Doc ID# 43**
CR Exhibit 34 Request for hearing
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CR Exhibit 35 Motion issuing Notice of Formal Hearing
06/29/2015 Exhibit **Doc ID# 45**
CR Exhibit 69 Hrg Exhibit CCM 5
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CR Exhibit 70 Hrg Exhibit CCM 6
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CR Exhibit 71 Hrg Exhibit CCM 7
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CR Exhibit 50 Hrg Exhibit CV 3
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CR Exhibit 51 Hrg Exhibit CV 4
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CR Exhibit 53 Hrg Exhibit CV 6
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CR Exhibit 54 Hrg Exhibit CV 7
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CR Exhibit 55 Hrg Exhibit CV 8
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CR Exhibit 56 Hrg Exhibit CV 9
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CR Exhibit 57 Hrg Exhibit CV 10
06/29/2015 Exhibit **Doc ID# 56**
CR Exhibit 58 Hrg Exhibit CV 11
06/29/2015 Exhibit **Doc ID# 57**
CR Exhibit 59 Hrg Exhibit CV 12
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CR Exhibit 78 Hrg Exhibit CCM 14
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CR Exhibit 80 Hrg Exhibit CCM 16
06/29/2015 Exhibit **Doc ID# 60**
CR Exhibit 81 Hrg Exhibit PSC 3
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CR Exhibit 82 Hrg Exhibit PSC 4
06/29/2015 Exhibit **Doc ID# 62**
CR Exhibit 83 Hrg Exhibit PSC 5
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CR Exhibit 84 Hrg Exhibit PSC 6
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CR Exhibit 85 Hrg Exhibit PSC 7
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CR Exhibit 87 Hrg Exhibit PSC 9
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CR Exhibit 88 Hrg Exhibit PSC 10
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CR Exhibit 89 CV request to admit late-filed exhibits
06/29/2015 Exhibit **Doc ID# 69**
CR Exhibit 90 CCM response to request to admit late filed exhibits
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CR Exhibit 63 Hrg Exhibit CV 16
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CR Exhibit 64 Hrg Exhibit CV 17
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CR Exhibit 65 Hrg Exhibit CC 1
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CR Exhibit 66 Hrg Exhibit CCM 2

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CR Exhibit 67 Hrg Exhibit CCM 3
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CR Exhibit 68 Hrg Exhibit CCM 4
06/29/2015 Exhibit **Doc ID# 76**
CR Exhibit 60 Hrg Exhibit CV 13
06/29/2015 Exhibit **Doc ID# 77**
CR Exhibit 61 Hrg Exhibit CV 14
06/29/2015 Exhibit **Doc ID# 78**
CR Exhibit 73 Hrg Exhibit CCM 9
06/29/2015 Exhibit **Doc ID# 79**
CR Exhibit 74 Hrg Exhibit CCM 10
06/29/2015 Exhibit **Doc ID# 80**
CR Exhibit 75 Hrg Exhibit CCM 11
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CR Exhibit 76 Hrg Exhibit CCM 12
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CR Exhibit 77 Hrg Exhibit CCM 13
06/29/2015 Exhibit **Doc ID# 83**
CR Exhibit 36 Notice of Formal Hearing
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CR Exhibit 37 Request for ALJ
06/29/2015 Exhibit **Doc ID# 85**
CR Exhibit 38 Notice of Appearance of Counsel
06/29/2015 Exhibit **Doc ID# 86**
CR Exhibit 39 Letter designating ALJ
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CR Exhibit 40 Affidavit of Service
06/29/2015 Exhibit **Doc ID# 88**
CR Exhibit 41 Letter re Court Reporter
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CR Exhibit 42 Request for documents
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CR Exhibit 43 Docketed in error
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CR Exhibit 44 Revised designation of ALJ
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CR Exhibit 45 Affidavits of Publication
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CR Exhibit 46 Late filed Exhibit E to CCM Exhibit #13
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CR Exhibit 47 ALJ Exhibit list
06/29/2015 Exhibit **Doc ID# 95**
CR Exhibit 48 Hrg Exhibit CV 1
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CR Exhibit 92 Order on Late-filed exhibits
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CR Exhibit 93 Affidavit of Charles Norris
06/30/2015 Exhibit **Doc ID# 98**
CR Exhibit 94 Affidavit of Bruce Beechie
06/30/2015 Exhibit **Doc ID# 99**
CR Exhibit 95 Late filed CV Exhibit 18
06/30/2015 Exhibit **Doc ID# 100**
CR Exhibit 96 Late filed CV Exhibit 19
06/30/2015 Exhibit **Doc ID# 101**
CR Exhibit 97 Late filed CV Exhibit 20
06/30/2015 Exhibit **Doc ID# 102**
CR Exhibit 98 Letter changing ALJ
06/30/2015 Exhibit **Doc ID# 103**
CR Exhibit 99 Request to 2009 Admit AVF determination by CV
06/30/2015 Exhibit **Doc ID# 104**
CR Exhibit 100 Affidavit of David Bickel and Objection to admission of Norris Affidavit by CCM
06/30/2015 Exhibit **Doc ID# 105**
CR Exhibit 101 PSC Request for Extension
06/30/2015 Exhibit **Doc ID# 106**
CR Exhibit 102 ALJ Approval of PSC extension
06/30/2015 Exhibit **Doc ID# 107**
CR Exhibit 103 Second Affidavit of Bruce Beechie
06/30/2015 Exhibit **Doc ID# 108**
CR Exhibit 104 CV Objection and Response
06/30/2015 Exhibit **Doc ID# 109**
CR Exhibit 105 CCM Request for Extension
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CR Exhibit 106 ALJ Approval of CCM Extension
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CR Exhibit 107 Order admitting Exhibits with partial exclusions
06/30/2015 Exhibit **Doc ID# 112**
CR Exhibit 108 CV Closing Argument
06/30/2015 Exhibit **Doc ID# 113**
CR Exhibit 62 Hrg Exhibit CV 15 part 3
06/30/2015 Exhibit **Doc ID# 114**
CR Exhibit 109 CV Proposed Findings of Fact, Conclusions of Law and Order
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CR Exhibit 110 CV Affidavit of Service
06/30/2015 Exhibit **Doc ID# 116**
CR Exhibit 111 Late filed CV Exhibit 21
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CR Exhibit 112 Late filed CV Exhibit 22 Redacted
06/30/2015 Exhibit **Doc ID# 118**
CR Exhibit 113 Late filed CCM Exhibit 17 Redacted
06/30/2015 Exhibit **Doc ID# 119**
CR Exhibit 114 Late filed PSC Exhibit 11

06/30/2015 **Exhibit** **Doc ID# 120**
CR Exhibit 115 Late filed PSC Exhibit 12 Redacted
06/30/2015 **Exhibit** **Doc ID# 121**
CR Exhibit 116 CCM Proposed Findings of Fact, Conclusions of Law and Order
06/30/2015 **Exhibit** **Doc ID# 122**
CR Exhibit 117 CCM Closing Argument
06/30/2015 **Exhibit** **Doc ID# 123**
CR Exhibit 118 CCM Certificate of Service
06/30/2015 **Exhibit** **Doc ID# 124**
CR Exhibit 119 Commission Motion adopting Findings of Fact, Conclusions of Law and Order
06/30/2015 **Exhibit** **Doc ID# 125**
CR Exhibit 120 Findings of Fact, Conclusions of Law and Order
06/30/2015 **Exhibit** **Doc ID# 126**
CR Exhibit 121 Attendance Sheet 12-19-14 Formal Hearing
06/30/2015 **Exhibit** **Doc ID# 127**
CR Exhibit 122 Letter closing OAH file
06/30/2015 **Exhibit** **Doc ID# 128**
CR Exhibit 123 Affidavit of Service
06/30/2015 **Exhibit** **Doc ID# 129**
CR Exhibit 124 PSC Docket Card
06/30/2015 **Exhibit** **Doc ID# 130**
CR Exhibit 62 Hrg Exhibit CV 15 part 1
06/30/2015 **Exhibit** **Doc ID# 131**
CR Exhibit 62 Hrg Exhibit CV 15 part 2
06/30/2015 **Exhibit** **Doc ID# 132**
CR Exhibit 72 Hrg Exhibit CCM 8 part 2
06/30/2015 **Exhibit** **Doc ID# 133**
CR Exhibit 49 Hrg Exhibit CV 2 part 1
06/30/2015 **Exhibit** **Doc ID# 134**
CR Exhibit 49 Hrg Exhibit CV 2 part 2
06/30/2015 **Exhibit** **Doc ID# 135**
CR Exhibit 91 Transcript of formal hearings part 5
06/30/2015 **Exhibit** **Doc ID# 136**
CR Exhibit 91 Transcript of formal hearings part 6
06/30/2015 **Exhibit** **Doc ID# 137**
CR Exhibit 91 Transcript of formal hearings part 7
06/30/2015 **Exhibit** **Doc ID# 138**
CR Exhibit 91 Transcript of formal hearings part 8
06/30/2015 **Exhibit** **Doc ID# 139**
CR Exhibit 91 Transcript of formal hearings part 1
06/30/2015 **Exhibit** **Doc ID# 140**
CR Exhibit 91 Transcript of formal hearings part 2
06/30/2015 **Exhibit** **Doc ID# 141**
CR Exhibit 91 Transcript of formal hearings part 3
06/30/2015 **Exhibit** **Doc ID# 142**
CR Exhibit 91 Transcript of formal hearings part 4
06/30/2015 **Exhibit** **Doc ID# 143**
CR Exhibit 72 Hrg Exhibit CCM 8 part 1
06/30/2015 **Stipulation / Agreement** **Doc ID# 144**
Stipulation for Extension of Time
06/30/2015 **Service Document** **Doc ID# 145**
Affidavit of Electronic Service
06/30/2015 **Service Document** **Doc ID# 146**
Affidavit of Service by Regular Mail
06/30/2015 **Service Document** **Doc ID# 147**
Affidavit of Electronic Service
07/01/2015 **Exhibit** **Doc ID# 148**
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CR Exhibit 3 Response to Deficiency Letter from CCM
07/07/2015 **Exhibit** **Doc ID# 151**
CR Exhibit 79 Hrg Exhibit CCM 15
07/07/2015 **Assignment** **Doc ID# 152**
of Judge Feland
07/08/2015 **Demand for Change of Judge** **Doc ID# 153**
Demand for Change of Judge
07/08/2015 **Service Document** **Doc ID# 154**
Affidavit of Electronic Service (Jeffcoat-Sacco, Schuh, Braaten)
07/09/2015 **Assignment** **Doc ID# 155**
of Judge Hagerty
07/09/2015 **Demand for Change of Judge** **Doc ID# 156**
Demand for Change of Judge
07/09/2015 **Service Document** **Doc ID# 157**
Certificate of Service
07/10/2015 **Assignment** **Doc ID# 158**
of Judge Romanick
08/07/2015 **Stipulation / Agreement** **Doc ID# 159**
Stipulation for Extension of Time
08/07/2015 **Service Document** **Doc ID# 160**
Affidavit of Electronic Service - Jeffcoat-Sacco and Braaten
08/07/2015 **Proposed Order** **Doc ID# 161**
Proposed Order for Extension of Time
08/21/2015 **Brief** **Doc ID# 162**
Brief of Appellant
08/24/2015 **Service Document** **Doc ID# 163**
Certificate of Service
08/26/2015 **Order** **Doc ID# 164**
for Extension of Time - granted
09/10/2015 **Notice** **Doc ID# 165**
Notice of Motion and Motion for Leave to File Paper Copies of Aerial Photographs and Map
09/10/2015 **Stipulation / Agreement** **Doc ID# 166**
Stipulation Allowing Hard Copies to Be Filed with the Court

09/10/2015	**Service Document** **Doc ID# 167** *Certificate of Service*
09/11/2015	**Stipulation / Agreement** **Doc ID# 168** *Stipulation for Extension of Time*
09/11/2015	**Proposed Order** **Doc ID# 169** *Proposed Order for Extension of Time*
09/11/2015	**Service Document** **Doc ID# 170** *Affidavit of Service*
09/14/2015	**Proposed Order** **Doc ID# 171** *Proposed Order Granting Leave to File Paper Copies of Aerial Photographs and Map*
09/14/2015	**Service Document** **Doc ID# 172** *Certificate of Service*
09/15/2015	**Order** **Doc ID# 173** *for Extension of Time - Granted*
09/28/2015	**Notice** **Doc ID# 174** *Notice of Entry of Order*
09/30/2015	**Brief** **Doc ID# 175** *Brief of Coyote Creek Mining Company*
09/30/2015	**Exhibit** **Doc ID# 176** *Exhibit A to Brief of Coyote Creek Mining Company - Surface and Coal Lease Agreement*
09/30/2015	**Exhibit** **Doc ID# 177** *Exhibit B to Coyote Creek Mining Company Brief - AVF Report*
09/30/2015	**Exhibit** **Doc ID# 178** *Exhibit C to Coyote Creek Mining Company Brief - Reclamation Division Memorandum re Field Investigation*
09/30/2015	**Exhibit** **Doc ID# 179** *Exhibit D to Coyote Creek Mining Company Brief - AVF Study prepared for Dakota Westmoreland*
09/30/2015	**Exhibit** **Doc ID# 180** *Exhibit E to Coyote Creek Mining Company Brief - Reclamation Division Memorandum re Dakota Westmoreland*
09/30/2015	**Service Document** **Doc ID# 181** *Affidavit of Electronic Service upon Illona Jeffcoat-Sacco and Derrick Braaten*
09/30/2015	**Service Document** **Doc ID# 182** *Affidavit of Service*
09/30/2015	**Service Document** **Doc ID# 183** *Affidavit of Service*
09/30/2015	**Brief** **Doc ID# 184** *Brief of Appellee North Dakota Public Service Commission*
11/10/2015	**Order** **Doc ID# 185** *Denying Request for Oral Argument*
11/13/2015	**Notice** **Doc ID# 186** *Notice of Entry of Order Denying Request for Oral Argument*
11/13/2015	**Service Document** **Doc ID# 187** *Affidavit of Service - Notice of Entry of Order Denying Request for Oral Argument*
01/19/2016	**Order** **Doc ID# 188** *Order*
01/22/2016	**Notice** **Doc ID# 189** *Notice of Entry of Order*
01/22/2016	**Service Document** **Doc ID# 190** *Affidavit of Service*
01/25/2016	**Proposed Judgment** **Doc ID# 191** *Proposed Judgment*
01/25/2016	**Service Document** **Doc ID# 192** *Affidavit of Service*
01/26/2016	**Proposed Judgment** **Doc ID# 193** *Proposed Judgment*
01/26/2016	**Service Document** **Doc ID# 194** *Affidavit of Electronic Service of Proposed Judgment to Jeffcoat-Sacco and Braaten*
01/26/2016	**Response** **Doc ID# 195** *Public Service Commission Response to Coyote Creek Mining Company Proposed Judgment*
01/26/2016	**Service Document** **Doc ID# 196** *Affidavit of Electronic Service*
01/28/2016	**Judgment** **Doc ID# 197**
02/01/2016	**Notice** **Doc ID# 198** *Notice of Appeal by Casey Voigt*
02/01/2016	**Notice** **Doc ID# 199** *Corrected Notice of Appeal by Casey Voigt*
02/01/2016	**Notice of Filing the Notice of Appeal** **Doc ID# 200** *Notice of Filing Notice of Appeal and Corrected Notice of Appeal*
02/01/2016	**Service Document** **Doc ID# 201** *Affidavit of Service for Notice of Filing Notice of Appeal and Corrected Notice of Appeal*
02/26/2016	**Clerk's Certificate on Appeal** **Doc ID# 202**
03/02/2016	**Clerk's Certificate on Appeal** **Doc ID# 203** *Amended Clerk's Certificate on Appeal*
03/24/2016	**Letter** **Doc ID# 204** *from Public Service Commission (w/ CD)*
03/29/2016	**Clerk's Supplemental Certificate of Appeal** **Doc ID# 205**

Financial Information

	Appellant Voigt, Casey			
	Total Financial Assessment			80.00
	Total Payments and Credits			80.00
	Balance Due as of 04/05/2016			**0.00**
05/18/2015	Transaction Assessment			80.00
05/18/2015	Mail Payment	Receipt # 08-2015-8206	Voigt, Casey	(80.00)

A31FA24D-DF1D-4F94-AE6D-1A4CB0825E50BF0F6F7C-2EAA-46CF-A7EC-FFE4BCCF1A002EF40227-5AEA-4B84-990B-68886AA8D3FAD0D6B31D-7CC4-430A-86A6-3268A92A94EEC5255338-C377-420B-9239-CC3499EEE67E5A171ACC-C566-40BA-A874-0030B275DE079160AB59-2496-45A4-94D4-8A3074DF3E02D674C5B2-

STATE OF NORTH DAKOTA | IN DISTRICT COURT

COUNTY OF BURLEIGH | SOUTH CENTRAL JUDICIAL DISTRICT

Casey Voigt,

Appellant,

v.

North Dakota Public Service Commission and Coyote Creek Mining Company, LLC,

Appellees.

Case Number: 08-2015-CV-01056

ORDER

INTRODUCTION

[¶1] The Appellant, Casey Voigt (Voigt), filed a Notice of Appeal and Specification of Errors, arguing the decision issued by Appellee, North Dakota Public Service Commission (PSC) is not in accordance with law, the findings of fact are insufficient and not supported by a preponderance of the evidence, and the conclusions of law are not supported by its findings of fact.

[¶2] Appellee, PSC, filed a brief, arguing it was correct in concluding the area in question is not an alluvial valley floor under federal and state mining regulations. Appellee, Coyote Creek Mining Company (CCMC), filed a brief supporting the PSC's assertion.

BACKGROUND

[¶3] This is an appeal from an administrative decision issued by the Public Service Commission affirming its earlier decision to grant a coal mining permit to Coyote Creek Mining Company for the operation of the Coyote Creek Mine in Mercer County, North Dakota. On November 1, 2013, CCMC applied for Surface Coal Mining Permit No. NACC-1302 for a new mine approximately ten miles southwest of Beulah, North Dakota. The permit application covers 8,091.511 acres of land located in Mercer County, North Dakota. On October 22, 2014, the PSC conditionally approved Permit No. NACC-1302, allowing CCMC to engage in surface coal mining operations at the Coyote Creek Mine, subject to the right of any interested person to request a formal hearing on the decision.

[¶4] Casey Voigt requested a hearing, noting concerns with regard to the size of the permit area, the reclamation practices to be used and his loss of agricultural production. Voigt and his wife own and lease much of the land in the eastern half of the 8,092 acre permit area. The Voigts' land includes a ranching operation, native grassland used for livestock grazing, cropland used for hay production, and an occupied farmstead where their family resides.

[¶5] A hearing was held before the PSC December 19 and 23, 2014, and January 2, 2015. The following issues were considered at the hearing: (1) the appropriate size of the permit area; (2) the reclamation practices that would be used on land to be mined; and (3) Voigt's loss of agricultural production. The PSC made the following Conclusions of Law:

1. The Commission has jurisdiction over CCMC's planned mining and reclamation operations in North Dakota, including Permit No. NACC-1302.
2. CCMC's application for Surface Cole Mining Permit NACC-1302 meets all permit application standards under North Dakota Century Code Chapter 38-14.1 and North Dakota Administrative Code Article 69-05.2.
3. There is no basis for the Commission to rescind or revoke Permit No. NACC-1302.
4. It is reasonable to require Coyote Creek Mining Company to revise Permit NACC-1302 to describe the detailed methods that will be used to minimize compaction of topsoil and subsoil that is replaced on reclaimed lands and to provide a testing plan to determine if there is any excess compaction in the replaced topsoil and subsoil and describe measures that will be used to alleviate excessive compaction if detected.
5. It is reasonable to require Coyote Creek Mining Company to revise Permit NACC-1302 to state that Casey Voigt will be consulted when they select and establish management practices for undisturbed reference areas that will be used to demonstrate reclamation success on Mr. Voigt's reclaimed native grasslands.

6. The alluvium along Coyote Creek is not an alluvial valley floor as defined by subsection 1 of N.D.C.C. Section 38-14.1-02.
7. The Commission does not have any jurisdiction over coal or surface leasing terms, conditions or practices.
8. The Commission has no jurisdiction over the closure of county roads.

[¶6] Based on its conclusions of law, the PSC entered an Order affirming the conditional approval of Permit No. NACC-1302. The PSC also ordered CCMC to submit a revision application to Permit NACC-1302 to add plans for: (1) describing detailed methods used to minimize compaction on replaced subsoil and topsoil; (2) conducting testing to determine if excess compaction in topsoil and subsoil exists on reclaimed land and describe measures for alleviating potential compaction; and (3) consulting with Voigt in establishing management practices on reclaimed native grasslands owned by Voigt.

LAW AND DECISION

[¶7] The Administrative Agencies Practice Act governs this Court's review of an administrative agency's decision to grant a coal mining permit. *N.D.C.C. § 28-32-46* This Court must affirm the agency's decision, unless:

(1) The order is not in accordance with the law;
(2) The order is in violation of the constitutional rights of the appellant;
(3) The provisions of this chapter have not been complied with in the proceedings before the agency;
(4) The rules or procedure of the agency have not afforded the appellant a fair hearing;
(5) The findings of fact made by the agency are not supported by a preponderance of the evidence;
(6) The conclusions of law and order of the agency are not supported by its findings of fact;
(7) The findings of fact made by the agency do not sufficiently address the evidence presented to the agency by the appellant;
(8) The conclusions of law and order of the agency do not sufficiently explain the agency's rationale for not adopting any contrary recommendations by a hearing officer or an administrative law judge.

N D C C § 28-32-46. "Courts exercise limited review in appeals from administrative agency decisions, and the agency's decision is accorded great deference." *Berger v. N.D. Dep't of Transp*, 2011 ND 55, ¶ 5, 795 N.W.2d 707. This Court does not make "independent findings or substitute our own judgment for that of the agency." *Dettler v. Sprynczynatyk*, 2004 ND 54, ¶ 10, 676 N.W.2d 799. "We instead determine only whether a reasoning mind reasonably could have concluded the findings were supported by the weight of the evidence from the entire record." *Id*

[¶8] Voigt argues the PSC's order is not in compliance with N.D.C.C. § 38-14.1-21(3)(e) and N.D. Admin. Code § 69-05.2-08-13(1) because the 2009 AVF Study and 2009 AVF Field Review "include almost none of the information required by subsections (d), (e), (f) of [N.D. Admin. Code § 69-05.2-08-13(1)]." Chapter 38-14.1 of the North Dakota Century Code governs surface mining and reclamation procedures and the PSC has adopted rules implementing that law under chapter 69-05.2 of the North Dakota Administrative Code. Permit approval and denial standards are found at N.D.C.C. § 38-14.1-21, which states in relevant part,

> (3) No permit or revision application may be approved unless the applicant affirmatively demonstrates and the commission finds in writing on the basis of the information set forth in the application or from information otherwise available which will be documented in the approval and made available to the applicant, that all the following requirements are met:
>
> > (e) The proposed surface coal mining operation, if located west of the one hundredth meridian west longitude, would:
> >
> > > (1) Not interrupt, discontinue, or preclude farming on alluvial valley floors that are irrigated or naturally subirrigated, . . .
> > >
> > > or
> > >
> > > (2) Not materially damage the quantity or quality of water in surface or underground water systems that supply these alluvial valley floors. . . .

N D C C. § 38-14 1-21(3)(e). An "alluvial valley floor" is defined as:

> the unconsolidated stream-laid deposits holding streams where water availability is sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of sediment from sheet erosion, deposits by unconcentrated runoff or slope wash, together with talus, other mass movement accumulation, and windblown deposits.

N D C C § 38-14 1-02(1)

[¶9] Section 69-05.2-08-13 of the North Dakota Administrative Code outlines the procedure the PSC and permit applicants must follow when determining whether an alluvial valley floor exists:

> 1. Before applying for a permit to conduct operations within a valley holding a stream or in a location where the adjacent area includes any stream, the applicant shall either affirmatively demonstrate, based on available data, the presence of an alluvial valley floor, or submit the results of a field investigation of the permit and adjacent areas. The investigations must include sufficiently detailed geologic, hydrologic, land use, soils, and vegetation studies on areas required to be investigated by the commission, after consultation with the applicant, to enable the commission to make an evaluation regarding the existence of the probable alluvial valley floor in the permit or adjacent area and to determine which areas, if any, require more detailed study in order to make a final determination regarding the existence of an alluvial valley floor. Studies performed during the investigation by the applicant or subsequent studies required of the applicant must include an appropriate combination, adapted to site-specific conditions, of:
>
> > a. Mapping of the probable alluvial valley floor including geologic maps of unconsolidated deposits, delineating the streamlaid deposits, maps of streams, delineation of surface watersheds and directions of shallow ground water flows through and into the unconsolidated deposits, topography showing local and regional terrace levels, and topography of terraces, floodplains, and channels showing surface drainage patterns.
> >
> > b. Mapping of all lands included in the area used for agricultural activities, showing the different types of agricultural lands and accompanied by measurements of vegetation productivity and type.

c. Topographic maps of all lands that are or were historically flood-irrigated, showing the location of each diversion structure, ditch, dam, and related reservoir.

d. Documentation that areas identified in this section are, or are not, subirrigated, based on ground water monitoring data, representative water quality, soil moisture measurements, and measurements of rooting depth, soil mottling, and water requirements of vegetation.

e. Documentation, based on representative sampling, that areas identified under this subdivision are, or are not, flood irrigable, based on streamflow, water quality, water yield, soils measurements, and topographic characteristics.

f. Analysis of a series of aerial photographs, including color infrared imagery capable of showing any late summer and fall differences between upland and valley floor vegetative growth and of a scale adequate for reconnaissance identification of areas that may be alluvial valley floors.

N.D. Admin. Code § 69-05.2-08-13(1). After reviewing studies submitted by the permit applicant, the PSC will determine an alluvial valley floor exists when certain conditions are present:

2. Based on the investigations conducted under subsection 1, the commission will determine the extent of any alluvial valley floors within the study area and whether any stream in the study area may be excluded from further consideration. The commission will determine that an alluvial valley floor exists if:

a. Unconsolidated stream laid deposits holding streams are present; and

b. There is sufficient water to support agricultural activities as shown by:

(1) The existence of flood irrigation in the area or its historical use;

(2) The capability to be flood-irrigated, based on streamflow water yield, soils, water quality, and topography; or

> (3) Subirrigation of the lands from the ground water system of the valley floor.

N.D. Admin. Code § 69-05.2-08-13.

[¶10] The rules require an applicant, prior to applying for a permit, to "affirmatively demonstrate, based on available data, the presence of an alluvial valley floor, *or* submit the results of a field investigation of the permit and adjacent areas." *N.D. Admin Code § 69-05.2-08-13(1).* If an alluvial valley floor exists, the PSC may impose additional restrictions or requirements on the permit applicant to preserve essential hydrologic functions of alluvial valley floors. *See N.D.C.C. § 38-14.1-24(8)(g).*

[¶11] Prior to submitting its permit application in this case, CCMC submitted an Alluvial Valley Floor Evaluation Report prepared by Dr. David Bickel in 2013, wherein Bickel concluded, "[t]here is no evidence that the Knife River and Coyote Creek or other drainages within or adjacent to the AVF study area meet any of the criteria essential for determining them to be AVF." (Doc ID #82). A 2013 Field Review conducted by the PSC also concluded the areas along the Knife River and Coyote Creek do not meet the criteria of an AVF. (Doc ID #101). The PSC also relied on an Alluvial Valley Floor Study conducted by Dakota Westmoreland Corporation in 2009, concluding the Coyote Creek stream valley does not contain an AVF. (Doc ID #48). A 2009 Field Review conducted by Dakota Westmoreland Corporation also concluded no AVF existed in the areas adjacent to the Coyote Creek. (Doc ID #66).

[¶12] Dr. Bickel testified sufficient data was available to make the AVF determination. All four of the available reports concluded no AVF existed in the Coyote Creek and Knife River areas. The PSC also considered testimony of Voigt's expert, Charles Norris, a geologist/hydrologist with Geohydro, Inc. in Denver, Colorado. Norris testified more data should have been collected for the Coyote Creek AVF determination because some areas along the Coyote Creek show subirrigation and is likely an AVF. Norris also testified he has never visited the site and said, "if subirrigation occurs and hay production is enhanced in that area, such an area would be considered an AVF." Although there was conflicting testimony as to whether sufficient information was available and whether an alluvial valley floor exists, the PSC considered all of the data available to it at the time. Thus, its decision finding no AVF exists in the permit application area was supported by the evidence and was in accordance with applicable laws.

[¶13] Voigt argues the PSC's order is not in accordance with law because it did not determine whether Voigt's lowland alfalfa fields were subirrigated, and therefore, the alluvial valley floor determination does not contain data necessary to identify "subirrigation" as defined by law. With respect to alluvial valley floors, "subirrigation" means, "the supplying of water to plants from a semisaturated or saturated subsurface zone where water is available for use by vegetation." *N.D Admin Code § 69-05 2-01-02(103).* Additionally, subirrigation may be identified by:

> a. Diurnal fluctuation of the water table, due to the differences in nighttime and daytime evapotranspiration rates;
>
> b. Increasing soil moisture from a portion of the root zone down to the saturated zone, due to capillary action;
>
> c. Mottling of the soils in the root zones;
>
> d. Existence of an important part of the root zone within the capillary fringe or water table of an alluvial aquifer; or
>
> e. An increase in streamflow or a rise in ground water levels, shortly after the first killing frost on the valley floor.

Id.

[¶14] The PSC considered testimony from Voigt and his expert, Charles Norris, in addition to considering testimony from CCMC's experts, David Bickel, Bruce Beechie, Dean Moos, and Sarah Flath. Specifically, the PSC stated in its findings of fact that Norris "believes subirrigation occurs along Coyote Creek and enhances the production of alfalfa on Mr. Voigt's hay field located on the Coyote Creek alluvium." The PSC also considered evidence submitted in Exhibit CV-7 regarding Voigt's hay yields in lowland fields along Coyote Creek and others in upland areas. Additionally, the PSC considered the OSM's AVF Study Guidelines, Exhibit CV-15, regarding water extraction depths for alfalfa. The PSC relied on a statement from page C-11 of the OSM AVF Study Guidelines that "subirrigation may provide enough water to maintain alfalfa but not enough to enhance its production."

[¶15] The PSC found "[n]one of the evidence presented at the hearing indicates that subirrigation significantly enhances hay production on Mr. Voigt's fields along Coyote Creek," but rather, determined "the overall higher hay production from those fields compared to his upland hay fields is due to the inherent high productivity of the Straw soils, which the NRCS classified as not subirrigated." The PSC considered the evidence and testimony presented it to it and determined the evidence did not support a finding of subirrigation on Voigt's lowland alfalfa fields. Therefore, the PSC's findings on subirrigation were supported by the evidence and made in accordance with law.

[¶16] Voigt argues the PSC's conclusions of law numbers two and six are not supported by its findings of fact. The PSC concluded "CCMC's application for Surface Coal Mining Permit NACC-1302 meets all permit applications standards under North Dakota Century Code Chapter 38-14.1 and North Dakota Administrative Code Article 69-05.2." The PSC considered all available reports and studies. All four reports concluded no alluvial valley floor exists in the

Coyote Creek area. Before approving the permit application, the PSC was required to determine whether an alluvial valley floor exists in the permit application area, and if so, whether surface coal mining would disturb farming on alluvial valley floors or damage underground water systems that supply alluvial valley floors. *See Ch. 38-14.1, N.D.C.C., See Article 69-05.2, N D Admin. Code*. The PSC determined no alluvial valley floor existed and therefore, its conclusion that CCMC's permit application meets all permit application standards was supported by its findings of fact.

[¶17] The PSC also concluded "[t]he alluvium along Coyote Creek is not an alluvial valley floor as defined by subsection 1 of N.D.C.C. Section 38-14.1-02." Again, the PSC relied on all four reports made available to it in its findings of fact. Because all four reports concluded the minimal alluvium that exists in the Coyote Creek area did not amount to an alluvial valley floor, the PSC's conclusion is supported by its findings of fact.

CONCLUSION

[¶18] The PSC's decision was supported by the weight of the evidence from the record and the Order affirming the PSC's conditional approval of Permit No. NACC-1302 is AFFIRMED.

Dated January 19, 2016.

BY THE COURT:

Bruce Romanick
District Judge

cc. Derrick Braaten
Brian Bjella

STATE OF NORTH DAKOTA	IN DISTRICT COURT
COUNTY OF BURLEIGH	SOUTH CENTRAL JUDICIAL DISTRICT

Casey Voigt)
)
Appellant,)
)
vs.)
)
North Dakota Public Service Commission,)
and Coyote Creek Mining Company, L.L.C.,)
)
Appellees.)
)
)
PSC Case No. PU-13-850)
)

Civil No. 08-2015-CV-1056

JUDGMENT

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[1] The Court having entered its order on 19 January 2016 in the captioned administrative appeal;

[2] IT IS HEREBY ORDERED, ADJUDGED AND DECREED that the Public Service Commission's 14 April 2015 Findings of Fact, Conclusions of Law and Order affirming the Public Service Commission's conditional approval of Permit No. NACC-1302 is affirmed, and

[3] That the appeal be dismissed with prejudice and without costs to any party.

[4] Dated this 26th day of January, 2016.

BY THE COURT:
Signed: 1/28/2016 3:07:33 PM

Michelle Bring
Clerk of Court

IN THE SUPREME COURT
STATE OF NORTH DAKOTA

Casey Voigt, Appellant, vs. North Dakota Public Service Commission and Coyote Creek Mining Company, L.L.C., Appellees.	)	Supreme Court Case No.: xxxxxxxx Burleigh County District Court Case No.: 18-2014-CV-01058 **NOTICE OF APPEAL AND SPECIFICATION OF ERRORS**

[¶1] PLEASE TAKE NOTICE that Casey Voigt, by and through his counsel, hereby gives notice of his appeal under N.D.C.C. § 28-27-02 to the North Dakota Supreme Court of the trial court's Order, dated January 19, 2016, and final judgment in this matter, dated January 28th, 2016.

STATEMENT OF ISSUES

[¶2] Mr. Voigt presents the following issues for appeal:

A. Whether the trial court erred in concluding that the Public Service Commission's order in this matter complied with applicable surface mining laws relating to identification and protection of alluvial valley floors;

B. Whether the trial court erred in concluding that the Public Service Commission's order in this matter sufficiently addressed evidence presented by Appellant in the administrative process identifying pertinent alluvial valley floors immediately adjacent to Coyote Creek Mine;

C. Whether the trial court erred in concluding that the Public Service Commission's conclusions of law regarding lack of alluvial valley floors adjacent to Coyote Creek Mine were supported by its findings of fact;

Dated this 29th day of January, 2016.

BAUMSTARK BRAATEN LAW PARTNERS
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Fax: 701-221-5842

By: /s/ Derrick Braaten
Derrick Braaten (ND ID No. 06394)
JJ England (ND ID No. 08135)

CERTIFICATE OF SERVICE

I hereby certify that on January 29th, 2016, a true and correct copy of Appellant's **NOTICE OF APPEAL** was served via electronic mail on:

- Brian Bjella, counsel for Appellee Coyote Creek Mining Company at bbjella@crowleyfleck.com; and
- Illona Jeffcoat-Sacco, counsel for Appellee Public Service Commission at ijs@nd.gov.

Dated this 29th day of January, 2016.

/s/ JJ England
JJ England

IN THE SUPREME COURT
STATE OF NORTH DAKOTA

Casey Voigt, Appellant, vs. North Dakota Public Service Commission and Coyote Creek Mining Company, L.L.C., Appellees.	)	Supreme Court Case No.: xxxxxxxx Burleigh County District Court Case No.: 08-2015-CV-1056 **NOTICE OF APPEAL AND SPECIFICATION OF ERRORS**

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/s/ JJ England
JJ England